Shasta Temperature Control Device
CFD Modeling Study

October 1999

U.S. DEPARTMENT OF THE INTERIOR
Bureau of Reclamation
Technical Service Center
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Executive summary

Background

Shasta Dam and Lake, located 10 miles north of Redding in northern California, are principal components of the Shasta/Trinity River Divisions of the Central Valley Project (CVP), which is a federal water project operated by the Bureau of Reclamation (Reclamation). The Shasta/Trinity River Divisions provide flood and navigation control, irrigation and domestic water supplies, power generation, fish and wildlife conservation, and protection of Sacramento-San Joaquin Delta water quality. Completed in 1945 on the Sacramento River, Shasta Dam is a 602-foot-high curved concrete gravity structure with a crest elevation of 1,065 feet above mean sea level (figure 1). Shasta Dam impounds water from the Pit, McCloud, and upper Sacramento Rivers to form Shasta Lake, 24 miles in length (figure 2). Pertinent physical data on Shasta Lake include; 4.55 million acre-feet (AF) capacity, 29,740-acre surface area, 365-mile shoreline, 517 feet maximum depth, and 6,665 square mile watershed.

Figure 1. Shasta Dam with penstocks, powerplant, and spillway in the foreground, and Shasta Lake in the background.

Shasta Dam includes extensive outlet works with intakes at three elevations and a gated spillway (figure 3; Johnson et al., 1991). Five power penstock intakes are located on the right abutment about 240 feet above the bottom of the reservoir near the center of the dam, but only 25 feet from the reservoir bottom directly in front of the dam. The power plant includes five turbines with a combined rated capacity of 583 megawatts. Discharge capacity of the power plant is 17,600 ft^3/s. The power plant is operated as a peaking plant with releases varying hourly, daily, and seasonally as a function of power and water demand. Largest reservoir releases occur during late spring and summer resulting in lower reservoir water levels.

Shasta Lake provides a popular, diverse sport fishery with both cold and warm-water species including chinook salmon, rainbow trout, brown trout, kokanee, largemouth bass, smallmouth bass, spotted bass, black crappie, bluegill, channel catfish, and white catfish. Other abundant species include Sacramento sucker, Sacramento squawfish, threadfin shad, green sunfish, and brown bullhead (Reclamation 1991).

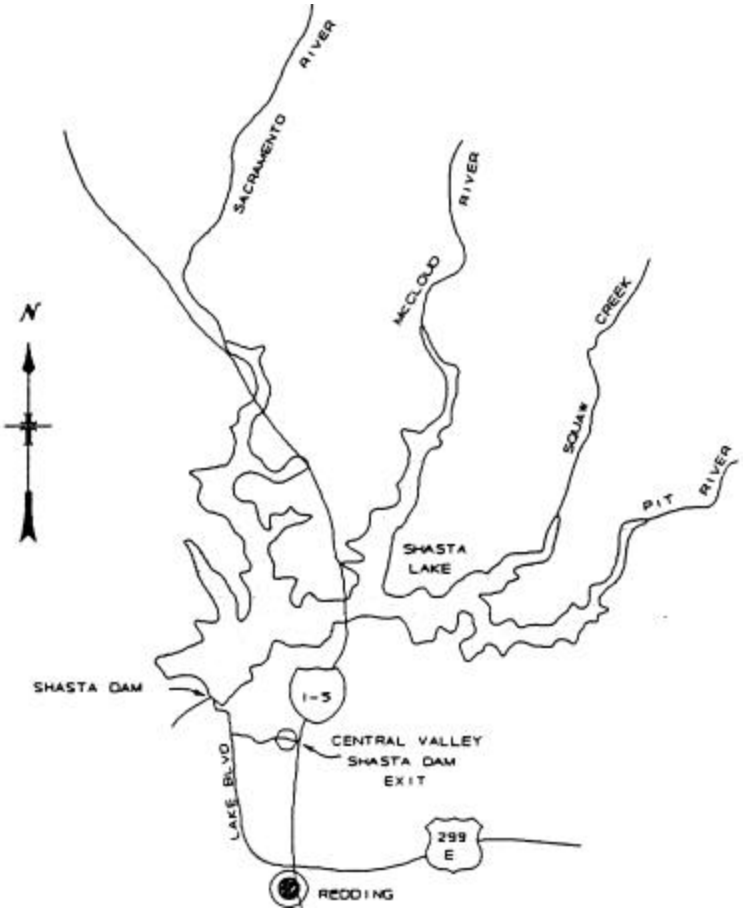

Figure 2. Shasta Lake and tributaries.

In order to control the water temperature below Shasta to protect salmon, combined with the need to minimize power generation losses, a Temperature Control Device (TCD) was installed at Shasta Dam (Johnson 1991). The new TCD has allowed warm-shallow water withdrawal early in the season (spring/early summer) and cold-deep withdrawal later in the season (late summer/early fall). The warm-shallow water releases allow cold water reserves to be saved and used to achieve colder river temperatures during the late summer and early fall.

The TCD is a steel shutter device installed on the face of Shasta Dam, and includes a low level intake structure (figure 4). The TCD selectively controls water withdrawal from the lake over a wide range of depths and corresponding temperatures (Reclamation 1991). The shutter structure consists of a series of fixed panels and adjustable shutters that permit withdrawal from water levels at, and above, the existing intake elevation (Johnson et al. 1991). The 250-ft-wide by 300-ft-high shutter structure is composed of five separate units that are attached to the dam around each penstock intake. These units extend 50 feet upstream from the face of the dam and are open between units to permit cross flow through the shutter structure. Trashracks on the upstream face of the TCD prevent debris accumulation within the device.

The low-level intake structure is attached to the side of the shutter structure (figure 4). This structure also extends 50 feet upstream from the face of the dam and acts as a conduit extension to access the deeper, colder water near the center of the dam. The 150-ft wide by 160-ft high low-level intake structure is made of three intake units that were individually assembled and attached to the dam. These intakes have openings at elevation 720. Two slide gates, mounted on the side of the shutter structure, control the flow from the low-level intake structure to the shutter structure.

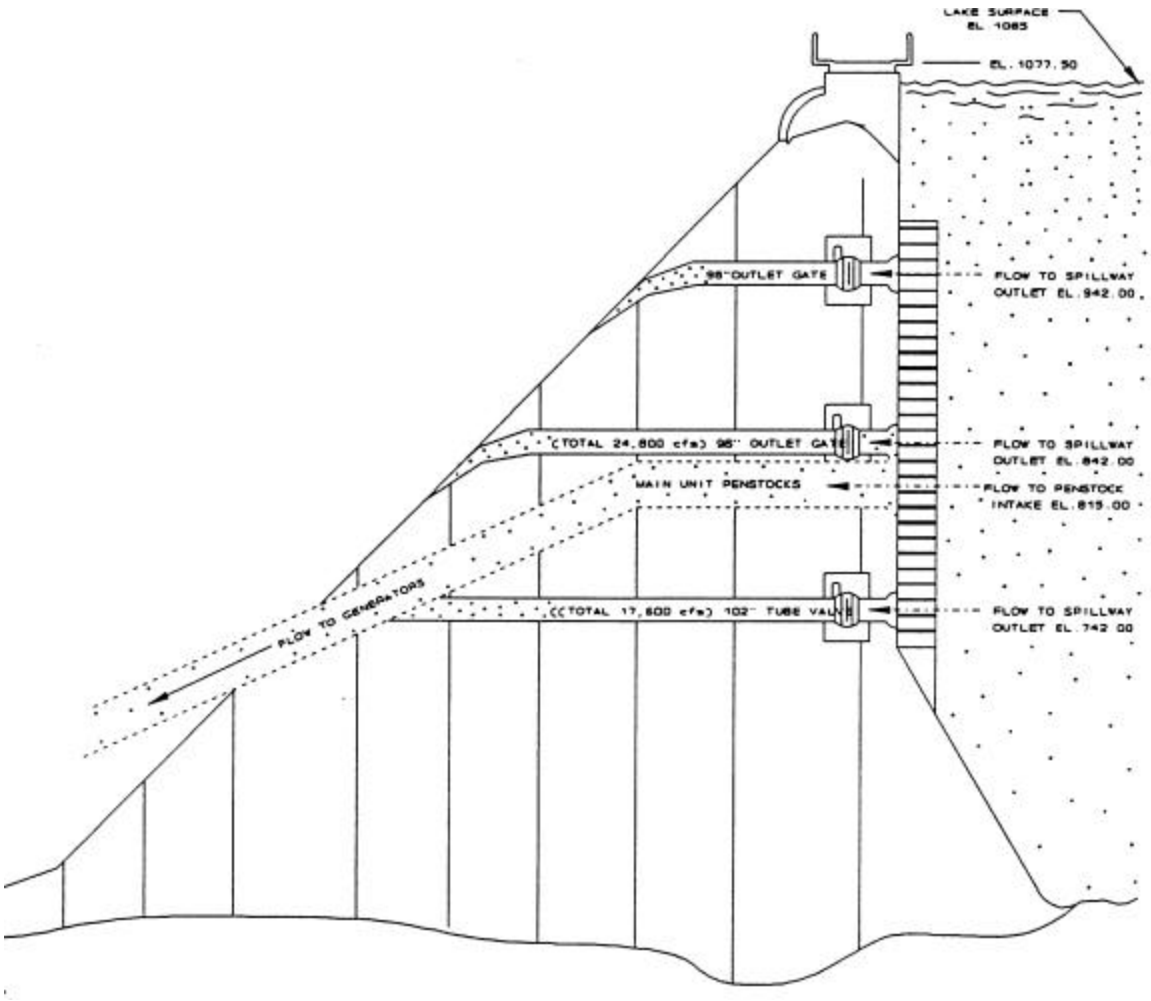

Figure 3. Existing Shasta Dam spillway outlets and penstocks.

TCD withdrawals from Shasta Lake are significantly different from historical withdrawals. Between 1945 and the installation of the TCD, water has been withdrawn mainly from deep hypolimnetic layers where penstocks, for hydropower production, are positioned. The mid-point depth for the penstocks is at about elevation 815, some 250 feet below the surface of Shasta Lake when full. Currently, the TCD withdraws from shallow, epilimnetic waters during spring and early summer, and from depths deeper than historically available during summer and early fall (Vermeyen 1995).

Purpose of study

The purpose of this CFD modeling effort is to optimize cold water storage by calculating release temperatures based on TCD open gate positions, forebay temperature profile in the reservoir, penstock discharge, and reservoir water level.

Conclusions

A three-dimensional computer model of the Shasta TCD was developed using a computer flow simulation software package called FLOW-3D® by Flow Science, Inc. Ten unique simulations were used in the development, validation, and verification of the model. In general, the computer model is an accurate tool for predicting the release temperatures.

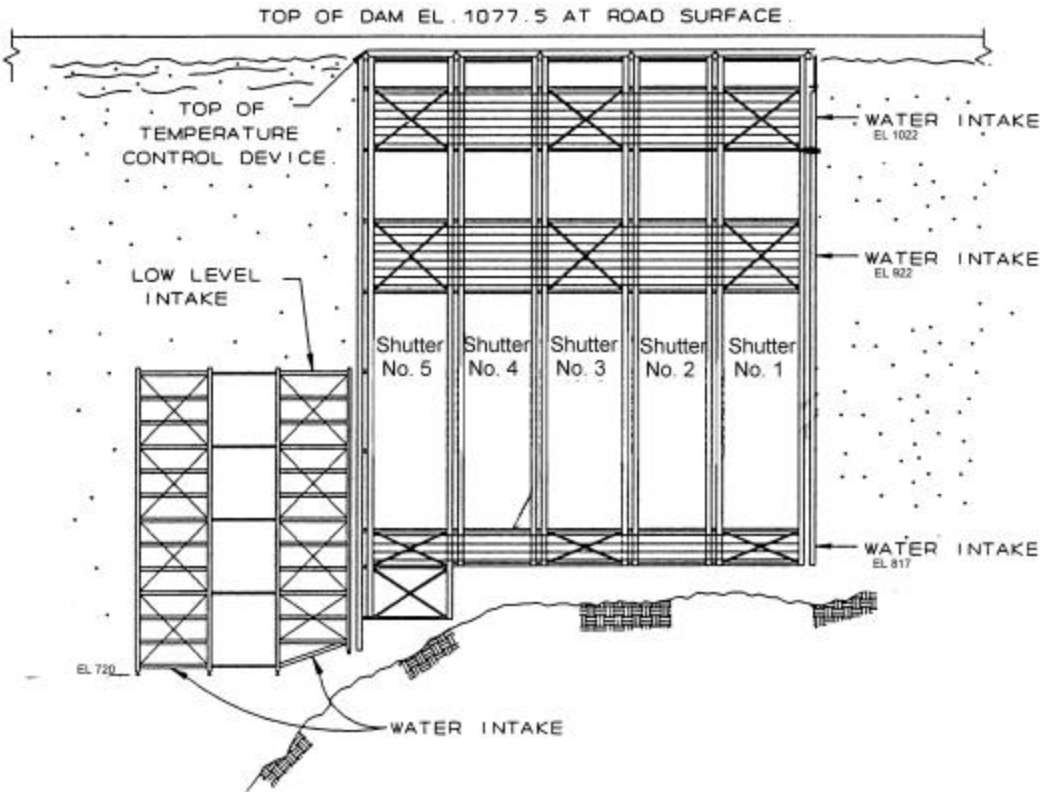

Figure 4. The Shasta Temperature Control Device (TCD) looking downstream. Penstock inlets are behind the lowest water intake in this image. Penstock No. 1 is behind Shutter No. 1, Penstock No. 2 is behind Shutter No. 2, and so forth.

There is a considerable discrepancy between tailrace temperatures measured at the Shasta monitoring station and the penstock release temperatures. Typically, the difference is usually about 1EF. It is important to establish an accurate reference temperature (penstock or river) before any additional model improvements are made. Likewise, it is recommended that if any additional leakage areas are blocked or the TCD is modified, the leakage areas should be recalibrated and a new optimized model be created.

The TCD structure has significant leakage area, which impacts outflow temperatures and increases the complexity of the model. The known TCD leakage areas were incorporated into the model and were calibrated using one set of operational conditions. For that data set, there was a 0.8° F discrepancy between the measured averaged turbine temperature and the river temperature.

The maximum error from the river temperature found from modeling ten different data sets is 1.3° F, and the average of the absolute value of the errors was 0.6° F.

No verification runs for low-level releases were made because the low-level intakes were not used during this study. Thus, no penstock temperature data were available.

The modeling routine has been automated to the point that an operational scenario can be modeled and analyzed in about 3 to 4 hours. The maximum time that it took a 300 MHz Pentium II to model any of the ten data sets was 1.2 hours.

The CFD Model

The model was developed using FLOW-3D® with some modifications to the program. FLOW-3D® by Flow Science is a finite difference, free surface, transient flow modeling system that was developed based on the Navier-Stokes equations, using up to three spatial dimensions. The finite difference equations are based on a fixed Eulerian mesh of non-uniform rectangular control volumes using the Fractional Area/Volume Ratios (FAVOR) method (Sicilian 1990). Free surfaces and material interfaces are defined by a fractional volume-of-fluid (VOF) function. FLOW-3D® uses an orthogonal coordinate system as opposed to a body-fitted system.

Temperature – Density Subroutine

A new subroutine was developed for FLOW-3D® to approximate the temperature- density relationship of clean water. For each 10-degree range starting at 35° F, a quadratic equation has been developed to approximate the density given a temperature. The subroutine is presented in appendix A.

Upstream Boundary Routine

The upstream boundary (FLOW-3D® side 1) routine uses temperature data supplied from PREPTCD.EXE (see Modeling Routine). It evaluates temperatures at cell centers used in FLOW-3D® by linear interpolation. It also evaluates the thermal energy, density, and pressure of each upstream boundary cell.

This routine is appended to the BC.FOR subroutine, and used in Flow Sciences' PREP3D.FOR and HYDR3D.FOR. The routine is presented in appendix B.

Downstream Boundary Routine

Since the exact area of the penstocks modeled by FLOW-3D® can change due to variations in meshing, this routine calculates the area of each penstock. To account for variously sized penstocks, the program evaluates the open area on the downstream boundary (FLOW-3D® side 2).

This routine is appended to the BC.FOR subroutine, and used in Flow Sciences' PREP3D.FOR and HYDR3D.FOR and is presented in appendix C.

Flow Field Temperature Initiation Routine

The reservoir temperatures are not initialized in PREP3D due to flowfield initialization subroutine modification limitations, but rather they are initialized within the first 0.1 seconds of HYDR3D. This routine evaluates the temperature, thermal energy, density, and pressure of each cell in the flow field. This routine is appended to QSADD.FOR and used in HYD3D.FOR and is presented in appendix D.

Discharge Temperature Routine

This routine evaluates the discharge temperature for each penstock, then writes the result to 3PENSTOCKS.DAT. The data is output at the "short print interval" (sprtdt) defined in the Flow3D PREPIN.INP file. This routine is appended to QSADD.FOR and used in HYD3D.FOR and is presented in appendix E.

The discharge-temperature routine is independent of the meshing and modeled penstock shape and size. On the right (outflow) boundary, outflow for each penstock is discreatized at cell centers between 0 to 50-ft, 50 to 100-ft, 100 to 150-ft, 150 to 200-ft, and 200 to 250-ft along the Y-axis of the model. For each of these ranges, the following operation is preformed is used to evaluate outflow temperature:

$$\frac{\sum[afr(ijk)*dely(j)*delz(k)*u(ijk)*tn(ijk)]}{\sum[dely(j)*delz(k)]}$$

where

afr(ijk)…open area fraction of the right face of cell ijk,
dely(j)…width of each cell in plane j, and
delz(k)…height of each cell in plane k.
i…index of the cell in the X-direction,
j…index of the cell in the Y-direction,
k…index of the cell in the Z-direction,
ijk…index of the cell in the mesh,
u(ijk)…downstream velocity of flow in cell ijk
tn(ijk))…temperature of cell ijk

The average outflow is evaluted by taking the temperature of each penstock multiplied by the size of that penstock divided by the total flow.

Model Meshing

Model performance is greatly improved if grid lines are defined at significant object locations, like the face of the dam and the face of the TCD structure. Defining the mesh in this matter provides the model with a sharp edge of object, instead of using partially filled cells. Tables 1 through 3 shows edges which were used to define the significant grids:

Table 1. X-coordinate (downstream direction).

X-Coordinate	Description
-400-ft	Beginning of model
-50-ft	Face of TCD structure
0-ft	Face of Shasta Dam
15-ft	End of model

Table 2. Y-coordinate (parallel to face of dam).

Y-coordinate	Description
-100-ft	Side of model
2-ft	Side of gate No. 1
52-ft	Side of gate No. 2
102-ft	Side of gate No. 3
152-ft	Side of gate No. 4
202-ft	Side of gate No. 5
251-ft	Side of Low Level Intake
381.08-ft	Side of Low Level Intake
500-ft	Side of model

The number and size of the mesh cells between these significant locations effects the model stability, time for computation, and accuracy. The adjacent cell size ratio of two cells is the size of the largest cell divided by the smallest cell in any given direction. A maximum adjacent cell size ratio close to 1 indicates a smoothly varying mesh. The final mesh was roughly based on a 13.5 ft cell within the TCD structure, and provides a low maximum adjacent cell size ratio.

Table 3. Z-coordinate (elevation).

Z-coordinate	Description
670.0-ft	Bottom of model
720.0-ft	Bottom of Low Level Intakes 2 and 3
749.5-ft	Bottom of Low Level Gate
780.0-ft	Bottom of Shutters 1 through 4
804.0-ft	Bottom of pressure relief gates
831.0-ft	Top of Pressure Relief Gates
889.0-ft	Top of Low Level Gate
900.0-ft	Bottom of Middle Gates
945.0-ft	Top of Middle Gates
1000.0-ft	Bottom of Upper Gates
1045.0-ft	Top of Upper gates
Water surface	Top of model

For cases where the reservoir water surface elevation is between 1045 ft and 1055 ft, the resulting top grid spacing is less than 10 ft. This can cause a large maximum adjacent cell size ratio, numeric instabilities, and very long run times. To mitigate this problem, the top cell height is set to 11.25 ft, and the next lowest grid line is adjusted accordingly. This causes the top

of the TCD structure to be modeled with a partially filled cell, and is plotted as if downstream face is filled. However, it produces much better results and shorter run times.

Object Definitions

Objects in the TCD model include topography, the dam with penstock inlets, internal trash rack structure, and the TCD structure.

Topography

Topography is included in the model by using the Stereolithography (STL) file format. The near field topography was generated using the bathymetric survey by Oceaneering Technologies Inc., and Reclamation drawing 214-D-22131, elevations were read off the maps at 50-ft and 100-ft spacing respectively. An in-house FORTRAN program designed for converting XYZ data to STL data was used to generate a STL file. The resulting STL file is read directly by FLOW-3D®. The Stereolithography image is presented in figure 5.

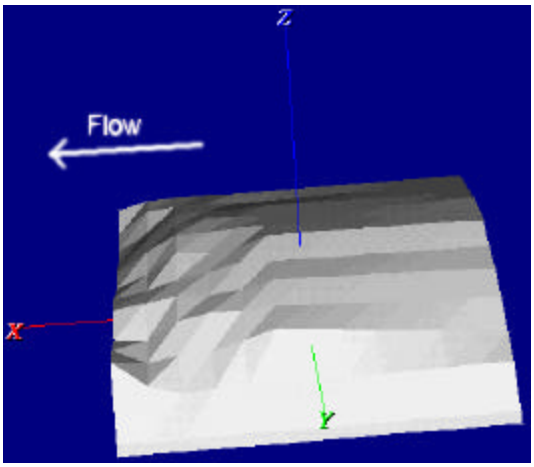

Figure 5. Visualization of the Stereolithography file used to import topography into the TCD model.

Structures

The upstream face of Shasta Dam is modeled using a vertical plane. Penstocks were modeled using different size and shapes to optimize the run time of the model (see Simulated Penstock Size).

The inner trash racks were modeled using a cylindrical shaped baffles using open area fraction of 0.6785 that extends to the bottom of the TCD structure. The concrete structure above the trash racks is modeled using a cylindrical shaped baffle with a 16.83 ft radius. At the meshings presented in this study, the baffles appear to be retangular rather than cylindrical.

The TCD structure was modeled using both baffles and objects. Baffles proved to be more difficult to work with for this model since they require using an entire face of the cell, where objects can use partial faces.

The Shasta TCD has a significant amount of leakage. Various methods were used to model leakage areas by cutting holes in the TCD structure. Numeric instabilities from this approach resulted in very long run times and several iteration crashes. It was apparent now that the long run times and iteration crashes were mostly due to a roughly defined mesh. The final TCD model was developed using several objects with differing porosity. Porosity was included in the model based on a worksheet by Richard LaFond, which estimates leakage areas. FLOW-3D® uses open volumes to define the porosity of objects. Since there is no direct correlation between open areas used in the worksheet and open volumes in FLOW-3D®, the values of open volumes were prorated based on open area while matching the discharge temperature in the river on 8-18-1998 while only the Low-Level Intake was open. Results of this analysis are displayed in table 4.

The TCD gates were modeled by "making a hole" through the TCD structure at the correct location. Each gate has been assigned a unique FLOW-3D® region. If a gate was not open for a model run, the region was defined outside of model space (i.e. the Z value is set to -1000).

The TCD trash racks were modeled using baffles with an open area fraction of 0.9143.

Table 4. Region and Obstacle definitions of leakage areas in the TCD structure. The open area fraction is the open area listed on the worksheet by Richard LaFond divided by the panel area.

FLOW-3D® Region	FLOW-3D® Obstacle	TCD Face	X-coordinate plane or range (ft)	Y-coordinate plane or range (ft)	Z-coordinate plane or range (ft)	Open Area Fraction (Estimated from Worksheet)	Open Volume Fraction (Multiplied by 0.6345)
11	4	Side of shutter No. 1	0 to -50	0	945 to 1000	0.006455	0.0041
12	5	Side of shutter No. 5	0 to -50	250	945 to 1000	0.006244	0.00396
13	6	Front face	-50	0-250	945 to 1000	0.008251	0.00524
14	7	Side of shutter No. 1	0 to -50	0	900 to 945	0.006996	0.00444
15	8	Side of shutter No. 5	0 to -50	250	900 to 945	0.033578	0.02131
16	9	Front face	-50	0-250	900 to 945	0.011738	0.00745
17	10	Side of shutter No. 1	0 to -50	0	831 to 900	0.005681	0.0036
18	11	Side of shutter No. 5	0 to -50	250	831 to 900	0.010877	0.0069
19	12	Front face	-50	0-250	831 to 900	0.005001	0.00317
20	13	Side of shutter No. 1	0 to -50	0	804 to 831	0.008622	0.00547
21	14	Front face	-50	0-250	804 to 831	0.016815	0.01067
22	15	Side of shutter No. 1	0 to -50	0	780 to 804	0.011867	0.00753
23	16	Front face	-50	0-250	780 to 804	0.004875	0.00309
26	17	Front face of Side of shutter No. 5	-50	200-250	749.5 to 780	0.013333	0.00846
27	18	Bottom of shutters Nos. 1 to 4	0 to -50	0-200	780	0.03528	0.02239
28	19	Bottom of shutters No. 5	0 to -50	200-250	749.5	0.03072	0.01949

Model Optimization

Turbulence models

This study evaluated three turbulence models for the Shasta TCD study. They are local viscosity evaluation, Renormalized Group Theory (RNG) model, and the Large Eddy Simulation (LES) model. The porosity of the leaky parts of the TCD were analyzed using the local viscosity evaluation for flows on 8-18-98, then RNG and LES were tested to see if the prediction of temperatures were improved. During early meshing configurations, these two turbulence models caused instabilities in the model and iteration crashes. Using latter meshing configurations, there was a significant increase in computation time and little change in the predicted temperatures. For the presented mesh configuration and leakage calibration, local viscosity evaluation appears optimal.

Advection models

This study evaluated four momentum equation approximations available in FLOW-3D®. They are linear approximation, first-order approximation, second-order approximation, and monotonicity-preserving second-order approximation. The linear approximation proved to be stable and accurate. The first-order approximation proved to be stable, more accurate, with a slight increase in computation time. The second-order approximation and the monotonicity-preserving second-order approximation provided no significant improvements. For the current mesh configuration and leakage calibration, first-order approximation appears optimal.

Simulated Penstock Size

The penstocks at Shasta Dam have a 7.5 ft radius, which does not allow for a refined definition of the intakes while using the mesh configurations that have reasonable computation times. However, to predict the average river temperature it was most important to accurately model the flow going into the TCD rather than the flow into the penstocks. Thus, providing for the proper flow conditions at the inlets of the TCD became the prime objective of the model. This allows for distortion of the modeled penstock, as long as it does not significantly impact the results.

The highest velocities in the model occur in the penstocks. One of the time-step limiting factors in FLOW-3D® is based on convective stability. This limits the maximum time step to 0.45 times the cell width divided by the velocity in that direction. As a resoult, high velocities in short cells most often limit the time step size in this model.

To improve the computation time of the model, various penstock sizes were tested. This included both lengthening the cells (increasing the convective distance), and increasing the penstock size (decreasing the velocity).

The best penstock configuration tested was a 25-ft-wide by 27-ft-tall rectangular inlets. In addition to reducing the velocity thus increasing the time step, this greatly simplified the meshing since a grid line at elevation 815 ft (elevation of the centerline of the penstocks) was not needed. The X-distance of the penstock cell was lengthened to 10% more than the adjacent cell inside the TCD, which provided for a good adjacent cell size ratio for numeric stability.

Results

A variety of flow conditions were selected for model validation. Two were from the same date in 1998 with extremely different gate positions, and the rest from May to August 1999. On these dates, there were significant discrepancies between the measured average turbine temperatures and the measured river

temperature as shown in table 5. Recent calibration of the temperature measurement devices indicates that the turbine readings are probably provide a more accurate temperature reading, and that the water in the river is not well mixed at the temperature measurement location. However, since the determining the average release temperature was the main objective of this study, the TCD leakage was calibrated to the river temperature data using the 8/18/98(b) data set.

Modeling results are presented in table 6. Each simulation modeled 20 minutes prototype time. These simulations used the local viscosity evaluation (turbulence model) and the first-order approximation advection model. Run time is the amount of CPU time the simulation took on a 300 MHz Pentium II processor.

Table 5. Modeling information.

Modeled data set (date)	River Temperature (°F)	Average turbine temperature (°F)	Water Surface Elevation (ft)	Upper Gates	Middle Gates	Pressure Relief Gates	Low Level Gate
5/19/99	47.8	48.6	1058.7	All Open	1, 2, and 3 Open	All Closed	Closed
5/20/99	46.8	47.5	1058.6	All Closed	All Open	All Closed	Closed
6/18/99	46.4	48.2	1057.0	All Closed	All Open	All Closed	Closed
7/5/99	48.9	49.8	1049.0	3 Open	1, 2, 4, and 5 Open	All Closed	Closed
7/8/99	48.9	49.1	1048.3	All Closed	All Open	All Closed	Closed
7/23/99	50.3	51.1	1041.1	3 open	1, 2, 4, and 5 Open	All Closed	Closed
7/24/99	50.1	51.0	1040.5	All Closed	All Open	All Closed	Closed
8/13/99	48.6	49.1	1032.2	All Closed	2 Open	1, 3, 4, 5 Open	Closed
8/18/98 (a)	50.1	50.3	1043.7	All Closed	1, 2, and 3 Open	All Open	Closed
8/18/98 (b)	50.2	50.9	1043.7	All Closed	All Closed	All Closed	Open

Table 6. Run Times and Calculated Temperatures. Modeling results for 20 minutes prototype time. Run time is the amount of CPU time the simulation took on a 300 MHz Pentium II processor.

Data Set (date)	River Temperature (°F)	Average Penstock Temperature (°F)	Run Time (hours)	Computed Temperature (°F)	Error from River (°F)	Error from Penstock (°F)
5/19/99	47.8	48.6	0.6	47.9	0.1	-0.7
5/20/99	46.8	47.5	0.6	46.7	-0.1	-0.7
6/18/99	46.4	48.2	0.7	47.0	0.6	-1.2
7/5/99	48.9	49.8	1.0	49.9	1.0	0.1
7/8/99	48.8	49.1	0.8	49.3	0.5	0.2
7/23/99	50.3	51.1	0.7	51.1	0.8	0.0
7/24/99	50.1	51.0	0.8	50.7	0.6	-0.3
8/13/99	48.6	49.1	0.4	49.3	-0.7	0.2
8/18/98 (a)	50.1	50.3	0.4	51.4	-1.3	-1.1
8/18/98 (b)	50.2	50.9	1.2	50.1	0.1	0.8

Penstock Temperature Analysis

While evaluating average release temperature was the main goal of this study, analysis of individual penstock temperatures was not originally included in the scope of work. However, the penstock temperatures are presented for future reference.

The model was developed based on the concept that "what goes into the TCD, goes out to the river." While optimizing computation time and calculating river temperature, flow within the TCD structure and penstocks are roughly modeled allowing for longer time-steps and shorter computation times. This modeling approach allows for more mixing of the flow in the model that would physically occur. This modeling approach causes the highest temperature calculated to be lower than one would expect, and the lowest temperature to be higher than one would expect.

While evaluating the results presented below, it is important to consider that the leakage was calibrated using the river temperature data, rather than the average turbine release temperatures. The discrepancies between penstock and river temperatures were was typically around 1°F.

Tables 7 though 16 shows penstock flows, the measured temperature of each penstock, the calculated temperature of each penstock, standard deviation of the last 3 minutes of the simulation, and gate positions.

Analysis of tables 7 though 16 showed that most of the calculated penstock temperature ranges are smaller than the actual temperature ranges. But it appears that this effect is overwhelmed by the discrepancy between the measured river and turbine temperatures. Calculated penstock temperature ranges for 7-5-99, 5-19-99, 8-18-98(a), and 8-18-98(b) were larger than the measured temperature ranges. Analysis of the results from these four dates might provide direction for further refinements to the model.

Table 7. Details of results for 5-19-1999. Modeling specifics for this date are presented in appendix F.

	Penstock / Shutter 1	Penstock / Shutter 2	Penstock / Shutter 3	Penstock / Shutter 4	Penstock / Shutter 5
Discharge (ft^3/s)	**3327**	**3358**	**0**	**3781**	**0**
Measured temperature (°F)	**48.1**	**47.8**		**49.8**	
Calculated temperature (°F)	**47.3**	**47.3**		**49.1**	
Standard Deviation of Last 3 Minutes (°F)	**0.07**	**0.11**		**0.20**	
Upper gates	**Open**	**Open**	**Open**	**Open**	**Open**
Middle gates	**Open**	**Open**	**Open**	**Closed**	**Closed**
Pressure Relief Gates	**Closed**	**Closed**	**Closed**	**Closed**	**Closed**

Table 8. Details of results for 5-20-1999. Modeling specifics for this date are presented in appendix G.

	Penstock / Shutter 1	Penstock / Shutter 2	Penstock / Shutter 3	Penstock / Shutter 4	Penstock / Shutter 5
Discharge (ft^3/s)	**3327**	**3358**	**0**	**3781**	**0**
Measured temperature (°F)	**47.8**	**47.4**		**47.7**	
Calculated temperature (°F)	**46.9**	**46.8**		**46.6**	
Standard Deviation of Last 3 Minutes (°F)	**0.03**	**0.02**		**0.05**	
Upper gates	**Closed**	**Closed**	**Closed**	**Closed**	**Closed**
Middle gates	**Open**	**Open**	**Open**	**Open**	**Open**
Pressure Relief Gates	**Closed**	**Closed**	**Closed**	**Closed**	**Closed**

Table 9. Details of results for 6-18-1999. Modeling specifics for this date are presented in appendix H.

	Penstock / Shutter 1	Penstock / Shutter 2	Penstock / Shutter 3	Penstock / Shutter 4	Penstock / Shutter 5
Discharge (ft^3/s)	**2800**	**2800**	**2850**	**2560**	**0**
Measured temperature (°F)	**48.4**	**48.0**	**47.9**	**48.3**	
Calculated temperature (°F)	**47.3**	**47.1**	**47.1**	**46.4**	
Standard Deviation of Last 3 Minutes (°F)	**0.03**	**0.02**	**0.01**	**0.02**	
Upper gates	**Closed**	**Closed**	**Closed**	**Closed**	**Closed**
Middle gates	**Open**	**Open**	**Open**	**Open**	**Open**
Pressure Relief Gates	**Closed**	**Closed**	**Closed**	**Closed**	**Closed**

Table 10. Details of results for 7-5-1999. Modeling specifics for this date are presented in appendix I.

	Penstock / Shutter 1	Penstock / Shutter 2	Penstock / Shutter 3	Penstock / Shutter 4	Penstock / Shutter 5
Discharge (ft^3/s)	**2881**	**2881**	**2881**	**2881**	**3457**
Measured temperature (°F)	**49.1**	**49.7**	**51.2**	**49.7**	**49.1**
Calculated temperature (°F)	**50.3**	**49.7**	**51.1**	**49.2**	**49.1**
Standard Deviation of Last 3 Minutes (°F)	**0.07**	**0.06**	**0.11**	**0.08**	**0.04**
Upper gates	**Closed**	**Closed**	**Open**	**Closed**	**Closed**
Middle gates	**Open**	**Open**	**Closed**	**Open**	**Open**
Pressure Relief Gates	**Closed**	**Closed**	**Closed**	**Closed**	**Closed**

Table 11. Details of results for 7-8-1999. Modeling specifics for this date are presented in appendix J.

	Penstock / Shutter 1	Penstock / Shutter 2	Penstock / Shutter 3	Penstock / Shutter 4	Penstock / Shutter 5
Discharge (ft^3/s)	**2305**	**2305**	**2276**	**2593**	**3457**
Measured temperature (°F)	**49.3**	**49.1**	**48.7**	**49.1**	**49.4**
Calculated temperature (°F)	**50.0**	**49.6**	**49.8**	**49.3**	**48.2**
Standard Deviation of Last 3 Minutes (°F)	**0.07**	**0.09**	**0.12**	**0.13**	**0.06**
Upper gates	**Closed**	**Closed**	**Closed**	**Closed**	**Closed**
Middle gates	**Open**	**Open**	**Open**	**Open**	**Open**
Pressure Relief Gates	**Closed**	**Closed**	**Closed**	**Closed**	**Closed**

Table 12. Details of results for 7-23-1999. Modeling specifics for this date are presented in appendix K.

	Penstock / Shutter 1	Penstock / Shutter 2	Penstock / Shutter 3	Penstock / Shutter 4	Penstock / Shutter 5
Discharge (ft^3/s)	**0**	**2766**	**2766**	**2794**	**3601**
Measured temperature (°F)		**50.7**	**51.5**	**51.7**	**50.6**
Calculated temperature (°F)		**51.3**	**52.4**	**50.7**	**50.3**
Standard Deviation of Last 3 Minutes (°F)		**0.09**	**0.08**	**0.08**	**0.04**
Upper gates	**Closed**	**Closed**	**Open**	**Closed**	**Closed**
Middle gates	**Open**	**Open**	**Closed**	**Open**	**Open**
Pressure Relief Gates	**Closed**	**Closed**	**Closed**	**Closed**	**Closed**

Table 13. Details of results for 7-24-1999. Modeling specifics for this date are presented in appendix L.

	Penstock / Shutter 1	Penstock / Shutter 2	Penstock / Shutter 3	Penstock / Shutter 4	Penstock / Shutter 5
Discharge (ft^3/s)	**2881**	**3025**	**2017**	**2881**	**3601**
Measured temperature (°F)	**51.0**	**51.1**	**50.4**	**51.2**	**51.0**
Calculated temperature (°F)	**51.6**	**51.2**	**51.4**	**50.6**	**49.4**
Standard Deviation of Last 3 Minutes (°F)	**0.03**	**0.04**	**0.08**	**0.12**	**0.12**
Upper gates	**Closed**	**Closed**	**Closed**	**Closed**	**Closed**
Middle gates	**Open**	**Open**	**Open**	**Open**	**Open**
Pressure Relief Gates	**Closed**	**Closed**	**Closed**	**Closed**	**Closed**

Table 14. Details of results for 8-13-1999. Modeling specifics for this date are presented in appendix M.

	Penstock / Shutter 1	Penstock / Shutter 2	Penstock / Shutter 3	Penstock / Shutter 4	Penstock / Shutter 5
Discharge (ft^3/s)	**2420**	**2391**	**2391**	**2881**	**0**
Measured temperature (°F)	**49.4**	**51.9**	**49.1**	**47.6**	
Calculated temperature (°F)	**52.2**	**51.1**	**47.6**	**46.6**	
Standard Deviation of Last 3 Minutes (°F)	**0.07**	**0.08**	**0.02**	**0.01**	
Upper gates	**Closed**	**Closed**	**Closed**	**Closed**	**Closed**
Middle gates	**Closed**	**Open**	**Closed**	**Closed**	**Closed**
Pressure Relief Gates	**Open**	**Closed**	**Open**	**Open**	**Open**

Table 15. Details of results for 8-18-1998a. Modeling specifics for this date are presented in appendix N.

	Penstock / Shutter 1	Penstock / Shutter 2	Penstock / Shutter 3	Penstock / Shutter 4	Penstock / Shutter 5
Discharge (ft^3/s)	**2500**	**2500**	**2500**	**2500**	**2500**
Measured temperature (°F)	**50.7**	**51.2**	**50.3**	**49.9**	**48.3**
Calculated temperature (°F)	**51.7**	**51.8**	**51.8**	**51.4**	**50.1**
Standard Deviation of Last 3 Minutes (°F)	**0.01**	**0.01**	**0.01**	**0.02**	**0.03**
Upper gates	**Closed**	**Closed**	**Closed**	**Closed**	**Closed**
Middle gates	**Open**	**Open**	**Open**	**Closed**	**Closed**
Pressure Relief Gates	**Open**	**Open**	**Open**	**Open**	**Open**

Table 16. Details of results for 8-18-98b. Only the Low Level Inlet is open during this test. Modeling specifics for this date are presented in appendix O.

	Penstock / Shutter 1	Penstock / Shutter 2	Penstock / Shutter 3	Penstock / Shutter 4	Penstock / Shutter 5
Discharge (ft^3/s)	**2500**	**2500**	**2500**	**2500**	**2500**
Measured temperature (°F)	**51.9**	**50.5**	**50.3**	**50.0**	**48.4**
Calculated temperature (°F)	**51.5**	**50.1**	**50.1**	**50.2**	**48.8**
Standard Deviation of Last 3 Minutes (°F)	**0.03**	**0.02**	**0.04**	**0.04**	**0.01**
Upper gates	**Closed**	**Closed**	**Closed**	**Closed**	**Closed**
Middle gates	**Closed**	**Closed**	**Closed**	**Closed**	**Closed**
Pressure Relief Gates	**Closed**	**Closed**	**Closed**	**Closed**	**Closed**

Modeling routine

To make future modeling easy, a FORTRAN program was written to create the required files for the simulations. PREPTCD.EXE reads PREP.DAT, generates the PREPIN.INP file, Stereolithography file for the geometry, and supporting files for the special subroutines modified for FLOW-3D®. PREPTCD.EXE was developed using Visual Fortran Professional Edition 5.0.D in Developer Studio 97. PREPTCD.EXE is a 32-bit console based program.

The input file PREP.DAT uses the FORTRAN namelist format. In it, the user specifies the model title, penstock discharge, the TCD gate configuration, the reservoir water surface, and several temperatures in the reservoir, and corresponding elevations. The PREP.DAT file has very simple format and is easy to create. It is important to note that a gate is closed by setting the gate value to 1, and is open by setting the gate value to 0, and elevation should be indexed in descending order. The PREP.DAT file is included in the appendixes for each data set modeled.

The Stereolithography file, STLF07.INP, is created in the default directory every time PREPTCD.EXE runs. This was done limit user responsibilities while running models. This file can be editted with a text editor, or visualized using a Stereolithography viewer.

In addition to the standard FLOW-3D® files, there are 4 additional files used in this process. 0_TCD.DAT, 1_TCD.DAT, 2_TCD.DAT, and 3PENSTOCK.DAT. Numbers are included in the file names to keep them together in sorted directory listings.

0_TCD.DAT contains elevation-temperature data. 1_TCD.DAT contains run time information for the special subroutines for FLOW-3D®. 2_TCD.DAT contain elevation-temperature data that has been evaluated at cell centers. 3PENSTOCKS.DAT contain penstock temperature data at the short print intervals.

A temperature profile file is written for the boundary condition subroutine. This file is 0_TCD.DAT. It has closely spaced second-order interpolated elevation-temperature data. While the FLOW-3D® preprocessor is running, an additional temperature profile file, 2_TCD.DAT, is created. This file has temperatures evaluated at mesh specific elevations (cell centers). Every data set with a different water surface elevation will have unique elevations that the temperatures must be evaluated. This data is used in the boundary condition and flow field initialization routines.

If a user changes the penstocks, temperature distribution, or meshing after FLOW-3D® has started, the first 3 values of 1_TCD.DAT must be set to 1 which instructs the subroutines to re-evaluate temperature profile, the open area of the penstocks, and the mesh locations of the penstock, respectively.

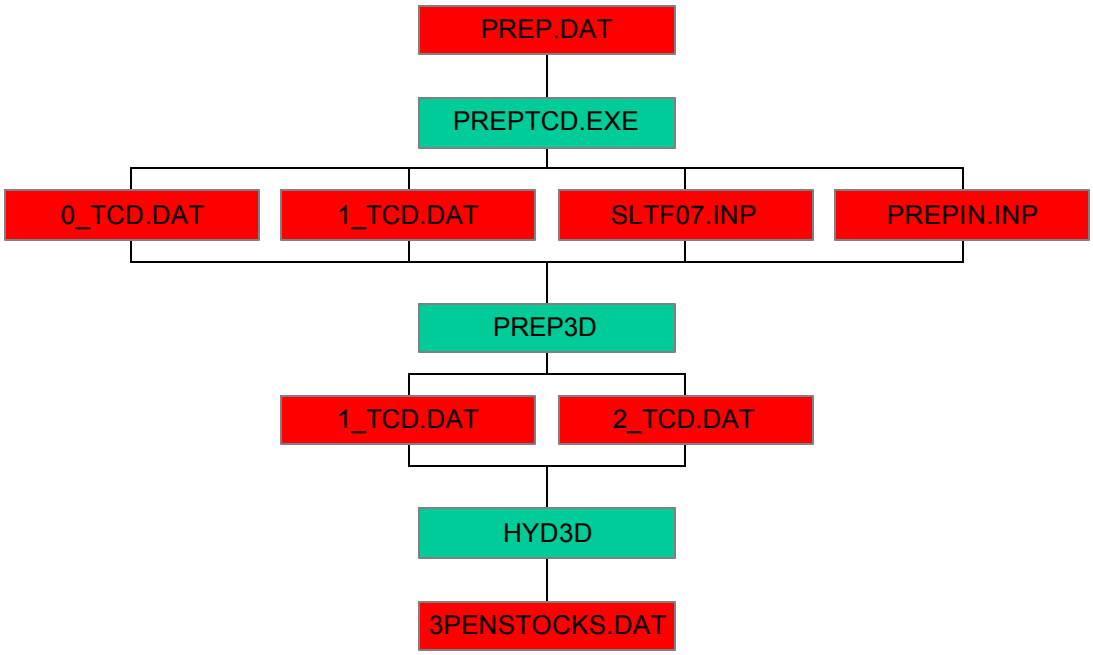

Figure 6. Modeling routine flowchart. Data files are shown in red, prorgrams are shown in green. Once PREPTCD creates the the proper files, PREP3D AND HYD3D can be ran by running RUNALL.BAT from a console window, or the FLOW-3D® GUI interface.

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Appendix A - Temperature-Density Subroutine

This subroutine replaces RHO1CL.FOR, and is used in both PREP3D.FOR and HYD3D.FOR.

```
function rho1cl(p,temp)
        include '..\comdeck\precis.for'
        include '..\comdeck\params.for'
        include '..\comdeck\state.for'
        include '..\comdeck\dumn.for'
        if(idum1.lt.100) then
                rho1cl=rhof+dr1dt(p,temp)*(temp-tstar)
                return
        end if
        if(temp.ge.35.0.and. temp .le.45.0) then
                rho1cl=temp**2*(-5.612E-06)
   &    +temp*4.429E-04+1.931649434
        else if(temp.gt.45.0.and. temp .le.55.0) then
                rho1cl=temp**2*(-3.108E-06)
   &    +temp*2.176E-04+1.936656928
        else if(temp.gt.55.0.and. temp .le.65.0) then
                rho1cl=temp**2*(-4.662E-06)
   &    +temp*3.885E-04+1.931994778
        else if(temp.gt.65.0.and. temp .le.75.0) then
                rho1cl=temp**2*(-1.554E-06)
   &    +temp*-1.554E-05+1.945048797
        else if(temp.gt.75.0.and. temp .le.85.0) then
                rho1cl=temp**2*(-4.662E-06)
   &    +temp*4.507E-04+1.927643439
        else if(temp.gt.85.0.and. temp .le.95.0) then
                rho1cl=temp**2*(1.097E-15)
   &    +temp*-3.419E-04+1.961210916
        else if(temp.gt.95.0.and. temp .le.105.0) then
                rho1cl=temp**2*(-3.626E-06)
   &    +temp*3.471E-04+1.928575869
         else
                rho1cl=1.937
                write(65,*)'temp, rho=',temp,rho1cl
         end if
        return
        end
```

Appendix B - Upstream Boundary routine

The upstream boundary (FLOW-3D® side 1) routine uses temperature data supplied from PREPTCD.EXE (see modeling routine). It evaluates temperatures at cell centers used in FLOW-3D® by linear interpolation of 0_TCD.DAT to produce 2_TCD.DAT. It also evaluates the thermal energy, density, and pressure of each upstream boundary cell.

This routine is appended to the BC.FOR subroutine, and used in Flow Sciences' PREP3D.FOR and HYDR3D.FOR.

```
      do 7002 k=km1+1,1,-1
            ijk_edge=ii2*(k-1)+imax*(j-1)+i+ii5
7001                  if (zk(k)-zelev1.gt.-0.01)then
                        tn(ijk_edge)=temper1
                  else if (zk(k)-zelev2.gt.0.01) then
                        tn(ijk_edge)=temper1-(temper1-temper2)*
     &                  (zelev1-zk(k))/(zelev1-zelev2)
                  else if (zk(k)-zelev2.gt.-0.01)then
                        tn(ijk_edge)=temper2
                  else
                        zelev1=zelev2
                        temper1=temper2
                        read(65,*)zelev2,temper2
                        goto 7001
                  end if
                  rbcl(k)=rho1cl(1,tn(ijk_edge))
                  rho(ijk_edge)=rbcl(k)
                  rhoe(ijk_edge)=rhoecl(ijk_edge)
                  if(k.eq.km1+1) then
                        pcabove=-rho(ijk_edge)*gz*(flhtl-zk(k))
                  else
                  pcabove=p(ijk_edge+ii2)-gz*0.5*delz(k+1)*rho(ijk_edge+ii2)
                  end if
                  p(ijk_edge)=-gz*0.5*(delz(k)*rho(ijk_edge))+pcabove
                  write(67,*)zk(k),tn(ijk_edge)
7002        end do
            close(65)
            close(67)
            itempr=0
            include '..\utility\tcd1write.for'
      else                        !read in previous data
            Open(67,file='2_TCD.DAT',action='read')
            i=1
            j=1
            do 7003 k=km1+1,1,-1
                  ijk_edge=ii2*(k-1)+imax*(j-1)+i+ii5
                  read(67,*)ztrash,tn(ijk_edge)
                  rbcl(k)=rho1cl(1,tn(ijk_edge))
                  rho(ijk_edge)=rbcl(k)
                  rhoe(ijk_edge)=rhoecl(ijk_edge)
                  if(k.eq.km1+1) then
                        pcabove=-rho(ijk_edge)*gz*(flhtl-zk(k))
                  else
                  pcabove=p(ijk_edge+ii2)-gz*0.5*delz(k+1)*rho(ijk_edge+ii2)
                  end if
```

```
                        p(ijk_edge)=-gz*0.5*(delz(k)*rho(ijk_edge))+pcabove
7003            end do
                close(67)
        end if  ! of (t.lt.delt*1.1)
        i=1
        j=1
        k=km1
                ijk_edge=ii2*(k-1)+imax*(j-1)+i+ii5
c initialize upstream boundary elements, and {flow field if t<0.1}
        if (t.gt.delt*1.01) then
                irange=2
        else
                irange=imax
        end if
        do 5001 k=km1,1,-1
                i=1
                j=1
          ijk_edge=ii2*(k-1)+imax*(j-1)+i+ii5
                do 5001 j=jm1+1,1,-1
                        do 5001 i=irange,1,-1
                                        ijk=ii2*(k-1)+imax*(j-1)+i+ii5
                                        tn(ijk)=tn(ijk_edge)
                                        rho(ijk)=rho(ijk_edge)
                                        rhoe(ijk)=rhoe(ijk_edge)
                                        p(ijk)=p(ijk_edge)
5001                    continue
```

Appendix C - Downstream routine

Since the exact area of the penstocks modeled by FLOW-3D® can change due to variations in meshing, this routine starts by calculating the area of each penstock. To account for variously sized penstocks, the program evaluates open area on the downstream boundary (FLOW-3D® side 2). Areas are stored in file 1_TCD.DAT.

This routine is appended to the BC.FOR subroutine, and used in Flow Sciences' PREP3D.FOR and HYDR3D.FOR.

```
      if (iarea.eq.1) then          !calculate areas and assign velocities
            if(t.lt.delt*1.01)then
                  Open(68,file='3penstocks.dat',action='write',
     &                        status='unknown')
                  write(68,*)'Penstock data '
                  write(68,*)'Time, temperature of each bay, total average'
                  close(68)   !empty the file
            end if
            i=imax-1
            area1=0.0         !set total areas to zero
            area2=0.0
            area3=0.0
            area4=0.0
            area5=0.0
            izmax=km1
            izmin=2
            iymax=jm1
            iymin=2
            if(irbound.eq.1)then
                  do 8990 k=1,km1
                        if (zk(k).gt.840 .and. zk(k).lt.zk(izmax)) izmax=k
                        if (zk(k).lt.790 .and. zk(k).gt.zk(izmin)) izmin=k
 8990                 continue
                  do 8991 j=1,jm1
                        if (yj(j).gt.250 .and. yj(j).lt.yj(iymax)) iymax=j
                        if (yj(j).lt.0 .and. yj(j).gt.yj(iymin)) iymin=j
 8991                 continue
            irbound=0
            end if
            do 8003 k=izmin,izmax
                  do 8001 j=iymin,iymax
                        ijk=ii2*(k-1)+imax*(j-1)+i+ii5
                        if(vf(ijk).lt.em6)goto 8000
                        if(yj(j).lt.50.0)then
                              area1=afr(ijk-1)*dely(j)*delz(k)+area1
                        else if(yj(j).lt.100.0)then
                              area2=afr(ijk-1)*dely(j)*delz(k)+area2
                        else if(yj(j).lt.150.0)then
                              area3=afr(ijk-1)*dely(j)*delz(k)+area3
                        else if(yj(j).lt.200.0)then
                              area4=afr(ijk-1)*dely(j)*delz(k)+area4
                        else if(yj(j).lt.250.0)then
                              area5=afr(ijk-1)*dely(j)*delz(k)+area5
                        end if
 8000                 continue
```

```
8001                    end do
8002            continue
8003            end do
                iarea=0
                include '..\utility\tcd1write.for'
        end if
        i=imax          !assign velocities to boundary
        izmax=km1
        izmin=2
        iymax=jm1
        iymin=2
        if(irbound.eq.1)then
                do 8995 k=1,km1
                        if (zk(k).gt.840 .and. zk(k).lt.zk(izmax)) izmax=k
                        if (zk(k).lt.790 .and. zk(k).gt.zk(izmin)) izmin=k
8995            continue
                do 8996 j=1,jm1
                        if (yj(j).gt.250 .and. yj(j).lt.yj(iymax)) iymax=j
                        if (yj(j).lt.0 .and. yj(j).gt.yj(iymin)) iymin=j
                        irbound=0
8996            continue
        end if
        do 8013 k=izmin,izmax
                do 8011 j=iymin,iymax
                        ijk=ii2*(k-1)+imax*(j-1)+i+ii5
                        if(yj(j).lt.50.0)then
                                u(ijk)=real(idum1)/area1
                                u(ijk-1)=real(idum1)/area1
                        else if(yj(j).lt.100.0)then
                                u(ijk)=real(idum2)/area2
                                u(ijk-1)=real(idum2)/area2
                        else if(yj(j).lt.150.0)then
                                u(ijk)=real(idum3)/area3
                                u(ijk-1)=real(idum3)/area3
                        else if(yj(j).lt.200.0)then
                                u(ijk)=real(idum4)/dum4
                                u(ijk-1)=real(idum4)/area4
                        else if(yj(j).lt.250.0)then
                                u(ijk)=real(idum5)/area5
                                u(ijk-1)=real(idum5)/area5
                        end if
8010    continue
8011    end do
8012    continue
8013    end do
```

Appendix D - Flow Field Temperature Initiation Routine

The reservoir temperatures are not initialized in PREP3D due to limitations, but rather they are initialized within the first 0.1 seconds of HYDR3D. This routine evaluates the temperature, thermal energy, density, and pressure of each cell in the flow field. This routine is appended to QSADD.FOR and used in HYD3D.FOR.

```
      if (idum6.ne.100) return
      include '..\utility\tcd1read.for'
      if (t.gt.delt*1.001)goto 100
      Open(67,file='2_TCD.DAT',action='read')
      do 5001 k=km1,1,-1
            i=1
            j=1
            ijk_edge=ii2*(k-1)+imax*(j-1)+i+ii5
            read(67,*)ztrash,tn(ijk_edge)        !retrieve values saved in bc.for during preprosessing
            rho(ijk_edge)=rho1cl(1,tn(ijk_edge))
            rhoe(ijk_edge)=rhoecl(ijk_edge)
            if(k.eq.km1+1) then
                  pcabove=-rho(ijk_edge)*gz*(flhtl-zk(k))
            else
                  pcabove=p(ijk_edge+ii2)-gz*0.5*(delz(k+1)*rho(ijk_edge+ii2))
            end if
            p(ijk_edge)=-gz*0.5*(delz(k)*rho(ijk_edge))+pcabove        !pressure at center of cell

            do 5001 j=jm1+1,1,-1
                  do 5001 i=imax,1,-1
                        ijk=ii2*(k-1)+imax*(j-1)+i+ii5
                        tn(ijk)=tn(ijk_edge)
                        rho(ijk)=rho(ijk_edge)
                        rhoe(ijk)=rhoe(ijk_edge)
                        p(ijk)=p(ijk_edge)
5001  continue
      close(67)
100   continue
```

Appendix E - Discharge Temperature Routine

This routine evaluates the temperature for each penstock, then write the results to 3PENSTOCKS.DAT. The data is output at the "short print interval" (sprtdt) defined in the Flow3D PREPIN.INP file. This routine is appended to QSADD.FOR and used in HYD3D.FOR.

```
      if(abs(t/sprtdt-NINT(t/sprtdt))
     &                  .lt.delt*0.500001/sprtdt) then                  !it is time to print
            Open(68,file='3penstocks.dat',action='write',
     &                        access='append',status='unknown')
            penstk1=0.0
            penstk2=0.0
            penstk3=0.0
            penstk4=0.0
            penstk5=0.0
            i=imax-1
            izmax=km1
            izmin=2
            iymax=jm1
            iymin=2
            do 9003 k=izmin,izmax
                  do 9001 j=iymin,iymax
                        ijk=ii2*(k-1)+imax*(j-1)+i+ii5
                        if(vf(ijk).lt.em6)goto 9000
                        if(yj(j).lt.50.0)then
                              penstk1=afr(ijk)*dely(j)*delz(k)*u(ijk)*tn(ijk)+
     &                                    penstk1
                        else if(yj(j).lt.100.0)then
                              penstk2=afr(ijk)*dely(j)*delz(k)*u(ijk)*tn(ijk)+
     &                                    penstk2
                        else if(yj(j).lt.150.0)then
                              penstk3=afr(ijk)*dely(j)*delz(k)*u(ijk)*tn(ijk)+
     &                                    penstk3
                        else if(yj(j).lt.200.0)then
                              penstk4=afr(ijk)*dely(j)*delz(k)*u(ijk)*tn(ijk)+
     &                                    penstk4
                        else if(yj(j).lt.250.0)then
                              penstk5=afr(ijk)*dely(j)*delz(k)*u(ijk)*tn(ijk)+
     &                                    penstk5
                        end if
 9000                   continue
 9001             end do
 9003       end do
            penstk1=penstk1/real(idum1)
            penstk2=penstk2/real(idum2)
            penstk3=penstk3/real(idum3)
            penstk4=penstk4/real(idum4)
            penstk5=penstk5/real(idum5)
            write(68,9010) t,penstk1,penstk2,penstk3,penstk4,penstk5,
     &      (penstk1*idum1+penstk2*idum2+penstk3*idum3+penstk4*idum4+
     &      penstk5*idum5)/(idum1+idum2+idum3+idum4+idum5)
 9010       format(f11.2,6f7.2)
            close(68)
      end if
```

Appendix F – 5-19-1999

Table 1. PREP.DAT for 5-19-1999.

```
&Title
        t(1)='Shasta TCD model input data 5-19-99'
        t(2)=''
        t(3)=''
        t(4)=''
        t(5)=''
/
&penstocks
        q(1)=2875
        q(2)=2875
        q(3)=0
        q(4)=2875
        q(5)=0
/
&gates
        iupper(1)=0
        iupper(2)=0
        iupper(3)=0
        iupper(4)=0
        iupper(5)=0
        imiddle(1)=0
        imiddle(2)=0
        imiddle(3)=0
        imiddle(4)=1
        imiddle(5)=1
        ipg(1)=1
        ipg(2)=1
        ipg(3)=1
        ipg(4)=1
        ipg(5)=1
        ill=1
/
&reser
        wsel=1058.7
        n_measure=24
        elev(1)=1053.6,         tempr(1)=60.9
        elev(2)=1043.6,         tempr(2)=59.8
        elev(3)=1032.12,tempr(3)=58.52
        elev(4)=1009.88,tempr(4)=52.6
        elev(5)=998.6,          tempr(5)=49.9
        elev(6)=987.63,         tempr(6)=49.1
        elev(7)=965.39,         tempr(7)=48.19
        elev(8)=943.14,         tempr(8)=47.47
        elev(9)=933.6,          tempr(9)=47.2
        elev(10)=920.9,         tempr(10)=46.69
        elev(11)=908.6,         tempr(11)=46.2
        elev(12)=898.65,tempr(12)=45.97
        elev(13)=876.41,tempr(13)=45.58
        elev(14)=854.16,tempr(14)=45.49
        elev(15)=831.92,tempr(15)=45.1
        elev(16)=809.67,tempr(16)=44.81
        elev(17)=787.42,tempr(17)=44.75
        elev(18)=765.18,tempr(18)=44.52
        elev(19)=742.93,tempr(19)=44.3
        elev(20)=720.69,tempr(20)=44.23
        elev(21)=698.44,tempr(21)=44.23
        elev(22)=676.2,         tempr(22)=44.24
        elev(23)=653.95,tempr(23)=44.24
        elev(24)=600.0, tempr(24)=44.2
/
```

Table 1F. PREPIN.INP for 5-19-1999.

```
Shasta TCD model input data 5-19-99
$xput
     lpr=1,itb=0,iwsh=0,ifvis=0,epsadj=1.0,
     prtdt=10000.0,gz=-32.14,ipdis=1,
     nmat=1,iadix=1,iadiy=1,iadiz=1,
     iorder=1,ifrho=1,ifenrg=2,ichm=0,
     ihtrst=0, iresf1=0, irstoe=0, iscrst=0, itrst=0,
     idum1=   2875.000
     idum2=   2875.000
     idum3=   1.000000
     idum4=   2875.000
     idum5=   1.000000
     idum6=100,
     twfin=1200.,
     pltdt=1200.0,
     delt=0.01,
     deltr=0.0001
     sprtdt=20.0,
     HPLTDT=20.0,
 $end
 $limits
     irpr=1,jbkpr=1,ktpr=1,
 $end
 $props
     rhof=1.937,mui=2.25E-05,tstar=0.0000001,mu1=2.25E-05,mu2=2.25E-05,
 $end
 $scalar
      nsc=1,isclr(1)=0,
 $end
 $bcdata
     pbctyp=1.,
     tbc(1)=100.0,tbc(2)=60.0,tbc(3)=60.0,
     tbc(4)=60.0,tbc(5)=60.0,tbc(6)=60.0,
     wl=5,wr=6,wf=2,wbk=2,wt=2,wb=2,
     flhtl=1043.7,
 $end
 $mesh
   nxcelt=17,
     px(1)=-400.0,     nxcell(1)=10,
     px(2)= -50.0,     nxcell(2)=4,
     px(3)=   0.0,     nxcell(3)=1,
     px(4)=  15.0,
   nycelt=30,
     py(1)=-100.0,     nycell(1)=4,
     py(2)= 2.0,       nycell(2)=3,
     py(3)=52.0,       nycell(3)=3,
     py(4)= 102.0,     nycell(4)=3,
     py(5)= 152.0,     nycell(5)=3,
     py(6)=202.0,      nycell(6)=3,
     py(7)=251.0,      nycell(7)=6,
     py(8)=381.08,     nycell(8)=5,
     py(9)=500.0,
   nzcelt=100,
     pz(1)=670.0,      nzcell(1)=2,
     pz(2)=704.0,      nzcell(2)=1,
     pz(3)=720.0,      nzcell(3)=2,
     pz(4)=749.5,      nzcell(4)=2,
     pz(5)=780.0,      nzcell(5)= 2,
     pz(6)=804.0,      nzcell(6)= 2,
     pz(7)=831.0,      nzcell(7)= 4,
     pz(8)= 889.0,     nzcell(8)= 1,
     pz(9)= 900.0,     nzcell(9)= 3,
     pz(10)= 945.0,    nzcell(10)=4,
     pz(11)=1000.,     nzcell(11)=4,
     pz(12)=1045.0,    nzcell(12)= 1
     pz(13)=   1058.700
 $end
 $obs
```

```
  avrck=-2.1,
  nobs=19,
  iob(1)=1,xl(1)=0.0,xh(1)=100.0,zh(1)=1079.7,
  iob(2)=1,ioh(2)=0,yh(2)=12.5,yl(2)=-12.5,trny(2)=25.0,zh(2)=831.0,zl(2)=804.0,
  iob(3)=1,ioh(3)=0,yh(3)=12.5,yl(3)=-12.5,trny(3)=75.0,zh(3)=831.0,zl(3)=804.0,
  iob(4)=1,ioh(4)=0,yh(4)=12.5,yl(4)=-12.5,trny(4)=125.0,zh(4)=831.0,zl(4)=804.0,
  iob(5)=1,ioh(5)=0,yh(5)=12.5,yl(5)=-12.5,trny(5)=175.0,zh(5)=831.0,zl(5)=804.0,
  iob(6)=1,ioh(6)=0,yh(6)=12.5,yl(6)=-12.5,trny(6)=225.0,zh(6)=831.0,zl(6)=804.0,
  iob(7)=2,igen(7)=3,ioh(7)=1,
  iob(8)=3,xh(8)=0.01,xl(8)=-52.0,yh(8)=2.01,yl(8)=0.03,zh(8)=1045.01,zl(8)=999.99,
  iob(9)=3,xh(9)=0.01,xl(9)=-52.0,yh(9)=253.0,yl(9)=250.99,zh(9)=1045.01,zl(9)=999.99,
  iob(10)=3,xh(10)=-49.99,xl(10)=-52.0,yh(10)=253.0,yl(10)=0.03,zh(10)=1045.01,zl(10)=999.99,
  iob(11)=4,opor(4)=0.004015302,xh(11)=0.01,xl(11)=-50.01,yh(11)=2.01,yl(11)=0.03,zh(11)=1000.01,zl(11)=944.99,
  iob(12)=5,opor(5)=0.003884098,xh(12)=0.01,xl(12)=-50.01,yh(12)=253.0,yl(12)=250.99,zh(12)=1000.01,zl(12)=944.99,
  iob(13)=6,opor(6)=0.0051328,xh(13)=-49.99,xl(13)=-52.0,yh(13)=253.0,yl(13)=0.03,zh(13)=1000.01,zl(13)=944.99,
  iob(14)=7,opor(7)=0.004351858,xh(14)=0.01,xl(14)=-50.01,yh(14)=2.01,yl(14)=0.03,zh(14)=945.01,zl(14)=899.99,
  iob(15)=8,opor(8)=0.020888367,xh(15)=0.01,xl(15)=-50.01,yh(15)=253.0,yl(15)=250.99,zh(15)=945.01,zl(15)=899.9,
  iob(16)=9,opor(9)=0.007301943,xh(16)=-49.99,xl(16)=-52.0,yh(16)=253.0,yl(16)=0.03,zh(16)=945.01,zl(16)=899.99,
  iob(17)=10,opor(10)=0.003534187,xh(17)=0.01,xl(17)=-50.01,yh(17)=2.01,yl(17)=0.03,zh(17)=900.01,zl(17)=830.99
  iob(18)=11,opor(11)=0.006766415,xh(18)=0.01,xl(18)=-50.01,yh(18)=253.0,yl(18)=250.99,zh(18)=900.01,zl(18)=830.99
  iob(19)=12,opor(12)=0.003110806,xh(19)=-49.99,xl(19)=-52.0,yh(19)=253.0,yl(19)=0.03,zh(19)=900.01,zl(19)=830.99,
  iob(20)=13,opor(13)=0.00536379,xh(20)=0.01,xl(20)=-50.01,yh(20)=2.01,yl(20)=0.03,zh(20)=831.01,zl(20)=803.9,
  iob(21)=14,opor(14)=0.0099,xh(21)=-49.99,xl(21)=-52.0,yh(21)=253.0,yl(21)=0.03,zh(21)=831.01,zl(21)=803.99,
  iob(22)=15,opor(15)=0.007382123,xh(22)=0.01,xl(22)=-50.01,yh(22)=2.01,yl(22)=0.03,zh(22)=804.01,zl(22)=779.9,
  iob(23)=16,opor(16)=0.003032684,xh(23)=-49.99,xl(23)=-52.0,yh(23)=253.0,yl(23)=0.03,zh(23)=804.01,zl(23)=779.99,
  iob(24)=3,xh(24)=0.01,xl(24)=-50.01,yh(24)=202.01,yl(24)=201.0,zh(24)=780.01,zl(24)=749.51,
  iob(25)=3,xh(25)=0.01,xl(25)=-50.01,yh(25)=253.0,yl(25)=250.99,zh(25)=831.01,zl(25)=719.99,
  iob(26)=17,opor(18)=0.00829452,xh(26)=-49.99,xl(26)=-52.0,yh(26)=253.0,yl(26)=201.0,zh(26)=780.01,zl(26)=749.51,
  iob(27)=18,opor(18)=0.00829452,xl(27)=-52.0,yh(27)=202.2,yl(27)=0.03,zh(27)=780.01,zl(27)=779.0,
  iob(28)=19,opor(19)=0.019110575,xl(28)=-52.0,yh(28)=253.0,yl(28)=201.0,zh(28)=749.51,zl(28)=748.50,
  iob(29)=3,xl(29)=-52.0,yh(29)=382.08,yl(29)=250.99,zh(29)=892.06,zl(29)=888.99,
  iob(30)=3,xh(30)=-49.99,xl(30)=-52.0,yh(30)=382.08,yl(30)=250.99,zh(30)=892.06,zl(30)=719.99,
  iob(31)=3,xl(31)=-52.0,yh(31)=382.08,yl(31)=381.07,zh(31)=892.06,zl(31)=719.99,
  iob(32)=3, zh(32)=-888.9
  iob(33)=3,ioh(33)=0,yl(33)= 2.0,yh(33)=48.0,zh(33)=1045.0,zl(33)=1000.0,
  iob(34)=3,ioh(34)=0,yl(34)=52.0,yh(34)=98.0,zh(34)=1045.0,zl(34)=1000.0,
  iob(35)=3,ioh(35)=0,yl(35)=102.0,yh(35)=148.0,zh(35)=1045.0,zl(35)=1000.0,
  iob(36)=3,ioh(36)=0,yl(36)=152.0,yh(36)=198.0,zh(36)=1045.0,zl(36)=1000.0,
  iob(37)=3,ioh(37)=0,yl(37)=202.0,yh(37)=248.0,zh(37)=1045.0,zl(37)=1000.0,
  iob(38)=9,ioh(38)=0,yl(38)= 2.0,yh(38)=48.0,zh(38)=945.0,zl(38)=900.0,
  iob(39)=9,ioh(39)=0,yl(39)=52.0,yh(39)=98.0,zh(39)=945.0,zl(39)=900.0,
  iob(40)=9,ioh(40)=0,yl(40)=102.0,yh(40)=148.0,zh(40)=945.0,zl(40)=900.0,
  iob(41)=3,zh(41)=-1000.0,
  iob(42)=3,zh(42)=-1000.0,
  iob(43)=3,zh(43)=-1000.0,
  iob(44)=3,zh(44)=-1000.0,
  iob(45)=3,zh(45)=-1000.0,
  iob(46)=3,zh(46)=-1000.0,
  iob(47)=3,zh(47)=-1000.0,
 $end
 $fl
   presi=0.0,nfls=1,
   flht=   1058.700
 $end
 $bf
   nbafs=4,pbaf(1)=0.9143,
    ibaf(1)=1,bxh(1)=0.0,bxl(1)=-50.0,by(1)=0.0,bzh(1)=1066.6,bzl(1)=1044.99,
    ibaf(2)=1,bxh(2)=0.0,bxl(2)=-50.0,by(2)=250.0,bzh(2)=1066.6,bzl(2)=1044.99,
    ibaf(3)=1,bx(3)=-50.0,byh(3)=250.0,byl(3)=0.0,bzh(3)=1066.6,bzl(3)=803.99,
    pbaf(2)=0.6785,
    ibaf(4)=2,bra(4)=16.8333,bxh(4)=0.01,btrny(4)=25.0,bzl(4)=780.0,
    ibaf(5)=2,bra(5)=16.8333,bxh(5)=0.01,btrny(5)=75.0,bzl(5)=780.0,
    ibaf(6)=2,bra(6)=16.8333,bxh(6)=0.01,btrny(6)=125.0,bzl(6)=780.0,
    ibaf(7)=2,bra(7)=16.8333,bxh(7)=0.01,btrny(7)=175.0,bzl(7)=780.0,
    ibaf(8)=2,bra(8)=16.8333,bxh(8)=0.01,btrny(8)=225.0,bzl(8)=749.5,
    ibaf(9)=3,bra(9)=16.8333,bxh(9)=0.01,bzl(9)=895.69,btrny(9)=25.0,
    ibaf(10)=3,bra(10)=16.8333,bxh(10)=0.01,bzl(10)=895.69,btrny(10)=75.0,
    ibaf(11)=3,bra(11)=16.8333,bxh(11)=0.01,bzl(11)=895.69,btrny(11)=125.0,
    ibaf(12)=3,bra(12)=16.8333,bxh(12)=0.01,bzl(12)=895.69,btrny(12)=175.0,
    ibaf(13)=3,bra(13)=16.8333,bxh(13)=0.01,bzl(13)=895.69,btrny(13)=225.0,
```

```
    pbaf(4)=0.0,
    ibaf(14)=4,bz(14)=780.0,byh(14)=98.0,byl(14)=52.0,bxh(14)=0.0,bxl(14)=-50.0,
    ibaf(15)=4,bz(15)=780.0,byh(15)=198.0,byl(15)=152.0,bxh(15)=0.0,bxl(15)=-50.0,
 $end
 $temp
   tempi=100.0,ntmp=1,
 $end
 $grafic
   nvplts=0,
 $end
 $parts
 $end
```

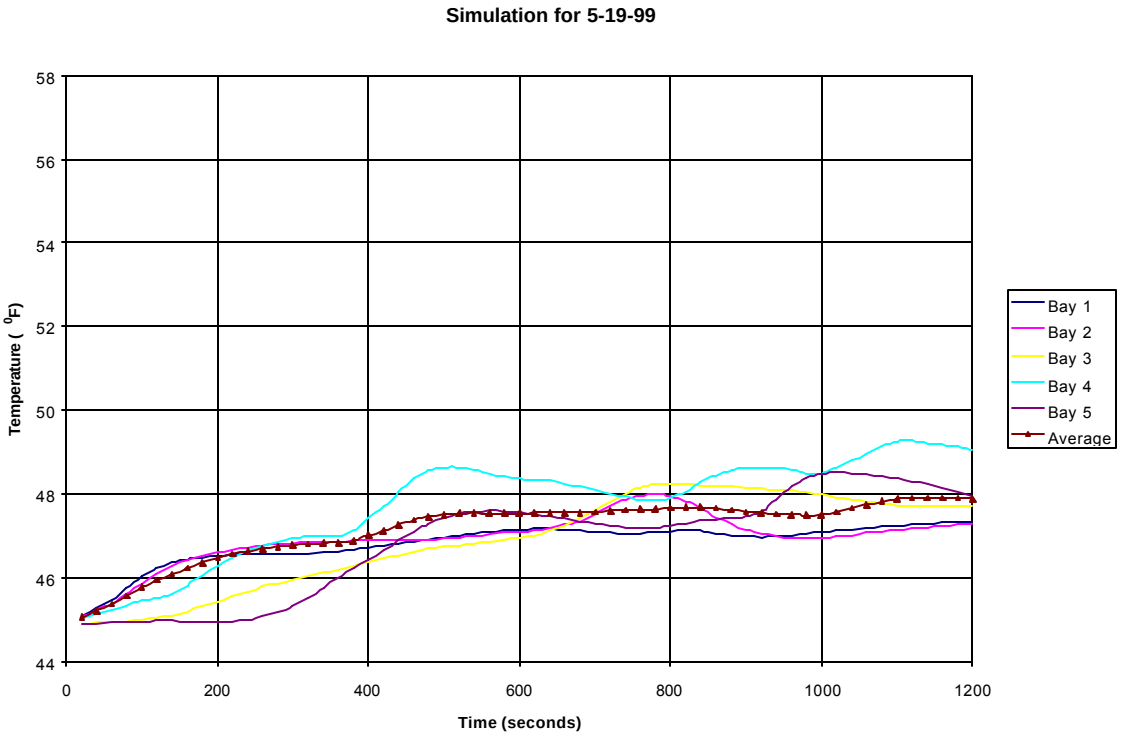

Figure 1F. Convergence graphic.

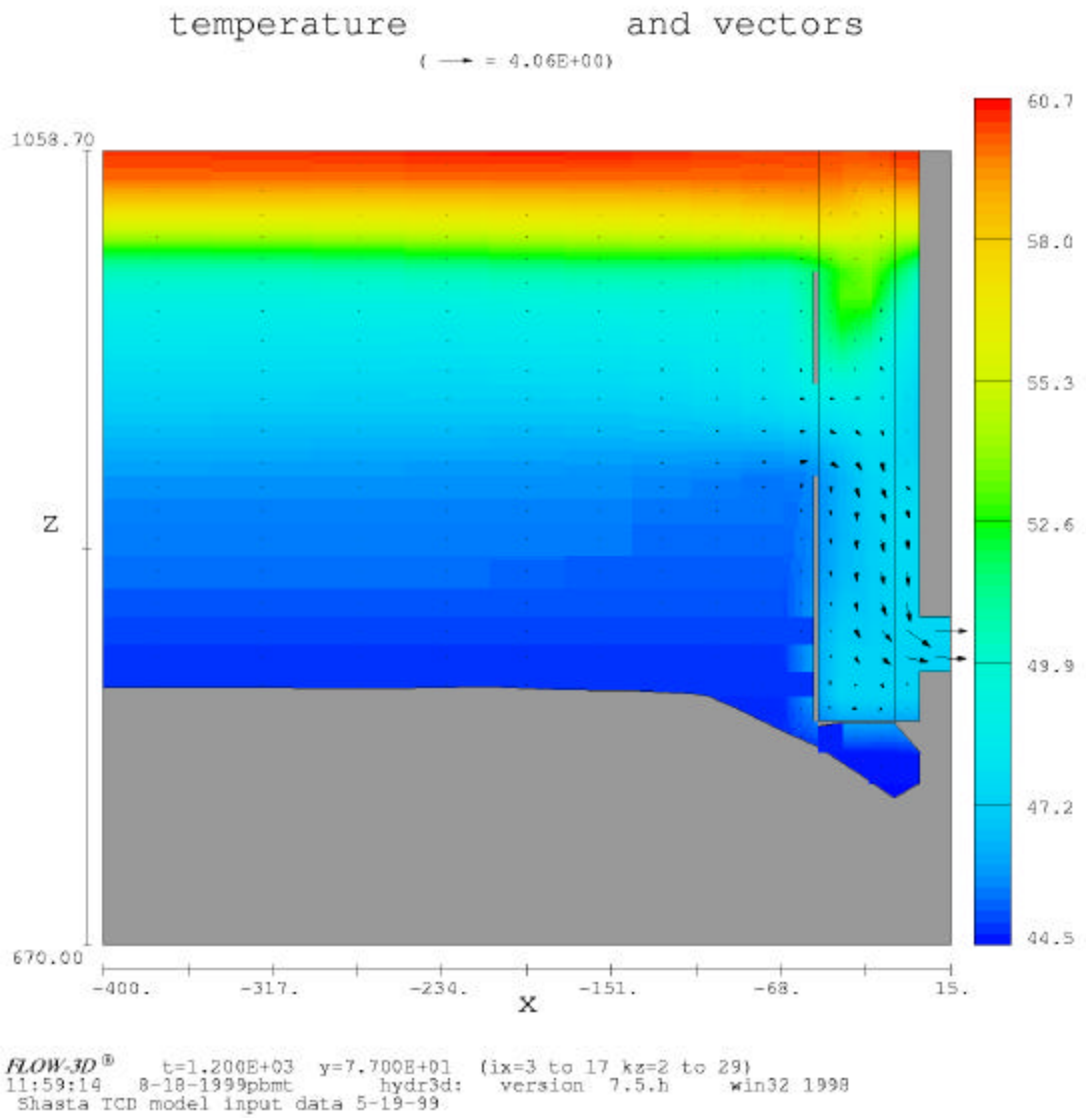

Figure 2F. Temperature Profile Through Penstock No. 2.

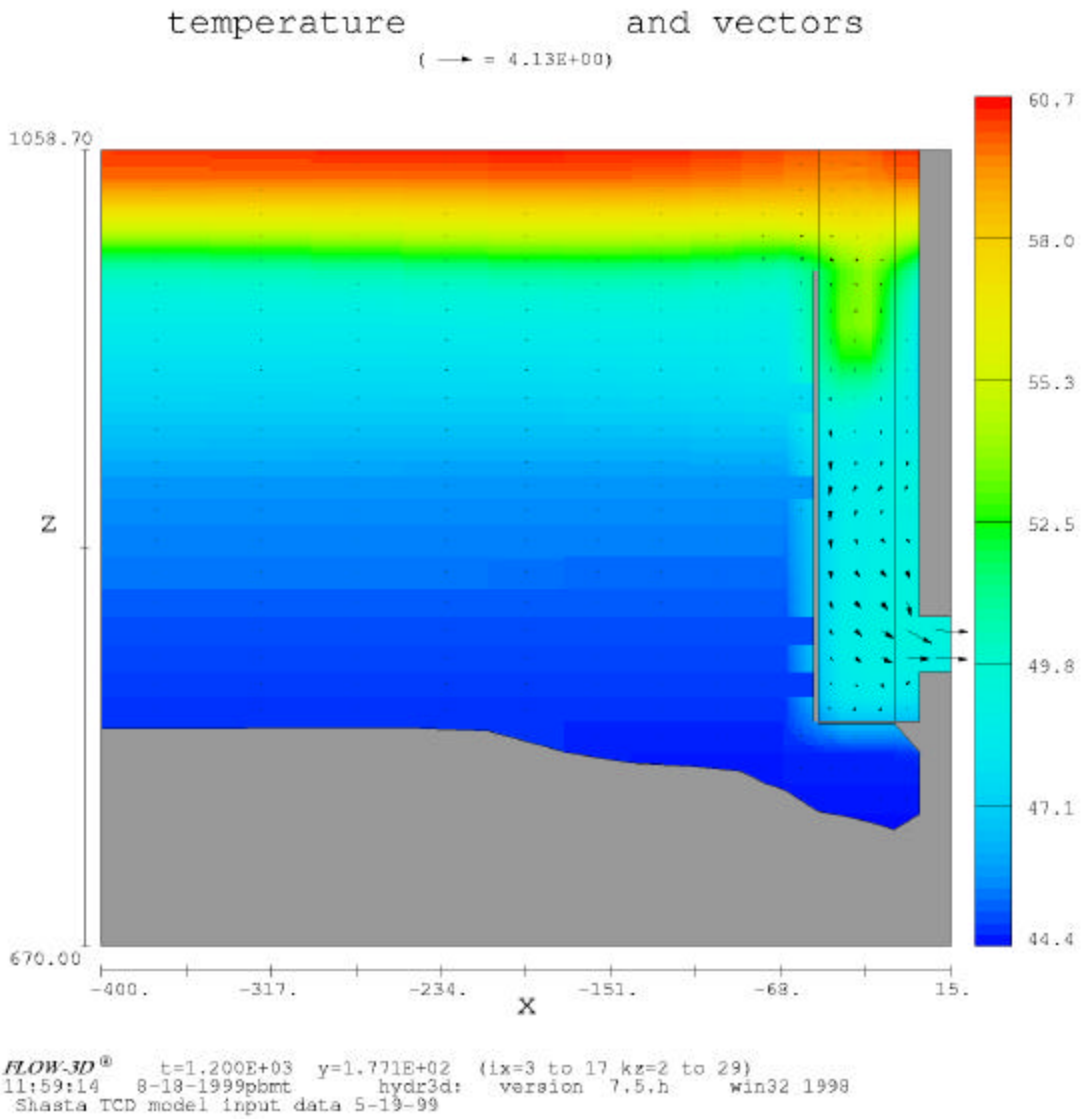

Figure 3F. Temperature Profile Through Penstock No. 4.

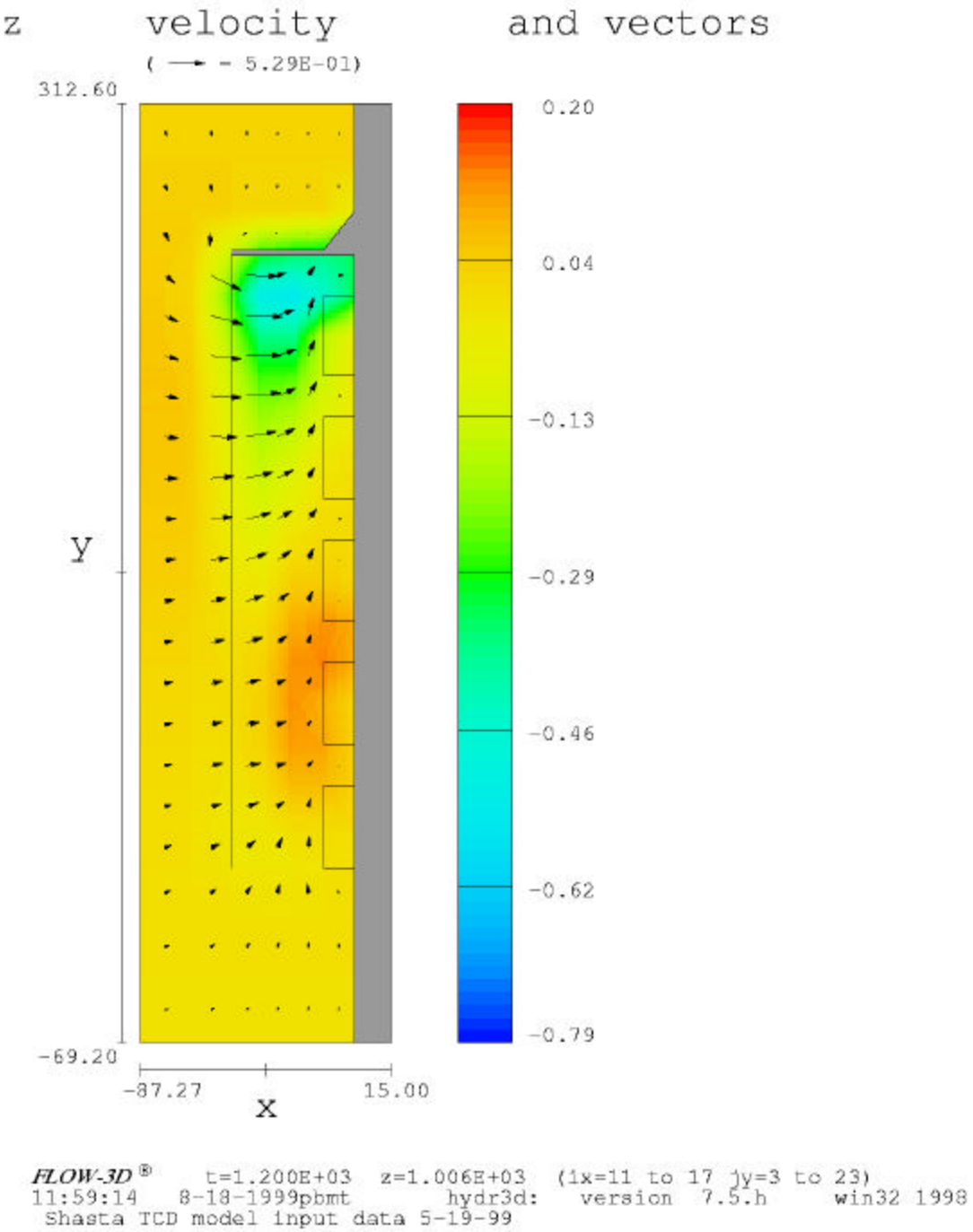

Figure 4F. Vertical Velocity Contours near the Bottom of the Upper Gates.

Appendix G – 5-20-1999

Table 1G. PREP.DAT.

```
&Title
        t(1)='Shasta TCD model input data 5-20-99'
        t(2)=''
        t(3)=''
        t(4)=''
        t(5)=''
/
&penstocks
        q(1)=3327
        q(2)=3358
        q(3)=0
        q(4)=3781
        q(5)=0
/
&gates
        iupper(1)=1
        iupper(2)=1
        iupper(3)=1
        iupper(4)=1
        iupper(5)=1
        imiddle(1)=0
        imiddle(2)=0
        imiddle(3)=0
        imiddle(4)=0
        imiddle(5)=0
        ipg(1)=1
        ipg(2)=1
        ipg(3)=1
        ipg(4)=1
        ipg(5)=1
        ill=1
/
&reser
        wsel=1058.6
        n_measure=24
        elev(1)=1053.6,     tempr(1)=60.9
        elev(2)=1043.6,     tempr(2)=59.8
        elev(3)=1032.12,tempr(3)=58.52
        elev(4)=1009.88,tempr(4)=52.6
        elev(5)=998.6,      tempr(5)=49.9
        elev(6)=987.63,     tempr(6)=49.1
        elev(7)=965.39,     tempr(7)=48.19
        elev(8)=943.14,     tempr(8)=47.47
        elev(9)=933.6,      tempr(9)=47.2
        elev(10)=920.9,     tempr(10)=46.69
        elev(11)=908.6,     tempr(11)=46.2
        elev(12)=898.65,tempr(12)=45.97
        elev(13)=876.41,tempr(13)=45.58
        elev(14)=854.16,tempr(14)=45.49
        elev(15)=831.92,tempr(15)=45.1
        elev(16)=809.67,tempr(16)=44.81
        elev(17)=787.42,tempr(17)=44.75
        elev(18)=765.18,tempr(18)=44.52
        elev(19)=742.93,tempr(19)=44.3
        elev(20)=720.69,tempr(20)=44.23
        elev(21)=698.44,tempr(21)=44.23
        elev(22)=676.2,     tempr(22)=44.24
        elev(23)=653.95,tempr(23)=44.24
        elev(24)=600.0, tempr(24)=44.2
/
```

Table 2G. PREPIN.INP.

```
Shasta TCD model input data 5-20-99
 $xput
    lpr=1,itb=0,iwsh=0,ifvis=0,epsadj=1.0,
    prtdt=10000.0,gz=-32.14,ipdis=1,
    nmat=1,iadix=1,iadiy=1,iadiz=1,
    iorder=1,ifrho=1,ifenrg=2,ichm=0,
    ihtrst=0, iresf1=0, irstoe=0, iscrst=0, itrst=0,
    idum1=   3327.000
    idum2=   3358.000
    idum3=   1.000000
    idum4=   3781.000
    idum5=   1.000000
    idum6=100,
    twfin=1200.,
    pltdt=1200.0,
    delt=0.01,
    deltr=0.0001
    sprtdt=20.0,
    HPLTDT=20.0,
 $end
 $limits
    irpr=1,jbkpr=1,ktpr=1,
 $end
 $props
    rhof=1.937,mui=2.25E-05,tstar=0.0000001,mu1=2.25E-05,mu2=2.25E-05,
 $end
 $scalar
     nsc=1,isclr(1)=0,
 $end
 $bcdata
    pbctyp=1.,
    tbc(1)=100.0,tbc(2)=60.0,tbc(3)=60.0,
    tbc(4)=60.0,tbc(5)=60.0,tbc(6)=60.0,
    wl=5,wr=6,wf=2,wbk=2,wt=2,wb=2,
    flhtl=1043.7,
 $end
 $mesh
  nxcelt=17,
    px(1)=-400.0,    nxcell(1)=10,
    px(2)= -50.0,    nxcell(2)=4,
    px(3)=   0.0,    nxcell(3)=1,
    px(4)=  15.0,
  nycelt=30,
    py(1)=-100.0,    nycell(1)=4,
    py(2)= 2.0,      nycell(2)=3,
    py(3)=52.0,      nycell(3)=3,
    py(4)= 102.0,    nycell(4)=3,
    py(5)= 152.0,    nycell(5)=3,
    py(6)=202.0,     nycell(6)=3,
    py(7)=251.0,     nycell(7)=6,
    py(8)=381.08,    nycell(8)=5,
    py(9)=500.0,
nzcelt=100,
    pz(1)=670.0,     nzcell(1)=2,
    pz(2)=704.0,     nzcell(2)=1,
    pz(3)=720.0,     nzcell(3)=2,
    pz(4)=749.5,     nzcell(4)=2,
    pz(5)=780.0,     nzcell(5)= 2,
    pz(6)=804.0,     nzcell(6)= 2,
    pz(7)=831.0,     nzcell(7)= 4,
    pz(8)= 889.0,    nzcell(8)= 1,
    pz(9)= 900.0,    nzcell(9)= 3,
    pz(10)= 945.0,   nzcell(10)=4,
    pz(11)=1000.,    nzcell(11)=4,
    pz(12)=1045.0,   nzcell(12)= 1
    pz(13)=   1058.600
 $end
 $obs
```

```
  avrck=-2.1,
  nobs=19,
  iob(1)=1,xl(1)=0.0,xh(1)=100.0,zh(1)=1079.7,
  iob(2)=1,ioh(2)=0,yh(2)=12.5,yl(2)=-12.5,trny(2)=25.0,zh(2)=831.0,zl(2)=804.0,
  iob(3)=1,ioh(3)=0,yh(3)=12.5,yl(3)=-12.5,trny(3)=75.0,zh(3)=831.0,zl(3)=804.0,
  iob(4)=1,ioh(4)=0,yh(4)=12.5,yl(4)=-12.5,trny(4)=125.0,zh(4)=831.0,zl(4)=804.0,
  iob(5)=1,ioh(5)=0,yh(5)=12.5,yl(5)=-12.5,trny(5)=175.0,zh(5)=831.0,zl(5)=804.0,
  iob(6)=1,ioh(6)=0,yh(6)=12.5,yl(6)=-12.5,trny(6)=225.0,zh(6)=831.0,zl(6)=804.0,
  iob(7)=2,igen(7)=3,ioh(7)=1,
  iob(8)=3,xh(8)=0.01,xl(8)=-52.0,yh(8)=2.01,yl(8)=0.03,zh(8)=1045.01,zl(8)=999.99,
  iob(9)=3,xh(9)=0.01,xl(9)=-52.0,yh(9)=253.0,yl(9)=250.99,zh(9)=1045.01,zl(9)=999.99,
  iob(10)=3,xh(10)=-49.99,xl(10)=-52.0,yh(10)=253.0,yl(10)=0.03,zh(10)=1045.01,zl(10)=999.99,
  iob(11)=4,opor(4)=0.004015302,xh(11)=0.01,xl(11)=-50.01,yh(11)=2.01,yl(11)=0.03,zh(11)=1000.01,zl(11)=944.99,
  iob(12)=5,opor(5)=0.003884098,xh(12)=0.01,xl(12)=-50.01,yh(12)=253.0,yl(12)=250.99,zh(12)=1000.01,zl(12)=944.99,
  iob(13)=6,opor(6)=0.0051328,xh(13)=-49.99,xl(13)=-52.0,yh(13)=253.0,yl(13)=0.03,zh(13)=1000.01,zl(13)=944.99,
  iob(14)=7,opor(7)=0.004351858,xh(14)=0.01,xl(14)=-50.01,yh(14)=2.01,yl(14)=0.03,zh(14)=945.01,zl(14)=899.99,
  iob(15)=8,opor(8)=0.020888367,xh(15)=0.01,xl(15)=-50.01,yh(15)=253.0,yl(15)=250.99,zh(15)=945.01,zl(15)=899.9,
  iob(16)=9,opor(9)=0.007301943,xh(16)=-49.99,xl(16)=-52.0,yh(16)=253.0,yl(16)=0.03,zh(16)=945.01,zl(16)=899.99,
  iob(17)=10,opor(10)=0.003534187,xh(17)=0.01,xl(17)=-50.01,yh(17)=2.01,yl(17)=0.03,zh(17)=900.01,zl(17)=830.99
  iob(18)=11,opor(11)=0.006766415,xh(18)=0.01,xl(18)=-50.01,yh(18)=253.0,yl(18)=250.99,zh(18)=900.01,zl(18)=830.99
  iob(19)=12,opor(12)=0.003110806,xh(19)=-49.99,xl(19)=-52.0,yh(19)=253.0,yl(19)=0.03,zh(19)=900.01,zl(19)=830.99,
  iob(20)=13,opor(13)=0.00536379,xh(20)=0.01,xl(20)=-50.01,yh(20)=2.01,yl(20)=0.03,zh(20)=831.01,zl(20)=803.9,
  iob(21)=14,opor(14)=0.0099,xh(21)=-49.99,xl(21)=-52.0,yh(21)=253.0,yl(21)=0.03,zh(21)=831.01,zl(21)=803.99,
  iob(22)=15,opor(15)=0.007382123,xh(22)=0.01,xl(22)=-50.01,yh(22)=2.01,yl(22)=0.03,zh(22)=804.01,zl(22)=779.9,
  iob(23)=16,opor(16)=0.003032684,xh(23)=-49.99,xl(23)=-52.0,yh(23)=253.0,yl(23)=0.03,zh(23)=804.01,zl(23)=779.99,
  iob(24)=3,xh(24)=0.01,xl(24)=-50.01,yh(24)=202.01,yl(24)=201.0,zh(24)=780.01,zl(24)=749.51,
  iob(25)=3,xh(25)=0.01,xl(25)=-50.01,yh(25)=253.0,yl(25)=250.99,zh(25)=831.01,zl(25)=719.99,
  iob(26)=17,opor(18)=0.00829452,xh(26)=-49.99,xl(26)=-52.0,yh(26)=253.0,yl(26)=201.0,zh(26)=780.01,zl(26)=749.51,
  iob(27)=18,opor(18)=0.00829452,xl(27)=-52.0,yh(27)=202.2,yl(27)=0.03,zh(27)=780.01,zl(27)=779.0,
  iob(28)=19,opor(19)=0.019110575,xl(28)=-52.0,yh(28)=253.0,yl(28)=201.0,zh(28)=749.51,zl(28)=748.50,
  iob(29)=3,xl(29)=-52.0,yh(29)=382.08,yl(29)=250.99,zh(29)=892.06,zl(29)=888.99,
  iob(30)=3,xh(30)=-49.99,xl(30)=-52.0,yh(30)=382.08,yl(30)=250.99,zh(30)=892.06,zl(30)=719.99,
  iob(31)=3,xl(31)=-52.0,yh(31)=382.08,yl(31)=381.07,zh(31)=892.06,zl(31)=719.99,
  iob(32)=3, zh(32)=-888.9
  iob(33)=3,zh(33)=-1000.0,
  iob(34)=3,zh(34)=-1000.0,
  iob(35)=3,zh(35)=-1000.0,
  iob(36)=3,zh(36)=-1000.0,
  iob(37)=3,zh(37)=-1000.0,
  iob(38)=9,ioh(38)=0,yl(38)= 2.0,yh(38)=48.0,zh(38)=945.0,zl(38)=900.0,
  iob(39)=9,ioh(39)=0,yl(39)=52.0,yh(39)=98.0,zh(39)=945.0,zl(39)=900.0,
  iob(40)=9,ioh(40)=0,yl(40)=102.0,yh(40)=148.0,zh(40)=945.0,zl(40)=900.0,
  iob(41)=9,ioh(41)=0,yl(41)=152.0,yh(41)=198.0,zh(41)=945.0,zl(41)=900.0,
  iob(42)=9,ioh(42)=0,yl(42)=202.0,yh(42)=248.0,zh(42)=945.0,zl(42)=900.0,
  iob(43)=3,zh(43)=-1000.0,
  iob(44)=3,zh(44)=-1000.0,
  iob(45)=3,zh(45)=-1000.0,
  iob(46)=3,zh(46)=-1000.0,
  iob(47)=3,zh(47)=-1000.0,
 $end
 $fl
   presi=0.0,nfls=1,
   flht=   1058.600
 $end
 $bf
   nbafs=4,pbaf(1)=0.9143,
    ibaf(1)=1,bxh(1)=0.0,bxl(1)=-50.0,by(1)=0.0,bzh(1)=1066.6,bzl(1)=1044.99,
    ibaf(2)=1,bxh(2)=0.0,bxl(2)=-50.0,by(2)=250.0,bzh(2)=1066.6,bzl(2)=1044.99,
    ibaf(3)=1,bx(3)=-50.0,byh(3)=250.0,byl(3)=0.0,bzh(3)=1066.6,bzl(3)=803.99,
   pbaf(2)=0.6785,
    ibaf(4)=2,bra(4)=16.8333,bxh(4)=0.01,btrny(4)=25.0,bzl(4)=780.0,
    ibaf(5)=2,bra(5)=16.8333,bxh(5)=0.01,btrny(5)=75.0,bzl(5)=780.0,
    ibaf(6)=2,bra(6)=16.8333,bxh(6)=0.01,btrny(6)=125.0,bzl(6)=780.0,
    ibaf(7)=2,bra(7)=16.8333,bxh(7)=0.01,btrny(7)=175.0,bzl(7)=780.0,
    ibaf(8)=2,bra(8)=16.8333,bxh(8)=0.01,btrny(8)=225.0,bzl(8)=749.5,
    ibaf(9)=3,bra(9)=16.8333,bxh(9)=0.01,bzl(9)=895.69,btrny(9)=25.0,
    ibaf(10)=3,bra(10)=16.8333,bxh(10)=0.01,bzl(10)=895.69,btrny(10)=75.0,
    ibaf(11)=3,bra(11)=16.8333,bxh(11)=0.01,bzl(11)=895.69,btrny(11)=125.0,
    ibaf(12)=3,bra(12)=16.8333,bxh(12)=0.01,bzl(12)=895.69,btrny(12)=175.0,
    ibaf(13)=3,bra(13)=16.8333,bxh(13)=0.01,bzl(13)=895.69,btrny(13)=225.0,
```

```
    pbaf(4)=0.0,
    ibaf(14)=4,bz(14)=780.0,byh(14)=98.0,byl(14)=52.0,bxh(14)=0.0,bxl(14)=-50.0,
    ibaf(15)=4,bz(15)=780.0,byh(15)=198.0,byl(15)=152.0,bxh(15)=0.0,bxl(15)=-50.0,
 $end
 $temp
   tempi=100.0,ntmp=1,
 $end
 $grafic
   nvplts=0,
 $end
 $parts
 $end
```

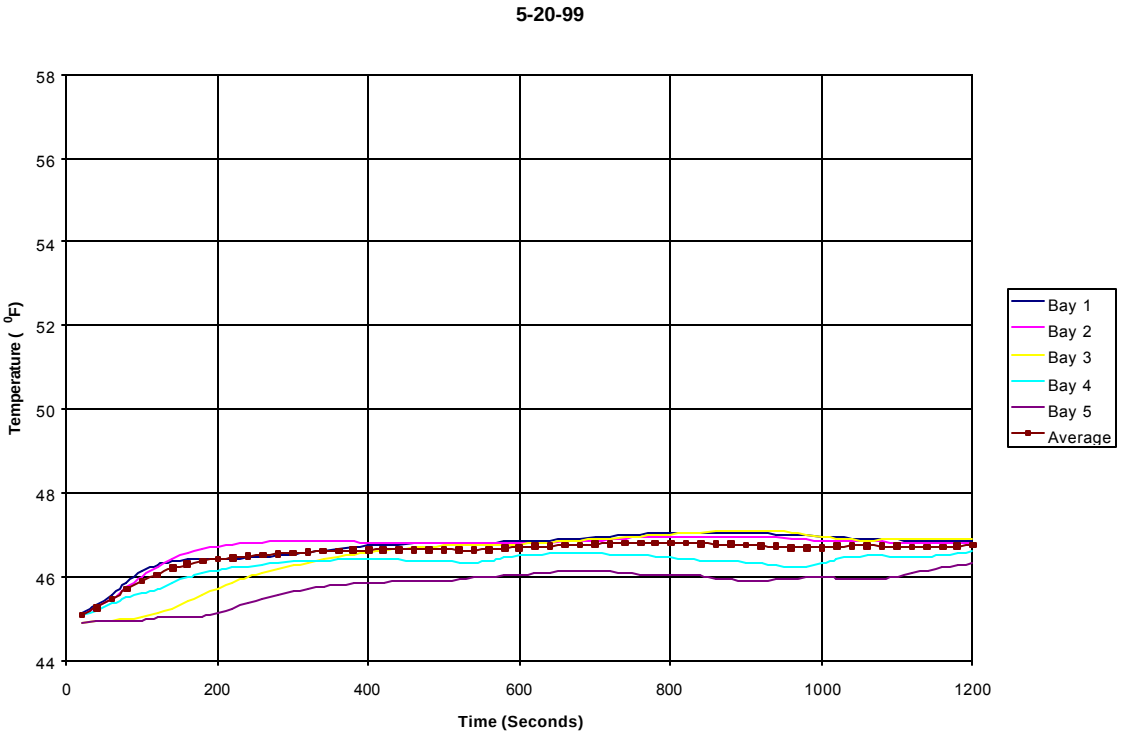

Figure 1G. Convergence graphic.

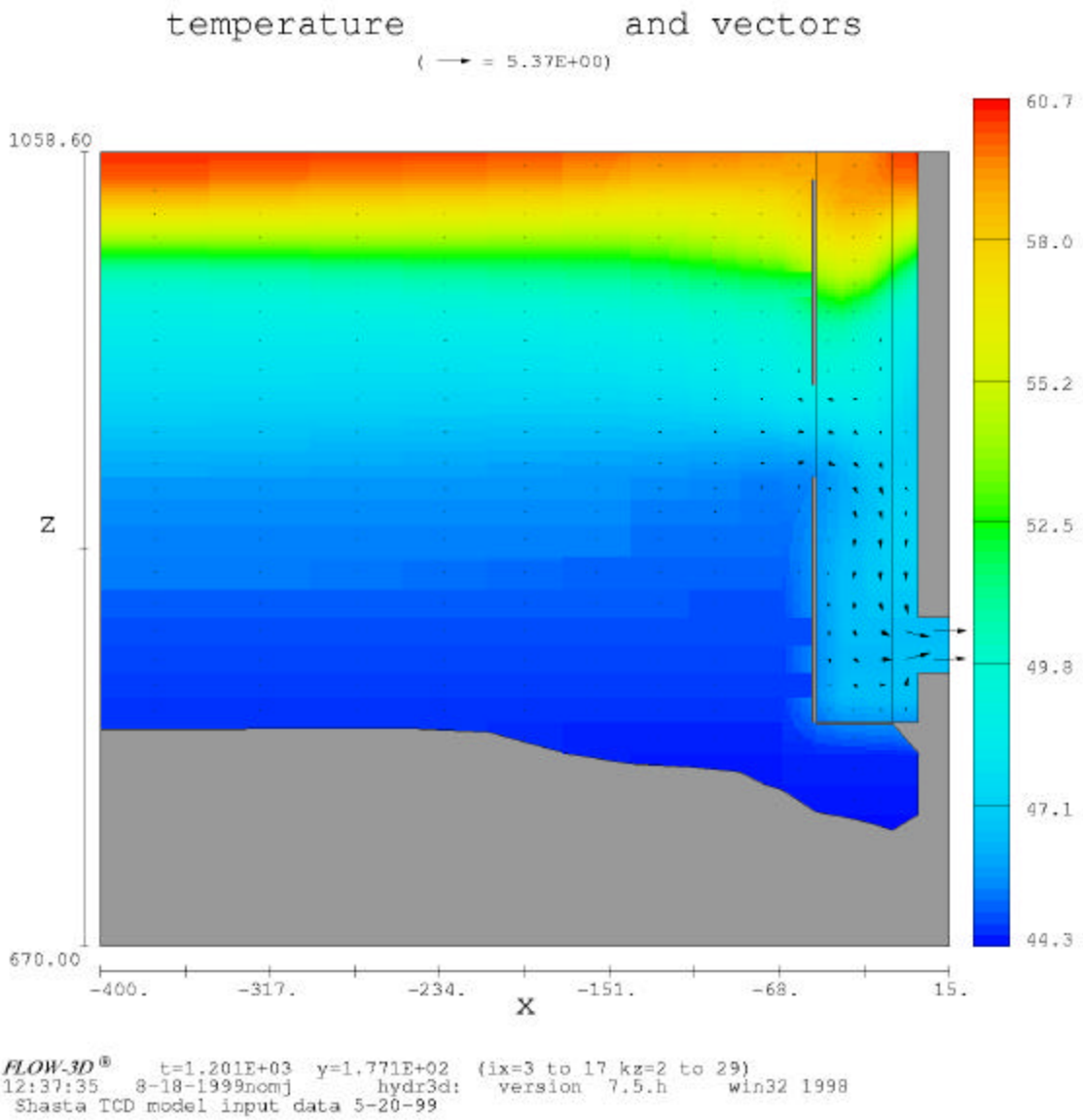

Figure 2G. Temperature Profile Through Penstock No. 4.

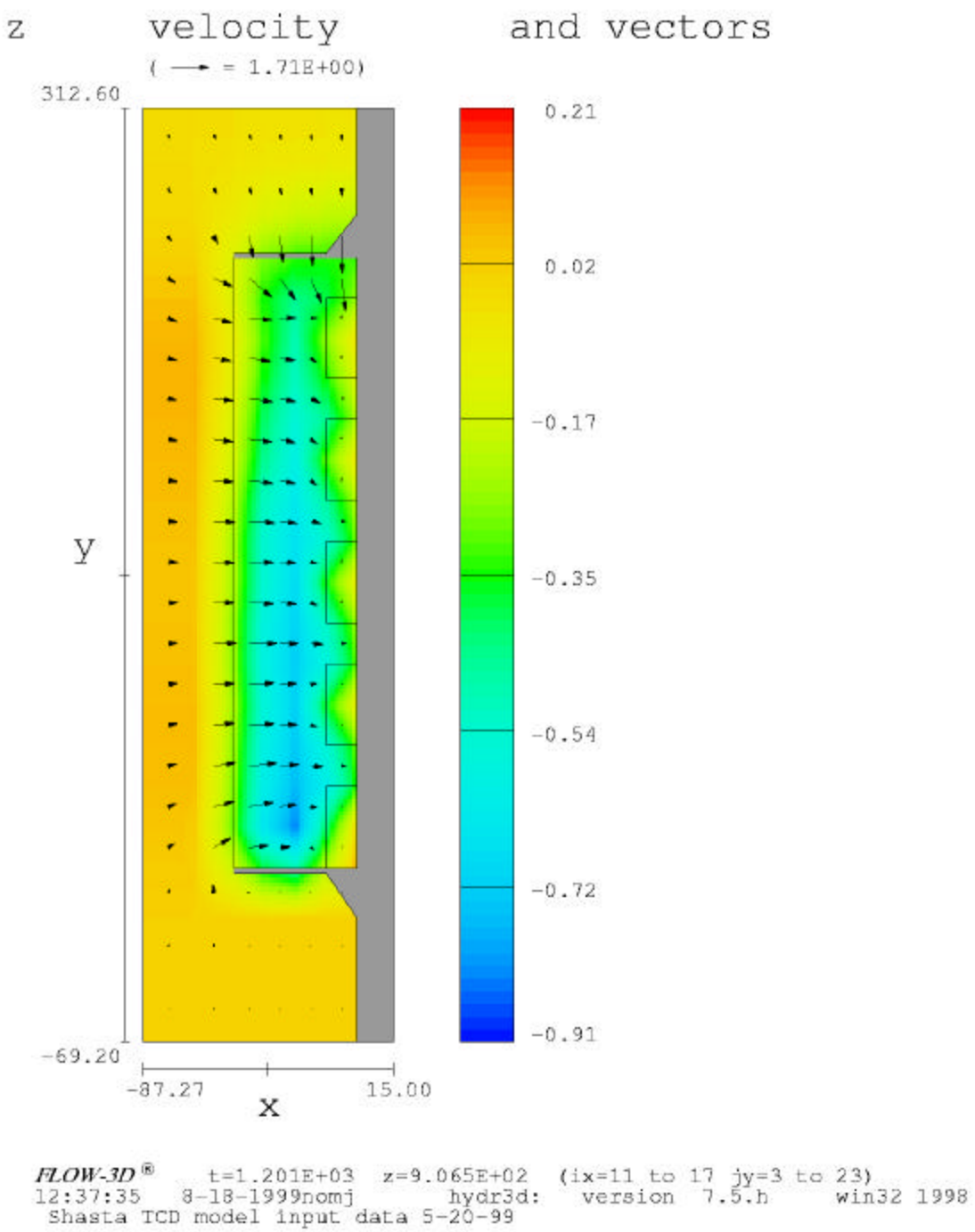

Figure 3G. Vertical Velocity Contours near the Bottom of the Middle Gates. Near the top of the image, significant leakage occurs, which is near the top of the Low Level Intake.

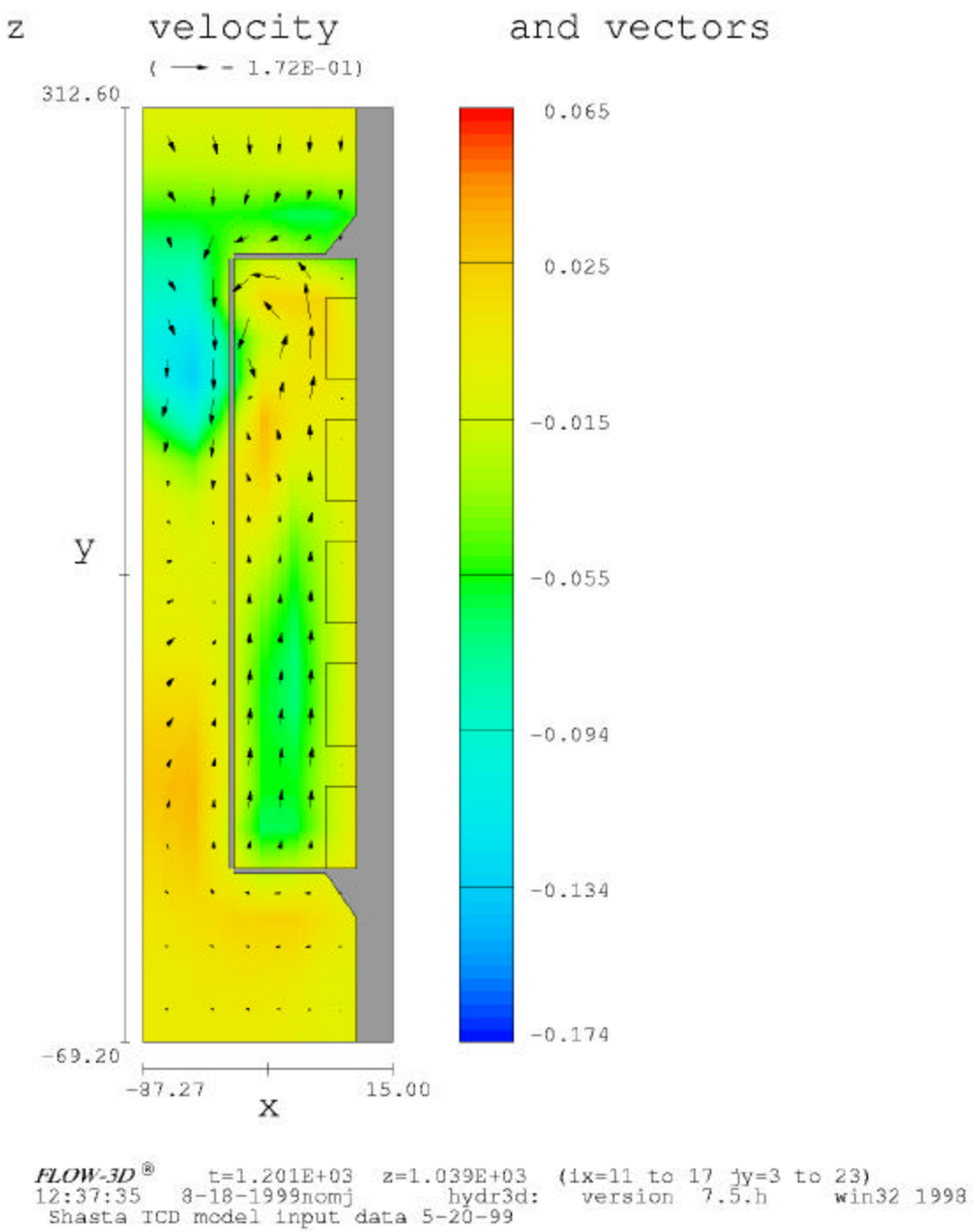

Figure 4G. Vertical Velocity Contours through the Upper Gates.

Appendix H – 6-18-1999

Table 1H. PREP.DAT.

```
&Title
        t(1)='Shasta TCD model input data 6-18-99'
        t(2)=''
        t(3)=''
        t(4)=''
        t(5)=''
/
&penstocks
        q(1)=2800
        q(2)=2800
        q(3)=2850
        q(4)=2560
        q(5)=0
/
&gates
        iupper(1)=1
        iupper(2)=1
        iupper(3)=1
        iupper(4)=1
        iupper(5)=1
        imiddle(1)=0
        imiddle(2)=0
        imiddle(3)=0
        imiddle(4)=0
        imiddle(5)=0
        ipg(1)=1
        ipg(2)=1
        ipg(3)=1
        ipg(4)=1
        ipg(5)=1
        ill=1
/
&reser
        wsel=1057.
        n_measure=37
        elev(1)=1056.3,     tempr(1)=74.62
        elev(2)=1055.4,     tempr(2)=74.59
        elev(3)=1049.5,tempr(3)=73.18
        elev(4)=1046.8,tempr(4)=72.77
        elev(5)=1041.9,     tempr(5)=72.48
        elev(6)=1036.3,     tempr(6)=72.16
        elev(7)=1031.1,     tempr(7)=67.35
        elev(8)=1026.8,     tempr(8)=63.39
        elev(9)=1021.6,     tempr(9)=60.8
        elev(10)=1016.3,tempr(10)=59.22
        elev(11)=1011.7,tempr(11)=58.46
        elev(12)=1006.8,tempr(12)=57.31
        elev(13)=1001.6,tempr(13)=56.7
        elev(14)=997.3,tempr(14)=55.87
        elev(15)=991.4,tempr(15)=54.79
        elev(16)=987.1,tempr(16)=54.0
        elev(17)=982.2,tempr(17)=53.35
        elev(18)=976.3,tempr(18)=52.34
        elev(19)=966.1,tempr(19)=51.24
        elev(20)=956,tempr(20)=49.10
        elev(21)=951.7,tempr(21)=48.31
        elev(22)=946.8,tempr(22)=48.06
        elev(23)=937.2,tempr(23)=47.48
        elev(24)=931.0, tempr(24)=47.1
        elev(25)=925.8,tempr(25)=46.94
        elev(26)=900,tempr(26)=46.
        elev(27)=875,tempr(27)=45.3
        elev(28)=850,tempr(28)=44.9
        elev(29)=825,tempr(29)=44.7
        elev(30)=800,tempr(30)=44.5
```

```
              elev(31)=775,tempr(31)=44.3
              elev(32)=750,tempr(32)=44.2
              elev(33)=725,tempr(33)=44.1
              elev(34)=700, tempr(34)=44.0
              elev(35)=675, tempr(35)=43.9
              elev(36)=650, tempr(36)=43.9
              elev(37)=625, tempr(37)=43.8
/
```

Table 2H. PREPIN.INP.

```
Shasta TCD model input data 6-18-99
 $xput
    lpr=1,itb=0,iwsh=0,ifvis=0,epsadj=1.0,
    prtdt=10000.0,gz=-32.14,ipdis=1,
    nmat=1,iadix=1,iadiy=1,iadiz=1,
    iorder=1,ifrho=1,ifenrg=2,ichm=0,
    ihtrst=0, iresf1=0, irstoe=0, iscrst=0, itrst=0,
    idum1=   2800.000
    idum2=   2800.000
    idum3=   2850.000
    idum4=   2560.000
    idum5=   1.000000
    idum6=100,
    twfin=1200.,
    pltdt=1200.0,
    delt=0.01,
    deltr=0.0001
    sprtdt=20.0,
    HPLTDT=20.0,
 $end
 $limits
    irpr=1,jbkpr=1,ktpr=1,
 $end
 $props
    rhof=1.937,mui=2.25E-05,tstar=0.0000001,mu1=2.25E-05,mu2=2.25E-05,
 $end
 $scalar
     nsc=1,isclr(1)=0,
 $end
 $bcdata
    pbctyp=1.,
    tbc(1)=100.0,tbc(2)=60.0,tbc(3)=60.0,
    tbc(4)=60.0,tbc(5)=60.0,tbc(6)=60.0,
    wl=5,wr=6,wf=2,wbk=2,wt=2,wb=2,
    flhtl=1043.7,
 $end
 $mesh
  nxcelt=17,
    px(1)=-400.0,    nxcell(1)=10,
    px(2)= -50.0,    nxcell(2)=4,
    px(3)=   0.0,    nxcell(3)=1,
    px(4)=  15.0,
  nycelt=30,
    py(1)=-100.0,    nycell(1)=4,
    py(2)= 2.0,      nycell(2)=3,
    py(3)=52.0,      nycell(3)=3,
    py(4)= 102.0,    nycell(4)=3,
    py(5)= 152.0,    nycell(5)=3,
    py(6)=202.0,     nycell(6)=3,
    py(7)=251.0,     nycell(7)=6,
    py(8)=381.08,    nycell(8)=5,
    py(9)=500.0,
  nzcelt=100,
    pz(1)=670.0,     nzcell(1)=2,
    pz(2)=704.0,     nzcell(2)=1,
    pz(3)=720.0,     nzcell(3)=2,
    pz(4)=749.5,     nzcell(4)=2,
    pz(5)=780.0,     nzcell(5)= 2,
    pz(6)=804.0,     nzcell(6)= 2,
```

```
    pz(7)=831.0,    nzcell(7)= 4,
    pz(8)= 889.0,   nzcell(8)= 1,
    pz(9)= 900.0,   nzcell(9)= 3,
    pz(10)= 945.0,  nzcell(10)=4,
    pz(11)=1000.,   nzcell(11)=4,
    pz(12)=1045.0,  nzcell(12)= 1
    pz(13)=  1057.000
 $end
 $obs
  avrck=-2.1,
  nobs=19,
  iob(1)=1,xl(1)=0.0,xh(1)=100.0,zh(1)=1079.7,
  iob(2)=1,ioh(2)=0,yh(2)=12.5,yl(2)=-12.5,trny(2)=25.0,zh(2)=831.0,zl(2)=804.0,
  iob(3)=1,ioh(3)=0,yh(3)=12.5,yl(3)=-12.5,trny(3)=75.0,zh(3)=831.0,zl(3)=804.0,
  iob(4)=1,ioh(4)=0,yh(4)=12.5,yl(4)=-12.5,trny(4)=125.0,zh(4)=831.0,zl(4)=804.0,
  iob(5)=1,ioh(5)=0,yh(5)=12.5,yl(5)=-12.5,trny(5)=175.0,zh(5)=831.0,zl(5)=804.0,
  iob(6)=1,ioh(6)=0,yh(6)=12.5,yl(6)=-12.5,trny(6)=225.0,zh(6)=831.0,zl(6)=804.0,
  iob(7)=2,igen(7)=3,ioh(7)=1,
  iob(8)=3,xh(8)=0.01,xl(8)=-52.0,yh(8)=2.01,yl(8)=0.03,zh(8)=1045.01,zl(8)=999.99,
  iob(9)=3,xh(9)=0.01,xl(9)=-52.0,yh(9)=253.0,yl(9)=250.99,zh(9)=1045.01,zl(9)=999.99,
  iob(10)=3,xh(10)=-49.99,xl(10)=-52.0,yh(10)=253.0,yl(10)=0.03,zh(10)=1045.01,zl(10)=999.99,
  iob(11)=4,opor(4)=0.004015302,xh(11)=0.01,xl(11)=-50.01,yh(11)=2.01,yl(11)=0.03,zh(11)=1000.01,zl(11)=944.99,
  iob(12)=5,opor(5)=0.003884098,xh(12)=0.01,xl(12)=-50.01,yh(12)=253.0,yl(12)=250.99,zh(12)=1000.01,zl(12)=944.99,
  iob(13)=6,opor(6)=0.0051328,xh(13)=-49.99,xl(13)=-52.0,yh(13)=253.0,yl(13)=0.03,zh(13)=1000.01,zl(13)=944.99,
  iob(14)=7,opor(7)=0.004351858,xh(14)=0.01,xl(14)=-50.01,yh(14)=2.01,yl(14)=0.03,zh(14)=945.01,zl(14)=899.99,
  iob(15)=8,opor(8)=0.020888367,xh(15)=0.01,xl(15)=-50.01,yh(15)=253.0,yl(15)=250.99,zh(15)=945.01,zl(15)=899.9,
  iob(16)=9,opor(9)=0.007301943,xh(16)=-49.99,xl(16)=-52.0,yh(16)=253.0,yl(16)=0.03,zh(16)=945.01,zl(16)=899.99,
  iob(17)=10,opor(10)=0.003534187,xh(17)=0.01,xl(17)=-50.01,yh(17)=2.01,yl(17)=0.03,zh(17)=900.01,zl(17)=830.99
  iob(18)=11,opor(11)=0.006766415,xh(18)=0.01,xl(18)=-50.01,yh(18)=253.0,yl(18)=250.99,zh(18)=900.01,zl(18)=830.99
  iob(19)=12,opor(12)=0.003110806,xh(19)=-49.99,xl(19)=-52.0,yh(19)=253.0,yl(19)=0.03,zh(19)=900.01,zl(19)=830.99,
  iob(20)=13,opor(13)=0.00536379,xh(20)=0.01,xl(20)=-50.01,yh(20)=2.01,yl(20)=0.03,zh(20)=831.01,zl(20)=803.9,
  iob(21)=14,opor(14)=0.0099,xh(21)=-49.99,xl(21)=-52.0,yh(21)=253.0,yl(21)=0.03,zh(21)=831.01,zl(21)=803.99,
  iob(22)=15,opor(15)=0.007382123,xh(22)=0.01,xl(22)=-50.01,yh(22)=2.01,yl(22)=0.03,zh(22)=804.01,zl(22)=779.9,
  iob(23)=16,opor(16)=0.003032684,xh(23)=-49.99,xl(23)=-52.0,yh(23)=253.0,yl(23)=0.03,zh(23)=804.01,zl(23)=779.99,
  iob(24)=3,xh(24)=0.01,xl(24)=-50.01,yh(24)=202.01,yl(24)=201.0,zh(24)=780.01,zl(24)=749.51,
  iob(25)=3,xh(25)=0.01,xl(25)=-50.01,yh(25)=253.0,yl(25)=250.99,zh(25)=831.01,zl(25)=719.99,
  iob(26)=17,opor(18)=0.00829452,xh(26)=-49.99,xl(26)=-52.0,yh(26)=253.0,yl(26)=201.0,zh(26)=780.01,zl(26)=749.51,
  iob(27)=18,opor(18)=0.00829452,xl(27)=-52.0,yh(27)=202.2,yl(27)=0.03,zh(27)=780.01,zl(27)=779.0,
  iob(28)=19,opor(19)=0.019110575,xl(28)=-52.0,yh(28)=253.0,yl(28)=201.0,zh(28)=749.51,zl(28)=748.50,
  iob(29)=3,xl(29)=-52.0,yh(29)=382.08,yl(29)=250.99,zh(29)=892.06,zl(29)=888.99,
  iob(30)=3,xh(30)=-49.99,xl(30)=-52.0,yh(30)=382.08,yl(30)=250.99,zh(30)=892.06,zl(30)=719.99,
  iob(31)=3,xl(31)=-52.0,yh(31)=382.08,yl(31)=381.07,zh(31)=892.06,zl(31)=719.99,
  iob(32)=3, zh(32)=-888.9
  iob(33)=3,zh(33)=-1000.0,
  iob(34)=3,zh(34)=-1000.0,
  iob(35)=3,zh(35)=-1000.0,
  iob(36)=3,zh(36)=-1000.0,
  iob(37)=3,zh(37)=-1000.0,
  iob(38)=9,ioh(38)=0,yl(38)= 2.0,yh(38)=48.0,zh(38)=945.0,zl(38)=900.0,
  iob(39)=9,ioh(39)=0,yl(39)=52.0,yh(39)=98.0,zh(39)=945.0,zl(39)=900.0,
  iob(40)=9,ioh(40)=0,yl(40)=102.0,yh(40)=148.0,zh(40)=945.0,zl(40)=900.0,
  iob(41)=9,ioh(41)=0,yl(41)=152.0,yh(41)=198.0,zh(41)=945.0,zl(41)=900.0,
  iob(42)=9,ioh(42)=0,yl(42)=202.0,yh(42)=248.0,zh(42)=945.0,zl(42)=900.0,
  iob(43)=3,zh(43)=-1000.0,
  iob(44)=3,zh(44)=-1000.0,
  iob(45)=3,zh(45)=-1000.0,
  iob(46)=3,zh(46)=-1000.0,
  iob(47)=3,zh(47)=-1000.0,
 $end
 $fl
    presi=0.0,nfls=1,
    flht=  1057.000
 $end
 $bf
    nbafs=4,pbaf(1)=0.9143,
     ibaf(1)=1,bxh(1)=0.0,bxl(1)=-50.0,by(1)=0.0,bzh(1)=1066.6,bzl(1)=1044.99,
     ibaf(2)=1,bxh(2)=0.0,bxl(2)=-50.0,by(2)=250.0,bzh(2)=1066.6,bzl(2)=1044.99,
     ibaf(3)=1,bx(3)=-50.0,byh(3)=250.0,byl(3)=0.0,bzh(3)=1066.6,bzl(3)=803.99,
     pbaf(2)=0.6785,
     ibaf(4)=2,bra(4)=16.8333,bxh(4)=0.01,btrny(4)=25.0,bzl(4)=780.0,
```

```
    ibaf(5)=2,bra(5)=16.8333,bxh(5)=0.01,btrny(5)=75.0,bzl(5)=780.0,
    ibaf(6)=2,bra(6)=16.8333,bxh(6)=0.01,btrny(6)=125.0,bzl(6)=780.0,
    ibaf(7)=2,bra(7)=16.8333,bxh(7)=0.01,btrny(7)=175.0,bzl(7)=780.0,
    ibaf(8)=2,bra(8)=16.8333,bxh(8)=0.01,btrny(8)=225.0,bzl(8)=749.5,
    ibaf(9)=3,bra(9)=16.8333,bxh(9)=0.01,bzl(9)=895.69,btrny(9)=25.0,
    ibaf(10)=3,bra(10)=16.8333,bxh(10)=0.01,bzl(10)=895.69,btrny(10)=75.0,
    ibaf(11)=3,bra(11)=16.8333,bxh(11)=0.01,bzl(11)=895.69,btrny(11)=125.0,
    ibaf(12)=3,bra(12)=16.8333,bxh(12)=0.01,bzl(12)=895.69,btrny(12)=175.0,
    ibaf(13)=3,bra(13)=16.8333,bxh(13)=0.01,bzl(13)=895.69,btrny(13)=225.0,
    pbaf(4)=0.0,
    ibaf(14)=4,bz(14)=780.0,byh(14)=98.0,byl(14)=52.0,bxh(14)=0.0,bxl(14)=-50.0,
    ibaf(15)=4,bz(15)=780.0,byh(15)=198.0,byl(15)=152.0,bxh(15)=0.0,bxl(15)=-50.0,
 $end
 $temp
   tempi=100.0,ntmp=1,
 $end
 $grafic
   nvplts=0,
 $end
 $parts
 $end
```

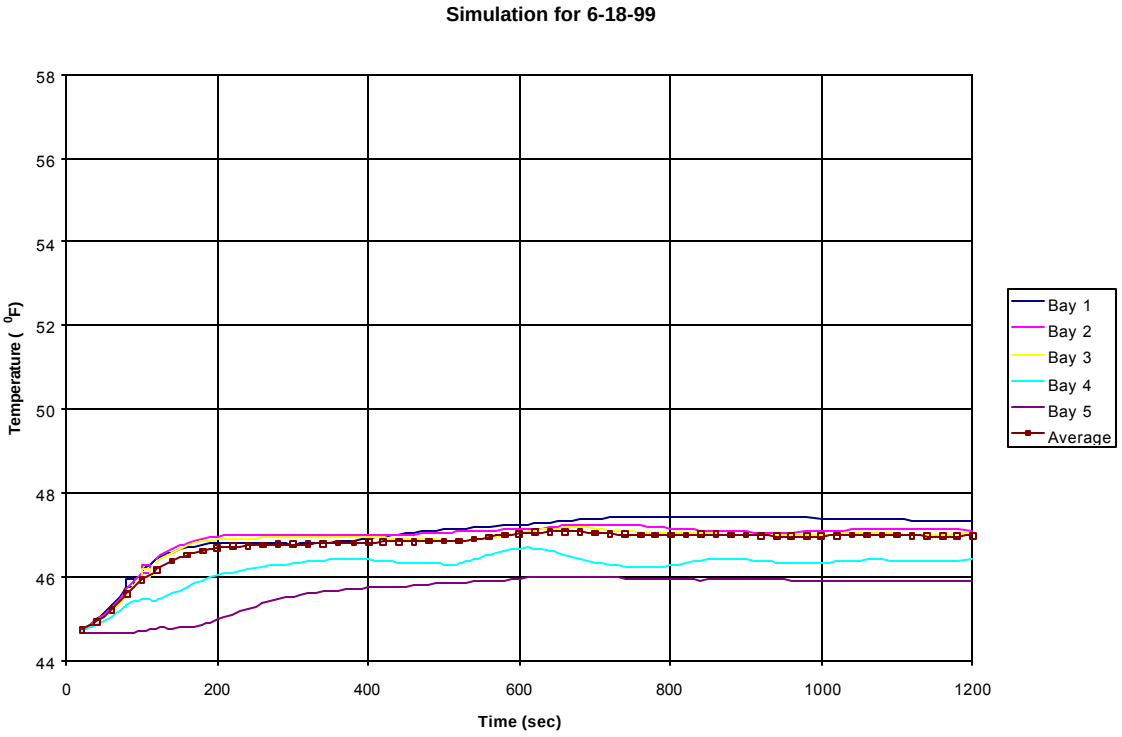

Figure 1H. Convergence graphic.

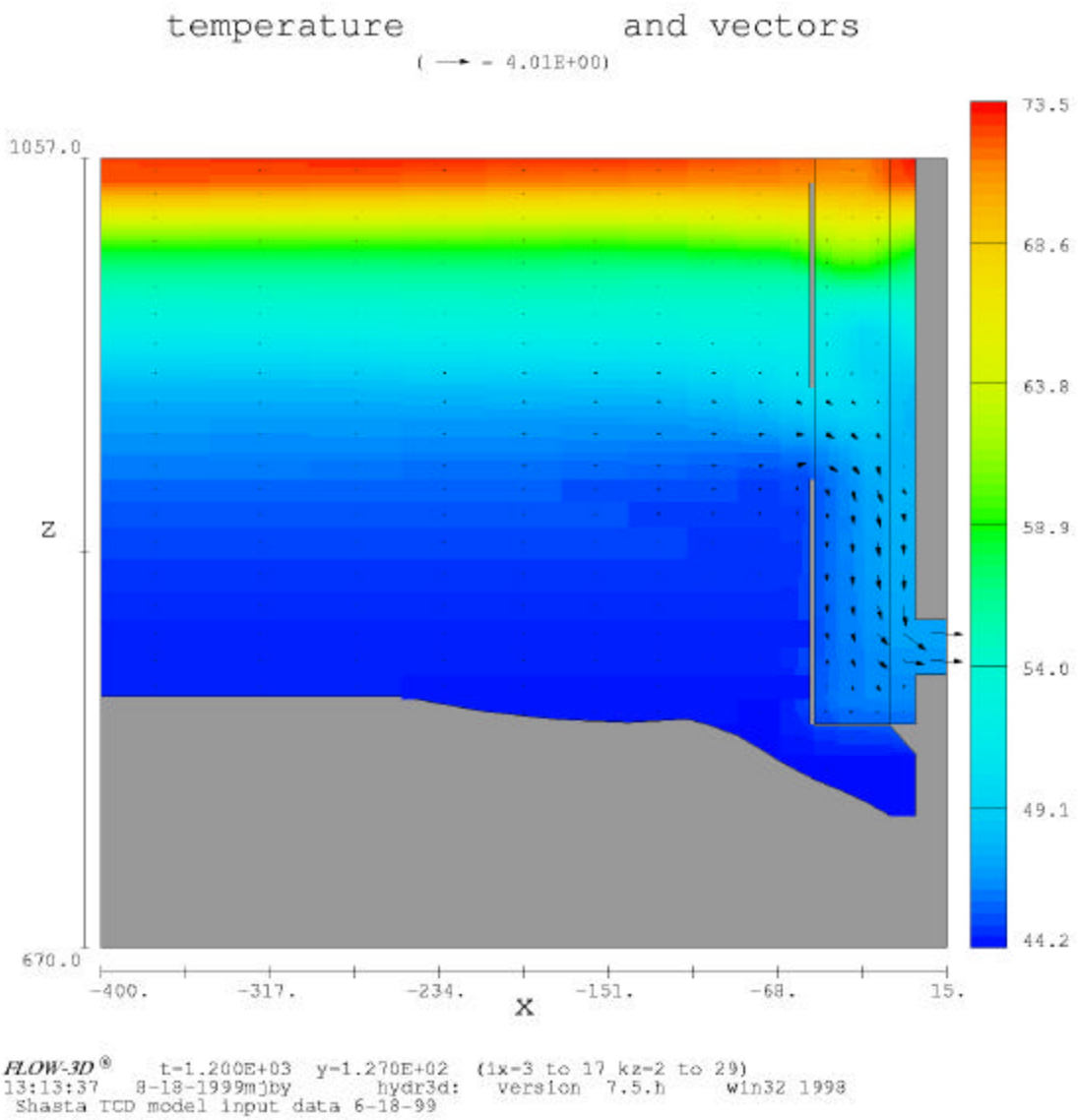

Figure 2H. Temperature Profile Through Penstock No. 3.

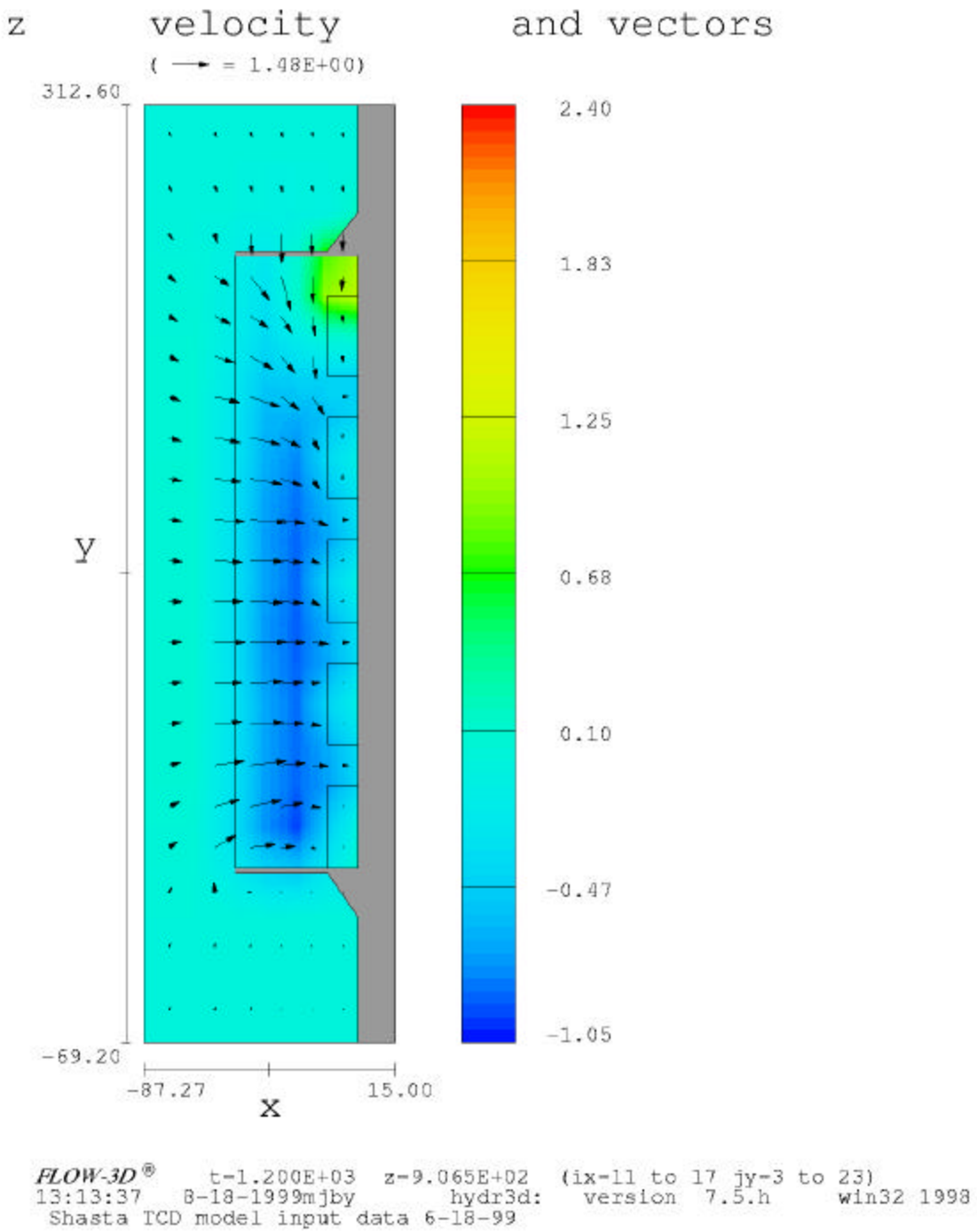

Figure 3H. Vertical Velocity Contours near the Bottom of the Middle Gates.

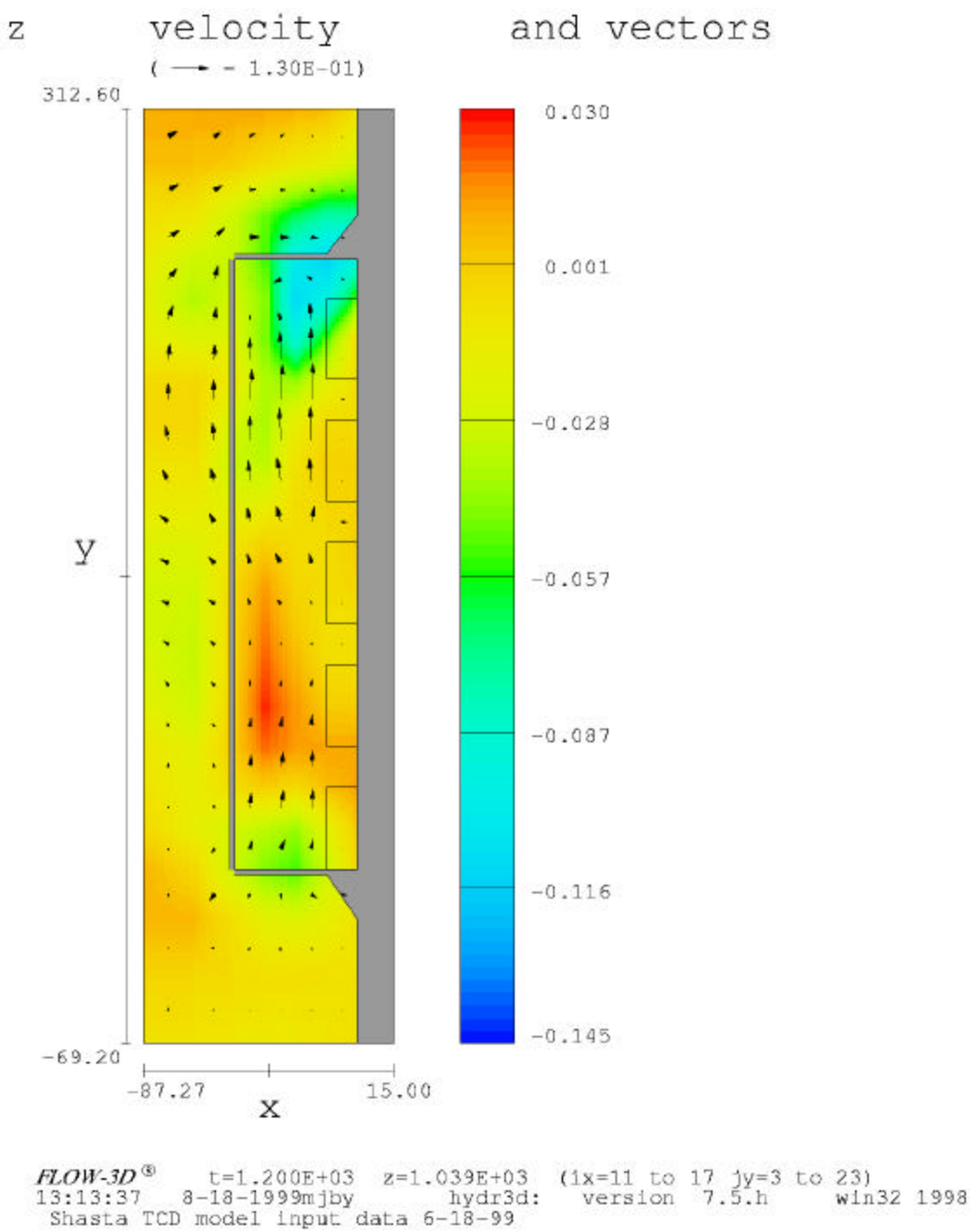

Figure 4H. Vertical Velocity Contours Through the Upper Gates.

Appendix I – 7-5-1999

Table 1I. PREP.DAT.

```
&Title
        t(1)='Shasta TCD model input data 7-5-99'
        t(2)=''
        t(3)=''
        t(4)=''
/
&penstocks
        q(1)=2881
        q(2)=2881
        q(3)=2881
        q(4)=2881
        q(5)=3457
/
&gates
        iupper(1)=1
        iupper(2)=1
        iupper(3)=0
        iupper(4)=1
        iupper(5)=1
        imiddle(1)=0
        imiddle(2)=0
        imiddle(3)=1
        imiddle(4)=0
        imiddle(5)=0
        ipg(1)=1
        ipg(2)=1
        ipg(3)=1
        ipg(4)=1
        ipg(5)=1
        ill=1
/
&reser
        wsel=1049.0
        n_measure=30
        elev(1)=1047.7,     tempr(1)=72.9
        elev(2)=1046.2,     tempr(2)=72.9
        elev(3)=1038.1,     tempr(3)=72.9
        elev(4)=1018.9,     tempr(4)=72.8
        elev(5)=1013.0,     tempr(5)=64.8
        elev(6)=1009.2,     tempr(6)=63.7
        elev(7)=1002.6,     tempr(7)=61.5
        elev(8)=992.8,      tempr(8)=60.0
        elev(9)=983.7,      tempr(9)=58.6
        elev(10)=975.5,     tempr(10)=57.3
        elev(11)=970.7,     tempr(11)=56.3
        elev(12)=963.7,     tempr(12)=55.1
        elev(13)=953.0,     tempr(13)=54.0
        elev(14)=945.9,     tempr(14)=53.0
        elev(15)=940.9,     tempr(15)=52.0
        elev(16)=936.9,     tempr(16)=51.2
        elev(17)=932.8,     tempr(17)=50.6
        elev(18)=927.2,     tempr(18)=49.8
        elev(19)=917.9,     tempr(19)=48.9
        elev(20)=898.0,     tempr(20)=47.7
        elev(21)=878.5,     tempr(21)=46.9
        elev(22)=853.3,     tempr(22)=46.1
        elev(23)=840.9,     tempr(23)=45.9
        elev(24)=810.5,     tempr(24)=45.5
        elev(25)=786.0,     tempr(25)=45.2
        elev(26)=750.3,     tempr(26)=45.0
        elev(27)=714.1,     tempr(27)=44.9
        elev(28)=682.8,     tempr(28)=44.8
        elev(29)=632.1,     tempr(29)=44.7
        elev(30)=607.0,     tempr(30)=44.7
/
```

Table 2I. PREPIN.INP.

```
Shasta TCD model input data 7-5-99
 $xput
    lpr=1,itb=0,iwsh=0,ifvis=0,epsadj=1.0,
    prtdt=10000.0,gz=-32.14,ipdis=1,
    nmat=1,iadix=1,iadiy=1,iadiz=1,
    iorder=1,ifrho=1,ifenrg=2,ichm=0,
    ihtrst=0, iresf1=0, irstoe=0, iscrst=0, itrst=0,
    idum1=   2881.000
    idum2=   2881.000
    idum3=   2881.000
    idum4=   2881.000
    idum5=   3457.000
    idum6=100,
    twfin=1200.,
    pltdt=1200.0,
    delt=0.01,
    deltr=0.0001
    sprtdt=20.0,
    HPLTDT=20.0,
 $end
 $limits
    irpr=1,jbkpr=1,ktpr=1,
 $end
 $props
    rhof=1.937,mui=2.25E-05,tstar=0.0000001,mu1=2.25E-05,mu2=2.25E-05,
 $end
 $scalar
     nsc=1,isclr(1)=0,
 $end
 $bcdata
    pbctyp=1.,
    tbc(1)=100.0,tbc(2)=60.0,tbc(3)=60.0,
    tbc(4)=60.0,tbc(5)=60.0,tbc(6)=60.0,
    wl=5,wr=6,wf=2,wbk=2,wt=2,wb=2,
    flhtl=1043.7,
 $end
 $mesh
  nxcelt=17,
    px(1)=-400.0,     nxcell(1)=10,
    px(2)= -50.0,     nxcell(2)=4,
    px(3)=   0.0,     nxcell(3)=1,
    px(4)=  15.0,
  nycelt=30,
    py(1)=-100.0,     nycell(1)=4,
    py(2)= 2.0,       nycell(2)=3,
    py(3)=52.0,       nycell(3)=3,
    py(4)= 102.0,     nycell(4)=3,
    py(5)= 152.0,     nycell(5)=3,
    py(6)=202.0,      nycell(6)=3,
    py(7)=251.0,      nycell(7)=6,
    py(8)=381.08,     nycell(8)=5,
    py(9)=500.0,
  nzcelt=100,
    pz(1)=670.0,      nzcell(1)=2,
    pz(2)=704.0,      nzcell(2)=1,
    pz(3)=720.0,      nzcell(3)=2,
    pz(4)=749.5,      nzcell(4)=2,
    pz(5)=780.0,      nzcell(5)= 2,
    pz(6)=804.0,      nzcell(6)= 2,
    pz(7)=831.0,      nzcell(7)= 4,
    pz(8)= 889.0,     nzcell(8)= 1,
    pz(9)= 900.0,     nzcell(9)= 3,
    pz(10)= 945.0,    nzcell(10)=4,
    pz(11)=1000.,     nzcell(11)=4,
    pz(12)=1045.0,    nzcell(12)= 1
    pz(13)=   1049.000
    pz(12)=   1037.750
 $end
```

```
 $obs
  avrck=-2.1,
  nobs=19,
  iob(1)=1,xl(1)=0.0,xh(1)=100.0,zh(1)=1079.7,
  iob(2)=1,ioh(2)=0,yh(2)=12.5,yl(2)=-12.5,trny(2)=25.0,zh(2)=831.0,zl(2)=804.0,
  iob(3)=1,ioh(3)=0,yh(3)=12.5,yl(3)=-12.5,trny(3)=75.0,zh(3)=831.0,zl(3)=804.0,
  iob(4)=1,ioh(4)=0,yh(4)=12.5,yl(4)=-12.5,trny(4)=125.0,zh(4)=831.0,zl(4)=804.0,
  iob(5)=1,ioh(5)=0,yh(5)=12.5,yl(5)=-12.5,trny(5)=175.0,zh(5)=831.0,zl(5)=804.0,
  iob(6)=1,ioh(6)=0,yh(6)=12.5,yl(6)=-12.5,trny(6)=225.0,zh(6)=831.0,zl(6)=804.0,
  iob(7)=2,igen(7)=3,ioh(7)=1,
  iob(8)=3,xh(8)=0.01,xl(8)=-52.0,yh(8)=2.01,yl(8)=0.03,zh(8)=1045.01,zl(8)=999.99,
  iob(9)=3,xh(9)=0.01,xl(9)=-52.0,yh(9)=253.0,yl(9)=250.99,zh(9)=1045.01,zl(9)=999.99,
  iob(10)=3,xh(10)=-49.99,xl(10)=-52.0,yh(10)=253.0,yl(10)=0.03,zh(10)=1045.01,zl(10)=999.99,
  iob(11)=4,opor(4)=0.004015302,xh(11)=0.01,xl(11)=-50.01,yh(11)=2.01,yl(11)=0.03,zh(11)=1000.01,zl(11)=944.99,
  iob(12)=5,opor(5)=0.003884098,xh(12)=0.01,xl(12)=-50.01,yh(12)=253.0,yl(12)=250.99,zh(12)=1000.01,zl(12)=944.99,
  iob(13)=6,opor(6)=0.0051328,xh(13)=-49.99,xl(13)=-52.0,yh(13)=253.0,yl(13)=0.03,zh(13)=1000.01,zl(13)=944.99,
  iob(14)=7,opor(7)=0.004351858,xh(14)=0.01,xl(14)=-50.01,yh(14)=2.01,yl(14)=0.03,zh(14)=945.01,zl(14)=899.99,
  iob(15)=8,opor(8)=0.020888367,xh(15)=0.01,xl(15)=-50.01,yh(15)=253.0,yl(15)=250.99,zh(15)=945.01,zl(15)=899.9,
  iob(16)=9,opor(9)=0.007301943,xh(16)=-49.99,xl(16)=-52.0,yh(16)=253.0,yl(16)=0.03,zh(16)=945.01,zl(16)=899.99,
  iob(17)=10,opor(10)=0.003534187,xh(17)=0.01,xl(17)=-50.01,yh(17)=2.01,yl(17)=0.03,zh(17)=900.01,zl(17)=830.99
  iob(18)=11,opor(11)=0.006766415,xh(18)=0.01,xl(18)=-50.01,yh(18)=253.0,yl(18)=250.99,zh(18)=900.01,zl(18)=830.99
  iob(19)=12,opor(12)=0.003110806,xh(19)=-49.99,xl(19)=-52.0,yh(19)=253.0,yl(19)=0.03,zh(19)=900.01,zl(19)=830.99,
  iob(20)=13,opor(13)=0.00536379,xh(20)=0.01,xl(20)=-50.01,yh(20)=2.01,yl(20)=0.03,zh(20)=831.01,zl(20)=803.9,
  iob(21)=14,opor(14)=0.0099,xh(21)=-49.99,xl(21)=-52.0,yh(21)=253.0,yl(21)=0.03,zh(21)=831.01,zl(21)=803.99,
  iob(22)=15,opor(15)=0.007382123,xh(22)=0.01,xl(22)=-50.01,yh(22)=2.01,yl(22)=0.03,zh(22)=804.01,zl(22)=779.9,
  iob(23)=16,opor(16)=0.003032684,xh(23)=-49.99,xl(23)=-52.0,yh(23)=253.0,yl(23)=0.03,zh(23)=804.01,zl(23)=779.99,
  iob(24)=3,xh(24)=0.01,xl(24)=-50.01,yh(24)=202.01,yl(24)=201.0,zh(24)=780.01,zl(24)=749.51,
  iob(25)=3,xh(25)=0.01,xl(25)=-50.01,yh(25)=253.0,yl(25)=250.99,zh(25)=831.01,zl(25)=719.99,
  iob(26)=17,opor(18)=0.00829452,xh(26)=-49.99,xl(26)=-52.0,yh(26)=253.0,yl(26)=201.0,zh(26)=780.01,zl(26)=749.51,
  iob(27)=18,opor(18)=0.00829452,xl(27)=-52.0,yh(27)=202.2,yl(27)=0.03,zh(27)=780.01,zl(27)=779.0,
  iob(28)=19,opor(19)=0.019110575,xl(28)=-52.0,yh(28)=253.0,yl(28)=201.0,zh(28)=749.51,zl(28)=748.50,
  iob(29)=3,xl(29)=-52.0,yh(29)=382.08,yl(29)=250.99,zh(29)=892.06,zl(29)=888.99,
  iob(30)=3,xh(30)=-49.99,xl(30)=-52.0,yh(30)=382.08,yl(30)=250.99,zh(30)=892.06,zl(30)=719.99,
  iob(31)=3,xl(31)=-52.0,yh(31)=382.08,yl(31)=381.07,zh(31)=892.06,zl(31)=719.99,
  iob(32)=3, zh(32)=-888.9
  iob(33)=3,zh(33)=-1000.0,
  iob(34)=3,zh(34)=-1000.0,
  iob(35)=3,ioh(35)=0,yl(35)=102.0,yh(35)=148.0,zh(35)=1045.0,zl(35)=1000.0,
  iob(36)=3,zh(36)=-1000.0,
  iob(37)=3,zh(37)=-1000.0,
  iob(38)=9,ioh(38)=0,yl(38)= 2.0,yh(38)=48.0,zh(38)=945.0,zl(38)=900.0,
  iob(39)=9,ioh(39)=0,yl(39)=52.0,yh(39)=98.0,zh(39)=945.0,zl(39)=900.0,
  iob(40)=3,zh(40)=-1000.0,
  iob(41)=9,ioh(41)=0,yl(41)=152.0,yh(41)=198.0,zh(41)=945.0,zl(41)=900.0,
  iob(42)=9,ioh(42)=0,yl(42)=202.0,yh(42)=248.0,zh(42)=945.0,zl(42)=900.0,
  iob(43)=3,zh(43)=-1000.0,
  iob(44)=3,zh(44)=-1000.0,
  iob(45)=3,zh(45)=-1000.0,
  iob(46)=3,zh(46)=-1000.0,
  iob(47)=3,zh(47)=-1000.0,
 $end
 $fl
    presi=0.0,nfls=1,
    flht=   1049.000
 $end
 $bf
    nbafs=4,pbaf(1)=0.9143,
     ibaf(1)=1,bxh(1)=0.0,bxl(1)=-50.0,by(1)=0.0,bzh(1)=1066.6,bzl(1)=1044.99,
     ibaf(2)=1,bxh(2)=0.0,bxl(2)=-50.0,by(2)=250.0,bzh(2)=1066.6,bzl(2)=1044.99,
     ibaf(3)=1,bx(3)=-50.0,byh(3)=250.0,byl(3)=0.0,bzh(3)=1066.6,bzl(3)=803.99,
    pbaf(2)=0.6785,
     ibaf(4)=2,bra(4)=16.8333,bxh(4)=0.01,btrny(4)=25.0,bzl(4)=780.0,
     ibaf(5)=2,bra(5)=16.8333,bxh(5)=0.01,btrny(5)=75.0,bzl(5)=780.0,
     ibaf(6)=2,bra(6)=16.8333,bxh(6)=0.01,btrny(6)=125.0,bzl(6)=780.0,
     ibaf(7)=2,bra(7)=16.8333,bxh(7)=0.01,btrny(7)=175.0,bzl(7)=780.0,
     ibaf(8)=2,bra(8)=16.8333,bxh(8)=0.01,btrny(8)=225.0,bzl(8)=749.5,
     ibaf(9)=3,bra(9)=16.8333,bxh(9)=0.01,bzl(9)=895.69,btrny(9)=25.0,
     ibaf(10)=3,bra(10)=16.8333,bxh(10)=0.01,bzl(10)=895.69,btrny(10)=75.0,
     ibaf(11)=3,bra(11)=16.8333,bxh(11)=0.01,bzl(11)=895.69,btrny(11)=125.0,
     ibaf(12)=3,bra(12)=16.8333,bxh(12)=0.01,bzl(12)=895.69,btrny(12)=175.0,
```

```
    ibaf(13)=3,bra(13)=16.8333,bxh(13)=0.01,bzl(13)=895.69,btrny(13)=225.0,
   pbaf(4)=0.0,
    ibaf(14)=4,bz(14)=780.0,byh(14)=98.0,byl(14)=52.0,bxh(14)=0.0,bxl(14)=-50.0,
    ibaf(15)=4,bz(15)=780.0,byh(15)=198.0,byl(15)=152.0,bxh(15)=0.0,bxl(15)=-50.0,
 $end
 $temp
   tempi=100.0,ntmp=1,
 $end
 $grafic
   nvplts=0,
 $end
 $parts
 $end
```

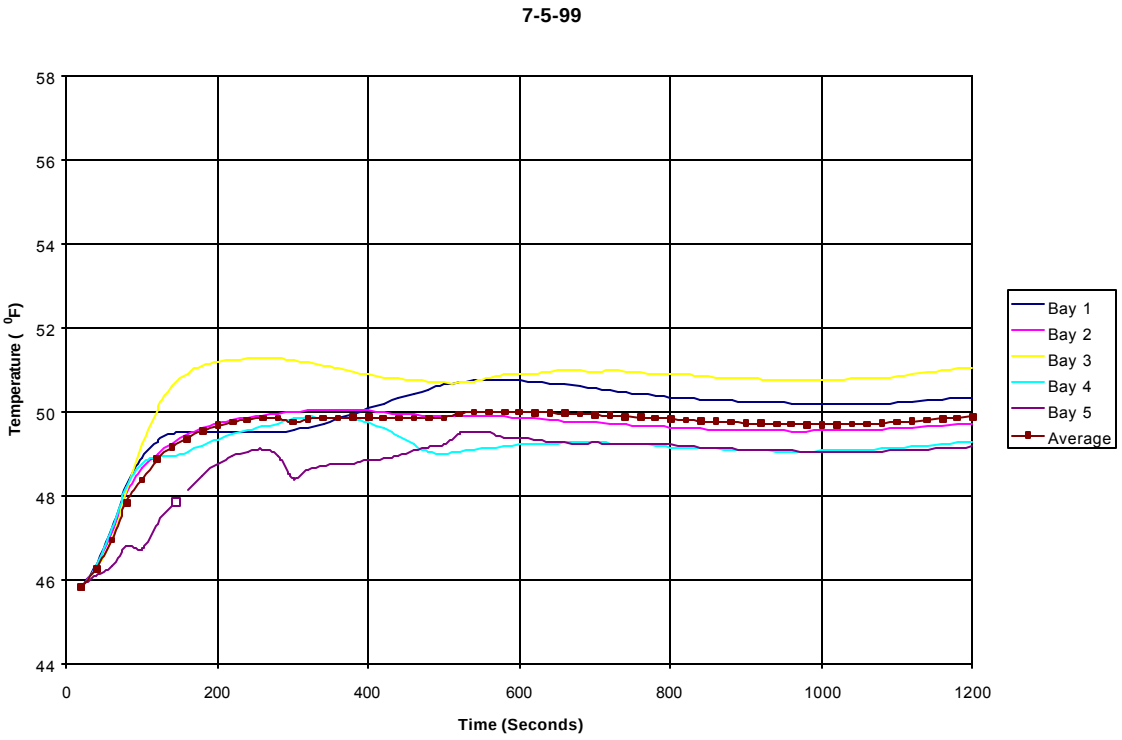

Figure 1I. Convergence graphic.

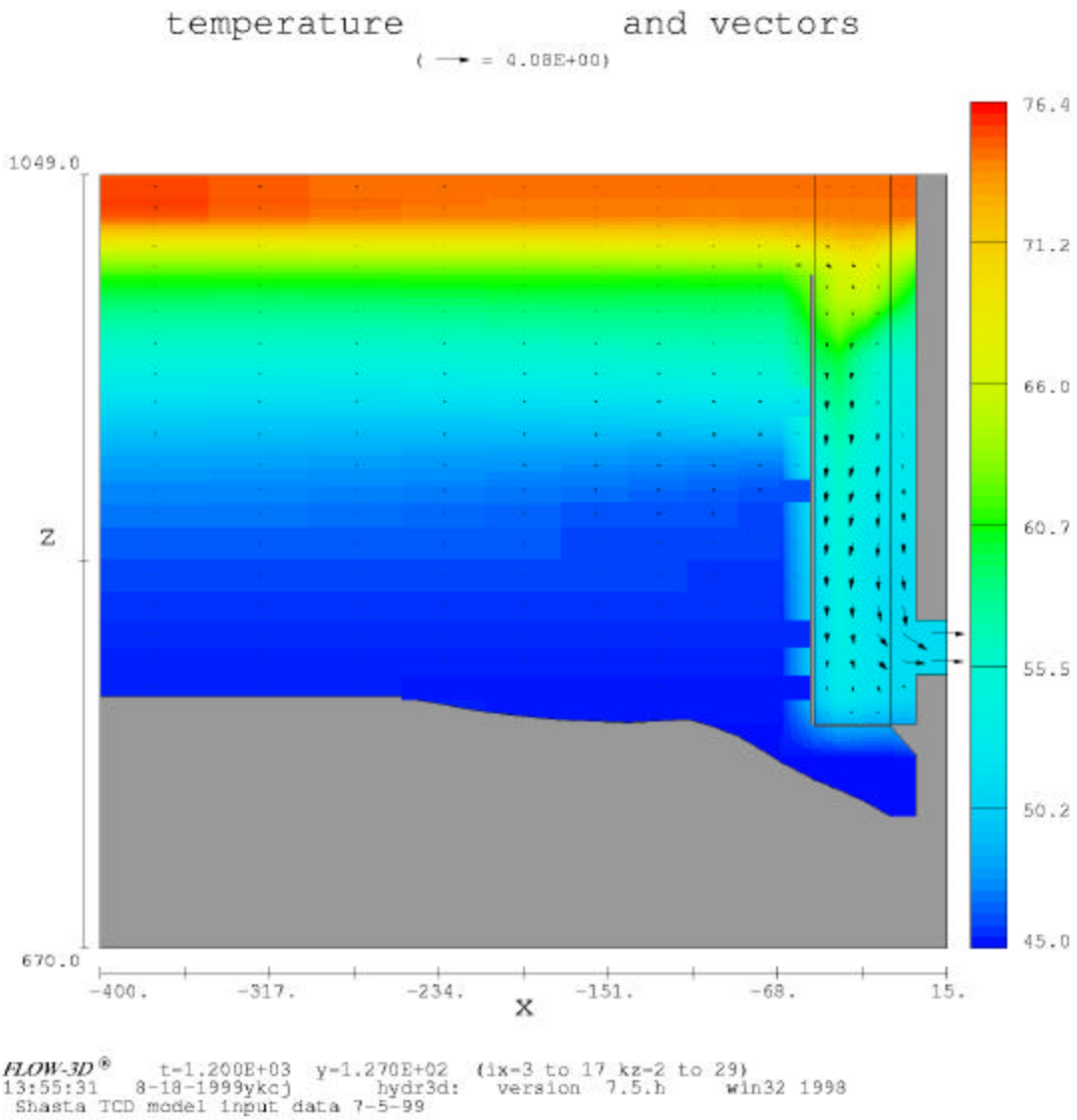

Figure 2I. Temperature Profile Through Penstock No. 3.

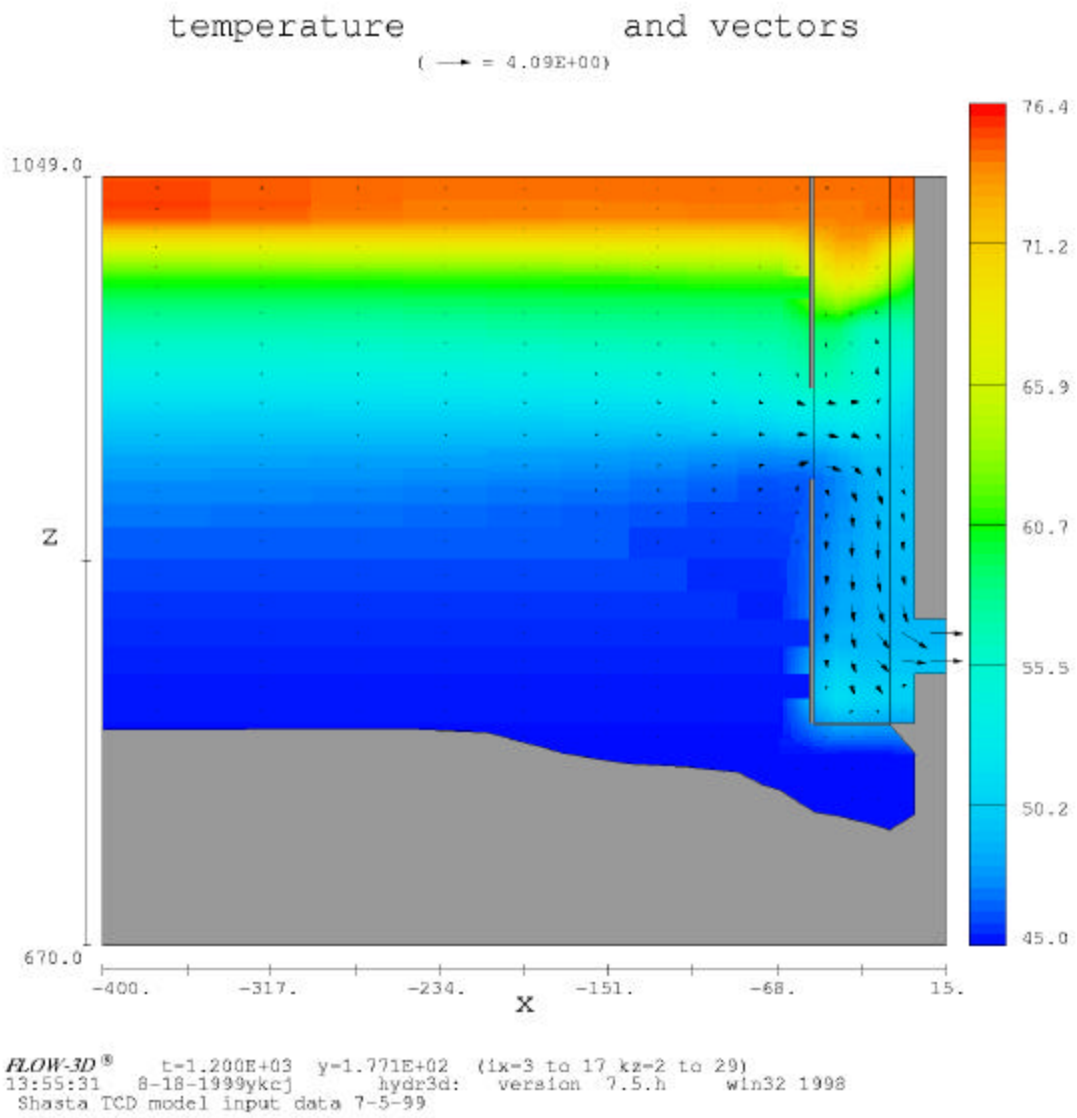

Figure 3I. Temperature Profile Through Penstock No. 4.

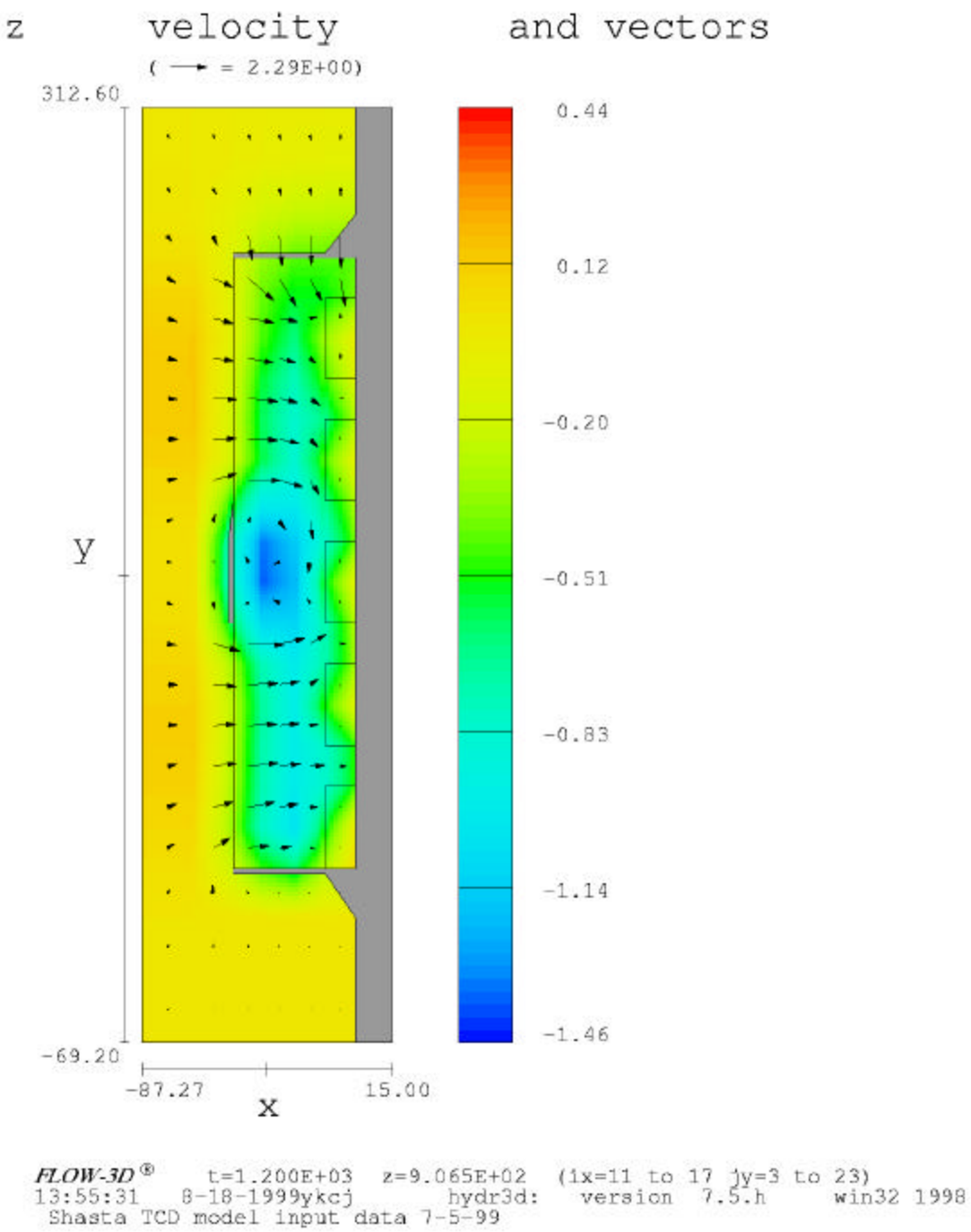

Figure 4H. Vertical Velocity Contours near the Bottom of the Middle Gates.

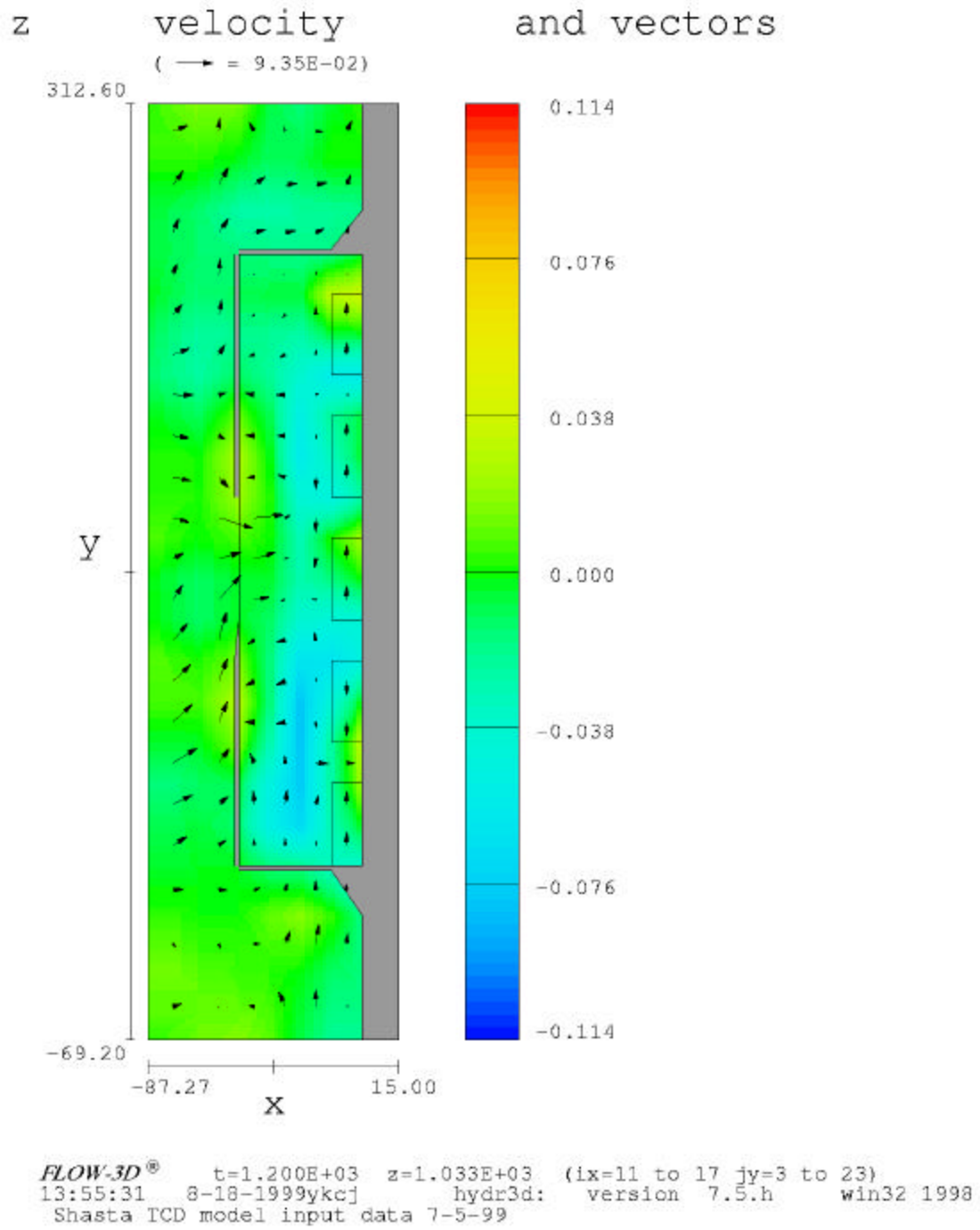

Figure 5H. Vertical Velocity Contours Through the Upper Gates.

Appendix J – 7-8-1999

Table 1J. PREP.DAT.

```
&Title
        t(1)='Shasta TCD model input data 7-8-99'
        t(2)=''
        t(3)=''
        t(4)='      t(5)=''
/
&penstocks
        q(1)=2305
        q(2)=2305
        q(3)=2276
        q(4)=2593
        q(5)=3457
/
&gates
        iupper(1)=1
        iupper(2)=1
        iupper(3)=1
        iupper(4)=1
        iupper(5)=1
        imiddle(1)=0
        imiddle(2)=0
        imiddle(3)=0
        imiddle(4)=0
        imiddle(5)=0
        ipg(1)=1
        ipg(2)=1
        ipg(3)=1
        ipg(4)=1
        ipg(5)=1
        ill=1
/
&reser
        wsel=1048.3
        n_measure=30
        elev(1)=1047.7,     tempr(1)=72.9
        elev(2)=1046.2,     tempr(2)=72.9
        elev(3)=1038.1,     tempr(3)=72.9
        elev(4)=1018.9,     tempr(4)=72.8
        elev(5)=1013.0,     tempr(5)=64.8
        elev(6)=1009.2,     tempr(6)=63.7
        elev(7)=1002.6,     tempr(7)=61.5
        elev(8)=992.8,      tempr(8)=60.0
        elev(9)=983.7,      tempr(9)=58.6
        elev(10)=975.5,     tempr(10)=57.3
        elev(11)=970.7,     tempr(11)=56.3
        elev(12)=963.7,     tempr(12)=55.1
        elev(13)=953.0,     tempr(13)=54.0
        elev(14)=945.9,     tempr(14)=53.0
        elev(15)=940.9,     tempr(15)=52.0
        elev(16)=936.9,     tempr(16)=51.2
        elev(17)=932.8,     tempr(17)=50.6
        elev(18)=927.2,     tempr(18)=49.8
        elev(19)=917.9,     tempr(19)=48.9
        elev(20)=898.0,     tempr(20)=47.7
        elev(21)=878.5,     tempr(21)=46.9
        elev(22)=853.3,     tempr(22)=46.1
        elev(23)=840.9,     tempr(23)=45.9
        elev(24)=810.5,     tempr(24)=45.5
        elev(25)=786.0,     tempr(25)=45.2
        elev(26)=750.3,     tempr(26)=45.0
        elev(27)=714.1,     tempr(27)=44.9
        elev(28)=682.8,     tempr(28)=44.8
        elev(29)=632.1,     tempr(29)=44.7
        elev(30)=607.0,     tempr(30)=44.7
/
```

Table 2J. PREPIN.INP.

```
Shasta TCD model input data 7-8-99
 $xput
    lpr=1,itb=0,iwsh=0,ifvis=0,epsadj=1.0,
    prtdt=10000.0,gz=-32.14,ipdis=1,
    nmat=1,iadix=1,iadiy=1,iadiz=1,
    iorder=1,ifrho=1,ifenrg=2,ichm=0,
    ihtrst=0, iresf1=0, irstoe=0, iscrst=0, itrst=0,
    idum1=   2305.000
    idum2=   2305.000
    idum3=   2276.000
    idum4=   2593.000
    idum5=   3457.000
    idum6=100,
    twfin=1200.,
    pltdt=1200.0,
    delt=0.01,
    deltr=0.0001
    sprtdt=20.0,
    HPLTDT=20.0,
 $end
 $limits
    irpr=1,jbkpr=1,ktpr=1,
 $end
 $props
    rhof=1.937,mui=2.25E-05,tstar=0.0000001,mu1=2.25E-05,mu2=2.25E-05,
 $end
 $scalar
     nsc=1,isclr(1)=0,
 $end
 $bcdata
    pbctyp=1.,
    tbc(1)=100.0,tbc(2)=60.0,tbc(3)=60.0,
    tbc(4)=60.0,tbc(5)=60.0,tbc(6)=60.0,
    wl=5,wr=6,wf=2,wbk=2,wt=2,wb=2,
    flhtl=1043.7,
 $end
 $mesh
  nxcelt=17,
    px(1)=-400.0,    nxcell(1)=10,
    px(2)= -50.0,    nxcell(2)=4,
    px(3)=   0.0,    nxcell(3)=1,
    px(4)=  15.0,
  nycelt=30,
    py(1)=-100.0,    nycell(1)=4,
    py(2)= 2.0,      nycell(2)=3,
    py(3)=52.0,      nycell(3)=3,
    py(4)= 102.0,    nycell(4)=3,
    py(5)= 152.0,    nycell(5)=3,
    py(6)=202.0,     nycell(6)=3,
    py(7)=251.0,     nycell(7)=6,
    py(8)=381.08,    nycell(8)=5,
    py(9)=500.0,
  nzcelt=100,
    pz(1)=670.0,     nzcell(1)=2,
    pz(2)=704.0,     nzcell(2)=1,
    pz(3)=720.0,     nzcell(3)=2,
    pz(4)=749.5,     nzcell(4)=2,
    pz(5)=780.0,     nzcell(5)= 2,
    pz(6)=804.0,     nzcell(6)= 2,
    pz(7)=831.0,     nzcell(7)= 4,
    pz(8)= 889.0,    nzcell(8)= 1,
    pz(9)= 900.0,    nzcell(9)= 3,
    pz(10)= 945.0,   nzcell(10)=4,
    pz(11)=1000.,    nzcell(11)=4,
    pz(12)=1045.0,   nzcell(12)= 1
    pz(13)=   1048.300
    pz(12)=   1037.050
```

```
 $end
 $obs
  avrck=-2.1,
  nobs=19,
  iob(1)=1,xl(1)=0.0,xh(1)=100.0,zh(1)=1079.7,
  iob(2)=1,ioh(2)=0,yh(2)=12.5,yl(2)=-12.5,trny(2)=25.0,zh(2)=831.0,zl(2)=804.0,
  iob(3)=1,ioh(3)=0,yh(3)=12.5,yl(3)=-12.5,trny(3)=75.0,zh(3)=831.0,zl(3)=804.0,
  iob(4)=1,ioh(4)=0,yh(4)=12.5,yl(4)=-12.5,trny(4)=125.0,zh(4)=831.0,zl(4)=804.0,
  iob(5)=1,ioh(5)=0,yh(5)=12.5,yl(5)=-12.5,trny(5)=175.0,zh(5)=831.0,zl(5)=804.0,
  iob(6)=1,ioh(6)=0,yh(6)=12.5,yl(6)=-12.5,trny(6)=225.0,zh(6)=831.0,zl(6)=804.0,
  iob(7)=2,igen(7)=3,ioh(7)=1,
  iob(8)=3,xh(8)=0.01,xl(8)=-52.0,yh(8)=2.01,yl(8)=0.03,zh(8)=1045.01,zl(8)=999.99,
  iob(9)=3,xh(9)=0.01,xl(9)=-52.0,yh(9)=253.0,yl(9)=250.99,zh(9)=1045.01,zl(9)=999.99,
  iob(10)=3,xh(10)=-49.99,xl(10)=-52.0,yh(10)=253.0,yl(10)=0.03,zh(10)=1045.01,zl(10)=999.99,
  iob(11)=4,opor(4)=0.004015302,xh(11)=0.01,xl(11)=-50.01,yh(11)=2.01,yl(11)=0.03,zh(11)=1000.01,zl(11)=944.99,
  iob(12)=5,opor(5)=0.003884098,xh(12)=0.01,xl(12)=-50.01,yh(12)=253.0,yl(12)=250.99,zh(12)=1000.01,zl(12)=944.99,
  iob(13)=6,opor(6)=0.0051328,xh(13)=-49.99,xl(13)=-52.0,yh(13)=253.0,yl(13)=0.03,zh(13)=1000.01,zl(13)=944.99,
  iob(14)=7,opor(7)=0.004351858,xh(14)=0.01,xl(14)=-50.01,yh(14)=2.01,yl(14)=0.03,zh(14)=945.01,zl(14)=899.99,
  iob(15)=8,opor(8)=0.020888367,xh(15)=0.01,xl(15)=-50.01,yh(15)=253.0,yl(15)=250.99,zh(15)=945.01,zl(15)=899.9,
  iob(16)=9,opor(9)=0.007301943,xh(16)=-49.99,xl(16)=-52.0,yh(16)=253.0,yl(16)=0.03,zh(16)=945.01,zl(16)=899.99,
  iob(17)=10,opor(10)=0.003534187,xh(17)=0.01,xl(17)=-50.01,yh(17)=2.01,yl(17)=0.03,zh(17)=900.01,zl(17)=830.99
  iob(18)=11,opor(11)=0.006766415,xh(18)=0.01,xl(18)=-50.01,yh(18)=253.0,yl(18)=250.99,zh(18)=900.01,zl(18)=830.99
  iob(19)=12,opor(12)=0.003110806,xh(19)=-49.99,xl(19)=-52.0,yh(19)=253.0,yl(19)=0.03,zh(19)=900.01,zl(19)=830.99,
  iob(20)=13,opor(13)=0.00536379,xh(20)=0.01,xl(20)=-50.01,yh(20)=2.01,yl(20)=0.03,zh(20)=831.01,zl(20)=803.9,
  iob(21)=14,opor(14)=0.0099,xh(21)=-49.99,xl(21)=-52.0,yh(21)=253.0,yl(21)=0.03,zh(21)=831.01,zl(21)=803.99,
  iob(22)=15,opor(15)=0.007382123,xh(22)=0.01,xl(22)=-50.01,yh(22)=2.01,yl(22)=0.03,zh(22)=804.01,zl(22)=779.9,
  iob(23)=16,opor(16)=0.003032684,xh(23)=-49.99,xl(23)=-52.0,yh(23)=253.0,yl(23)=0.03,zh(23)=804.01,zl(23)=779.99,
  iob(24)=3,xh(24)=0.01,xl(24)=-50.01,yh(24)=202.01,yl(24)=201.0,zh(24)=780.01,zl(24)=749.51,
  iob(25)=3,xh(25)=0.01,xl(25)=-50.01,yh(25)=253.0,yl(25)=250.99,zh(25)=831.01,zl(25)=719.99,
  iob(26)=17,opor(18)=0.00829452,xh(26)=-49.99,xl(26)=-52.0,yh(26)=253.0,yl(26)=201.0,zh(26)=780.01,zl(26)=749.51,
  iob(27)=18,opor(18)=0.00829452,xl(27)=-52.0,yh(27)=202.2,yl(27)=0.03,zh(27)=780.01,zl(27)=779.0,
  iob(28)=19,opor(19)=0.019110575,xl(28)=-52.0,yh(28)=253.0,yl(28)=201.0,zh(28)=749.51,zl(28)=748.50,
  iob(29)=3,xl(29)=-52.0,yh(29)=382.08,yl(29)=250.99,zh(29)=892.06,zl(29)=888.99,
  iob(30)=3,xh(30)=-49.99,xl(30)=-52.0,yh(30)=382.08,yl(30)=250.99,zh(30)=892.06,zl(30)=719.99,
  iob(31)=3,xl(31)=-52.0,yh(31)=382.08,yl(31)=381.07,zh(31)=892.06,zl(31)=719.99,
  iob(32)=3, zh(32)=-888.9
  iob(33)=3,zh(33)=-1000.0,
  iob(34)=3,zh(34)=-1000.0,
  iob(35)=3,zh(35)=-1000.0,
  iob(36)=3,zh(36)=-1000.0,
  iob(37)=3,zh(37)=-1000.0,
  iob(38)=9,ioh(38)=0,yl(38)= 2.0,yh(38)=48.0,zh(38)=945.0,zl(38)=900.0,
  iob(39)=9,ioh(39)=0,yl(39)=52.0,yh(39)=98.0,zh(39)=945.0,zl(39)=900.0,
  iob(40)=9,ioh(40)=0,yl(40)=102.0,yh(40)=148.0,zh(40)=945.0,zl(40)=900.0,
  iob(41)=9,ioh(41)=0,yl(41)=152.0,yh(41)=198.0,zh(41)=945.0,zl(41)=900.0,
  iob(42)=9,ioh(42)=0,yl(42)=202.0,yh(42)=248.0,zh(42)=945.0,zl(42)=900.0,
  iob(43)=3,zh(43)=-1000.0,
  iob(44)=3,zh(44)=-1000.0,
  iob(45)=3,zh(45)=-1000.0,
  iob(46)=3,zh(46)=-1000.0,
  iob(47)=3,zh(47)=-1000.0,
 $end
 $fl
    presi=0.0,nfls=1,
    flht=   1048.300
 $end
 $bf
    nbafs=4,pbaf(1)=0.9143,
     ibaf(1)=1,bxh(1)=0.0,bxl(1)=-50.0,by(1)=0.0,bzh(1)=1066.6,bzl(1)=1044.99,
     ibaf(2)=1,bxh(2)=0.0,bxl(2)=-50.0,by(2)=250.0,bzh(2)=1066.6,bzl(2)=1044.99,
     ibaf(3)=1,bx(3)=-50.0,byh(3)=250.0,byl(3)=0.0,bzh(3)=1066.6,bzl(3)=803.99,
    pbaf(2)=0.6785,
     ibaf(4)=2,bra(4)=16.8333,bxh(4)=0.01,btrny(4)=25.0,bzl(4)=780.0,
     ibaf(5)=2,bra(5)=16.8333,bxh(5)=0.01,btrny(5)=75.0,bzl(5)=780.0,
     ibaf(6)=2,bra(6)=16.8333,bxh(6)=0.01,btrny(6)=125.0,bzl(6)=780.0,
     ibaf(7)=2,bra(7)=16.8333,bxh(7)=0.01,btrny(7)=175.0,bzl(7)=780.0,
     ibaf(8)=2,bra(8)=16.8333,bxh(8)=0.01,btrny(8)=225.0,bzl(8)=749.5,
     ibaf(9)=3,bra(9)=16.8333,bxh(9)=0.01,bzl(9)=895.69,btrny(9)=25.0,
     ibaf(10)=3,bra(10)=16.8333,bxh(10)=0.01,bzl(10)=895.69,btrny(10)=75.0,
     ibaf(11)=3,bra(11)=16.8333,bxh(11)=0.01,bzl(11)=895.69,btrny(11)=125.0,
```

```
    ibaf(12)=3,bra(12)=16.8333,bxh(12)=0.01,bzl(12)=895.69,btrny(12)=175.0,
    ibaf(13)=3,bra(13)=16.8333,bxh(13)=0.01,bzl(13)=895.69,btrny(13)=225.0,
    pbaf(4)=0.0,
    ibaf(14)=4,bz(14)=780.0,byh(14)=98.0,byl(14)=52.0,bxh(14)=0.0,bxl(14)=-50.0,
    ibaf(15)=4,bz(15)=780.0,byh(15)=198.0,byl(15)=152.0,bxh(15)=0.0,bxl(15)=-50.0,
 $end
 $temp
    tempi=100.0,ntmp=1,
 $end
 $grafic
    nvplts=0,
 $end
 $parts
 $end
```

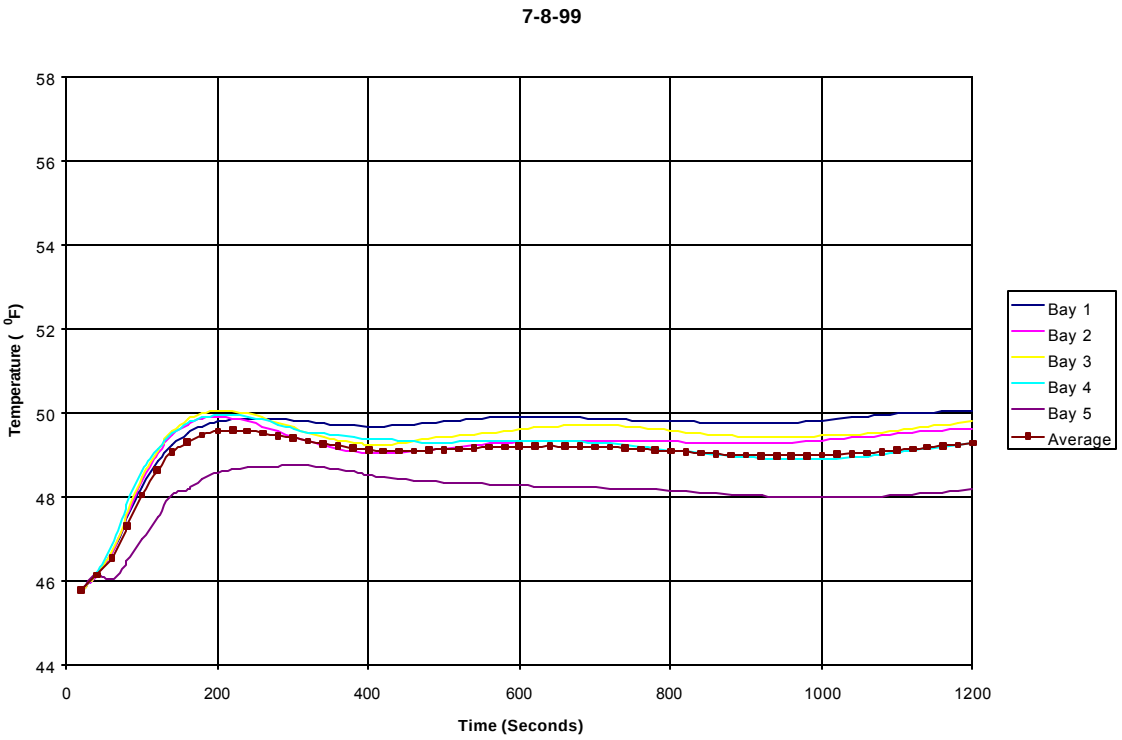

Figure 1J. Convergence graphic.

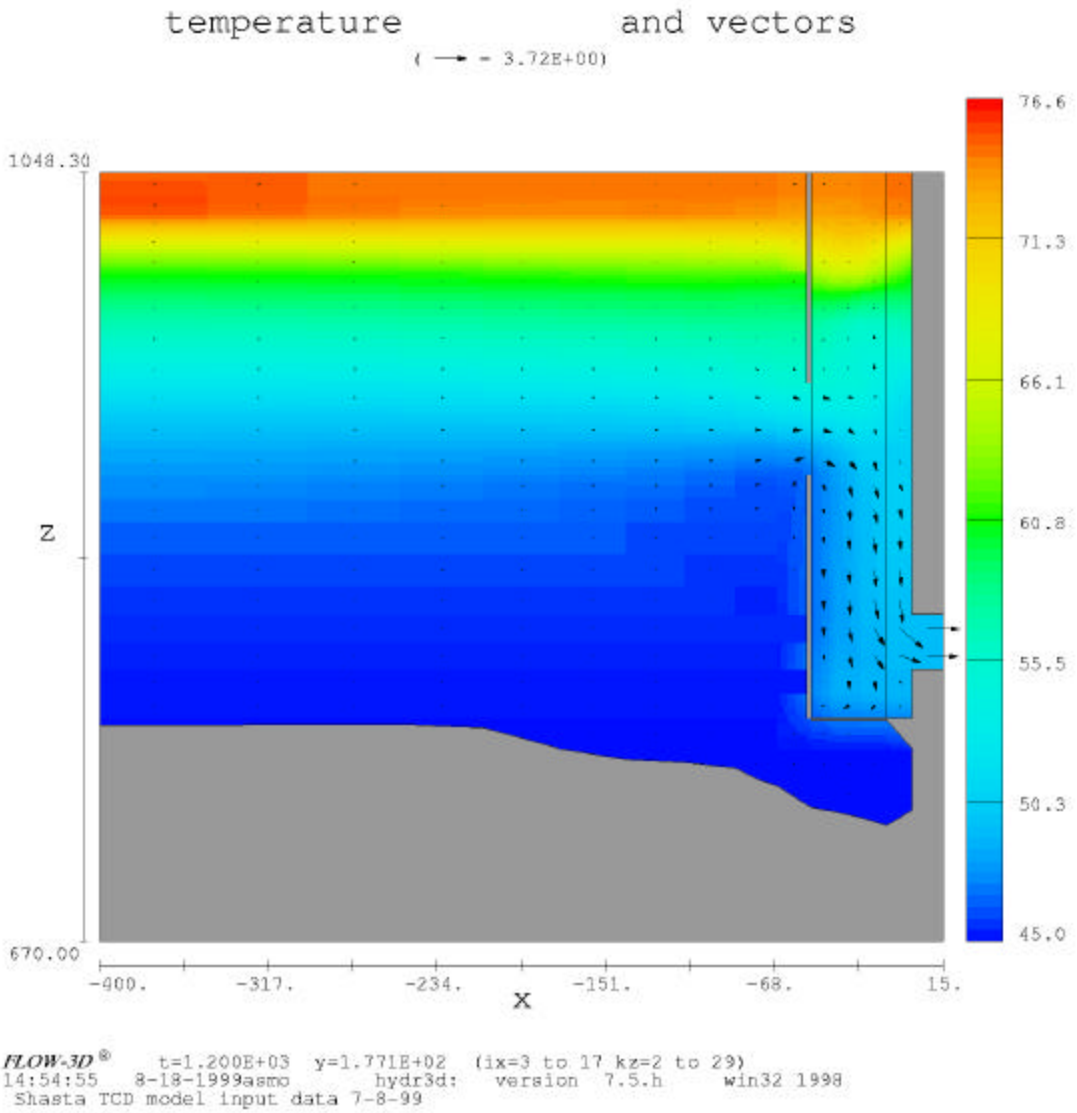

Figure 2J. Temperature Profile Through Penstock No. 4.

Appendix K – 7-23-1999

Table 1K. PREP.DAT.

```
&Title
        t(1)='Shasta TCD model input data 7-23-99'
        t(2)='      t(3)='
        t(4)='      t(5)='
/
&penstocks
        q(1)=1
        q(2)=2766
        q(3)=2766
        q(4)=2794
        q(5)=3601
/
&gates
        iupper(1)=1
        iupper(2)=1
        iupper(3)=0
        iupper(4)=1
        iupper(5)=1
        imiddle(1)=0
        imiddle(2)=0
        imiddle(3)=1
        imiddle(4)=0
        imiddle(5)=0
        ipg(1)=1
        ipg(2)=1
        ipg(3)=1
        ipg(4)=1
        ipg(5)=1
        ill=1
/
&reser
        wsel=1041.1
        n_measure=31
        elev(1)=1040.2,     tempr(1)=76.24
        elev(2)=1039.1,     tempr(2)=76.24
        elev(3)=1036.8,     tempr(3)=76.17
        elev(4)=1031.2,     tempr(4)=75.84
        elev(5)=1029.8,     tempr(5)=75.79
        elev(6)=1024.9,     tempr(6)=75.68
        elev(7)=1020.8,     tempr(7)=75.66
        elev(8)=1015.0,     tempr(8)=75.63
        elev(9)=1010.6,     tempr(9)=75.57
        elev(10)=1008.2,    tempr(10)=72.35
        elev(11)=1005.8,    tempr(11)=69.31
        elev(12)=1003.3,    tempr(12)=67.4
        elev(13)=1000.9,    tempr(13)=66.52
        elev(14)=996.4,     tempr(14)=65.24
        elev(15)=991.1,     tempr(15)=63.6
        elev(16)=988.6,     tempr(16)=63.14
        elev(17)=979.8,     tempr(17)=61.44
        elev(18)=969.8,     tempr(18)=60.26
        elev(19)=960.9,     tempr(19)=58.26
        elev(20)=950.4,     tempr(20)=56.37
        elev(21)=940.2,     tempr(21)=54.26
        elev(22)=930.4,     tempr(22)=52.98
        elev(23)=919.3,     tempr(23)=51.
        elev(24)=909.2,     tempr(24)=49.53
        elev(25)=899.2,     tempr(25)=48.62
        elev(26)=889.6,     tempr(26)=47.98
        elev(27)=878.6,     tempr(27)=47.24
        elev(28)=868.6,     tempr(28)=46.97
        elev(29)=854.9,     tempr(29)=46.48
        elev(30)=838.8,     tempr(30)=45.95
        elev(31)=820.5,     tempr(31)=45.68
/
```

Table 2K. PREPIN.INP.

```
Shasta TCD model input data 7-23-99
 $xput
    lpr=1,itb=0,iwsh=0,ifvis=0,epsadj=1.0,
    prtdt=10000.0,gz=-32.14,ipdis=1,
    nmat=1,iadix=1,iadiy=1,iadiz=1,
    iorder=1,ifrho=1,ifenrg=2,ichm=0,
    ihtrst=0, iresf1=0, irstoe=0, iscrst=0, itrst=0,
    idum1=   1.000000
    idum2=   2766.000
    idum3=   2766.000
    idum4=   2794.000
    idum5=   3601.000
    idum6=100,
    twfin=1200.,
    pltdt=1200.0,
    delt=0.01,
    deltr=0.0001
    sprtdt=20.0,
    HPLTDT=20.0,
 $end
 $limits
    irpr=1,jbkpr=1,ktpr=1,
 $end
 $props
    rhof=1.937,mui=2.25E-05,tstar=0.0000001,mu1=2.25E-05,mu2=2.25E-05,
 $end
 $scalar
     nsc=1,isclr(1)=0,
 $end
 $bcdata
    pbctyp=1.,
    tbc(1)=100.0,tbc(2)=60.0,tbc(3)=60.0,
    tbc(4)=60.0,tbc(5)=60.0,tbc(6)=60.0,
    wl=5,wr=6,wf=2,wbk=2,wt=2,wb=2,
    flhtl=1043.7,
 $end
 $mesh
  nxcelt=17,
    px(1)=-400.0,    nxcell(1)=10,
    px(2)= -50.0,    nxcell(2)=4,
    px(3)=   0.0,    nxcell(3)=1,
    px(4)=  15.0,
  nycelt=30,
    py(1)=-100.0,    nycell(1)=4,
    py(2)= 2.0,      nycell(2)=3,
    py(3)=52.0,      nycell(3)=3,
    py(4)= 102.0,    nycell(4)=3,
    py(5)= 152.0,    nycell(5)=3,
    py(6)=202.0,     nycell(6)=3,
    py(7)=251.0,     nycell(7)=6,
    py(8)=381.08,    nycell(8)=5,
    py(9)=500.0,
  nzcelt=100,
    pz(1)=670.0,     nzcell(1)=2,
    pz(2)=704.0,     nzcell(2)=1,
    pz(3)=720.0,     nzcell(3)=2,
    pz(4)=749.5,     nzcell(4)=2,
    pz(5)=780.0,     nzcell(5)= 2,
    pz(6)=804.0,     nzcell(6)= 2,
    pz(7)=831.0,     nzcell(7)= 4,
    pz(8)= 889.0,    nzcell(8)= 1,
    pz(9)= 900.0,    nzcell(9)= 3,
    pz(10)= 945.0,   nzcell(10)=4,
    pz(11)=1000.,    nzcell(11)= 3
    pz(12)=   1041.100
 $end
 $obs
```

```
  avrck=-2.1,
  nobs=19,
  iob(1)=1,xl(1)=0.0,xh(1)=100.0,zh(1)=1079.7,
  iob(2)=1,ioh(2)=0,yh(2)=12.5,yl(2)=-12.5,trny(2)=25.0,zh(2)=831.0,zl(2)=804.0,
  iob(3)=1,ioh(3)=0,yh(3)=12.5,yl(3)=-12.5,trny(3)=75.0,zh(3)=831.0,zl(3)=804.0,
  iob(4)=1,ioh(4)=0,yh(4)=12.5,yl(4)=-12.5,trny(4)=125.0,zh(4)=831.0,zl(4)=804.0,
  iob(5)=1,ioh(5)=0,yh(5)=12.5,yl(5)=-12.5,trny(5)=175.0,zh(5)=831.0,zl(5)=804.0,
  iob(6)=1,ioh(6)=0,yh(6)=12.5,yl(6)=-12.5,trny(6)=225.0,zh(6)=831.0,zl(6)=804.0,
  iob(7)=2,igen(7)=3,ioh(7)=1,
  iob(8)=3,xh(8)=0.01,xl(8)=-52.0,yh(8)=2.01,yl(8)=0.03,zh(8)=1045.01,zl(8)=999.99,
  iob(9)=3,xh(9)=0.01,xl(9)=-52.0,yh(9)=253.0,yl(9)=250.99,zh(9)=1045.01,zl(9)=999.99,
  iob(10)=3,xh(10)=-49.99,xl(10)=-52.0,yh(10)=253.0,yl(10)=0.03,zh(10)=1045.01,zl(10)=999.99,
  iob(11)=4,opor(4)=0.004015302,xh(11)=0.01,xl(11)=-50.01,yh(11)=2.01,yl(11)=0.03,zh(11)=1000.01,zl(11)=944.99,
  iob(12)=5,opor(5)=0.003884098,xh(12)=0.01,xl(12)=-50.01,yh(12)=253.0,yl(12)=250.99,zh(12)=1000.01,zl(12)=944.99,
  iob(13)=6,opor(6)=0.0051328,xh(13)=-49.99,xl(13)=-52.0,yh(13)=253.0,yl(13)=0.03,zh(13)=1000.01,zl(13)=944.99,
  iob(14)=7,opor(7)=0.004351858,xh(14)=0.01,xl(14)=-50.01,yh(14)=2.01,yl(14)=0.03,zh(14)=945.01,zl(14)=899.99,
  iob(15)=8,opor(8)=0.020888367,xh(15)=0.01,xl(15)=-50.01,yh(15)=253.0,yl(15)=250.99,zh(15)=945.01,zl(15)=899.9,
  iob(16)=9,opor(9)=0.007301943,xh(16)=-49.99,xl(16)=-52.0,yh(16)=253.0,yl(16)=0.03,zh(16)=945.01,zl(16)=899.99,
  iob(17)=10,opor(10)=0.003534187,xh(17)=0.01,xl(17)=-50.01,yh(17)=2.01,yl(17)=0.03,zh(17)=900.01,zl(17)=830.99
  iob(18)=11,opor(11)=0.006766415,xh(18)=0.01,xl(18)=-50.01,yh(18)=253.0,yl(18)=250.99,zh(18)=900.01,zl(18)=830.99
  iob(19)=12,opor(12)=0.003110806,xh(19)=-49.99,xl(19)=-52.0,yh(19)=253.0,yl(19)=0.03,zh(19)=900.01,zl(19)=830.99,
  iob(20)=13,opor(13)=0.00536379,xh(20)=0.01,xl(20)=-50.01,yh(20)=2.01,yl(20)=0.03,zh(20)=831.01,zl(20)=803.9,
  iob(21)=14,opor(14)=0.0099,xh(21)=-49.99,xl(21)=-52.0,yh(21)=253.0,yl(21)=0.03,zh(21)=831.01,zl(21)=803.99,
  iob(22)=15,opor(15)=0.007382123,xh(22)=0.01,xl(22)=-50.01,yh(22)=2.01,yl(22)=0.03,zh(22)=804.01,zl(22)=779.9,
  iob(23)=16,opor(16)=0.003032684,xh(23)=-49.99,xl(23)=-52.0,yh(23)=253.0,yl(23)=0.03,zh(23)=804.01,zl(23)=779.99,
  iob(24)=3,xh(24)=0.01,xl(24)=-50.01,yh(24)=202.01,yl(24)=201.0,zh(24)=780.01,zl(24)=749.51,
  iob(25)=3,xh(25)=0.01,xl(25)=-50.01,yh(25)=253.0,yl(25)=250.99,zh(25)=831.01,zl(25)=719.99,
  iob(26)=17,opor(18)=0.00829452,xh(26)=-49.99,xl(26)=-52.0,yh(26)=253.0,yl(26)=201.0,zh(26)=780.01,zl(26)=749.51,
  iob(27)=18,opor(18)=0.00829452,xl(27)=-52.0,yh(27)=202.2,yl(27)=0.03,zh(27)=780.01,zl(27)=779.0,
  iob(28)=19,opor(19)=0.019110575,xl(28)=-52.0,yh(28)=253.0,yl(28)=201.0,zh(28)=749.51,zl(28)=748.50,
  iob(29)=3,xl(29)=-52.0,yh(29)=382.08,yl(29)=250.99,zh(29)=892.06,zl(29)=888.99,
  iob(30)=3,xh(30)=-49.99,xl(30)=-52.0,yh(30)=382.08,yl(30)=250.99,zh(30)=892.06,zl(30)=719.99,
  iob(31)=3,xl(31)=-52.0,yh(31)=382.08,yl(31)=381.07,zh(31)=892.06,zl(31)=719.99,
  iob(32)=3, zh(32)=-888.9
  iob(33)=3,zh(33)=-1000.0,
  iob(34)=3,zh(34)=-1000.0,
  iob(35)=3,ioh(35)=0,yl(35)=102.0,yh(35)=148.0,zh(35)=1045.0,zl(35)=1000.0,
  iob(36)=3,zh(36)=-1000.0,
  iob(37)=3,zh(37)=-1000.0,
  iob(38)=9,ioh(38)=0,yl(38)= 2.0,yh(38)=48.0,zh(38)=945.0,zl(38)=900.0,
  iob(39)=9,ioh(39)=0,yl(39)=52.0,yh(39)=98.0,zh(39)=945.0,zl(39)=900.0,
  iob(40)=3,zh(40)=-1000.0,
  iob(41)=9,ioh(41)=0,yl(41)=152.0,yh(41)=198.0,zh(41)=945.0,zl(41)=900.0,
  iob(42)=9,ioh(42)=0,yl(42)=202.0,yh(42)=248.0,zh(42)=945.0,zl(42)=900.0,
  iob(43)=3,zh(43)=-1000.0,
  iob(44)=3,zh(44)=-1000.0,
  iob(45)=3,zh(45)=-1000.0,
  iob(46)=3,zh(46)=-1000.0,
  iob(47)=3,zh(47)=-1000.0,
 $end
 $fl
   presi=0.0,nfls=1,
   flht=   1041.100
 $end
 $bf
   nbafs=4,pbaf(1)=0.9143,
    ibaf(1)=1,bxh(1)=0.0,bxl(1)=-50.0,by(1)=0.0,bzh(1)=1066.6,bzl(1)=1044.99,
    ibaf(2)=1,bxh(2)=0.0,bxl(2)=-50.0,by(2)=250.0,bzh(2)=1066.6,bzl(2)=1044.99,
    ibaf(3)=1,bx(3)=-50.0,byh(3)=250.0,byl(3)=0.0,bzh(3)=1066.6,bzl(3)=803.99,
    pbaf(2)=0.6785,
    ibaf(4)=2,bra(4)=16.8333,bxh(4)=0.01,btrny(4)=25.0,bzl(4)=780.0,
    ibaf(5)=2,bra(5)=16.8333,bxh(5)=0.01,btrny(5)=75.0,bzl(5)=780.0,
    ibaf(6)=2,bra(6)=16.8333,bxh(6)=0.01,btrny(6)=125.0,bzl(6)=780.0,
    ibaf(7)=2,bra(7)=16.8333,bxh(7)=0.01,btrny(7)=175.0,bzl(7)=780.0,
    ibaf(8)=2,bra(8)=16.8333,bxh(8)=0.01,btrny(8)=225.0,bzl(8)=749.5,
    ibaf(9)=3,bra(9)=16.8333,bxh(9)=0.01,bzl(9)=895.69,btrny(9)=25.0,
    ibaf(10)=3,bra(10)=16.8333,bxh(10)=0.01,bzl(10)=895.69,btrny(10)=75.0,
    ibaf(11)=3,bra(11)=16.8333,bxh(11)=0.01,bzl(11)=895.69,btrny(11)=125.0,
    ibaf(12)=3,bra(12)=16.8333,bxh(12)=0.01,bzl(12)=895.69,btrny(12)=175.0,
    ibaf(13)=3,bra(13)=16.8333,bxh(13)=0.01,bzl(13)=895.69,btrny(13)=225.0,
```

```
    pbaf(4)=0.0,
    ibaf(14)=4,bz(14)=780.0,byh(14)=98.0,byl(14)=52.0,bxh(14)=0.0,bxl(14)=-50.0,
    ibaf(15)=4,bz(15)=780.0,byh(15)=198.0,byl(15)=152.0,bxh(15)=0.0,bxl(15)=-50.0,
 $end
 $temp
   tempi=100.0,ntmp=1,
 $end
 $grafic
   nvplts=0,
 $end
 $parts
 $end
```

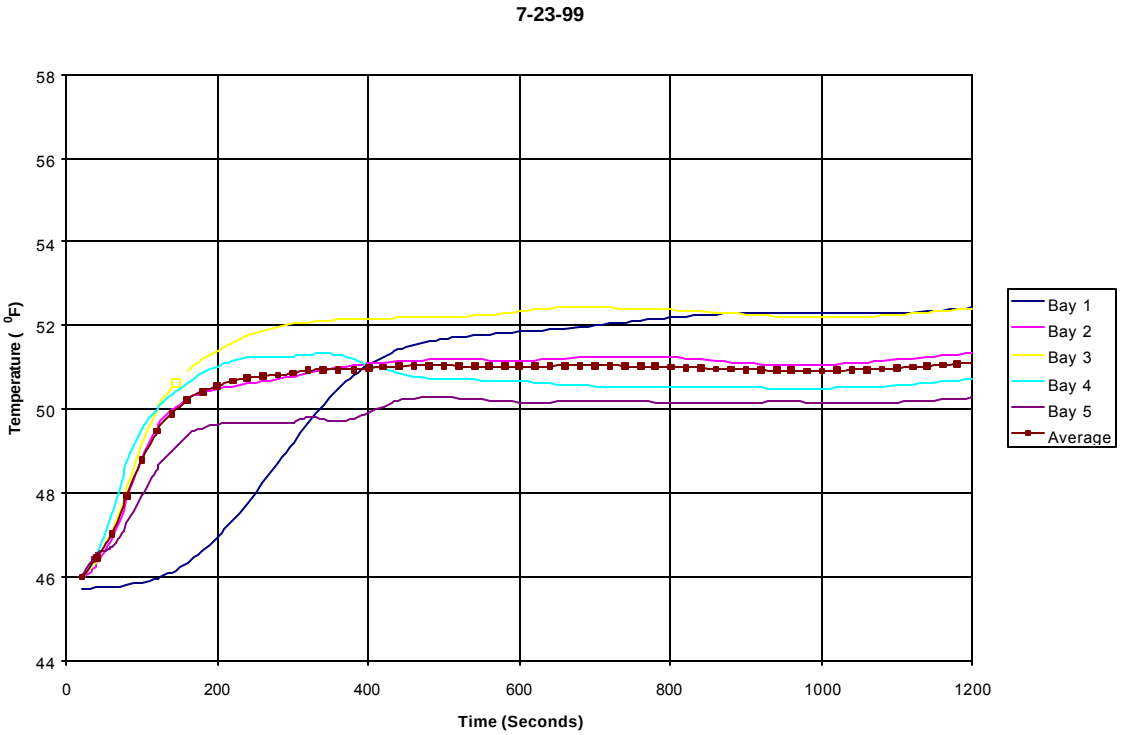

Figure 1K. Convergence graphic.

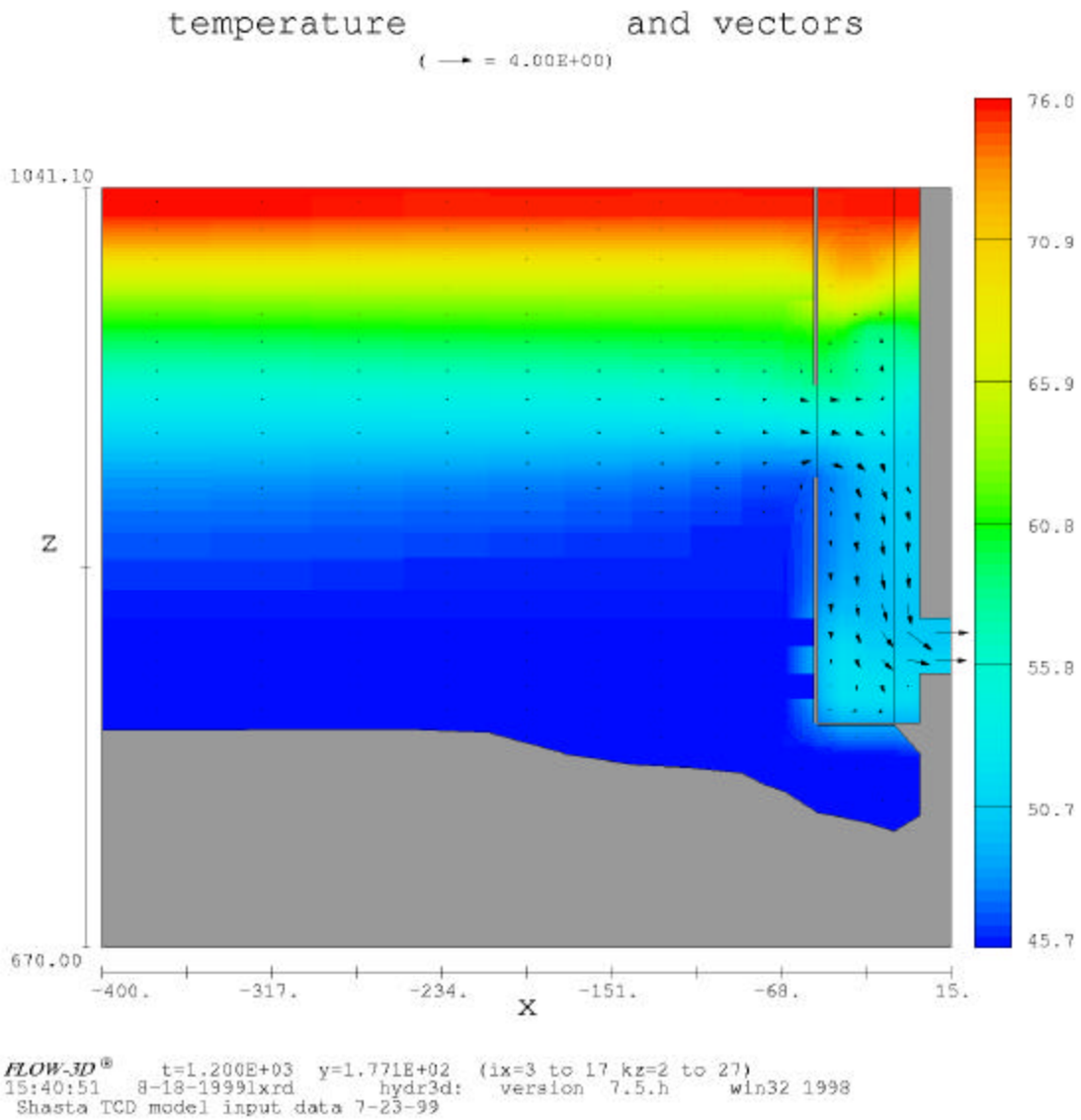

Figure 2K. Temperature Profile Through Penstock No. 4.

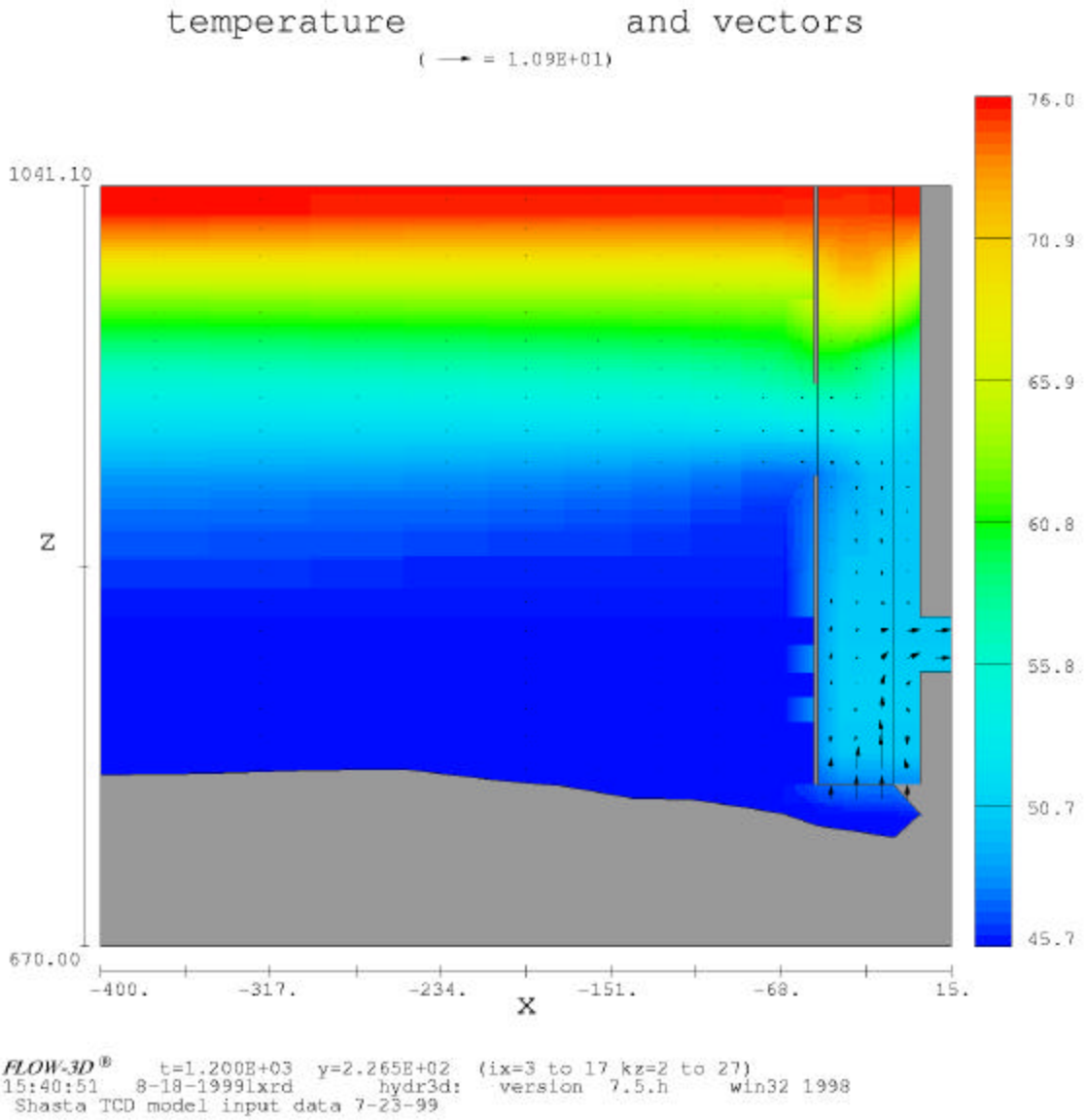

Figure 3K. Temperature Profile Through Penstock No. 5.

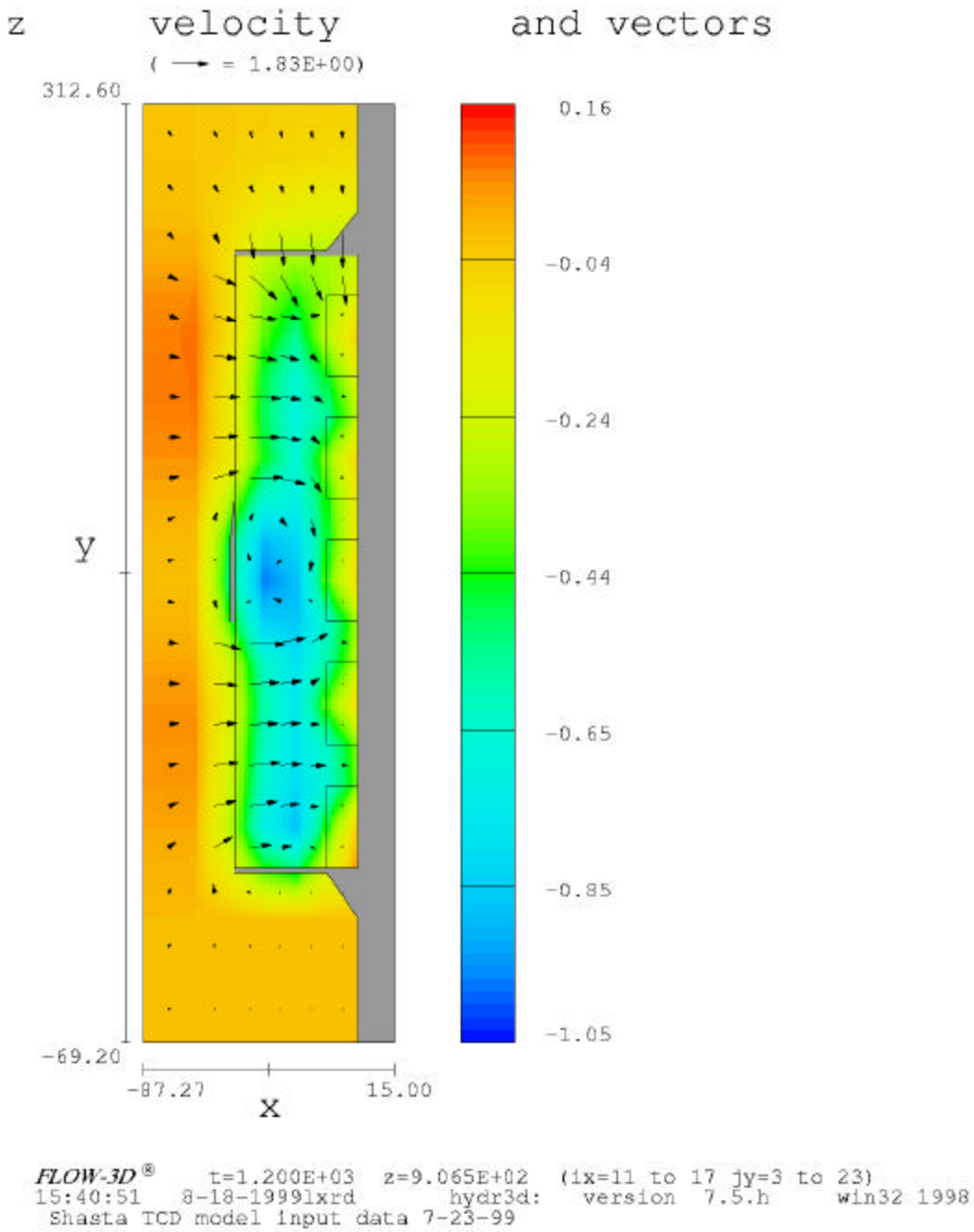

Figure 4K. Vertical Velocity Contours near the Bottom of the Middle Gates.

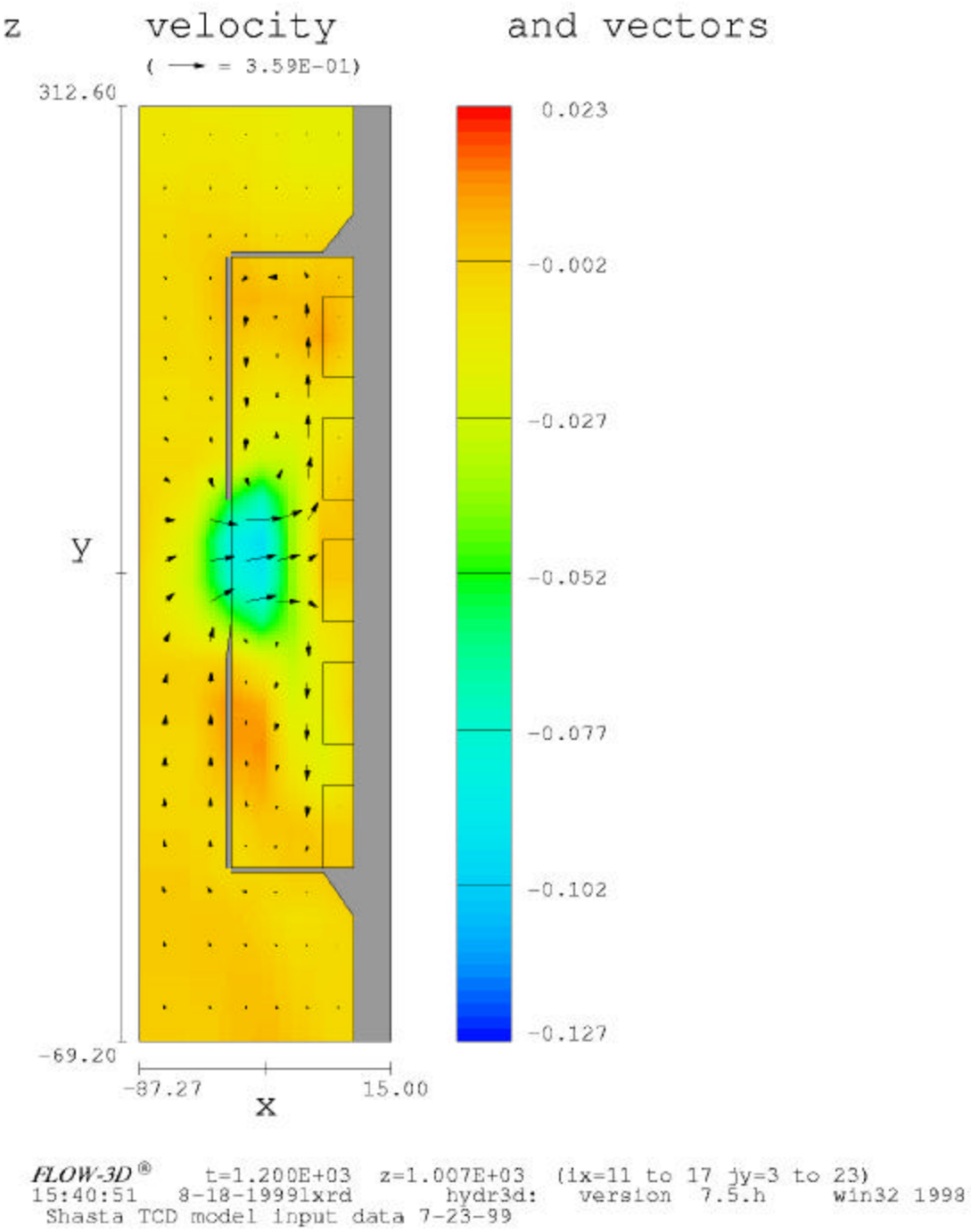

Figure 5K. Vertical Velocity Contours Through the Upper Gates.

Appendix L – 7-24-1999

Table 1L. PREP.DAT.

```
&Title
        t(1)='Shasta TCD model input data 7-24-99'
        t(2)='      t(3)='
        t(4)='      t(5)='
/
&penstocks
        q(1)=2881
        q(2)=3025
        q(3)=2017
        q(4)=2881
        q(5)=3601
/
&gates
        iupper(1)=1
        iupper(2)=1
        iupper(3)=1
        iupper(4)=1
        iupper(5)=1
        imiddle(1)=0
        imiddle(2)=0
        imiddle(3)=0
        imiddle(4)=0
        imiddle(5)=0
        ipg(1)=1
        ipg(2)=1
        ipg(3)=1
        ipg(4)=1
        ipg(5)=1
        ill=1
/
&reser
        wsel=1040.5
        n_measure=31
        elev(1)=1040.2,     tempr(1)=76.24
        elev(2)=1039.1,     tempr(2)=76.24
        elev(3)=1036.8,     tempr(3)=76.17
        elev(4)=1031.2,     tempr(4)=75.84
        elev(5)=1029.8,     tempr(5)=75.79
        elev(6)=1024.9,     tempr(6)=75.68
        elev(7)=1020.8,     tempr(7)=75.66
        elev(8)=1015.0,     tempr(8)=75.63
        elev(9)=1010.6,     tempr(9)=75.57
        elev(10)=1008.2,    tempr(10)=72.35
        elev(11)=1005.8,    tempr(11)=69.31
        elev(12)=1003.3,    tempr(12)=67.4
        elev(13)=1000.9,    tempr(13)=66.52
        elev(14)=996.4,     tempr(14)=65.24
        elev(15)=991.1,     tempr(15)=63.6
        elev(16)=988.6,     tempr(16)=63.14
        elev(17)=979.8,     tempr(17)=61.44
        elev(18)=969.8,     tempr(18)=60.26
        elev(19)=960.9,     tempr(19)=58.26
        elev(20)=950.4,     tempr(20)=56.37
        elev(21)=940.2,     tempr(21)=54.26
        elev(22)=930.4,     tempr(22)=52.98
        elev(23)=919.3,     tempr(23)=51.
        elev(24)=909.2,     tempr(24)=49.53
        elev(25)=899.2,     tempr(25)=48.62
        elev(26)=889.6,     tempr(26)=47.98
        elev(27)=878.6,     tempr(27)=47.24
        elev(28)=868.6,     tempr(28)=46.97
        elev(29)=854.9,     tempr(29)=46.48
        elev(30)=838.8,     tempr(30)=45.95
        elev(31)=820.5,     tempr(31)=45.68
/
```

Table 2L. PREPIN.INP.

```
Shasta TCD model input data 7-24-99
 $xput
    lpr=1,itb=0,iwsh=0,ifvis=0,epsadj=1.0,
    prtdt=10000.0,gz=-32.14,ipdis=1,
    nmat=1,iadix=1,iadiy=1,iadiz=1,
    iorder=1,ifrho=1,ifenrg=2,ichm=0,
    ihtrst=0, iresf1=0, irstoe=0, iscrst=0, itrst=0,
    idum1=   2881.000
    idum2=   3025.000
    idum3=   2017.000
    idum4=   2881.000
    idum5=   3601.000
    idum6=100,
    twfin=1200.,
    pltdt=1200.0,
    delt=0.01,
    deltr=0.0001
    sprtdt=20.0,
    HPLTDT=20.0,
 $end
 $limits
    irpr=1,jbkpr=1,ktpr=1,
 $end
 $props
    rhof=1.937,mui=2.25E-05,tstar=0.0000001,mu1=2.25E-05,mu2=2.25E-05,
 $end
 $scalar
     nsc=1,isclr(1)=0,
 $end
 $bcdata
    pbctyp=1.,
    tbc(1)=100.0,tbc(2)=60.0,tbc(3)=60.0,
    tbc(4)=60.0,tbc(5)=60.0,tbc(6)=60.0,
    wl=5,wr=6,wf=2,wbk=2,wt=2,wb=2,
    flhtl=1043.7,
 $end
 $mesh
  nxcelt=17,
    px(1)=-400.0,    nxcell(1)=10,
    px(2)= -50.0,    nxcell(2)=4,
    px(3)=   0.0,    nxcell(3)=1,
    px(4)=  15.0,
  nycelt=30,
    py(1)=-100.0,    nycell(1)=4,
    py(2)= 2.0,      nycell(2)=3,
    py(3)=52.0,      nycell(3)=3,
    py(4)= 102.0,    nycell(4)=3,
    py(5)= 152.0,    nycell(5)=3,
    py(6)=202.0,     nycell(6)=3,
    py(7)=251.0,     nycell(7)=6,
    py(8)=381.08,    nycell(8)=5,
    py(9)=500.0,
  nzcelt=100,
    pz(1)=670.0,     nzcell(1)=2,
    pz(2)=704.0,     nzcell(2)=1,
    pz(3)=720.0,     nzcell(3)=2,
    pz(4)=749.5,     nzcell(4)=2,
    pz(5)=780.0,     nzcell(5)= 2,
    pz(6)=804.0,     nzcell(6)= 2,
    pz(7)=831.0,     nzcell(7)= 4,
    pz(8)= 889.0,    nzcell(8)= 1,
    pz(9)= 900.0,    nzcell(9)= 3,
    pz(10)= 945.0,   nzcell(10)=4,
    pz(11)=1000.,    nzcell(11)= 3
    pz(12)=   1040.500
 $end
 $obs
```

```
  avrck=-2.1,
  nobs=19,
  iob(1)=1,xl(1)=0.0,xh(1)=100.0,zh(1)=1079.7,
  iob(2)=1,ioh(2)=0,yh(2)=12.5,yl(2)=-12.5,trny(2)=25.0,zh(2)=831.0,zl(2)=804.0,
  iob(3)=1,ioh(3)=0,yh(3)=12.5,yl(3)=-12.5,trny(3)=75.0,zh(3)=831.0,zl(3)=804.0,
  iob(4)=1,ioh(4)=0,yh(4)=12.5,yl(4)=-12.5,trny(4)=125.0,zh(4)=831.0,zl(4)=804.0,
  iob(5)=1,ioh(5)=0,yh(5)=12.5,yl(5)=-12.5,trny(5)=175.0,zh(5)=831.0,zl(5)=804.0,
  iob(6)=1,ioh(6)=0,yh(6)=12.5,yl(6)=-12.5,trny(6)=225.0,zh(6)=831.0,zl(6)=804.0,
  iob(7)=2,igen(7)=3,ioh(7)=1,
  iob(8)=3,xh(8)=0.01,xl(8)=-52.0,yh(8)=2.01,yl(8)=0.03,zh(8)=1045.01,zl(8)=999.99,
  iob(9)=3,xh(9)=0.01,xl(9)=-52.0,yh(9)=253.0,yl(9)=250.99,zh(9)=1045.01,zl(9)=999.99,
  iob(10)=3,xh(10)=-49.99,xl(10)=-52.0,yh(10)=253.0,yl(10)=0.03,zh(10)=1045.01,zl(10)=999.99,
  iob(11)=4,opor(4)=0.004015302,xh(11)=0.01,xl(11)=-50.01,yh(11)=2.01,yl(11)=0.03,zh(11)=1000.01,zl(11)=944.99,
  iob(12)=5,opor(5)=0.003884098,xh(12)=0.01,xl(12)=-50.01,yh(12)=253.0,yl(12)=250.99,zh(12)=1000.01,zl(12)=944.99,
  iob(13)=6,opor(6)=0.0051328,xh(13)=-49.99,xl(13)=-52.0,yh(13)=253.0,yl(13)=0.03,zh(13)=1000.01,zl(13)=944.99,
  iob(14)=7,opor(7)=0.004351858,xh(14)=0.01,xl(14)=-50.01,yh(14)=2.01,yl(14)=0.03,zh(14)=945.01,zl(14)=899.99,
  iob(15)=8,opor(8)=0.020888367,xh(15)=0.01,xl(15)=-50.01,yh(15)=253.0,yl(15)=250.99,zh(15)=945.01,zl(15)=899.9,
  iob(16)=9,opor(9)=0.007301943,xh(16)=-49.99,xl(16)=-52.0,yh(16)=253.0,yl(16)=0.03,zh(16)=945.01,zl(16)=899.99,
  iob(17)=10,opor(10)=0.003534187,xh(17)=0.01,xl(17)=-50.01,yh(17)=2.01,yl(17)=0.03,zh(17)=900.01,zl(17)=830.99
  iob(18)=11,opor(11)=0.006766415,xh(18)=0.01,xl(18)=-50.01,yh(18)=253.0,yl(18)=250.99,zh(18)=900.01,zl(18)=830.99
  iob(19)=12,opor(12)=0.003110806,xh(19)=-49.99,xl(19)=-52.0,yh(19)=253.0,yl(19)=0.03,zh(19)=900.01,zl(19)=830.99,
  iob(20)=13,opor(13)=0.00536379,xh(20)=0.01,xl(20)=-50.01,yh(20)=2.01,yl(20)=0.03,zh(20)=831.01,zl(20)=803.9,
  iob(21)=14,opor(14)=0.0099,xh(21)=-49.99,xl(21)=-52.0,yh(21)=253.0,yl(21)=0.03,zh(21)=831.01,zl(21)=803.99,
  iob(22)=15,opor(15)=0.007382123,xh(22)=0.01,xl(22)=-50.01,yh(22)=2.01,yl(22)=0.03,zh(22)=804.01,zl(22)=779.9,
  iob(23)=16,opor(16)=0.003032684,xh(23)=-49.99,xl(23)=-52.0,yh(23)=253.0,yl(23)=0.03,zh(23)=804.01,zl(23)=779.99,
  iob(24)=3,xh(24)=0.01,xl(24)=-50.01,yh(24)=202.01,yl(24)=201.0,zh(24)=780.01,zl(24)=749.51,
  iob(25)=3,xh(25)=0.01,xl(25)=-50.01,yh(25)=253.0,yl(25)=250.99,zh(25)=831.01,zl(25)=719.99,
  iob(26)=17,opor(18)=0.00829452,xh(26)=-49.99,xl(26)=-52.0,yh(26)=253.0,yl(26)=201.0,zh(26)=780.01,zl(26)=749.51,
  iob(27)=18,opor(18)=0.00829452,xl(27)=-52.0,yh(27)=202.2,yl(27)=0.03,zh(27)=780.01,zl(27)=779.0,
  iob(28)=19,opor(19)=0.019110575,xl(28)=-52.0,yh(28)=253.0,yl(28)=201.0,zh(28)=749.51,zl(28)=748.50,
  iob(29)=3,xl(29)=-52.0,yh(29)=382.08,yl(29)=250.99,zh(29)=892.06,zl(29)=888.99,
  iob(30)=3,xh(30)=-49.99,xl(30)=-52.0,yh(30)=382.08,yl(30)=250.99,zh(30)=892.06,zl(30)=719.99,
  iob(31)=3,xl(31)=-52.0,yh(31)=382.08,yl(31)=381.07,zh(31)=892.06,zl(31)=719.99,
  iob(32)=3, zh(32)=-888.9
  iob(33)=3,zh(33)=-1000.0,
  iob(34)=3,zh(34)=-1000.0,
  iob(35)=3,zh(35)=-1000.0,
  iob(36)=3,zh(36)=-1000.0,
  iob(37)=3,zh(37)=-1000.0,
  iob(38)=9,ioh(38)=0,yl(38)= 2.0,yh(38)=48.0,zh(38)=945.0,zl(38)=900.0,
  iob(39)=9,ioh(39)=0,yl(39)=52.0,yh(39)=98.0,zh(39)=945.0,zl(39)=900.0,
  iob(40)=9,ioh(40)=0,yl(40)=102.0,yh(40)=148.0,zh(40)=945.0,zl(40)=900.0,
  iob(41)=9,ioh(41)=0,yl(41)=152.0,yh(41)=198.0,zh(41)=945.0,zl(41)=900.0,
  iob(42)=9,ioh(42)=0,yl(42)=202.0,yh(42)=248.0,zh(42)=945.0,zl(42)=900.0,
  iob(43)=3,zh(43)=-1000.0,
  iob(44)=3,zh(44)=-1000.0,
  iob(45)=3,zh(45)=-1000.0,
  iob(46)=3,zh(46)=-1000.0,
  iob(47)=3,zh(47)=-1000.0,
 $end
 $fl
   presi=0.0,nfls=1,
   flht=   1040.500
 $end
 $bf
   nbafs=4,pbaf(1)=0.9143,
   ibaf(1)=1,bxh(1)=0.0,bxl(1)=-50.0,by(1)=0.0,bzh(1)=1066.6,bzl(1)=1044.99,
   ibaf(2)=1,bxh(2)=0.0,bxl(2)=-50.0,by(2)=250.0,bzh(2)=1066.6,bzl(2)=1044.99,
   ibaf(3)=1,bx(3)=-50.0,byh(3)=250.0,byl(3)=0.0,bzh(3)=1066.6,bzl(3)=803.99,
   pbaf(2)=0.6785,
   ibaf(4)=2,bra(4)=16.8333,bxh(4)=0.01,btrny(4)=25.0,bzl(4)=780.0,
   ibaf(5)=2,bra(5)=16.8333,bxh(5)=0.01,btrny(5)=75.0,bzl(5)=780.0,
   ibaf(6)=2,bra(6)=16.8333,bxh(6)=0.01,btrny(6)=125.0,bzl(6)=780.0,
   ibaf(7)=2,bra(7)=16.8333,bxh(7)=0.01,btrny(7)=175.0,bzl(7)=780.0,
   ibaf(8)=2,bra(8)=16.8333,bxh(8)=0.01,btrny(8)=225.0,bzl(8)=749.5,
   ibaf(9)=3,bra(9)=16.8333,bxh(9)=0.01,bzl(9)=895.69,btrny(9)=25.0,
   ibaf(10)=3,bra(10)=16.8333,bxh(10)=0.01,bzl(10)=895.69,btrny(10)=75.0,
   ibaf(11)=3,bra(11)=16.8333,bxh(11)=0.01,bzl(11)=895.69,btrny(11)=125.0,
   ibaf(12)=3,bra(12)=16.8333,bxh(12)=0.01,bzl(12)=895.69,btrny(12)=175.0,
   ibaf(13)=3,bra(13)=16.8333,bxh(13)=0.01,bzl(13)=895.69,btrny(13)=225.0,
```

```
    pbaf(4)=0.0,
    ibaf(14)=4,bz(14)=780.0,byh(14)=98.0,byl(14)=52.0,bxh(14)=0.0,bxl(14)=-50.0,
    ibaf(15)=4,bz(15)=780.0,byh(15)=198.0,byl(15)=152.0,bxh(15)=0.0,bxl(15)=-50.0,
 $end
 $temp
   tempi=100.0,ntmp=1,
 $end
 $grafic
   nvplts=0,
 $end
 $parts
 $end
```

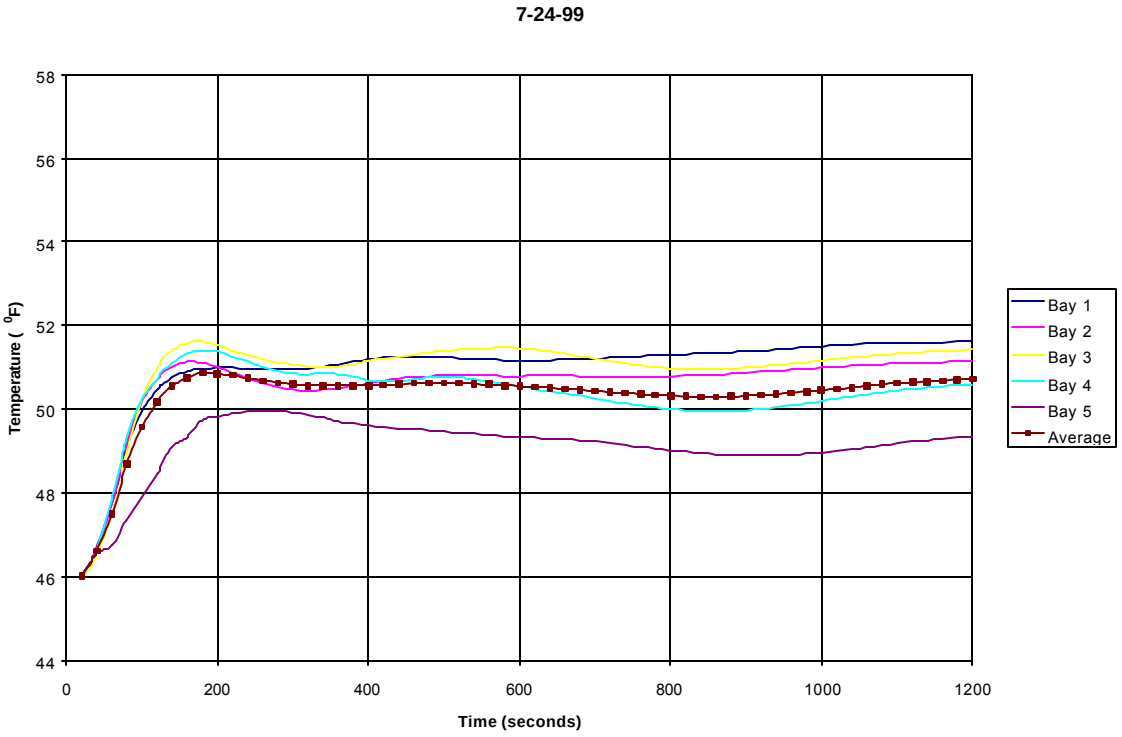

Figure 1L. Convergence graphic.

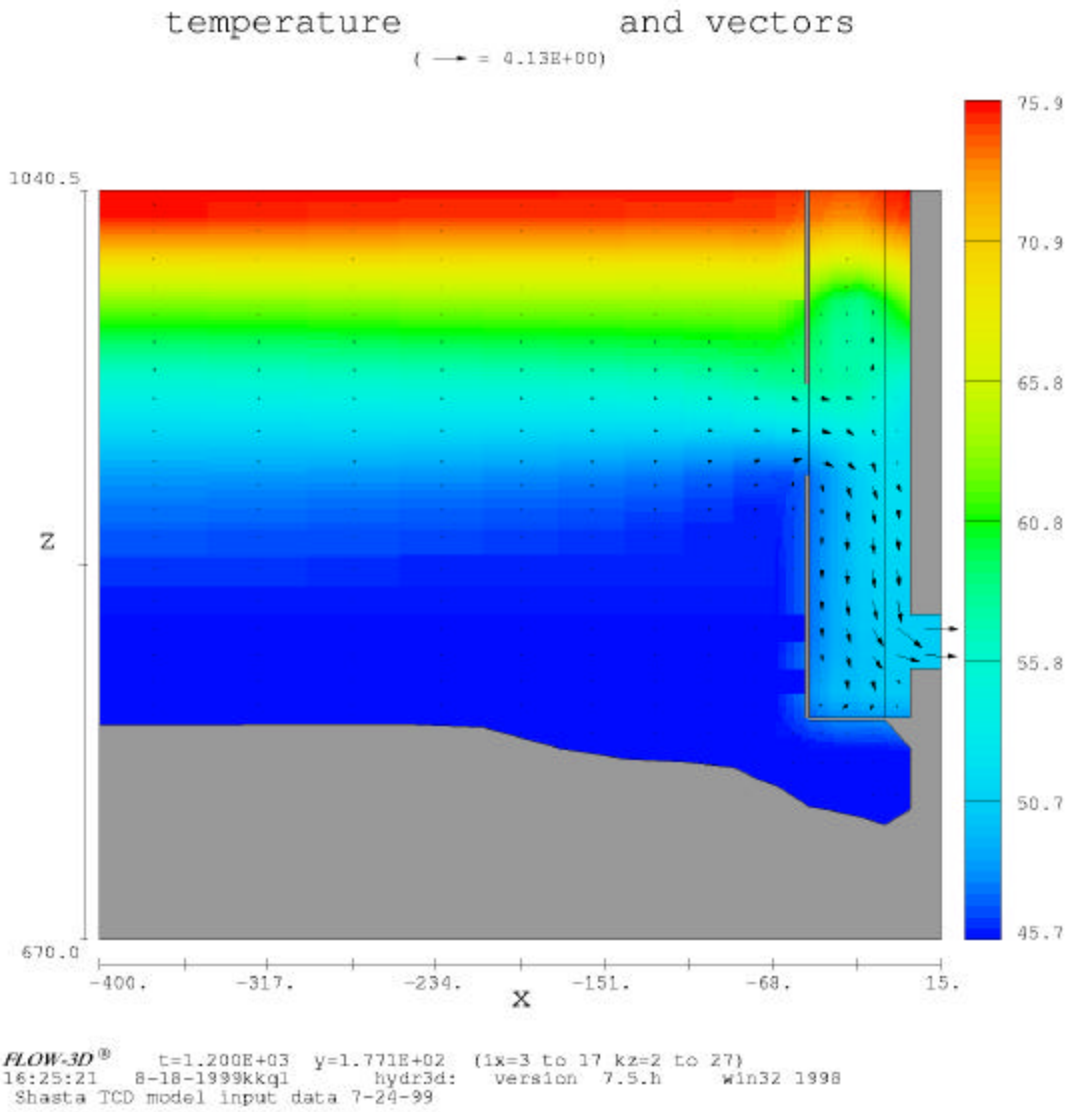

Figure 2L. Temperature Profile Through Penstock No. 3.

Appendix M – 8-13-1999

Table 1M. PREP.dat

```
&Title
        t(1)='Shasta TCD model input data 8-13-99'
        t(2)=''
        t(3)=''
        t(4)=''
        t(5)=''
/
&penstocks
        q(1)=2420
        q(2)=2391
        q(3)=2391
        q(4)=2881
        q(5)=0
/
&gates
        iupper(1)=1
        iupper(2)=1
        iupper(3)=1
        iupper(4)=1
        iupper(5)=1
        imiddle(1)=1
        imiddle(2)=0
        imiddle(3)=1
        imiddle(4)=1
        imiddle(5)=1
        ipg(1)=0
        ipg(2)=1
        ipg(3)=0
        ipg(4)=0
        ipg(5)=0
        ill=1
/
&reser
        wsel=1032.2
        n_measure=43
        elev(1)=1031.09,    tempr(1)=75.52
        elev(2)=1030.79,    tempr(2)=75.52
        elev(3)=1029.56,    tempr(3)=75.48
        elev(4)=1027.82,    tempr(4)=75.47
        elev(5)=1025.19,    tempr(5)=75.36
        elev(6)=1022.27,    tempr(6)=75.21
        elev(7)=1020.00,    tempr(7)=75.11
        elev(8)=1017.26,    tempr(8)=75.01
        elev(9)=1014.41,    tempr(9)=74.96
        elev(10)=1011.58,   tempr(10)=74.91
        elev(11)=1009.31,tempr(11)=74.87
        elev(12)=1007.52,tempr(12)=74.83
        elev(13)=1005.19,tempr(13)=74.44
        elev(14)=1003.54,tempr(14)=73.47
        elev(15)=1002.29,tempr(15)=72.26
        elev(16)=1000.86,tempr(16)=71.13
        elev(17)=999.82,tempr(17)=70.28
        elev(18)=995.88,tempr(18)=68.19
        elev(19)=990.87,tempr(19)=66.63
        elev(20)=985.42,tempr(20)=65.66
        elev(21)=980.32,tempr(21)=64.74
        elev(22)=970.87,tempr(22)=63.19
        elev(23)=960.96,tempr(23)=61.66
        elev(24)=950.99,tempr(24)=59.5
        elev(25)=939.66,tempr(25)=57.73
        elev(26)=929.68,tempr(26)=55.95
        elev(27)=920.10,tempr(27)=54.32
        elev(28)=910.54,tempr(28)=52.84
        elev(29)=900.30,tempr(29)=51.29
```

```
              elev(30)=889.64,tempr(30)=49.42
              elev(31)=879.98,tempr(31)=48.59
              elev(32)=864.87,tempr(32)=47.62
              elev(33)=834.34,tempr(33)=46.61
              elev(34)=819.43,tempr(34)=45.91
              elev(35)=800.95,tempr(35)=45.62
              elev(36)=785.92,tempr(36)=45.44
              elev(37)=750.75,tempr(37)=45.15
              elev(38)=724.56,tempr(38)=45.01
              elev(39)=699.56,tempr(39)=44.92
              elev(40)=674.73,tempr(40)=44.85
              elev(41)=624.35,tempr(41)=44.78
              elev(42)=597.96,tempr(42)=44.74
              elev(43)=579.72,tempr(43)=44.76
/
```

Table 2M. PREPIN.INP

```
Shasta TCD model input data 8-13-99
 $xput
    lpr=1,itb=0,iwsh=0,ifvis=0,epsadj=1.0,
    prtdt=10000.0,gz=-32.14,ipdis=1,
    nmat=1,iadix=1,iadiy=1,iadiz=1,
    iorder=1,ifrho=1,ifenrg=2,ichm=0,
    ihtrst=0, iresf1=0, irstoe=0, iscrst=0, itrst=0,
    idum1=  2420,
    idum2=  2391,
    idum3=  2391,
    idum4=  2881,
    idum5=  1,
    idum6=100,
    twfin=1200.,
    pltdt=1200.0,
    delt=0.1,
    deltr=0.01,
    sprtdt=20.0,
    HPLTDT=20.0,
 $end
 $limits
    irpr=1,jbkpr=1,ktpr=1,
 $end
 $props
    rhof=1.937,mui=2.25E-05,tstar=0.0000001,mu1=2.25E-05,mu2=2.25E-05,
 $end
 $scalar
     nsc=1,isclr(1)=0,
 $end
 $bcdata
    pbctyp=1.,
    tbc(1)=100.0,tbc(2)=60.0,tbc(3)=60.0,
    tbc(4)=60.0,tbc(5)=60.0,tbc(6)=60.0,
    wl=5,wr=6,wf=2,wbk=2,wt=2,wb=2,
    flhtl=1043.7,
 $end
 $mesh
  nxcelt=17,
    px(1)=-400.0,    nxcell(1)=10,
    px(2)= -50.0,    nxcell(2)=4,
    px(3)=  0.0,    nxcell(3)=1,
    px(4)=  15.0,
  nycelt=30,
    py(1)=-100.0,    nycell(1)=4,
    py(2)= 2.0,      nycell(2)=3,
    py(3)=52.0,      nycell(3)=3,
    py(4)= 102.0,    nycell(4)=3,
    py(5)= 152.0,    nycell(5)=3,
    py(6)=202.0,     nycell(6)=3,
    py(7)=251.0,     nycell(7)=6,
    py(8)=381.08,    nycell(8)=5,
    py(9)=500.0,
```

```
   nzcelt=100,
    pz(1)=670.0,     nzcell(1)=2,
    pz(2)=704.0,     nzcell(2)=1,
    pz(3)=720.0,     nzcell(3)=2,
    pz(4)=749.5,     nzcell(4)=2,
    pz(5)=780.0,     nzcell(5)= 2,
    pz(6)=804.0,     nzcell(6)= 2,
    pz(7)=831.0,     nzcell(7)= 4,
    pz(8)= 889.0,    nzcell(8)= 1,
    pz(9)= 900.0,    nzcell(9)= 3,
    pz(10)= 945.0,   nzcell(10)=4,
    pz(11)=1000.,    nzcell(11)= 2,
    pz(12)=   1032.200,
  $end
  $obs
   avrck=-2.1,
   nobs=19,
   iob(1)=1,xl(1)=0.0,xh(1)=100.0,zh(1)=1079.7,
   iob(2)=1,ioh(2)=0,yh(2)=12.5,yl(2)=-12.5,trny(2)=25.0,zh(2)=831.0,zl(2)=804.0,
   iob(3)=1,ioh(3)=0,yh(3)=12.5,yl(3)=-12.5,trny(3)=75.0,zh(3)=831.0,zl(3)=804.0,
   iob(4)=1,ioh(4)=0,yh(4)=12.5,yl(4)=-12.5,trny(4)=125.0,zh(4)=831.0,zl(4)=804.0,
   iob(5)=1,ioh(5)=0,yh(5)=12.5,yl(5)=-12.5,trny(5)=175.0,zh(5)=831.0,zl(5)=804.0,
   iob(6)=1,ioh(6)=0,yh(6)=12.5,yl(6)=-12.5,trny(6)=225.0,zh(6)=831.0,zl(6)=804.0,
   iob(7)=2,igen(7)=3,ioh(7)=1,
   iob(8)=3,xh(8)=0.01,xl(8)=-52.0,yh(8)=2.01,yl(8)=0.03,zh(8)=1045.01,zl(8)=999.99,
   iob(9)=3,xh(9)=0.01,xl(9)=-52.0,yh(9)=253.0,yl(9)=250.99,zh(9)=1045.01,zl(9)=999.99,
   iob(10)=3,xh(10)=-49.99,xl(10)=-52.0,yh(10)=253.0,yl(10)=0.03,zh(10)=1045.01,zl(10)=999.99,
   iob(11)=4,opor(4)=0.004015302,xh(11)=0.01,xl(11)=-50.01,yh(11)=2.01,yl(11)=0.03,zh(11)=1000.01,zl(11)=944.99,
   iob(12)=5,opor(5)=0.003884098,xh(12)=0.01,xl(12)=-50.01,yh(12)=253.0,yl(12)=250.99,zh(12)=1000.01,zl(12)=944.99,
   iob(13)=6,opor(6)=0.0051328,xh(13)=-49.99,xl(13)=-52.0,yh(13)=253.0,yl(13)=0.03,zh(13)=1000.01,zl(13)=944.99,
   iob(14)=7,opor(7)=0.004351858,xh(14)=0.01,xl(14)=-50.01,yh(14)=2.01,yl(14)=0.03,zh(14)=945.01,zl(14)=899.99,
   iob(15)=8,opor(8)=0.020888367,xh(15)=0.01,xl(15)=-50.01,yh(15)=253.0,yl(15)=250.99,zh(15)=945.01,zl(15)=899.9,
   iob(16)=9,opor(9)=0.007301943,xh(16)=-49.99,xl(16)=-52.0,yh(16)=253.0,yl(16)=0.03,zh(16)=945.01,zl(16)=899.99,
   iob(17)=10,opor(10)=0.003534187,xh(17)=0.01,xl(17)=-50.01,yh(17)=2.01,yl(17)=0.03,zh(17)=900.01,zl(17)=830.99,
   iob(18)=11,opor(11)=0.006766415,xh(18)=0.01,xl(18)=-50.01,yh(18)=253.0,yl(18)=250.99,zh(18)=900.01,zl(18)=830.99,
   iob(19)=12,opor(12)=0.003110806,xh(19)=-49.99,xl(19)=-52.0,yh(19)=253.0,yl(19)=0.03,zh(19)=900.01,zl(19)=830.99,
   iob(20)=13,opor(13)=0.00536379,xh(20)=0.01,xl(20)=-50.01,yh(20)=2.01,yl(20)=0.03,zh(20)=831.01,zl(20)=803.9,
   iob(21)=14,opor(14)=0.0099,xh(21)=-49.99,xl(21)=-52.0,yh(21)=253.0,yl(21)=0.03,zh(21)=831.01,zl(21)=803.99,
   iob(22)=15,opor(15)=0.007382123,xh(22)=0.01,xl(22)=-50.01,yh(22)=2.01,yl(22)=0.03,zh(22)=804.01,zl(22)=779.9,
   iob(23)=16,opor(16)=0.003032684,xh(23)=-49.99,xl(23)=-52.0,yh(23)=253.0,yl(23)=0.03,zh(23)=804.01,zl(23)=779.99,
   iob(24)=3,xh(24)=0.01,xl(24)=-50.01,yh(24)=202.01,yl(24)=201.0,zh(24)=780.01,zl(24)=749.51,
   iob(25)=3,xh(25)=0.01,xl(25)=-50.01,yh(25)=253.0,yl(25)=250.99,zh(25)=831.01,zl(25)=719.99,
   iob(26)=17,opor(18)=0.00829452,xh(26)=-49.99,xl(26)=-52.0,yh(26)=253.0,yl(26)=201.0,zh(26)=780.01,zl(26)=749.51,
   iob(27)=18,opor(18)=0.00829452,xl(27)=-52.0,yh(27)=202.2,yl(27)=0.03,zh(27)=780.01,zl(27)=779.0,
   iob(28)=19,opor(19)=0.019110575,xl(28)=-52.0,yh(28)=253.0,yl(28)=201.0,zh(28)=749.51,zl(28)=748.50,
   iob(29)=3,xl(29)=-52.0,yh(29)=382.08,yl(29)=250.99,zh(29)=892.06,zl(29)=888.99,
   iob(30)=3,xh(30)=-49.99,xl(30)=-52.0,yh(30)=382.08,yl(30)=250.99,zh(30)=892.06,zl(30)=719.99,
   iob(31)=3,xl(31)=-52.0,yh(31)=382.08,yl(31)=381.07,zh(31)=892.06,zl(31)=719.99,
   iob(32)=3, zh(32)=-888.9,
   iob(33)=3,zh(33)=-1000.0,
   iob(34)=3,zh(34)=-1000.0,
   iob(35)=3,zh(35)=-1000.0,
   iob(36)=3,zh(36)=-1000.0,
   iob(37)=3,zh(37)=-1000.0,
   iob(38)=3,zh(38)=-1000.0,
   iob(39)=9,ioh(39)=0,yl(39)=52.0,yh(39)=98.0,zh(39)=945.0,zl(39)=900.0,
   iob(40)=3,zh(40)=-1000.0,
   iob(41)=3,zh(41)=-1000.0,
   iob(42)=3,zh(42)=-1000.0,
   iob(43)=14,ioh(43)=0,yl(43)= 2.0,yh(43)=48.0,zh(43)=831.0,zl(43)=804.0,
   iob(44)=3,zh(44)=-1000.0,
   iob(45)=14,ioh(45)=0,yl(45)=102.0,yh(45)=148.0,zh(45)=831.0,zl(45)=804.0,
   iob(46)=14,ioh(46)=0,yl(46)=152.0,yh(46)=198.0,zh(46)=831.0,zl(46)=804.0,
   iob(47)=14,ioh(47)=0,yl(47)=202.0,yh(47)=248.0,zh(47)=831.0,zl(47)=804.0,
  $end
  $fl
     presi=0.0,nfls=1,
     flht=   1032.200,
  $end
  $bf
```

```
    nbafs=4,pbaf(1)=0.9143,
     ibaf(1)=1,bxh(1)=0.0,bxl(1)=-50.0,by(1)=0.0,bzh(1)=1066.6,bzl(1)=1044.99,
     ibaf(2)=1,bxh(2)=0.0,bxl(2)=-50.0,by(2)=250.0,bzh(2)=1066.6,bzl(2)=1044.99,
     ibaf(3)=1,bx(3)=-50.0,byh(3)=250.0,byl(3)=0.0,bzh(3)=1066.6,bzl(3)=899.99,
    pbaf(2)=0.6785,
     ibaf(4)=2,bra(4)=16.8333,bxh(4)=0.01,btrny(4)=25.0,bzl(4)=780.0,
     ibaf(5)=2,bra(5)=16.8333,bxh(5)=0.01,btrny(5)=75.0,bzl(5)=780.0,
     ibaf(6)=2,bra(6)=16.8333,bxh(6)=0.01,btrny(6)=125.0,bzl(6)=780.0,
     ibaf(7)=2,bra(7)=16.8333,bxh(7)=0.01,btrny(7)=175.0,bzl(7)=780.0,
     ibaf(8)=2,bra(8)=16.8333,bxh(8)=0.01,btrny(8)=225.0,bzl(8)=749.5,
     ibaf(9)=3,bra(9)=16.8333,bxh(9)=0.01,bzl(9)=895.69,btrny(9)=25.0,
     ibaf(10)=3,bra(10)=16.8333,bxh(10)=0.01,bzl(10)=895.69,btrny(10)=75.0,
     ibaf(11)=3,bra(11)=16.8333,bxh(11)=0.01,bzl(11)=895.69,btrny(11)=125.0,
     ibaf(12)=3,bra(12)=16.8333,bxh(12)=0.01,bzl(12)=895.69,btrny(12)=175.0,
     ibaf(13)=3,bra(13)=16.8333,bxh(13)=0.01,bzl(13)=895.69,btrny(13)=225.0,
    pbaf(4)=0.0,
     ibaf(14)=4,bz(14)=780.0,byh(14)=98.0,byl(14)=52.0,bxh(14)=0.0,bxl(14)=-50.0,
     ibaf(15)=4,bz(15)=780.0,byh(15)=198.0,byl(15)=152.0,bxh(15)=0.0,bxl(15)=-50.0,
  $end
  $temp
    tempi=100.0,ntmp=1,
  $end
  $grafic
    nvplts=0,
  $end
  $parts
  $end
```

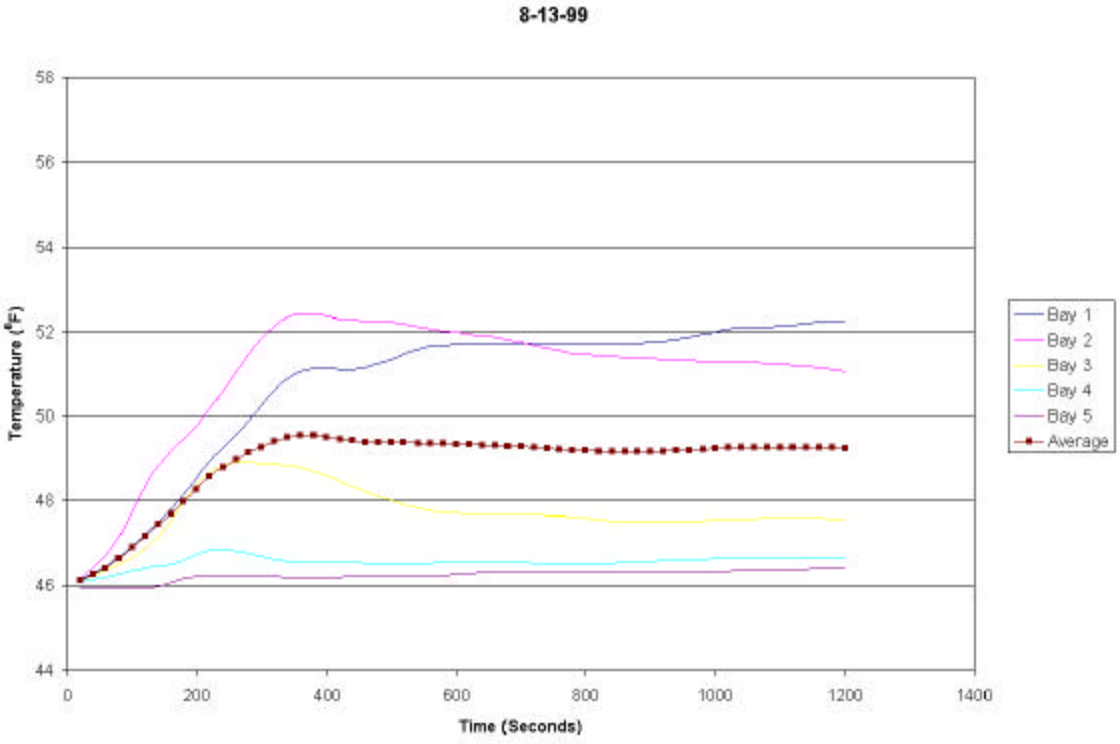

Figure 1M. Convergence graphic.

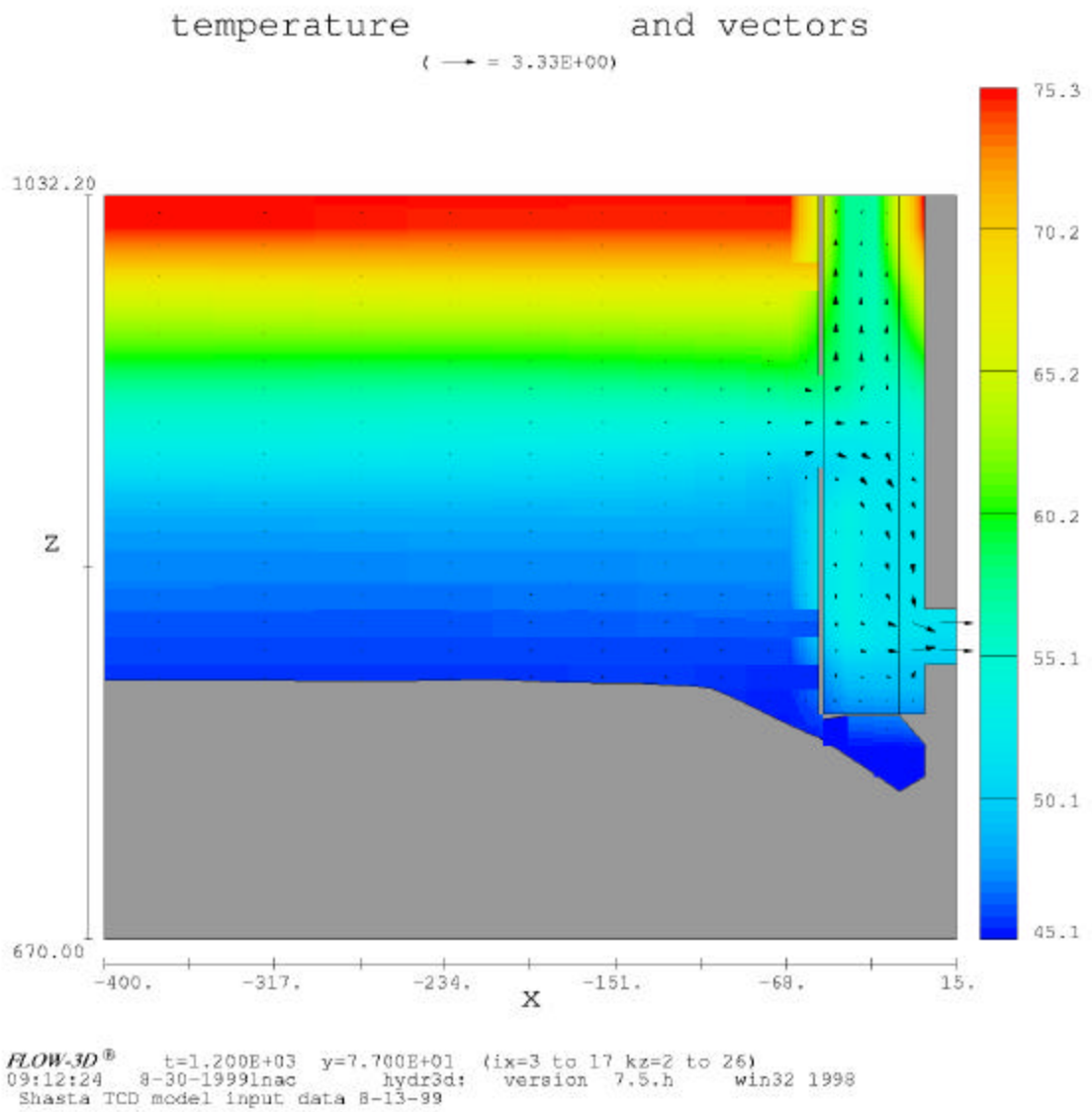

Figure 2M. Temperature Profile Through Penstock No. 2.

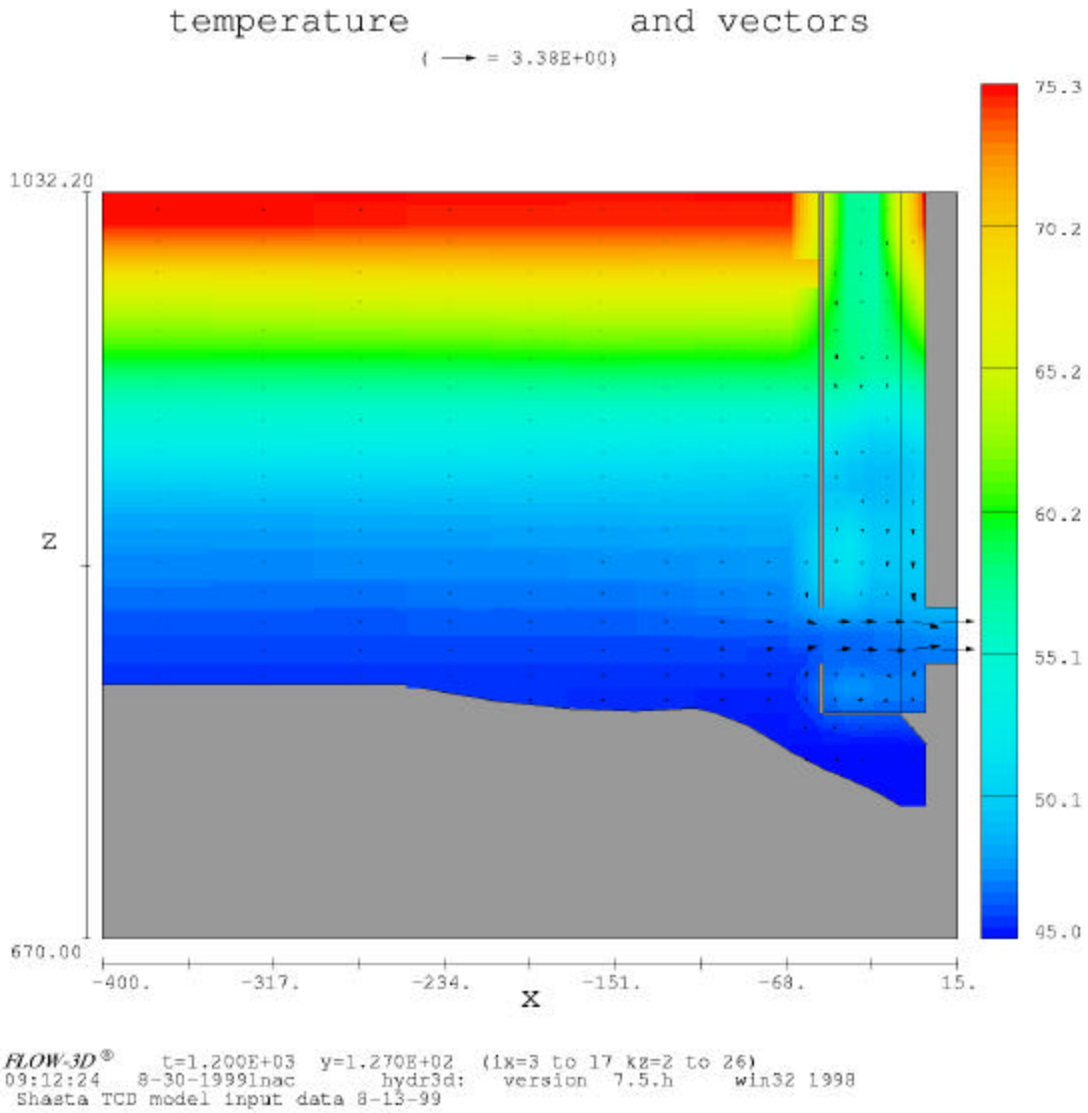

Figure 3M. Temperature Profile Through Penstock No. 3.

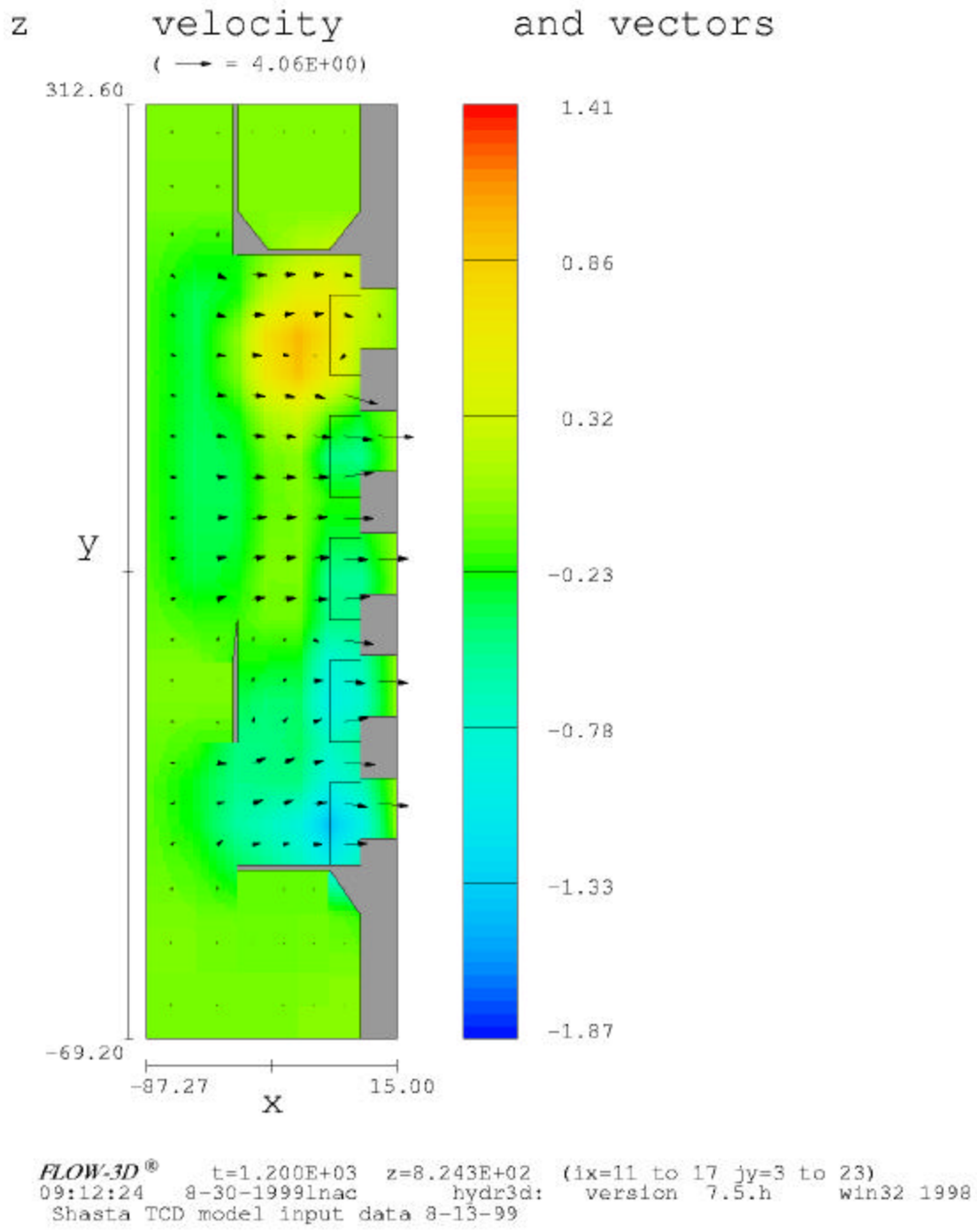

Figure 4M. Vertical Velocity Contours near the Top of the Lower Gates

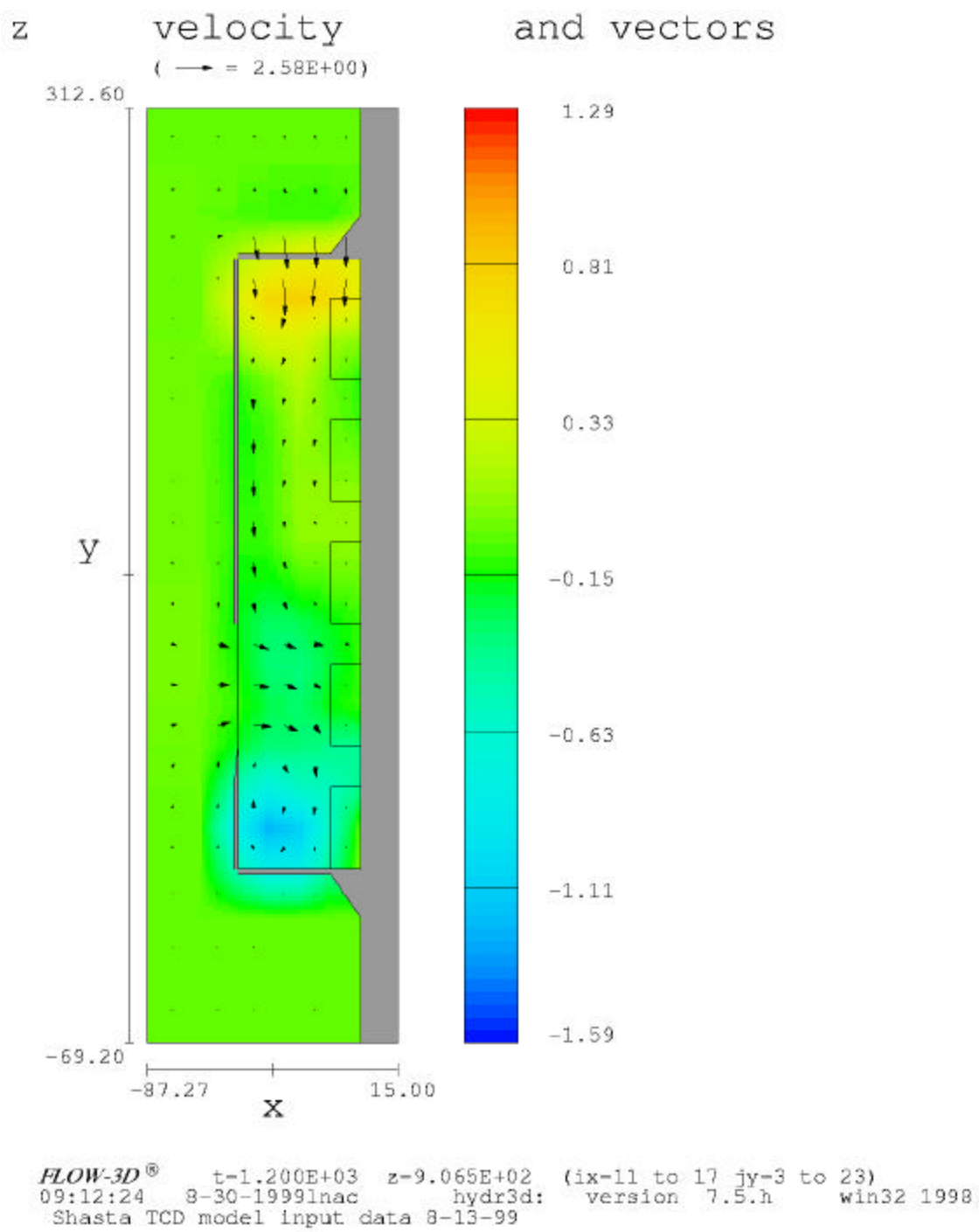

Figure 5M. Vertical Velocity Contours near the Bottom of the Middle Gates

Appendix N – 8-18-1998a

Table 1N. PREP.DAT.

```
&Title
        t(1)='Shasta TCD model input data 8-18-98a'
        t(2)=''
        t(3)=''
        t(4)=''
        t(5)=''
/
&penstocks
        q(1)=2500
        q(2)=2500
        q(3)=2500
        q(4)=2500
        q(5)=2500
/
&gates
        iupper(1)=1
        iupper(2)=1
        iupper(3)=1
        iupper(4)=1
        iupper(5)=1
        imiddle(1)=0
        imiddle(2)=0
        imiddle(3)=0
        imiddle(4)=1
        imiddle(5)=1
        ipg(1)=0
        ipg(2)=0
        ipg(3)=0
        ipg(4)=0
        ipg(5)=0
        ill=1
/
&reser
        wsel=1043.7
        n_measure=20
        elev(1)=1043.70,    tempr(1)=79.70
        elev(2)=1037.73,    tempr(2)=79.61
        elev(3)=1014.72,    tempr(3)=68.14
        elev(4)=991.70,     tempr(4)=63.43
        elev(5)=968.69,     tempr(5)=59.71
        elev(6)=945.67,     tempr(6)=55.90
        elev(7)=922.66,     tempr(7)=54.32
        elev(8)=899.64,     tempr(8)=52.95
        elev(9)=876.63,     tempr(9)=51.71
        elev(10)=853.61,tempr(10)= 50.52
        elev(11)=830.60,    tempr(11)=49.78
        elev(12)=807.58,    tempr(12)=49.39
        elev(13)=784.57,    tempr(13)=49.00
        elev(14)=761.55,    tempr(14)=48.61
        elev(15)=738.54,    tempr(15)=48.22
        elev(16)=715.52,    tempr(16)=47.83
        elev(17)=692.51,    tempr(17)=47.44
        elev(18)=669.49,    tempr(18)=47.05
        elev(19)=646.48,    tempr(19)=46.66
        elev(20)=623.46,    tempr(20)=46.27
/
```

Table 2N. PREPIN.INP.

```
Shasta TCD model input data 8-18-98a
  $xput
     lpr=1,itb=0,iwsh=0,ifvis=0,epsadj=1.0,
     prtdt=10000.0,gz=-32.14,ipdis=1,
     nmat=1,iadix=1,iadiy=1,iadiz=1,
      iorder=1,ifrho=1,ifenrg=2,ichm=0,
```

```
    ihtrst=0, iresf1=0, irstoe=0, iscrst=0, itrst=0,
    idum1=   2500,
    idum2=   2500,
    idum3=   2500,
    idum4=   2500,
    idum5=   2500,
    idum6=100,
    twfin=1200.,
    pltdt=1200.0,
    delt=0.01,
    deltr=0.0001,
    sprtdt=20.0,
    HPLTDT=20.0,
 $end
 $limits
    irpr=1,jbkpr=1,ktpr=1,
 $end
 $props
    rhof=1.937,mui=2.25E-05,tstar=0.0000001,mu1=2.25E-05,mu2=2.25E-05,
 $end
 $scalar
     nsc=1,isclr(1)=0,
 $end
 $bcdata
    pbctyp=1.,
    tbc(1)=100.0,tbc(2)=60.0,tbc(3)=60.0,
    tbc(4)=60.0,tbc(5)=60.0,tbc(6)=60.0,
    wl=5,wr=6,wf=2,wbk=2,wt=2,wb=2,
    flhtl=1043.7,
 $end
 $mesh
  nxcelt=17,
    px(1)=-400.0,     nxcell(1)=10,
    px(2)= -50.0,     nxcell(2)=4,
    px(3)=   0.0,     nxcell(3)=1,
    px(4)=  15.0,
  nycelt=30,
    py(1)=-100.0,     nycell(1)=4,
    py(2)= 2.0,       nycell(2)=3,
    py(3)=52.0,       nycell(3)=3,
    py(4)= 102.0,     nycell(4)=3,
    py(5)= 152.0,     nycell(5)=3,
    py(6)=202.0,      nycell(6)=3,
    py(7)=251.0,      nycell(7)=6,
    py(8)=381.08,     nycell(8)=5,
    py(9)=500.0,
  nzcelt=100,
    pz(1)=670.0,      nzcell(1)=2,
    pz(2)=704.0,      nzcell(2)=1,
    pz(3)=720.0,      nzcell(3)=2,
    pz(4)=749.5,      nzcell(4)=2,
    pz(5)=780.0,      nzcell(5)= 2,
    pz(6)=804.0,      nzcell(6)= 2,
    pz(7)=831.0,      nzcell(7)= 4,
    pz(8)= 889.0,     nzcell(8)= 1,
    pz(9)= 900.0,     nzcell(9)= 3,
    pz(10)= 945.0,    nzcell(10)=4,
    pz(11)=1000.,     nzcell(11)= 3,
    pz(12)=   1043.700,
 $end
 $obs
  avrck=-2.1,
  nobs=19,
  iob(1)=1,xl(1)=0.0,xh(1)=100.0,zh(1)=1079.7,
  iob(2)=1,ioh(2)=0,yh(2)=12.5,yl(2)=-12.5,trny(2)=25.0,zh(2)=831.0,zl(2)=804.0,
  iob(3)=1,ioh(3)=0,yh(3)=12.5,yl(3)=-12.5,trny(3)=75.0,zh(3)=831.0,zl(3)=804.0,
  iob(4)=1,ioh(4)=0,yh(4)=12.5,yl(4)=-12.5,trny(4)=125.0,zh(4)=831.0,zl(4)=804.0,
  iob(5)=1,ioh(5)=0,yh(5)=12.5,yl(5)=-12.5,trny(5)=175.0,zh(5)=831.0,zl(5)=804.0,
  iob(6)=1,ioh(6)=0,yh(6)=12.5,yl(6)=-12.5,trny(6)=225.0,zh(6)=831.0,zl(6)=804.0,
  iob(7)=2,igen(7)=3,ioh(7)=1,
```

```
  iob(8)=3,xh(8)=0.01,xl(8)=-52.0,yh(8)=2.01,yl(8)=0.03,zh(8)=1045.01,zl(8)=999.99,
  iob(9)=3,xh(9)=0.01,xl(9)=-52.0,yh(9)=253.0,yl(9)=250.99,zh(9)=1045.01,zl(9)=999.99,
  iob(10)=3,xh(10)=-49.99,xl(10)=-52.0,yh(10)=253.0,yl(10)=0.03,zh(10)=1045.01,zl(10)=999.99,
  iob(11)=4,opor(4)=0.004015302,xh(11)=0.01,xl(11)=-50.01,yh(11)=2.01,yl(11)=0.03,zh(11)=1000.01,zl(11)=944.99,
  iob(12)=5,opor(5)=0.003884098,xh(12)=0.01,xl(12)=-50.01,yh(12)=253.0,yl(12)=250.99,zh(12)=1000.01,zl(12)=944.99,
  iob(13)=6,opor(6)=0.0051328,xh(13)=-49.99,xl(13)=-52.0,yh(13)=253.0,yl(13)=0.03,zh(13)=1000.01,zl(13)=944.99,
  iob(14)=7,opor(7)=0.004351858,xh(14)=0.01,xl(14)=-50.01,yh(14)=2.01,yl(14)=0.03,zh(14)=945.01,zl(14)=899.99,
  iob(15)=8,opor(8)=0.020888367,xh(15)=0.01,xl(15)=-50.01,yh(15)=253.0,yl(15)=250.99,zh(15)=945.01,zl(15)=899.9,
  iob(16)=9,opor(9)=0.007301943,xh(16)=-49.99,xl(16)=-52.0,yh(16)=253.0,yl(16)=0.03,zh(16)=945.01,zl(16)=899.99,
  iob(17)=10,opor(10)=0.003534187,xh(17)=0.01,xl(17)=-50.01,yh(17)=2.01,yl(17)=0.03,zh(17)=900.01,zl(17)=830.99,
  iob(18)=11,opor(11)=0.006766415,xh(18)=0.01,xl(18)=-50.01,yh(18)=253.0,yl(18)=250.99,zh(18)=900.01,zl(18)=830.99,
  iob(19)=12,opor(12)=0.003110806,xh(19)=-49.99,xl(19)=-52.0,yh(19)=253.0,yl(19)=0.03,zh(19)=900.01,zl(19)=830.99,
  iob(20)=13,opor(13)=0.00536379,xh(20)=0.01,xl(20)=-50.01,yh(20)=2.01,yl(20)=0.03,zh(20)=831.01,zl(20)=803.9,
  iob(21)=14,opor(14)=0.0099,xh(21)=-49.99,xl(21)=-52.0,yh(21)=253.0,yl(21)=0.03,zh(21)=831.01,zl(21)=803.99,
  iob(22)=15,opor(15)=0.007382123,xh(22)=0.01,xl(22)=-50.01,yh(22)=2.01,yl(22)=0.03,zh(22)=804.01,zl(22)=779.9,
  iob(23)=16,opor(16)=0.003032684,xh(23)=-49.99,xl(23)=-52.0,yh(23)=253.0,yl(23)=0.03,zh(23)=804.01,zl(23)=779.99,
  iob(24)=3,xh(24)=0.01,xl(24)=-50.01,yh(24)=202.01,yl(24)=201.0,zh(24)=780.01,zl(24)=749.51,
  iob(25)=3,xh(25)=0.01,xl(25)=-50.01,yh(25)=253.0,yl(25)=250.99,zh(25)=831.01,zl(25)=719.99,
  iob(26)=17,opor(18)=0.00829452,xh(26)=-49.99,xl(26)=-52.0,yh(26)=253.0,yl(26)=201.0,zh(26)=780.01,zl(26)=749.51,
  iob(27)=18,opor(18)=0.00829452,xl(27)=-52.0,yh(27)=202.2,yl(27)=0.03,zh(27)=780.01,zl(27)=779.0,
  iob(28)=19,opor(19)=0.019110575,xl(28)=-52.0,yh(28)=253.0,yl(28)=201.0,zh(28)=749.51,zl(28)=748.50,
  iob(29)=3,xl(29)=-52.0,yh(29)=382.08,yl(29)=250.99,zh(29)=892.06,zl(29)=888.99,
  iob(30)=3,xh(30)=-49.99,xl(30)=-52.0,yh(30)=382.08,yl(30)=250.99,zh(30)=892.06,zl(30)=719.99,
  iob(31)=3,xl(31)=-52.0,yh(31)=382.08,yl(31)=381.07,zh(31)=892.06,zl(31)=719.99,
  iob(32)=3, zh(32)=-888.9,     iob(33)=3,zh(33)=-1000.0,     iob(34)=3,zh(34)=-1000.0,
  iob(35)=3,zh(35)=-1000.0,     iob(36)=3,zh(36)=-1000.0,     iob(37)=3,zh(37)=-1000.0,
  iob(38)=9,ioh(38)=0,yl(38)= 2.0,yh(38)=48.0,zh(38)=945.0,zl(38)=900.0,
  iob(39)=9,ioh(39)=0,yl(39)=52.0,yh(39)=98.0,zh(39)=945.0,zl(39)=900.0,
  iob(40)=9,ioh(40)=0,yl(40)=102.0,yh(40)=148.0,zh(40)=945.0,zl(40)=900.0,
  iob(41)=3,zh(41)=-1000.0,     iob(42)=3,zh(42)=-1000.0,
  iob(43)=14,ioh(43)=0,yl(43)= 2.0,yh(43)=48.0,zh(43)=831.0,zl(43)=804.0,
  iob(44)=14,ioh(44)=0,yl(44)=52.0,yh(44)=98.0,zh(44)=831.0,zl(44)=804.0,
  iob(45)=14,ioh(45)=0,yl(45)=102.0,yh(45)=148.0,zh(45)=831.0,zl(45)=804.0,
  iob(46)=14,ioh(46)=0,yl(46)=152.0,yh(46)=198.0,zh(46)=831.0,zl(46)=804.0,
  iob(47)=14,ioh(47)=0,yl(47)=202.0,yh(47)=248.0,zh(47)=831.0,zl(47)=804.0,
 $end
 $fl
   presi=0.0,nfls=1,
   flht=   1043.700,
 $end
 $bf
   nbafs=4,pbaf(1)=0.9143,
   ibaf(1)=1,bxh(1)=0.0,bxl(1)=-50.0,by(1)=0.0,bzh(1)=1066.6,bzl(1)=1044.99,
   ibaf(2)=1,bxh(2)=0.0,bxl(2)=-50.0,by(2)=250.0,bzh(2)=1066.6,bzl(2)=1044.99,
   ibaf(3)=1,bx(3)=-50.0,byh(3)=250.0,byl(3)=0.0,bzh(3)=1066.6,bzl(3)=899.99,
   pbaf(2)=0.6785,
   ibaf(4)=2,bra(4)=16.8333,bxh(4)=0.01,btrny(4)=25.0,bzl(4)=780.0,
   ibaf(5)=2,bra(5)=16.8333,bxh(5)=0.01,btrny(5)=75.0,bzl(5)=780.0,
   ibaf(6)=2,bra(6)=16.8333,bxh(6)=0.01,btrny(6)=125.0,bzl(6)=780.0,
   ibaf(7)=2,bra(7)=16.8333,bxh(7)=0.01,btrny(7)=175.0,bzl(7)=780.0,
   ibaf(8)=2,bra(8)=16.8333,bxh(8)=0.01,btrny(8)=225.0,bzl(8)=749.5,
   ibaf(9)=3,bra(9)=16.8333,bxh(9)=0.01,bzl(9)=895.69,btrny(9)=25.0,
   ibaf(10)=3,bra(10)=16.8333,bxh(10)=0.01,bzl(10)=895.69,btrny(10)=75.0,
   ibaf(11)=3,bra(11)=16.8333,bxh(11)=0.01,bzl(11)=895.69,btrny(11)=125.0,
   ibaf(12)=3,bra(12)=16.8333,bxh(12)=0.01,bzl(12)=895.69,btrny(12)=175.0,
   ibaf(13)=3,bra(13)=16.8333,bxh(13)=0.01,bzl(13)=895.69,btrny(13)=225.0,
   pbaf(4)=0.0,
   ibaf(14)=4,bz(14)=780.0,byh(14)=98.0,byl(14)=52.0,bxh(14)=0.0,bxl(14)=-50.0,
   ibaf(15)=4,bz(15)=780.0,byh(15)=198.0,byl(15)=152.0,bxh(15)=0.0,bxl(15)=-50.0,
 $end
 $temp
   tempi=100.0,ntmp=1,
 $end
 $grafic
   nvplts=0,
 $end
 $parts
 $end
```

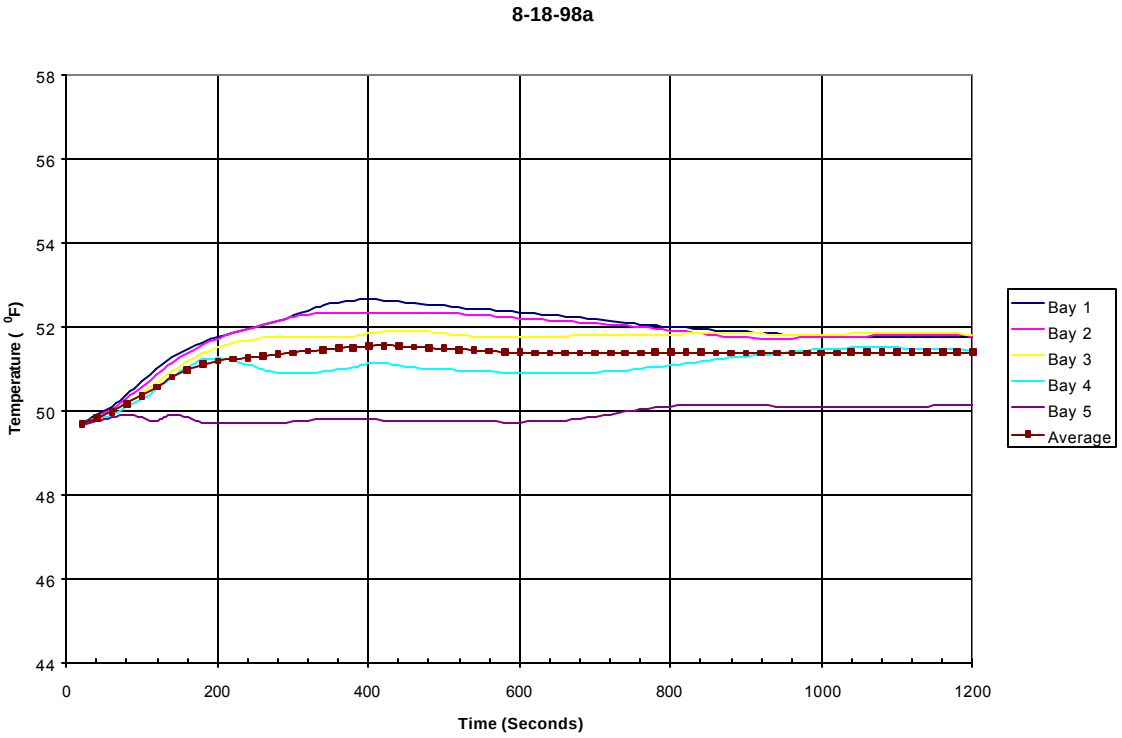

Figure 1N. Convergence graphic.

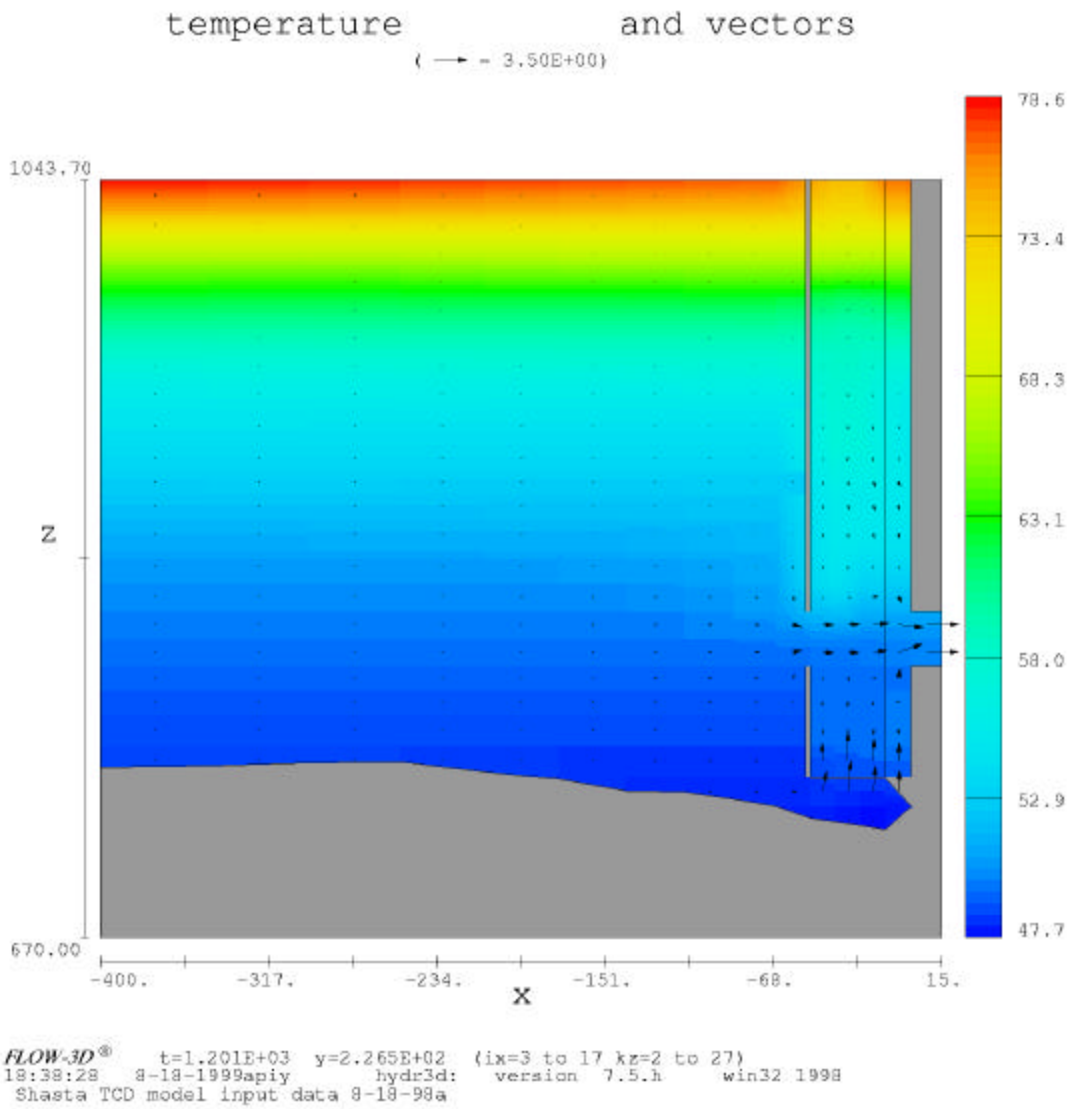

Figure 2N. Temperature Profile Through Penstock No. 5.

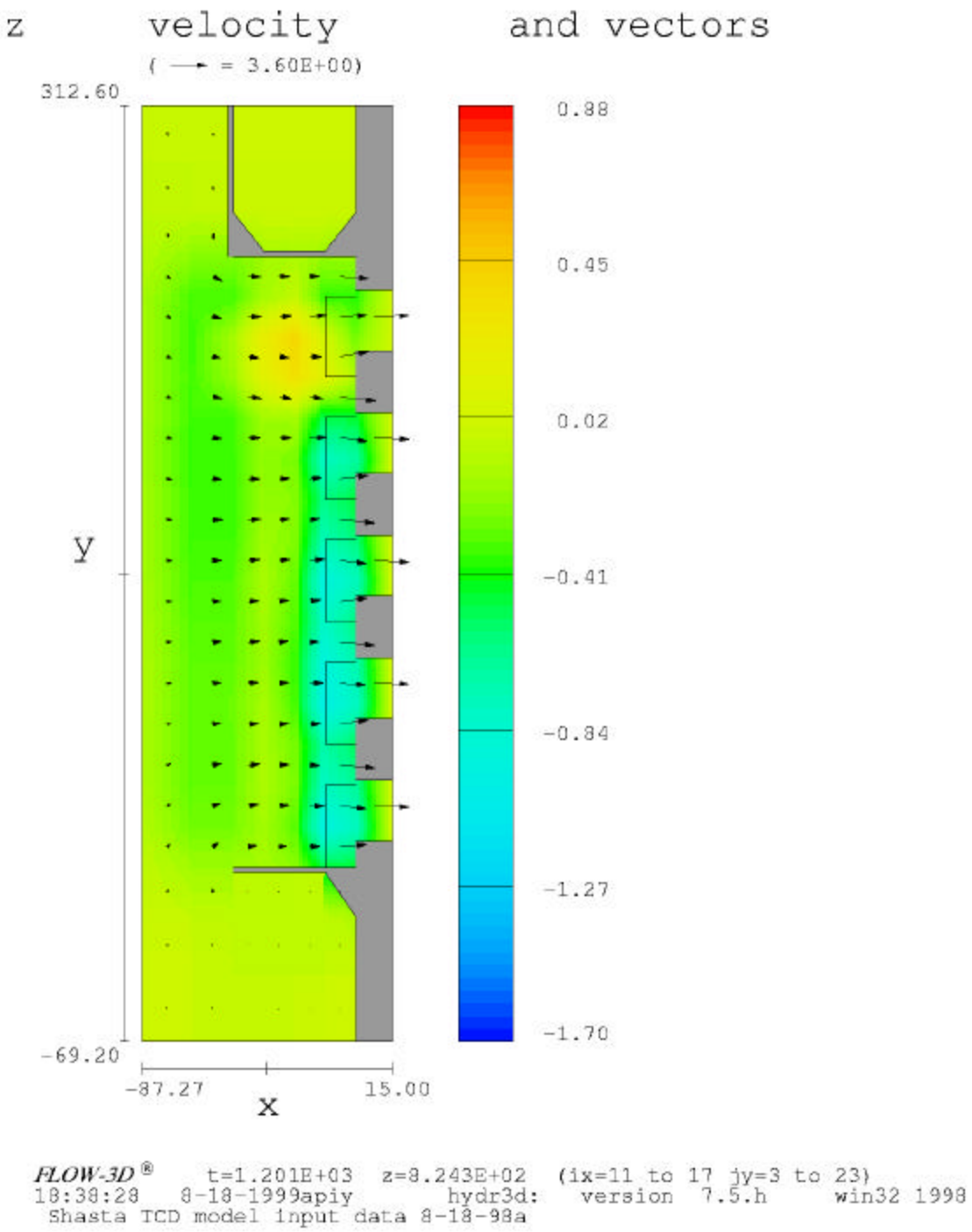

Figure 3N. Vertical Velocity Contours near the Top of the Lower Gates.

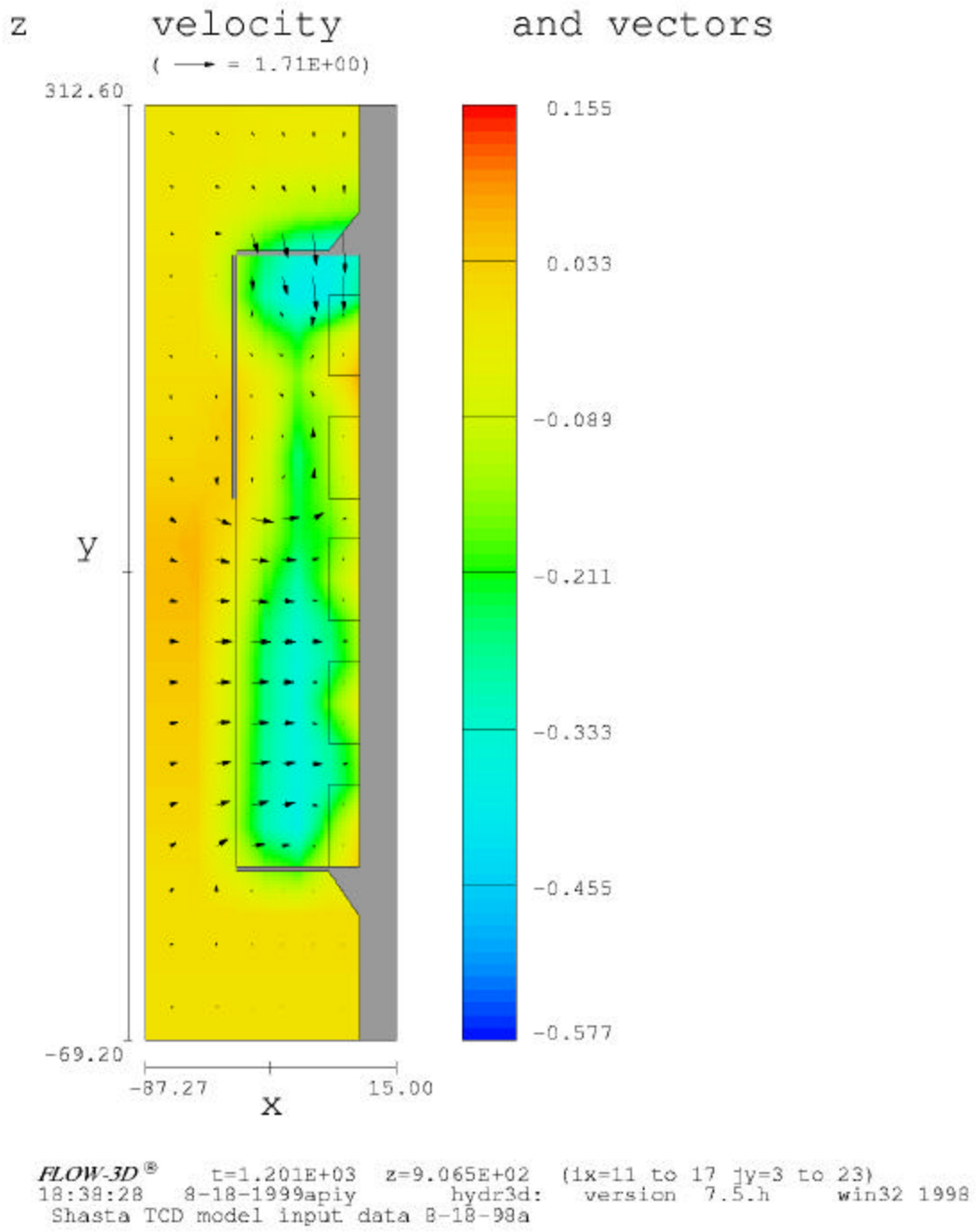

Figure 4N. Vertical Velocity Contours near the Bottom of the Middle Gates.

Appendix O – 8-18-1998b

Table 1O. PREP.DAT.

```
&Title
        t(1)='Shasta TCD model input data 8-18-98b'
        t(2)=''
        t(3)=''
        t(4)=''
        t(5)=''
/
&penstocks
        q(1)=2500
        q(2)=2500
        q(3)=2500
        q(4)=2500
        q(5)=2500
/
&gates
        iupper(1)=1
        iupper(2)=1
        iupper(3)=1
        iupper(4)=1
        iupper(5)=1
        imiddle(1)=1
        imiddle(2)=1
        imiddle(3)=1
        imiddle(4)=1
        imiddle(5)=1
        ipg(1)=1
        ipg(2)=1
        ipg(3)=1
        ipg(4)=1
        ipg(5)=1
        ill=0
/
&reser
        wsel=1043.7
        n_measure=20
        elev(1)=1043.70,    tempr(1)=79.70
        elev(2)=1037.73,    tempr(2)=79.61
        elev(3)=1014.72,    tempr(3)=68.14
        elev(4)=991.70,     tempr(4)=63.43
        elev(5)=968.69,     tempr(5)=59.71
        elev(6)=945.67,     tempr(6)=55.90
        elev(7)=922.66,     tempr(7)=54.32
        elev(8)=899.64,     tempr(8)=52.95
        elev(9)=876.63,     tempr(9)=51.71
        elev(10)=853.61,tempr(10)= 50.52
        elev(11)=830.60,    tempr(11)=49.78
        elev(12)=807.58,    tempr(12)=49.39
        elev(13)=784.57,    tempr(13)=49.00
        elev(14)=761.55,    tempr(14)=48.61
        elev(15)=738.54,    tempr(15)=48.22
        elev(16)=715.52,    tempr(16)=47.83
        elev(17)=692.51,    tempr(17)=47.44
        elev(18)=669.49,    tempr(18)=47.05
        elev(19)=646.48,    tempr(19)=46.66
        elev(20)=623.46,    tempr(20)=46.27
/
```

Table 2O. PREPIN.INP.

```
Shasta TCD model input data 8-18-98b
 $xput
    lpr=1,itb=0,iwsh=0,ifvis=0,epsadj=1.0,
    prtdt=10000.0,gz=-32.14,ipdis=1,
    nmat=1,iadix=1,iadiy=1,iadiz=1,
    iorder=1,ifrho=1,ifenrg=2,ichm=0,
    ihtrst=0, iresf1=0, irstoe=0, iscrst=0, itrst=0,
    idum1=   2500.000
    idum2=   2500.000
    idum3=   2500.000
    idum4=   2500.000
    idum5=   2500.000
    idum6=100,
    twfin=1200.,
    pltdt=1200.0,
    delt=0.01,
    deltr=0.0001
    sprtdt=20.0,
    HPLTDT=20.0,
 $end
 $limits
    irpr=1,jbkpr=1,ktpr=1,
 $end
 $props
    rhof=1.937,mui=2.25E-05,tstar=0.0000001,mu1=2.25E-05,mu2=2.25E-05,
 $end
 $scalar
     nsc=1,isclr(1)=0,
 $end
 $bcdata
    pbctyp=1.,
    tbc(1)=100.0,tbc(2)=60.0,tbc(3)=60.0,
    tbc(4)=60.0,tbc(5)=60.0,tbc(6)=60.0,
    wl=5,wr=6,wf=2,wbk=2,wt=2,wb=2,
    flhtl=1043.7,
 $end
 $mesh
  nxcelt=17,
    px(1)=-400.0,     nxcell(1)=10,
    px(2)= -50.0,     nxcell(2)=4,
    px(3)=   0.0,     nxcell(3)=1,
    px(4)=  15.0,
  nycelt=30,
    py(1)=-100.0,     nycell(1)=4,
    py(2)= 2.0,       nycell(2)=3,
    py(3)=52.0,       nycell(3)=3,
    py(4)= 102.0,     nycell(4)=3,
    py(5)= 152.0,     nycell(5)=3,
    py(6)=202.0,      nycell(6)=3,
    py(7)=251.0,      nycell(7)=6,
    py(8)=381.08,     nycell(8)=5,
    py(9)=500.0,
  nzcelt=100,
    pz(1)=670.0,      nzcell(1)=2,
    pz(2)=704.0,      nzcell(2)=1,
    pz(3)=720.0,      nzcell(3)=2,
    pz(4)=749.5,      nzcell(4)=2,
    pz(5)=780.0,      nzcell(5)= 2,
    pz(6)=804.0,      nzcell(6)= 2,
    pz(7)=831.0,      nzcell(7)= 4,
    pz(8)= 889.0,     nzcell(8)= 1,
    pz(9)= 900.0,     nzcell(9)= 3,
    pz(10)= 945.0,    nzcell(10)=4,
    pz(11)=1000.,     nzcell(11)= 3
    pz(12)=   1043.700
 $end
 $obs
  avrck=-2.1,
```

```
  nobs=19,
  iob(1)=1,xl(1)=0.0,xh(1)=100.0,zh(1)=1079.7,
  iob(2)=1,ioh(2)=0,yh(2)=12.5,yl(2)=-12.5,trny(2)=25.0,zh(2)=831.0,zl(2)=804.0,
  iob(3)=1,ioh(3)=0,yh(3)=12.5,yl(3)=-12.5,trny(3)=75.0,zh(3)=831.0,zl(3)=804.0,
  iob(4)=1,ioh(4)=0,yh(4)=12.5,yl(4)=-12.5,trny(4)=125.0,zh(4)=831.0,zl(4)=804.0,
  iob(5)=1,ioh(5)=0,yh(5)=12.5,yl(5)=-12.5,trny(5)=175.0,zh(5)=831.0,zl(5)=804.0,
  iob(6)=1,ioh(6)=0,yh(6)=12.5,yl(6)=-12.5,trny(6)=225.0,zh(6)=831.0,zl(6)=804.0,
  iob(7)=2,igen(7)=3,ioh(7)=1,
  iob(8)=3,xh(8)=0.01,xl(8)=-52.0,yh(8)=2.01,yl(8)=0.03,zh(8)=1045.01,zl(8)=999.99,
  iob(9)=3,xh(9)=0.01,xl(9)=-52.0,yh(9)=253.0,yl(9)=250.99,zh(9)=1045.01,zl(9)=999.99,
  iob(10)=3,xh(10)=-49.99,xl(10)=-52.0,yh(10)=253.0,yl(10)=0.03,zh(10)=1045.01,zl(10)=999.99,
  iob(11)=4,opor(4)=0.004015302,xh(11)=0.01,xl(11)=-50.01,yh(11)=2.01,yl(11)=0.03,zh(11)=1000.01,zl(11)=944.99,
  iob(12)=5,opor(5)=0.003884098,xh(12)=0.01,xl(12)=-50.01,yh(12)=253.0,yl(12)=250.99,zh(12)=1000.01,zl(12)=944.99,
  iob(13)=6,opor(6)=0.0051328,xh(13)=-49.99,xl(13)=-52.0,yh(13)=253.0,yl(13)=0.03,zh(13)=1000.01,zl(13)=944.99,
  iob(14)=7,opor(7)=0.004351858,xh(14)=0.01,xl(14)=-50.01,yh(14)=2.01,yl(14)=0.03,zh(14)=945.01,zl(14)=899.99,
  iob(15)=8,opor(8)=0.020888367,xh(15)=0.01,xl(15)=-50.01,yh(15)=253.0,yl(15)=250.99,zh(15)=945.01,zl(15)=899.9,
  iob(16)=9,opor(9)=0.007301943,xh(16)=-49.99,xl(16)=-52.0,yh(16)=253.0,yl(16)=0.03,zh(16)=945.01,zl(16)=899.99,
  iob(17)=10,opor(10)=0.003534187,xh(17)=0.01,xl(17)=-50.01,yh(17)=2.01,yl(17)=0.03,zh(17)=900.01,zl(17)=830.99
  iob(18)=11,opor(11)=0.006766415,xh(18)=0.01,xl(18)=-50.01,yh(18)=253.0,yl(18)=250.99,zh(18)=900.01,zl(18)=830.99
  iob(19)=12,opor(12)=0.003110806,xh(19)=-49.99,xl(19)=-52.0,yh(19)=253.0,yl(19)=0.03,zh(19)=900.01,zl(19)=830.99,
  iob(20)=13,opor(13)=0.00536379,xh(20)=0.01,xl(20)=-50.01,yh(20)=2.01,yl(20)=0.03,zh(20)=831.01,zl(20)=803.9,
  iob(21)=14,opor(14)=0.0099,xh(21)=-49.99,xl(21)=-52.0,yh(21)=253.0,yl(21)=0.03,zh(21)=831.01,zl(21)=803.99,
  iob(22)=15,opor(15)=0.007382123,xh(22)=0.01,xl(22)=-50.01,yh(22)=2.01,yl(22)=0.03,zh(22)=804.01,zl(22)=779.9,
  iob(23)=16,opor(16)=0.003032684,xh(23)=-49.99,xl(23)=-52.0,yh(23)=253.0,yl(23)=0.03,zh(23)=804.01,zl(23)=779.99,
  iob(24)=3,xh(24)=0.01,xl(24)=-50.01,yh(24)=202.01,yl(24)=201.0,zh(24)=780.01,zl(24)=749.51,
  iob(25)=3,xh(25)=0.01,xl(25)=-50.01,yh(25)=253.0,yl(25)=250.99,zh(25)=831.01,zl(25)=719.99,
  iob(26)=17,opor(18)=0.00829452,xh(26)=-49.99,xl(26)=-52.0,yh(26)=253.0,yl(26)=201.0,zh(26)=780.01,zl(26)=749.51,
  iob(27)=18,opor(18)=0.00829452,xl(27)=-52.0,yh(27)=202.2,yl(27)=0.03,zh(27)=780.01,zl(27)=779.0,
  iob(28)=19,opor(19)=0.019110575,xl(28)=-52.0,yh(28)=253.0,yl(28)=201.0,zh(28)=749.51,zl(28)=748.50,
  iob(29)=3,xl(29)=-52.0,yh(29)=382.08,yl(29)=250.99,zh(29)=892.06,zl(29)=888.99,
  iob(30)=3,xh(30)=-49.99,xl(30)=-52.0,yh(30)=382.08,yl(30)=250.99,zh(30)=892.06,zl(30)=719.99,
  iob(31)=3,xl(31)=-52.0,yh(31)=382.08,yl(31)=381.07,zh(31)=892.06,zl(31)=719.99,
  iob(32)=3,ioh(32)=0,yh(32)=270.,yl(32)=210.,xh(32)=-2.0,xl(32)=-48.0,zh(32)=888.9,zl(32)=750.0,
  iob(33)=3,zh(33)=-1000.0,
  iob(34)=3,zh(34)=-1000.0,
  iob(35)=3,zh(35)=-1000.0,
  iob(36)=3,zh(36)=-1000.0,
  iob(37)=3,zh(37)=-1000.0,
  iob(38)=3,zh(38)=-1000.0,
  iob(39)=3,zh(39)=-1000.0,
  iob(40)=3,zh(40)=-1000.0,
  iob(41)=3,zh(41)=-1000.0,
  iob(42)=3,zh(42)=-1000.0,
  iob(43)=3,zh(43)=-1000.0,
  iob(44)=3,zh(44)=-1000.0,
  iob(45)=3,zh(45)=-1000.0,
  iob(46)=3,zh(46)=-1000.0,
  iob(47)=3,zh(47)=-1000.0,
 $end
 $fl
   presi=0.0,nfls=1,
   flht=   1043.700
 $end
 $bf
   nbafs=4,pbaf(1)=0.9143,
    ibaf(1)=1,bxh(1)=0.0,bxl(1)=-50.0,by(1)=0.0,bzh(1)=1066.6,bzl(1)=1044.99,
    ibaf(2)=1,bxh(2)=0.0,bxl(2)=-50.0,by(2)=250.0,bzh(2)=1066.6,bzl(2)=1044.99,
    ibaf(3)=1,bx(3)=-50.0,byh(3)=250.0,byl(3)=0.0,bzh(3)=1066.6,bzl(3)=803.99,
   pbaf(2)=0.6785,
    ibaf(4)=2,bra(4)=16.8333,bxh(4)=0.01,btrny(4)=25.0,bzl(4)=780.0,
    ibaf(5)=2,bra(5)=16.8333,bxh(5)=0.01,btrny(5)=75.0,bzl(5)=780.0,
    ibaf(6)=2,bra(6)=16.8333,bxh(6)=0.01,btrny(6)=125.0,bzl(6)=780.0,
    ibaf(7)=2,bra(7)=16.8333,bxh(7)=0.01,btrny(7)=175.0,bzl(7)=780.0,
    ibaf(8)=2,bra(8)=16.8333,bxh(8)=0.01,btrny(8)=225.0,bzl(8)=749.5,
    ibaf(9)=3,bra(9)=16.8333,bxh(9)=0.01,bzl(9)=895.69,btrny(9)=25.0,
    ibaf(10)=3,bra(10)=16.8333,bxh(10)=0.01,bzl(10)=895.69,btrny(10)=75.0,
    ibaf(11)=3,bra(11)=16.8333,bxh(11)=0.01,bzl(11)=895.69,btrny(11)=125.0,
    ibaf(12)=3,bra(12)=16.8333,bxh(12)=0.01,bzl(12)=895.69,btrny(12)=175.0,
    ibaf(13)=3,bra(13)=16.8333,bxh(13)=0.01,bzl(13)=895.69,btrny(13)=225.0,
   pbaf(4)=0.0,
```

```
    ibaf(14)=4,bz(14)=780.0,byh(14)=98.0,byl(14)=52.0,bxh(14)=0.0,bxl(14)=-50.0,
    ibaf(15)=4,bz(15)=780.0,byh(15)=198.0,byl(15)=152.0,bxh(15)=0.0,bxl(15)=-50.0,
 $end
 $temp
    tempi=100.0,ntmp=1,
 $end
 $grafic
    nvplts=0,
 $end
 $parts
 $end
```

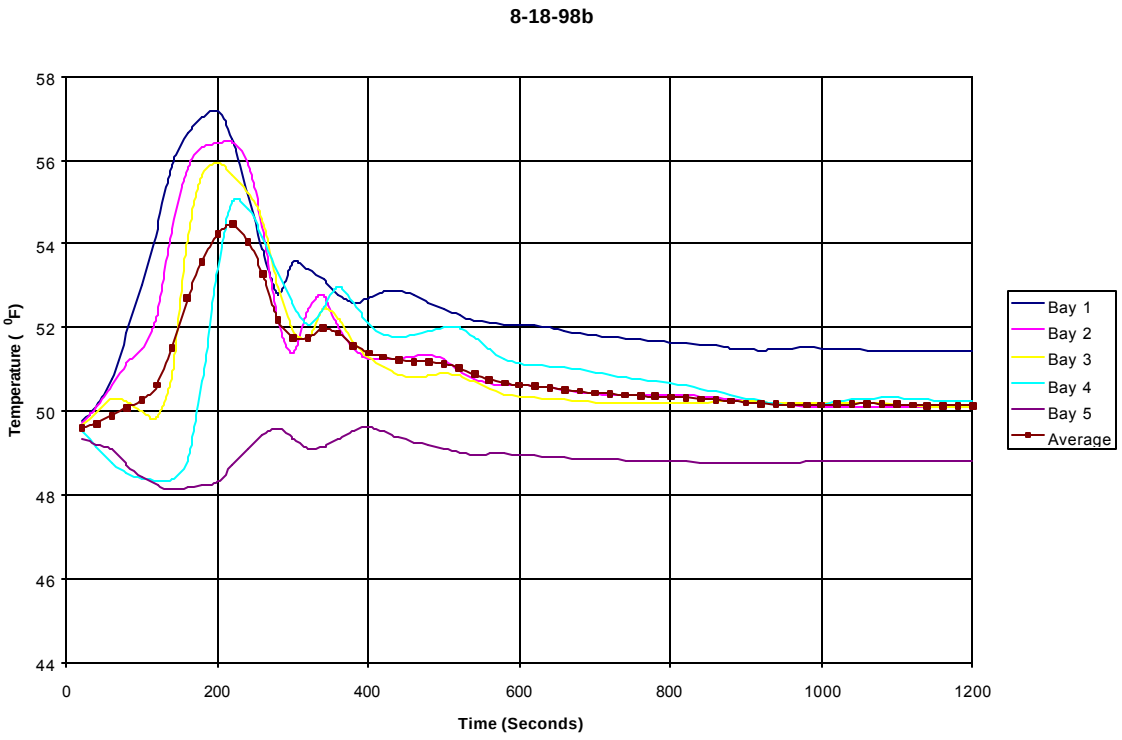

Figure 1O. Convergence graphic.

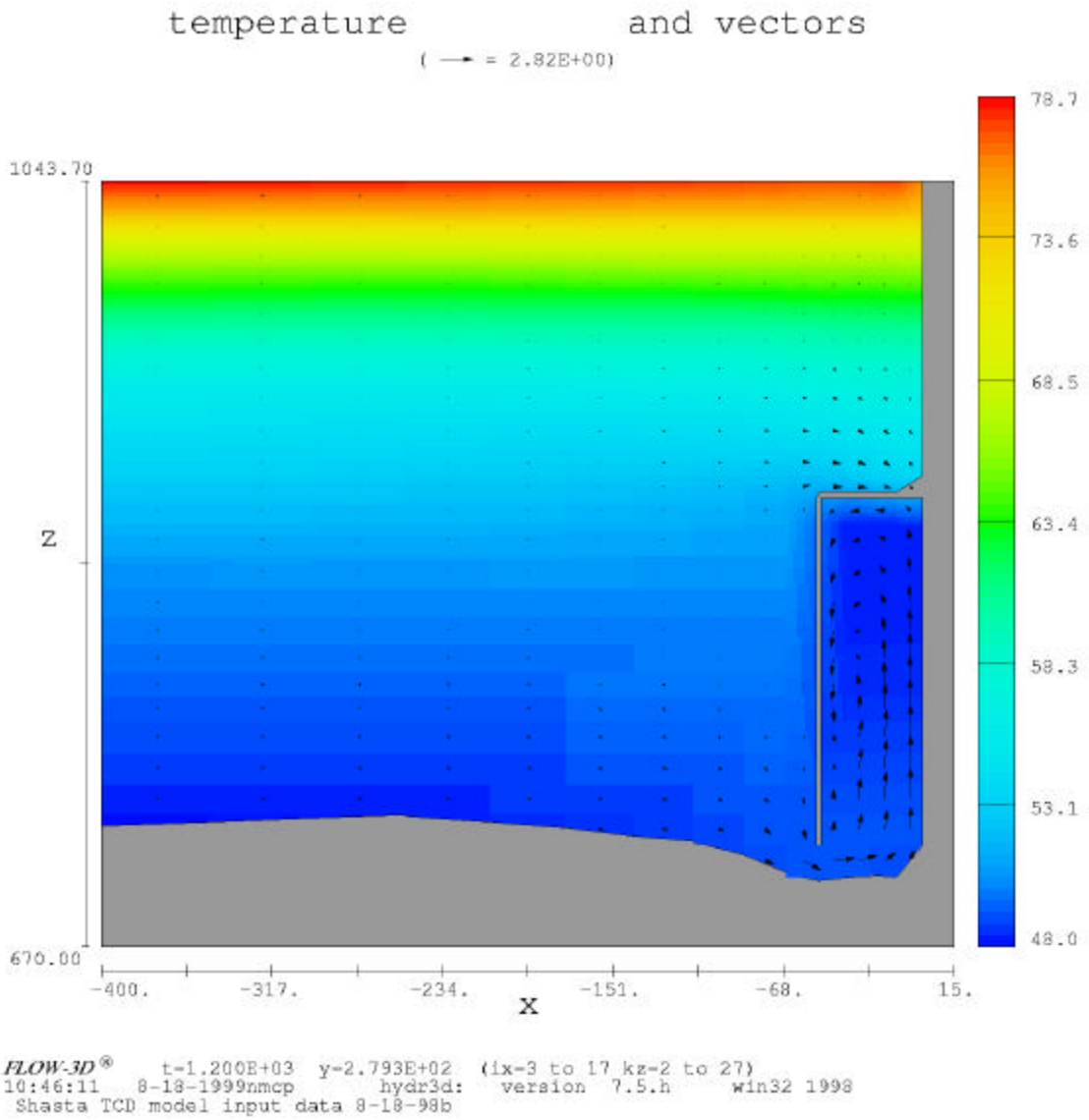

Figure 2O. Temperature Profile Through the Low Level Intake Structure.

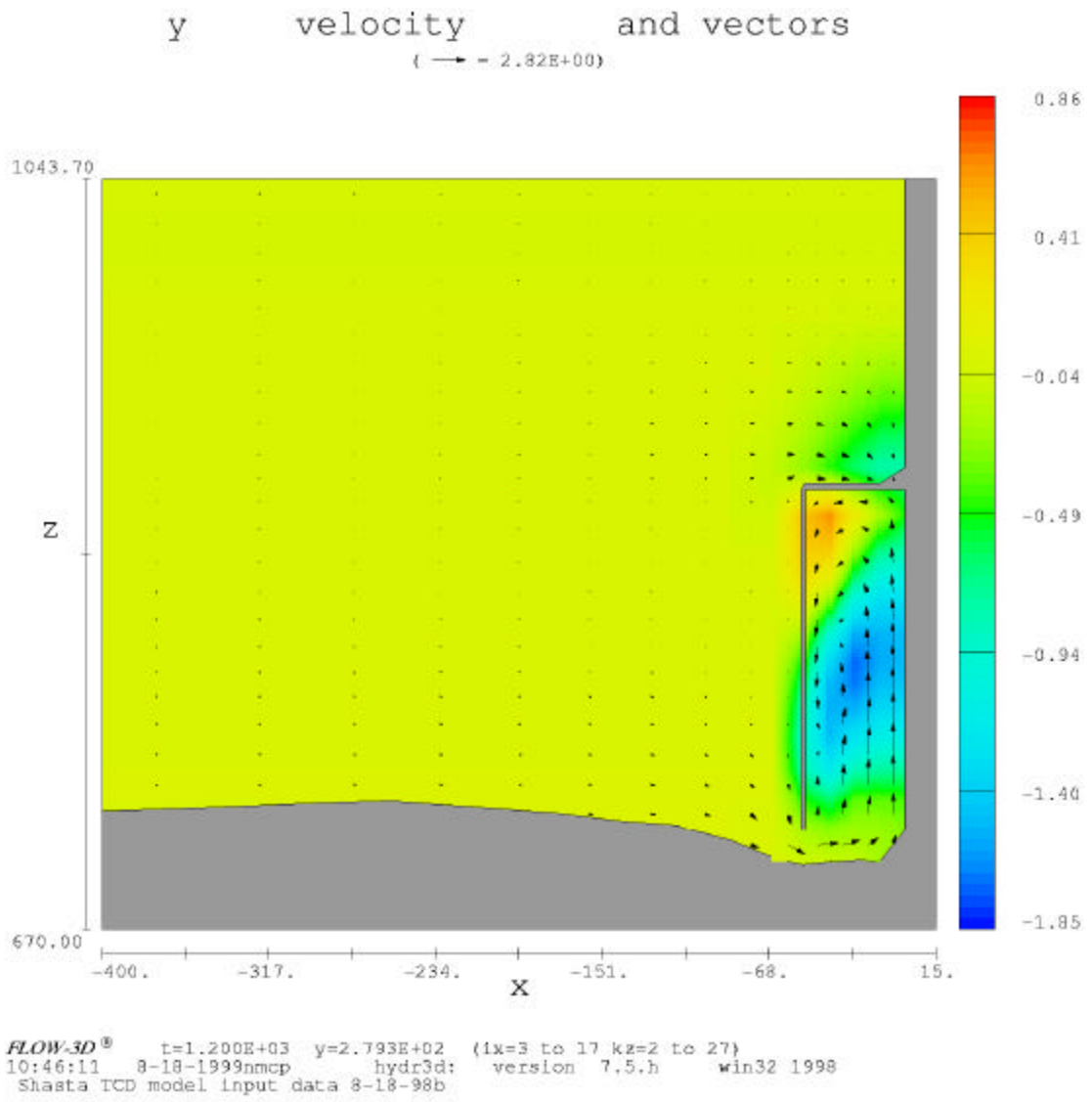

Figure 3O. Velocity Contours Through the Low Level Intake Structure.