Initial Simulations of 2000–2003 Flows and Water Quality in the San Joaquin River Using the DSM2-SJR Model

Introduction

The California Department of Water Resources (DWR) created the DSM2-SJR model by modifying the DSM2 model of the Delta to represent the San Joaquin River from Stevinson to Vernalis. Tributaries are not currently part of the model, but they are represented as inflows to the San Joaquin River in the input data files. DWR originally ran the “Hydro” portion of the model to simulate flow and the “Qual” portion of the model to simulate electrical conductivity (EC) for June 1997 through September 1999. The Qual portion of the DSM2 model is capable of simulating many additional water quality constituents, but these constituents were not initially simulated by DWR.

The original DWR work was described in Chapter 5 of DWR’s 2001 Annual Progress Report (Pate 2001). More recently, DWR has extended the simulation period back to January of 1990 (Wilde 2004).

The purpose of this report is to describe:

- the hydraulic channel geometry in the model
- the contents of two Excel spreadsheets used to manage data input and evaluate model output
- the modifications that were made to the original files received from DWR, and
- the initial model results for calendar years 2000 through 2003.

HydroQual staff are using the DSM2-SJR model to perform initial water quality modeling for the 2000-2003 calendar years.

San Joaquin River Hydraulic Geometry

The water quality model of the lower San Joaquin River from the upstream gage at Stevinson (Lander Avenue, Highway 165) to the downstream gage at Mossdale (I-5 bridge) requires that the hydraulic geometry (i.e., conveyance area, surface area, volume, and average depth as a function of flow) be developed and described using channel cross-section data collected along the river. Although the DSM2 model must calculate these volume and surface area properties along the river for each day of flow conditions, there is currently no method to request this geometry information from the DSM2 model as output. Only stage, flow, and velocity can be requested as output from the hydraulic model. Therefore, a brief summary of these hydraulic geometry values will provide a good foundation for understanding the water quality changes observed along the river.
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River Mile Locations

The length of the channel between the cross-sections is always uncertain because of the curves in the river channel. The river miles of the cross sections and river features (bridges and tributaries and pumping stations) must be located along the river using a standard river mile designation. Some of the USGS quad sheets (7.5 minute 1:24000 scale) include river mile marks (unfortunately, several do not). Sometimes the channel has shifted, and a few bends are now cut off from the channel as oxbow lakes, so there are a few ”missing” miles along the river.

Table 1 gives the DSM2-SJR model segment upstream boundary locations, listed by river mile, with specific geographic landmarks. The tributary and local inflows and diversions are specified at DSM2 model nodes, which are located at the upstream end of segments with the same numbers. The assumed length of the model segments is given. The DSM2 model river segments vary in length, but average about 1.25 miles long. There are 60 segments along the 76 miles that separate the Stevinson gage (SJR mile 132) from the Mossdale station (SJR mile 56).

An earlier model of the San Joaquin River for estimating monthly flow and salinity was prepared by Charlie Kratzer and others while they worked for the SWRCB in 1987; the model was called the SJR Input-Output (SJRIO) model (Kratzer et al. 1987). This SJRIO report remains the most comprehensive review of water budget and salinity budget information for this portion of the SJR. This model used one-mile segments to account for the flow (inflows and diversions) and salinity along the river from the Lander Avenue bridge (i.e., Stevinson gage) to the Airport Way bridge (i.e., Vernalis gage). The reported distance was 60.5 miles, using the US Army Corps of Engineers (COE) river miles from the 1984 Aerial Atlas of the SJR (which generally match the USGS quad sheet mile marks). This 1984 atlas indicated that the Stevinson Gage was at mile 133, and the Vernalis gage was at mile 72.5. The study period was 1977 through 1985.

The DSM2 model begins at the Bear Creek gage (node 653) that is about 2 miles upstream of Lander Avenue. The river mile location of the Stevinson gage (node 652) is uncertain, because the river channel wanders in this region, but is placed at SJR mile 132 in the model configuration. The first major inflows below the SJR Stevinson Gage are Salt Slough (SJR mile 129) and Mud Slough (with two mouths at mile 124 and 121) that drain westside agricultural and wildlife refuge wetlands. The Fremont Ford gage (SJR mile 125 is located downstream of Salt Slough but upstream of the two mouths of Mud Slough.

The Merced River (SJR mile 118) enters just upstream of the Hills Ferry bridge where the Newman gage is located (SJR mile 117). The Orestimba Creek enters from the Westside coastal mountains at SJR mile 109, just upstream of the Crows Landing bridge gage at SJR mile 108. The Patterson Road bridge and gage is located at SJR mile 99. The Patterson main canal and pumping plant is located at SJR mile 98. Del Puerto Creek enters from the westside at SJR mile 93. Grayson Road Bridge is located at SJR mile 89. The West Stanislaus main canal pumping plant is located at SJR mile 85, just upstream of the Tuolumne River mouth at SJR mile 84. Hospital and Ingram Creeks join with their mouth at SJR mile 83.

The Maze Road Bridge is located at SJR mile 77, just upstream of the Stanislaus River mouth at SJR mile 75. The Vernalis gage is located at SJR mile 72. The Banta-Carbona main canal and pumping plant is located at SJR mile 63. The Paradise Cut flood bypass weir is located at SJR mile 61, and the Mossdale Bridge and water quality monitoring station is located at SJR mile 56. There is about 1.5 miles of the old channel missing between Paradise Cut and Mossdale because of an Oxbow lake that has been cut-off from the main channel. The DSM2 model was extended from Vernalis to Mossdale to allow the extensive hourly water quality monitoring records from Mossdale to be used to calibrate the model results for EC, temperature, DO, pH, and algae (fluorescence).

SJR Channel Hydraulic Geometry

The hydraulic geometry of the San Joaquin River is simply the shape of the river channel as a function of flow. It is summarized as the surface elevation (stage), volume, downstream conveyance area, surface area, and average depth associated with each river section over the range of river flows. The river segment surface area and volume can be used to calculate many useful parameters that influence water quality. The volume determines the travel time (i.e., travel time = volume/flow). The surface area determines the primary productions that can occur, because the solar radiation input and average depth [i.e., average depth = volume/area] depend on the area. The surface area also controls the surface heat exchange and the re-aeration processes that affect DO and pH (i.e., CO_2 equilibrium). The surface width and average depth determine the average conveyance area and the average velocity in the segment. The surface elevation and bottom elevation give the maximum water depth.

The model calculates the flow, stage and velocity at each channel cross-section, but the stream geometry parameters are not provided as model output. To determine the model hydraulic geometry, the channel cross-sections that are specified in the input files (as top width and hydraulic radius values for several stage elevations) were extracted and used in a spreadsheet to calculate the geometry parameters for each model segment for a range of specified flows (Table 2). The DSM2 hydraulic model was run for a series of steady flows (specified for 10-day periods) and the resulting stages and velocities were output and evaluated with the cross section data. The range of flows evaluated was from 100 cfs to 50,000 cfs. This is the full range of expected flows along the SJR.

There are a total of 95 cross-sections used in the SJR-DSM2 model between Stevinson and Mossdale. There are 60 model segments, so several of the segments have only one cross-section. The model assumes linear (prismatic) channels between the cross-sections. The cross-sections include the conveyance area (A), the perimeter (P) and the surface width (W), as well as the hydraulic radius (A/P). The bottom stage is given for each cross-section.

The model stage and velocity can be used to determine the geometry at each of these cross-sections. The stage at each cross-section along with the bottom elevation provides a useful initial characterization of the general slope and depth of the river as a function of flows. Figure 1 shows the SJR channel bottom and surface water elevations for a range of flows from 1,000 cfs to 10,000 cfs. The average bottom slope is about one foot per mile, because the bottom drops from about 60 feet msl at mile 135 to about –10 feet msl at mile 60. The surface water slope is, of course, similar.

When these calculations were made for the initial DSM2-SJR model geometry values, several of the results looked suspicious, such as a large drop in water surface and a very wide channel upstream of the Tuolumne River, and travel times that were too long compared with dye study measurements. DWR reviewed the geometry cross-sections and found several that were erroneous. The San Joaquin River geometry values were updated and the following results are from the revised geometry.

Figure 2 shows an example of the hydraulic calculations from the DSM2 model. There is a single cross-section for model segment 624 at San Joaquin River mile 99 (Patterson gage). Figure 2a shows the model results for stage and velocity as a function of flow. Figure 2b shows the surface width calculated for a range of flows. The velocity and stage increase with a characteristic power curve. The stage at low flows must be controlled by a downstream section, because the minimum water surface is about 30 feet msl, while the bottom of the channel is about 24 feet msl. The top of the cross-section is at 43 feet, but the model simulates much higher elevations at flows above 10,000 cfs. The DSM2 model is supposed to hold the width constant above the top data elevation, but the spreadsheet extrapolates width using the top two data points. The simulated stage for 1,000 cfs, 2,000 cfs, 5,000 cfs and 10,000 cfs are within geometry data; flows of 20,000 cfs, 30,000 cfs, 40,000 cfs and 50,000 cfs use extrapolated geometry. Because the DSM2 model does not allow the calculated geometry (i.e., width, surface area, average depth) to be selected as output, it is difficult to check these values or know what exactly the model asumes.

The downstream conveyance area can be calculated from the model flow divided by the model velocity, or can be estimated from the stage and the area table given for each cross-section. The stage values are used to interpolate the surface width from the cross-section tables. The surface area is the length of the segment times the average width at the upstream and downstream ends of the segment. The volume is calculated as the length times the average of the upstream and downstream conveyance areas. The average depth is the volume divided by the surface area, and the travel time is the volume divided by the flow.

The river hydraulic geometry has been summarized in a series of tables (Table 3-10) for each of the model segments. The model segments may include one or more cross-sections. Channel widths, and volumes are linear interpolated between cross-sections and divided into model segments at the model node locations.

Figure 3 shows the surface width along the San Joaquin River for a range of flows from 1,000 cfs to 5,000 cfs. Figure 4 shows the cumulative surface area from the upstream end of the river, indicating the potential for surface heat exchange and primary productivity of algae and macrophytes (i.e., tule, cattails, or water hyacinth). Although the river width varies considerably along the river, the average increase in surface area is relatively linear. The total area along the 75-mile reach is about 1,899 acres with a flow of 1,000 cfs. This area represents the low flow channel area with pools behind the channel controls along the river. At a flow of 2,000 cfs the area increases to about 2,384 acres; at a flow of 3,000 cfs the total area is 3,783 acres; at a flow of 4,000 cfs the area is 3,106 acres, and with a flow of 5,000 cfs the area is about 3,368 acres (Table 8). The river width is expanding more slowly as the flows increase.

Figure 5 shows the average depth along the San Joaquin River, for the range of flows between 1,000 cfs and 5,000 cfs. Figure 6 shows the corresponding travel times (in hours) between the upstream end of the San Joaquin River and Mossdale for the same range of uniform flows between Stevinson and Mossdale. The travel time is the river volume divided by the flow. Generally the travel time decreases at higher flows. The travel time is about 4 days (92 hours) at a flow of 1,000 cfs, about 3 days (72 hours) at a flow of 2,000 cfs, and about 2.7 days (64 hours) at a flow of 3,000 cfs. The travel time is about 2.5 days (59 hours) at 4,000 cfs and 55 hours at 5,000 cfs. The change in travel time at higher flow is relatively small, with a travel time of 2 days at a uniform flow of 10,000 cfs.

Simulated River Stage Variations

Comparison of the measured and simulated San Joaquin River stages (elevations of water surface) at various gages locations along the river channel provides a general testing of the simulated river channel hydraulic geometry. Figure 7 shows the simulated and measured stage variations between high and low San Joaquin River flow at the Patterson and Vernalis locations for 2000. The simulated stages at higher flows (i.e., 6,000 cfs at Paterson, 16,000 cfs at Vernalis) generally match the measured stages. The match is not quite as good at Vernalis at lower flows. Confirmation of the channel geometry along the entire river channel will require more stage, depth, and width measurements at a range of flows.

USGS Travel Time Studies

The USGS has conducted a series of dye tracer releases along the San Joaquin River (Kratzer and Biagtan 1997). These data provide information to confirm the hydraulic geometry of the DSM2-SJR model. The initial DSM2-SJR model geometry was too large, with travel times that were substantially higher than the dye tracer studies would suggest. The modified geometry now matches the USGS dye study results. For example, a release near the mouth of the Merced River on February 8, 1994, with a Vernalis flow that increased from about 1,500 cfs to 3,000 cfs, indicated that the measured dye tracer travel time was about 38 hours. The DSM2 model travel time between the Merced River and the Vernalis is 55 hours at a uniform San Joaquin River flow of 1,000 cfs, 46 hours at a flow of 1,500 cfs, 44 hours at a flow of 2,000 cfs, and 37 hours at a flow of 3,000 cfs. The average SJR flow during the February tracer study was less than the Vernalis flow, and so the simulated travel times are somewhat greater (120%) than measured at this flow (assumed average uniform flow of 1,500 cfs).

A second dye release was made into Salt Slough on June 20, 1994. The Newman flow was about 300 cfs, the Patterson flow was about 500 cfs, and the Vernalis flow was about 1,200 cfs. The travel time from Newman to Patterson (20 miles) was about 24 hours, and the travel time from Patterson to Vernalis (26 miles) was about 30 hours. The measured travel time from Newman to Vernalis was about 54 hours, and the model travel time for a uniform flow of 750 cfs was 53 hours, nearly identical to the measured time. The adjustments that were made by DWR in the model geometry appear to give very reliable river volumes for these relatively low flows of 750 cfs to 1500 cfs, which are of most interest in water quality modeling.

Modifications to Original Version of DSM2-SJR

The original DSM2-SJR simulation files were changed in several ways that extended and simplified the modeling.

Extension to Mossdale – Mossdale is located on the San Joaquin River downstream of Vernalis and Paradise weir, but upstream of the head of Old River. It is in channel 6 of the DSM2 model of the Delta. Because data for many water quality constituents are collected at Mossdale, the DSM2-SJR model was extended downstream to include Mossdale. The model was extended by incorporating channel segments 1 through 6 from the DSM2 model of the Delta.

Combining Flows – The original version of the model had an input file for groundwater with 31 separate flows and an input file for agricultural flow with 17 diversions and 29 return flows. To simplify the data processing and evaluation of the effects of these flows, these flows were combined into one set each of agricultural diversions, agricultural drains, and groundwater inflows. The groundwater flows were made to enter the river at node 604 and the agricultural flows were made to enter and leave the river at node 610. The location description for these combined flows was included in the *input-hydro.inp* file along with the location descriptions for the inflows from the major tributaries and major agricultural flows that were originally present in the *input-rim_sjr-rt.inp* file. An additional simplification was that the flows for Hospital, Ingram, and Del Puerto Creeks were combined with the Orestimba flows.

Removal of Constant Accretion Flows – In the original model files for 1997-1999, the file with descriptions of the time series inputs (*input-rim_sjr-rt.inp*) specified 2 constant accretions flows, 150 cfs upstream of Vernalis and 200 cfs upstream of Patterson. This constant additional inflow of 350 cfs was also added by DWR to the 1990-1997 simulations. These flows had been added to improve the model estimates of flows at the downstream end of the San Joaquin River. For the initial 2000-2003 simulation, these constant accretions were removed because the mismatch between the gaged and estimated flows can be used to help identify the source of this water.

Organization of DSS input files – Time series model input is stored in DSS format, the format of the Data Storage System of the U.S. Army Corps of Engineers Hydrologic Engineering Center (HEC).

The original DSS time series files were organized by the type of data they contained (water quality and flow, with separate files for groundwater and agriculture). Some of these files contained large amounts of data with variable time steps. When evaluating data in a spreadsheet it is convenient to place together data with the same time steps. For this reason and to better understand the contents of the DSS files, the time series data were placed in input/output interface spreadsheets based on their time step. The tables in the interface spreadsheet were used to manipulate and view the data and to create new DSS input files. For the new simulations, there were 3 DSS input files, one for hourly data (meteorology), one for daily data (for major tributaries), and one for monthly data (agricultural and groundwater flows). A DSS utility is needed to allow the Excel file to import and export DSS files.

Simulation of Water Temperature – Water temperature was not included in the original version of the DSM2-SJR model. To include water temperature in the simulation, meteorological data for air temperature, wind speed, and wet bulb temperature must be provided as input. Hourly air temperature and wind speed data came from the California Irrigation Management Information System (CIMIS) stations at Lodi (stations 42 and 166). Wet bulb temperatures were calculated using the air and dew point temperatures form the Lodi CIMIS stations.

The model does not use measured solar radiation. Instead, it calculates solar radiation based on latitude, elevation, dust attenuation, and cloud cover. Cloud cover and atmospheric pressure can be specified as time series, but they are currently specified as constants in the *input-qual.inp* file. Cloud cover was assumed to be a constant of zero and atmospheric pressure was assumed to be a constant of 29 (inches of mercury).

The model applies the meteorological conditions to the entire system. For the model to use the meteorological data, a system-wide location name must be included in the *translations_SJR.inp* file. This location name must be “Delta” because the name specification has not been modified from the Delta version of the model.

For the simulation of water temperature, information for light extinction, location, dust attenuation, and evaporation were added to the *scalar.inp* file. All of these values are constants. In reality, light extinction varies with time and location along the river because of changes in particulates.

The *input-qual.inp* file specifies the location of the meteorological time series file (*sjr-hour.dss*) and provides the meteorological constants (cloud cover and atmospheric pressure). This file also includes the file location for the water temperature associated with all of the inflows. For the initial simulation, groundwater was assumed to have a constant temperature of 65°F and all other inflows (tributaries and agricultural returns) were assumed to have a temperature equal to the average daily air temperature at Lodi. In the future, inflow temperatures should be modified to use any measured water temperature data that are available for the inflows.

Input/Output Interface Files

There are multiple input and output files for the DSM2 model. To simplify the assessment of model inputs and outputs, two interface files were created, an hourly file (*IO Interface Hourly.xls*) and a monthly/daily file (*IO Interface MonDay.xls*). Each of these files contains the data that were used to generate the DSS time series inputs to the model as well as model results and measured data. The interface files contain data for 2000-2003, although some of the historic data go as far back as 1997. Yellow highlighting or red text indicates that the data had to be estimated because they were not available from the original DWR files or other data sources. These interface files are the primary tool for calibrating the DSM2-SJR model to match available field data.

Monthly/Daily Interface File

The contents of this file are described for each sheet in the file.

“Inputs Monthly” – This sheet contains the estimated monthly average flows for agricultural diversions, agricultural returns, the Modesto Wastewater Treatment Plant, and Ground Water. In addition, there are monthly estimates of EC corresponding to the monthly inflows. The input file *SJR-Month.DSS* is created from this sheet. HEC provides the DSS add-in for Excel that allows for the creation of DSS files from Excel tables (web site: http://www.hec.usace.army.mil/software/hec-dss/hecdss_msexcel_addin.htm).

In this sheet, the “all-gw” data is the sum of all estimated groundwater inflows and the “all-pumping” data represents all agricultural diversion and return flows that are not explicitly included elsewhere in the monthly data set. The monthly values prior to November 2000 came from the original DWR files. The more recent monthly values were estimated using the DWR values for prior years. One exception is the Banta-Carbona Irrigation District (BCID) data, which came from BCID data files. This is the major diversion in the extended portion of the model between Vernalis and Mossdale.

“Inputs Daily” – This sheet contains daily flow and EC values for the major tributaries to the modeled portion of the San Joaquin River: San Joaquin River at Stevinson, Salt Slough, Mud Slough, Merced River, Orestimba Creek, Tuolumne River, and Stanislaus River. In general, the flow and EC data are derived from data sources such as the California Data Exchange Center (CDEC).

Because flows from Del Puerto, Ingram, and Hospital Creeks are small, they were included with the Orestimba Creek flows. Some of the low flow values for Stevinson were raised to a minimum of 20 cfs in order to enable the temperature simulation to run through the entire 2000-2003 simulation period.

Estimated inflow temperatures are also included in the daily input file.

This sheet also contains a table on the right that calculates flow at major diversion sites. The calculations use the model inputs for daily and monthly flow. These calculations help to detect whether there are any locations with zero or negative flows. For example, these calculations indicated that the estimated WSID diversions for May and June of 2002 were too large, so they were reduced to maintain a positive river flow.

“Daily Output” – This sheet contains daily model output in two separate blocks, one for Hydro and one for Qual. It also contains some values derived from the output for evaluation purposes. Output is retrieved from the output DSS file by using the DSS add-in for Excel. The model output is retrieved in numerical order by node number.

“Hist Daily” – This sheet contains historic measured data. These data are used to evaluate model inputs as well as outputs.

“Graphs Inputs” – This sheet contains graphical evaluation of model inputs. Model inputs are compared to measured data. Generally the model inputs are the same as the measured data. The temperature graphs indicate that the daily average air temperature at Lodi (the initial input temperature for tributary and agricultural inflows) is not the same as the measured temperatures at Stevinson.

“Graphs Outputs” – This sheet contains graphs for evaluating model performance. There are comparisons of measured and simulated values for flow, stage, EC, and temperature. Other graphs help to evaluate the model performance by looking at values derived from the existing data, such as calculated flows, EC, and salt loads.

Hourly interface file

Currently the hourly interface file contains mostly meteorological and water temperature data. Other water quality constituents that have not yet been added to the model and that vary during the day, such as dissolved oxygen, pH, and algae, could eventually be added to the hourly interface file.

“Hourly Input” – This sheet contains hourly meteorological data for air temperature, wet bulb temperature, and wind speed. These data are necessary for the water temperature calculations. These values either came from or were derived from Lodi CIMIS data. Meteorological data for the Lodi CIMIS stations and other locations are stored and graphed in another file (*meteorology_hourly_00-03.xls*) in order to reduce the size of the hourly interface file.

“Hourly Output” – This sheet contains hourly model output. Currently the only outputs evaluated on an hourly basis are temperatures at Mossdale, Vernalis, and Patterson and EC at Mossdale. This sheet also contains simulated daily stage at Mossdale to be compared to measured hourly stage at Mossdale. At Mossdale, the measure stage is affected by tides and varies hourly whereas the simulated stage is affected only by daily flow and does not vary with tide.

“Hist Hourly” – This sheet contains measured hourly data to be compared to simulated hourly values. A section for calculating daily values from the hourly values is located to the right.

“Graphs Hourly” – This sheet uses graphs to evaluate hourly model performance for EC at Mossdale and temperature at Mossdale, Vernalis, and Patterson.

Initial Model Performance

Measured data are needed to evaluate model performance. In the San Joaquin River between Stevinson and Mossdale, measured data from the following upstream to downstream locations were used to evaluate model performance:

- Fremont Ford,
- Newman,
- Crows Landing,
- Patterson,
- Maze,
- Vernalis, and
- Mossdale.

For the most part, evaluation of model results for flow, stage, and EC can be done on a daily basis because these parameters change little during the course of a day. Because water temperature varies diurnally, the daily range in temperatures should be considered as part of the evaluation.

Flow

Sample model inputs for flow during 2000 are shown in Figures 8 and 9. For tributaries, measured data were available for developing model inputs. Generally, the Stanislaus and Tuolumne Rivers provide the largest flows (>500 cfs in 2000). Salt Slough and the Merced River provided moderate flows. Flows from Mud Slough, the San Joaquin River at Stevinson, and the creeks (Orestimba, Hospital, Del Puerto, and Ingram Creeks combined) were small, generally less than 100 cfs (Figure 8). Combined inflows from agricultural returns, ground water, and the Modesto Wastewater Treatment Plant are similar in magnitude to agricultural diversions, although the combined inflows tend to be lower than diversions in the summer and higher than diversions during the winter (Figure 9).

Initial model results show that the simulated flows match the measured flows fairly well at Fremont Ford, Newman, and Crows Landing. Farther downstream, simulated flows are less than the measured flows (Figures 10 and 11). For January 2000 through September 2001, approximately 250 cfs is missing upstream of Patterson with some additional water (approximately 150 cfs) missing downstream of Patterson (Figure 12). For 2002 and 2003, the model flow matches the Patterson flow fairly well and most of the missing water (roughly 300 cfs) occurs between Patterson and Vernalis (Figure 13).

The difference between the measured and simulated flows at Vernalis is variable, but generally around 200-500 cfs is missing at Vernalis with no strong annual pattern. This is similar in magnitude to the constant 150 cfs added upstream of

Vernalis plus the 200 cfs added upstream of Patterson by DWR in the original version of the model. The lack of an annual pattern to the amount of missing water indicates that the missing water is more likely to be ground water than agricultural runoff (which would be higher in the summer) or rain runoff (which would be higher in the winter).

Electrical Conductivity

Examples of model input for EC are shown for 2000 in Figures 14 and 15. Although the Merced, Tuolumne, and Stanislaus Rivers provide most of the flow, their EC values are relatively low, generally less than 250 umhos/cm. In contrast, the smaller tributaries have relatively high EC values, with Mud Slough having the highest values, approaching 4,000 umhos/cm (Figure 14). Estimated EC values for the agricultural returns, which were derived from the estimates for the 1997-1999 simulation, tend to be less than 1,000 umhos/cm, but the estimated EC for ground water is high, 3245 umhos/cm (Figure 15).

Flow and EC can be used to estimate salt loads. Even though estimated EC values for the agricultural flows and groundwater are constants, the salt loads for these inflows vary corresponding to the yearly flow pattern (Figure 15). Although the agricultural drain flow has low EC compared to groundwater, it has a greater salt load because of its higher flows.

During 2000-2003, EC was measured at Mossdale, Vernalis, Maze, and Patterson. Measurements were hourly or daily at these places except for at Maze, where they were taken approximately once every two weeks (Figures 16 and 17). The difference between the simulated and measured EC was highly variable, which can be expected because many of the EC input values for the local inflows are uncertain and do not change from day to day.

EC at downstream locations can be calculated from flow-weighted averages of upstream EC measurements. The EC at Maze and Vernalis can be fairly accurately calculated from upstream measurements at Patterson and for the Tuolumne and Stanislaus Rivers. This indicates that much of the error in simulated EC might be corrected if the EC at Patterson were higher (Figures 18 and 19). Additional EC measurements farther upstream (at Crows Landing, Newman, and Fremont Ford) could help to indicate where the model is missing EC (salt load).

Salt load calculations indicate that large discrepancies between salt loads estimated from simulated values and salt loads estimated from measured values occur at Patterson and Vernalis (Figures 20 and 21). At Vernalis, the simulated salt load is generally 500-1,000 tons/day less than measured. This is caused by a combination of the lower modeled flow and lower modeled EC values.

The simulated EC and flow at Vernalis could be made to match the measurements at Vernalis by adding water with relatively high EC to the model upstream of Vernalis. The total amount of added water would be equal to the amount of water missing from Vernalis. Appropriate EC values for the added water can be calculated from flow and EC values from current model results and measurements. The addition of water with the calculated EC values should give simulated EC values for Vernalis that are closer to the measured EC values at Vernalis, although the match might not be perfect because, depending on the river location where the water is added to the model, some of the added water may be diverted from the river before it reaches Vernalis. The estimated EC of the missing water varies considerably on a daily basis, but is generally between 500 and 2000 umhos/cm (Figures 22 and 23).

Water temperature

Water temperatures at Stevinson, the downstream ends of the tributaries, and the agricultural inflows are expected to be at similar near-equilibrium values. These temperatures were estimated as the average daily air temperature at Lodi. The top part of Figure 24 shows these estimated inflow temperatures for tributaries and agricultural flows compared to the measured temperatures at Stevinson for 2001. 2001 was chosen because it has a complete set of data for Stevinson. This comparison indicates that the estimated inflow temperatures may be too cool and have too much day-to-day variability.

During 2000-2003, water temperatures were measured in the San Joaquin River at Mossdale, Vernalis, and Patterson. Initial model results show that the match between the simulated and measured values is fairly good at Mossdale and Vernalis, although the simulated temperatures tend to have more day-to-day variability than the measured temperatures (Figures 24 and 25). Water temperature measurements at Stevinson and the major tributaries could be used to develop a better set of inflow temperatures, which would likely improve model performance.

Even with a modification to the inflow temperatures, however, there is likely to be some mismatch between simulated and measured values. Patterson is located well downstream of major inflows so the simulated temperatures at Patterson are unlikely to be greatly influenced by errors in the inflow temperatures. However, the simulated water temperature at Patterson still shows too much variability (both diurnally and from day to day) and it is too warm (Figures 24 and 25). The model may be warming shallow reaches of the river too much during the day. Additional calibration of temperatures is needed.

Model Improvements

These initial DSM2-SJR model results for 2000-2003 will likely be improved with additional calibration adjustments to model inputs and coefficients. Results might be improved by the careful addition of local inflows with relatively high EC upstream and/or downstream of Patterson. Temperatures can probably be improved by adjusting the model inputs for inflow temperature. Improvements in estimated channel geometry are needed to match the measured travel times because algae growth is dependent on travel time, as well as temperatures and depth (average light). To facilitate these calibration efforts, the IO interface files should be modified to graphically compare old and new model results.

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Table 1. Location of Segments in DSM2-SJR Model

Quad Sheet	Segment	Length (ft)	Length (miles)	Upstream River Distance (ft)	Upstream River Mile	River Mile from USGS Quad	Location Information
Lathrop	7			298438	56.5	55.2	
Lathrop	6	9878	1.9	308316	58.4	57	Mossdale station is at 56.2 Reported by IEP at kilometer 89 (mi 55)
Lathrop	5	12350	2.3	320666	60.7	60.8	Paradise Weir at 59.9 [1.2 miles lost in oxbow]
Vernalis	4	14050	2.7	334716	63.4		Banta-Carbona main canal and pumping plant (fish screen)
Vernalis	3	13000	2.5	347716	65.9		
Vernalis	2	14000	2.7	361716	68.5		
Vernalis	1	19500	3.7	381216	72.2		Vernalis gage. Reported by IEP as kilometer 112 (mile 69.6)
Ripon	17	13150	2.5	394366	74.7	74.7	
Ripon	601	1292	0.2	395658	74.9	74.9	Stanislaus Inflow
Ripon	602	5812	1.1	401470	76.0	76	
Ripon	603	7054	1.3	408524	77.4	77.2	Maze Bridge (Highway 132)
Ripon	604	5017	1.0	413541	78.3	78.3	
Ripon	605	8147	1.5	421688	79.9	80	
Ripon	606	6607	1.3	428295	81.1	81	
Westley	607	8942	1.7	437237	82.8		Hospital and Ingram Creeks
Westley	608	5415	1.0	442652	83.8		Tuolumne River mouth
Westley	609	1639	0.3	444291	84.1		West Stanislaus Main canal
Westley	610	6458	1.2	450749	85.4		
Westley	611	6011	1.1	456760	86.5		
Westley	612	3875	0.7	460635	87.2		
Westley	613	6243	1.2	466878	88.4		
Westley	614	5166	1.0	472044	89.4		Grayson Road Bridge
Westley	615	6060	1.1	478104	90.6		TID #2 lateral drain
Brush Lake	616	7418	1.4	485522	92.0	91.7	
Brush Lake	617	7205	1.4	492727	93.3	92.9	Del Puerto Creek
Brush Lake	618	2533	0.5	495260	93.8	93.1	TID #3 lateral drain
Brush Lake	619	5514	1.0	500774	94.8	94.1	
Brush Lake	620	4272	0.8	505046	95.7	95.1	Modesto sewage
Brush Lake	621	4902	0.9	509948	96.6	96.1	
Brush Lake	622	4288	0.8	514236	97.4	96.9	Patterson sewage
Crows Landing	623	4073	0.8	518309	98.2		Patterson Main Canal and pumping plant
Crows Landing	624	6260	1.2	524569	99.4		Patterson Road gage
Crows Landing	625	8942	1.7	533511	101.0		
Crows Landing	626	5564	1.1	539075	102.1		
Crows Landing	627	4602	0.9	543677	103.0		TID #5 lateral drain, Oxbow lake- river mile lost?
Crows Landing	628	8246	1.6	551923	104.5		
Crows Landing	629	6988	1.3	558911	105.9		
Crows Landing	630	5464	1.0	564375	106.9		
Crows Landing	631	9141	1.7	573516	108.6		Crows Landing bridge gage
Crows Landing	632	3428	0.6	576944	109.3		Orestimba Creek inflow
Hatch	633	8412	1.6	585356	110.9	110.7	TID #6 lateral drain
Hatch	634	4570	0.9	589926	111.7	111.8	
Hatch	635	4372	0.8	594298	112.6	112.8	
Hatch	636	4371	0.8	598669	113.4	114.2	
Hatch	637	8150	1.5	606819	114.9	115	
Gustine	638	6938	1.3	613757	116.2	116.3	
Gustine	639	6607	1.3	620364	117.5	117.3	Hills Ferry Bridge (Newman Gage) at mile 118.1
Gustine	640	3974	0.8	624338	118.2	118.2	Merced River mouth
Gustine	641	2759	0.5	627097	118.8	119	
Gustine	642	8974	1.7	636071	120.5	119.4	Newman Wasteway
Gustine	643	8163	1.5	644234	122.0	121.2	North Mouth of Mud Slough
Gustine	644	6458	1.2	650692	123.2	123	
Gustine	645	5067	1.0	655759	124.2	124.1	South mouth of Mud Slough
Gustine	646	2732	0.5	658491	124.7	125.1	Freemont Ford Bridge (gage)
Gustine	647	7750	1.5	666241	126.2	125.6	
Gustine	648	7103	1.3	673344	127.5	126.8	
Gustine	649	6623	1.3	679967	128.8	129	Salt Slough mouth old channel with miles is cut off- 0.5 mile lost?
Gustine	650	7848	1.5	687815	130.3	130.5	
Stevinson	651	4819	0.9	692634	131.2		
Stevinson	652	3974	0.8	696608	131.9		Stevinson (Lander Ave) gage
Stevinson	653	11641	2.2	708249	134.1		Bear Creek Gage is upstream of Stevinson gage (Lander Ave)

Table 2. Example cross-section used in DSM2

Cross-section:	602_0.91061						
Elev(NGVD)	A	P	W	Rh	Xc	Zc	
3.74	0	0	0	0	0	0	
4.38	16.2	50.3	50.3	0.3	89.3	4.1	
8.25	417	157.1	156.7	2.6	71.6	6.6	
8.77	501.9	172.5	172.1	2.9	69.9	7.1	
11.22	1171.4	374.5	373.9	3.1	40.7	9.4	
26.66	8770.2	613.2	610.2	14.3	17	19	
29.67	10627.4	626.8	623.4	16.9	19.8	21.3	
station:	341.637	140.9253	102.4911	57.65125	-25.6228	-200.712	-281.851
Elevation:	26.66667	8.258064	3.741936	4.387097	8.774194	11.22581	29.67742

Table 3. Width of Each DSM2-SJR Model Segment

		Flow (cfs)											
		750	1000	1250	1500	2000	2500	3000	3500	4000	5000	6000	7000
Upstream Node	Upstream SJR Mile												
653	134.1	165	184	198	210	248	282	311	337	360	401	436	468
652	131.9	255	274	290	304	329	350	367	382	396	420	441	459
651	131.2	174	192	207	221	244	263	285	309	331	368	401	426
650	130.3	152	165	177	188	206	220	233	244	254	271	286	298
649	128.8	204	219	232	243	264	280	294	305	316	334	349	363
648	127.5	171	202	228	253	300	335	364	389	411	449	458	462
647	126.2	119	133	146	159	184	219	248	273	295	334	370	401
646	124.7	166	181	194	207	228	244	257	268	278	296	312	322
645	124.2	163	172	180	222	302	362	412	455	493	560	621	675
644	123.2	178	246	305	354	438	506	567	618	665	723	730	734
643	122.0	190	218	242	263	297	326	351	372	391	426	450	456
642	120.5	185	204	221	237	263	287	321	354	383	433	469	479
641	118.8	134	139	144	149	157	165	172	179	185	197	208	215
640	118.2	129	151	170	187	217	244	268	291	312	349	381	409
639	117.5	207	215	222	231	248	263	277	289	301	322	340	356
638	116.2	214	227	239	250	269	286	302	315	329	353	392	475
637	114.9	246	264	281	296	324	350	373	394	413	448	481	507
636	113.4	197	214	230	244	270	297	319	338	354	381	405	426
635	112.6	115	126	137	147	168	216	261	302	339	404	462	515
634	111.7	190	214	237	259	295	329	387	439	485	568	643	713
633	110.9	144	154	162	172	189	205	220	236	253	285	314	340
632	109.3	266	300	329	355	401	443	479	510	533	548	562	574
631	108.6	165	176	186	195	212	232	250	265	279	305	328	349
630	106.9	118	129	138	147	162	175	199	229	257	280	298	315
629	105.9	164	170	176	181	190	197	204	212	220	235	248	260
628	104.5	155	169	184	197	223	246	268	289	309	347	380	409
627	103.0	190	235	268	294	339	379	413	444	472	524	570	613
626	102.1	143	161	177	191	216	234	244	253	261	276	290	302
625	101.0	195	207	214	221	231	242	252	261	269	284	297	309
624	99.4	258	274	287	299	320	338	353	367	380	402	414	426
623	98.2	303	318	329	337	370	402	431	457	482	526	566	602
622	97.4	182	197	210	221	241	259	276	291	304	330	352	373
621	96.6	222	233	242	251	267	283	297	310	322	344	364	382
620	95.7	109	143	167	187	224	240	250	258	265	278	290	300
619	94.8	173	195	214	232	262	290	318	343	367	410	449	482
618	93.8	156	168	179	189	218	243	265	285	303	335	363	388
617	93.3	184	197	209	221	244	263	280	295	309	333	356	375
616	92.0	103	112	120	127	146	168	198	216	234	274	310	341
615	90.6	81	88	94	99	108	116	123	131	145	192	253	303
614	89.4	153	166	178	190	210	227	242	256	268	289	308	326
613	88.4	147	159	170	179	195	208	220	231	240	258	273	287
612	87.2	127	160	189	217	246	265	282	297	310	335	357	378
611	86.5	82	91	99	106	122	140	175	208	238	273	297	318

610	85.4	133	149	161	172	190	206	223	241	255	283	306	326
609	84.1	92	104	113	115	120	129	139	147	157	186	212	234
608	83.8	149	166	180	192	212	233	253	270	286	315	344	373
607	82.8	226	244	260	276	302	324	344	361	377	406	430	452
606	81.1	211	229	246	260	287	314	338	359	378	414	444	469
605	79.9	156	180	203	224	249	272	297	318	337	374	407	437
604	78.3	144	157	168	177	211	273	301	307	312	322	332	341
603	77.4	189	198	206	213	226	246	264	280	295	322	345	366
602	76.0	178	202	232	258	283	300	315	330	343	366	387	407
601	74.9	206	271	308	314	324	336	358	380	402	443	479	512
17	74.7	223	242	258	273	298	319	338	355	368	390	409	427
1	72.2	237	249	260	270	288	303	316	329	340	360	378	394
2	68.5	207	221	234	246	266	283	298	312	322	333	343	353
3	65.9	175	195	213	229	258	283	306	326	339	361	381	399
4	63.4	218	228	238	248	265	282	296	310	318	330	342	353
5	60.7	307	309	311	314	318	323	327	331	334	341	347	352
6	58.4	262	266	271	276	286	295	304	308	312	319	326	331

Table 4. Maximum Depth of Each DSM2-SJR Model Segment

		Flow (cfs)											
		750	1000	1250	1500	2000	2500	3000	3500	4000	5000	6000	7000
Upstream	Upstream												
Node	SJR Mile	Maximum Depth (feet)											
653	134.1	6.5	7.2	7.9	8.5	9.6	10.6	11.4	12.1	12.7	13.9	14.8	15.7
652	131.9	7.3	8.1	8.9	9.6	10.7	11.7	12.5	13.2	13.9	15.0	15.9	16.8
651	131.2	6.7	7.5	8.3	8.9	10.1	11.0	11.8	12.5	13.1	14.2	15.2	16.0
650	130.3	12.2	13.0	13.8	14.4	15.6	16.5	17.3	18.0	18.6	19.7	20.7	21.5
649	128.8	9.1	9.8	10.4	11.0	12.0	12.7	13.4	13.9	14.4	15.2	16.0	16.6
648	127.5	6.5	7.2	7.8	8.3	9.3	10.1	10.7	11.3	11.7	12.6	13.3	13.9
647	126.2	5.3	5.9	6.5	7.0	7.9	8.6	9.2	9.7	10.2	11.0	11.7	12.3
646	124.7	4.9	5.5	6.1	6.7	7.5	8.2	8.8	9.3	9.7	10.5	11.1	11.7
645	124.2	4.4	5.0	5.6	6.1	7.0	7.7	8.3	8.7	9.2	9.9	10.6	11.2
644	123.2	3.9	4.5	5.1	5.6	6.5	7.2	7.8	8.3	8.8	9.6	10.4	11.1
643	122.0	7.5	8.2	8.7	9.2	10.1	10.8	11.4	11.9	12.4	13.2	14.0	14.7
642	120.5	8.6	9.2	9.6	10.1	10.8	11.5	12.1	12.6	13.1	14.0	14.8	15.5
641	118.8	5.6	6.1	6.5	6.8	7.5	8.1	8.7	9.3	9.8	10.7	11.6	12.4
640	118.2	2.3	2.9	3.5	4.0	4.9	5.6	6.4	7.0	7.6	8.7	9.6	10.4
639	117.5	6.9	7.5	8.1	8.6	9.4	10.2	10.9	11.5	12.1	13.2	14.1	14.9
638	116.2	2.8	3.4	3.9	4.4	5.2	6.0	6.7	7.3	7.9	8.9	9.8	10.6
637	114.9	5.3	5.9	6.4	6.8	7.6	8.4	9.0	9.6	10.2	11.2	12.0	12.8
636	113.4	2.1	2.7	3.2	3.7	4.6	5.6	6.3	7.0	7.6	8.5	9.4	10.1
635	112.6	3.9	4.6	5.2	5.8	6.8	7.7	8.5	9.1	9.7	10.8	11.7	12.5
634	111.7	4.5	5.3	5.9	6.5	7.5	8.4	9.2	9.8	10.4	11.5	12.5	13.4
633	110.9	6.0	6.7	7.3	7.9	8.8	9.6	10.4	11.0	11.6	12.6	13.6	14.4
632	109.3	4.7	5.4	6.0	6.5	7.4	8.2	8.9	9.5	10.0	11.0	11.9	12.8
631	108.6	5.2	5.8	6.4	6.8	7.7	8.5	9.2	9.8	10.4	11.4	12.3	13.1
630	106.9	5.0	5.6	6.2	6.7	7.6	8.4	9.1	9.7	10.3	11.4	12.3	13.2
629	105.9	5.6	6.3	6.9	7.4	8.3	9.2	9.9	10.5	11.1	12.2	13.1	14.0
628	104.5	6.3	7.0	7.6	8.1	9.0	9.8	10.5	11.1	11.7	12.8	13.7	14.6
627	103.0	4.5	5.1	5.7	6.3	7.2	8.0	8.6	9.3	9.8	10.9	11.8	12.7
626	102.1	6.4	7.2	7.8	8.4	9.3	10.1	10.8	11.5	12.0	13.1	14.1	14.9
625	101.0	9.2	9.9	10.5	11.1	12.0	12.8	13.5	14.1	14.7	15.7	16.7	17.5
624	99.4	17.5	18.1	18.7	19.2	20.1	20.9	21.6	22.2	22.8	23.8	24.7	25.5
623	98.2	7.7	8.3	8.8	9.3	10.1	10.8	11.4	12.0	12.5	13.5	14.4	15.2
622	97.4	5.1	5.6	6.1	6.6	7.4	8.1	8.7	9.3	9.8	10.8	11.7	12.5
621	96.6	5.4	5.9	6.4	6.8	7.5	8.2	8.9	9.5	10.0	11.0	11.9	12.7
620	95.7	6.2	6.9	7.7	8.3	9.4	10.3	11.1	11.8	12.3	13.4	14.3	15.2
619	94.8	8.9	9.7	10.4	11.0	12.1	12.9	13.7	14.3	14.9	16.0	16.9	17.7
618	93.8	7.5	8.3	8.9	9.5	10.6	11.4	12.1	12.7	13.3	14.3	15.3	16.1
617	93.3	7.0	7.7	8.4	9.0	10.1	10.9	11.6	12.2	12.7	13.7	14.7	15.4
616	92.0	3.9	4.6	5.2	5.8	6.8	7.6	8.3	8.9	9.5	10.5	11.5	12.3
615	90.6	6.0	6.7	7.4	7.9	8.9	9.8	10.5	11.1	11.7	12.8	13.8	14.7
614	89.4	7.4	8.0	8.6	9.1	9.9	10.6	11.3	11.8	12.3	13.2	14.0	14.8
613	88.4	5.1	5.7	6.3	6.7	7.6	8.2	8.8	9.4	9.8	10.7	11.5	12.2
612	87.2	7.0	7.7	8.2	8.6	9.4	10.0	10.6	11.1	11.5	12.3	13.1	13.8

611	86.5	2.9	3.3	3.8	4.2	4.9	5.6	6.2	6.8	7.3	8.4	9.3	10.1
610	85.4	3.8	4.4	5.0	5.4	6.3	7.1	7.7	8.4	9.0	10.0	11.0	11.8
609	84.1	5.9	6.7	7.4	8.0	9.0	9.8	10.6	11.2	11.8	12.9	13.8	14.6
608	83.8	6.8	7.6	8.3	8.9	9.9	10.7	11.5	12.1	12.7	13.8	14.7	15.5
607	82.8	7.7	8.5	9.2	9.8	10.7	11.5	12.3	12.9	13.5	14.5	15.4	16.2
606	81.1	8.1	8.8	9.4	10.0	10.9	11.7	12.5	13.1	13.7	14.8	15.7	16.5
605	79.9	6.9	7.6	8.1	8.6	9.5	10.3	11.1	11.7	12.2	13.2	14.0	14.8
604	78.3	5.5	6.1	6.6	7.0	7.9	8.6	9.5	10.1	10.6	11.5	12.3	13.1
603	77.4	5.5	6.2	6.8	7.3	8.3	9.1	9.9	10.6	11.2	12.3	13.3	14.2
602	76.0	4.9	5.5	6.1	6.7	7.6	8.4	9.2	9.9	10.5	11.6	12.6	13.5
601	74.9	5.1	5.7	6.4	6.9	7.9	8.7	9.5	10.2	10.8	11.9	12.9	13.8
17	74.7	7.9	8.6	9.2	9.8	10.7	11.6	12.3	13.0	13.6	14.7	15.6	16.5
1	72.2	5.4	6.1	6.7	7.2	8.1	8.9	9.6	10.2	10.8	11.8	12.7	13.6
2	68.5	8.8	9.5	10.1	10.6	11.5	12.3	13.0	13.7	14.2	15.3	16.2	17.1
3	65.9	5.9	6.5	7.0	7.5	8.4	9.1	9.8	10.4	11.0	11.9	12.8	13.7
4	63.4	8.5	8.9	9.3	9.7	10.5	11.3	11.9	12.5	13.1	14.1	15.0	15.9
5	60.7	8.1	8.3	8.7	9.0	9.7	10.3	10.9	11.4	11.9	12.9	13.7	14.5
6	58.4	9.7	10.0	10.3	10.6	11.2	11.8	12.4	12.9	13.4	14.3	15.2	15.9

Table 5. Average Depth of Each DSM2-SJR Model Segment

		Flow (cfs)											
		750	1000	1250	1500	2000	2500	3000	3500	4000	5000	6000	7000
Upstream	Upstream												
Node	SJR Mile	Average Depth (feet)											
653	134.1	3.3	3.6	4.0	4.4	4.8	5.1	5.4	5.6	5.9	6.4	6.8	7.2
652	131.9	4.0	4.5	5.0	5.3	6.0	6.4	6.9	7.3	7.7	8.3	8.8	9.3
651	131.2	4.7	5.1	5.4	5.7	6.2	6.7	7.0	7.1	7.2	7.5	7.8	8.1
650	130.3	5.4	5.9	6.3	6.7	7.4	8.0	8.5	9.0	9.4	10.2	10.9	11.6
649	128.8	4.2	4.6	5.0	5.3	6.0	6.5	6.9	7.3	7.5	8.1	8.5	8.9
648	127.5	3.0	3.2	3.3	3.5	3.9	4.1	4.4	4.7	4.9	5.2	5.9	6.5
647	126.2	4.1	4.4	4.7	5.0	5.3	5.2	5.2	5.2	5.3	5.4	5.5	5.6
646	124.7	3.1	3.5	3.8	4.1	4.6	5.0	5.4	5.7	6.0	6.5	7.0	7.5
645	124.2	3.2	3.6	4.1	3.8	3.5	3.4	3.4	3.4	3.4	3.5	3.5	3.6
644	123.2	3.3	3.1	3.1	3.2	3.3	3.5	3.6	3.7	3.8	4.2	4.7	5.2
643	122.0	3.1	3.5	3.9	4.3	4.8	5.4	5.8	6.2	6.5	7.1	7.6	8.3
642	120.5	2.9	3.1	3.3	3.5	3.8	4.1	4.2	4.3	4.4	4.6	5.0	5.5
641	118.8	3.2	3.6	4.0	4.4	5.1	5.8	6.5	7.2	7.9	9.3	10.6	11.8
640	118.2	4.5	4.7	4.9	5.0	5.3	5.6	5.9	6.1	6.3	6.7	7.1	7.4
639	117.5	3.2	3.7	4.1	4.5	5.0	5.5	5.9	6.3	6.6	7.3	7.9	8.4
638	116.2	3.5	3.9	4.2	4.5	4.9	5.3	5.6	5.9	6.2	6.7	6.8	6.2
637	114.9	2.7	3.0	3.3	3.5	3.9	4.4	4.7	5.0	5.3	5.8	6.2	6.6
636	113.4	2.6	2.9	3.2	3.5	4.0	4.5	4.9	5.2	5.5	6.1	6.6	7.1
635	112.6	3.4	3.9	4.3	4.7	5.3	5.0	5.0	5.0	5.1	5.3	5.6	5.9
634	111.7	3.9	4.2	4.4	4.6	4.9	5.2	5.1	5.1	5.1	5.2	5.4	5.6
633	110.9	4.6	5.2	5.9	6.3	7.1	7.9	8.5	8.9	9.3	9.8	10.4	10.8
632	109.3	2.2	2.4	2.6	2.8	3.1	3.4	3.6	3.9	4.1	4.8	5.4	5.9
631	108.6	3.5	3.9	4.2	4.5	5.0	5.3	5.6	5.9	6.1	6.5	6.9	7.2
630	106.9	3.3	3.7	4.0	4.3	4.8	5.3	5.3	5.3	5.2	5.9	6.4	6.9
629	105.9	2.2	2.6	3.0	3.3	3.9	4.5	5.0	5.4	5.9	6.8	7.6	8.4
628	104.5	3.2	3.7	4.0	4.2	4.6	5.0	5.3	5.5	5.7	6.1	6.5	6.9
627	103.0	2.5	2.6	2.8	3.0	3.4	3.7	4.0	4.2	4.5	4.9	5.3	5.7
626	102.1	3.4	3.9	4.3	4.6	5.2	5.9	6.5	7.1	7.7	8.7	9.7	10.5
625	101.0	5.5	5.8	6.2	6.6	7.2	7.7	8.2	8.5	8.9	9.6	10.1	10.7
624	99.4	5.0	5.1	5.4	5.5	5.8	6.0	6.2	6.4	6.6	7.0	7.4	7.8
623	98.2	3.3	3.6	3.9	4.2	4.5	4.7	4.9	5.1	5.3	5.6	5.9	6.2
622	97.4	4.0	4.4	4.8	5.1	5.7	6.2	6.7	7.2	7.6	8.5	9.3	9.9
621	96.6	2.2	2.6	2.9	3.1	3.6	4.0	4.4	4.8	5.1	5.7	6.2	6.7
620	95.7	5.4	5.1	5.3	5.6	6.0	6.7	7.4	8.0	8.5	9.4	10.1	10.8
619	94.8	3.6	4.0	4.3	4.7	5.4	5.8	6.2	6.5	6.7	7.2	7.7	8.1
618	93.8	4.8	5.2	5.6	5.9	6.2	6.4	6.5	6.7	6.8	7.2	7.5	7.7
617	93.3	3.3	3.7	4.0	4.3	4.8	5.2	5.5	5.8	6.1	6.6	7.0	7.5
616	92.0	3.1	3.6	4.0	4.4	4.9	5.1	5.0	5.2	5.3	5.5	5.7	6.0
615	90.6	4.1	4.5	4.9	5.3	5.9	6.4	6.8	7.1	7.1	6.4	5.8	5.6
614	89.4	4.0	4.3	4.5	4.7	5.0	5.3	5.5	5.7	5.9	6.3	6.7	7.0
613	88.4	5.1	5.3	5.5	5.7	6.1	6.4	6.7	6.9	7.2	7.6	8.0	8.3
612	87.2	2.7	2.7	2.7	2.8	3.2	3.6	3.9	4.1	4.4	4.8	5.2	5.6

611	86.5	3.2	3.5	3.8	4.1	4.6	5.1	4.9	4.9	4.9	5.4	6.0	6.4
610	85.4	2.1	2.4	2.6	2.9	3.3	3.8	4.2	4.5	4.8	5.3	5.8	6.2
609	84.1	6.5	7.0	7.5	8.2	9.4	9.9	10.3	10.7	11.0	10.7	10.7	10.7
608	83.8	4.3	4.7	5.0	5.3	5.8	6.0	6.2	6.4	6.6	7.0	7.2	7.4
607	82.8	3.4	3.8	4.2	4.5	4.9	5.3	5.7	6.0	6.3	6.9	7.3	7.8
606	81.1	3.0	3.4	3.7	3.9	4.4	4.8	5.2	5.4	5.8	6.4	6.9	7.3
605	79.9	3.1	3.4	3.6	3.8	4.3	4.7	5.2	5.4	5.6	6.1	6.4	6.7
604	78.3	2.8	3.4	3.9	4.3	4.6	4.3	4.8	5.3	5.6	6.5	7.2	7.9
603	77.4	2.6	3.1	3.4	3.8	4.4	4.8	5.2	5.5	5.9	6.4	6.9	7.4
602	76.0	3.1	3.5	3.6	3.8	4.3	4.9	5.3	5.7	6.1	6.7	7.3	7.8
601	74.9	2.2	2.2	2.5	2.9	3.8	4.5	5.0	5.4	5.7	6.3	6.7	7.2
17	74.7	3.6	4.0	4.4	4.7	5.3	5.8	6.2	6.6	7.0	7.7	8.4	9.0
1	72.2	3.5	3.9	4.4	4.7	5.3	5.8	6.3	6.7	7.0	7.6	8.2	8.7
2	68.5	4.5	5.0	5.4	5.7	6.2	6.6	7.0	7.3	7.6	8.3	9.0	9.5
3	65.9	3.2	3.5	3.7	3.9	4.3	4.7	5.0	5.3	5.7	6.3	6.9	7.3
4	63.4	4.3	4.5	4.7	4.9	5.3	5.7	6.0	6.3	6.7	7.4	8.1	8.7
5	60.7	5.0	5.2	5.4	5.7	6.3	6.7	7.2	7.7	8.1	8.9	9.5	10.1
6	58.4	4.9	5.1	5.3	5.5	6.1	6.5	7.0	7.4	7.9	8.7	9.3	9.9

Table 6. Surface Elevation of Each DSM2-SJR Model Segment

		Flow (cfs)											
		750	1000	1250	1500	2000	2500	3000	3500	4000	5000	6000	7000
Upstream	Upstream												
Node	SJR Mile	Surface Elevation (feet)											
653	134.1	63.1	63.8	64.5	65.1	66.3	67.2	68.0	68.7	69.3	70.5	71.4	72.3
652	131.9	61.4	62.3	63.0	63.7	64.9	65.8	66.7	67.4	68.0	69.1	70.1	70.9
651	131.2	61.2	62.1	62.9	63.5	64.7	65.6	66.4	67.1	67.7	68.8	69.8	70.6
650	130.3	61.2	62.1	62.9	63.5	64.7	65.6	66.4	67.1	67.7	68.8	69.8	70.6
649	128.8	60.2	60.9	61.5	62.0	63.0	63.8	64.4	65.0	65.5	66.3	67.1	67.7
648	127.5	59.7	60.4	60.9	61.5	62.5	63.2	63.9	64.4	64.9	65.7	66.4	67.1
647	126.2	57.9	58.6	59.1	59.7	60.6	61.3	61.9	62.4	62.8	63.6	64.3	65.0
646	124.7	57.5	58.2	58.7	59.3	60.2	60.9	61.4	61.9	62.3	63.1	63.8	64.4
645	124.2	57.5	58.2	58.7	59.3	60.2	60.9	61.4	61.9	62.3	63.1	63.8	64.4
644	123.2	56.0	56.7	57.3	57.8	58.6	59.3	59.9	60.4	60.9	61.8	62.5	63.2
643	122.0	56.0	56.7	57.3	57.8	58.6	59.3	59.9	60.4	60.9	61.8	62.5	63.2
642	120.5	54.1	54.6	55.1	55.6	56.3	57.0	57.5	58.0	58.5	59.4	60.2	61.0
641	118.8	53.6	54.1	54.5	54.8	55.5	56.1	56.7	57.3	57.8	58.7	59.6	60.4
640	118.2	50.0	50.7	51.2	51.7	52.6	53.4	54.1	54.7	55.4	56.4	57.4	58.2
639	117.5	49.7	50.4	50.9	51.4	52.3	53.0	53.7	54.4	55.0	56.0	56.9	57.7
638	116.2	49.5	50.1	50.6	51.1	51.9	52.7	53.4	54.0	54.6	55.6	56.5	57.3
637	114.9	48.4	49.0	49.4	49.9	50.7	51.5	52.1	52.7	53.3	54.3	55.1	55.9
636	113.4	46.0	46.6	47.2	47.7	48.6	49.5	50.3	50.9	51.5	52.5	53.3	54.0
635	112.6	43.6	44.3	45.0	45.6	46.6	47.5	48.2	48.9	49.5	50.5	51.4	52.3
634	111.7	42.6	43.4	44.1	44.7	45.7	46.5	47.3	48.0	48.5	49.6	50.6	51.5
633	110.9	41.4	42.1	42.7	43.3	44.2	45.1	45.8	46.4	47.0	48.0	49.0	49.8
632	109.3	40.2	40.8	41.4	41.9	42.8	43.6	44.3	44.9	45.5	46.5	47.3	48.2
631	108.6	38.7	39.3	39.9	40.4	41.3	42.1	42.8	43.3	43.9	44.9	45.8	46.6
630	106.9	37.8	38.5	39.0	39.5	40.4	41.2	41.9	42.6	43.1	44.2	45.1	46.0
629	105.9	36.5	37.2	37.8	38.3	39.2	40.0	40.7	41.4	42.0	43.1	44.0	44.9
628	104.5	35.8	36.5	37.1	37.6	38.6	39.4	40.1	40.7	41.3	42.3	43.3	44.1
627	103.0	35.4	36.0	36.6	37.2	38.1	38.9	39.5	40.2	40.7	41.8	42.7	43.6
626	102.1	34.7	35.5	36.1	36.7	37.6	38.4	39.1	39.8	40.3	41.4	42.4	43.2
625	101.0	34.0	34.7	35.3	35.8	36.7	37.5	38.2	38.8	39.4	40.5	41.4	42.2
624	99.4	33.9	34.6	35.2	35.7	36.6	37.4	38.1	38.7	39.2	40.3	41.2	42.0
623	98.2	33.7	34.3	34.8	35.3	36.0	36.7	37.4	37.9	38.5	39.5	40.3	41.1
622	97.4	33.7	34.3	34.8	35.2	36.0	36.7	37.3	37.9	38.4	39.4	40.3	41.1
621	96.6	32.3	32.8	33.2	33.6	34.3	35.0	35.7	36.3	36.8	37.9	38.8	39.6
620	95.7	29.0	29.8	30.5	31.2	32.3	33.2	34.0	34.6	35.2	36.3	37.2	38.0
619	94.8	28.4	29.2	29.9	30.5	31.6	32.4	33.2	33.8	34.4	35.4	36.4	37.2
618	93.8	28.0	28.7	29.4	30.0	31.1	31.9	32.6	33.2	33.8	34.8	35.7	36.5
617	93.3	27.8	28.5	29.2	29.8	30.9	31.6	32.3	32.9	33.5	34.5	35.4	36.2
616	92.0	26.4	27.1	27.7	28.3	29.3	30.1	30.8	31.4	32.0	33.0	34.0	34.8
615	90.6	25.3	26.0	26.6	27.2	28.2	29.0	29.7	30.4	30.9	32.0	33.1	34.0
614	89.4	23.5	24.1	24.7	25.2	26.0	26.8	27.4	27.9	28.4	29.4	30.2	30.9
613	88.4	23.3	24.0	24.5	25.0	25.8	26.5	27.0	27.6	28.1	28.9	29.7	30.4
612	87.2	21.8	22.4	22.9	23.3	24.1	24.8	25.3	25.8	26.2	27.1	27.8	28.5

611	86.5	18.5	19.0	19.4	19.8	20.5	21.2	21.8	22.4	23.0	24.0	24.9	25.7
610	85.4	17.0	17.7	18.2	18.7	19.5	20.3	21.0	21.6	22.2	23.3	24.2	25.0
609	84.1	14.9	15.8	16.5	17.1	18.0	18.9	19.6	20.3	20.9	21.9	22.9	23.7
608	83.8	14.7	15.5	16.2	16.8	17.8	18.6	19.4	20.0	20.6	21.7	22.6	23.4
607	82.8	14.4	15.2	15.9	16.5	17.4	18.3	19.0	19.6	20.2	21.2	22.1	22.9
606	81.1	13.6	14.3	14.9	15.5	16.4	17.2	18.0	18.6	19.2	20.3	21.2	22.0
605	79.9	12.2	12.8	13.3	13.8	14.7	15.5	16.3	16.9	17.4	18.4	19.3	20.1
604	78.3	11.4	12.0	12.5	13.0	13.8	14.6	15.5	16.1	16.5	17.4	18.3	19.1
603	77.4	9.4	10.1	10.7	11.2	12.2	13.0	13.8	14.5	15.1	16.2	17.2	18.1
602	76.0	8.6	9.3	9.9	10.4	11.3	12.2	12.9	13.6	14.2	15.3	16.3	17.2
601	74.9	8.2	8.9	9.5	10.1	11.1	11.9	12.6	13.3	13.9	15.1	16.1	17.0
17	74.7	7.6	8.3	8.9	9.5	10.5	11.3	12.0	12.7	13.3	14.4	15.4	16.3
1	72.2	5.6	6.2	6.8	7.3	8.2	9.0	9.7	10.4	10.9	12.0	12.9	13.8
2	68.5	4.0	4.7	5.3	5.8	6.8	7.6	8.3	8.9	9.5	10.5	11.4	12.3
3	65.9	1.7	2.3	2.8	3.3	4.1	4.9	5.6	6.2	6.7	7.7	8.6	9.4
4	63.4	0.8	1.3	1.7	2.1	2.9	3.6	4.3	4.9	5.5	6.5	7.4	8.3
5	60.7	0.5	0.8	1.1	1.4	2.1	2.7	3.3	3.8	4.4	5.3	6.2	6.9
6	58.4	0.4	0.7	1.0	1.3	1.9	2.5	3.1	3.6	4.1	5.0	5.8	6.6

Table 7. Velocity for Each DSM2-SJR Model Segment

		Flow (cfs)											
		750	1000	1250	1500	2000	2500	3000	3500	4000	5000	6000	7000
Upstream	Upstream												
Node	SJR Mile	Velocity (feet/second)											
653	134.1	1.4	1.5	1.6	1.6	1.7	1.8	1.8	1.8	1.9	2.0	2.0	2.1
652	131.9	0.7	0.8	0.9	0.9	1.0	1.1	1.2	1.3	1.3	1.4	1.5	1.6
651	131.2	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
650	130.3	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
649	128.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.9	2.0	2.2
648	127.5	1.5	1.6	1.6	1.7	1.7	1.8	1.9	1.9	2.0	2.1	2.2	2.3
647	126.2	1.6	1.7	1.8	1.9	2.0	2.2	2.3	2.5	2.6	2.8	3.0	3.1
646	124.7	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.3	2.4	2.6	2.8	2.9
645	124.2	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.3	2.4	2.6	2.8	2.9
644	123.2	1.3	1.3	1.3	1.3	1.4	1.4	1.5	1.5	1.6	1.7	1.8	1.8
643	122.0	1.3	1.3	1.3	1.3	1.4	1.4	1.5	1.5	1.6	1.7	1.8	1.8
642	120.5	1.4	1.6	1.8	1.9	2.1	2.2	2.3	2.4	2.4	2.5	2.6	2.6
641	118.8	1.7	2.0	2.1	2.3	2.5	2.6	2.7	2.7	2.7	2.7	2.7	2.8
640	118.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.0	2.1	2.2	2.3
639	117.5	1.1	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3
638	116.2	1.0	1.1	1.2	1.3	1.5	1.6	1.8	1.9	2.0	2.1	2.3	2.4
637	114.9	1.2	1.3	1.4	1.4	1.6	1.6	1.7	1.8	1.8	1.9	2.0	2.1
636	113.4	1.5	1.6	1.7	1.8	1.9	1.9	1.9	2.0	2.0	2.1	2.2	2.3
635	112.6	1.9	2.0	2.1	2.2	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
634	111.7	1.0	1.1	1.2	1.3	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8
633	110.9	1.2	1.3	1.3	1.4	1.5	1.6	1.6	1.7	1.7	1.8	1.9	1.9
632	109.3	1.3	1.4	1.5	1.5	1.6	1.7	1.7	1.8	1.8	1.9	2.0	2.1
631	108.6	1.3	1.5	1.6	1.7	1.9	2.0	2.1	2.3	2.4	2.5	2.7	2.8
630	106.9	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.2	3.2	3.2	3.3
629	105.9	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.3	3.2	3.3	3.3
628	104.5	1.5	1.6	1.7	1.8	1.9	2.1	2.2	2.2	2.3	2.4	2.5	2.5
627	103.0	1.6	1.6	1.6	1.7	1.7	1.8	1.8	1.9	1.9	1.9	2.0	2.0
626	102.1	1.5	1.6	1.6	1.7	1.8	1.8	1.9	1.9	2.0	2.1	2.1	2.2
625	101.0	0.7	0.9	1.0	1.1	1.2	1.4	1.5	1.6	1.7	1.8	2.0	2.1
624	99.4	0.6	0.7	0.8	0.9	1.1	1.2	1.4	1.5	1.6	1.8	2.0	2.1
623	98.2	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9
622	97.4	1.0	1.1	1.2	1.3	1.5	1.5	1.6	1.7	1.7	1.8	1.8	1.9
621	96.6	1.5	1.7	1.8	1.9	2.1	2.2	2.3	2.4	2.4	2.5	2.6	2.7
620	95.7	1.8	1.9	1.8	1.8	1.8	1.8	1.9	1.9	2.0	2.1	2.3	2.4
619	94.8	1.3	1.4	1.4	1.5	1.5	1.6	1.6	1.6	1.7	1.7	1.7	1.8
618	93.8	1.0	1.1	1.3	1.3	1.5	1.6	1.7	1.8	1.9	2.1	2.2	2.3
617	93.3	1.5	1.6	1.7	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5
616	92.0	2.3	2.5	2.6	2.7	2.8	3.0	3.1	3.2	3.3	3.5	3.5	3.5
615	90.6	2.3	2.5	2.7	2.9	3.1	3.4	3.6	3.8	3.9	4.1	4.1	4.1
614	89.4	1.3	1.4	1.6	1.7	1.9	2.1	2.3	2.4	2.5	2.7	2.9	3.1
613	88.4	1.0	1.2	1.3	1.5	1.7	1.9	2.0	2.2	2.3	2.5	2.8	2.9
612	87.2	2.3	2.4	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.4

611	86.5	2.9	3.1	3.3	3.4	3.5	3.5	3.5	3.4	3.4	3.4	3.4	3.4
610	85.4	2.7	2.9	3.0	3.1	3.2	3.2	3.2	3.3	3.3	3.3	3.4	3.5
609	84.1	1.2	1.4	1.5	1.6	1.8	2.0	2.1	2.2	2.3	2.5	2.7	2.8
608	83.8	1.2	1.3	1.4	1.5	1.6	1.8	1.9	2.0	2.1	2.3	2.4	2.6
607	82.8	1.0	1.1	1.2	1.2	1.4	1.5	1.6	1.6	1.7	1.8	1.9	2.0
606	81.1	1.2	1.3	1.4	1.5	1.6	1.7	1.7	1.8	1.8	1.9	2.0	2.0
605	79.9	1.6	1.7	1.7	1.8	1.9	2.0	2.0	2.0	2.1	2.2	2.3	2.4
604	78.3	1.8	1.9	1.9	2.0	2.1	2.1	2.1	2.2	2.3	2.4	2.5	2.6
603	77.4	1.5	1.6	1.8	1.9	2.0	2.1	2.2	2.3	2.3	2.4	2.5	2.6
602	76.0	1.4	1.4	1.5	1.5	1.6	1.7	1.8	1.9	1.9	2.0	2.1	2.2
601	74.9	1.7	1.7	1.7	1.6	1.6	1.6	1.7	1.7	1.7	1.8	1.9	1.9
17	74.7	1.1	1.2	1.2	1.3	1.3	1.4	1.5	1.5	1.6	1.7	1.8	1.8
1	72.2	1.0	1.1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
2	68.5	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.8	1.9	2.1
3	65.9	1.3	1.5	1.6	1.7	1.8	1.9	2.0	2.0	2.1	2.2	2.3	2.4
4	63.4	0.9	1.1	1.2	1.3	1.5	1.6	1.7	1.8	1.9	2.1	2.2	2.3
5	60.7	0.5	0.6	0.8	0.9	1.0	1.2	1.3	1.4	1.5	1.7	1.8	2.0
6	58.4	0.6	0.7	0.9	1.0	1.1	1.3	1.4	1.5	1.6	1.8	2.0	2.1

Table 8. Cumulative Surface Area (from Upstream) for each DSM2-SJR Model Segment

		Flow (cfs)											
		750	1000	1250	1500	2000	2500	3000	3500	4000	5000	6000	7000
Upstream Node	Upstream SJR Mile	Cumulative Surface Area from Upstream (acres)											
653	134.1	44	49	53	56	66	75	83	90	96	107	117	125
652	131.9	67	74	79	84	96	107	117	125	132	145	157	167
651	131.2	86	95	102	108	123	136	148	159	169	186	201	214
650	130.3	114	125	134	142	160	176	190	203	215	235	253	268
649	128.8	145	159	169	179	200	219	235	249	263	286	306	323
648	127.5	173	192	207	220	249	273	294	313	330	359	380	398
647	126.2	194	215	233	248	282	312	338	361	382	418	446	469
646	124.7	204	227	245	261	296	327	354	378	400	437	466	490
645	124.2	223	247	266	287	331	370	402	431	457	502	538	568
644	123.2	249	283	311	340	396	445	486	523	556	609	646	677
643	122.0	285	324	356	389	452	506	552	593	629	689	730	762
642	120.5	323	366	402	438	506	565	618	666	708	779	827	861
641	118.8	332	375	411	447	516	575	629	677	720	791	840	875
640	118.2	343	389	427	464	536	597	653	703	748	823	875	912
639	117.5	375	421	460	499	574	637	695	747	794	872	926	966
638	116.2	409	458	498	539	617	683	743	797	846	928	989	1,042
637	114.9	455	507	551	595	677	748	813	871	923	1,012	1,079	1,136
636	113.4	475	529	574	619	704	778	845	905	959	1,050	1,120	1,179
635	112.6	486	541	588	634	721	800	872	935	993	1,090	1,166	1,231
634	111.7	506	564	613	661	752	834	912	981	1,044	1,150	1,233	1,306
633	110.9	534	593	644	694	789	874	955	1,027	1,093	1,205	1,294	1,371
632	109.3	555	617	670	722	820	909	992	1,067	1,135	1,248	1,338	1,416
631	108.6	590	654	709	763	865	958	1,045	1,123	1,193	1,312	1,407	1,490
630	106.9	604	670	726	782	885	980	1,070	1,151	1,225	1,347	1,444	1,529
629	105.9	631	698	755	811	915	1,011	1,102	1,185	1,261	1,385	1,484	1,571
628	104.5	660	730	789	848	958	1,058	1,153	1,240	1,319	1,451	1,556	1,648
627	103.0	680	754	818	879	993	1,098	1,197	1,287	1,369	1,506	1,616	1,713
626	102.1	698	775	840	903	1,021	1,128	1,228	1,319	1,402	1,541	1,653	1,752
625	101.0	738	817	884	949	1,069	1,177	1,280	1,373	1,458	1,599	1,714	1,815
624	99.4	776	857	926	992	1,114	1,226	1,331	1,426	1,512	1,657	1,774	1,876
623	98.2	804	887	956	1,023	1,149	1,263	1,371	1,468	1,557	1,706	1,827	1,933
622	97.4	822	906	977	1,045	1,173	1,289	1,398	1,497	1,587	1,739	1,862	1,969
621	96.6	847	932	1,004	1,073	1,203	1,321	1,431	1,532	1,623	1,778	1,902	2,012
620	95.7	857	946	1,021	1,091	1,225	1,344	1,456	1,557	1,650	1,805	1,931	2,042
619	94.8	879	971	1,048	1,121	1,258	1,381	1,496	1,601	1,696	1,857	1,988	2,103
618	93.8	888	981	1,058	1,132	1,271	1,395	1,511	1,617	1,714	1,876	2,009	2,125
617	93.3	919	1,013	1,093	1,168	1,311	1,439	1,558	1,666	1,765	1,931	2,068	2,187
616	92.0	936	1,032	1,113	1,190	1,336	1,467	1,592	1,703	1,805	1,978	2,121	2,245
615	90.6	948	1,044	1,126	1,204	1,351	1,483	1,609	1,721	1,825	2,005	2,156	2,288
614	89.4	966	1,064	1,147	1,226	1,376	1,510	1,637	1,751	1,856	2,039	2,192	2,326
613	88.4	987	1,087	1,172	1,252	1,404	1,540	1,669	1,784	1,891	2,076	2,231	2,367
612	87.2	998	1,101	1,188	1,271	1,426	1,564	1,694	1,811	1,918	2,106	2,263	2,401

611	86.5	1,009	1,114	1,202	1,286	1,443	1,583	1,718	1,839	1,951	2,143	2,304	2,445
610	85.4	1,029	1,136	1,226	1,311	1,471	1,614	1,751	1,875	1,989	2,185	2,349	2,493
609	84.1	1,033	1,140	1,230	1,316	1,475	1,619	1,757	1,881	1,995	2,192	2,357	2,502
608	83.8	1,051	1,160	1,253	1,340	1,502	1,648	1,788	1,914	2,031	2,231	2,400	2,548
607	82.8	1,098	1,210	1,306	1,396	1,564	1,714	1,859	1,988	2,108	2,315	2,488	2,641
606	81.1	1,130	1,245	1,343	1,436	1,607	1,762	1,910	2,043	2,165	2,378	2,556	2,712
605	79.9	1,159	1,279	1,381	1,478	1,654	1,813	1,965	2,102	2,229	2,448	2,632	2,794
604	78.3	1,175	1,297	1,401	1,498	1,678	1,844	2,000	2,138	2,264	2,485	2,670	2,833
603	77.4	1,206	1,329	1,434	1,532	1,715	1,884	2,043	2,183	2,312	2,537	2,726	2,892
602	76.0	1,230	1,356	1,465	1,567	1,752	1,924	2,085	2,227	2,358	2,586	2,778	2,947
601	74.9	1,236	1,364	1,474	1,576	1,762	1,934	2,095	2,238	2,370	2,599	2,792	2,962
17	74.7	1,303	1,437	1,552	1,659	1,852	2,030	2,197	2,346	2,481	2,716	2,915	3,091
1	72.2	1,409	1,548	1,668	1,780	1,981	2,166	2,339	2,493	2,633	2,877	3,084	3,267
2	68.5	1,475	1,620	1,744	1,859	2,066	2,257	2,435	2,593	2,736	2,984	3,195	3,381
3	65.9	1,528	1,678	1,807	1,927	2,143	2,341	2,526	2,690	2,838	3,092	3,308	3,500
4	63.4	1,598	1,751	1,884	2,007	2,229	2,432	2,622	2,790	2,940	3,199	3,418	3,613
5	60.7	1,685	1,839	1,972	2,096	2,319	2,523	2,714	2,884	3,035	3,295	3,517	3,713
6	58.4	1,745	1,899	2,034	2,158	2,384	2,590	2,783	2,954	3,106	3,368	3,591	3,788

Table 9. Cumulative Volume (from Upstream) for Each DSM2-SJR Model Segment

		Flow(cfs)											
		750	1000	1250	1500	2000	2500	3000	3500	4000	5000	6000	7000
Upstream	Upstream												
Node	SJR Mile	Cumulative Volume from Upstream (acre-feet)											
653	134.1	143	179	214	246	316	382	445	508	569	682	794	895
652	131.9	236	292	345	393	495	587	677	762	845	999	1,147	1,284
651	131.2	326	400	470	533	664	782	897	1,005	1,110	1,306	1,493	1,666
650	130.3	473	577	673	760	939	1,099	1,255	1,402	1,542	1,806	2,056	2,287
649	128.8	602	731	849	956	1,179	1,375	1,563	1,739	1,904	2,215	2,507	2,778
648	127.5	687	835	972	1,100	1,367	1,601	1,825	2,034	2,230	2,600	2,944	3,263
647	126.2	772	940	1,094	1,241	1,541	1,803	2,053	2,288	2,506	2,920	3,306	3,664
646	124.7	805	979	1,140	1,294	1,607	1,881	2,140	2,384	2,611	3,041	3,443	3,816
645	124.2	865	1,052	1,225	1,392	1,729	2,024	2,303	2,564	2,805	3,267	3,697	4,097
644	123.2	952	1,166	1,366	1,558	1,942	2,283	2,605	2,905	3,183	3,713	4,205	4,662
643	122.0	1,061	1,310	1,543	1,768	2,212	2,611	2,988	3,336	3,660	4,278	4,847	5,374
642	120.5	1,173	1,442	1,696	1,940	2,421	2,854	3,266	3,648	4,005	4,691	5,329	5,919
641	118.8	1,200	1,474	1,733	1,982	2,472	2,915	3,336	3,729	4,098	4,807	5,468	6,081
640	118.2	1,253	1,538	1,808	2,067	2,577	3,039	3,479	3,890	4,277	5,021	5,715	6,357
639	117.5	1,354	1,659	1,948	2,223	2,765	3,258	3,727	4,166	4,581	5,378	6,121	6,810
638	116.2	1,473	1,800	2,108	2,402	2,976	3,499	3,997	4,462	4,904	5,754	6,544	7,278
637	114.9	1,596	1,949	2,280	2,597	3,215	3,785	4,325	4,832	5,312	6,237	7,099	7,908
636	113.4	1,647	2,012	2,355	2,683	3,323	3,918	4,482	5,010	5,509	6,471	7,369	8,213
635	112.6	1,686	2,061	2,414	2,752	3,411	4,027	4,612	5,161	5,682	6,687	7,630	8,520
634	111.7	1,764	2,155	2,524	2,877	3,564	4,208	4,821	5,396	5,943	7,000	7,994	8,937
633	110.9	1,891	2,311	2,708	3,086	3,825	4,519	5,181	5,804	6,396	7,541	8,621	9,649
632	109.3	1,936	2,367	2,775	3,164	3,923	4,637	5,318	5,960	6,570	7,748	8,860	9,917
631	108.6	2,057	2,511	2,939	3,348	4,145	4,896	5,613	6,286	6,926	8,165	9,333	10,445
630	106.9	2,105	2,571	3,008	3,427	4,243	5,013	5,746	6,437	7,095	8,371	9,574	10,719
629	105.9	2,162	2,642	3,092	3,523	4,362	5,154	5,908	6,621	7,303	8,628	9,878	11,070
628	104.5	2,258	2,759	3,230	3,681	4,558	5,386	6,175	6,922	7,637	9,030	10,347	11,606
627	103.0	2,308	2,825	3,310	3,775	4,680	5,535	6,349	7,120	7,861	9,302	10,667	11,974
626	102.1	2,371	2,905	3,407	3,888	4,824	5,710	6,553	7,351	8,118	9,611	11,026	12,380
625	101.0	2,589	3,150	3,680	4,186	5,166	6,093	6,976	7,809	8,611	10,168	11,645	13,058
624	99.4	2,775	3,352	3,902	4,423	5,432	6,385	7,293	8,149	8,972	10,569	12,085	13,535
623	98.2	2,868	3,460	4,023	4,556	5,588	6,562	7,491	8,368	9,211	10,846	12,398	13,883
622	97.4	2,939	3,545	4,122	4,667	5,723	6,721	7,673	8,574	9,440	11,121	12,719	14,248
621	96.6	2,995	3,613	4,200	4,755	5,831	6,849	7,820	8,741	9,625	11,342	12,975	14,536
620	95.7	3,052	3,683	4,286	4,857	5,963	7,007	8,002	8,943	9,846	11,598	13,263	14,854
619	94.8	3,131	3,781	4,403	4,994	6,141	7,220	8,250	9,225	10,158	11,974	13,700	15,350
618	93.8	3,175	3,832	4,461	5,059	6,220	7,310	8,351	9,335	10,279	12,114	13,858	15,524
617	93.3	3,276	3,951	4,599	5,215	6,414	7,535	8,605	9,617	10,588	12,476	14,273	15,987
616	92.0	3,331	4,020	4,682	5,311	6,537	7,680	8,774	9,808	10,800	12,731	14,575	16,334
615	90.6	3,376	4,075	4,746	5,384	6,625	7,783	8,890	9,937	10,943	12,901	14,778	16,571
614	89.4	3,449	4,160	4,841	5,489	6,750	7,925	9,049	10,111	11,132	13,118	15,021	16,841
613	88.4	3,555	4,281	4,976	5,636	6,921	8,117	9,259	10,340	11,379	13,399	15,333	17,183
612	87.2	3,586	4,320	5,022	5,691	6,990	8,201	9,356	10,449	11,499	13,543	15,498	17,370
611	86.5	3,622	4,364	5,075	5,751	7,069	8,298	9,475	10,590	11,662	13,748	15,743	17,652

610	85.4	3,663	4,416	5,138	5,825	7,163	8,414	9,613	10,750	11,843	13,970	16,005	17,952
609	84.1	3,686	4,444	5,170	5,860	7,205	8,462	9,667	10,809	11,907	14,046	16,090	18,046
608	83.8	3,765	4,540	5,282	5,987	7,357	8,636	9,863	11,025	12,144	14,320	16,400	18,390
607	82.8	3,924	4,733	5,508	6,240	7,663	8,992	10,267	11,472	12,633	14,893	17,047	19,109
606	81.1	4,021	4,850	5,645	6,396	7,855	9,219	10,531	11,768	12,964	15,292	17,509	19,629
605	79.9	4,111	4,964	5,782	6,555	8,055	9,459	10,818	12,091	13,320	15,716	17,997	20,180
604	78.3	4,158	5,025	5,857	6,642	8,166	9,595	10,983	12,277	13,523	15,956	18,272	20,491
603	77.4	4,238	5,123	5,971	6,773	8,327	9,785	11,203	12,528	13,804	16,290	18,659	20,927
602	76.0	4,313	5,216	6,083	6,902	8,490	9,980	11,428	12,779	14,082	16,619	19,036	21,350
601	74.9	4,326	5,234	6,105	6,930	8,527	10,026	11,481	12,840	14,150	16,702	19,132	21,459
17	74.7	4,567	5,524	6,444	7,318	9,003	10,581	12,113	13,546	14,924	17,611	20,168	22,620
1	72.2	4,934	5,964	6,953	7,888	9,691	11,373	13,003	14,529	15,992	18,840	21,550	24,148
2	68.5	5,236	6,319	7,359	8,337	10,223	11,976	13,672	15,261	16,779	19,731	22,539	25,228
3	65.9	5,403	6,520	7,593	8,606	10,556	12,372	14,128	15,777	17,351	20,409	23,319	26,101
4	63.4	5,705	6,850	7,953	8,998	11,008	12,885	14,701	16,408	18,040	21,201	24,209	27,085
5	60.7	6,139	7,304	8,434	9,506	11,573	13,502	15,371	17,129	18,807	22,056	25,142	28,093
6	58.4	6,427	7,610	8,759	9,853	11,968	13,938	15,850	17,648	19,364	22,683	25,829	28,839

Table 10. Cumulative Travel Time for Each DSM2-SJR Model Segment

		Flow (cfs)											
		750	1000	1250	1500	2000	2500	3000	3500	4000	5000	6000	7000
Upstream	Upstream												
Node	SJR Mile	Cumulative Travel Time from Upstream (hours)											
653	134.1	2.3	2.2	2.1	2.0	1.9	1.9	1.8	1.8	1.7	1.7	1.6	1.5
652	131.9	3.8	3.5	3.3	3.2	3.0	2.8	2.7	2.6	2.6	2.4	2.3	2.2
651	131.2	5.3	4.9	4.6	4.3	4.0	3.8	3.6	3.5	3.4	3.2	3.0	2.9
650	130.3	7.6	7.0	6.5	6.1	5.7	5.3	5.1	4.9	4.7	4.4	4.2	4.0
649	128.8	9.7	8.9	8.2	7.7	7.1	6.7	6.3	6.0	5.8	5.4	5.1	4.8
648	127.5	11.1	10.1	9.4	8.9	8.3	7.8	7.4	7.0	6.8	6.3	5.9	5.7
647	126.2	12.5	11.4	10.6	10.0	9.3	8.7	8.3	7.9	7.6	7.1	6.7	6.3
646	124.7	13.0	11.9	11.1	10.5	9.7	9.1	8.6	8.3	7.9	7.4	7.0	6.6
645	124.2	14.0	12.7	11.9	11.3	10.5	9.8	9.3	8.9	8.5	7.9	7.5	7.1
644	123.2	15.4	14.1	13.2	12.6	11.8	11.1	10.5	10.1	9.6	9.0	8.5	8.1
643	122.0	17.2	15.9	15.0	14.3	13.4	12.7	12.1	11.6	11.1	10.4	9.8	9.3
642	120.5	19.0	17.5	16.4	15.7	14.7	13.8	13.2	12.6	12.1	11.4	10.8	10.3
641	118.8	19.4	17.9	16.8	16.0	15.0	14.1	13.5	12.9	12.4	11.7	11.0	10.5
640	118.2	20.2	18.6	17.5	16.7	15.6	14.7	14.1	13.5	13.0	12.2	11.5	11.0
639	117.5	21.9	20.1	18.9	18.0	16.8	15.8	15.1	14.4	13.9	13.0	12.4	11.8
638	116.2	23.8	21.8	20.4	19.4	18.0	17.0	16.1	15.5	14.9	13.9	13.2	12.6
637	114.9	25.8	23.6	22.1	21.0	19.5	18.3	17.5	16.7	16.1	15.1	14.3	13.7
636	113.4	26.6	24.4	22.8	21.7	20.1	19.0	18.1	17.3	16.7	15.7	14.9	14.2
635	112.6	27.2	25.0	23.4	22.2	20.7	19.5	18.6	17.9	17.2	16.2	15.4	14.8
634	111.7	28.5	26.1	24.5	23.2	21.6	20.4	19.5	18.7	18.0	17.0	16.1	15.5
633	110.9	30.6	28.0	26.3	24.9	23.2	21.9	20.9	20.1	19.4	18.3	17.4	16.7
632	109.3	31.3	28.7	26.9	25.6	23.8	22.5	21.5	20.6	19.9	18.8	17.9	17.2
631	108.6	33.2	30.4	28.5	27.1	25.1	23.7	22.7	21.8	21.0	19.8	18.9	18.1
630	106.9	34.0	31.2	29.2	27.7	25.7	24.3	23.2	22.3	21.5	20.3	19.3	18.6
629	105.9	34.9	32.0	30.0	28.5	26.4	25.0	23.9	22.9	22.1	20.9	20.0	19.2
628	104.5	36.5	33.4	31.3	29.7	27.6	26.1	25.0	24.0	23.1	21.9	20.9	20.1
627	103.0	37.3	34.2	32.1	30.5	28.4	26.8	25.7	24.7	23.8	22.6	21.6	20.7
626	102.1	38.3	35.2	33.0	31.4	29.2	27.7	26.5	25.5	24.6	23.3	22.3	21.4
625	101.0	41.8	38.2	35.7	33.8	31.3	29.5	28.2	27.0	26.1	24.6	23.5	22.6
624	99.4	44.8	40.6	37.8	35.7	32.9	31.0	29.5	28.2	27.2	25.6	24.4	23.4
623	98.2	46.3	41.9	39.0	36.8	33.9	31.8	30.3	29.0	27.9	26.3	25.0	24.0
622	97.4	47.5	43.0	40.0	37.7	34.7	32.6	31.0	29.7	28.6	27.0	25.7	24.7
621	96.6	48.4	43.8	40.7	38.4	35.3	33.2	31.6	30.3	29.2	27.5	26.2	25.2
620	95.7	49.3	44.6	41.6	39.2	36.1	34.0	32.3	31.0	29.8	28.1	26.8	25.7
619	94.8	50.6	45.8	42.7	40.4	37.2	35.0	33.3	31.9	30.8	29.0	27.7	26.6
618	93.8	51.3	46.4	43.3	40.9	37.7	35.4	33.7	32.3	31.1	29.4	28.0	26.9
617	93.3	52.9	47.9	44.6	42.1	38.9	36.5	34.8	33.3	32.1	30.2	28.8	27.7
616	92.0	53.8	48.7	45.4	42.9	39.6	37.2	35.4	34.0	32.7	30.9	29.4	28.3
615	90.6	54.6	49.4	46.0	43.5	40.2	37.7	35.9	34.4	33.2	31.3	29.9	28.7
614	89.4	55.7	50.4	46.9	44.4	40.9	38.4	36.6	35.0	33.7	31.8	30.3	29.2
613	88.4	57.5	51.9	48.3	45.5	41.9	39.4	37.4	35.8	34.5	32.5	31.0	29.8
612	87.2	58.0	52.4	48.7	46.0	42.4	39.8	37.8	36.2	34.8	32.8	31.3	30.1

611	86.5	58.5	52.9	49.2	46.5	42.8	40.2	38.3	36.7	35.3	33.3	31.8	30.6
610	85.4	59.2	53.5	49.8	47.1	43.4	40.8	38.8	37.2	35.9	33.9	32.3	31.1
609	84.1	59.6	53.9	50.1	47.4	43.7	41.0	39.1	37.4	36.1	34.0	32.5	31.2
608	83.8	60.9	55.0	51.2	48.4	44.6	41.9	39.9	38.2	36.8	34.7	33.1	31.8
607	82.8	63.4	57.4	53.4	50.4	46.4	43.6	41.5	39.7	38.3	36.1	34.4	33.1
606	81.1	65.0	58.8	54.7	51.7	47.6	44.7	42.6	40.8	39.3	37.1	35.4	34.0
605	79.9	66.4	60.2	56.1	53.0	48.8	45.9	43.7	41.9	40.4	38.1	36.4	34.9
604	78.3	67.2	60.9	56.8	53.7	49.5	46.5	44.4	42.5	41.0	38.7	36.9	35.5
603	77.4	68.5	62.1	57.9	54.7	50.5	47.4	45.3	43.4	41.8	39.5	37.7	36.2
602	76.0	69.7	63.2	59.0	55.8	51.5	48.4	46.2	44.3	42.7	40.3	38.5	37.0
601	74.9	69.9	63.4	59.2	56.0	51.7	48.6	46.4	44.5	42.9	40.5	38.7	37.2
17	74.7	73.8	67.0	62.5	59.1	54.6	51.3	48.9	46.9	45.2	42.7	40.7	39.2
1	72.2	79.7	72.3	67.4	63.7	58.7	55.1	52.5	50.3	48.5	45.7	43.5	41.8
2	68.5	84.6	76.6	71.4	67.4	62.0	58.1	55.2	52.9	50.8	47.8	45.5	43.7
3	65.9	87.3	79.0	73.6	69.5	64.0	60.0	57.1	54.6	52.6	49.5	47.1	45.2
4	63.4	92.2	83.0	77.1	72.7	66.7	62.5	59.4	56.8	54.7	51.4	48.9	46.9
5	60.7	99.2	88.5	81.8	76.8	70.1	65.5	62.1	59.3	57.0	53.5	50.8	48.6
6	58.4	103.9	92.2	84.9	79.6	72.5	67.6	64.0	61.1	58.7	55.0	52.2	49.9

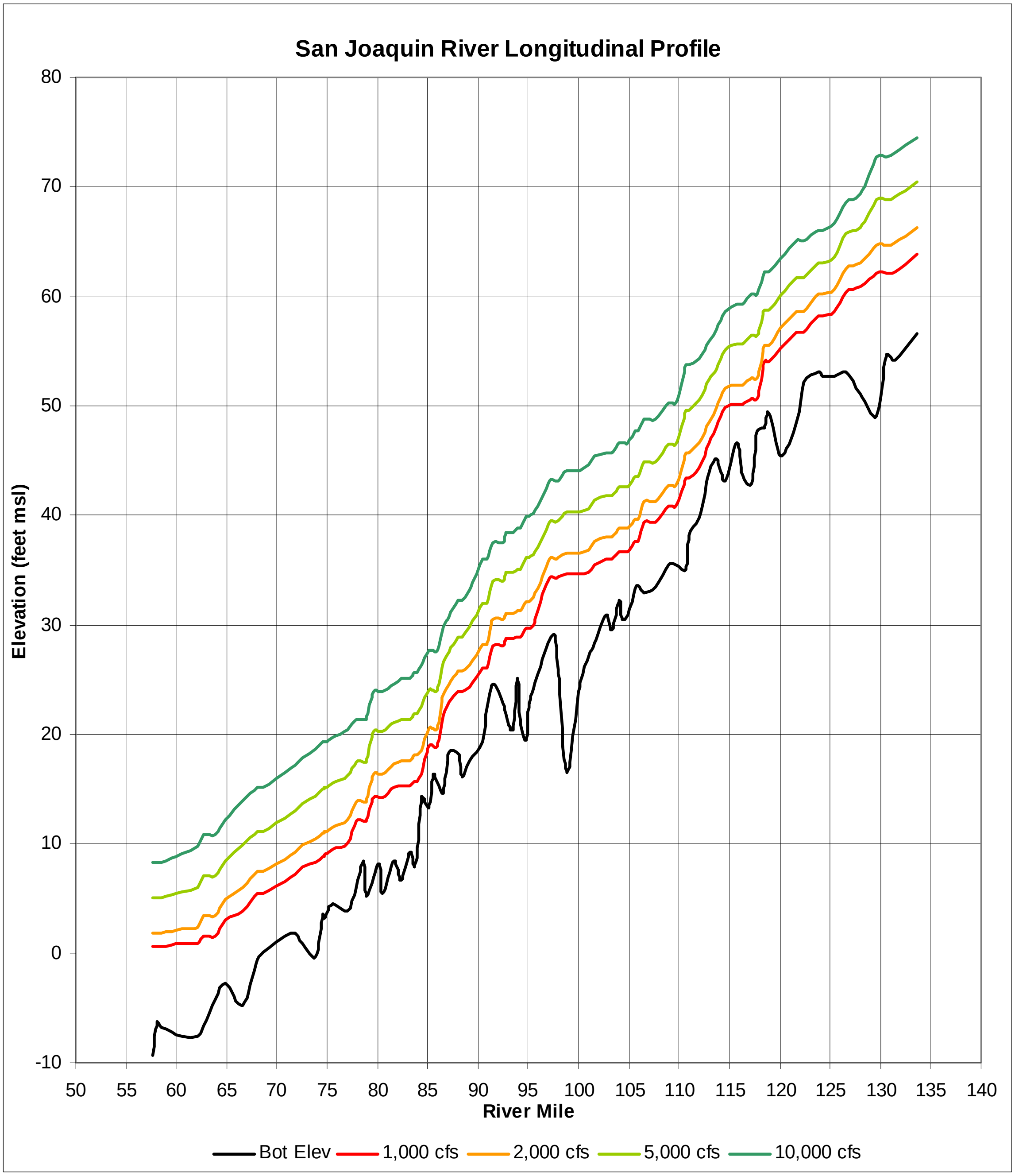


Figure 1. San Joaquin River bottom and water surface elevations at each cross-section used in the SJR model for a range of uniform flows from 1,000 cfs to 10,000 cfs from Mossdale (mile 56) to the Stevinson gage (mile 132).

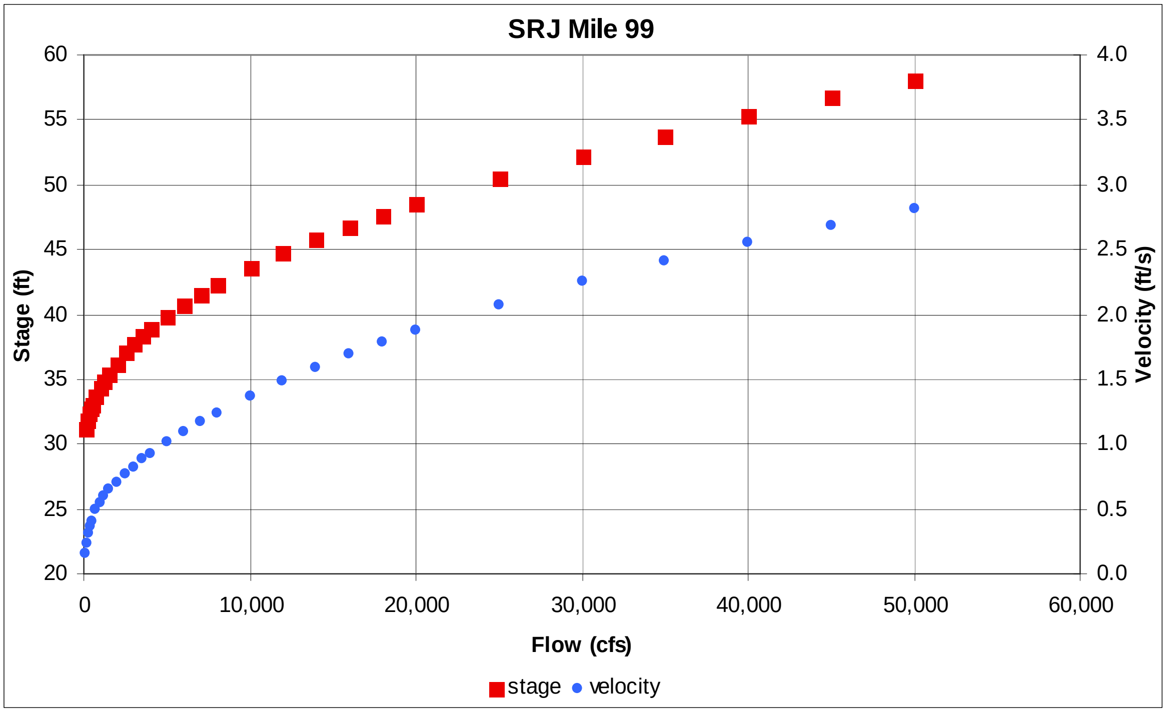


Figure 2a. Simulated stage and velocity at SJR mile 99 (Model segment 624) at the Patterson gage. Stage is regulated by downstream section, because the stage is 8 feet above channel bottom.

Figure 2b. Simulated stage and surface width at SJR mile 99 (Model segment 624) at the Patterson gage. Cross-section data end at elevation 43 feet.

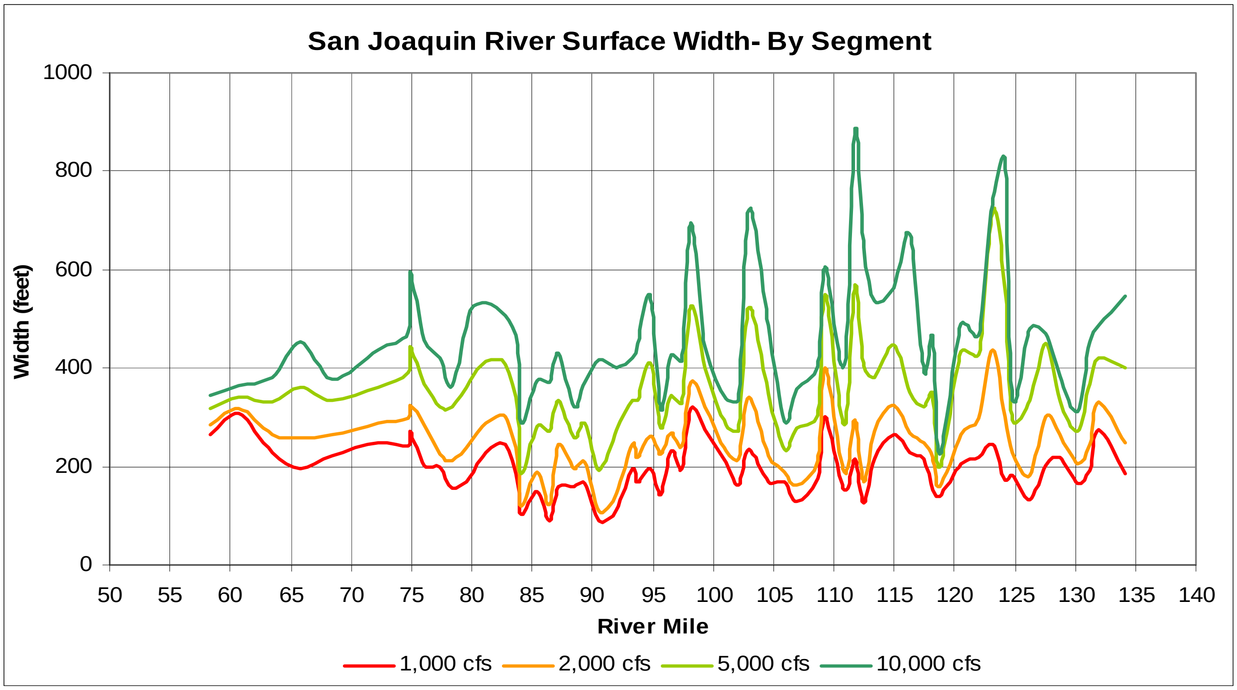


Figure 3. Simulated San Joaquin River Width between Mossdale (mile 57) and Stevinson (mile 134) for a range of flows.

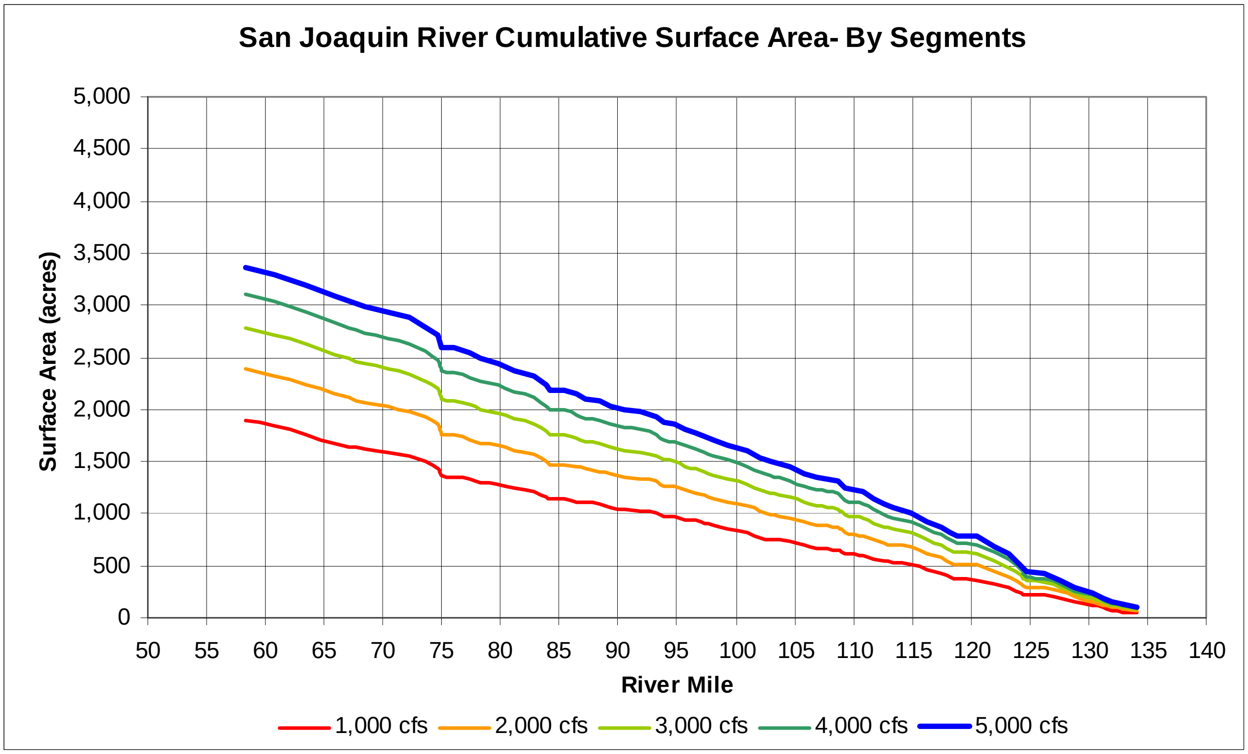


Figure 4. Simulated San Joaquin River surface area from Stevinson downstream to Mossdale for a range of flows from 1,000 cfs to 5,000 cfs.

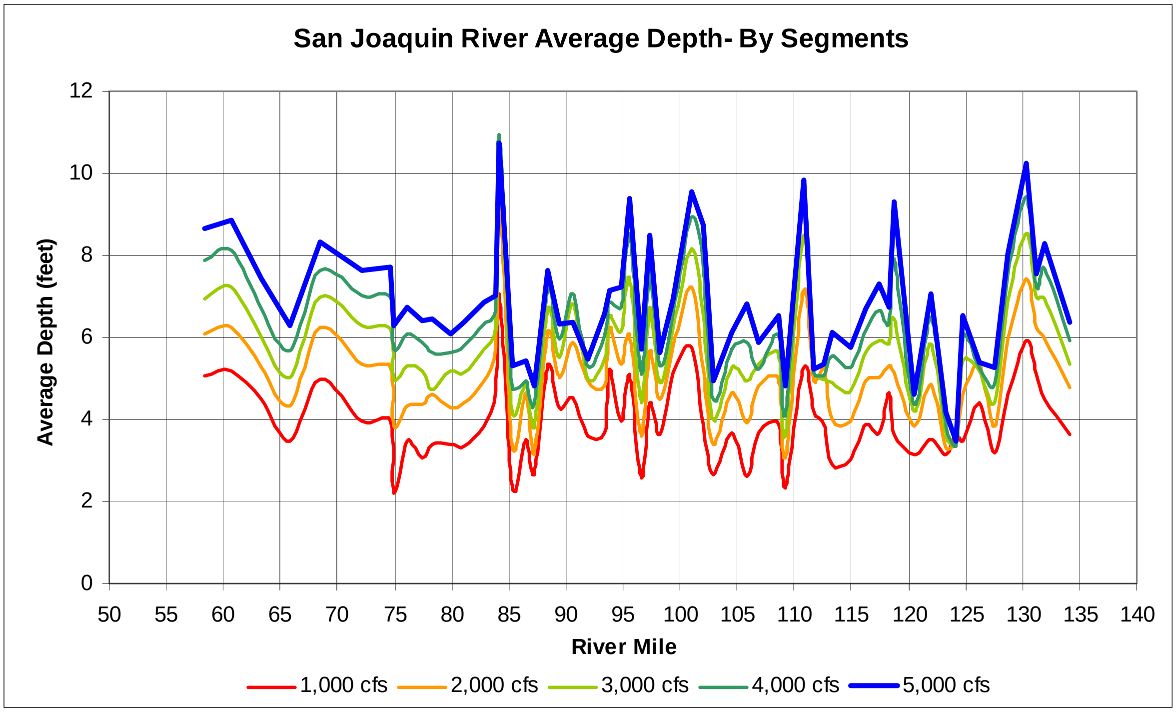


Figure 5. Simulated San Joaquin River Average Depth for a range of flows.

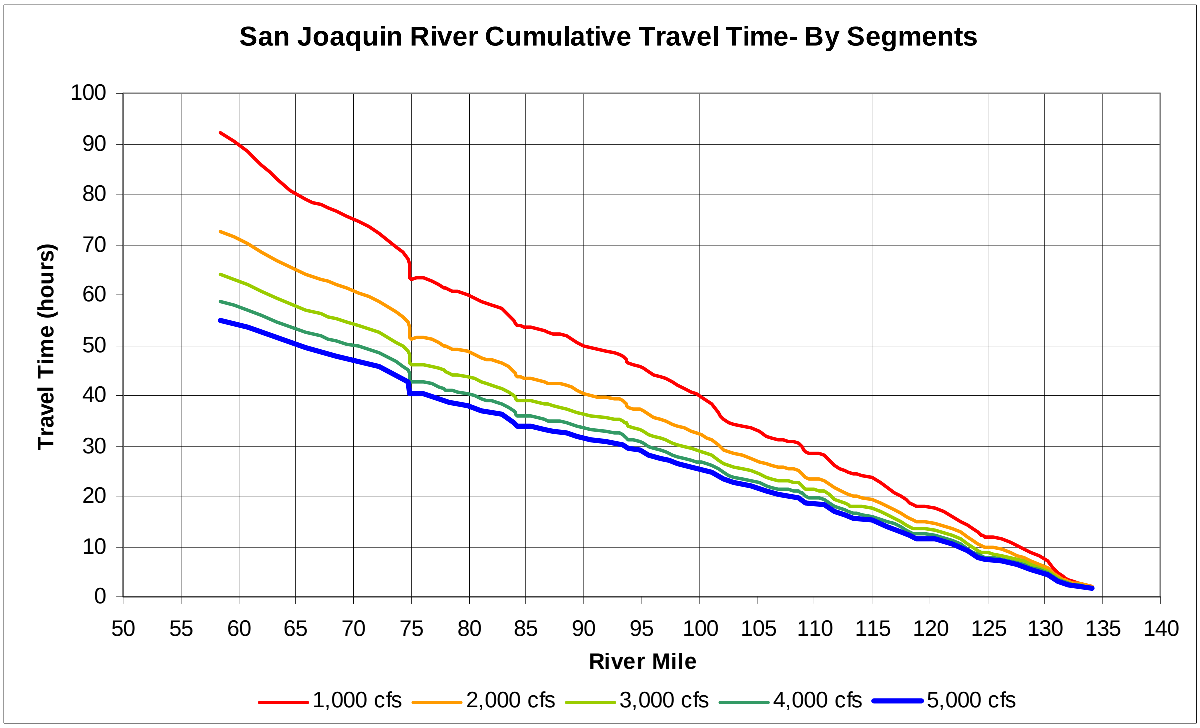
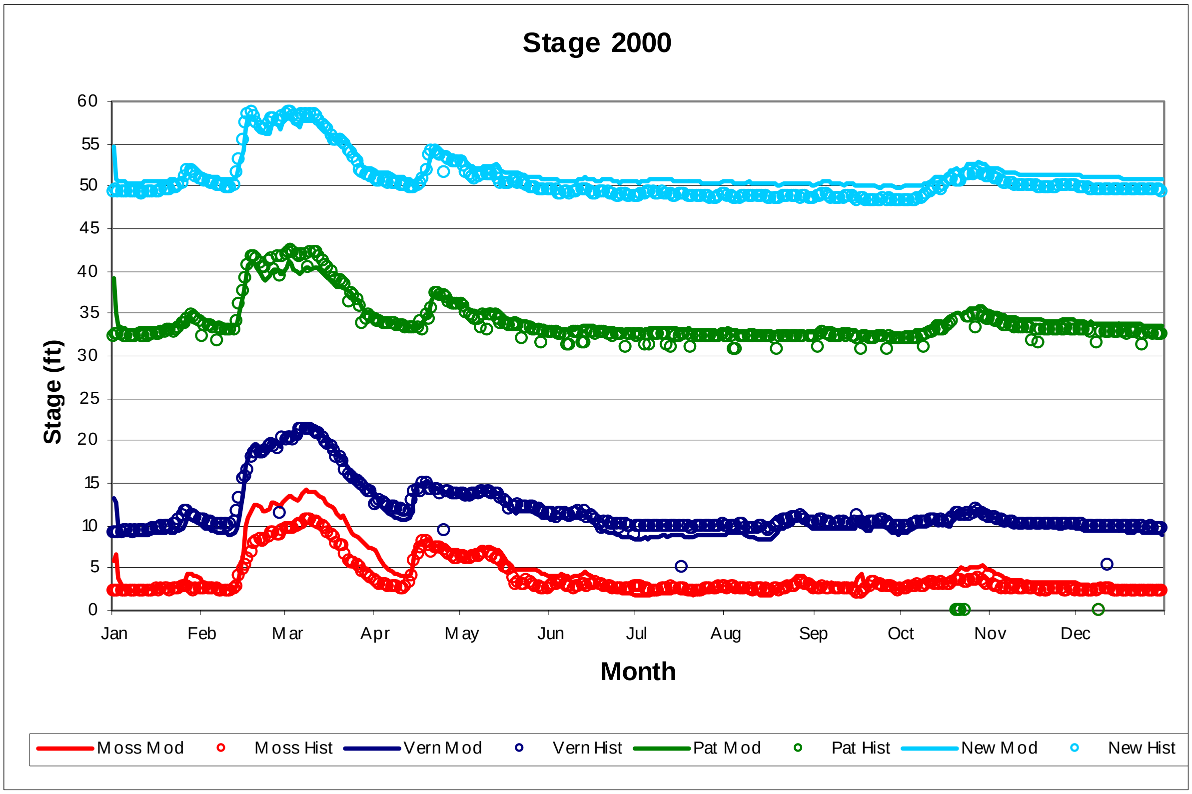


Figure 6. Simulated San Joaquin River Travel Time for a range of flows.



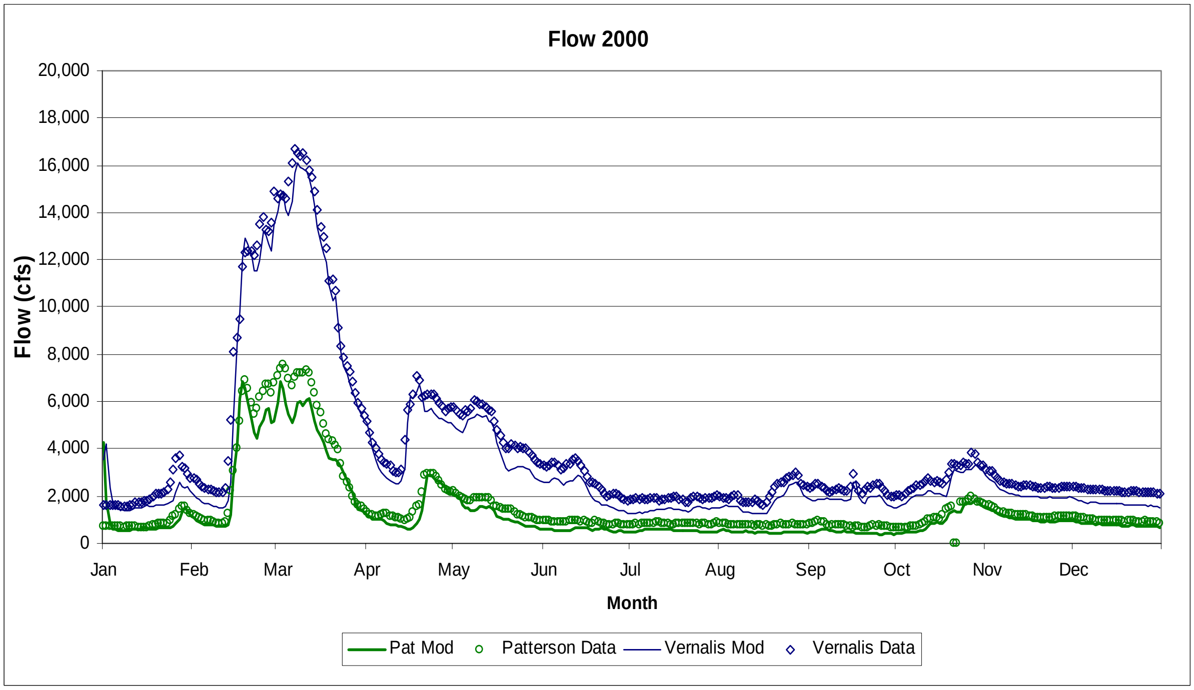
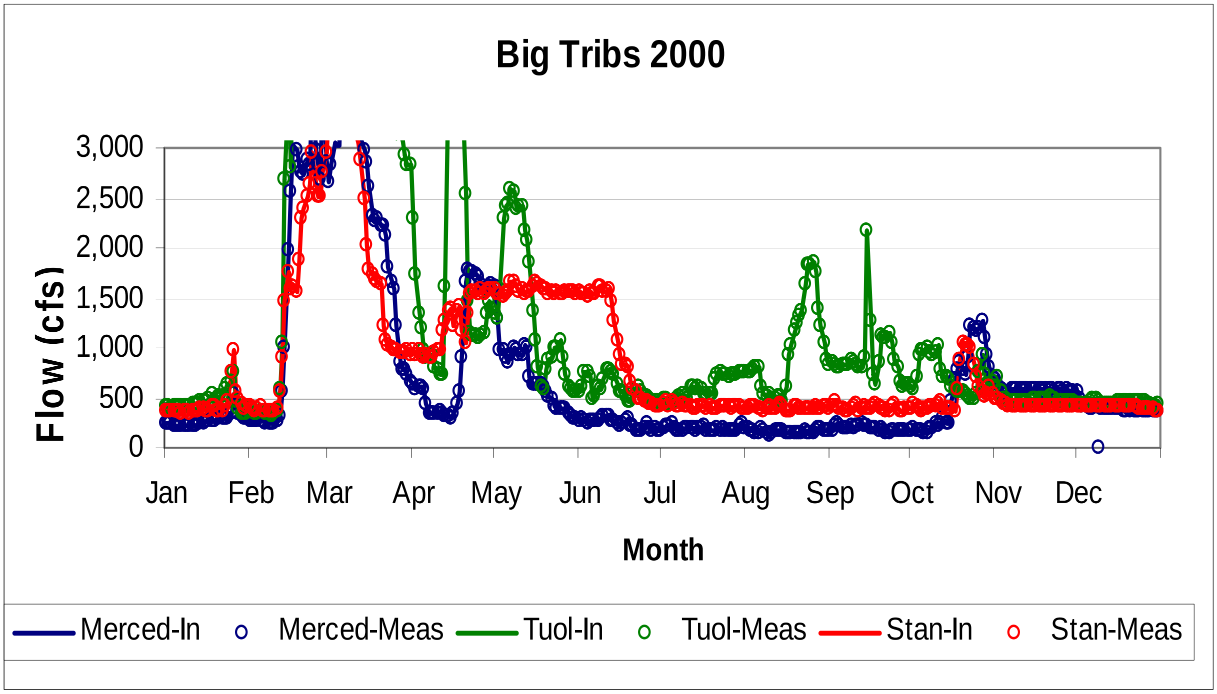


Figure 7. Comparison of measured and simulated SJR stages and flows for 2000.



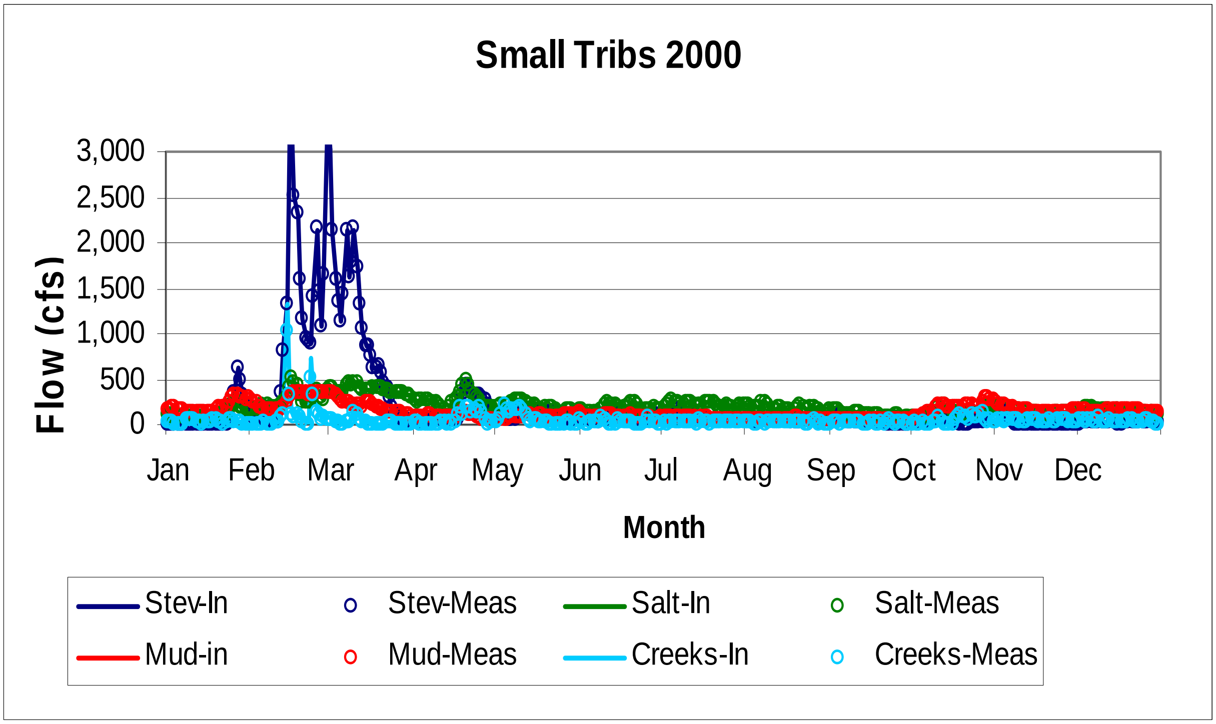


Figure 8. Daily Flow Inputs for the DSM2-SJR Model.

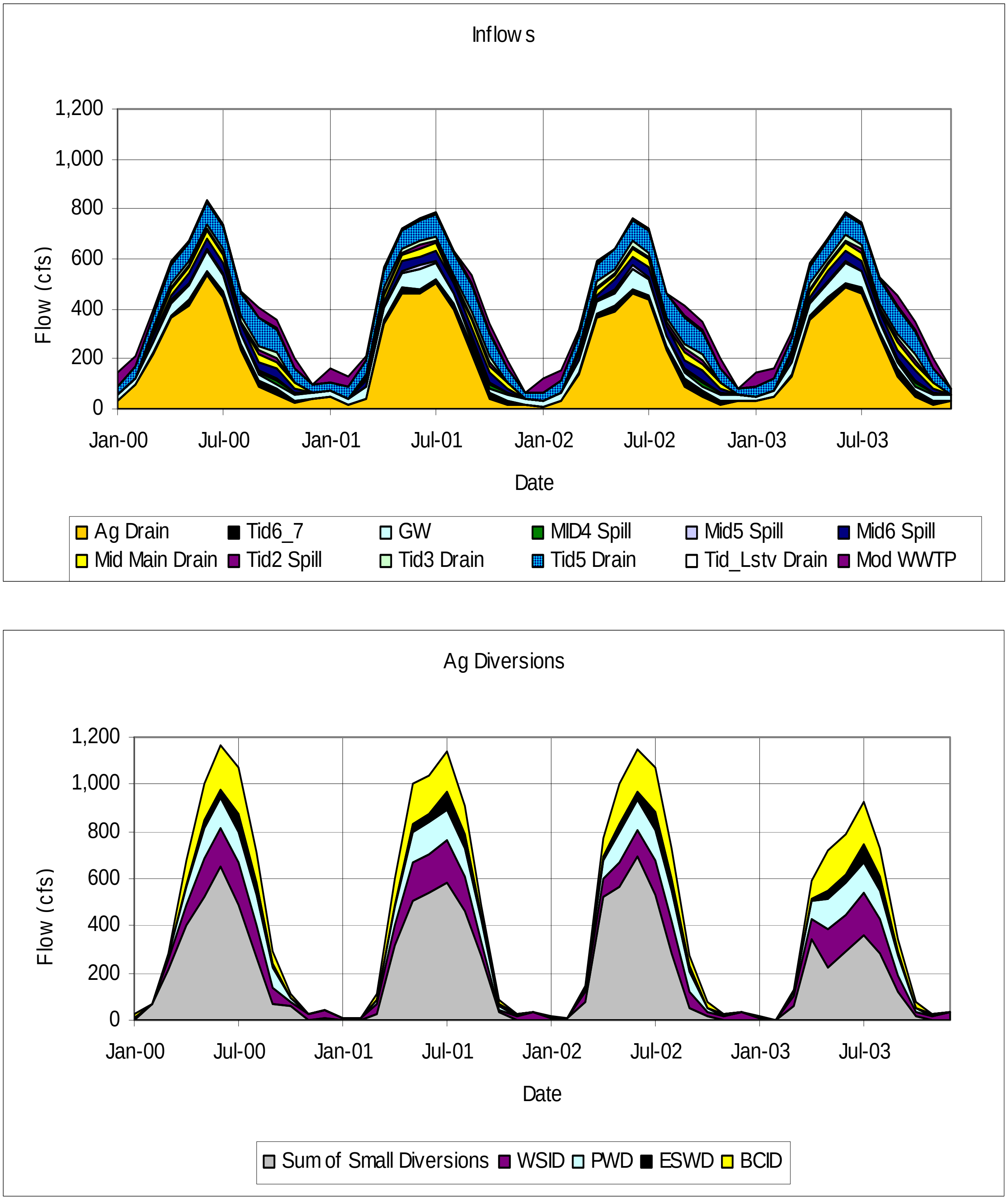
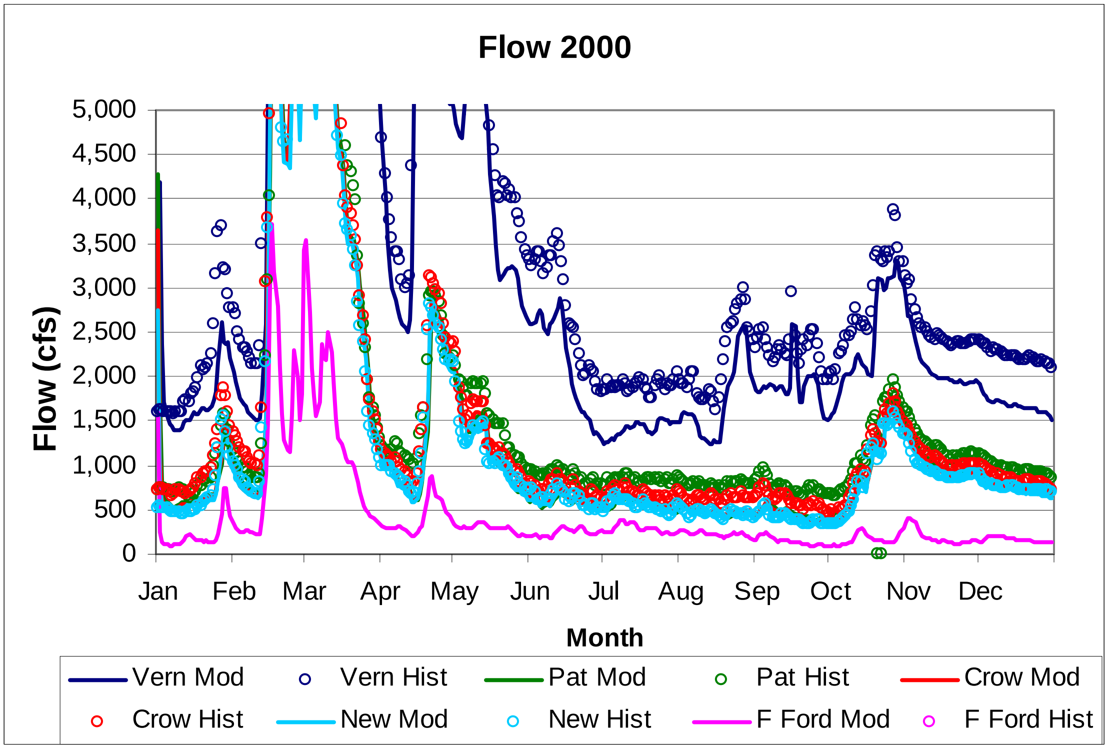


Figure 9. Monthly Flow Inputs for the DSM2-SJR Model.



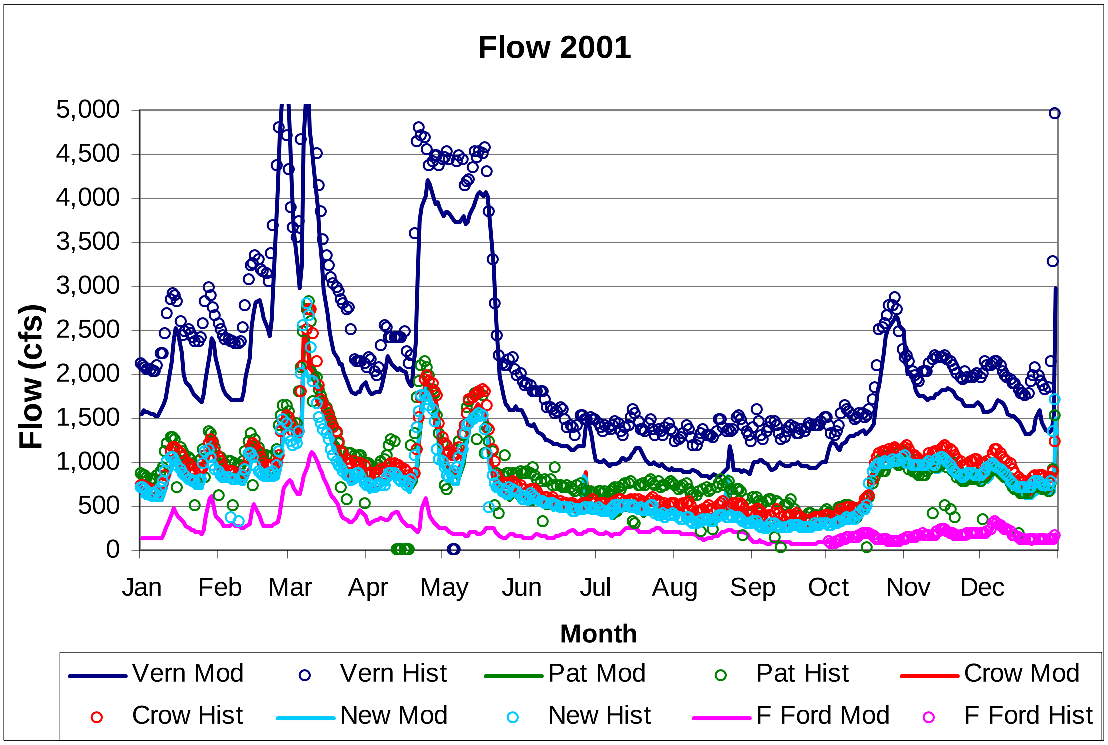
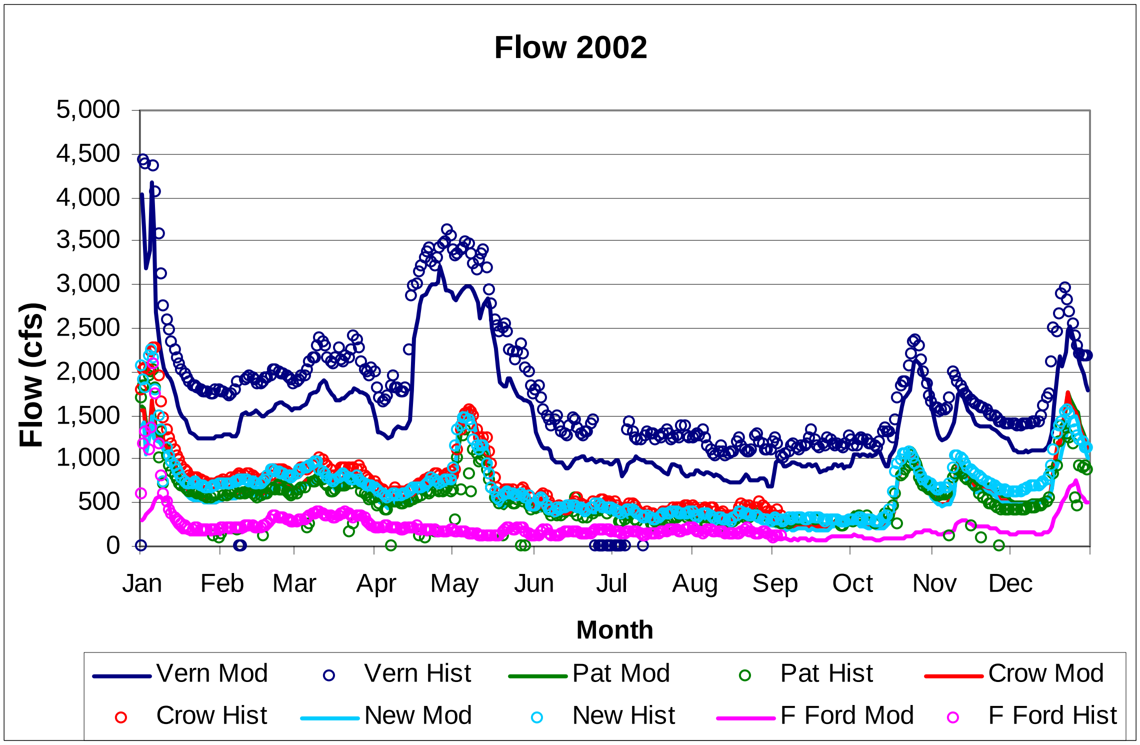


Figure 10. Measured and Simulated Flows for 2000 and 2001



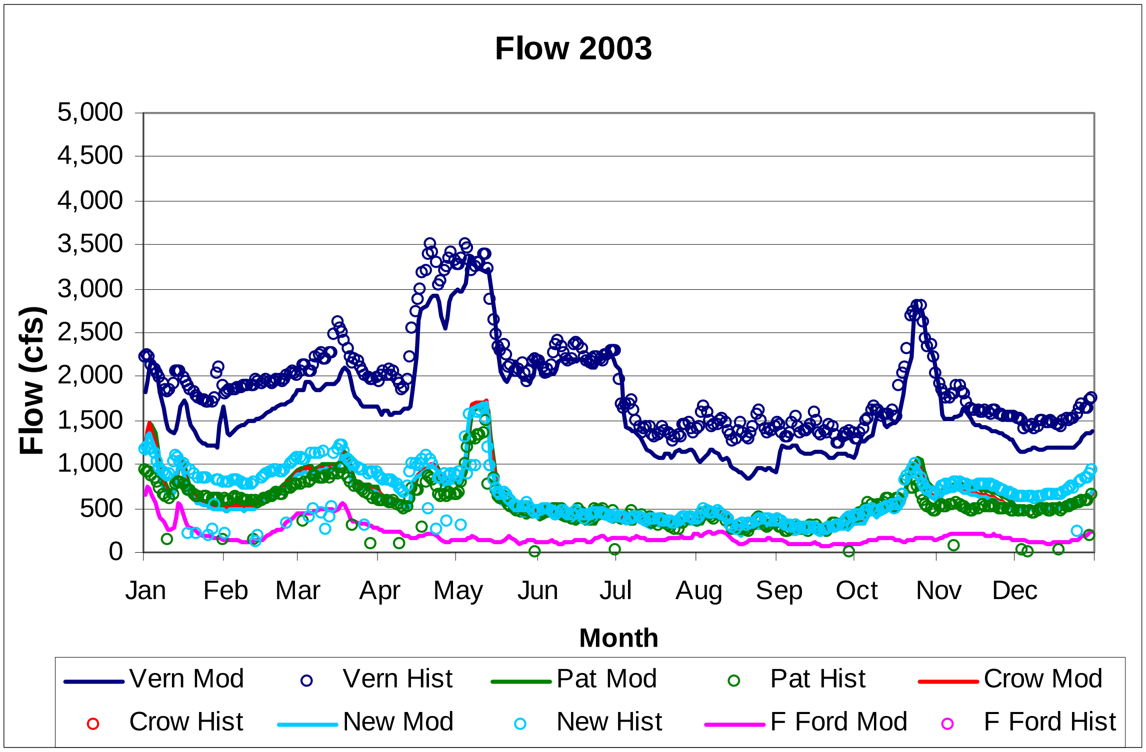
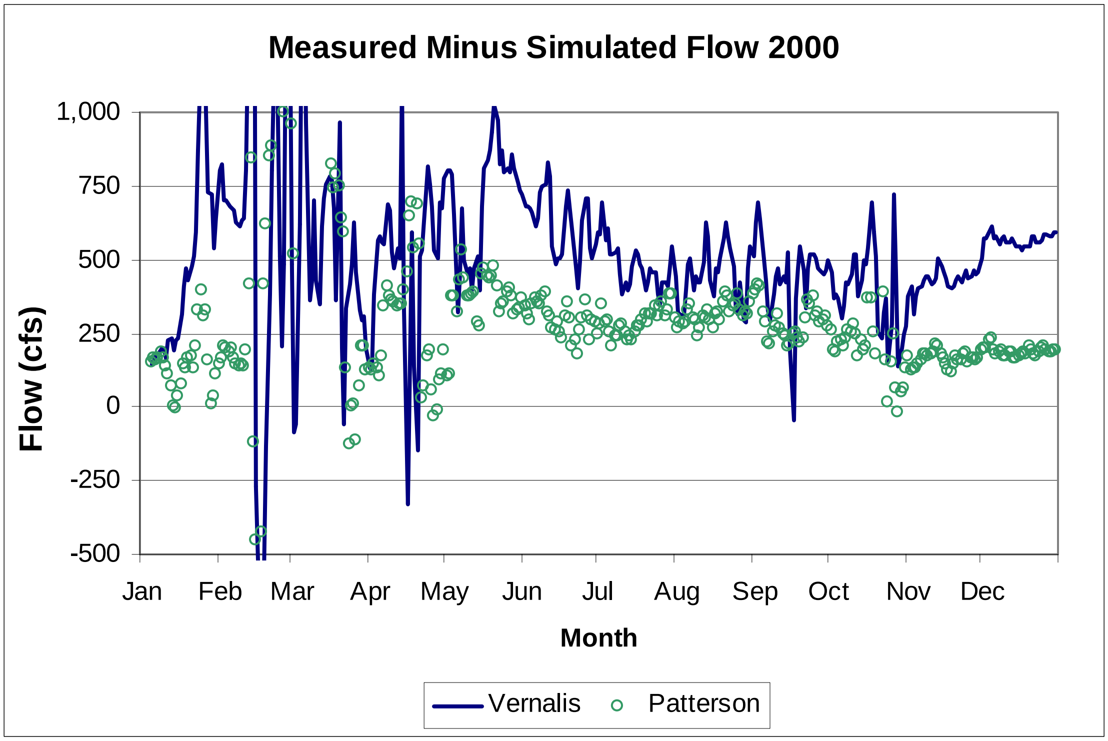


Figure 11. Measured and Simulated Flows for 2002 and 2003



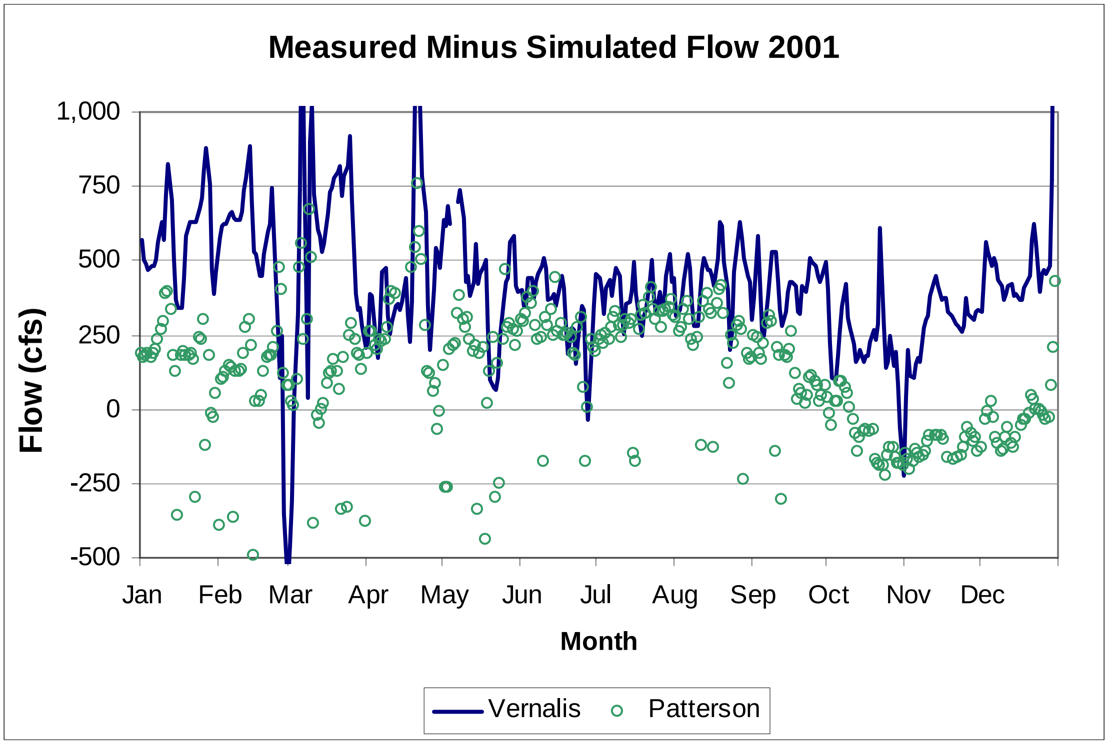
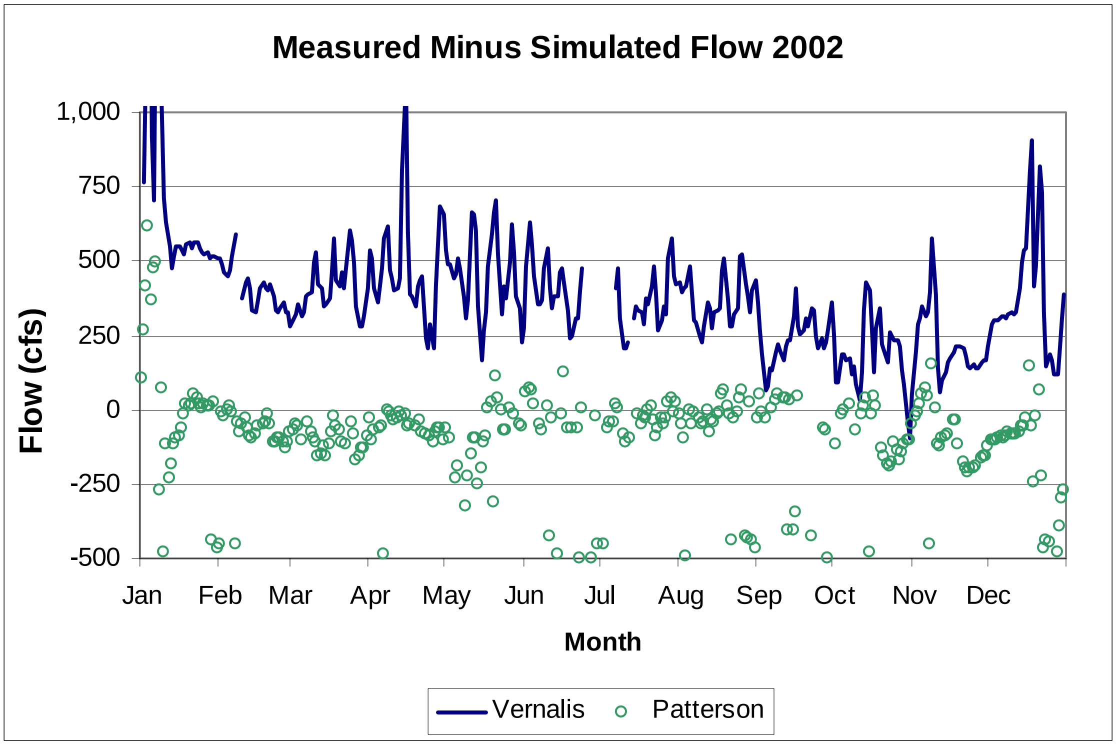


Figure 12. Deviation between Measured and Simulated Flow at Vernalis and Patterson for 2000 and 2001



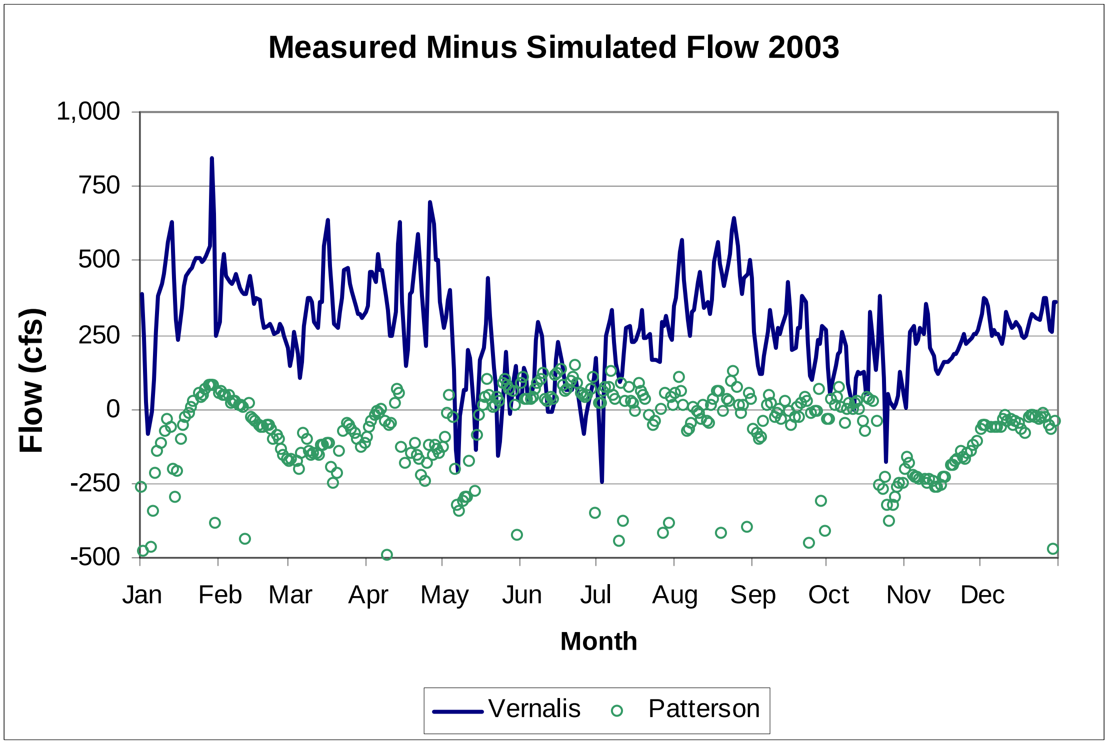
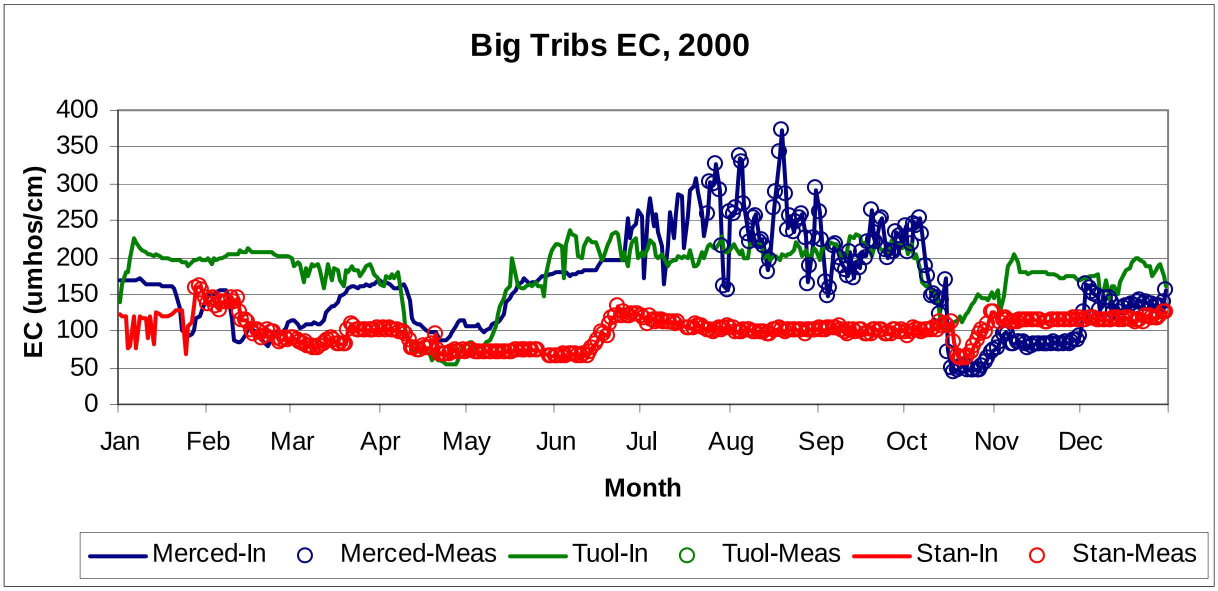


Figure 13. Deviation between Measured and Simulated Flow at Vernalis and Patterson for 2002 and 2003



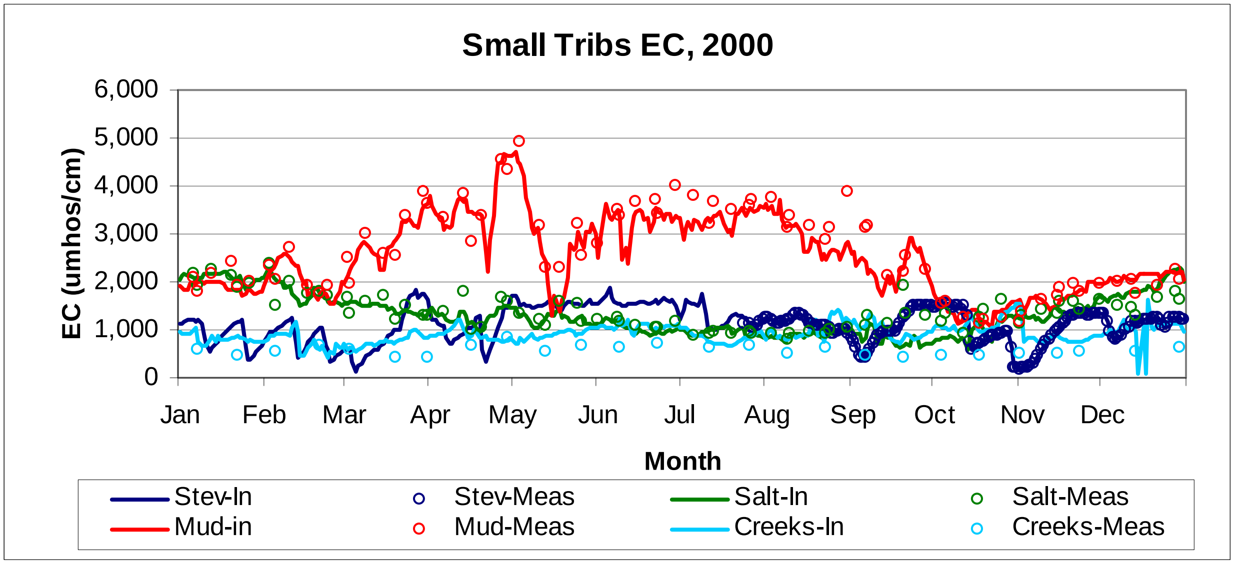
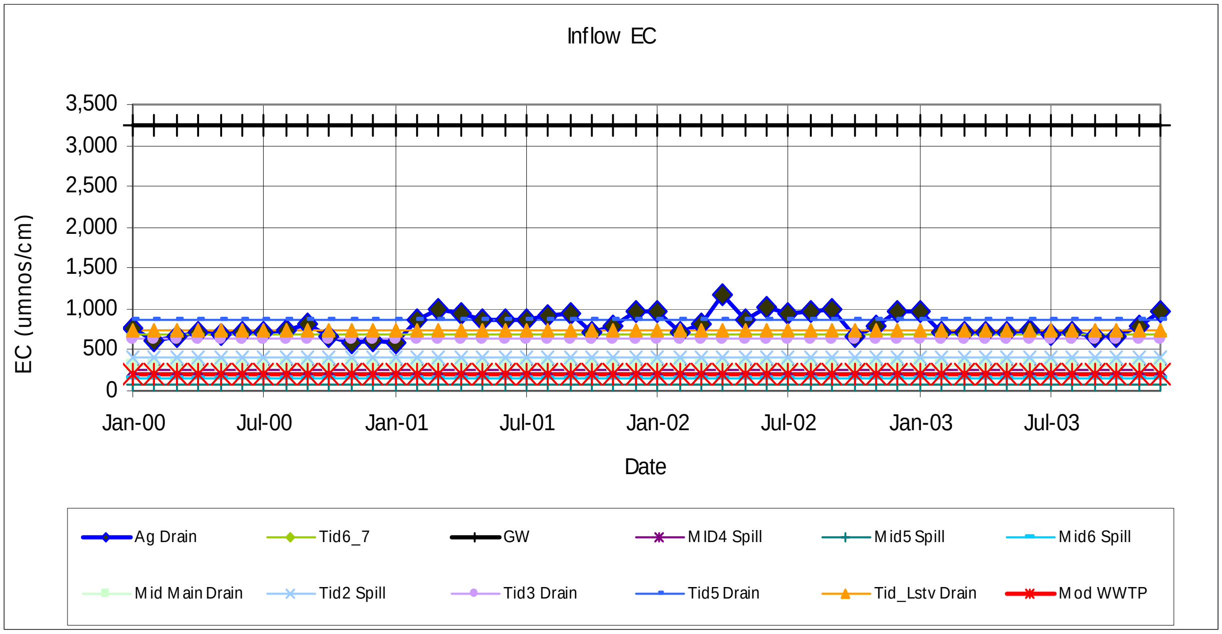


Figure 14. Example Input for Electrical Conductivity of Tributaries



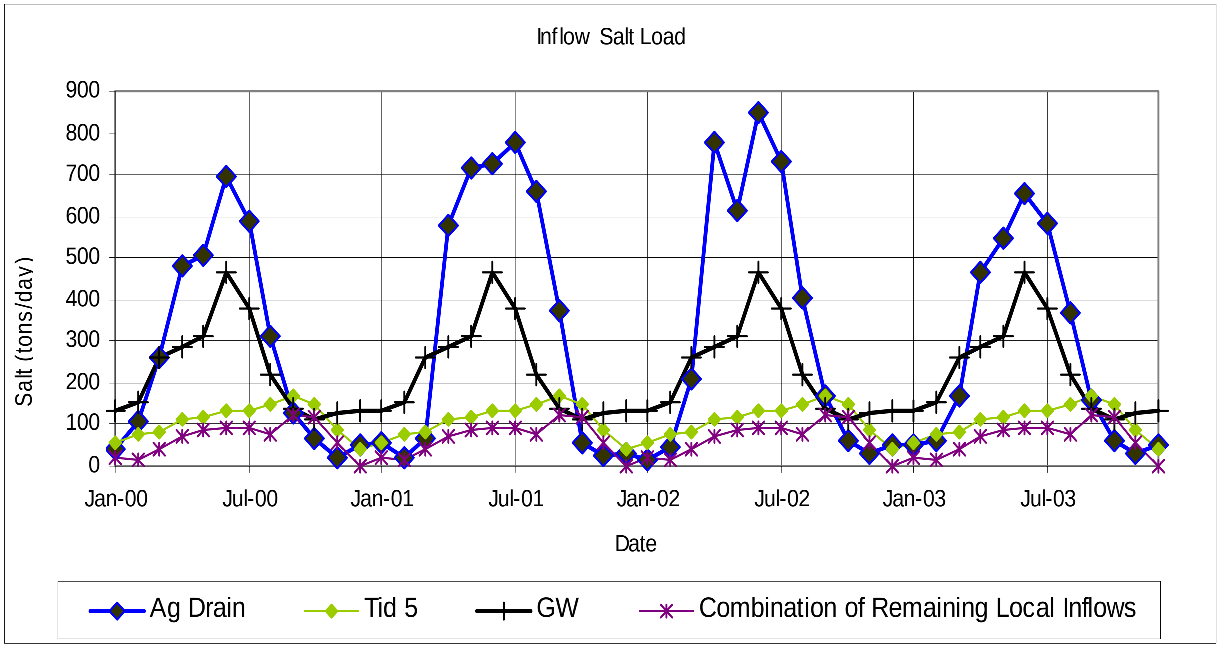
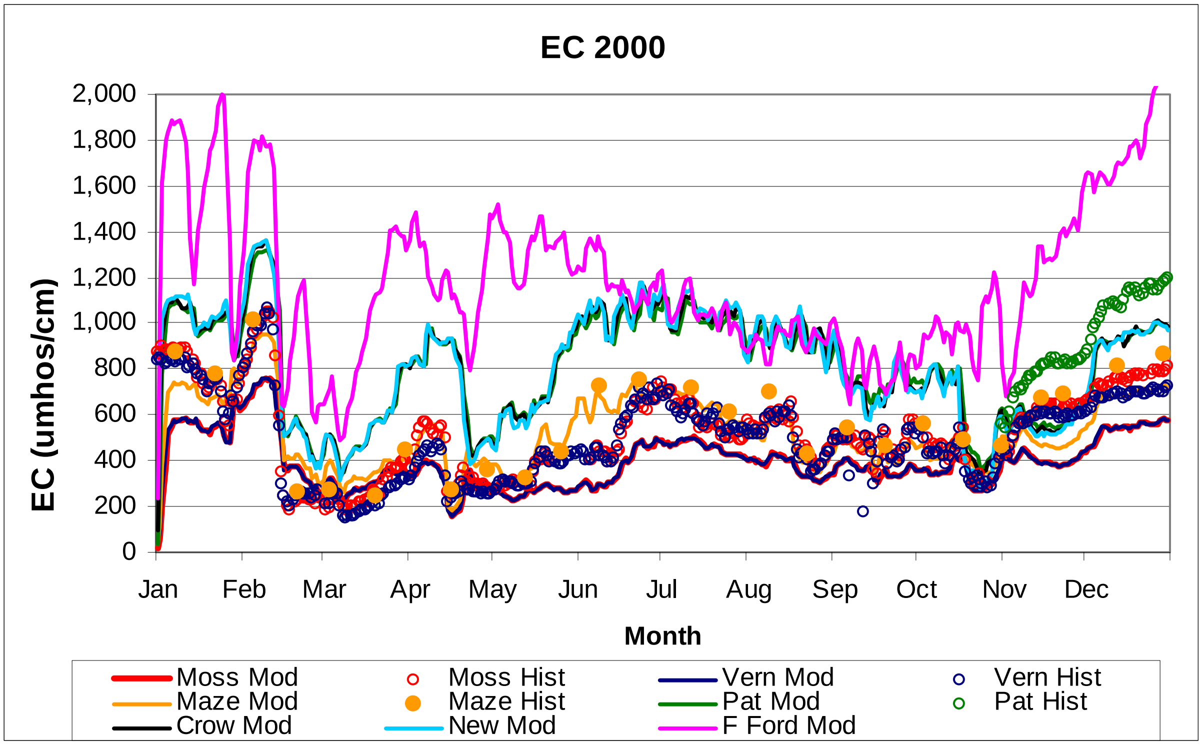


Figure 15. Estimated Electrical Conductivity and Salt Load of Local Inflows and Spills



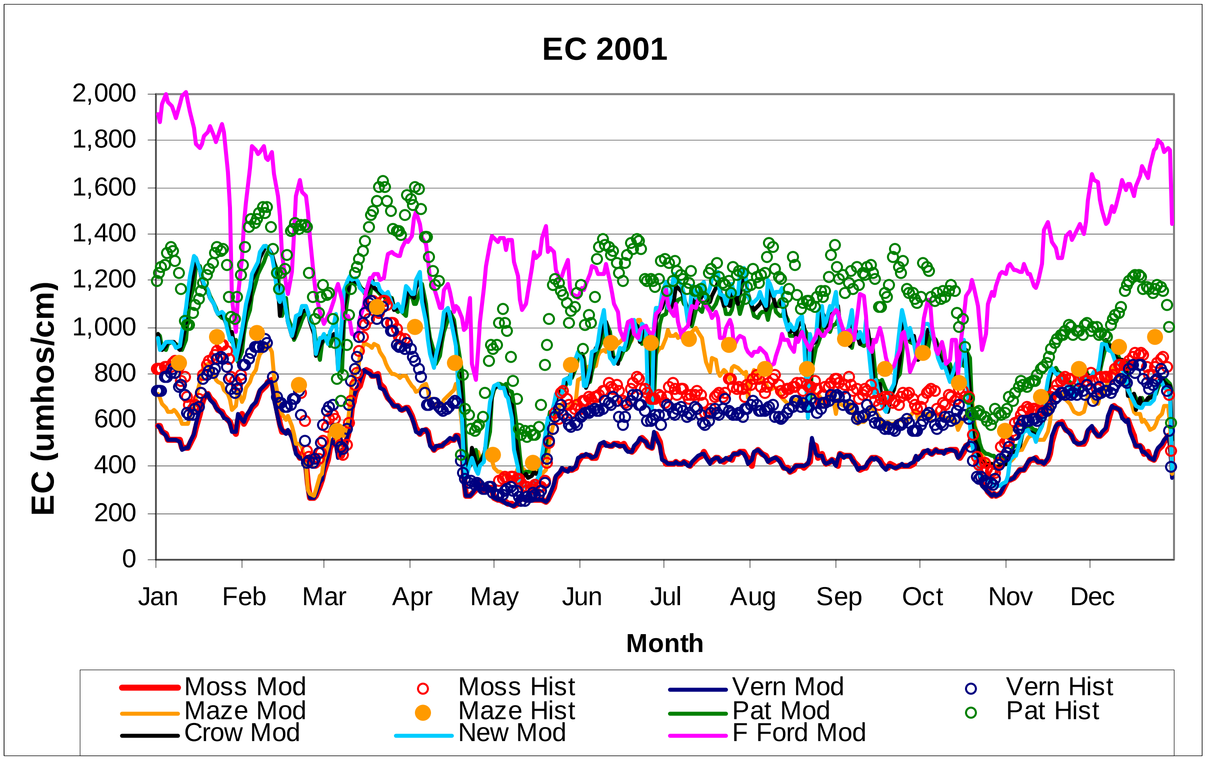
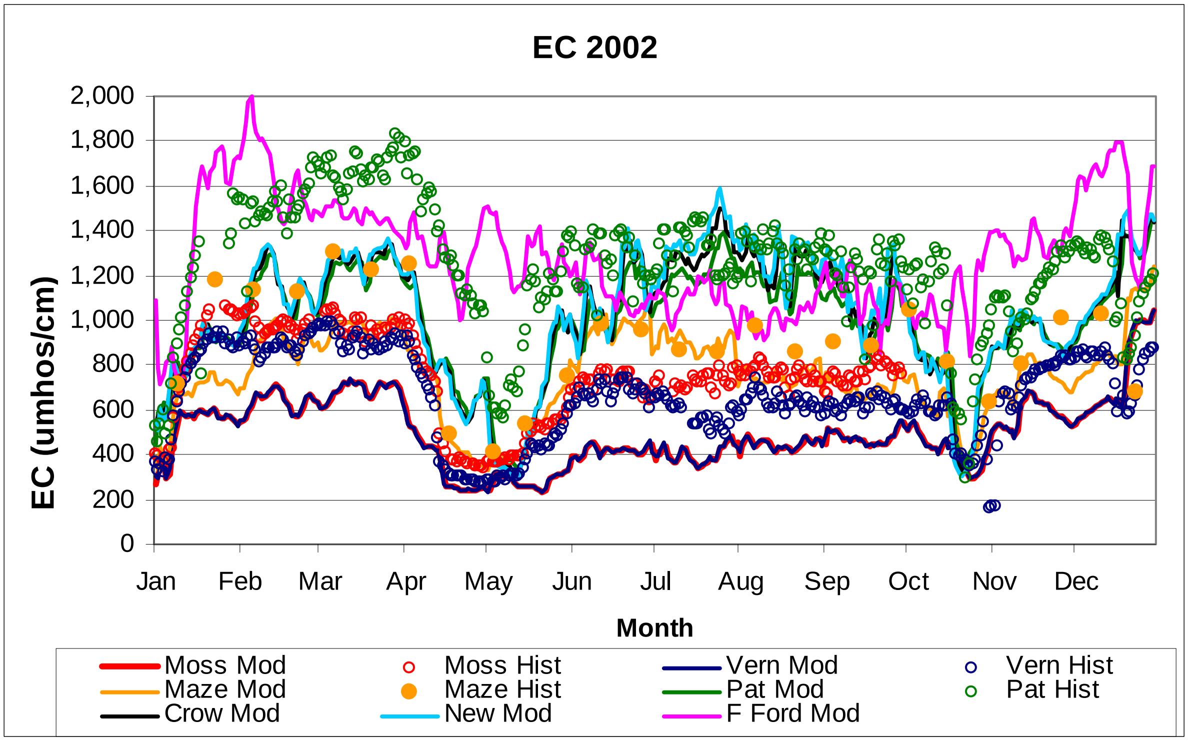


Figure 16. Simulated and Measured Electrical Conductivity for 2000 and 2001



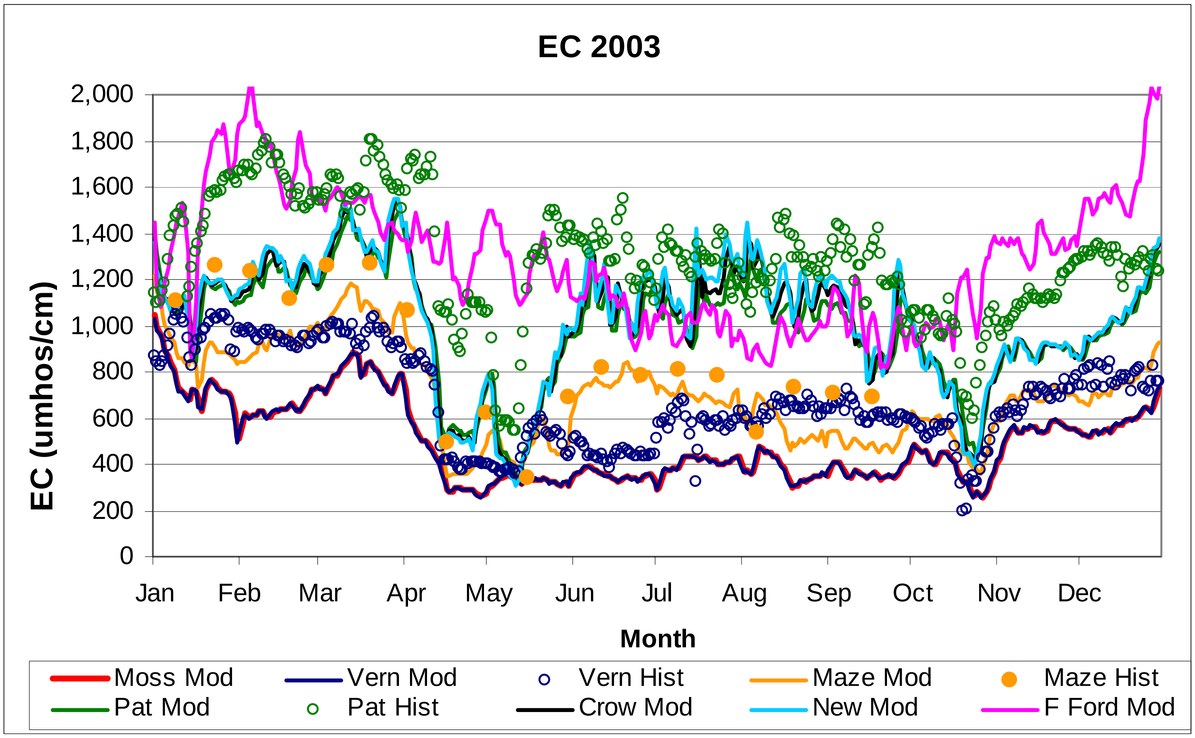
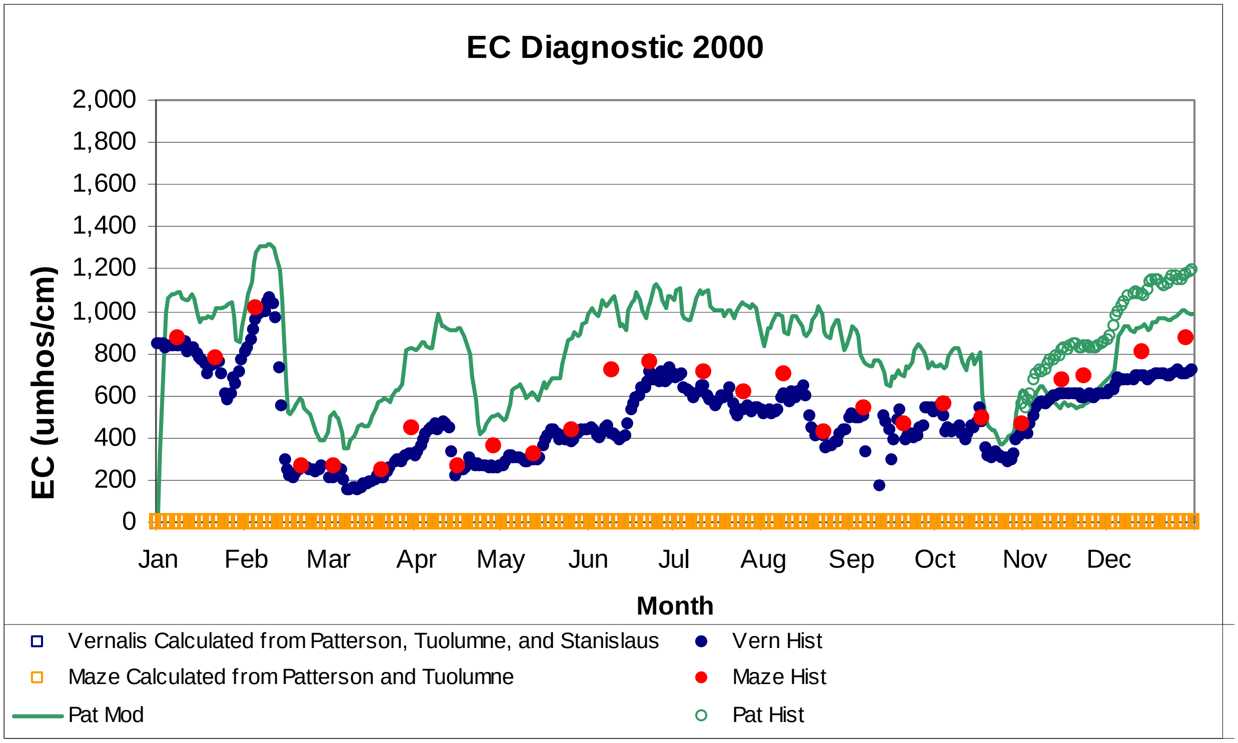


Figure 17. Simulated and Measured Electrical Conductivity for 2002 and 2003



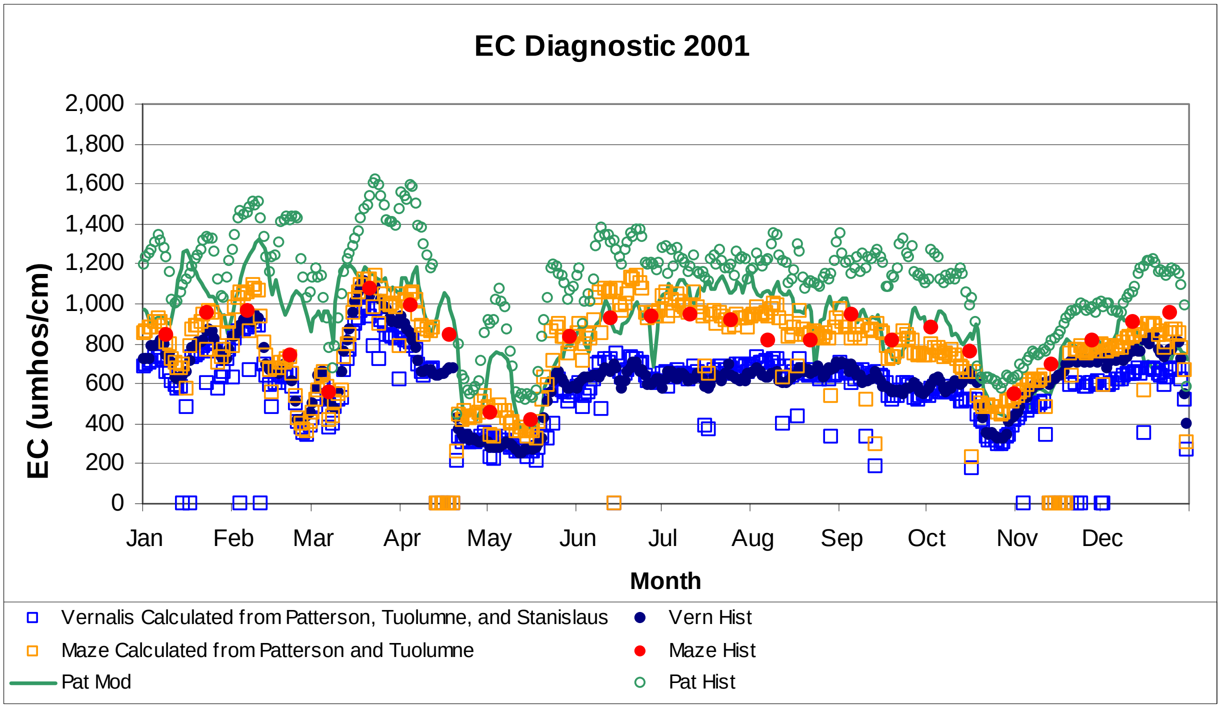
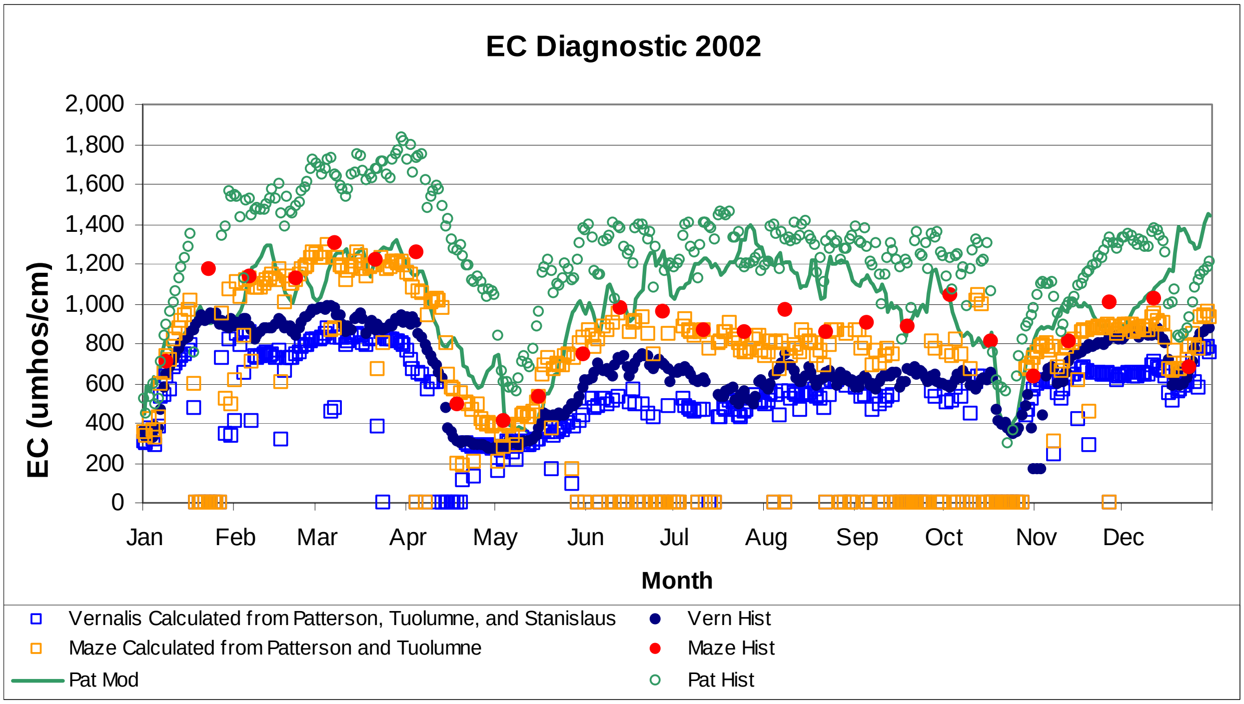


Figure 18. Evaluation of Electrical Conductivity Calculations for 2000 and 2001



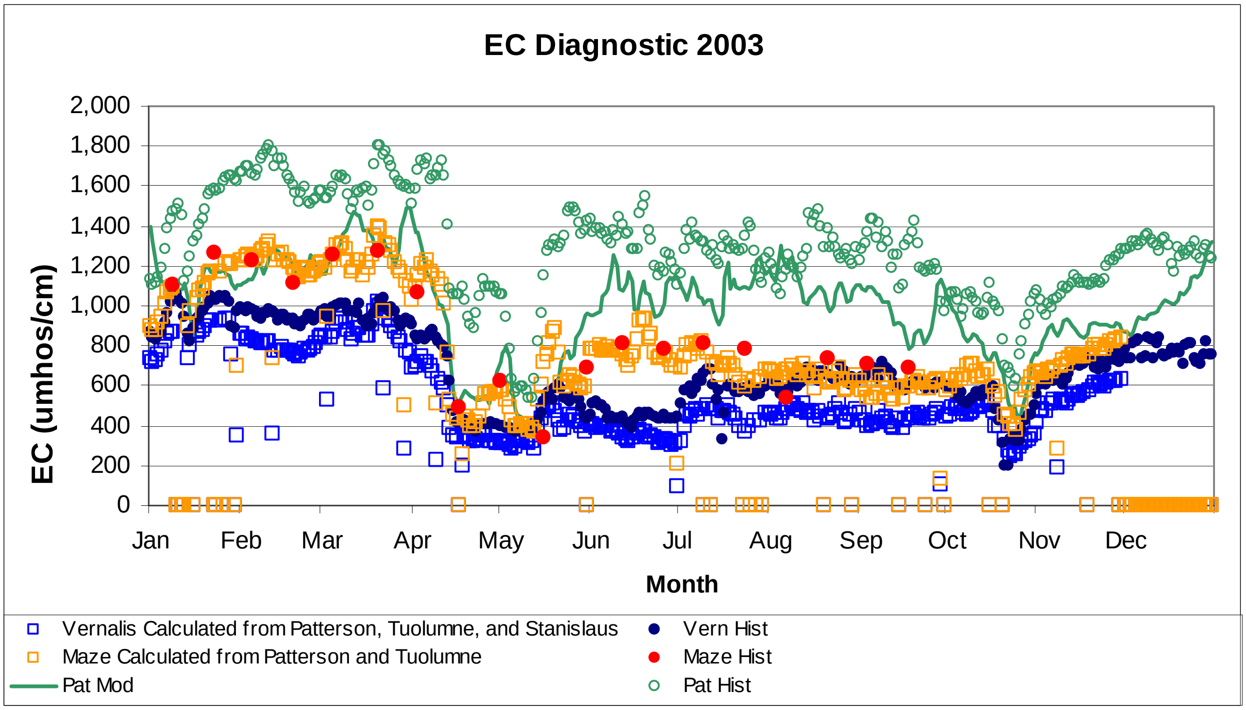
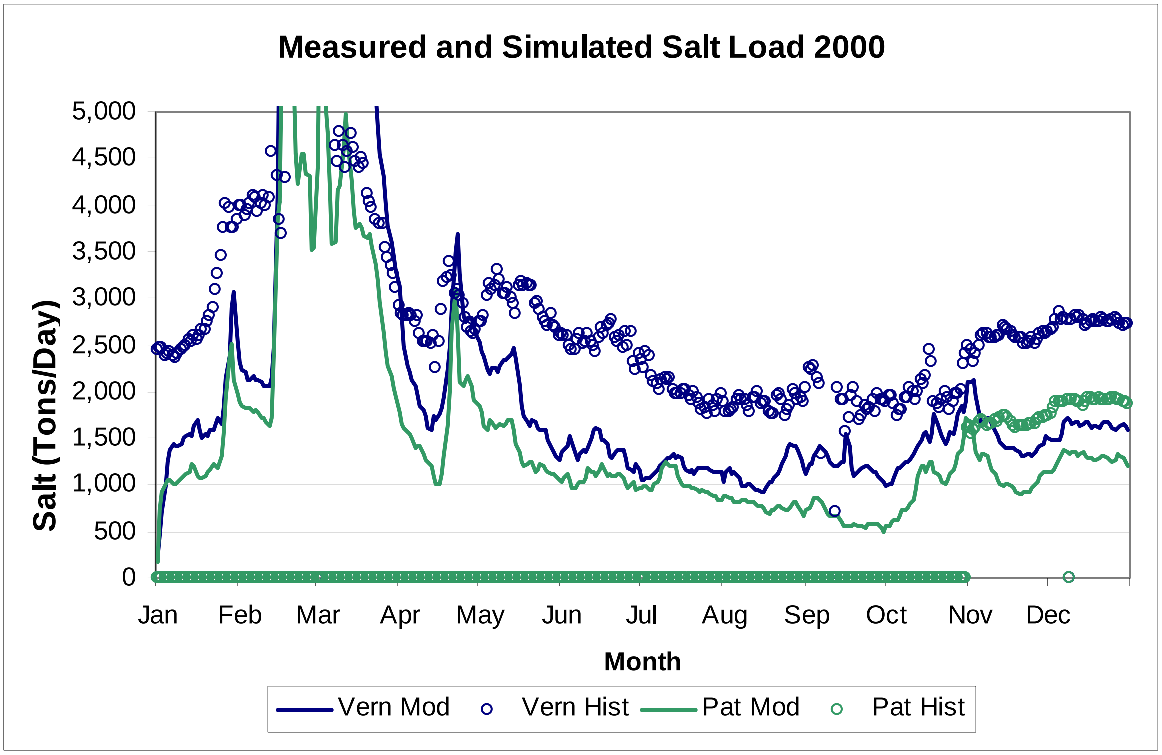


Figure 19. Evaluation of Electrical Conductivity Calculations for 2002 and 2003



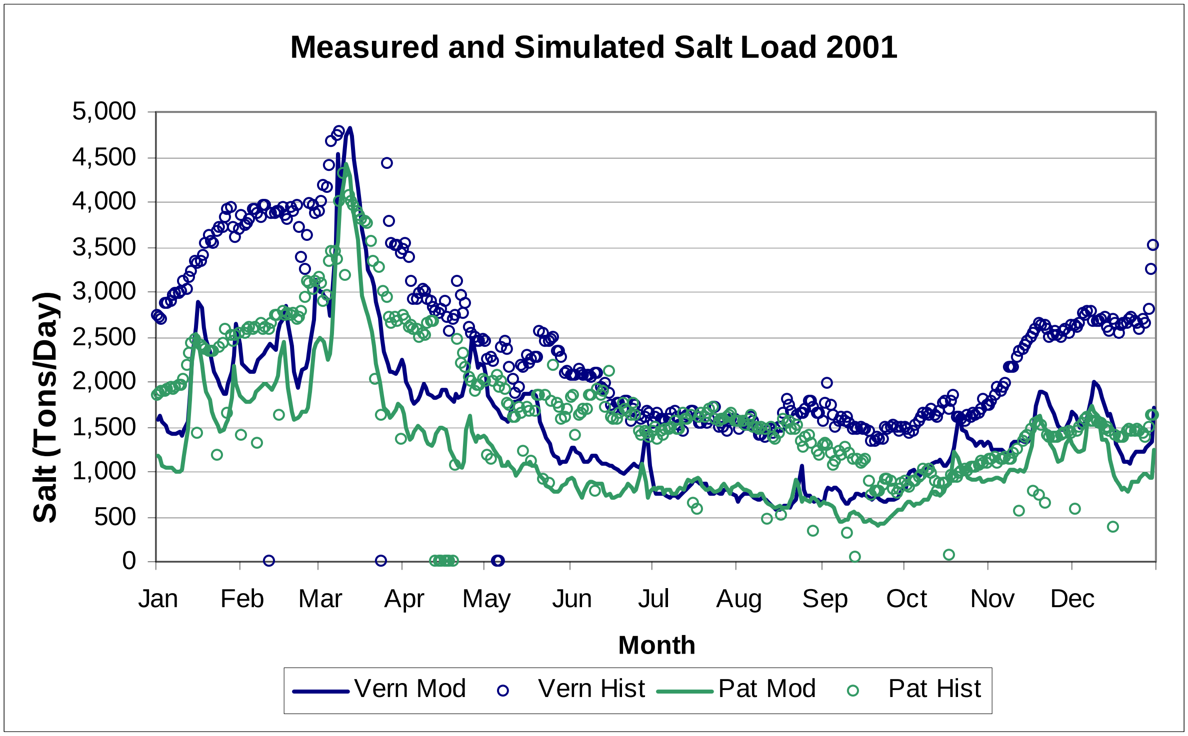
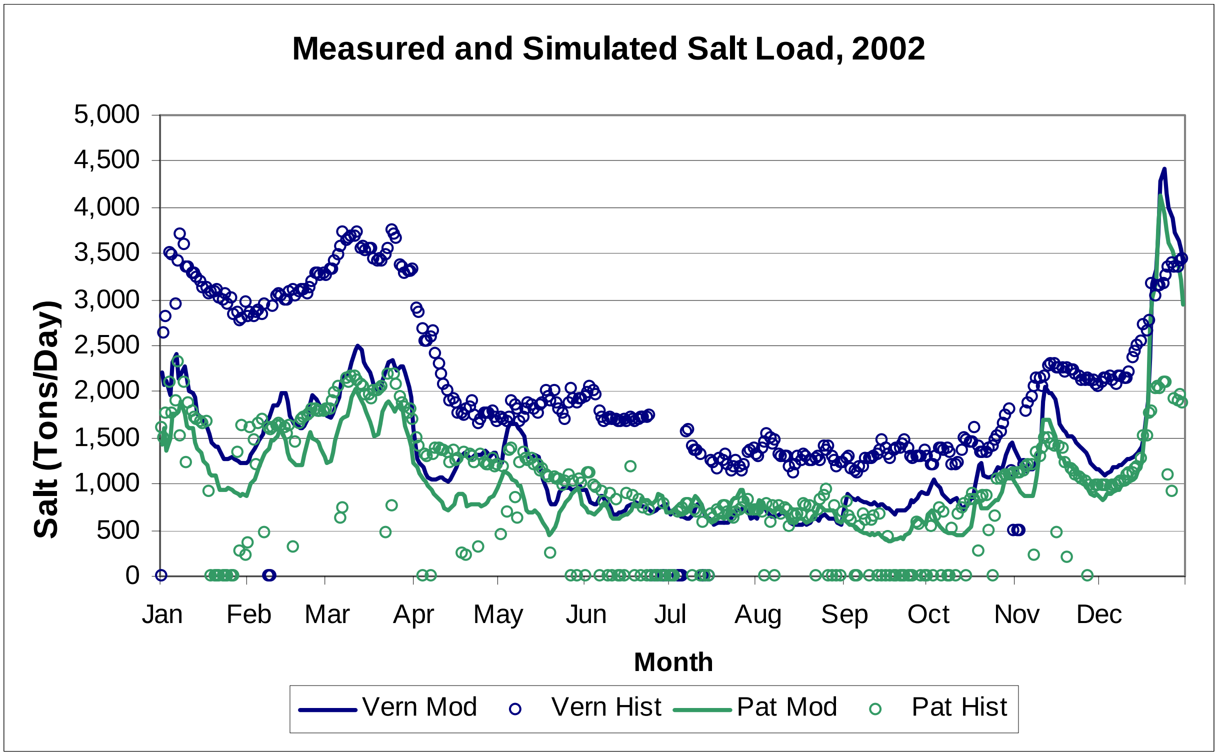


Figure 20. Estimated Salt Loads Calculated from Flows and Electrical Conductivity for 2000 and 2001



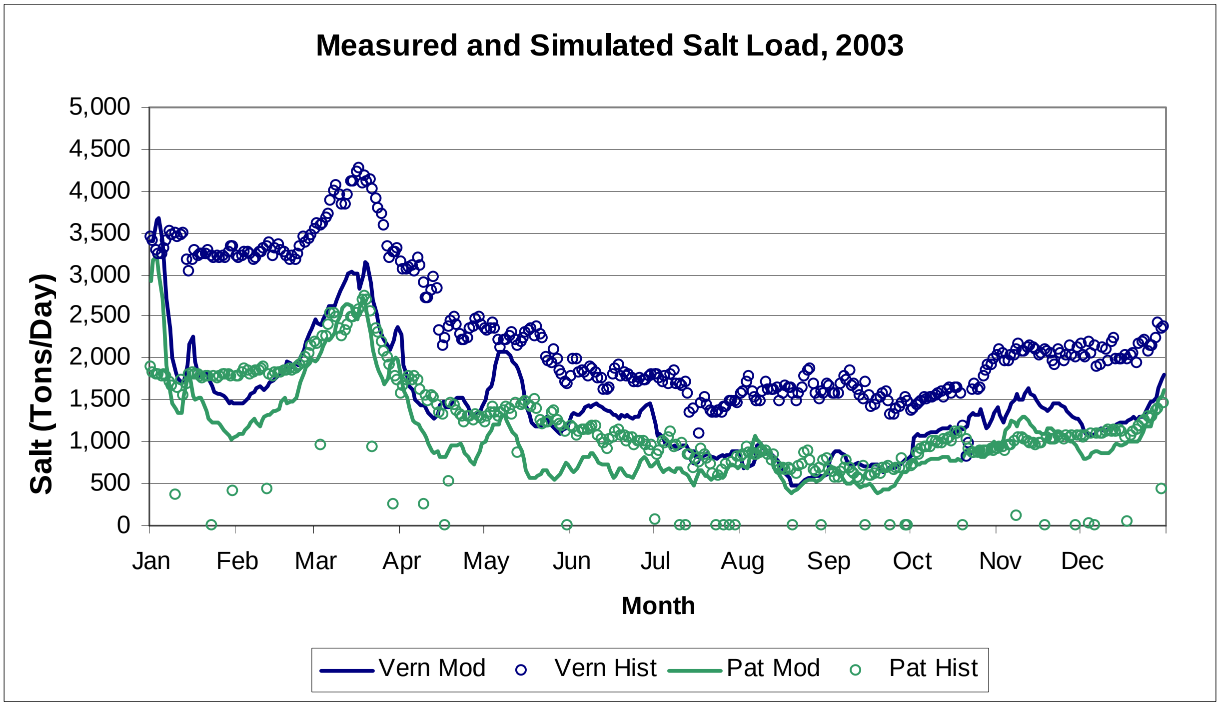
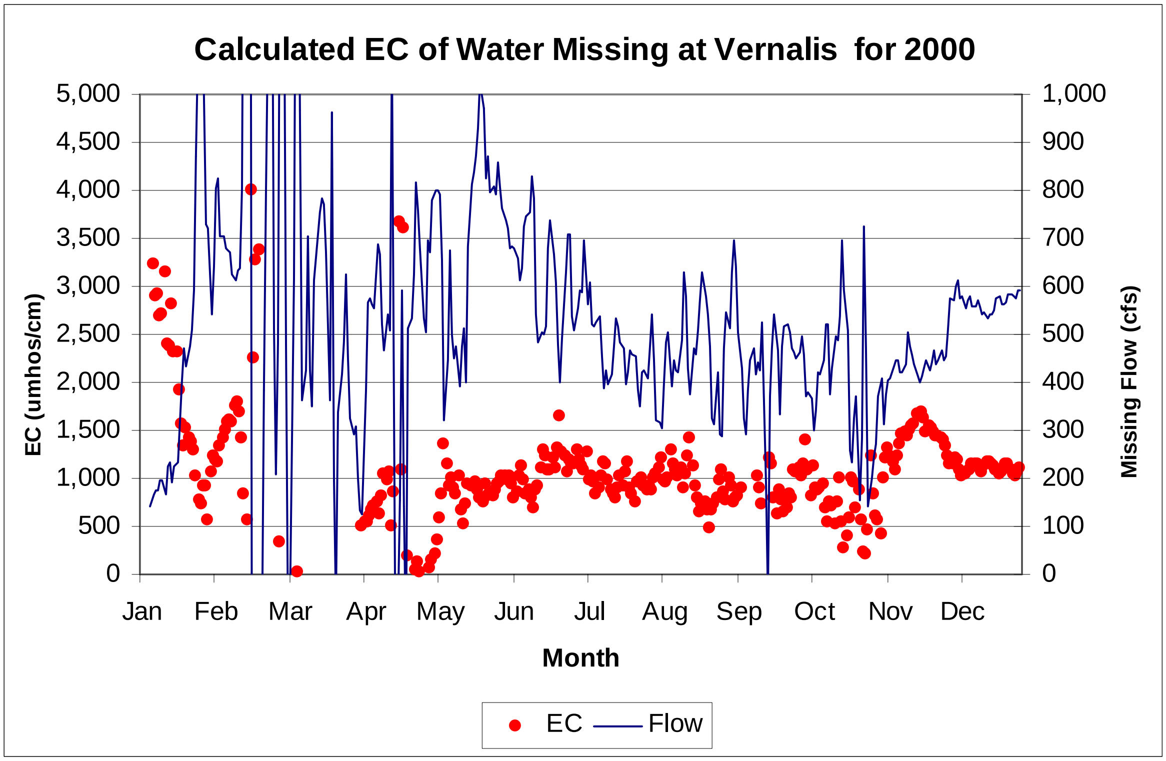


Figure 21. Estimated Salt Loads Calculated from Flows and Electrical Conductivity for 2002 and 2003



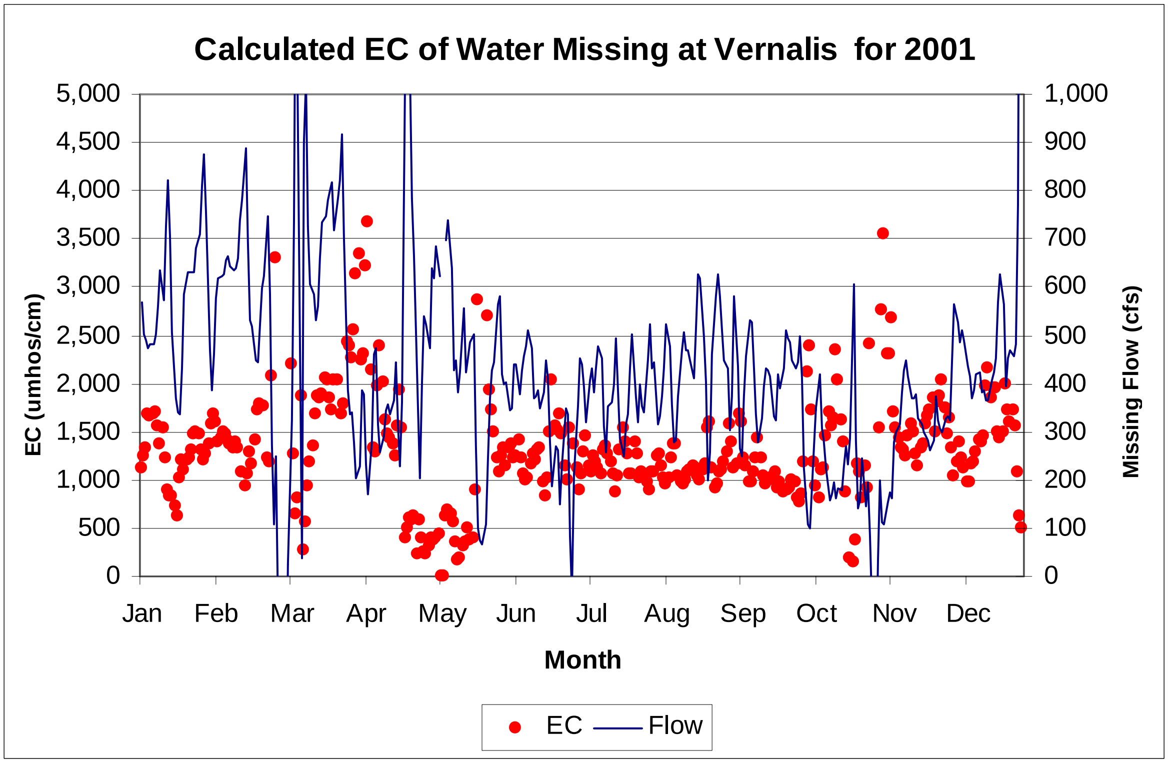
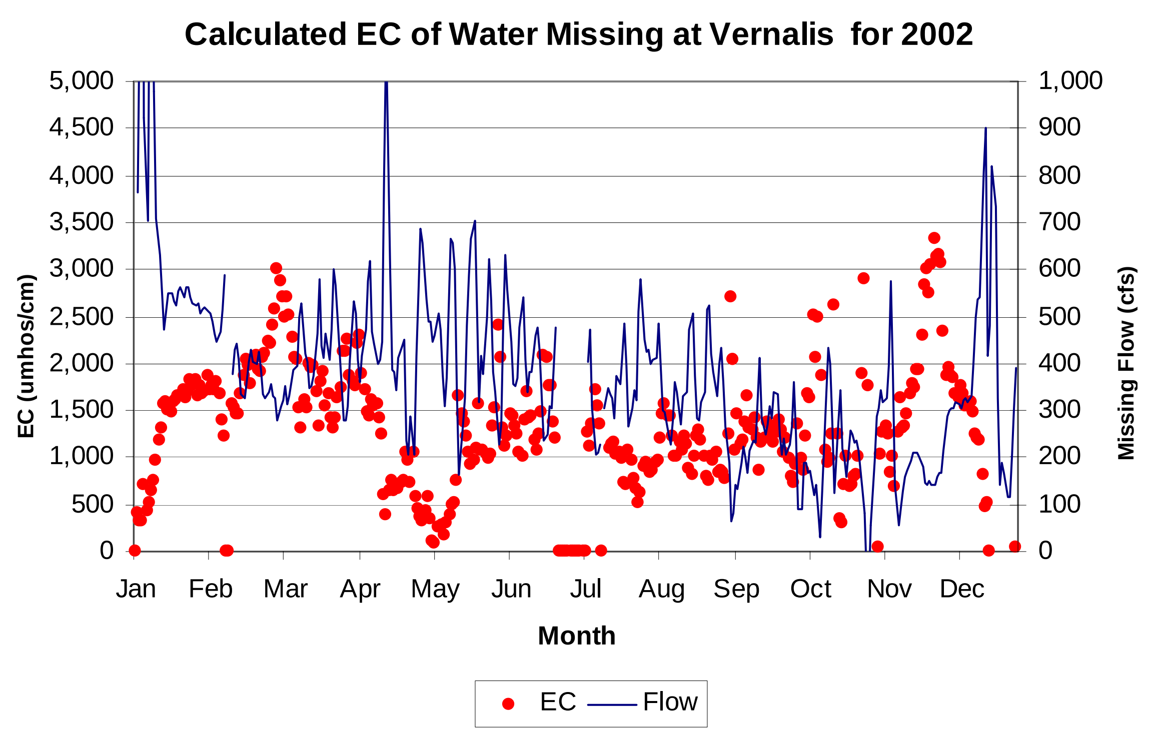


Figure 22. EC of Additional Flow Needed to Improve Model Results at Vernalis for 2000 and 2001



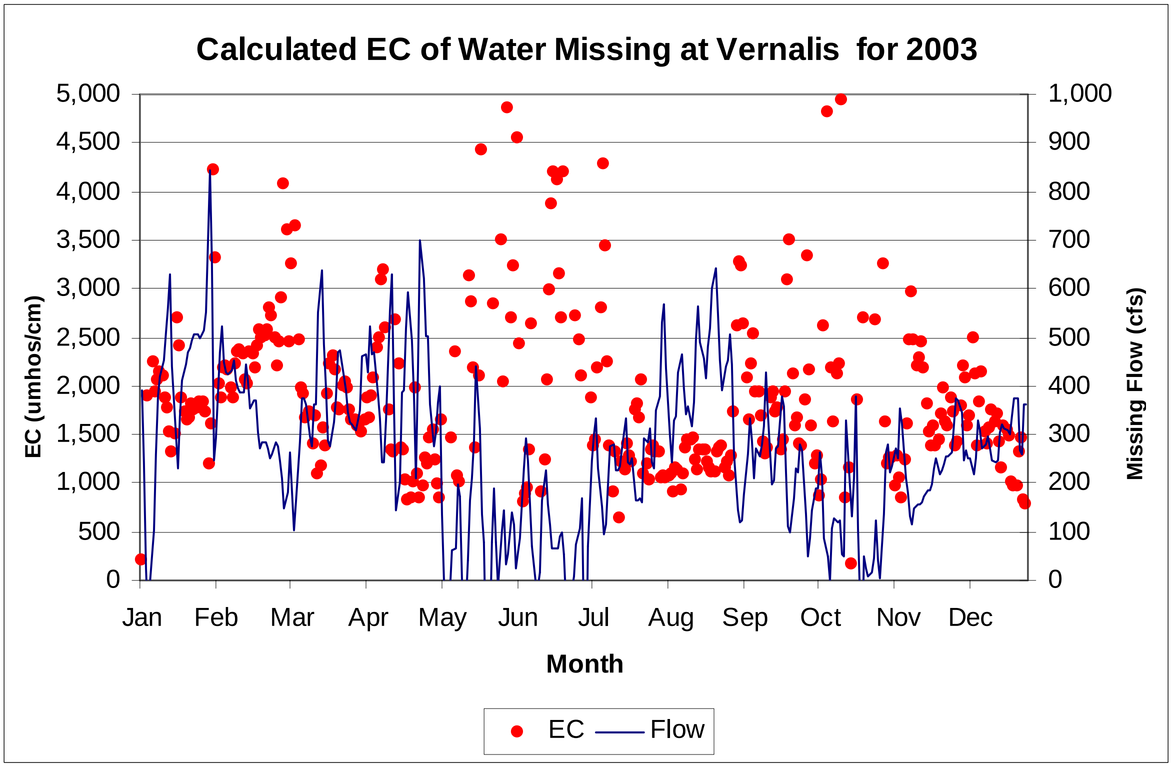
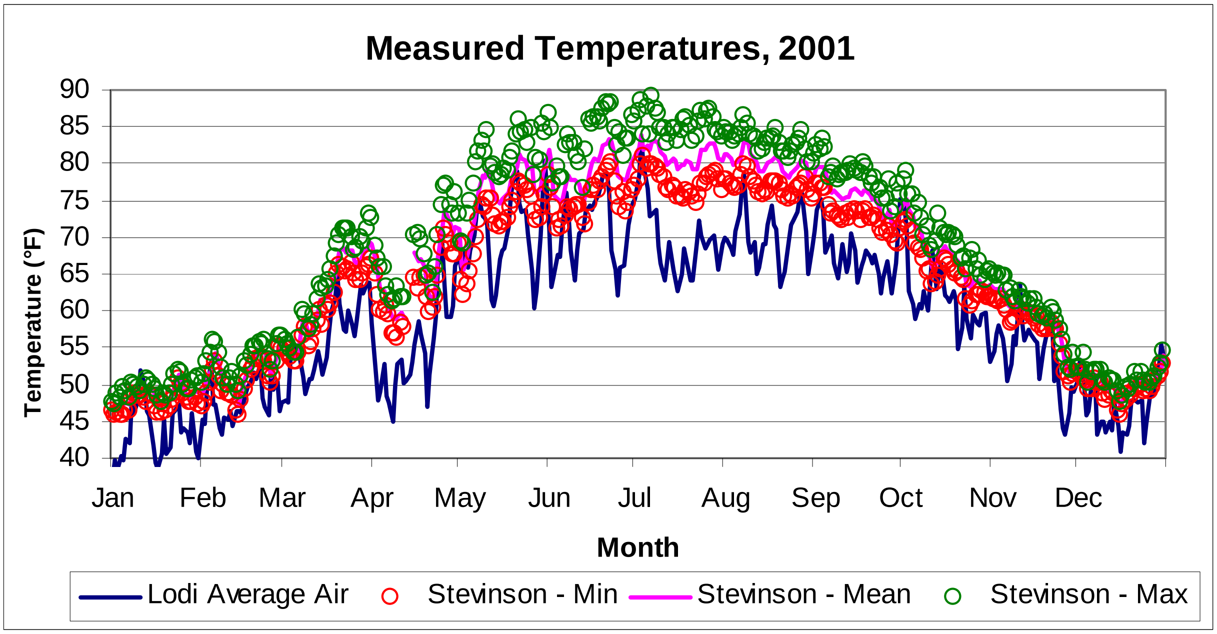


Figure 23. EC of Additional Flow Needed to Improve Model Results at Vernalis for 2002 and 2003



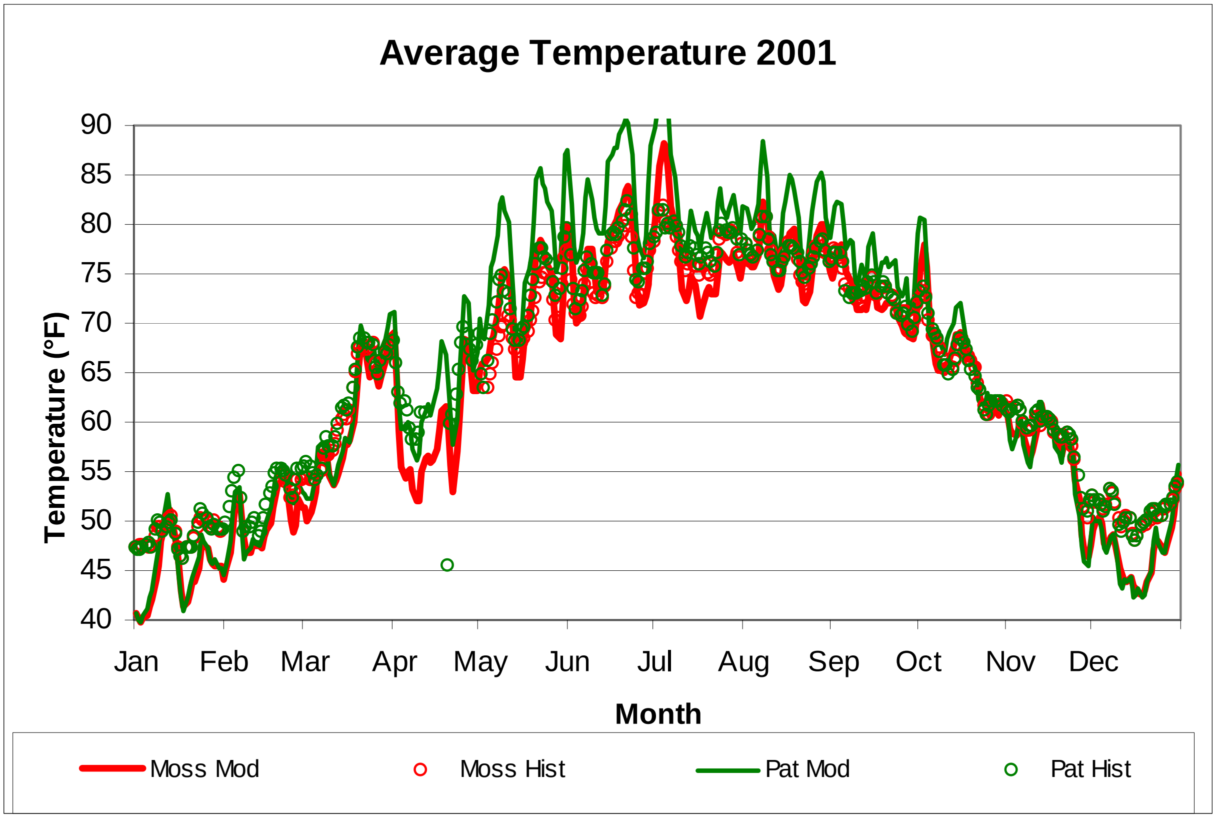
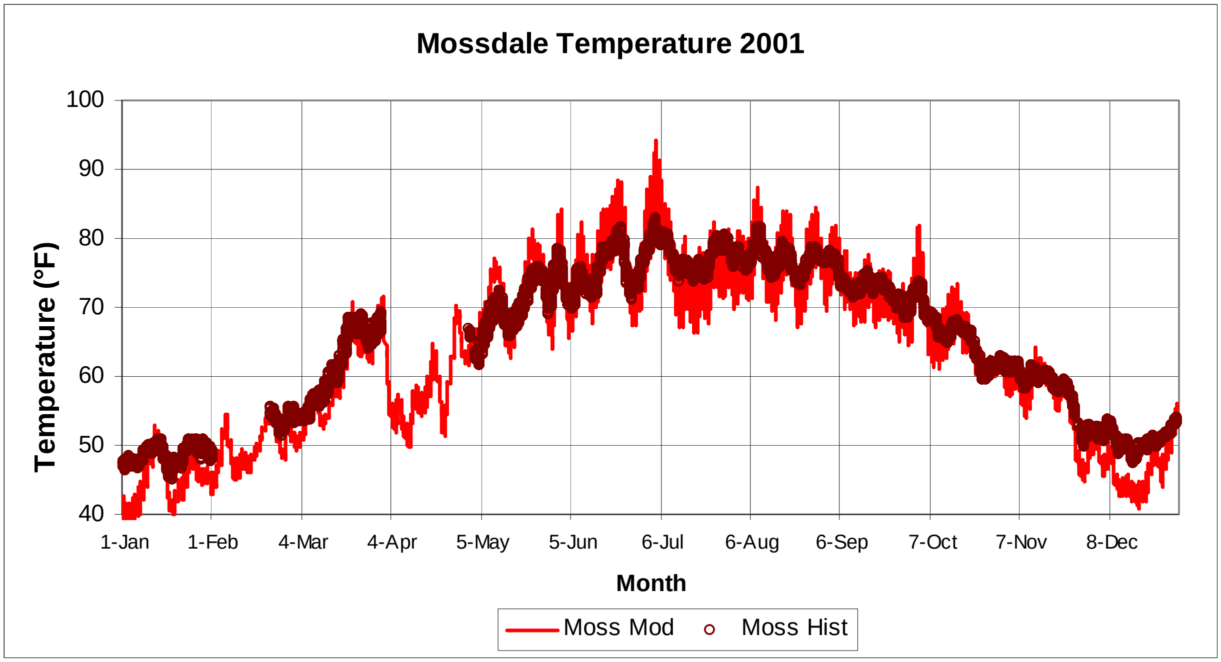


Figure 24. Example Inputs and Model Results for Water Temperature



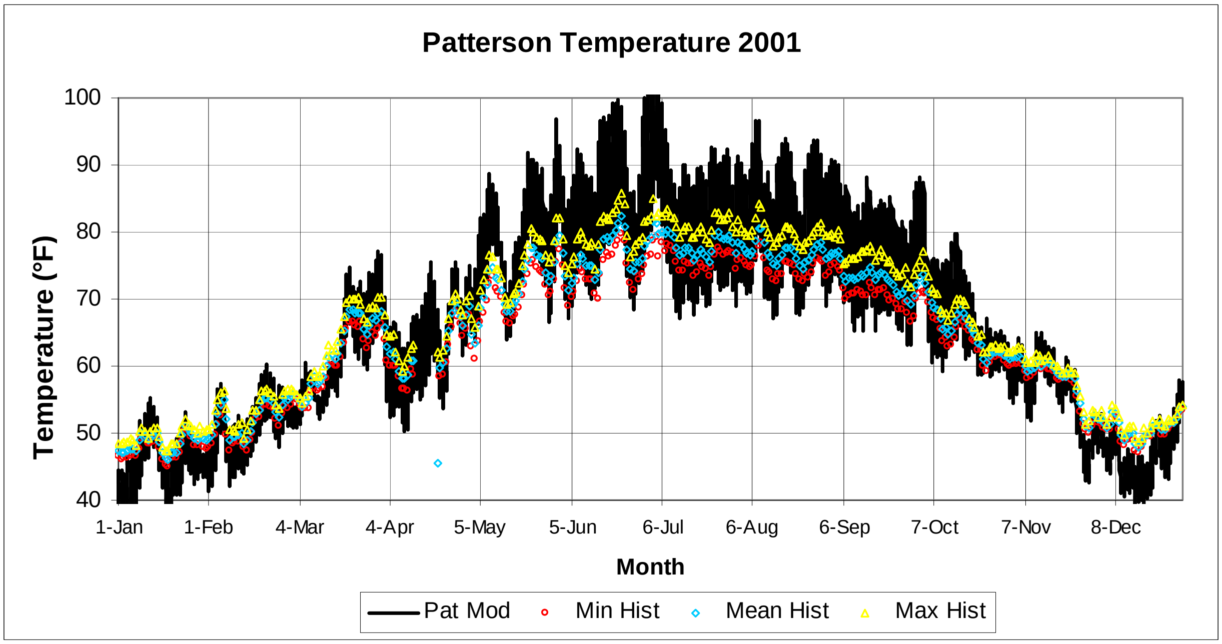


Figure 25. Diurnal Temperature Ranges for Measured and Simulated Water Temperatures for 2001