San Joaquin River
Water Quality Data Atlas

Prepared for:

California Bay-Delta Authority
650 Capitol Mall 5th Floor
Sacramento CA 95814
Contact: Barbara Marcotte

Prepared by:

Jones & Stokes
2600 V Street
Sacramento, CA 95818-1914
Contact: Russ Brown
916/737-3000

January 2005

Jones & Stokes. 2005. San Joaquin River Water Quality Data Atlas. January. (J&S 04118.04.) Sacramento, CA.

Contents

Figures

Follows Page

Acronyms and Abbreviations

BDAT	Bay Delta and Tributaries
BOD	biochemical oxygen demand
DWR	California Department of Water Resources
CIMIS	California Irrigation Management Information System
CBOD	carbonaceous-BOD
COS	City of Stockton
CD	compact disc
DOC	dissolved organic carbon
DO	dissolved oxygen
EC	electrical conductivity
ET	evapotranspiration
DSS	Hydrologic Engineering Center Data Storage System
IEP	Interagency Ecological Program
NTU	nephelometric turbidity units
NPDES	National Pollutant Discharge Elimination System
RWCF	Regional Wastewater Control Facility
RWQCB	Regional Water Quality Control Board
SJR	San Joaquin River
Data Atlas	SJR Water Quality Data Atlas
SR	State Route
DWSC	Stockton Deep Water Ship Channel
TMDL	total maximum daily load
TOC	total organic carbon
TSS	total suspended solids
Reclamation	U.S. Department of Interior, Bureau of Reclamation
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
UCD	University of California at Davis
VSS	volatile suspended solids
WY	water year

San Joaquin River Water Quality Data Atlas

Introduction

The successful analysis and modeling of water quality in the San Joaquin River (SJR) and the Stockton Deep Water Ship Channel (DWSC) require a large amount of reliable data. Many types of data are available for the SJR and DWSC from a variety of government agencies (e.g., California Department of Water Resources [DWR], U.S. Geological Survey [USGS], U.S. Department of Interior, Bureau of Reclamation [Reclamation], City of Stockton [COS]) that routinely measure river flow, temperature, salinity, and other water quality parameters with monitoring devices and samples for laboratory analysis. Different agencies have collected data during various time periods, at different stations, and with different parameters. These data are stored in several different public and private databases, operated by several different agencies, which makes it difficult for stakeholders, agencies, or interested persons to access the full range of available data. Each type of data must be individually downloaded, processed, compiled, and compared. These data retrieval tasks make the compilation, analysis, and modeling of the SJR and DWSC water quality a time-consuming and tedious exercise.

The SJR Water Quality Data Atlas (Data Atlas) was created to give stakeholders, agencies, and other interested persons a rapid and consistent method to access all available data on the SJR and DWSC flow and water quality conditions for the 20-year period of 1984 to 2003. The Data Atlas includes flow and water quality data from the SJR Stevinson gage (State Route [SR] 165 Bridge, also referred to as Lander Avenue), downstream to the DWSC portion of the SJR. Tributary flow and water quality data are included for the Merced, Tuolumne, and Stanislaus Rivers, as well as Salt Slough and Mud Slough. Some basic tidal stage, salinity, and water quality data from the Delta are included for reference. Figure 1 shows a map of the lower SJR basin, with the major sampling stations included in the data atlas.

The Data Atlas uses a spreadsheet format to allow daily flow and water quality data to be graphed and evaluated. Data Atlas users can rapidly review the 20-year sequence of flow and water quality conditions in the SJR and DWSC. SJR flow and water quality patterns for a wide variety of runoff conditions (i.e., seasonal flows) can be viewed in a series of annual graphs. This allows periods with water quality conditions of interest (e.g. low dissolved oxygen [DO] episodes) to be selected for more intensive analysis or for modeling evaluation. Data Atlas users can add other graphs of special interest to the spreadsheet files.

Selected data can be transferred easily from the annual atlas files to modeling input files or other data analysis tools.

Each calendar year of data is contained in a "master" annual spreadsheet. These sheets have all the data but contain no graphs. A number of different multi-year spreadsheets provide graphs for basic comparisons of different years for selected variables. These special multi-year spreadsheets have been created for SJR meteorology, SJR flow and salinity (electrical conductivity [EC]), DO in the DWSC data, COS Regional Wastewater Control Facility (RWCF) effluent data, COS river water quality data, and SJR algae, particulates, and nutrient data. The availability of the selected types of data for each year, as well as the seasonal patterns of various water quality parameters, can be reviewed rapidly by selecting the year of interest and viewing the graphs.

Retrieval and Display of Data

The identification of available data for the SJR and DWSC is a difficult process that requires searching and finding bits and pieces. This process is greatly facilitated by the Web-based search and database retrieval services provided by several agencies. Nevertheless, it is a slow-going and tedious process. Several of the database services that were used to compile this Data Atlas are described in this section.

The Data Atlas is possible only because of the dedicated and persistent efforts of the agency field crews, monitoring instrumentation maintenance crews, and supporting laboratory technicians and computer staff. These are the people who go to these stations and collect water samples, or prepare and process chemical measurements, or install and maintain the flow and water quality measurement equipment. The goal of the Data Atlas is to produce useful information from the wealth of data that has been collected over the years by these hard-working field and laboratory crews.

Some major data sources that should be included in this Data Atlas undoubtedly have been missed. The missing data sources that are identified in the future can be integrated into the initial 20-year sequence of data that has been created and distributed in this Data Atlas.

Each agency database has a different set of procedures for downloading data. Some databases offer Web-based retrieval, and others are stored on compact disc (CD) (e.g., USGS and U.S. Environmental Protection Agency [USEPA]). Some databases have interactive maps, while others allow only text or number searches for station names or identification numbers, respectively. Without a map, it is difficult to identify station locations or names. Some databases are not publicly viewable and must be acquired through individual agency staff. In short, each database has its own accessibility features and constraints.

The Data Atlas was designed for daily data. Grab samples collected monthly, for example, show up in the Data Atlas on the day they were collected. The daily column of data, if samples were collected monthly, will have just 12 values. Monitoring data from a temperature probe or DO probe may be hourly or 15-minute-interval data. These measurements are summarized in the Data Atlas as daily minimum, average, and maximum values in three separate columns of 365 values.

One major problem with compiling data is that various databases use different names for the same station. Typically, names are agency-dependent and relatively similar; however, some are very different. The Data Atlas has attempted to identify all "alias" names and station IDs for different database sources. The database sources and station ID names or numbers are given in the top of each column of data in the annual data atlas files. Additional "meta-data" that may describe the collection agency and sampling program objectives and general sampling and laboratory methods are sometimes available from the original database. No specific meta-data information is included in the Data Atlas.

Many datasets are recorded in hourly or 15-minute intervals, or they are recorded only sporadically. Additionally, most database retrieval procedures allow the user to download only one parameter at a time. The process therefore must be repeated for each parameter. But the greatest impediment encountered in downloading datasets is checking for missing intervals of data. For example, for an hourly dataset that covers a 10-day period, 240 lines of data would be expected (24 hours x 10 days). However, a downloaded dataset might have only 230 lines of data. The user must manually check each line of a dataset to insert a line where no line is present to represent a missing time period. For large datasets covering multiple years and including multiple parameters, this process can be frustrating. After cleaning up the 15-minute or hourly data intervals, the data can finally be processed into daily minimum, average, and maximum values for the daily Data Atlas. An excel spreadsheet that allows a year of minimum, average, and maximum values to be generated from 15-minute or hourly interval data, called Averager, is included in the Data Atlas "bonus files" collection.

Many of the database and retrieval Web sites have some simple graphics capabilities. However, the primary purpose of these graphs is to review the availability and patterns of recently collected data. The primary goal of the daily Data Atlas graphs is to provide annual "pictures" of the available data from several stations along the SJR to provide an initial comparative analysis tool. Individual Data Atlas users can add graphs to the comparative or annual data files. Additional years of data can be added to the Data Atlas master files to update this initial set of files and graphs.

The goal of the Data Atlas project was to download and process all available flow and water quality data, so that other stakeholders could avoid the tedious process of compiling data. However, the Data Atlas is not yet complete; additional data are likely to be identified and provided by other stakeholders and agencies. Not all available data have been located and integrated into this first version of the Data Atlas. A user may need additional data to compare and evaluate. This section provides a quick tutorial on how to search the major database Web sites to identify and download data that may be missing from the initial Data Atlas.

Interagency Ecological Program

The Interagency Ecological Program (IEP) Web site (http://iep.water.ca.gov) is maintained by DWR, through the Environmental Services Office. It contains current and historical flow, water quality, and meteorological data for the Delta and portions of the Sacramento and San Joaquin Watersheds. Users locate individual stations through a very good map interface. Users then select an individual parameter and a period of record for retrieval. For hourly or 15-minute data, selecting more than three or four years at a time will cause excessive download times, and may not be successful. Once a data sequence is displayed on the screen, it must be copied and pasted into Excel. Next, it is converted from text to values (using data> text to columns) so that the error checking process may begin. Figure 2 shows the screen images and the steps involved in identifying and downloading data from the IEP database. The example involves downloading data in the Hydrologic Engineering Center Data Storage System (DSS) format. An advantage for this data time-series format is that there are no missing sequences; missing data are coded with –901 or –902 values. There are additional data on the IEP server that are stored and downloaded in other database formats.

California Data Exchange Center

The California Data Exchange Center (http://cdec.water.ca.gov) is maintained by DWR, through the Division of Flood Management. It contains current and historical flow, water quality, and meteorological datasets for all of California. Users locate individual stations through a very nice map interface. Once the desired stations are located, a user may download one parameter from one station at a time, and the same limitations to downloading three or four years of hourly or 15-minute data at a time apply. After the data sequence is displayed on the screen, the user may select to save it to a file, or select a spreadsheet program to open it directly. After opening the database in a spreadsheet program, the error checking process can begin. Figure 3 shows the screen images and the steps involved in identifying and downloading data from the CDEC database. Because the CDEC is designed to provide direct access to "real-time" data, these data have not been reviewed by the collecting agencies and should be considered preliminary. However, some of these data do not have routine confirmation procedures and verified data may not be stored in other locations.

United States Geological Survey

The USGS maintains a database of current and historical flow and water quality data. The USGS maintains several flow and water quality stations in the SJR watershed. These data can be accessed on the Internet at (http://water.usgs.gov), as well as on a CD database product that is updated annually by a commercial vendor (Hydrosphere Data Products). This same vendor has a CD product for accessing the USEPA water quality storage and retrieval (STORET) database..

Hydrosphere Data Products Inc. releases a CD each year that updates the USGS database for one or more states in the United States. Their software, "Hydrodata," allows users to access the USGS database on their PCs and download datasets to a spreadsheet. Stations can be sorted in a number of ways (station name, identification number, state, county, elevation, etc.). After a station is selected, available parameters and their period of record are displayed. An advantage of Hydrodata is that multiple parameters can be exported at one time into a spreadsheet. The flows and stages are stored as daily values. The salinity (EC) and temperature records are stored as daily minimum, average, and maximum values, as separate parameters, with missing values shown as blanks. This is a direct match with the Data Atlas design. Datasets can be saved in a time-series format and then opened in a spreadsheet and checked for errors. A slight quirk is that February 29 is included in every year, with a missing value (blank) for non-leap years. The daily water quality data are no longer provided, because of a USGS database difficulty; daily EC and temperature data from USGS gages end in 1997. Daily flow data are available only for the last complete water year, and there is often a 6-month delay (e.g., water year [WY] 2003 [September 2003] was the latest available data even in January 2005).

The USGS Web site has current and historical flow and water quality (i.e., grab sample) datasets. Hourly or 15-minute flow, stage, EC, and temperature data are available in the real-time portion of the database. Stations can be selected by state, station name, identification number, period of record, etc. Once a station is picked, individual parameters can be saved in a tab-separated file and then opened in a spreadsheet and error-checked. This USGS Web site is one of the more user-friendly database interface and retrieval systems available. Periodic water quality samples are listed sequentially by date, and have to be expanded into the daily columns used in the Data Atlas. All parameters from a station can be selected and downloaded from the real-time portion of the database. Figure 4 shows the screen images and the steps involved in identifying and downloading data from the USGS database. A current limitation is that access to historical daily or hourly water quality data is not available. The "recent" data can be accessed, but not the historical records for the same station.

United States Department of Interior, Bureau of Reclamation

The mid-Pacific division of Reclamation maintains a Web site (http://www.usbr.gov/mp/mp150/grassland) with flow and water quality datasets for the San Joaquin Valley, with data that begin in 1997. This database is linked with the Grassland Bypass project and is focused on salinity, selenium, and boron. Water quality parameters can be downloaded in groups instead of individually. A time-series with several parameters can be copied and pasted into a word processing program, then saved as a text file. Then it can be opened in a spreadsheet and error-checked.

The process for downloading flow datasets can be more complicated. Some of the stations have datasets that appear in the Web browser as an Excel time-series. These can simply be copied and then pasted into a spreadsheet. Datasets for other stations appear as a text time-series. These can be copied and saved as text in a word processor and then opened in a spreadsheet. These two formats for datasets present minor processing problems before error checking can begin. The other possible format is text, but not in a time series. These datasets appear as a block, numbered 1-31 on the left side and January to December across the top. So after copying the dataset and pasting it into a word processing program, saving it as text, and opening it in a spreadsheet, the user must still manually place the months of the year in sequence into a column to match the Data Atlas format.

Other flow and water quality data are available from other portions of the Reclamation mid-Pacific Web site. The Central Valley Operations (http://www.usbr.gov/mp/CVO) provides links to several flow and water quality records. These monthly files with daily minimum, average, and maximum values are relatively easy to process for the Data Atlas.

California Irrigation Management Information System

The California Irrigation Management Information System (CIMIS) Web site (http://wwwcimis.water.ca.gov/cimis/welcome.jsp) is maintained by DWR, through the Office of Water Use Efficiency. The database contains meteorological datasets for stations in California from the mid 1980s through the present. Access to the database is public, but requires registration. Stations may be viewed on a map, but the map is not interactive. Stations must be selected from a list; however, the CIMIS database allows multiple stations to be selected and downloaded at a time. Once a station is selected, the dataset is opened in a spreadsheet, and then the whole dataset with multiple parameters can be copied and pasted into a user's spreadsheet. This Web site is more user-friendly than many other database sites.

Dahlgren–University of California, Davis, Algae and Nutrient Data

Dr. Randy Dahlgren, a professor in the Land, Air, and Water Resources Department at the University of California at Davis (UCD), has conducted a detailed sampling effort on various sites along the SJR from water year 2000 (October 1999) to the present, as part of a larger ecological investigation. The U.S. Fish and Wildlife Service funded this project to evaluate the aquatic food resources (i.e., nutrients and phytoplankton) in the Sacramento and SJR basins. Dr. Dahlgren has trained and employed several student assistants for this bi-weekly sampling and laboratory analysis program. Dr. Dahlgren has agreed to transfer these extremely valuable data from the SJR and tributaries stations to the Data Atlas. The original data file from Dr. Dahlgren is included in the Data Atlas bonus file collection as “Dahlgren_UCD_SJR” and the data have been integrated into the annual Data Atlas files for 2000-2003.

Bay Delta and Tributaries

The Bay Delta and Tributaries (BDAT) Project Web site (http://baydelta.water.ca.gov/index.html) is maintained by DWR. It consists of a database of water quality and meteorological datasets provided by more than 50 organizations. Although a map-based user interface to select data by location is being developed, data locations must be specified by location or ID code. This means that the user must already know the locations that are desired. Once a station is selected, the desired parameter(s) can be downloaded as an Excel file and then opened on the user’s computer.

To support this initial development of the Data Atlas, DWR staff with the BDAT program were kind enough to provide several of the stage and EC data from the Delta, all of the meteorology data, and some of the DO and temperature data (i.e., minimum, mean, maximum) from DWR water quality monitoring stations. This data retrieval and processing into the daily format were a great help in developing the initial Data Atlas.

San Joaquin River Water Quality Data Atlas Files

The data files (Excel spreadsheets) included in the Data Atlas are in four major file categories. The first group is USGS 7.5-minute quadrangle topographic maps of the SJR from Stockton to Stevinson. The second group contains comparison files for 20 years of selected data with graphs for comparison and evaluation among the different years. The third group is the master annual files containing all the daily data for each individual calendar year from 1984 to 2003. The fourth category is several bonus files, such as the original UCD Dahlgren data. These files will be described briefly in this section, with example graphs that illustrate the utility of the Data Atlas to display the data in easily understood annual graphs or correlation graphs that allows the water quality patterns and relationships along the SJR to be explored.

USGS 7.5-Minute Maps

The Data Atlas contains .pdf files of the ten USGS 7.5-minute (1:24,000 scale) topographic maps of the SJR from Stockton upstream to Stevinson. Opening the map files is a great place to begin your tour of the Data Atlas, because this is the best way to get a feel for the river and tributary geography without actually visiting the river in a car, boat, or helicopter. The SJR river mile designations (marked with +) are given on most of these topographic maps. Figure 5 shows the Stockton West map, illustrating the SJR DWSC and the Stockton RWCF. A brief index to the maps is provided in this section to help the user select a map of particular interest.

Stockton West: Contains the SJR channel from River Mile 37 to 46. This includes the Stockton DWSC and Port of Stockton, the Calaveras River confluence, the DWR monitoring station on Rough and Ready Island, Smith Canal confluence, the Turning Basin (upstream end of the DWSC), the Stockton RWCF, the USGS tidal flow meter upstream of the RWCF discharge, the Garwood Bridge (SR 4), and French Camp Slough.

Lathrop: Contains the SJR channel from River Mile 47 to 61. This section includes the Brandt Bridge EC station (no actual bridge) at Bowman Road, the head (upstream end) of Old River channel, the Mossdale Bridges (including I-5) where the Mossdale DWR water quality monitoring station is located, Walthall Slough, and the Paradise Cut flood control diversion weir from the SJR to Old River.

Vernalis: Contains the SJR channel from River Mile 62 to 73. This section contains the Banta-Carbona Irrigation District Canal (diversion with new fish screen facility), and the Vernalis Bridge (Airport Way) where the USGS flow gage and DWR and Reclamation water quality monitoring station for salinity (EC) are located.

Ripon: Contains the SJR channel from River Mile 74 to 81. This section includes the Stanislaus River confluence (mouth), SR 132 (Maze Boulevard), and the Hospital and Ingram Creek confluence (mouth).

Westley: Contains the SJR channel from River Mile 82 to 91. This section contains the Tuolumne River confluence, the West Stanislaus Main Canal (diversion), the Westley Wasteway (drainage), and Grayson Road Bridge.

Brush Lake: Contains the SJR channel from River Mile 92 to 97. This section includes the City of Modesto Sewage Ponds and Outfall, the Patterson Sewage Outfall, the Del and the Puerto Creek confluence (mouth).

Crows Landing: Contains the SJR channel from River Mile 98 to 110. This section includes the Patterson Main Canal (diversion), the Turlock Lateral No. 5 (drainage canal), the Crows Landing Bridge, and the Orestimba Creek confluence.

Hatch: Contains the SJR channel from River Mile 111 to 115. This section includes no major landmarks.

Gustine: Contains the SJR channel from River Mile 116 to 130. This section includes the Merced River confluence, the Newman Wasteway (drainage canal), which may be used to release water from the Delta-Mendota Canal to the SJR (called recirculation), the Mud Slough confluence, the Fremont Ford (SR 140 bridge), and the Salt Slough confluence.

Stevinson: Contains the SJR channel upstream of River Mile 131. This section includes the SR 165 bridge (Stevinson Gage, also called Lander Avenue), and the Bear Creek confluence at approximately River Mile 135. The SJR channel is not well defined in this upstream area. This section of the SJR is dry except during major runoff events.

Multi-Year Comparison Files

Each multi-year comparison file is designed to provide a graphic analysis tool for exploring selected flow and water quality parameters along the SJR. Each multi-year comparison file contains a graph worksheet in which the year can be selected (i.e., typed into a yellow box at the top of the graph sheet); when *enter* is pressed (or F9 to recalculate)], the graphs will automatically update with the new data from the selected year. A brief description of each comparison file and examples of the graphs are presented in the following sections.

Meteorology_Daily_84-03

The graphs sheet contains several graphs of the daily meteorology for the CIMIS stations at Lodi, Modesto, and Kesterson. These stations were chosen to represent the meteorology along the SJR from north to south. Figure 6 shows the seasonal pattern of daily air temperature (dry bulb) and dew point temperature at Lodi. The daily windspeed and solar radiation patterns at Lodi are shown in the bottom panel. These are the basic parameters required for water temperature and algal photosynthesis modeling.

Figure 7 compares air temperatures at the three SJR locations. The air temperatures (minimum, average, and maximum) are very similar along this section of the SJR. The bottom panel compares windspeed at the three SJR locations. This is the parameter with the largest variation among locations.

Figure 8 compares the monthly average meteorology at the three SJR locations. There appears to be a problem with the Modesto solar radiation data for 2002, which is much lower than the other two stations.

SJR_Flow_84-03

This file contains all the available SJR flow data, including the tributaries. Review of this file indicates that many stations have only partial periods of record. The downstream station at Vernalis is the most complete and is generally used as the representative SJR flow station. Most other flows are shown in comparison to the Vernalis flow. Figure 9 shows an example of the SJR mainstem and tributary flows for 2000. The Newman, Crows Landing, and Patterson gages are all downstream of the Merced River but upstream of the Tuolumne River, and the flows are usually about the same. The measured

Vernalis flow is similar to the sum of the SJR at Patterson plus the Tuolumne River and Stanislaus River inflows.

Figure 10 shows the daily SJR flows estimated upstream of the Stanislaus River at Maze and upstream of the Merced River at Fremont Ford for 2000. Water quality can change substantially from the dilution that is provided by the Merced, Tuolumne, and Stanislaus Rivers.

The SJR flow at Stockton can be estimated as 50% of Vernalis flow minus 5% of the combined CVP and SWP pumping. Figure 11 shows an example of this estimated Stockton DWSC flow for 2001, along with the measured USGS tidal flow at Stockton. The DWSC flow is greater than the estimate during periods when the head of Old River barrier weir has been in place (i.e., April 15–May 15, and October–November), or during the summer when the south Delta agricultural barriers were in place (June–September).

The flow file has a couple of examples of simple analyses of the raw data that can be done with the Data Atlas. The estimated flows upstream of the major tributary rivers must be calculated by difference, because it is not directly measured. In another case, the SJR flow at Stockton, which is only available beginning in 1996, can be estimated for other years, based on a relationship developed from the years with measured data.

SJR_EC_&_Flow_84-03

This file contains a number of graphs to compare salinity (EC) and flow variations and relationships along the SJR. Calculations of salt load for several tributaries and mainstem SJR stations are included. Graphs showing the "dilution" relationship between flow and EC values are given. The combination of flow and EC data provides an important analysis tool for checking the water and salt mass balances along the SJR.

Figure 12 compares the Vernalis flow with the EC and salt load estimates for the SJR at Vernalis for 1986. The diluting flow from the Stanislaus River is also shown. The daily salt load is calculated from the product of the flow and the EC values. The daily salt loads are quite stable at 2,000 tons/day to 3,000 tons/day and are increased only slightly during the high flows in February, March, and May. The EC shows a diluting pattern during periods when the load is stable.

Figure 13 shows the estimated SJR flow at Maze along with the measured and estimated EC at Maze, upstream of the Stanislaus River, for 1986. The calculated salt load at Maze is shown as a function of the flow, increasing somewhat during the winter runoff period. The EC is higher at Maze than at Vernalis, because of the diluting effects of the Stanislaus flow.

Figure 14 shows the SJR flow at Vernalis, with corresponding measured EC at Vernalis, Mossdale, and Brandt Bridge for 2000. The monthly average Vernalis EC and the calculated monthly average increase in EC between Vernalis and

Brandt Bridge are shown compared with the monthly average EC objectives of 700 µS/cm during the irrigation season and 1000 µS/cm in the remainder of the months. For the 8 years since these objectives were imposed in 1996, the Vernalis EC objective has never been violated.

Figure 15 shows the flow and EC and salt load for Salt Slough and Mud Slough (included San Luis Drain Bypass flow) for 2000. The Mud Slough EC and salt load are much higher than the EC and salt load for Salt Slough. This pattern of salt loading from Salt and Mud Sloughs was different prior to the San Luis Bypass project, which began in 1998.

Stockton_River_WQ_84-03

This file contains the water quality measurements that have been made by the COS for its National Pollutant Discharge Elimination System (NPDES) permit. The river sampling locations (R1 to R8) used by the COS are shown in Figure 16. This file contains most of the parameters, including DO, temperature, and nutrients. The frequency of these required river surveys was daily in the early years (1984–1992) and is now generally weekly under the current NPDES permit during the summer.

Figure 17 compares the DO concentrations and temperatures at the eight river stations for 1984. The DO is lowest at the DWSC stations R3, R4, R5, and R6. The variability from day to day can be assessed for years with daily data.

Figure 18 compares the nitrate (and nitrite) concentrations for 1984. The downstream stations R2, R3, and R4 have the highest TKN (ammonia and organic nitrogen) concentrations. Ammonia concentrations were measured in more recent years. The number of required samples has varied during the 20 years of river measurements. Daily samples were collected during the summer in the early years; weekly samples are currently required.

Stockton_RWCF_84-03

This file includes the daily discharge and water quality measurements of final effluent from the Stockton RWCF.

Figure 19 shows the effluent flow and the biochemical oxygen demand (BOD) and carbonaceous-BOD (CBOD) concentrations for 2001. The CBOD measurements, which are required in the current NPDES permit, eliminate the effects of ammonia nitrification, which can be estimated separately with the ammonia concentrations. Figure 20 shows the total suspended solids (TSS) and volatile suspended solids (VSS) and the ammonia-N and organic nitrogen concentrations for 2001. Other graphs with additional parameters, as well as the RWCF daily loads for several of these parameters, are given in the file.

DWSC_DO_84-03

This file contains the daily minimum, average, and maximum daily DO data from Mossdale and Rough and Ready Island station. The saturated DO concentration is shown for comparison, calculated from the daily temperature.

Figure 21 shows the Mossdale and Rough and Ready Island minimum and maximum DO data for 2000. The upstream river concentrations are usually near the saturated value and are supersaturated from algae photosynthesis in the summer. The Rough and Ready Island DO is generally below saturation in the summer and sometimes in the winter from high BOD loads from algae or ammonia.

Figure 22 shows the DO deficit in the DWSC for 2000 that is calculated from the measured (or estimated) Stockton DWSC flows and the minimum daily DO concentrations as:

Load (lb/day) = 5.4 ((DO target – Minimum DO) (Flow (cfs)

Figure 23 shows a comparison of the Rough and Ready DO and the COS River station DO measurements from R3 to R6 for 2000. The City measurements are collected in the morning and are similar to the minimum DO at the Rough and Ready station. This is an example of using data from two independent sources to confirm the measured data pattern.

Nutrients_and_Algae_84-03

This file contains the UCD Dahlgren data for nutrients, particulates, and algae pigments (e.g., chlorophyll and phaeophytin). The UCD data cover the water years 2000 to 2003. Historical nutrients and particulates are available for only a few stations in previous years. DWR collected nutrients and algae data monthly or bi-weekly in the SJR at Mossdale and Vernalis, and at Buckley Cove in the DWSC.

Figure 24 shows the algae concentrations in the SJR at Mossdale and Vernalis for 2002. The SJR flow at Vernalis is shown for reference. Year 2002 had the lowest summer river flows and the highest algae pigment concentrations of the 2000–2003 years with algae data. The peak total algae pigment (chlorophyll a plus phaeophytin) was about 150 µg/l. The seasonal pattern of high algae pigment is generally limited to the months of June–October. The Mossdale algae pigment concentrations appear to be higher than the Vernalis concentrations.

Figure 25 shows the algae concentrations in the SJR at Maze and Patterson for 2002. The SJR flow at each of these stations is shown for reference. The peak total algae pigment (chlorophyll a plus phaeophytin) was about 150 µg/l at these two stations also, although the algae load (biomass of organic material per day) was less because of the lower flows upstream of the Stanislaus and Tuolumne Rivers.

Figure 26 shows the algae concentrations in Mud Slough and in the San Luis Drain, which discharges into Mud Slough, for 2002. The San Luis Drain flow and Mud Slough flow are shown for reference. The summer flow is dominated by the San Luis Drain flow of about 50 cfs (i.e., Grasslands selenium bypass project). The peak total algae pigment in Mud Slough was about 150 µg/l, and the peak in the San Luis Drain was about 100 µg/l. This is considered to be a potential “seed source” for the algae in the SJR.

Figure 27 shows the algae concentrations in Salt Slough and along the SJR from Patterson to Mossdale for 2002. The peak total algae pigment in Salt Slough is only about 50 µg/l. This is higher than the eastside tributary rivers, which have peak pigment concentrations of only about 10 µg/l, but much lower than the Mud Slough or SJR pigment concentrations. A very interesting feature of the SJR algae pigment data is that the peak of about 150 µg/l is constant from Mud Slough all the way to Mossdale, suggesting light limitation as the dominant factor controlling algae biomass and pigment concentration.

Figure 28 shows the TSS and VSS and turbidity data from Mossdale and Vernalis for 2002. The TSS and turbidity values appear to have a seasonal pattern with the highest concentrations of particulates in the summer. Peak turbidity is about 25 nephelometric turbidity units (NTU) at both stations, and peak TSS values are about 50 to 75 mg/l at both stations. Some of the VSS particulates are algae, which contribute to the self-shading that may be limiting the maximum algae concentrations in the SJR.

Figure 29 shows the TSS and VSS and turbidity data from the SJR at Patterson and Mud Slough for 2002. The TSS and turbidity values appear to have a seasonal pattern, with the highest concentrations of particulates in the summer. Peak turbidity is about 50 to 75 NTU at both stations, and peak TSS values are about 75 to 100 mg/l at both of these stations.

Figure 30 shows the nitrogen and phosphorus concentrations at Mossdale and Maze (upstream of the Stanislaus) for 2002. The nitrogen (nitrate) concentrations are between 1 and 3 mg/l, which is a relatively high nutrient concentration. The total phosphorus concentrations are relatively high, about 200 to 400 µg/l, and the dissolved phosphorus and phosphate (PO_4–P) concentrations are about 100–200 µg/l (half the total). The suspended clay minerals can adsorb a high concentration of phosphorus, which may not be bioavailable for algae growth, so the dissolved or PO_4 concentrations are normally tracked in algae modeling studies.

Figure 31 shows the nutrients in the SJR at Patterson (upstream of the Tuolumne River) and in Mud Slough. The nitrate and orthophosphate concentrations are about twice as high at Patterson as at Maze and Mossdale. The nitrate concentrations in Mud Slough are exceptionally high, whereas the phosphate concentrations are relatively low (suggesting a groundwater source) and may be limiting algae growth during the summer.

Annual Master Files

Annual master files were created that contain all the daily data for each calendar year from 1984 to 2003; thus there are 20 individual files in the Data Atlas. Each annual file contains all parameters grouped into several sheets with related parameters. Each annual file has the following sheets.

- The "Meteorology" sheet has all meteorology data, including rainfall and some evapotranspiration (ET) estimates from CIMIS and evaporation pan data.
- The "Flow, Stage & Storage" sheet has the river flow and stage values, including several Delta stations. Upstream reservoir storage and releases and some major agricultural diversions are included.
- The "Day_Flow" sheet has the daily water budget for the Delta, including the river inflows, agricultural diversions (evapotranspiration) and drainage (rainfall) estimates, and CVP and SWP exports.
- The "EC & Minerals" sheet has the EC and minerals data, although very few stations have minerals data.
- The "Temperature, DO & pH" sheet has the water quality monitoring data for several SJR and Delta stations. These usually have a daily minimum, average, and maximum value.
- The "Nutrients" sheet contains the nutrient data collected by Dr. Dahlgren and at a few DWR stations.
- The "Particles" sheet contains the turbidity and TSS and VSS data collected by Dr. Dahlgren and at a few DWR stations.
- The "BOD, TOC & DOC" sheet contains the BOD and total organic carbon (TOC) and dissolved organic carbon (DOC) data collected by Dr. Dahlgren and at a few DWR stations.
- The "Stockton River 1" sheet contains the COS river water quality data from stations R1 to R6. The "Stockton River 2" sheet includes the river stations R7 and R8 as well as additional measurements at the DWSC turning basin, Mossdale, and Vernalis that were collected in 1999, 2000, and 2001.
- The "Stockton WWTP Effluent" sheet has the Stockton RWCF effluent flow and water quality data.
- The "Index" sheet contains a summary of the measurements stations that are contained in the Data Atlas and includes some general notes on data within the files.

A review of these annual data files indicates that the available hydrology and water quality data from the SJR and DWSC are relatively abundant. Additional data that may be available from other sources can be easily added to these files. Updated annual files for 2004 and subsequent years can also be prepared following this standardized format. Stations can be added to the master annual files as new monitoring locations are included in future studies.

Bonus Files

Several additional Excel files are included in the Data Atlas to provide more specific and detailed data sources. These files are briefly described below. There is a Web site that is maintained by the stakeholders in the SJR DO total maximum daily load (TMDL) process that can be accessed at: http://www.sjrdotmdl.org

Many of the reports on the previous CALFED studies are available on this Web site. The final reports from each of these studies are included in the bonus files. A SJR DO “strawman” evaluation report by the Regional Water Quality Control Board (RWQCB) staff and the resulting DO–TMDL technical report from the RWQCB to USEPA are included in this collection. These Data Atlas files will be available for downloading and periodic updating from this Web site.

RRI_Stratification_2002

This file contains hourly water temperature data collected at the Rough and Ready Island water quality monitoring station at several depths during the months of May–August 2002. This is the only record of temperature stratification patterns in the DWSC. The tidal stage and hourly windspeed data are provided along with mixing energy estimates for tidal and wind forcing. The Rough and Ready Island hourly temperature, DO, pH, and EC records are included in this file.

Dahlgren_UCD_WY2000-WY2003

This file contains the original data sent from Dr. Dahlgren at UCD for water years 2000 to 2003. This data has been incorporated into the Data Atlas master annual files and comparison files.

Meteorology_Hourly_99-03

This file contains hourly data at Lodi, Kesterson, and Rough and Ready Island (air temperature only) from 1999 to 2003. This file does not contain any graphs of the hourly data. Hourly meteorology data is needed for the temperature and light (solar radiation) modeling of the SJR water quality (e.g., algae growth) conditions.

Averager

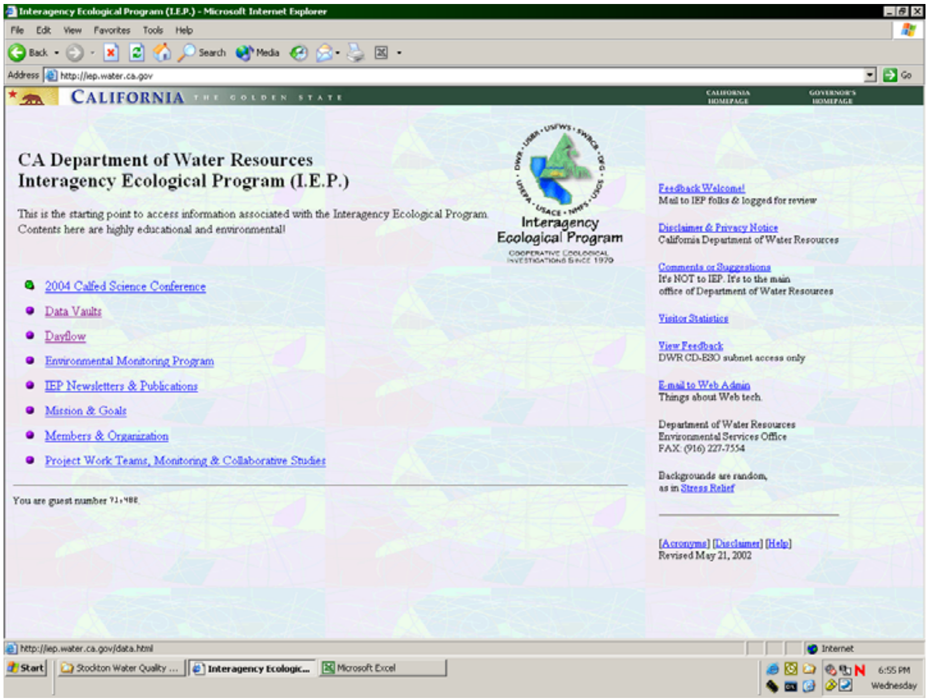
This Excel file contains sheets that can process a year of 15-minute or hourly data to provide an annual file with daily minimum, average, and maximum values.

DWSC_Sediment_Traps_2001

This Excel file contains the sediment trap data collected in the DWSC by Dr. Gary Litton in 2001. The TSS, VSS, chlorophyll a and phaeophytin concentrations in the traps as well as the water column concentrations are given.

Figure 1. Map of the lower SJR watershed with major flow and EC measurements stations. The Stockton DWSC is at the very top of the map

IEP.water.ca.gov



Click "Data Vaults."

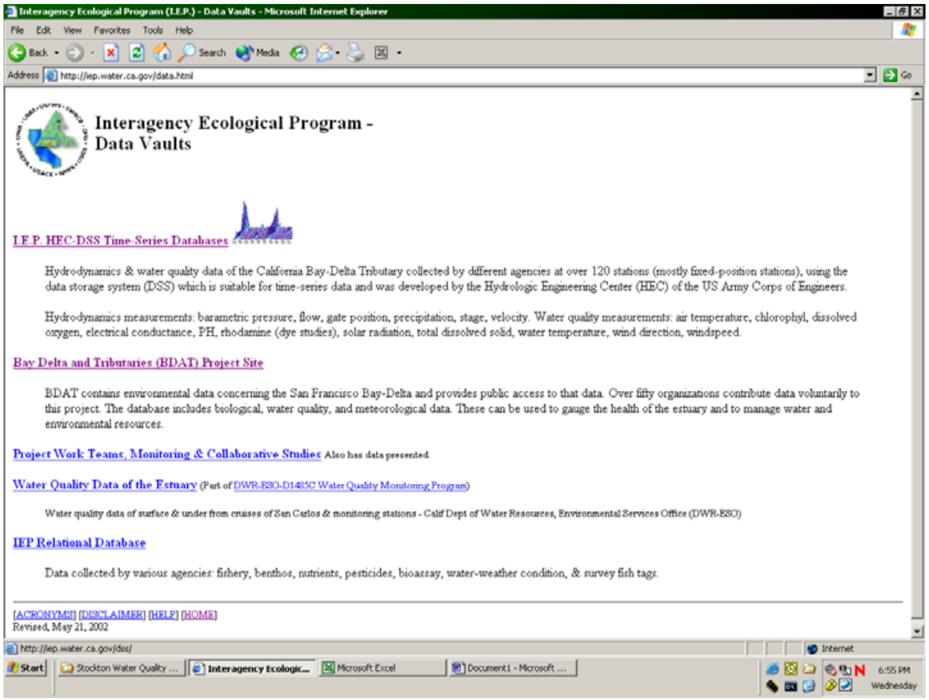
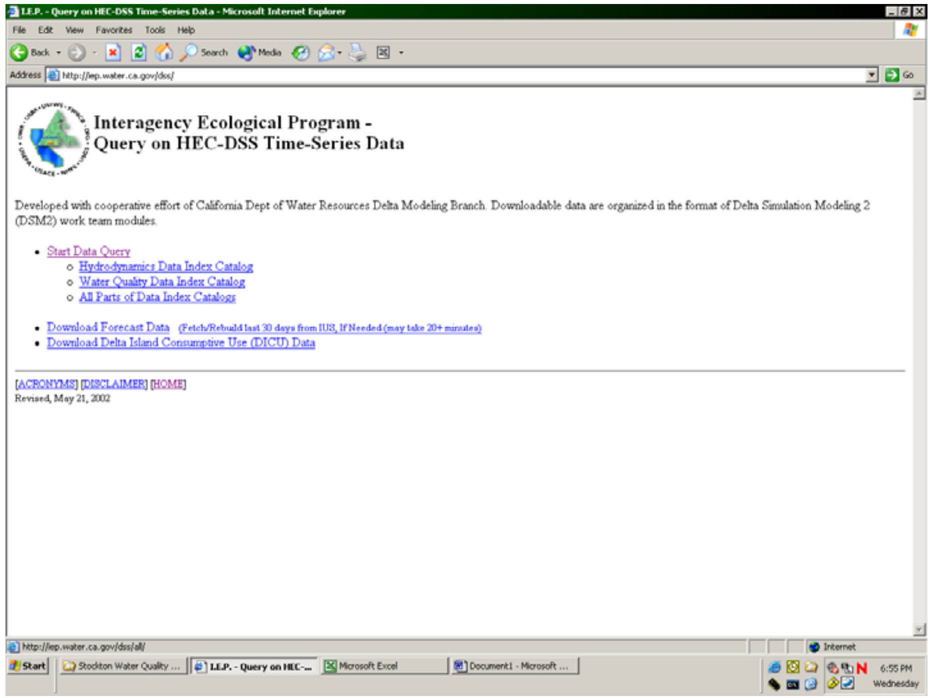


Figure 2. Procedures for Accessing and Retrieving Data from the IEP Web Site

Click “I.E.P. HEC-DSS Time-Series Databases.”



Click “Start Data Query.”

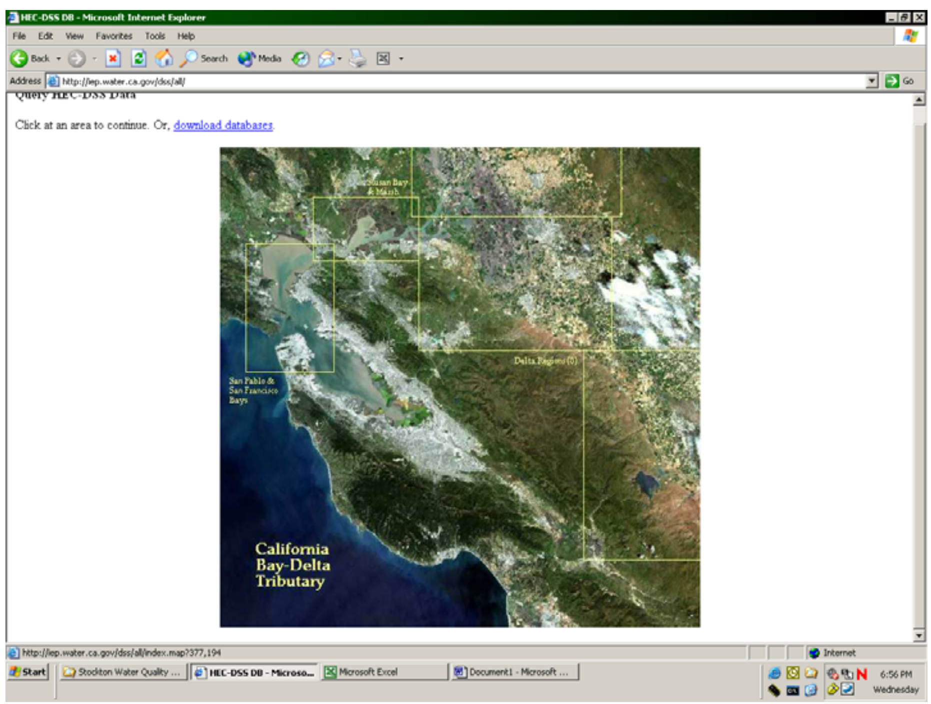
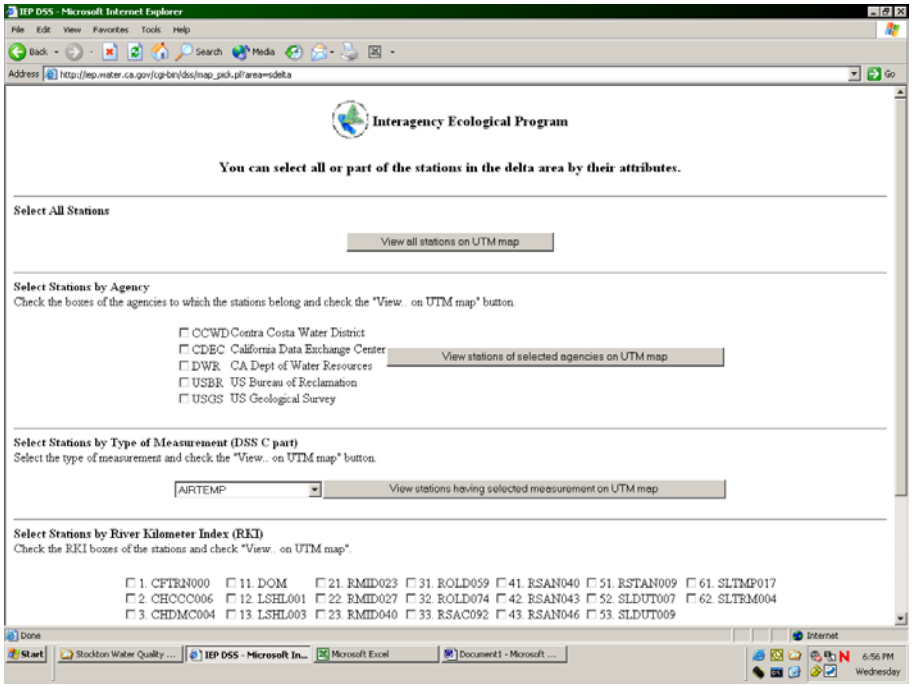


Figure 2. Continued

Click on the region where the station you want is located.



Click "View all stations on UTM map" to see a map of the stations, "View stations of selected agencies on UTM map" to filter the stations by agency, "View stations having selected measurement" to filter by measurement type, or select the stations you want to view and then click "View selected stations on UTM map."

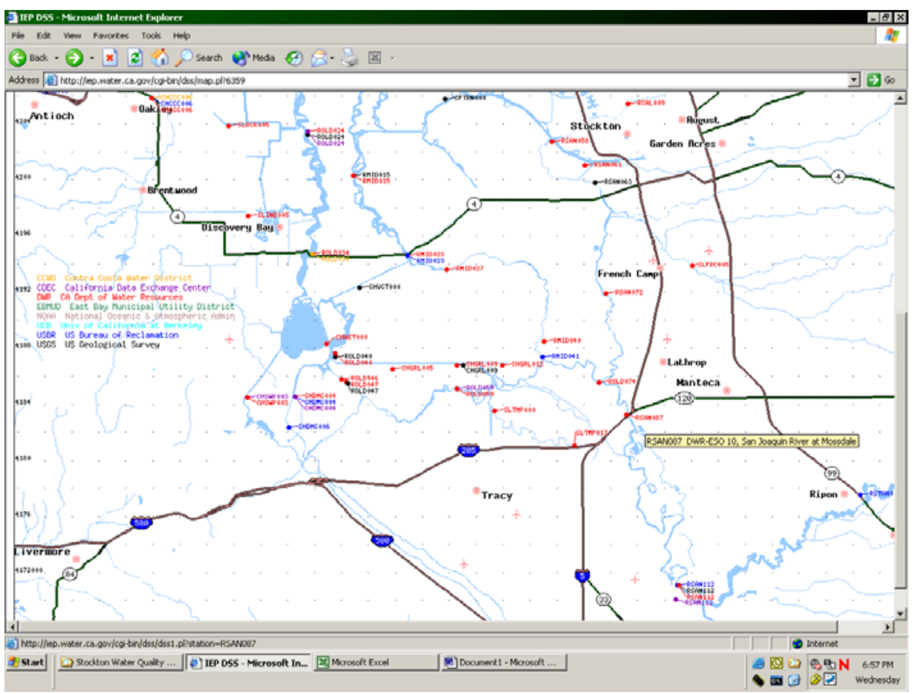
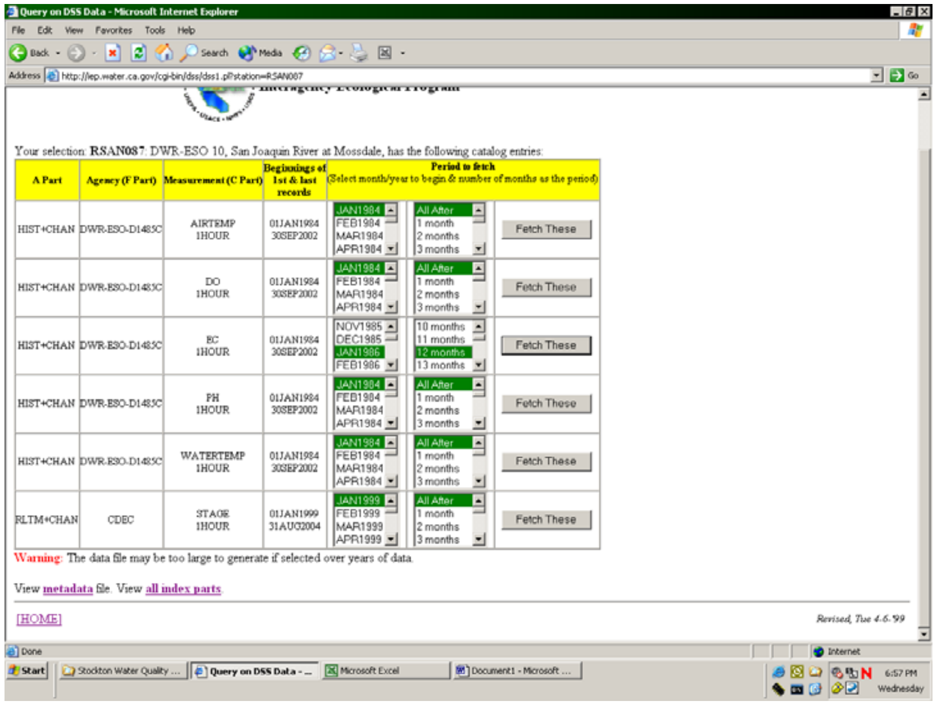


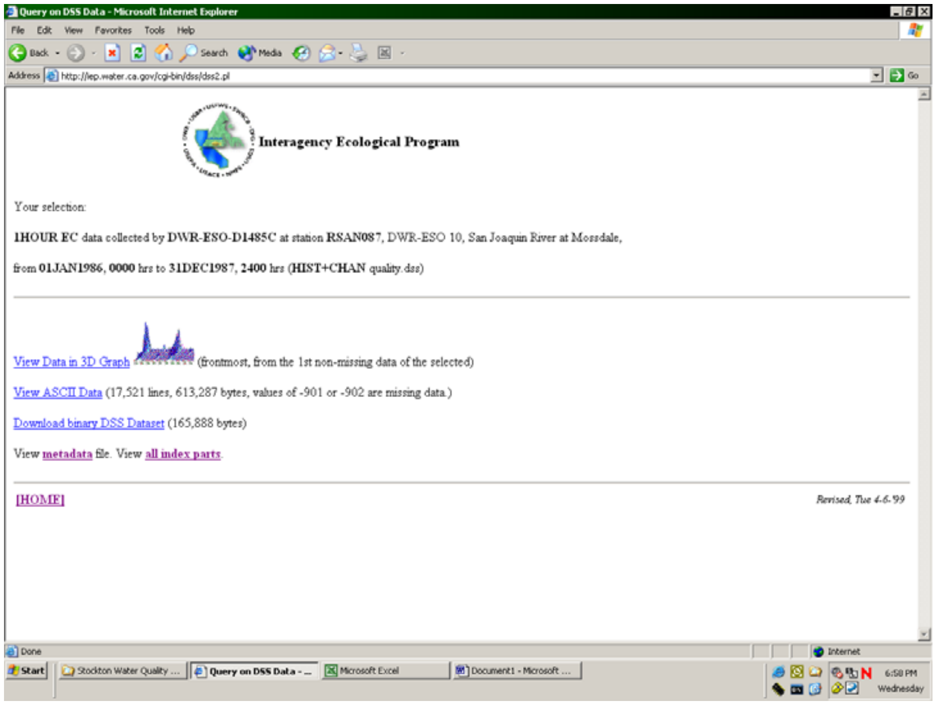
Figure 2. Continued

Either click “Station Location Info” to see information on each station shown, or choose the station from the selection box, or click on the station you want on the map. Holding the mouse over a station will display a screentip showing the station information.



Select the beginning time and duration then click “Fetch These.”

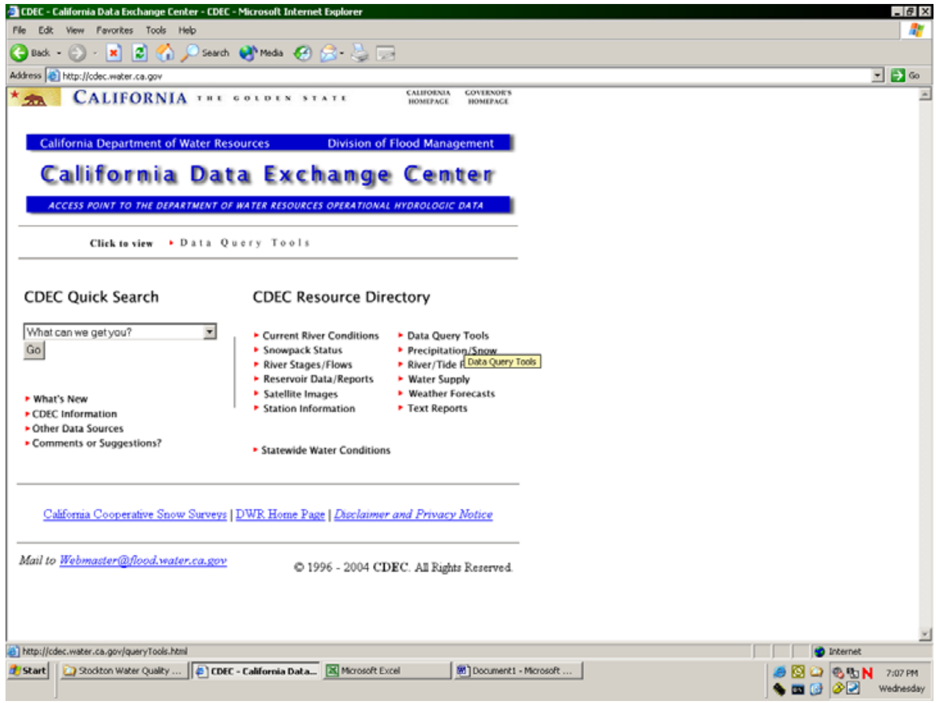
Figure 2. Continued



Here you can view a graph of the data, download the data as a DSS file, or display the data as text. A Microsoft Excel add-in for retrieving and storing data in a DSS file can be downloaded from:
http://www.hec.usace.army.mil/software/hec-dss/hecdss_msexcel_addin.htm

Figure 2. Continued

CDEC



Click "Data Query Tools."

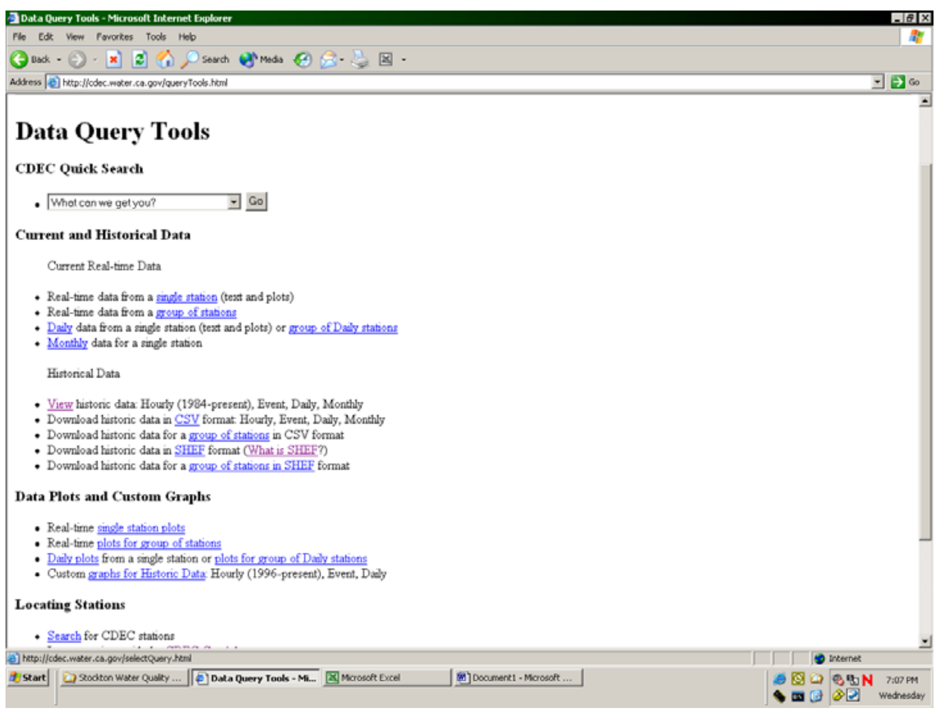
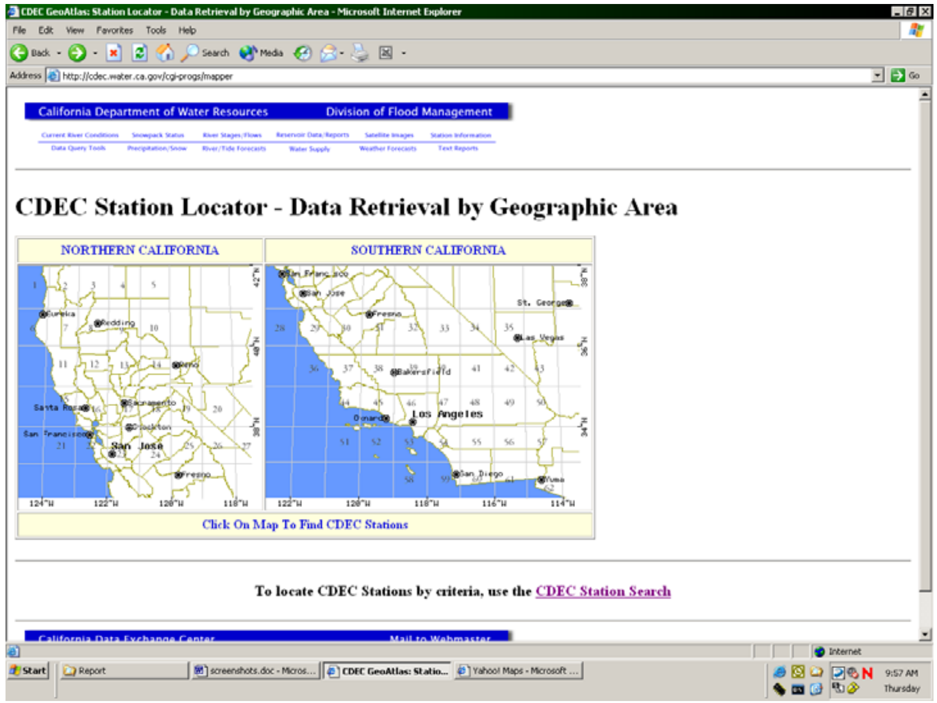


Figure 3. Procedures for accessing and retrieving data from the CDEC database Web site

Either click "View historic data" if you know the station ID or want to search on the ID by keywords, or click "CDEC GeoAtlas" to view an interactive map.



Click on an area to zoom in.

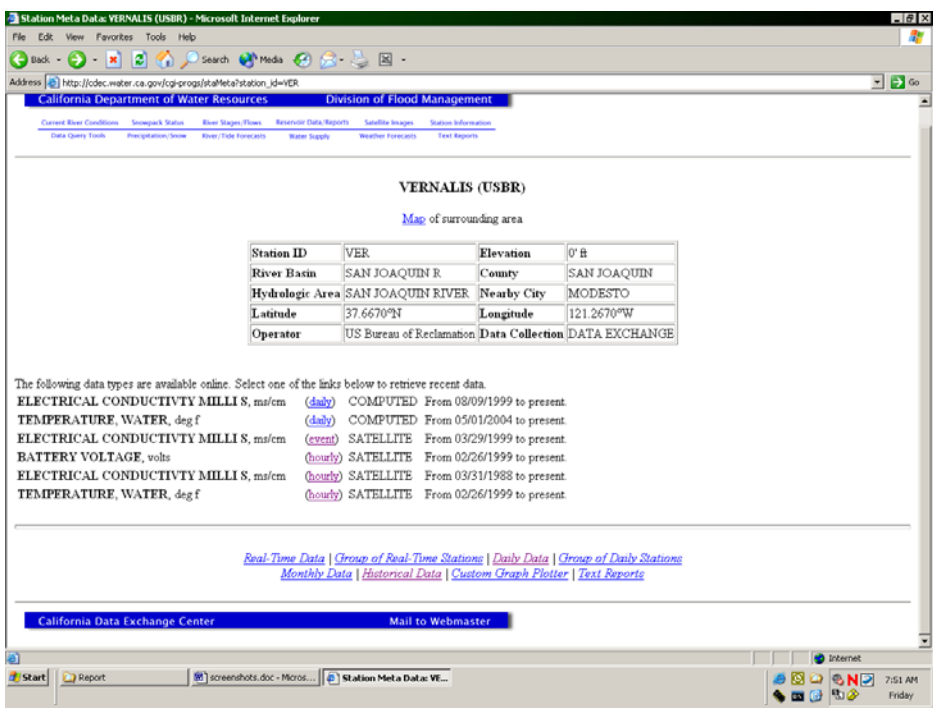
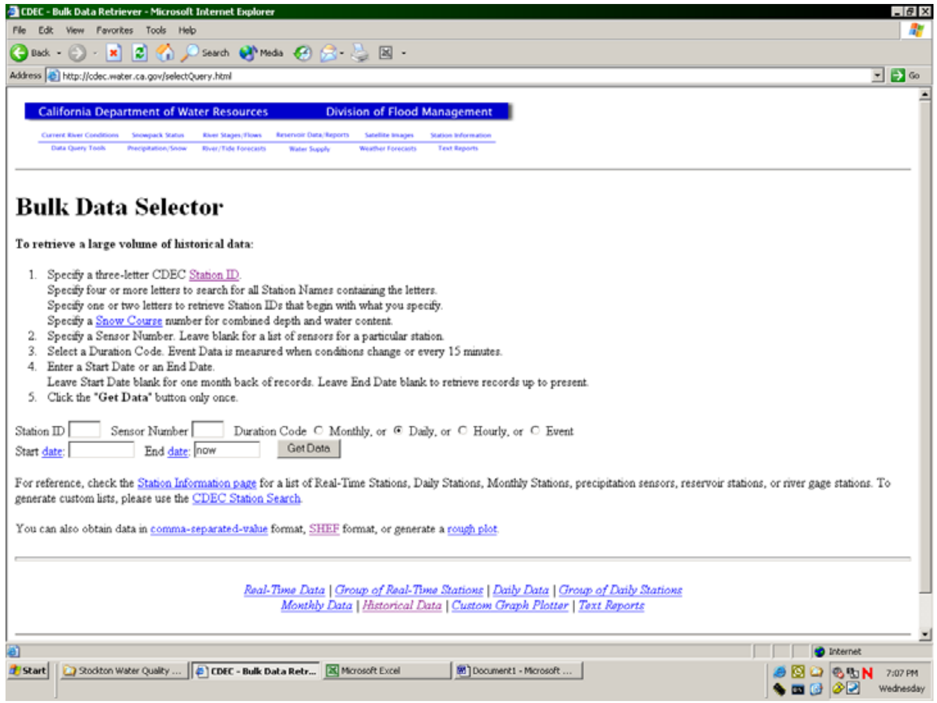


Figure 3. Continued

If you want historical data for the site you selected, you now have to click on "Historical Data" on the bottom of the screen.



Type in the station ID and the range you want. If you don't know the station ID, you can search for it by clicking on the "Station ID" button.

Figure 3. Continued

USGS

Click “Surface Water” to get flow data or “Water Quality” to get water quality data.

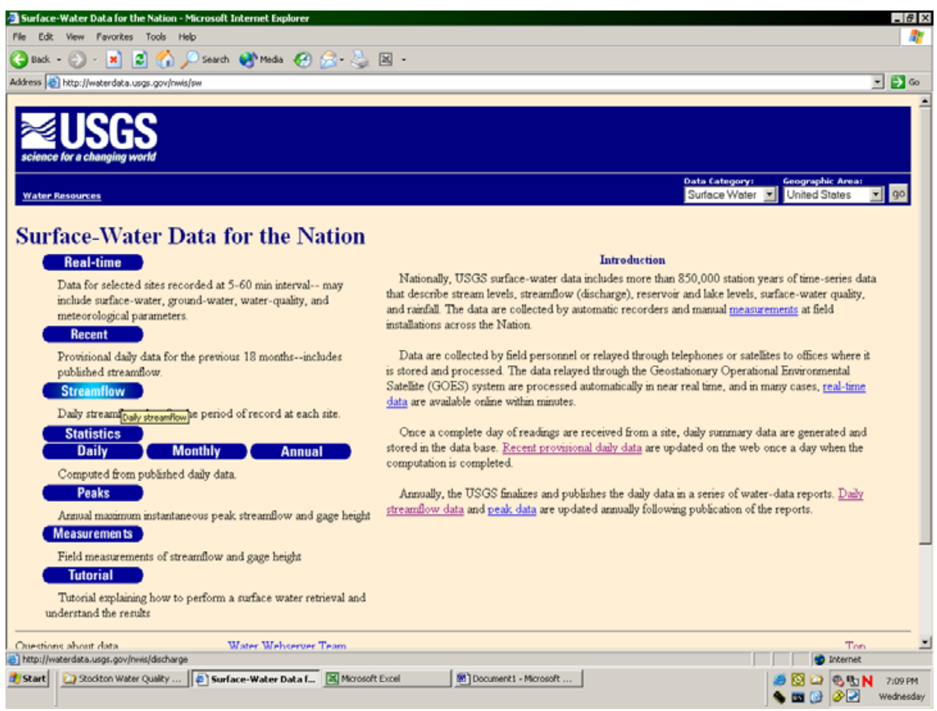
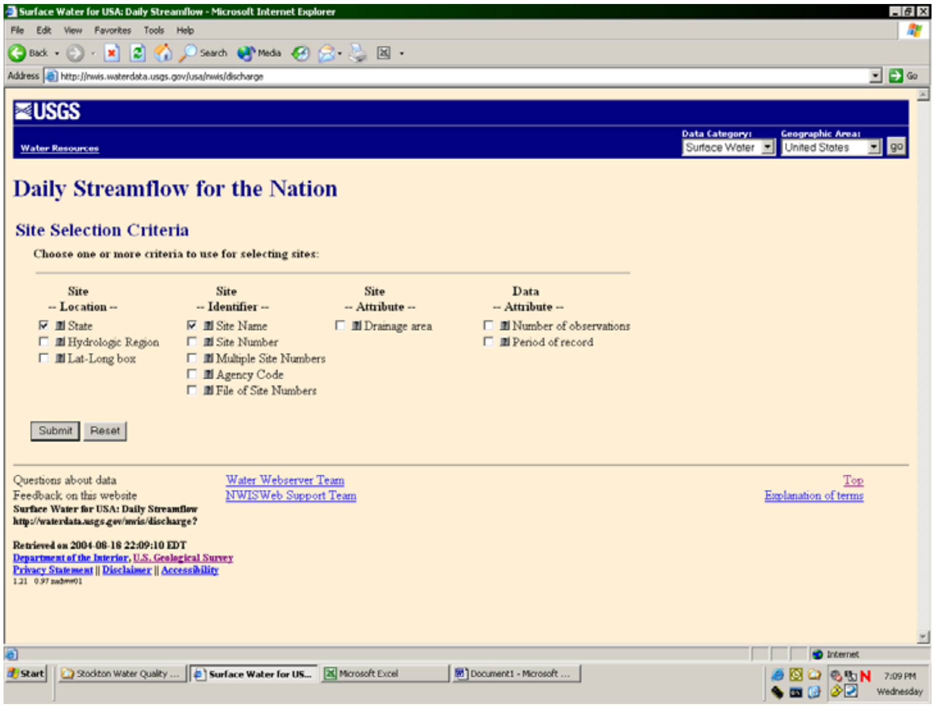


Figure 4. Procedures for accessing and retrieving data from the USGS database Web site

After "Surface Water," click "Streamflow."



Select the criteria you want to use for selecting sites.

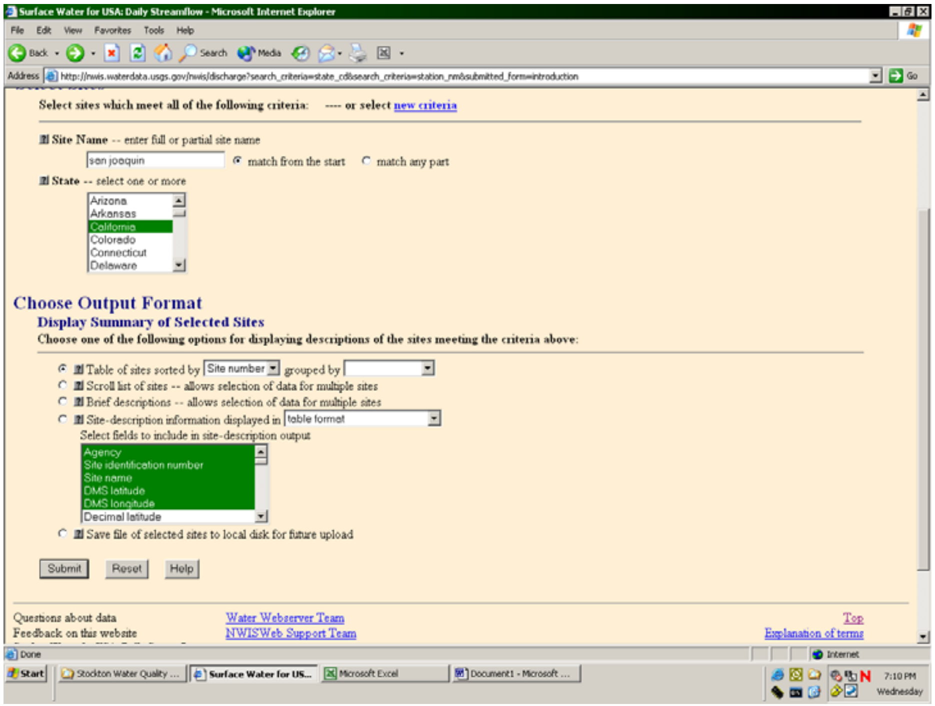
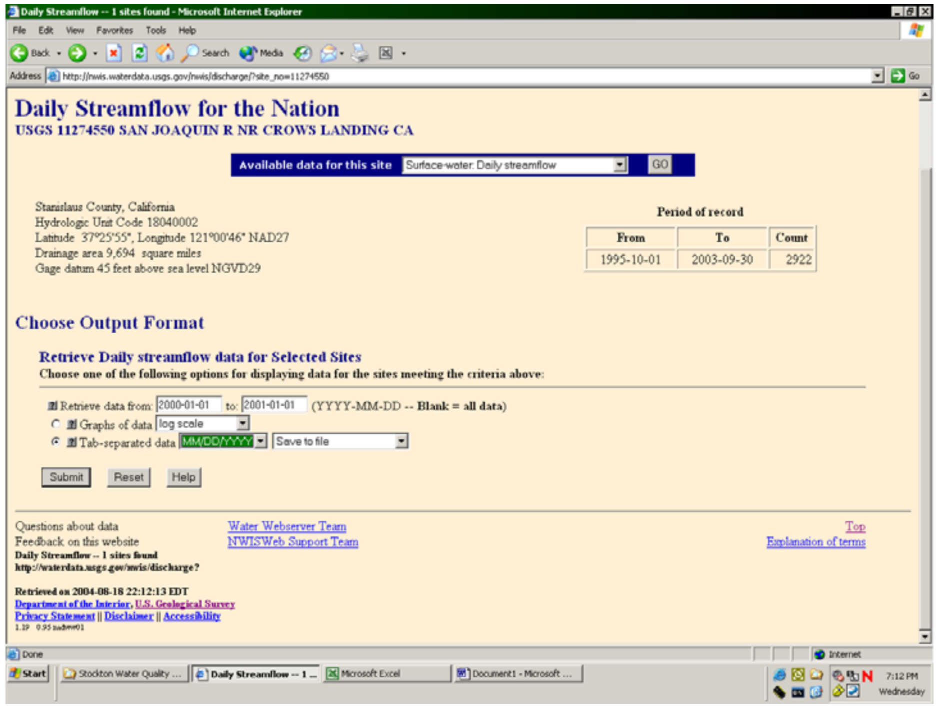


Figure 4. Continued

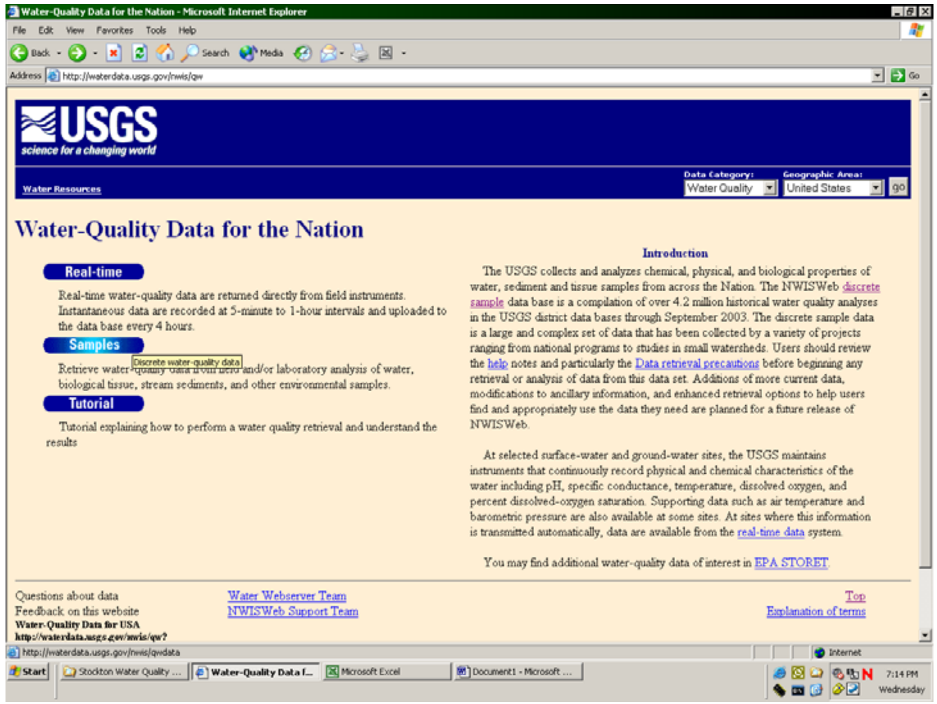
Enter your criteria and click “Submit.”



Type in the range you want and select either to graph the data or to display or save the data and click “Submit.”

Figure 4. Continued

To get water quality data, click on “Water Quality” from the homepage.



Click “Samples.”

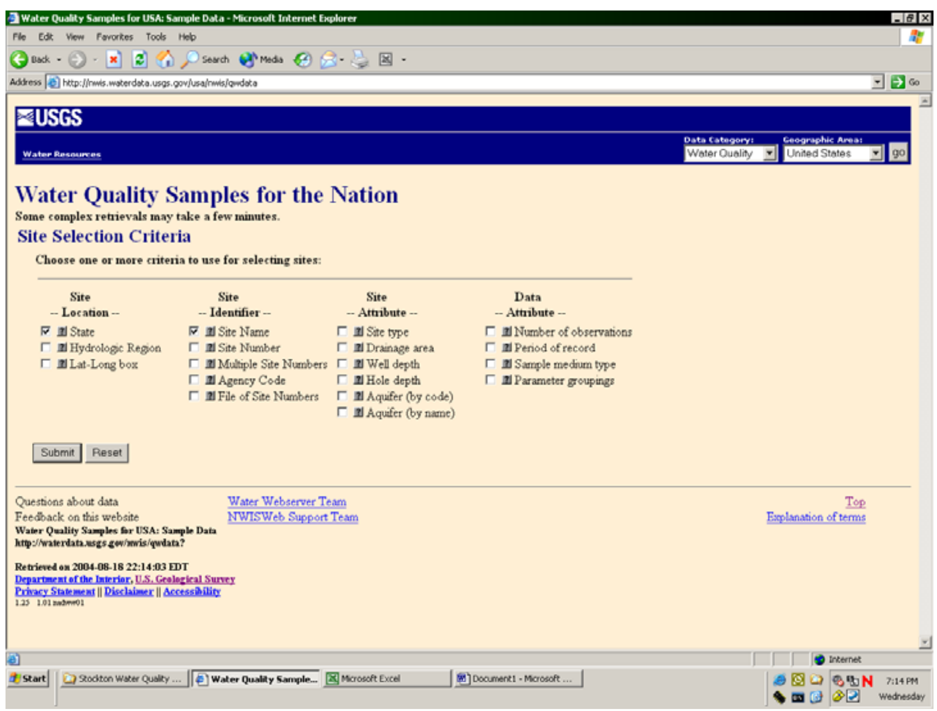
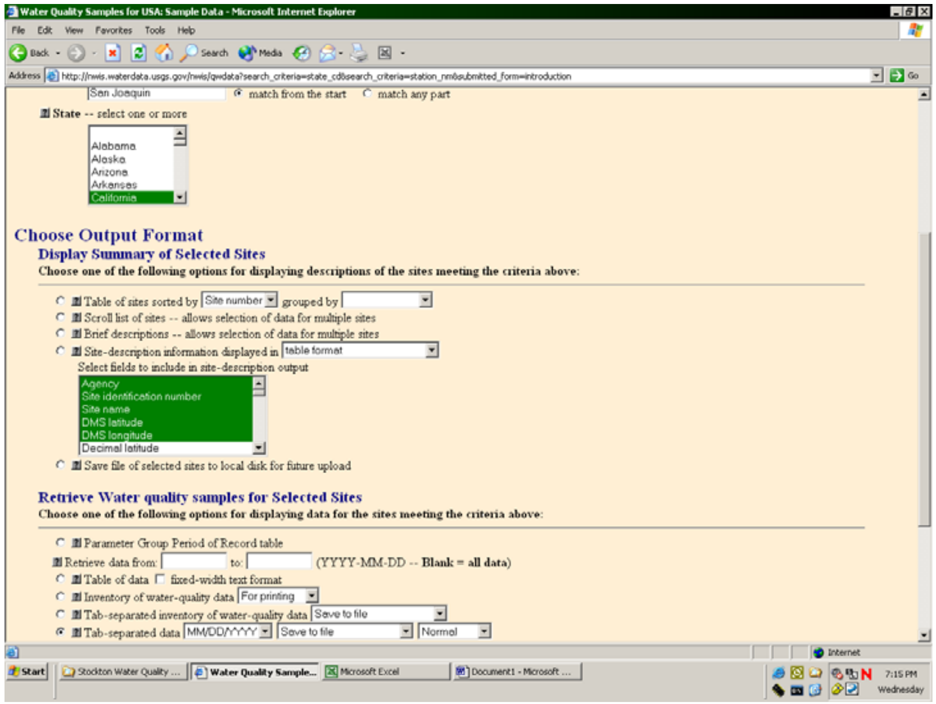


Figure 4. Continued

Select your criteria.



Enter your criteria and select the output settings you want.

Figure 4. Continued

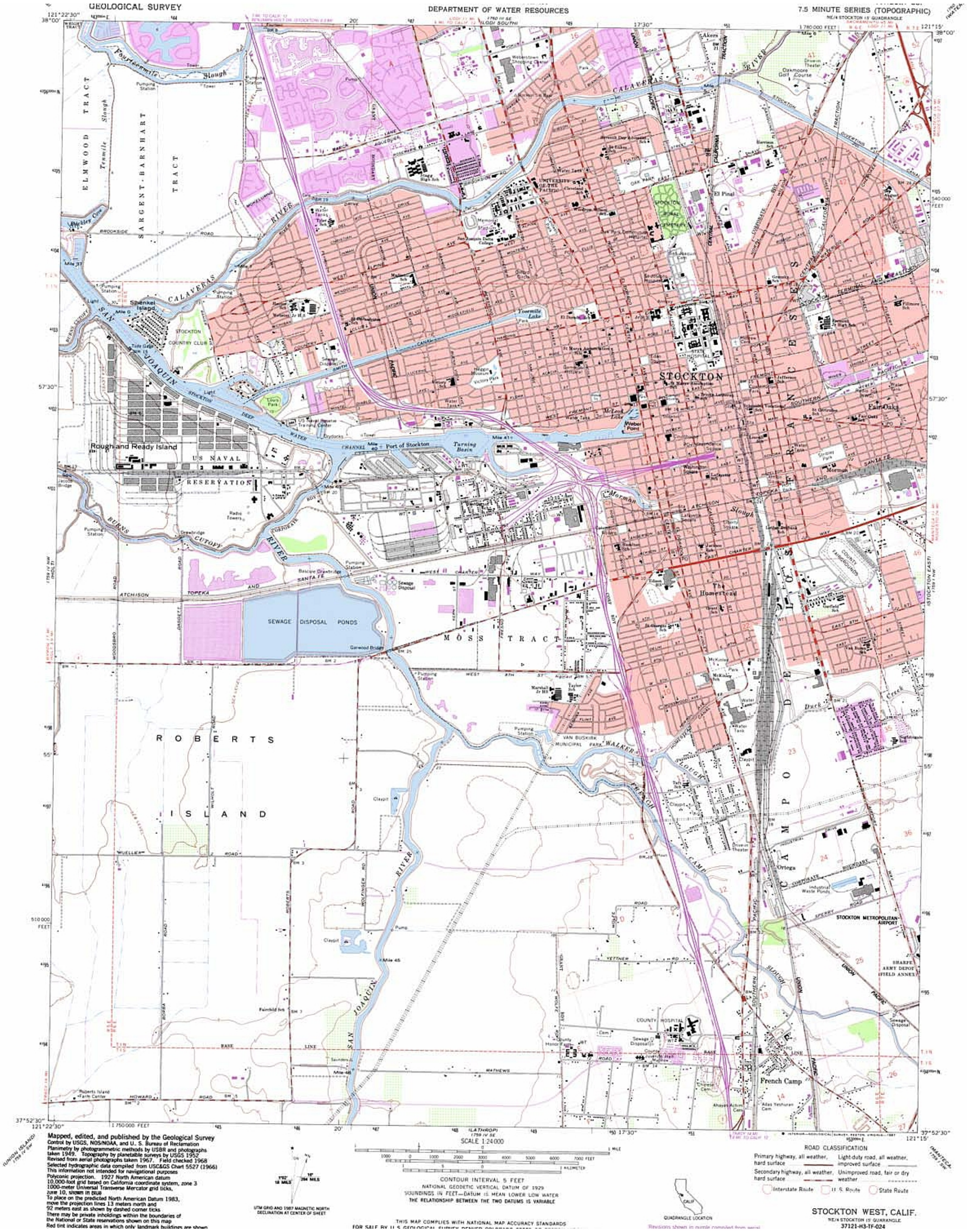
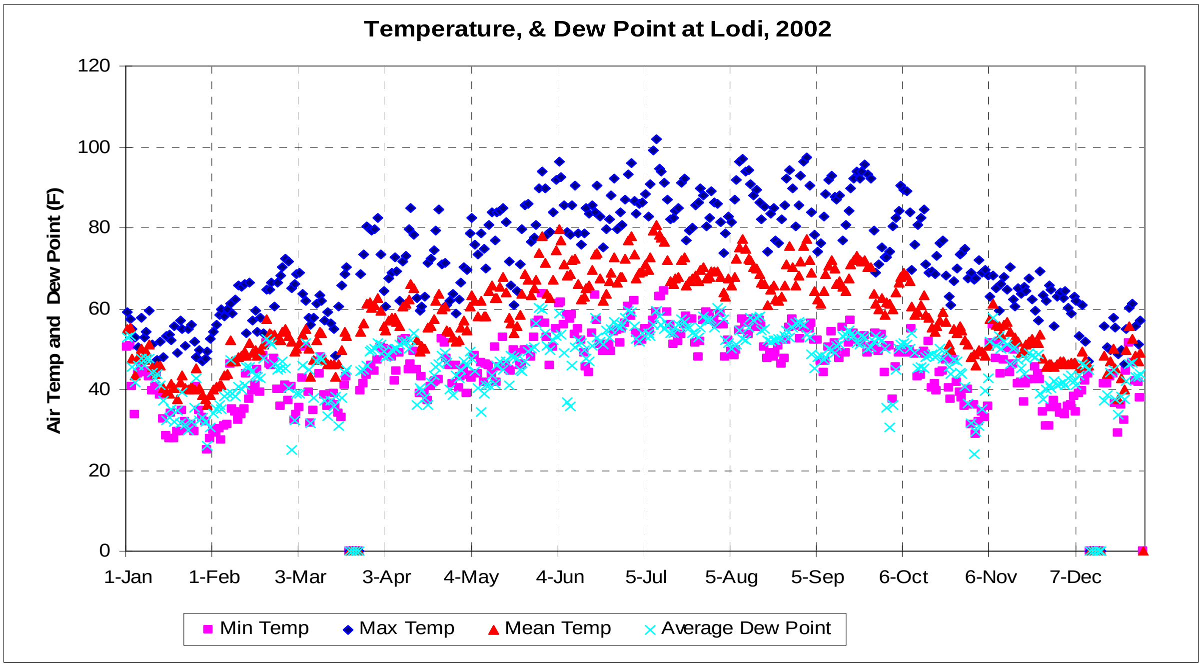


Figure 5. Stockton West USGS 7.5-minute map of the SJR channel



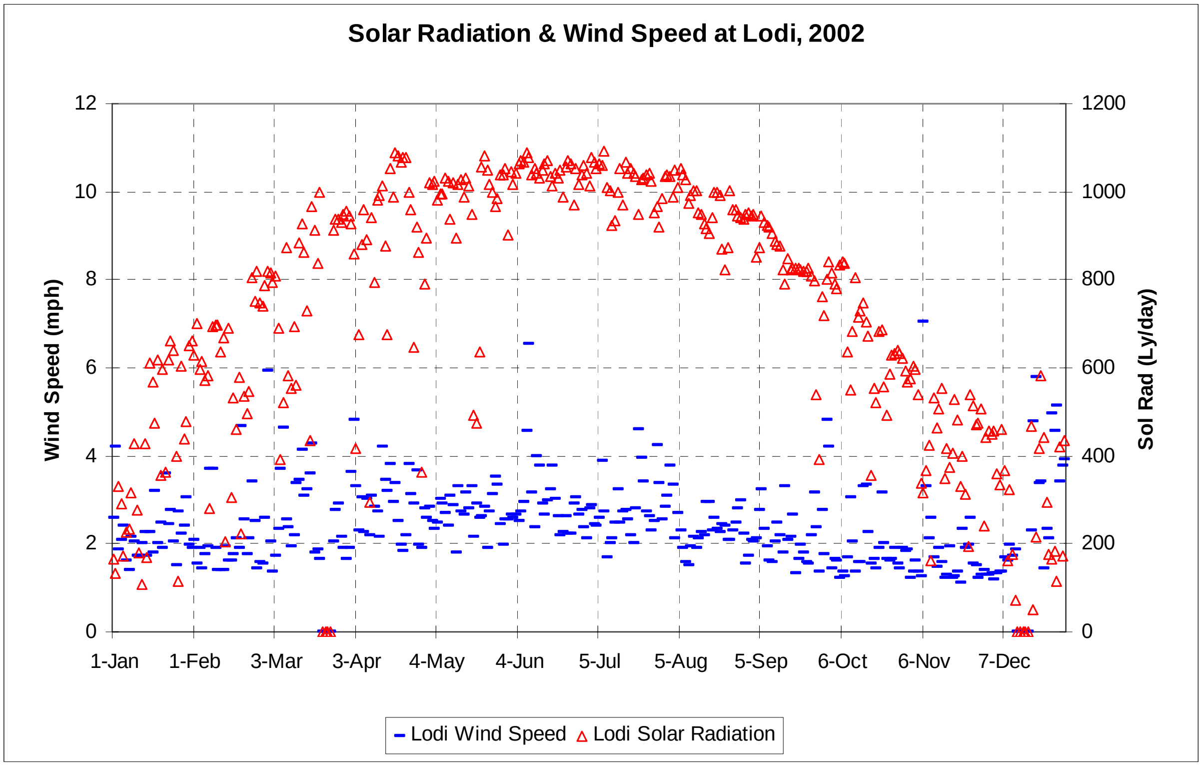
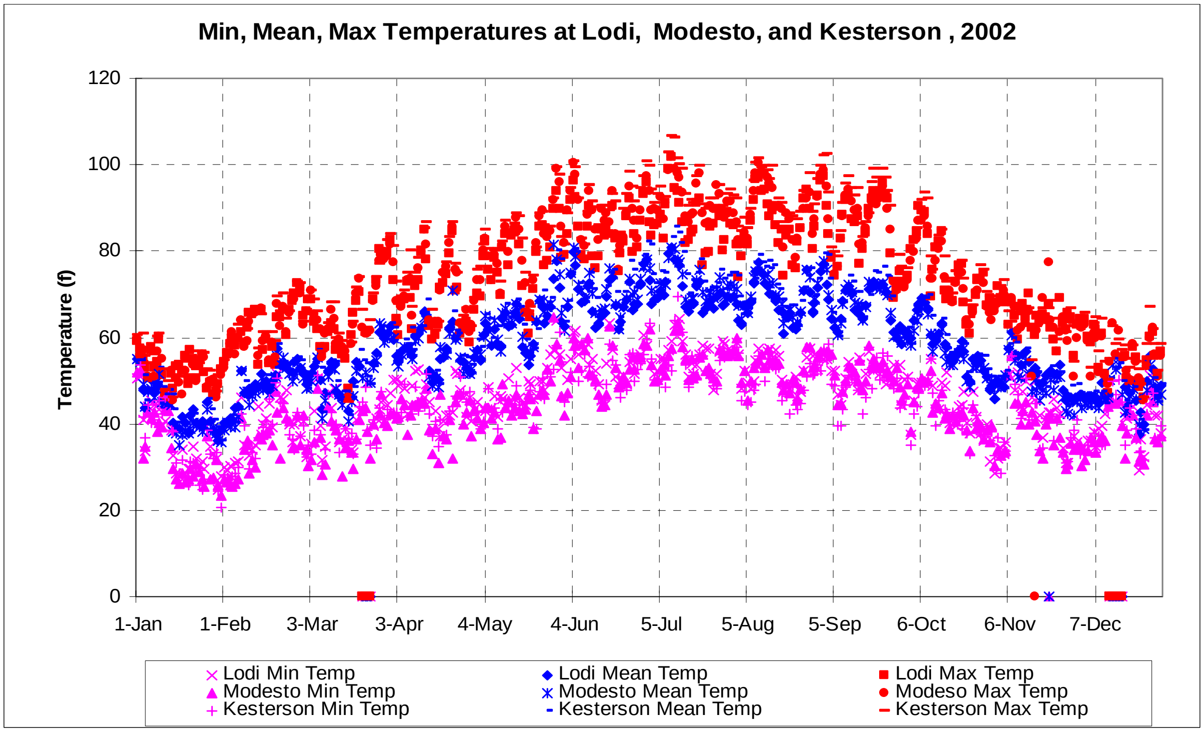


Figure 6. Lodi air temperature and dew point temperature and windspeed and solar radiation data for 2002



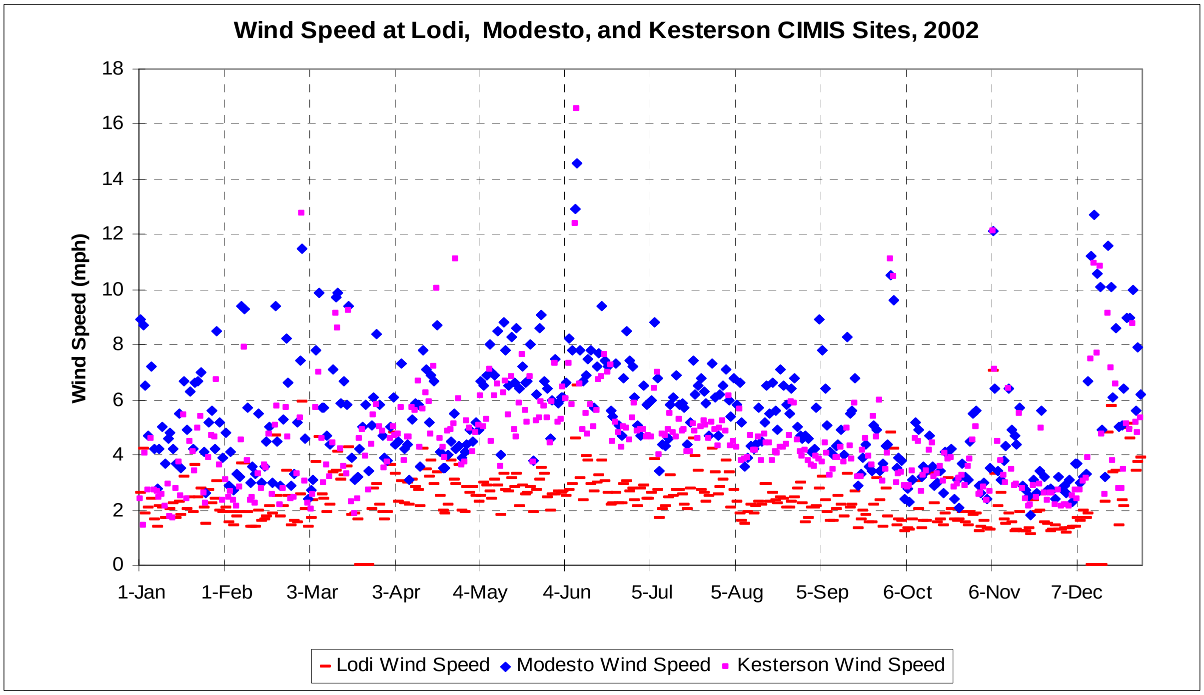
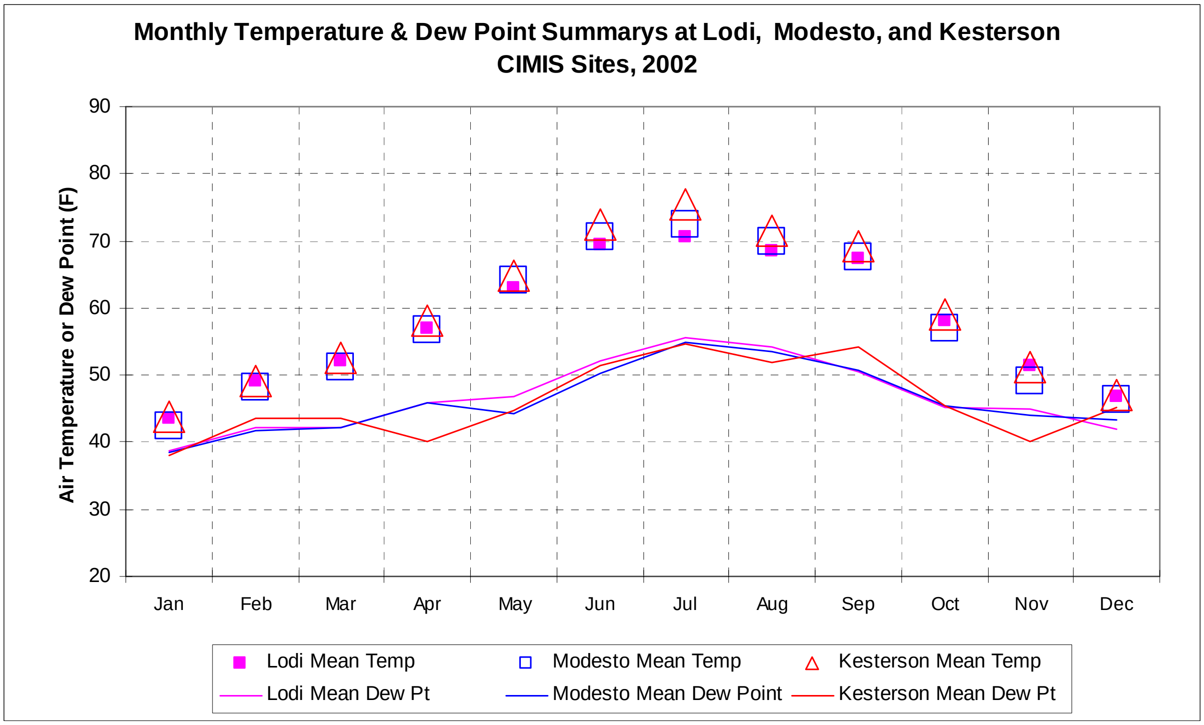


Figure 7. Comparison of daily meteorology data from Lodi, Modesto, and Kesterson for 2002



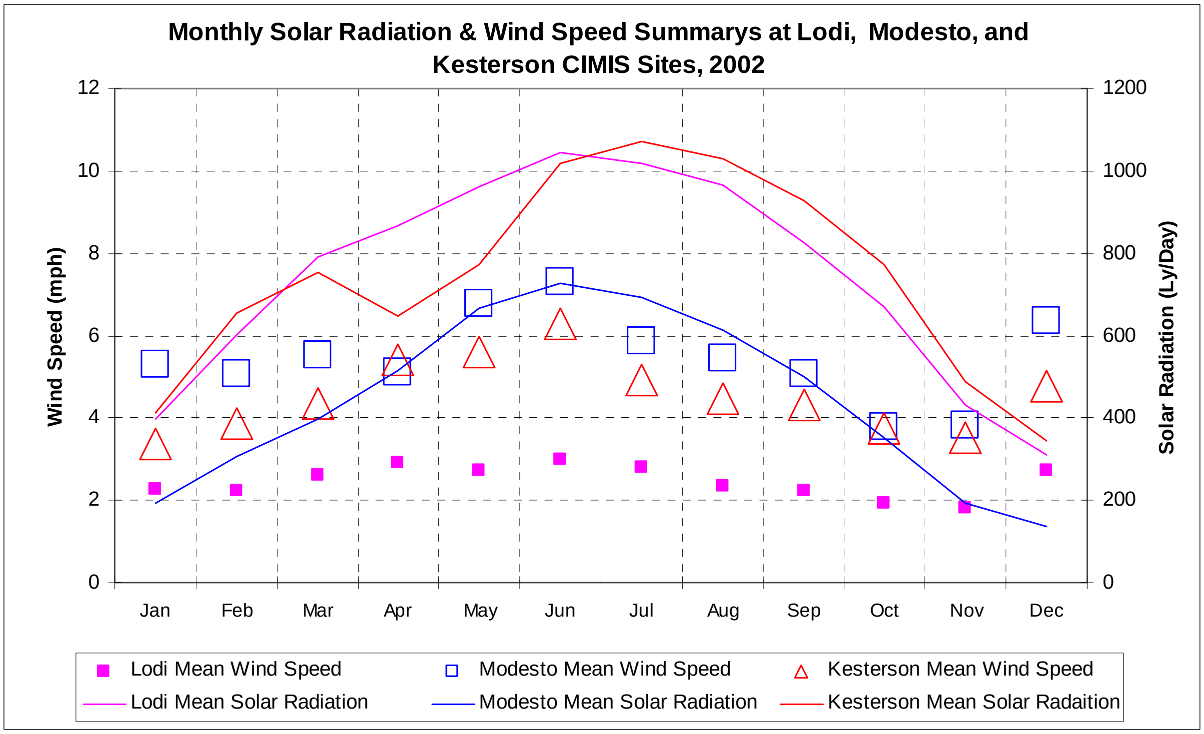
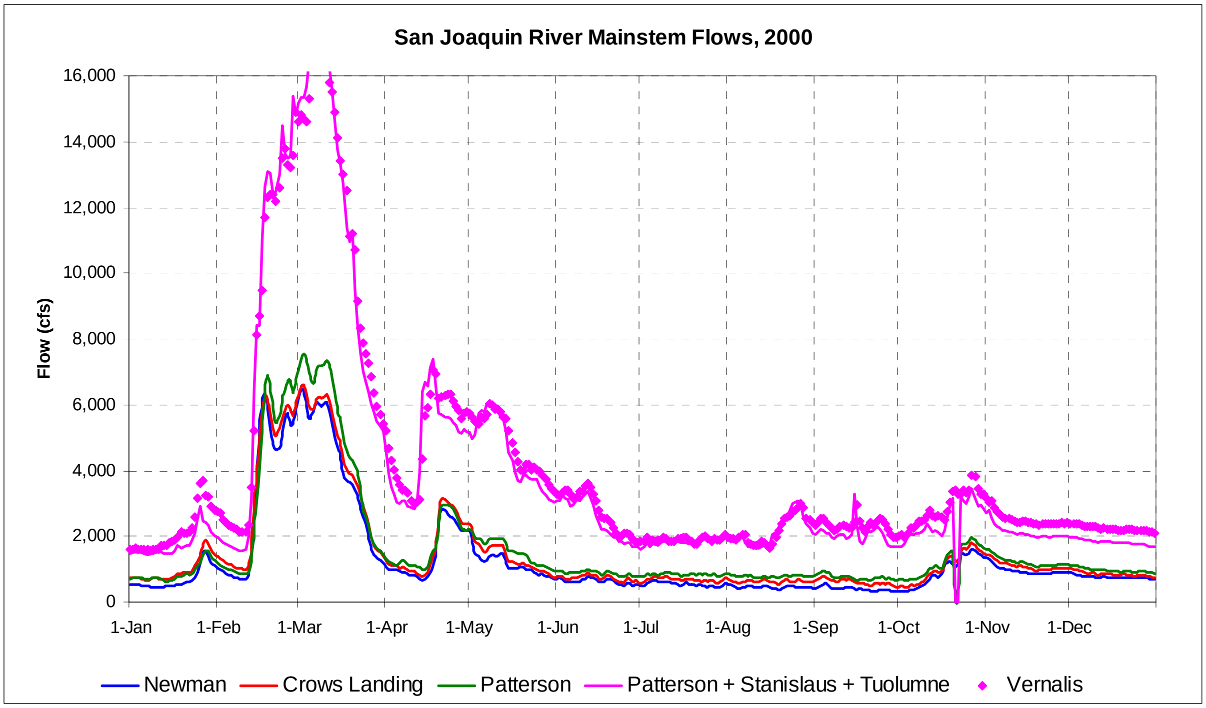


Figure 8. Comparison of monthly average meteorology at Lodi, Modesto, and Kesterson for 2002



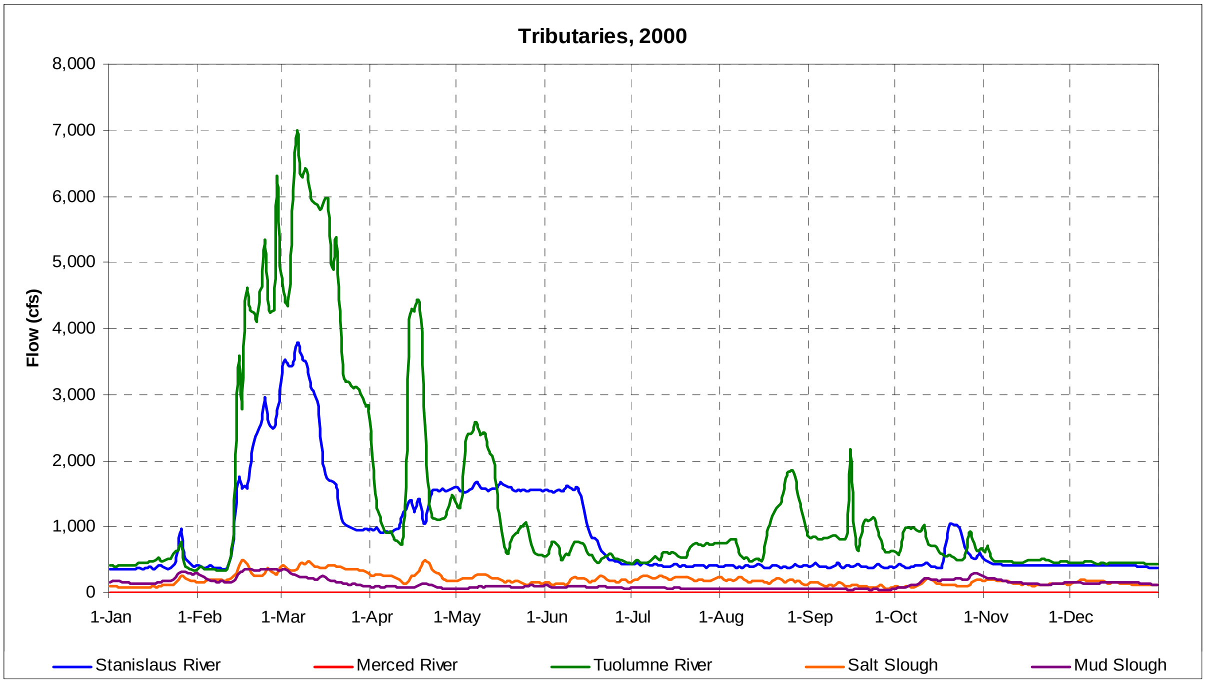
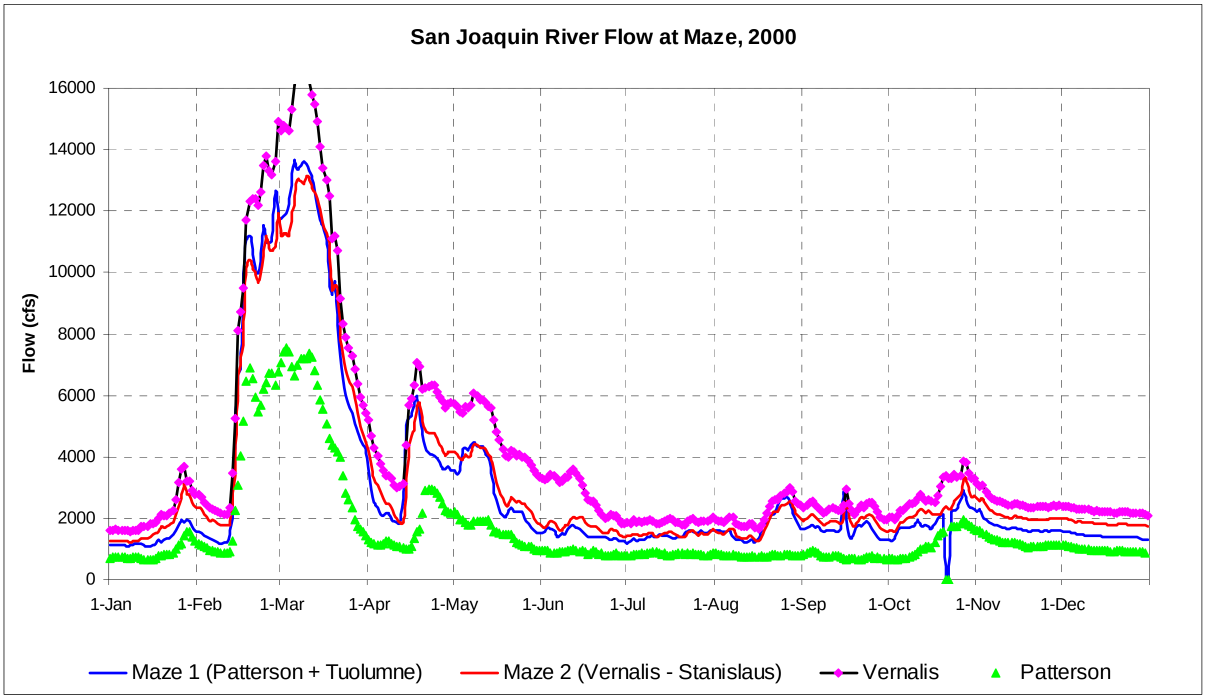


Figure 9. Daily SJR flow along the SJR mainstem and in the tributaries for 2000.



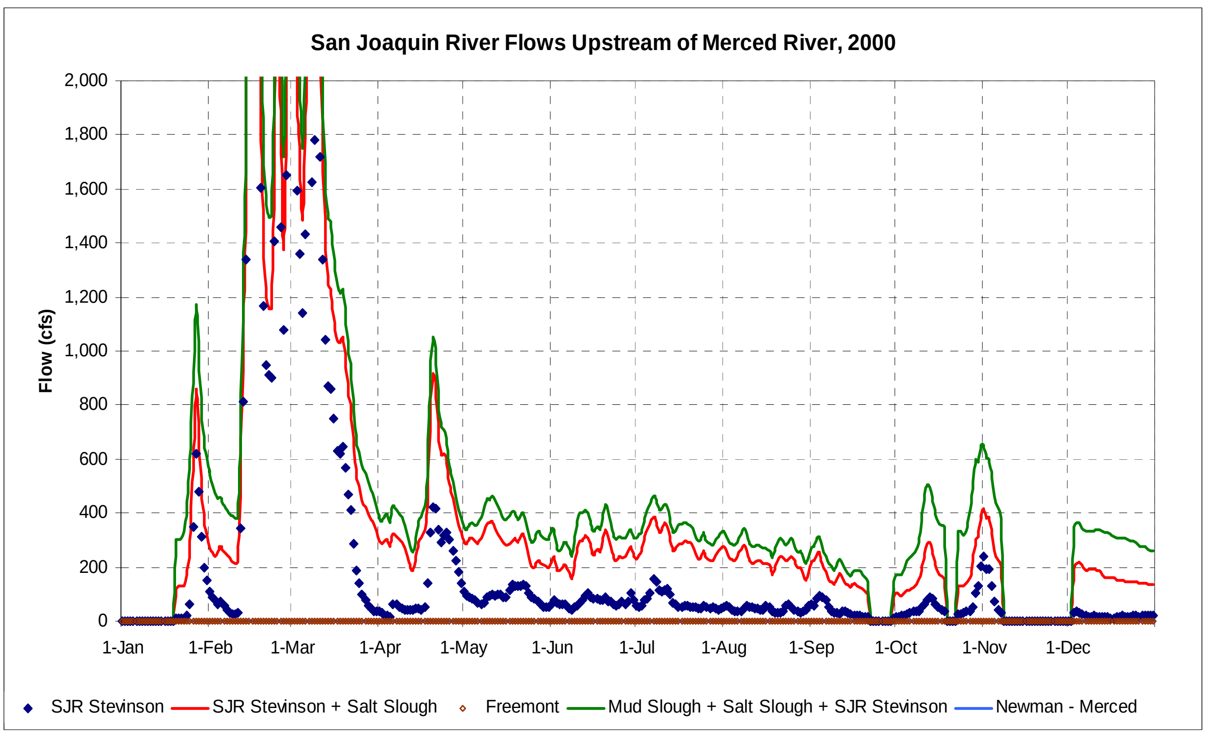
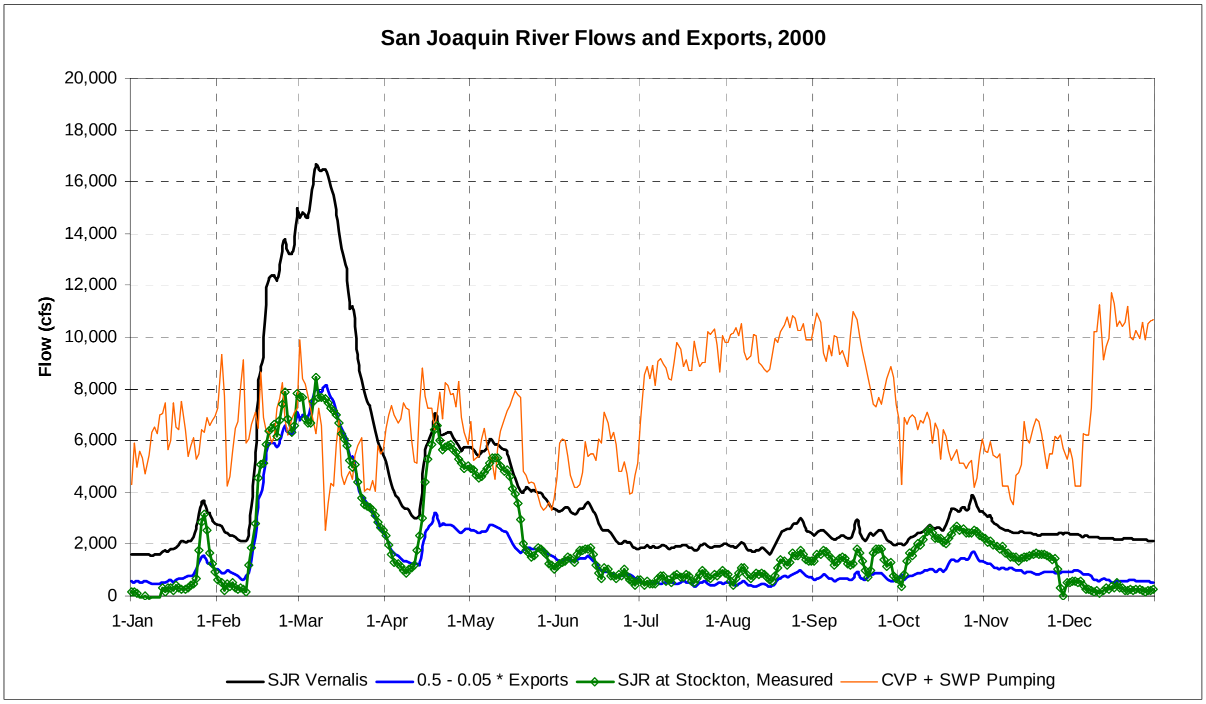


Figure 10. Daily SJR flow estimated upstream of the Stanislaus River at Maze and upstream of the Merced River at Fremont Ford for 2000.



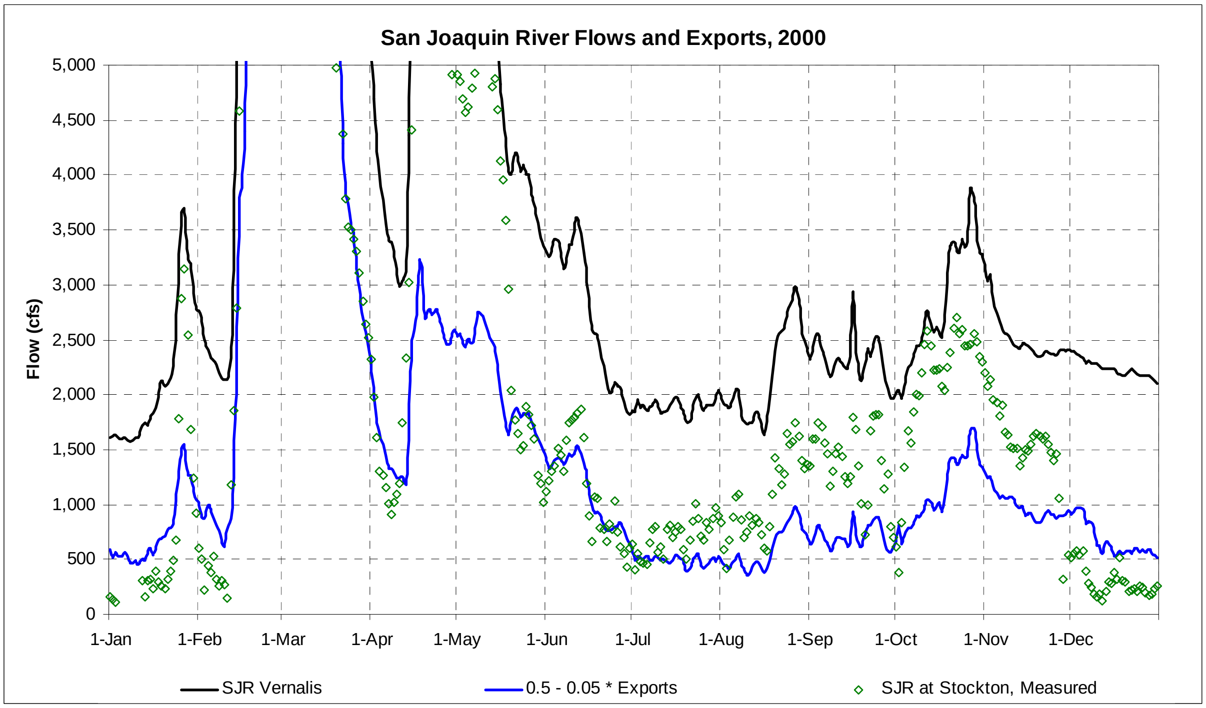
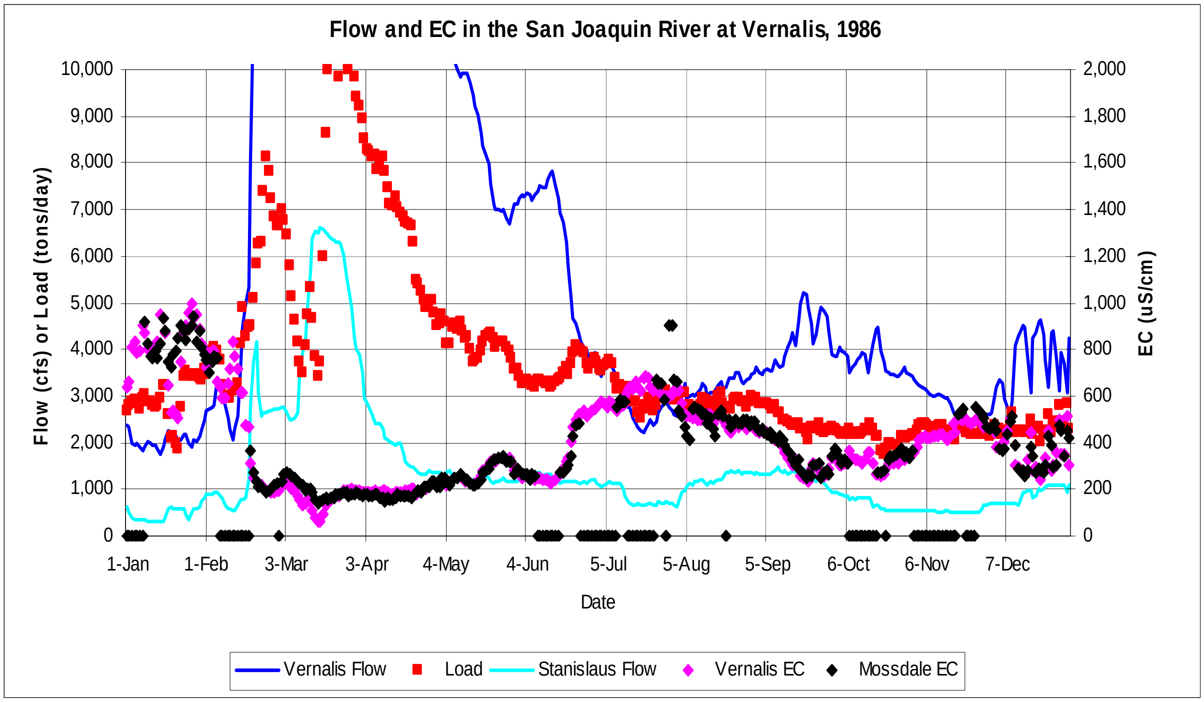


Figure 11. SJR flow at Vernalis and combined CVP and SWP pumping with estimate of Stockton DWSC flow compared with measured USGS tidal flow for 2000.



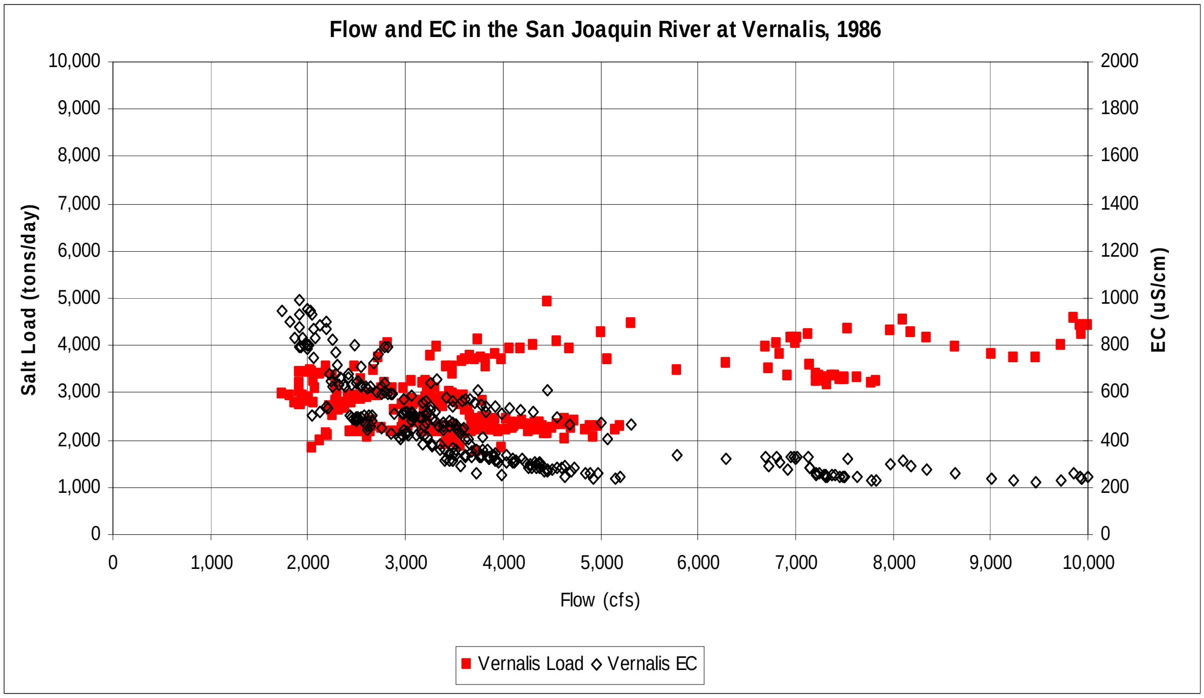
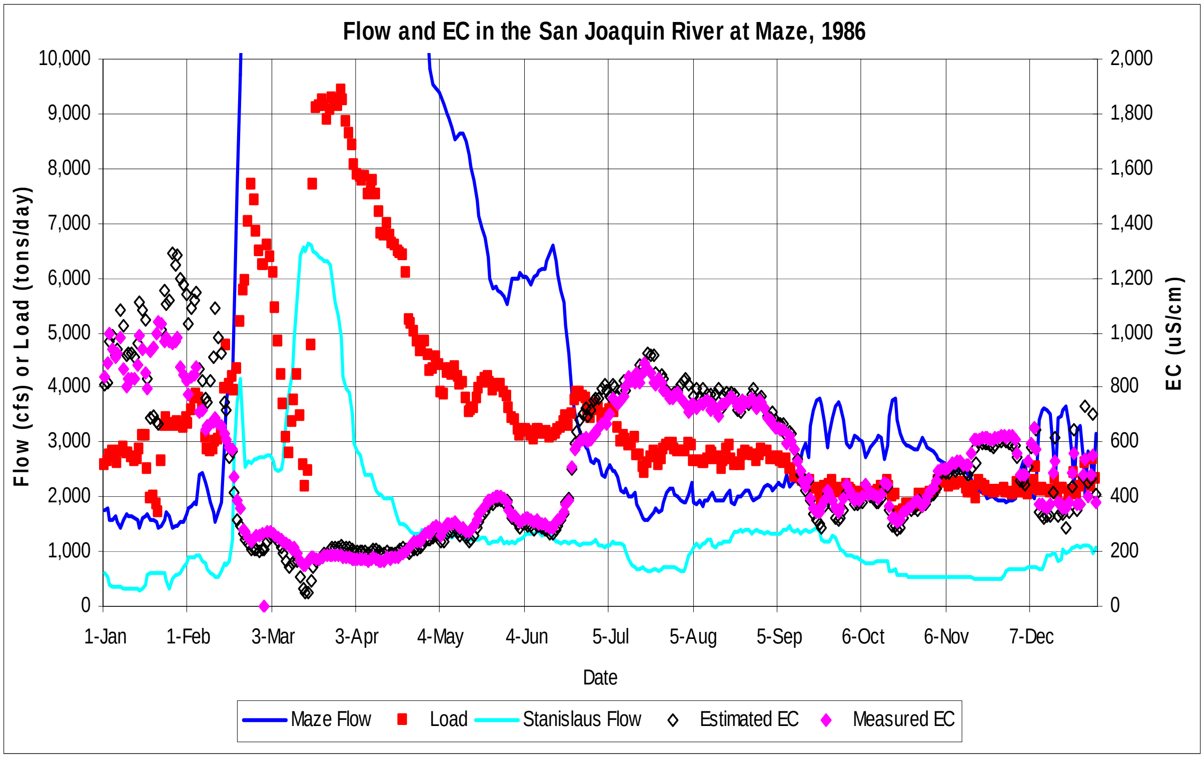


Figure 12. SJR Flow at Vernalis (and Stanislaus River) with corresponding EC at Vernalis and Mossdale for 1986. The calculated salt load at Vernalis is shown as a function of the salt load, which increases during the winter runoff period, and the flow (dilution pattern).



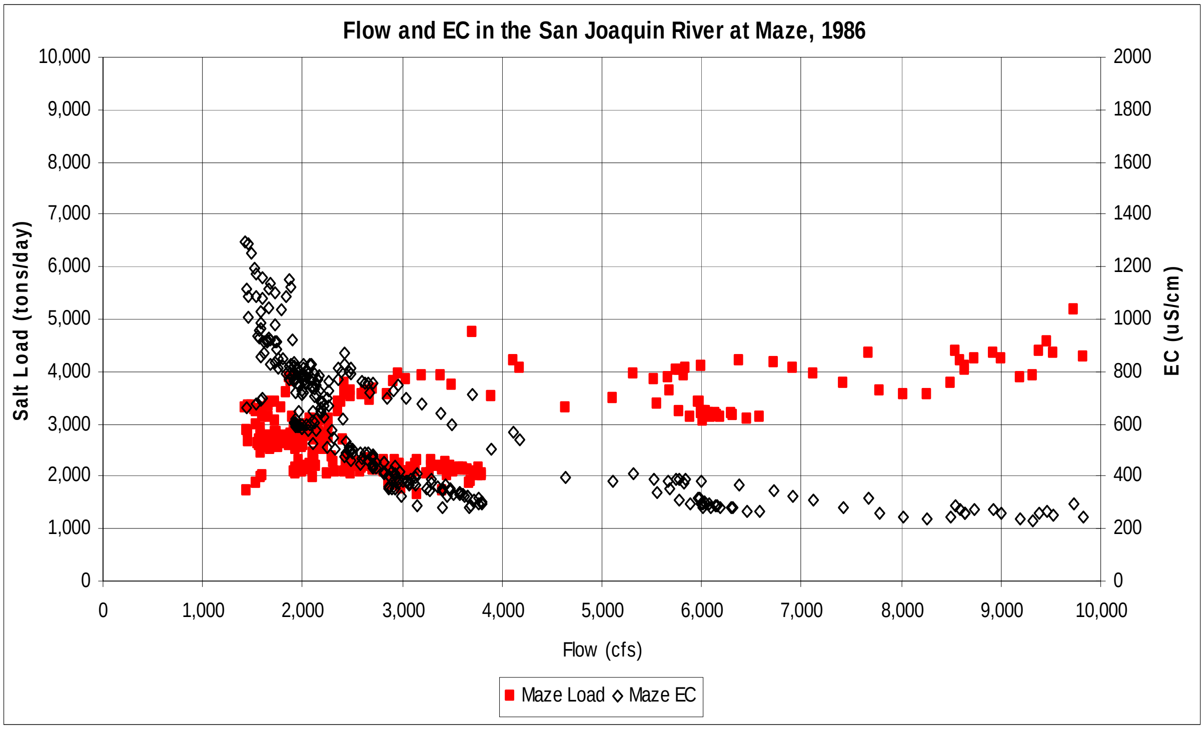
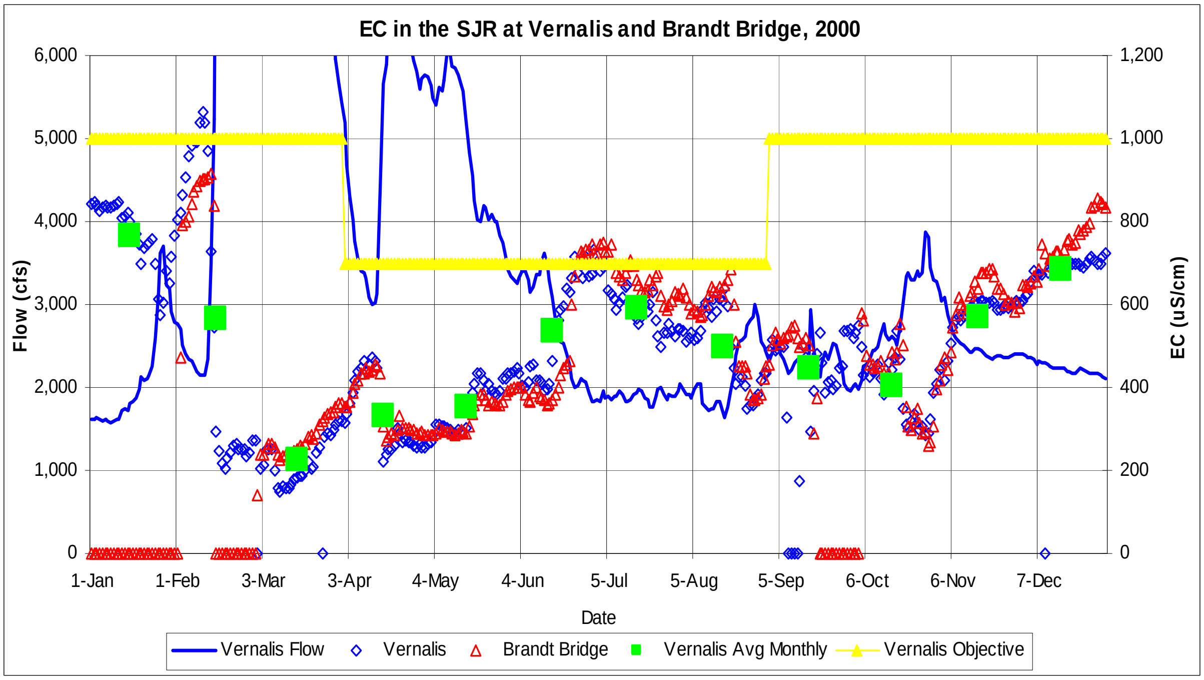


Figure 13. SJR Flow at Maze (and Stanislaus River) with corresponding measured and estimated EC at Maze for 1986. The calculated salt load at Maze is shown as a function of the salt load, which increases during the winter runoff period, and the flow (dilution pattern)



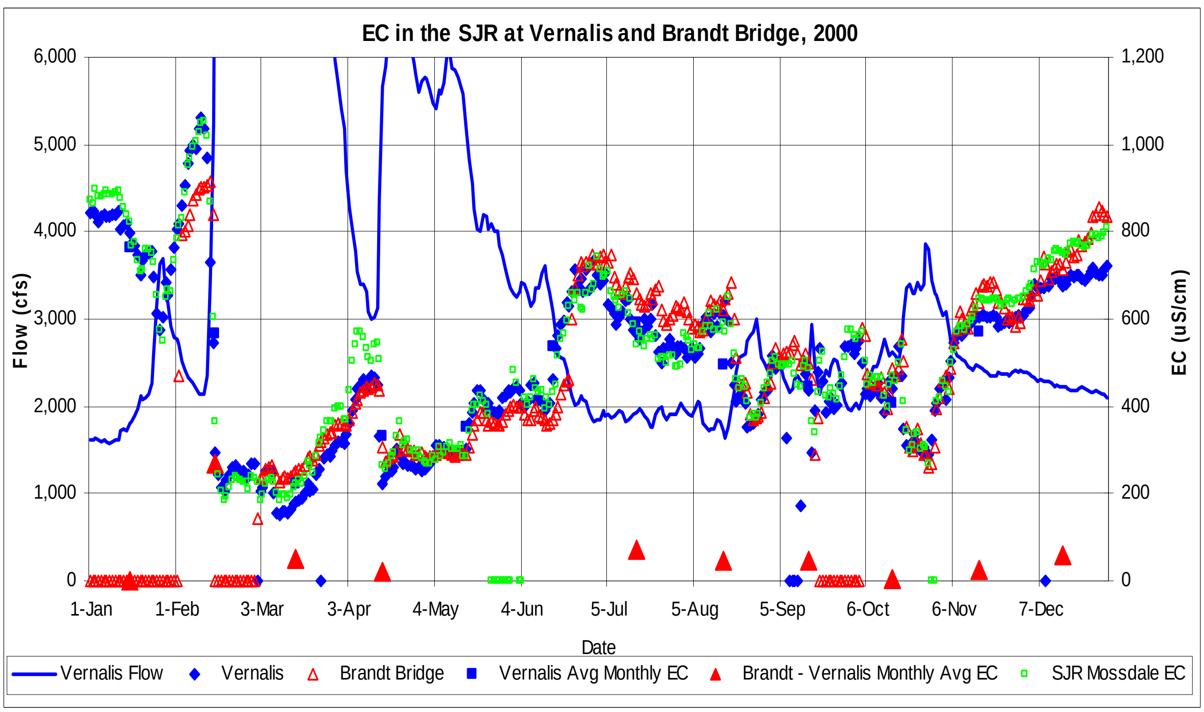
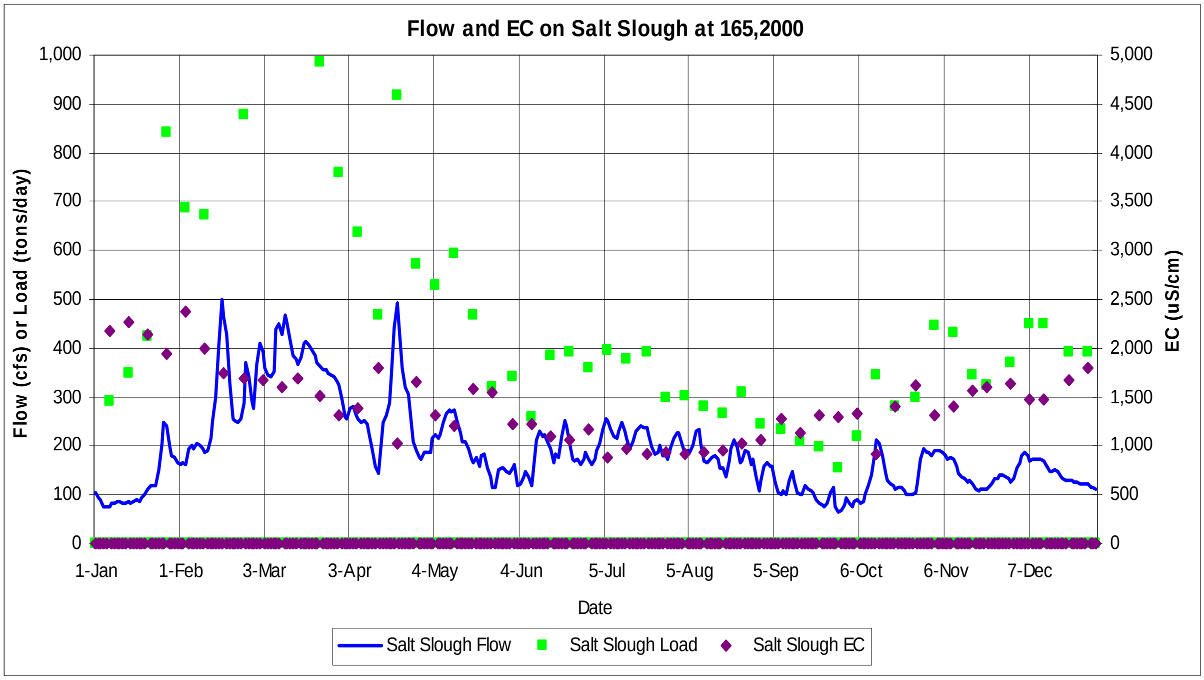


Figure 14. SJR Flow at Vernalis with corresponding measured EC at Vernalis, Mossdale, and Brandt Bridge for 2000. The monthly average Vernalis EC and the calculated monthly average increase in EC between Vernalis and Brandt Bridge are shown compared with the monthly EC objectives of 700 µS/cm during the irrigation season and 1,000 µS/cm in the remaining months



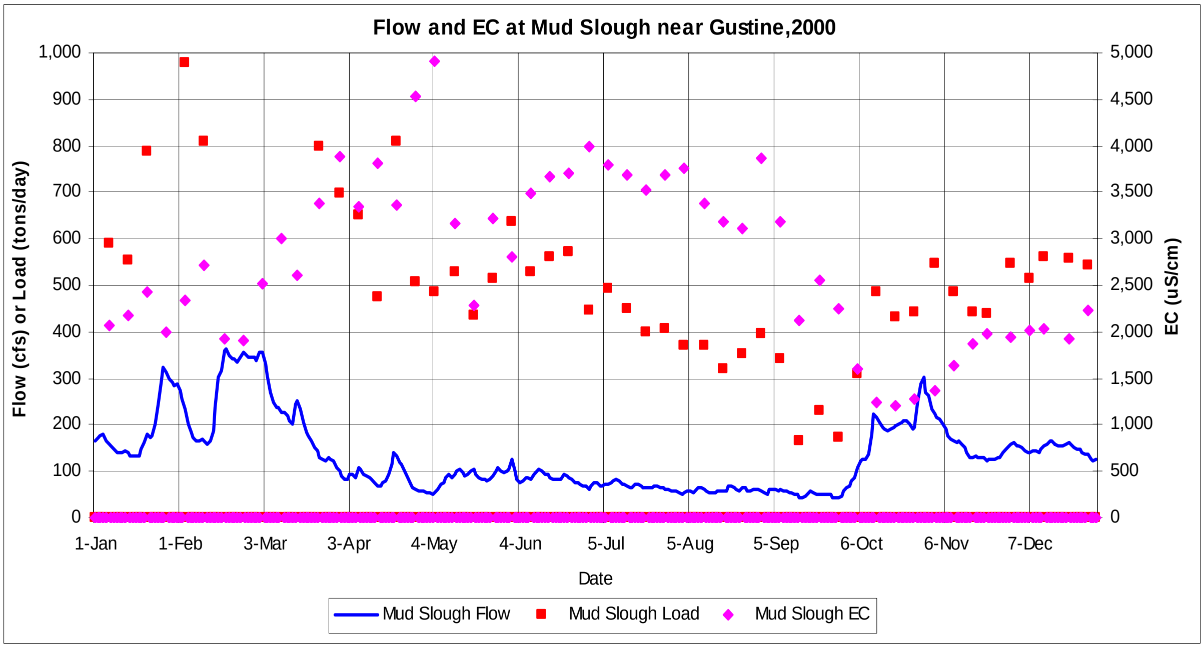
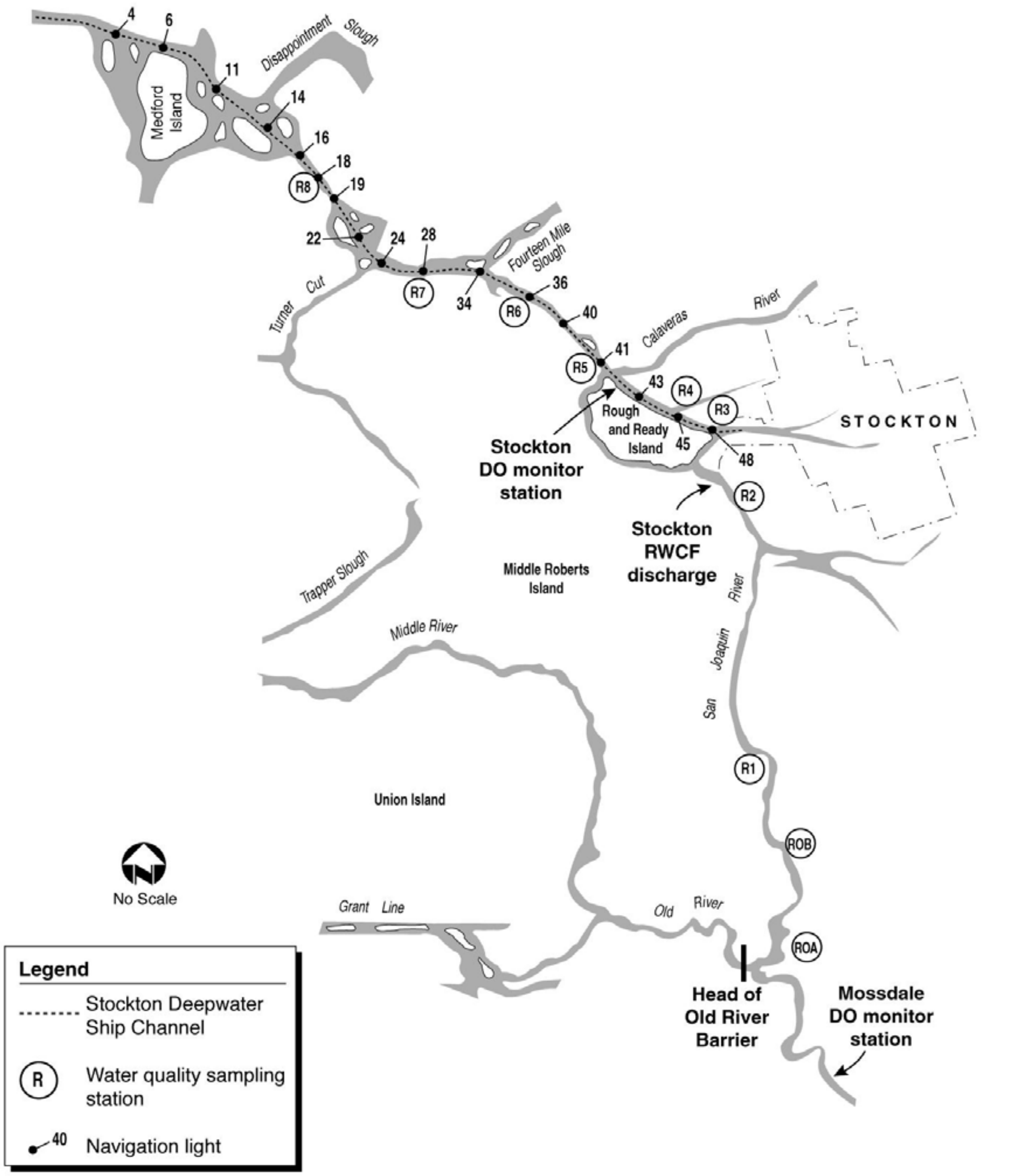
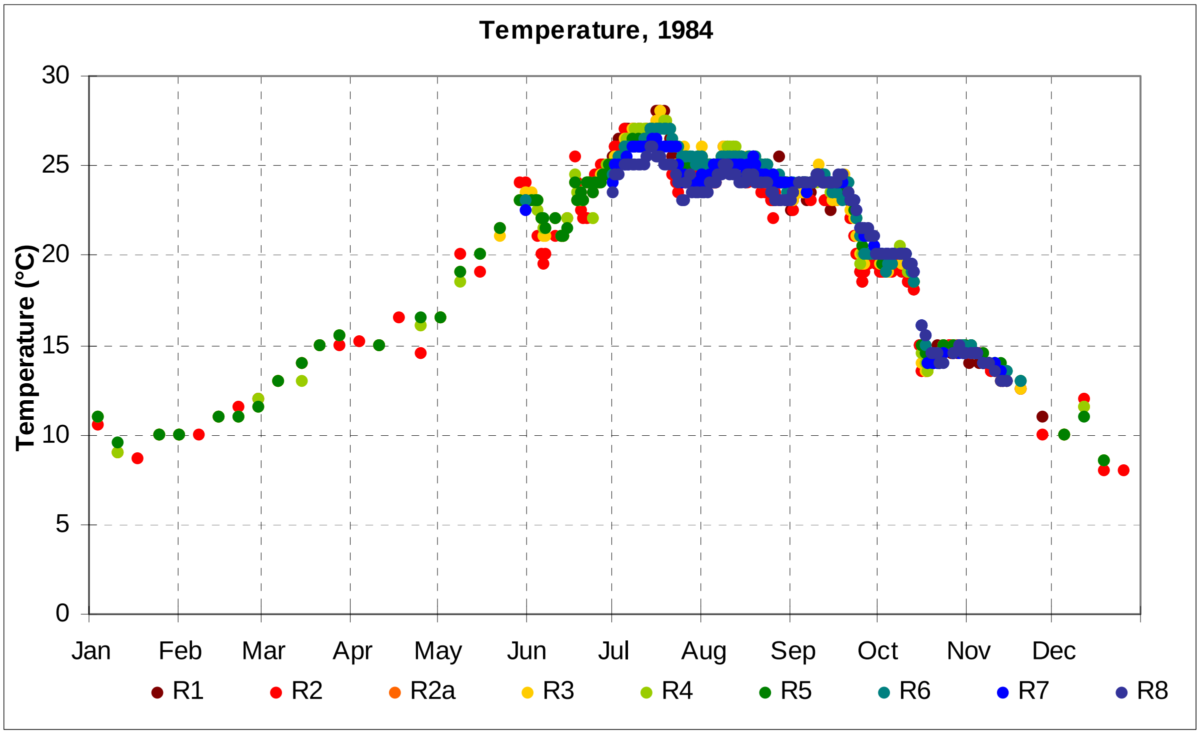


Figure 15. Flow and EC and salt load for Salt Slough and Mud Slough (including San Luis Drain Bypass flow) for 2000



Jones & Stokes

Figure 16. Map of the City of Stockton river water quality stations



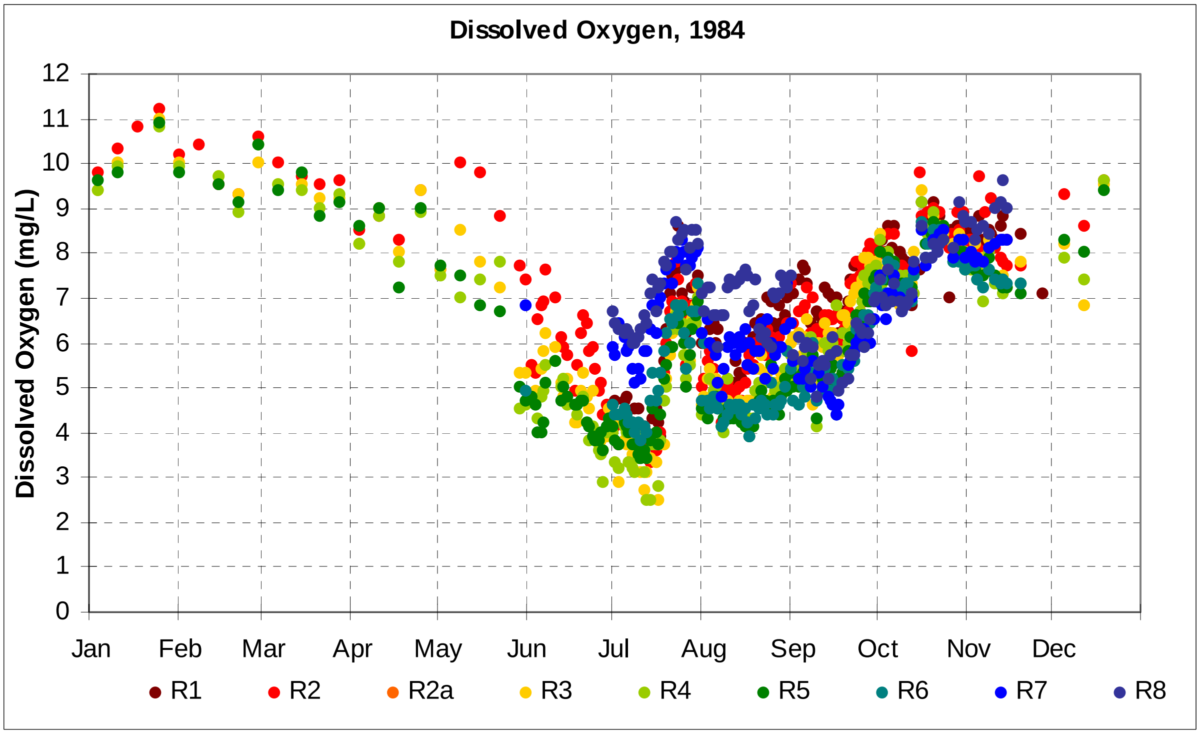
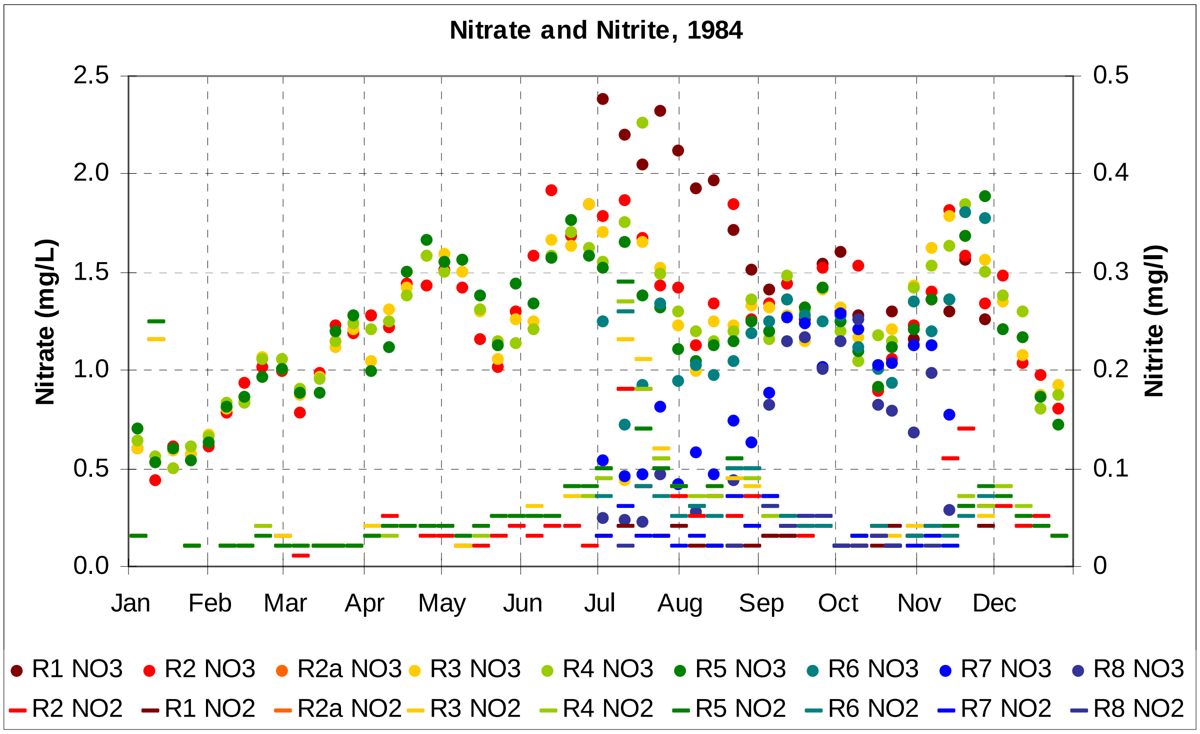


Figure 17. DO and temperature data from the City of Stockton river stations for 1984.



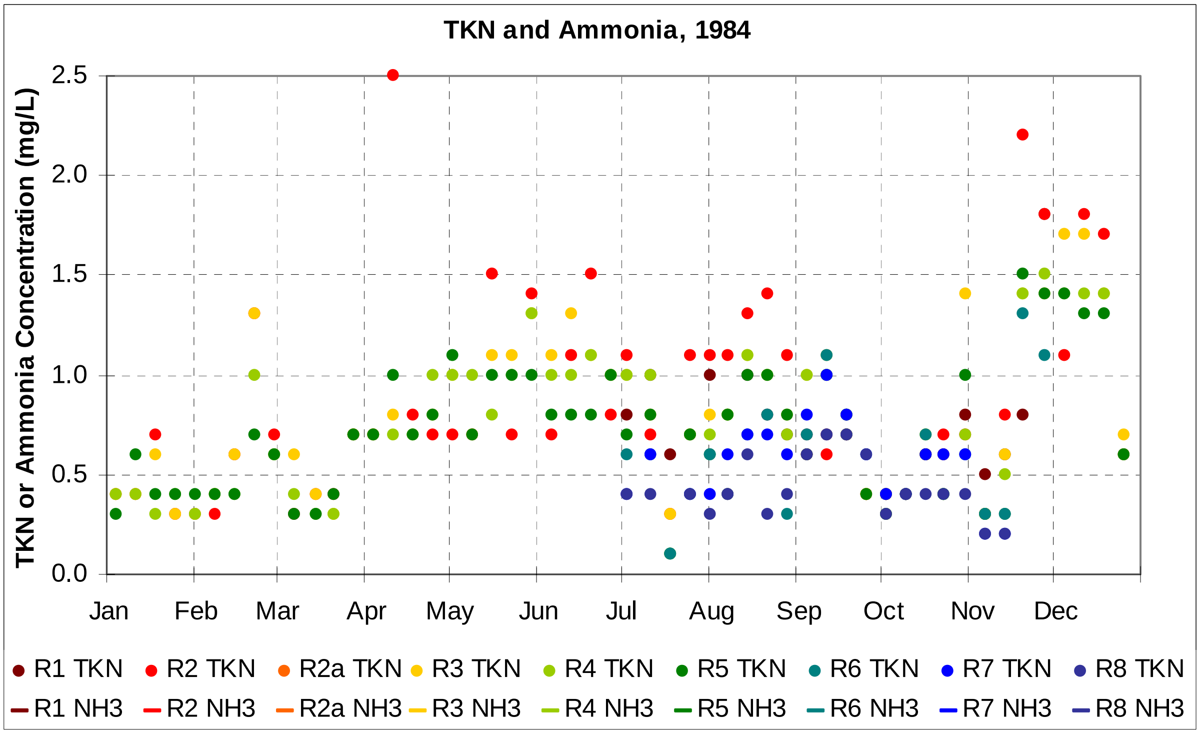
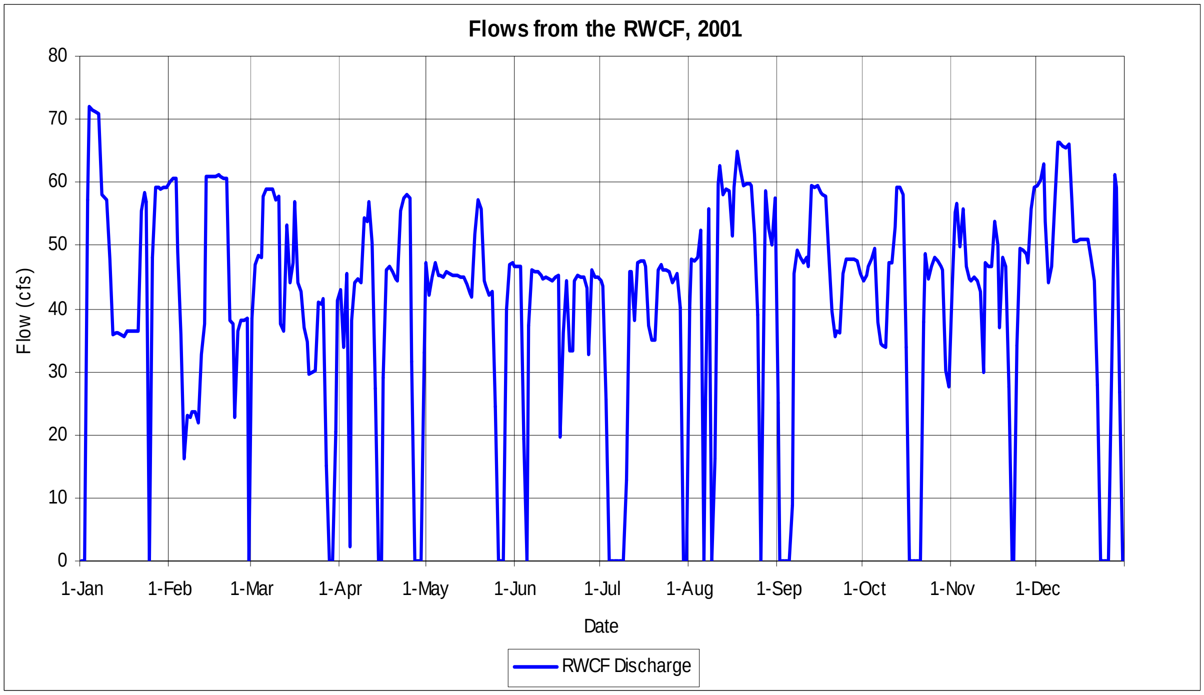


Figure 18. City of Stockton river samples of nitrate, nitrite and TKN (ammonia and organic nitrogen) for 1984. Ammonia was measured in more recent years.



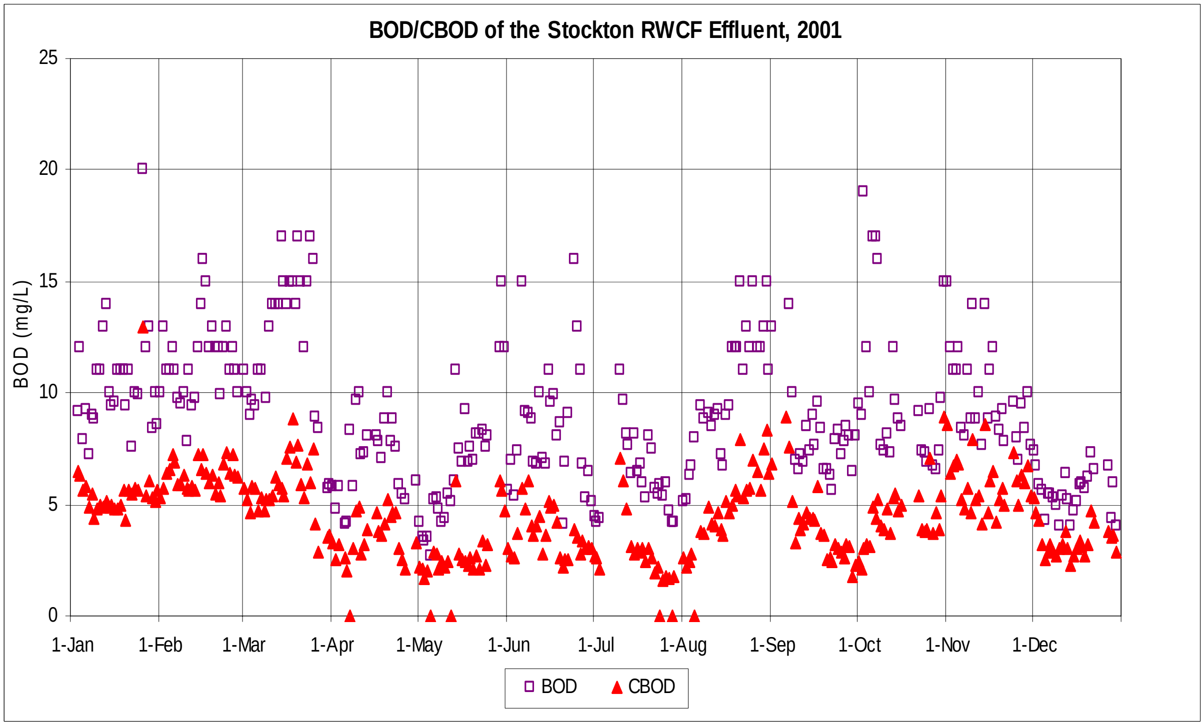
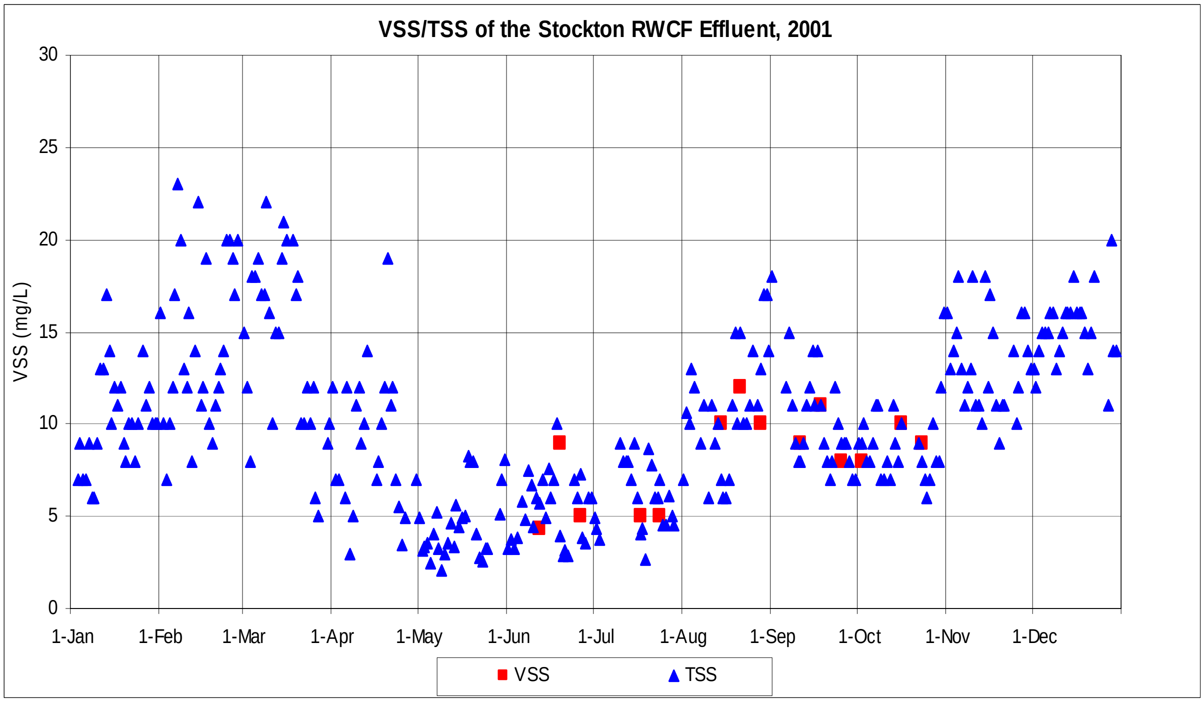


Figure 19. Stockton RWCF discharge and BOD and CBOD concentrations for 2001



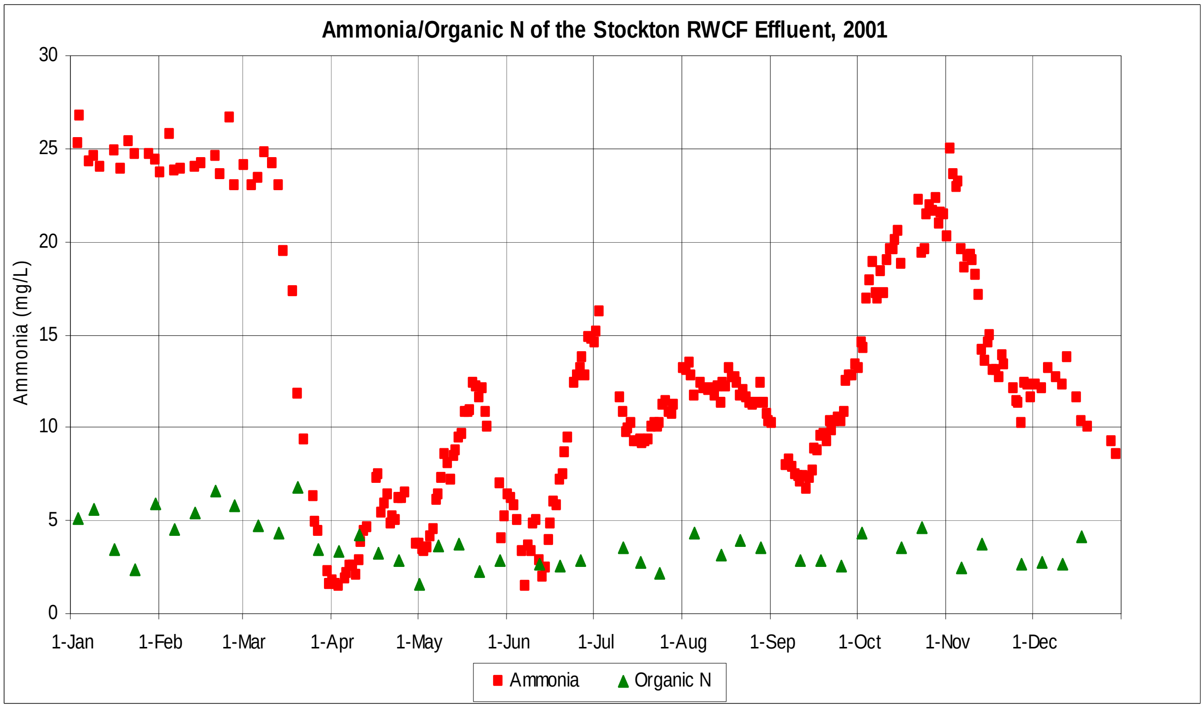
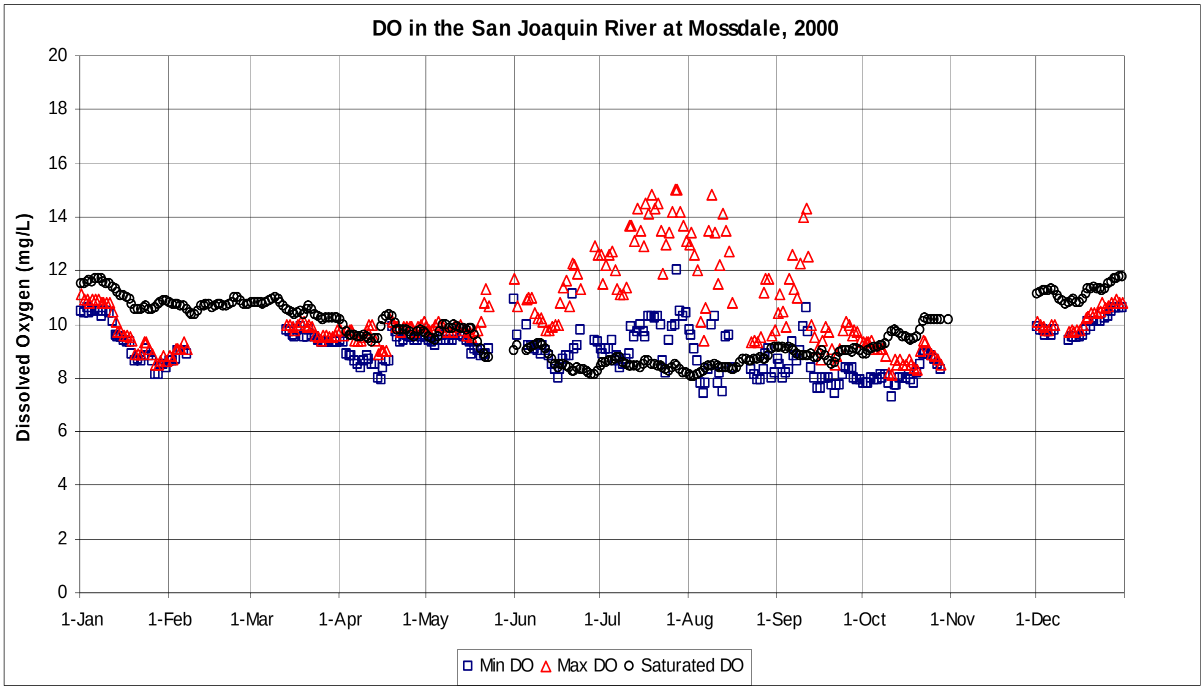


Figure 20. Stockton RWCF TSS/VSS and ammonia and organic-N concentrations for 2001



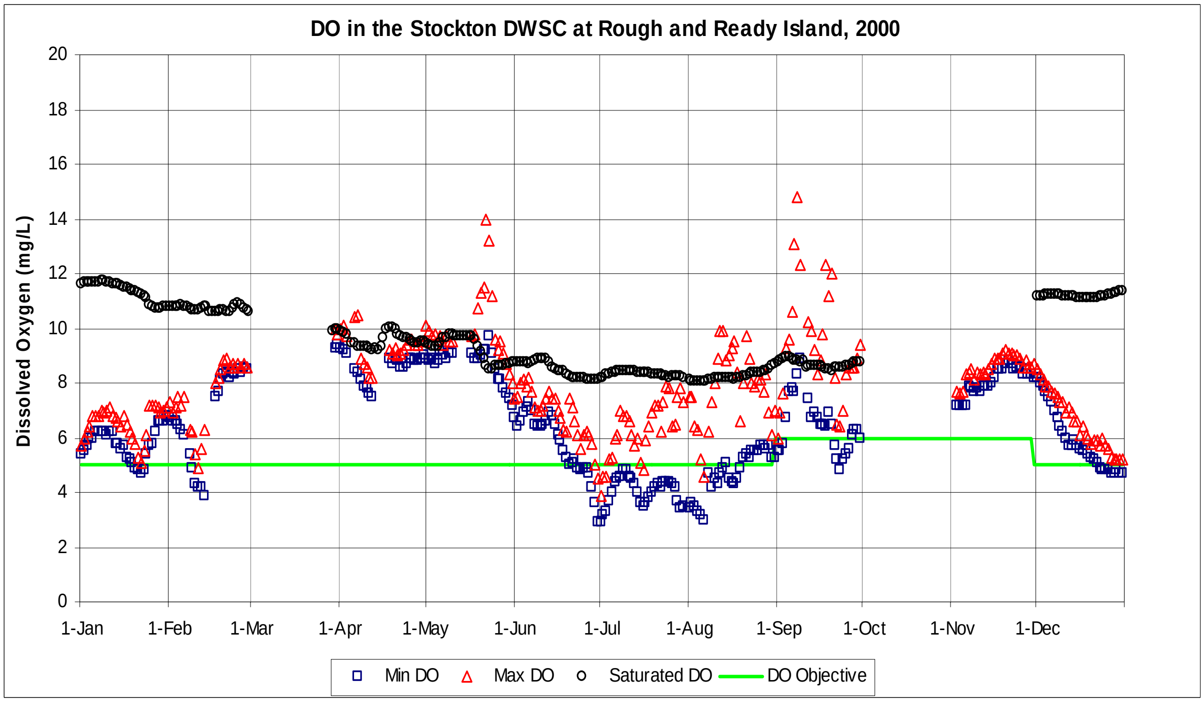
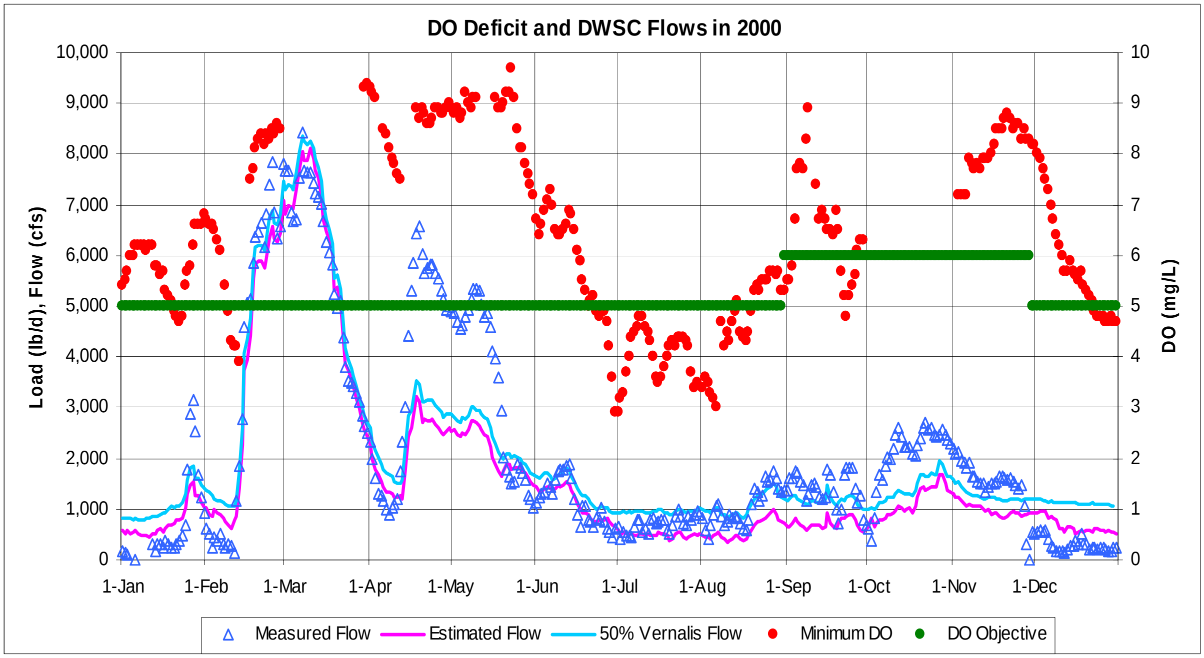


Figure 21. Minimum and maximum daily DO concentrations at Mossdale and Rough and Ready Island monitoring stations in 2000. Saturated DO and DO objective area shown for comparison.



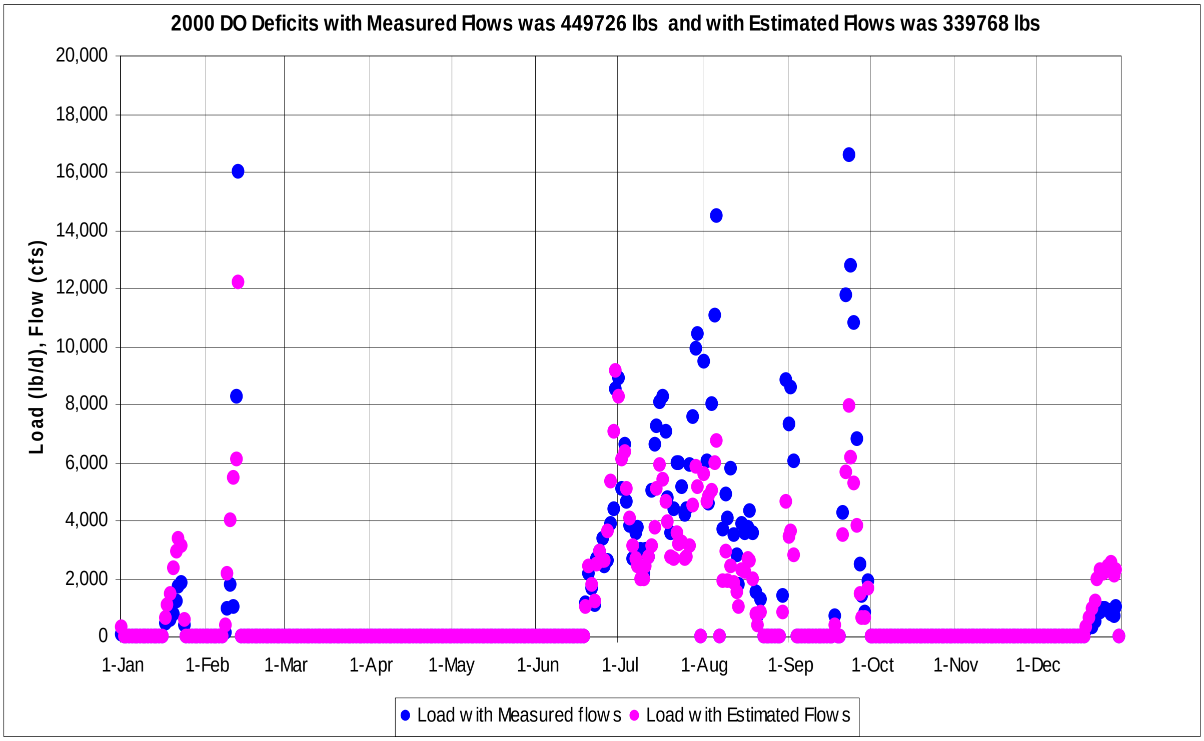


Figure 22. Daily flow (measured and estimated) and minimum daily DO concentrations in the DWSC at the Rough and Ready Island station and the DO objective deficit (lbs/day), calculated as the flow times the difference between the target (objective plus 0.5 mg/l) and the minimum DO for 2000

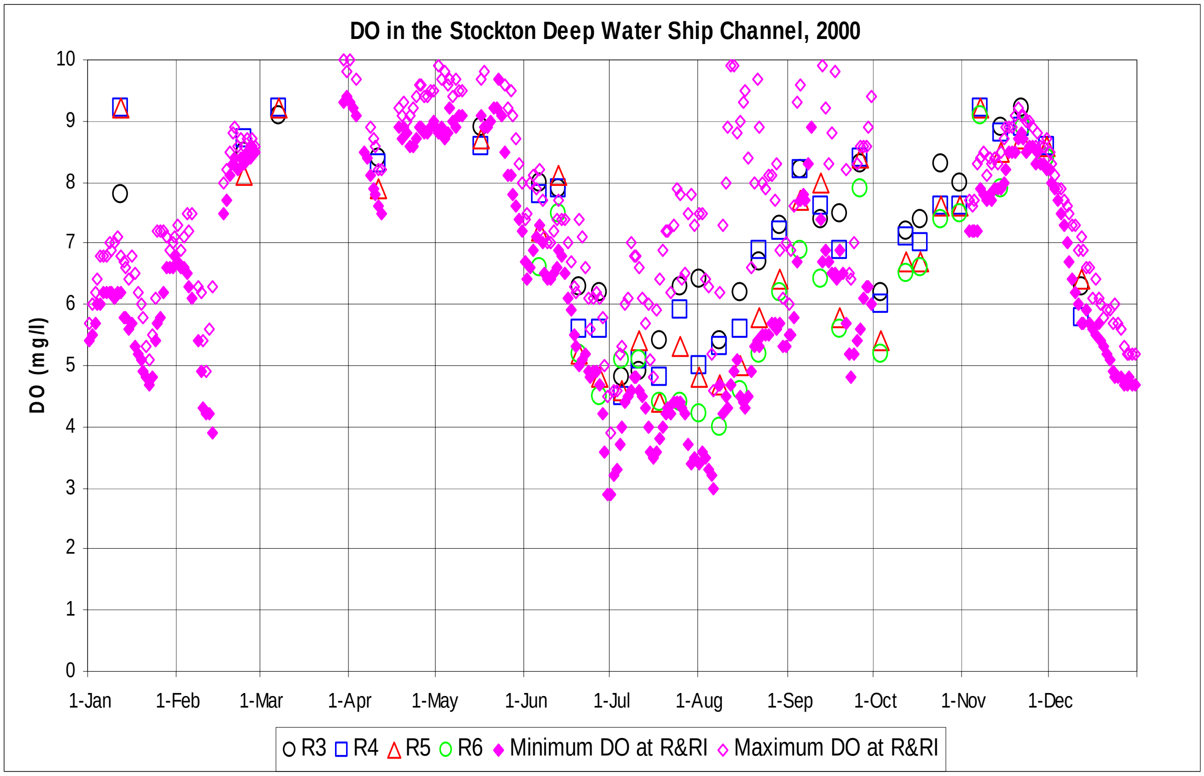


Figure 23. Comparison of DO concentrations measured at the City of Stockton river stations with the minimum and maximum DO from the DWR Rough and Ready Island station for 2000

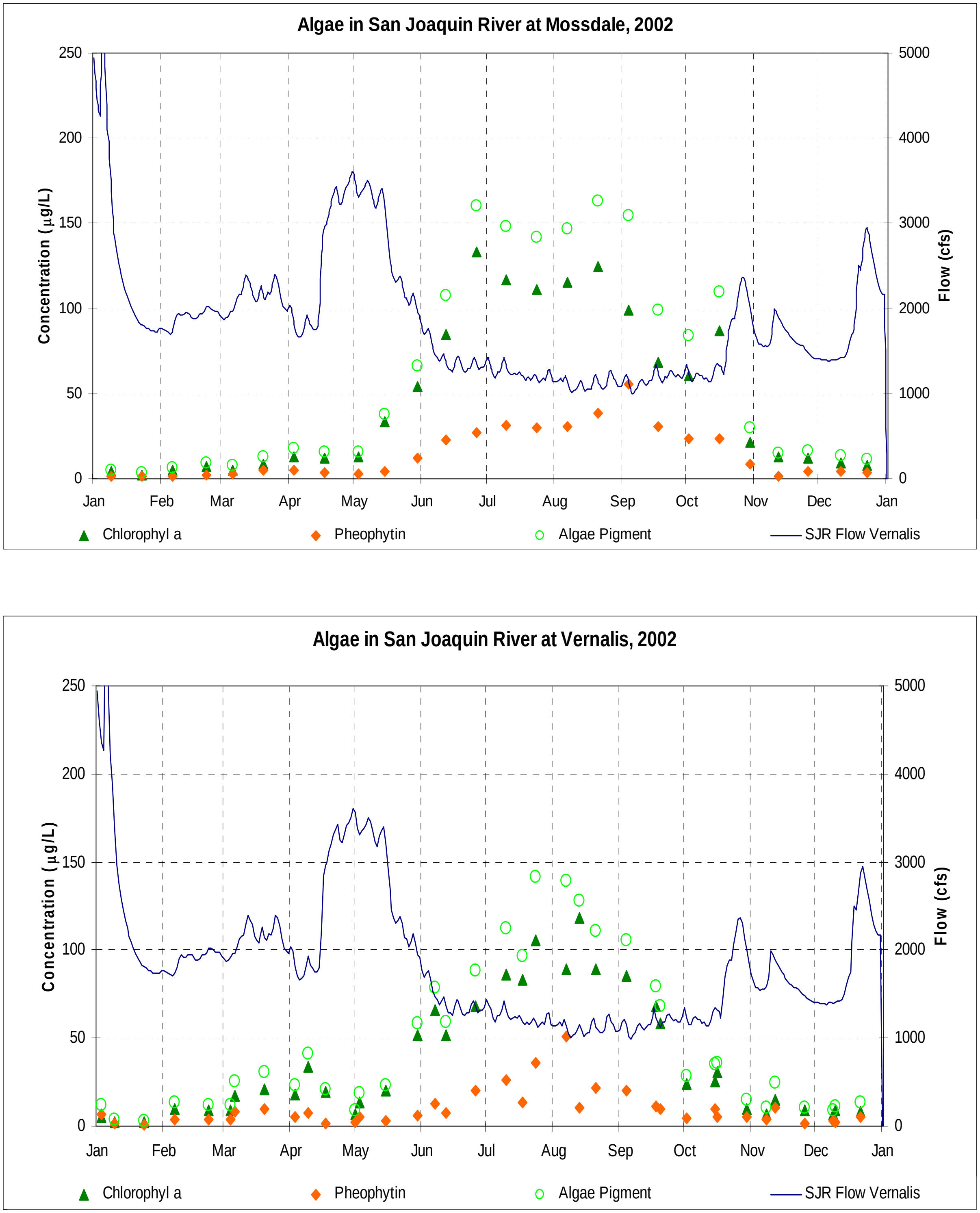
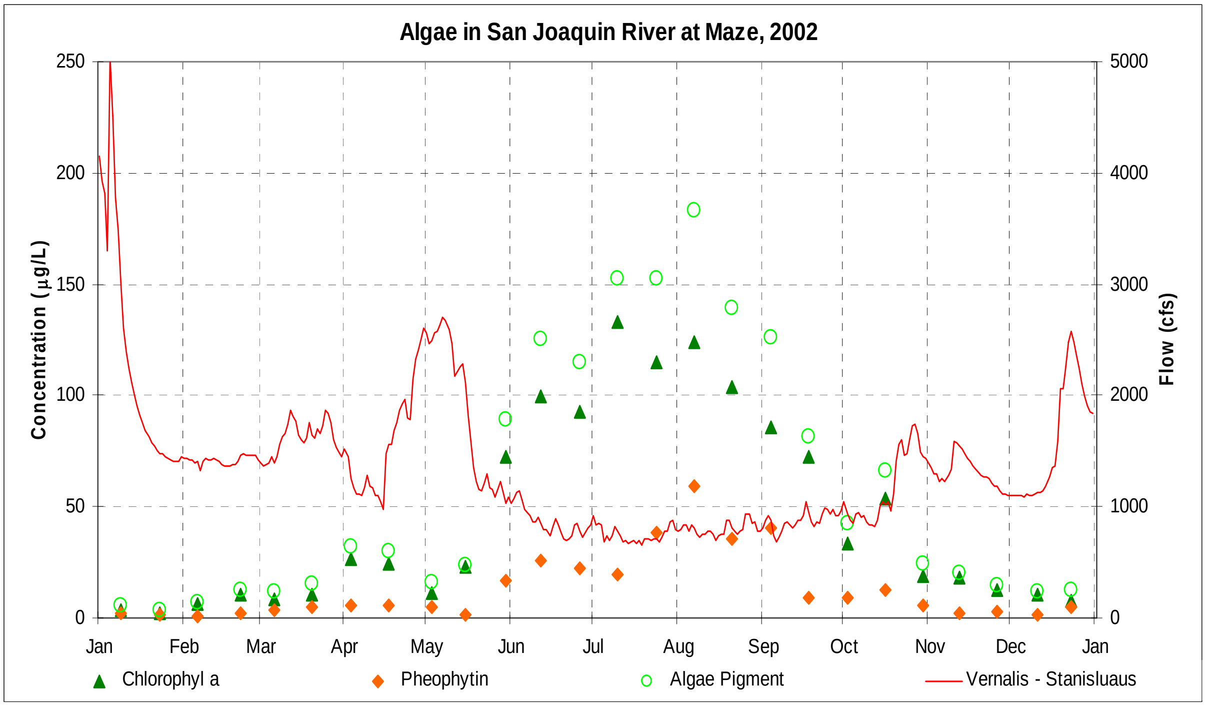


Figure 24. Algae pigment concentrations at Vernalis and Mossdale for 2002



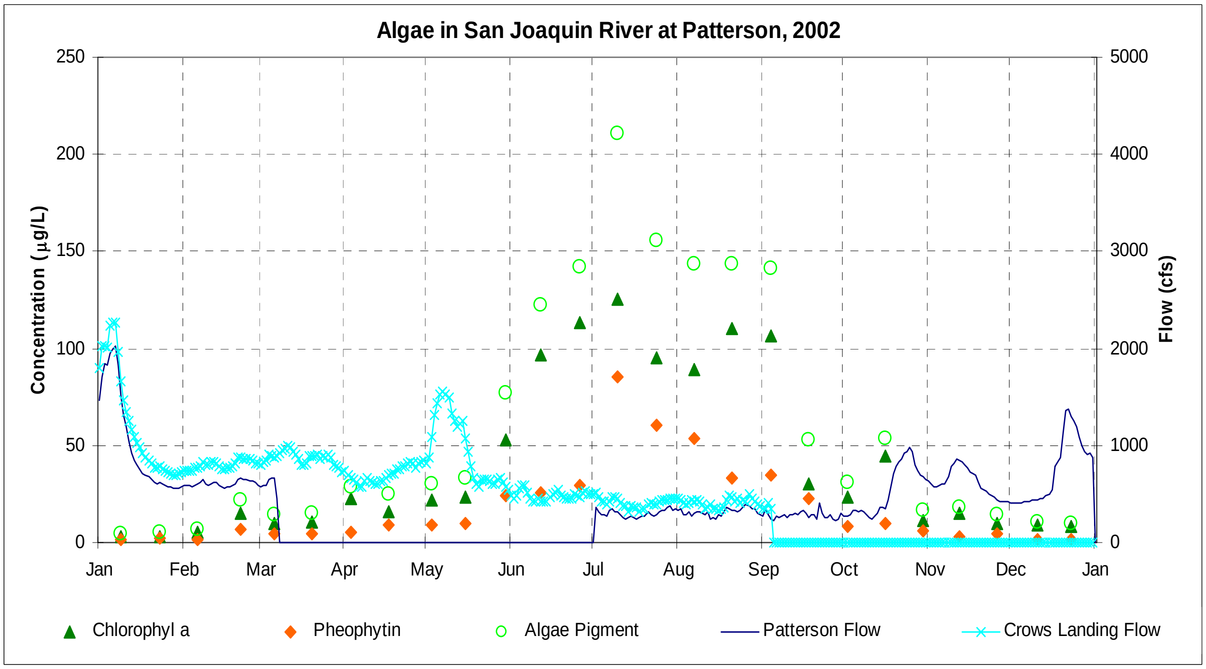
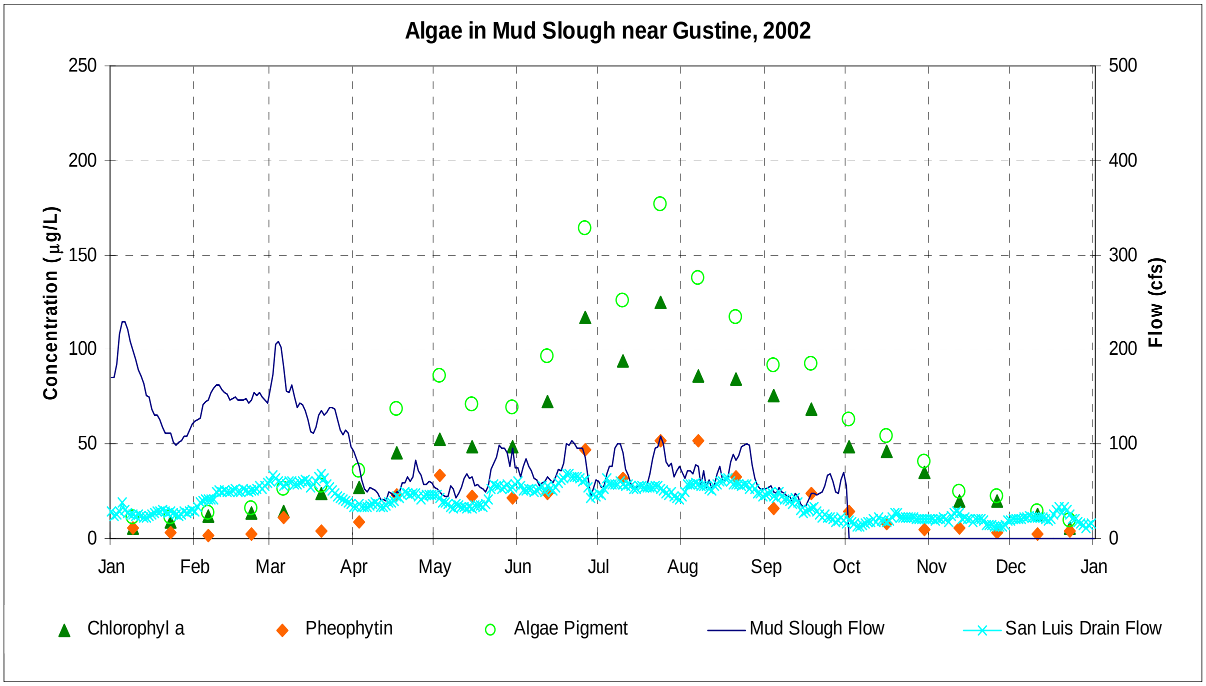


Figure 25. Algae pigment concentrations at Maze and Patterson for 2002



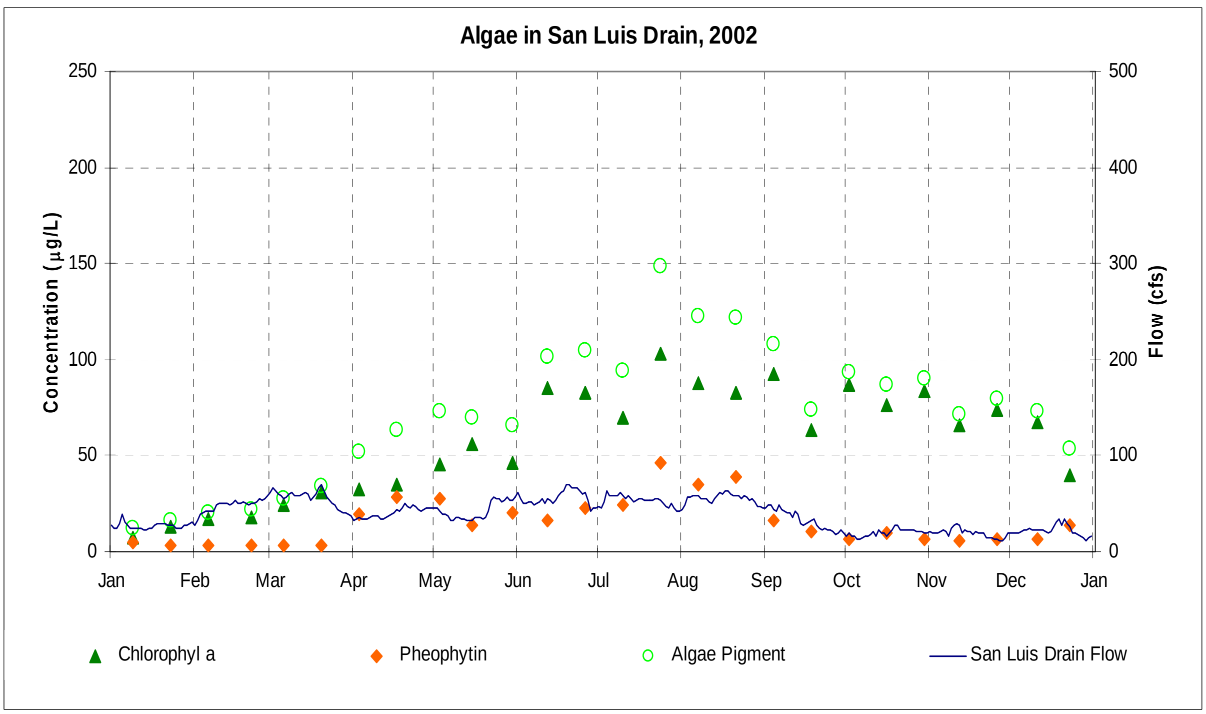
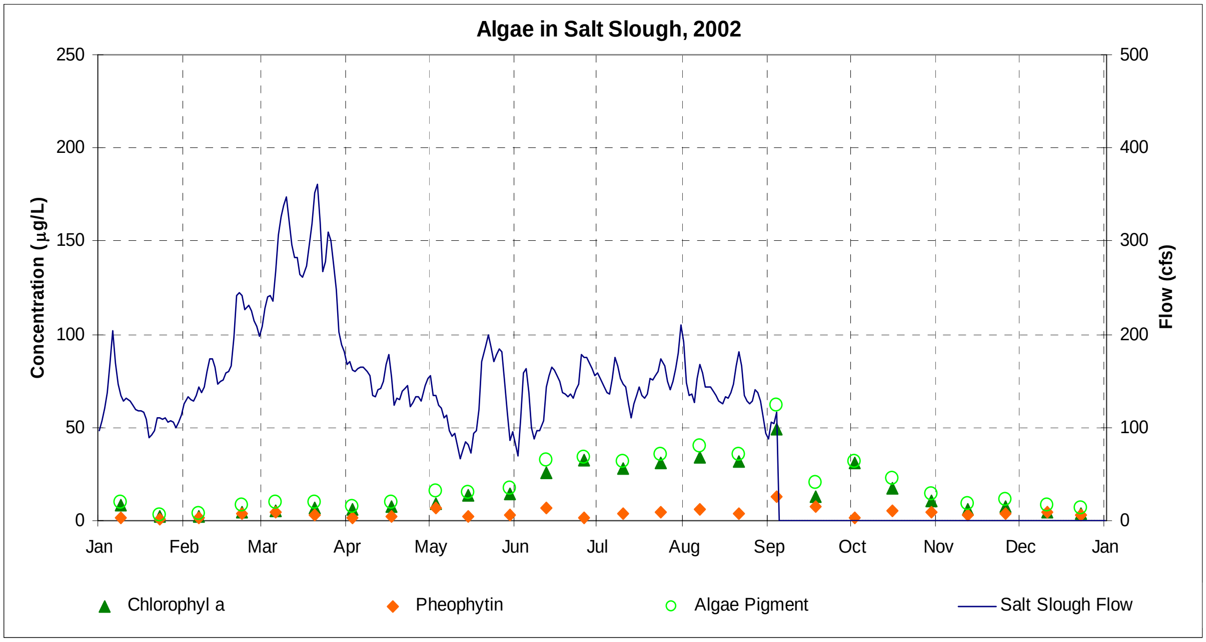


Figure 26. Algae pigment concentrations in Mud Slough and San Luis Drain for 2002



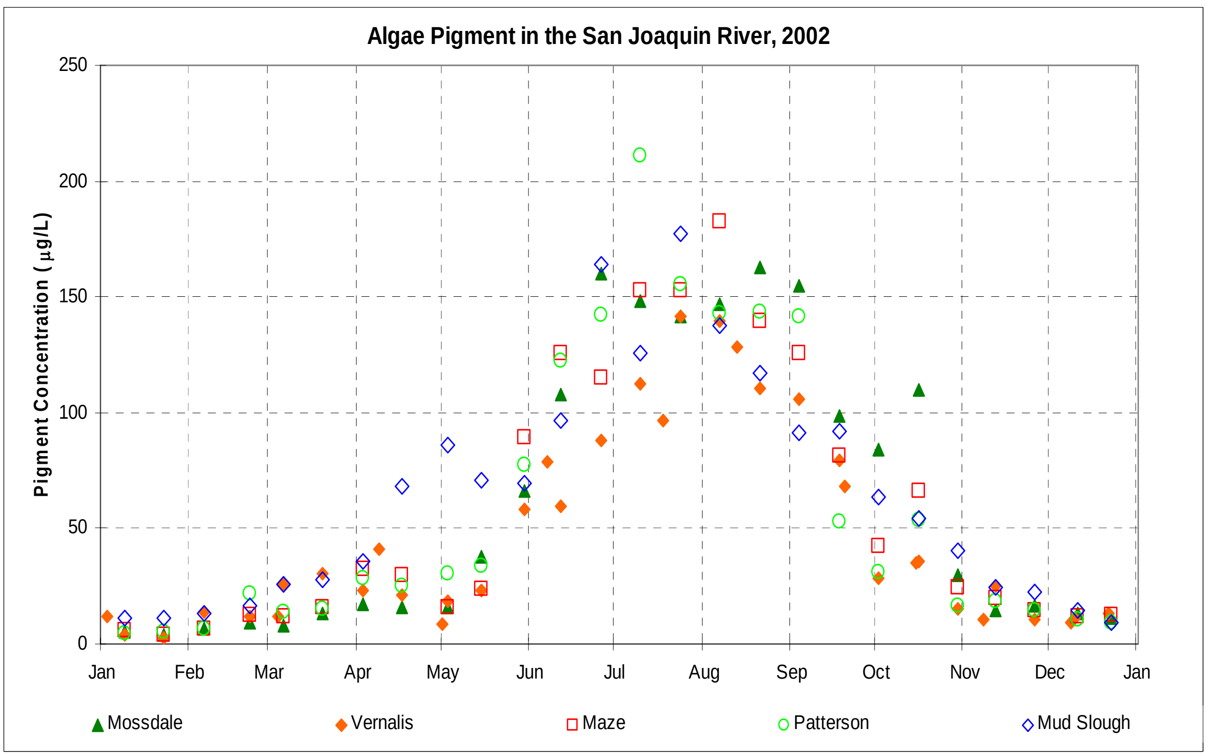
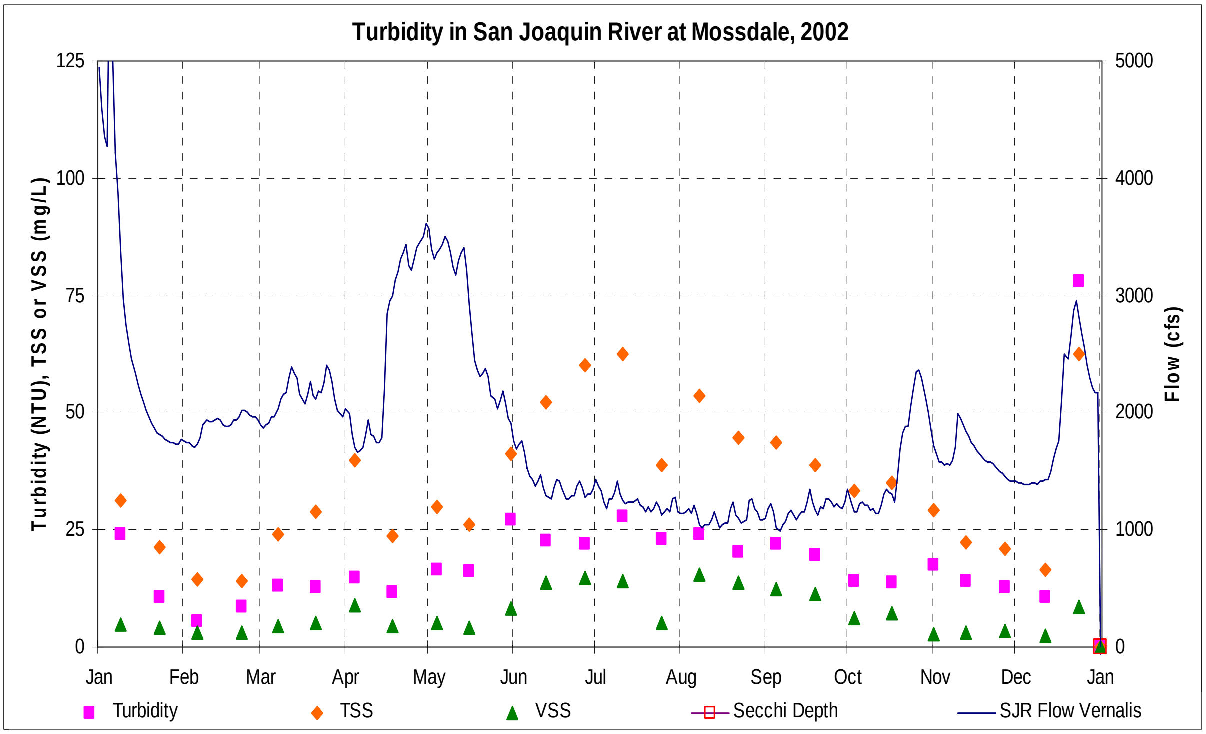


Figure 27. Algae pigment concentrations in Salt Slough and along the SJR for 2002



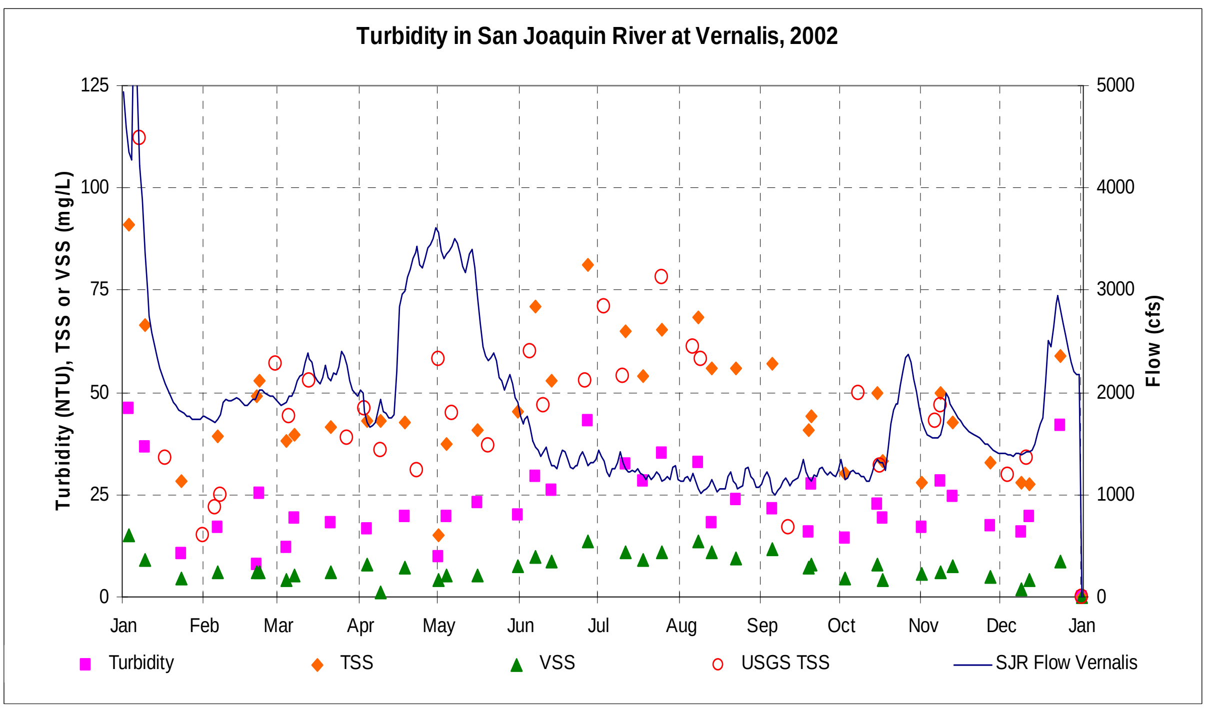
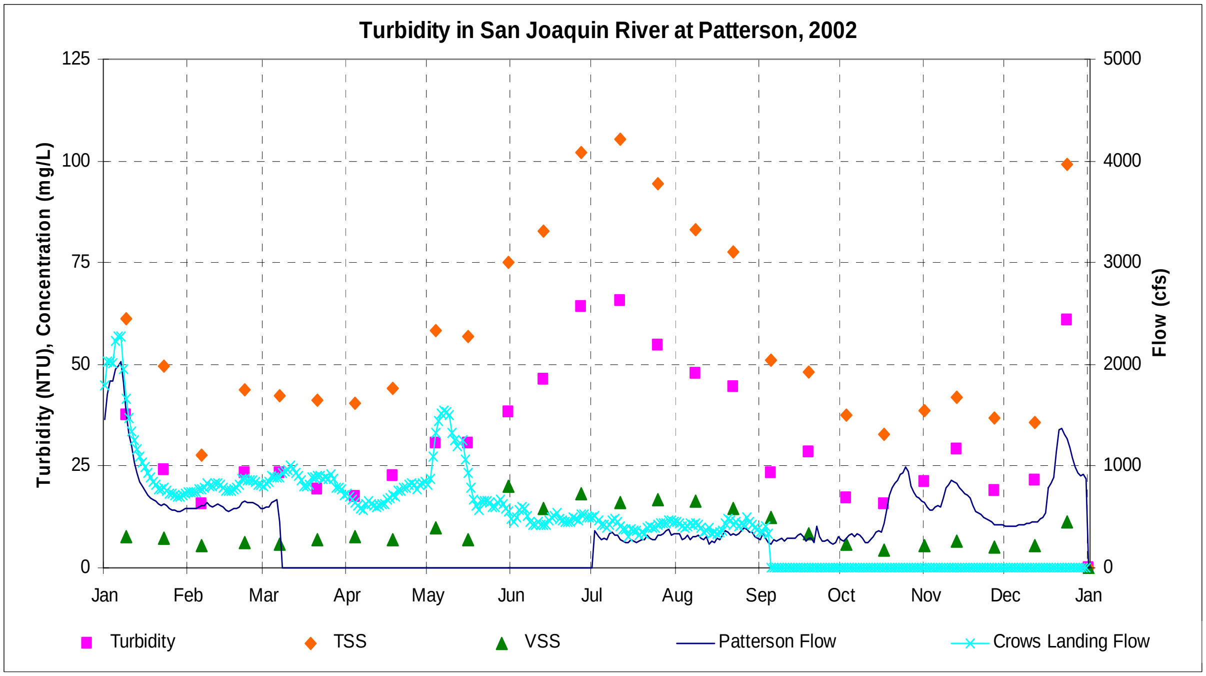


Figure 28. Turbidity and particulates (TSS and VSS) in the SJR at Mossdale and Vernalis for 2002



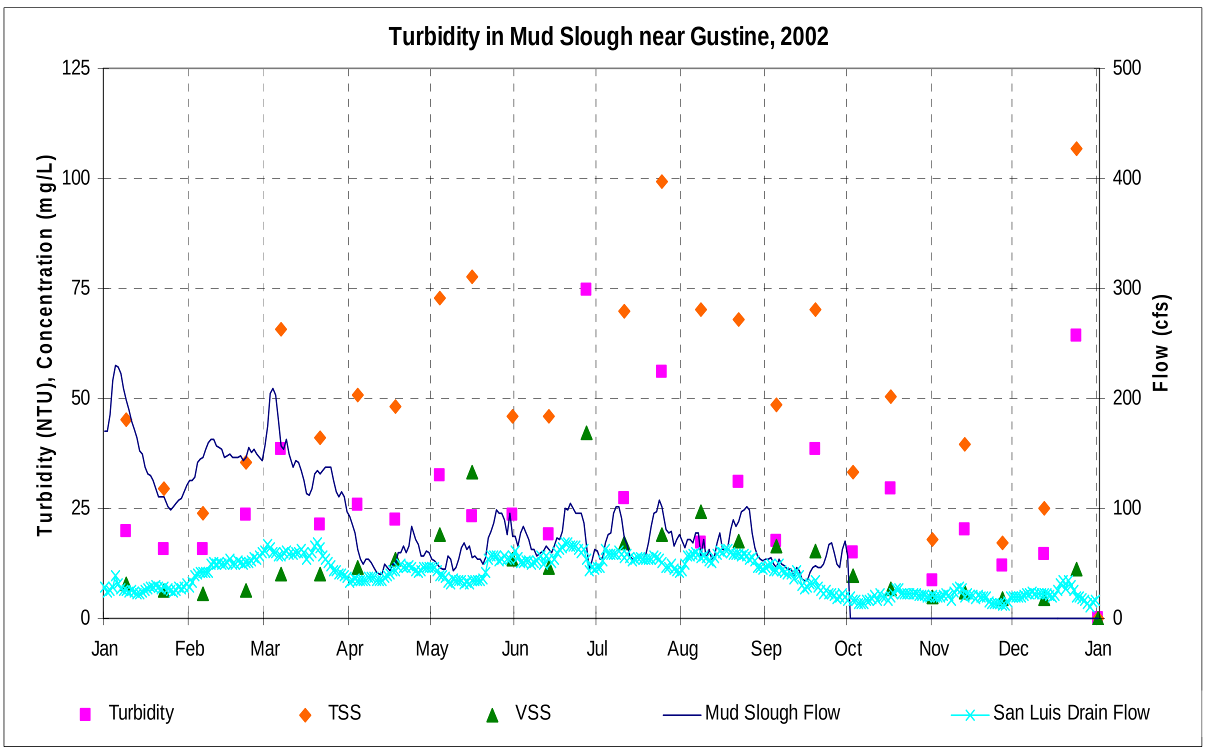
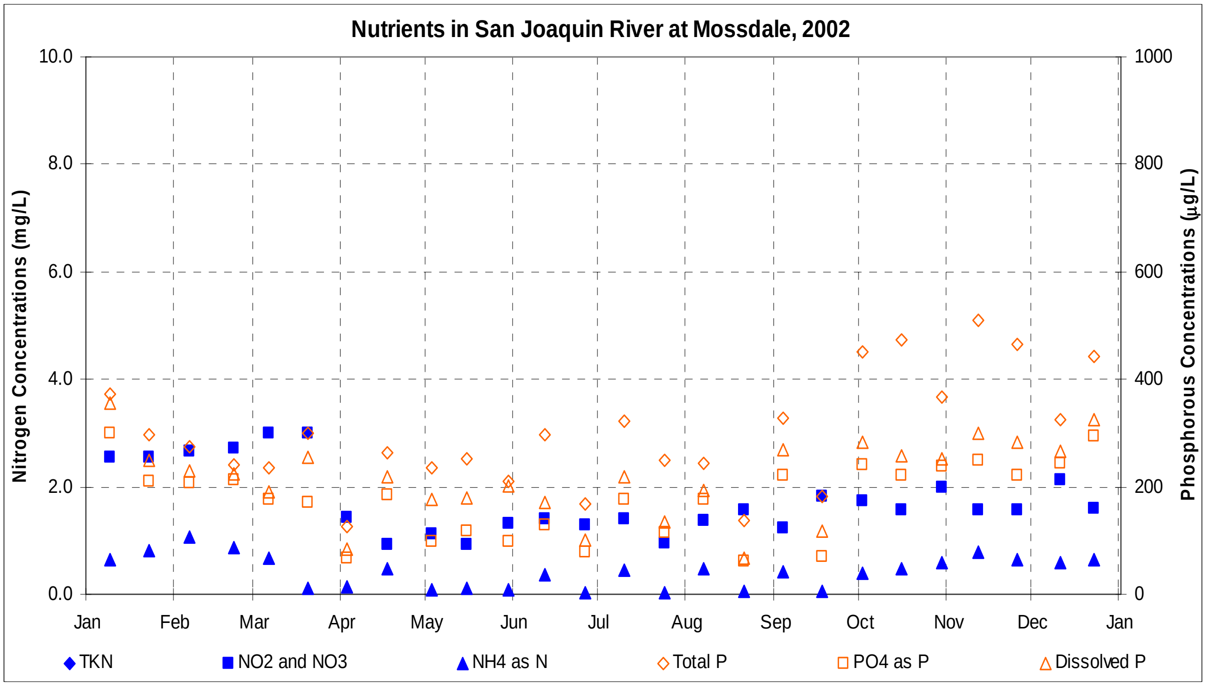


Figure 29. Turbidity and particulates (TSS and VSS) at Patterson and in Mud Slough for 2002



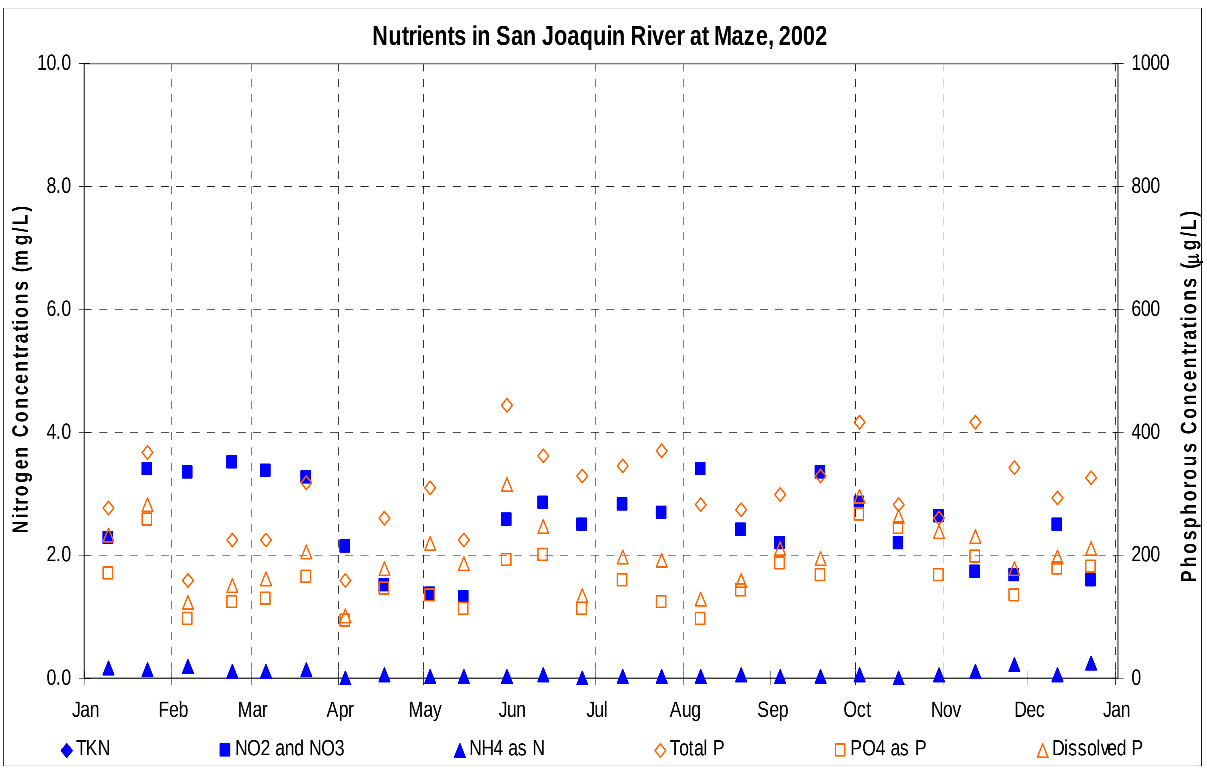
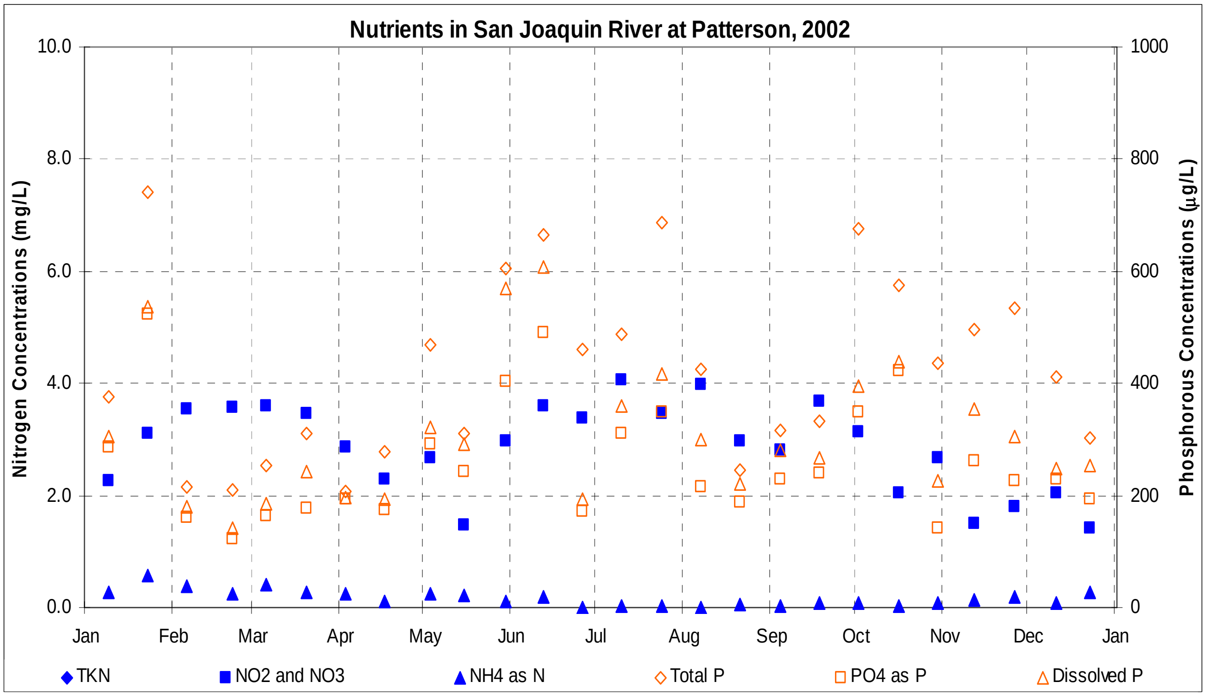


Figure 30. Nutrients (nitrogen and phosphorus) in the SJR at Mossdale and Maze for 2002



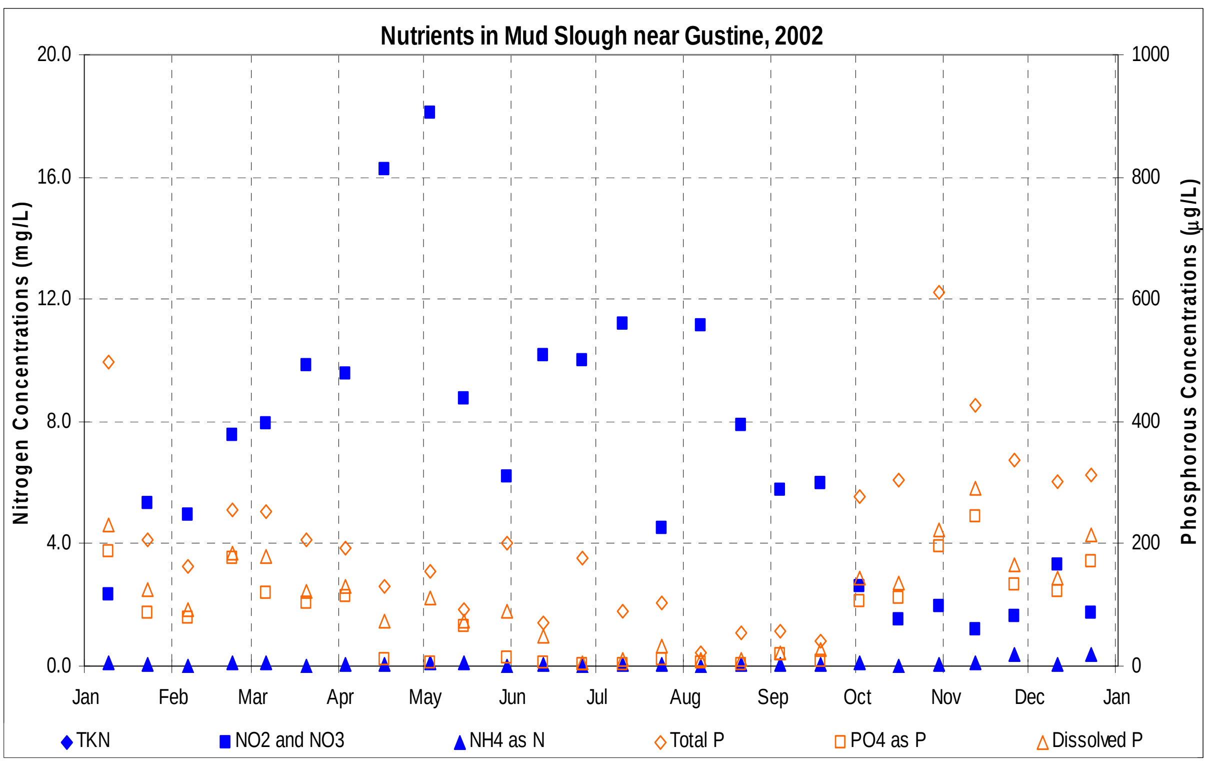


Figure 31. Nutrients in the SJR at Patterson and in Mud Slough for 2002