9 Dissolved Oxygen Modeling Using DSM2-QUAL

9.1 Introduction

DSM2 is capable of simulating the dynamics of primary production including dissolved oxygen, phytoplankton, nutrients, and temperature. A single water quality variable or any combination of 11 water quality variables can be modeled as specified by the user. Changes in mass of constituents because of decay, growth, and biochemical transformations are simulated using interconstituent relationships derived from the literature (see references). This year the Delta Modeling Section has prepared to calibrate DSM2 for dissolved oxygen, focusing on the San Joaquin River near Stockton. Dissolved oxygen levels frequently fall below 5 mg/l, especially during the warm months. There is concern that low DO levels may adversely affect resident fish and other aquatic life. Low dissolved oxygen levels can cause physiological stress to fish and can block upstream migration of salmon.

DSM2-QUAL was updated to reflect changes in hydrodynamics and general input/output modules. This involved a few changes in the computer code and several test simulations. Code changes include an increase in array size representing constituent variables and keeping model output units and the observed data units consistent. QUAL's capability to use non-zero initial conditions ("warm start") for 11 constituents and to generate DSS output of all the constituents was tested and verified after necessary changes in input/output. This work is in progress.

9.2 Data Requirements

Simulation of dissolved oxygen requires information on water temperature, BOD, chlorophyll, organic nitrogen, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, organic phosphorus, dissolved phosphorus (ortho-phosphate), and EC in the Delta. Continuous sources of data were available for DO, temperature, and EC at hourly intervals for some stations near model boundaries. These data provide boundary information needed by DSM2. At most stations in the Delta, only grab samples are available, usually on a biweekly or monthly interval, which will be used as initial conditions for the model. Since continuous data were not available at Vernalis (RSAN112), hourly averaged values of DO, EC, and temperature available from the nearby station at Mossdale (RSAN087) will be used to approximate these quantities for the boundary inflow at Vernalis. Data on effluent flows from the City of Stockton's Regional Wastewater Control Facility (RWCF) were obtained from the Stockton

Municipal Utilities District. An estimate of water qualities of agricultural drainage returns at internal Delta locations was prepared. Simulation of water temperature requires hourly values of air temperature, wetbulb temperature, wind speed, cloud cover, and atmospheric pressure. Climate data representing the above were purchased from the National Climatic Data Center, and are being converted to DSS format required by DSM2.

9.3 Comparison of DO at Mossdale & Stockton

While much of the time observed DO at Stockton (RSAN058) seems to fall to very low levels, during dry periods or when Mossdale DO goes down, there were times when this trend did not happen. Based upon examination of observed water and air temperature at these locations, flows at Vernalis, and stage at Martinez, it appears that the influence of air temperature and tide tend to be more dominant when Vernalis flows are low. This may have caused some dips and rises in the DO pattern for a few months in 1994 and 1997. The barrier at head of Old River installed in spring 1997 seems to have improved dissolved oxygen levels at the Stockton station, i.e. approach the DO levels at Mossdale. This seemed true also for spring 1994, but because some data were missing, this could not be verified for the whole of the period when the barrier was operating. DO plots for 1994 and 1997 are presented in Figures 9-1 and 9-2.

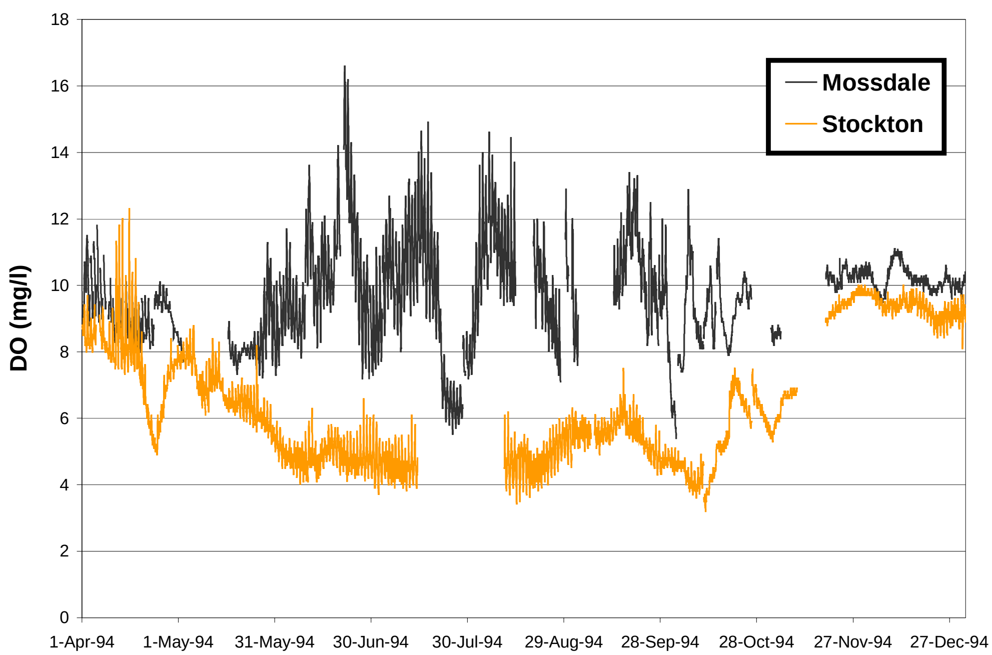

Figure 9-1: Dissolved Oxygen in the San Joaquin River (1994).

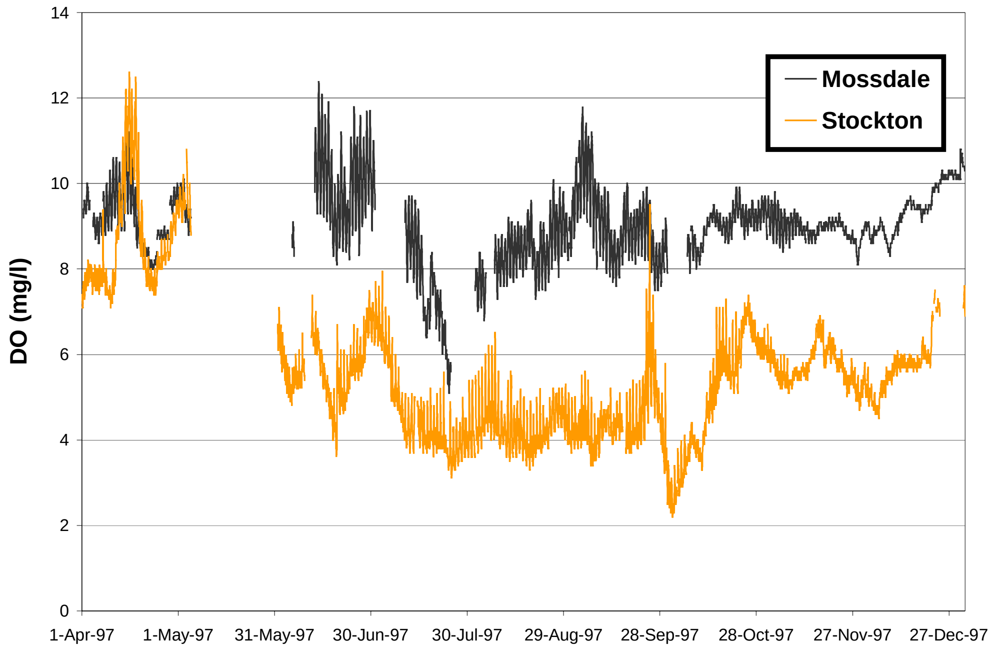

Figure 9-2: Dissolved Oxygen in the San Joaquin River (1997).

9.4 Calibration and Validation of DO

Based upon the examination of observed hourly temperature and DO for recent years at Mossdale, Stockton and Martinez, calibration/validation of DO will focus on the period from October 1997 through November 1998. The summer-fall period from 1998 is shown in Figure 9-3. Most other periods have blocks of data continuously missing both at Stockton and Mossdale at the same time, or air and water temperature missing at Mossdale at the same time.

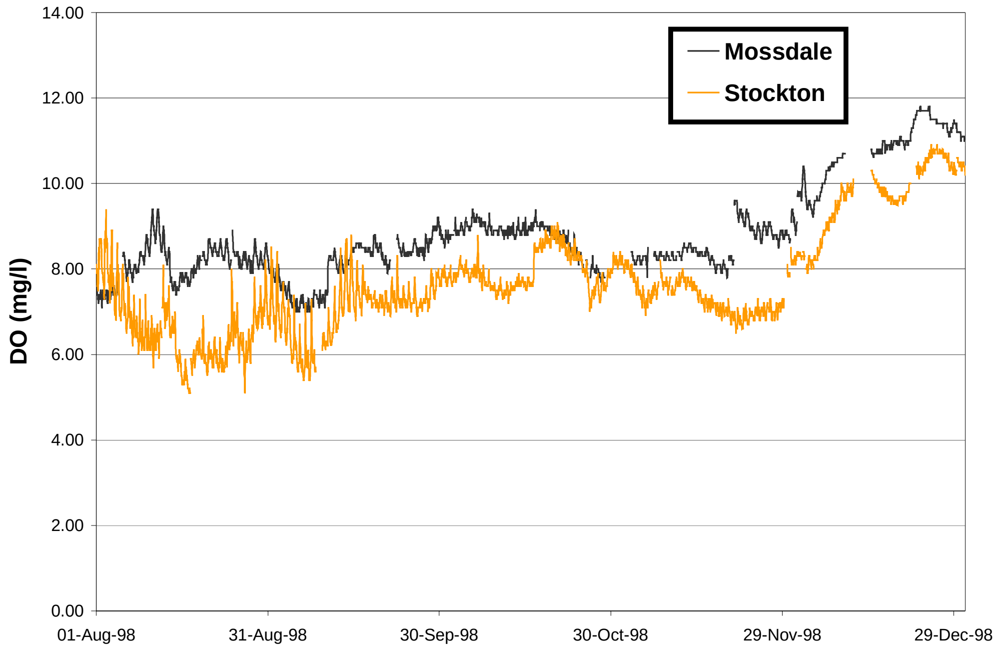

Figure 9-3: Dissolved Oxygen in the San Joaquin River (1998).

As a start, simulations were made with simplified hydrologic and water quality boundary conditions. Tests showed that the impact of increasing air temperature on dissolved oxygen varied significantly with location. The impact was higher in the interior Delta than at channels closer to model boundaries.

DSM2 calibration of EC is being conducted using the revised Delta grid that incorporates the latest bathymetry of the Delta (see Chapter 10). Calibration of dissolved oxygen will be based on that grid. Test simulations based on the revised grid showed that a few changes are necessary in the current QUAL input set-up. In addition to the data described above, physical, chemical and biological rate coefficients describing reaction kinetics are required as model input. Some of these coefficients are kept constant throughout the system; some are varied by location. Most of these coefficients are temperature dependent. For calibration of dissolved oxygen in the San Joaquin River, priorities will be put on the following parameters as control knobs: algae growth rate, algae settling rate, reaeration rate, sediment oxygen demand rate, light extinction coefficient, decay rates for ammonia nitrogen, organic nitrogen and BOD. Nitrification rate and the rates at which oxygen is produced from photosynthesis, and is lost to respiration, will also be used as knobs. The effect of the mixing coefficient on DO levels will be examined. Depending upon the results of the above calibration process, evaporation coefficient and dust attenuation factor that affect water temperature will also be examined. Sensitivity to initial and boundary quality conditions, nutrient levels of agricultural drainage and those from the City of Stockton's RWCF effluent will be evaluated.

9.5 Future Directions

The Delta Modeling Section plans to coordinate its attempts to develop tools, in this case a calibrated model, with the San Joaquin River Dissolved Oxygen Total Maximum Daily Load (TMDL) Stakeholder process. The model should help identify the main factors that contribute to low dissolved oxygen situation in this reach of the San Joaquin River. Through evaluations of different scenarios, the model can aid in developing potential management strategies to address water quality degradation. The TMDL process was started because the State is required by federal law to establish limits on discharges that adversely affect dissolved oxygen in the San Joaquin River from all sources (e.g. cities, agriculture, industry, etc.). The TMDL Steering Committee consists of stakeholders from industry, agriculture, cities and state government agencies and has been meeting monthly since January 1999. Details on the meetings and the status of the TMDL process are available from http://www.sjrtmdl.org/.

9.6 References

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