Thirty Years of Daily Modeling

Dr. Russ T. Brown

CWEMF Annual Meeting 2011

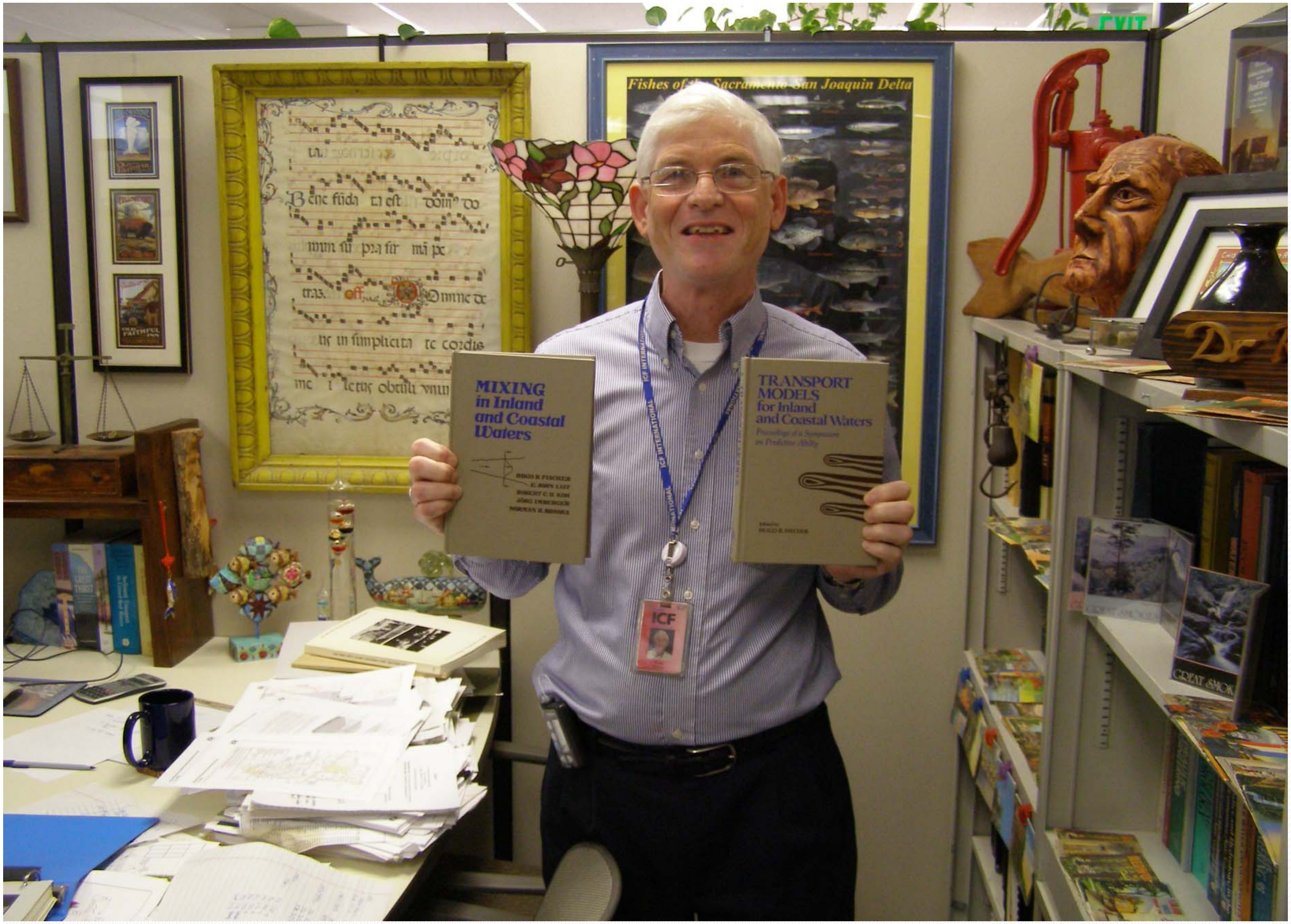
Acceptance of the Hugo B. Fischer Award

My Formative Years

- LA aqueduct and St. Francis Dam
- UC Santa Cruz-Creeks and Redwoods
- UC Irvine-Wastewater & Ocean Discharges
- MIT- Ocean Engineering and Water Resources
- USACOE- Vicksburg Experiment Station and HEC

“I’ve built and used models since I was a boy”

Mississippi Basin Model revived during 1973 Mississippi River Flood



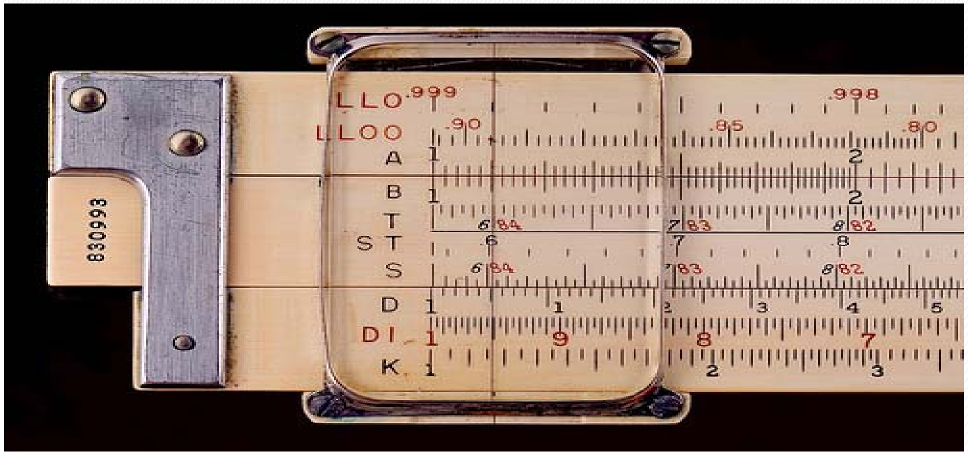
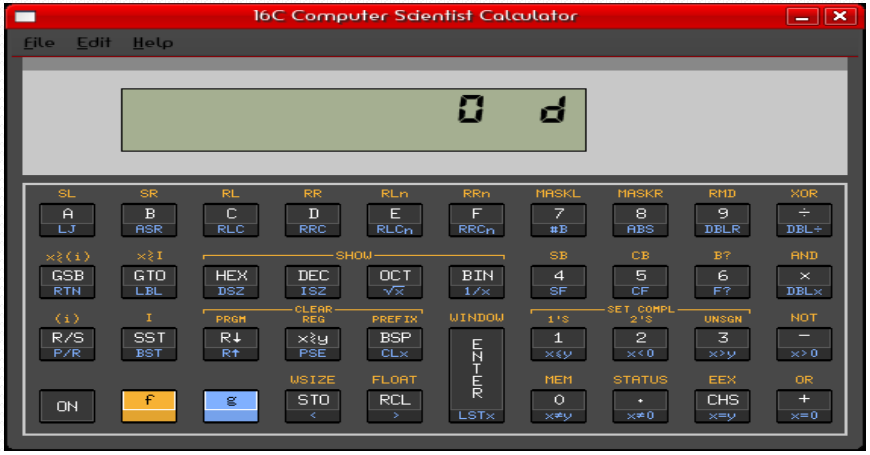
"Here I am 30 years later still trying to understand water movement and mixing processes"

"I bought and read Professor Fischer's books (1978,1981), so I was ready to make a living in Environmental Hydraulics"

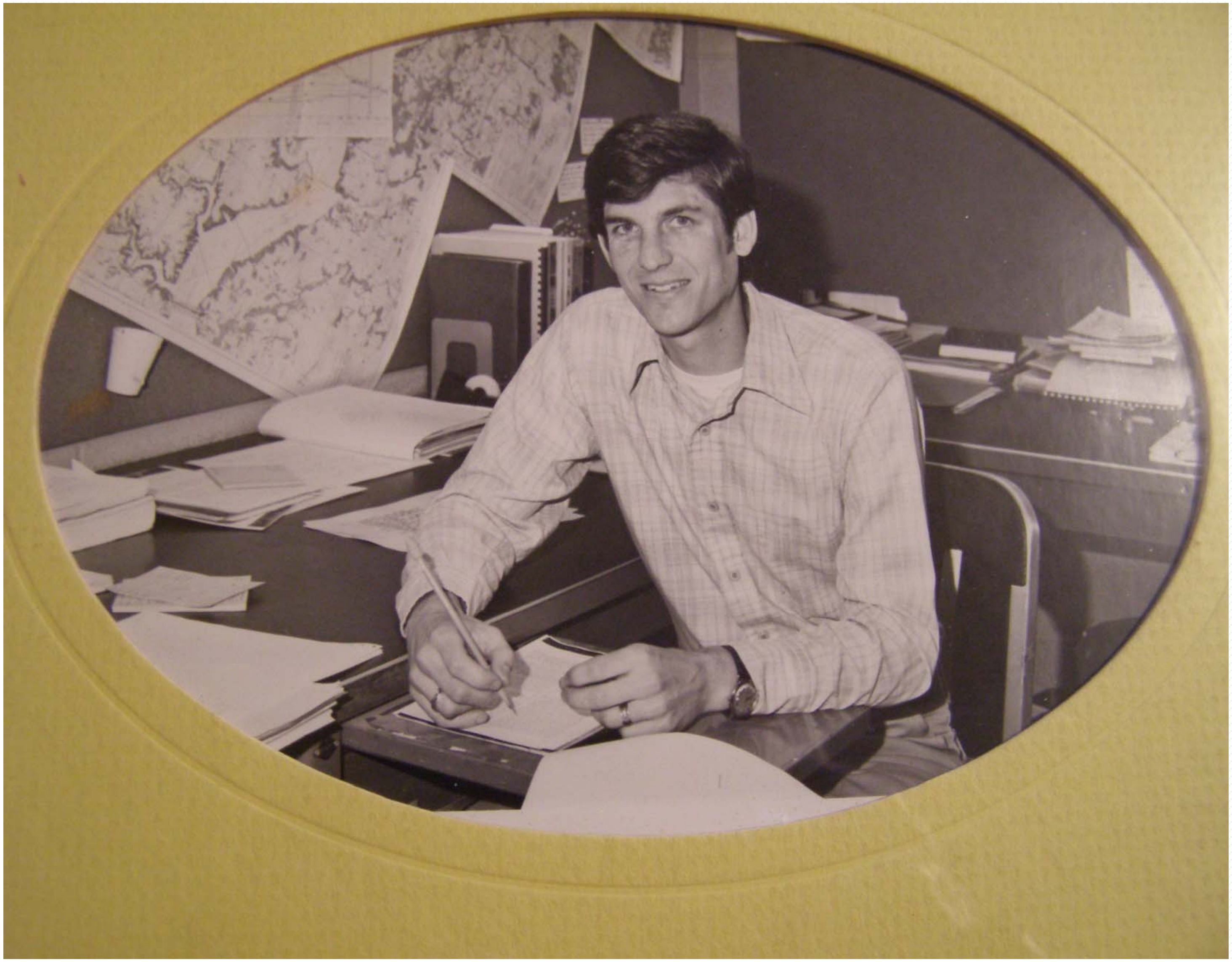
My Early Working Years

- TVA- Reservoir Temperatures and Water Quality, Aeration, and Suspended Sediment
- Tennessee Tech- Students and Modeling Studies

“Reading the old reports and studies is the best place to begin modeling”

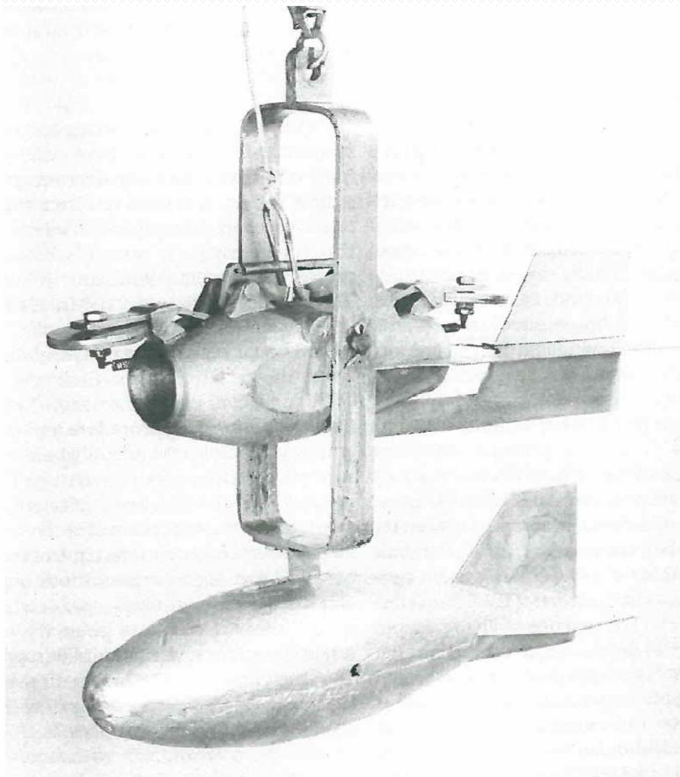
TVA Engineering Lab-Norris TN

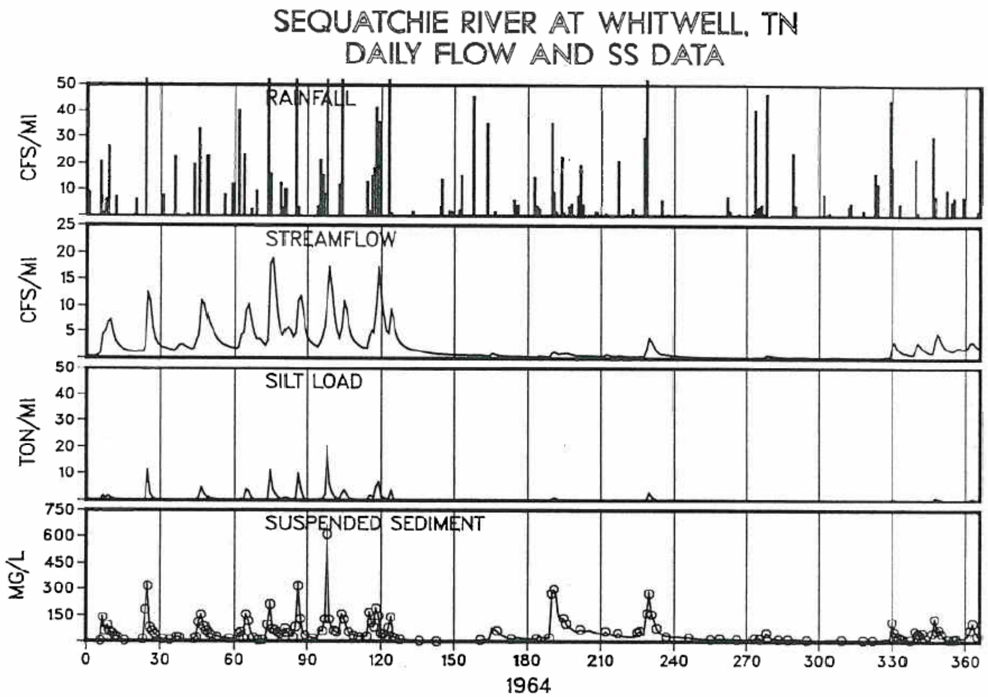


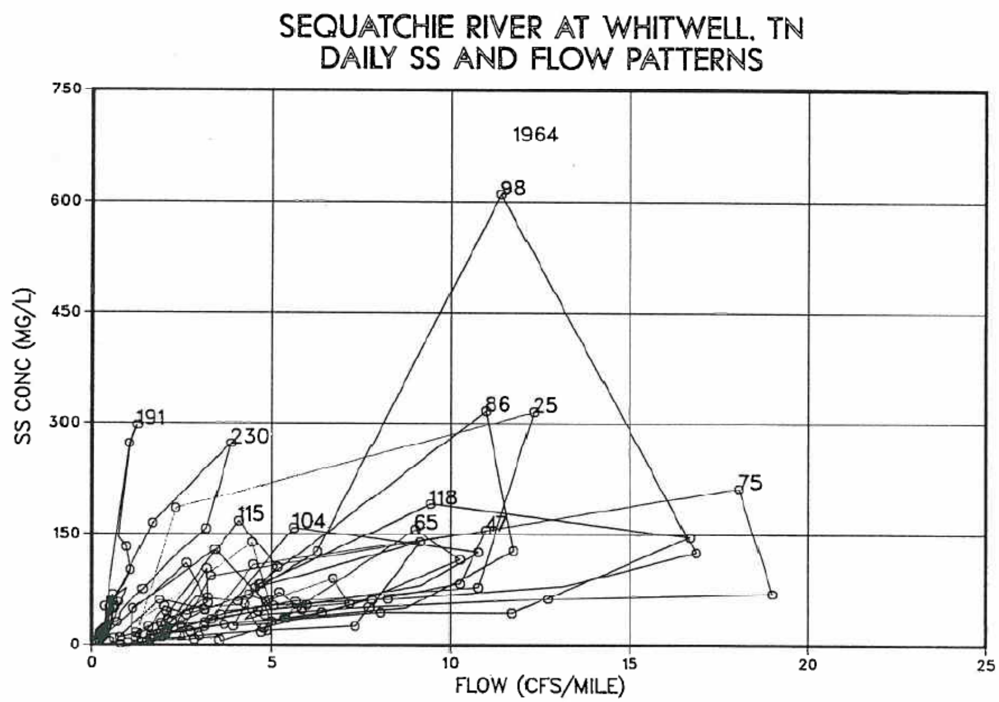
Analyzing hourly water temperature data from reservoirs and power plants

Analyzing daily suspended sediment data from tributary streams

TVA Daily Rainfall-Runoff and SS Data "Hydrographs and Sediment-graphs"

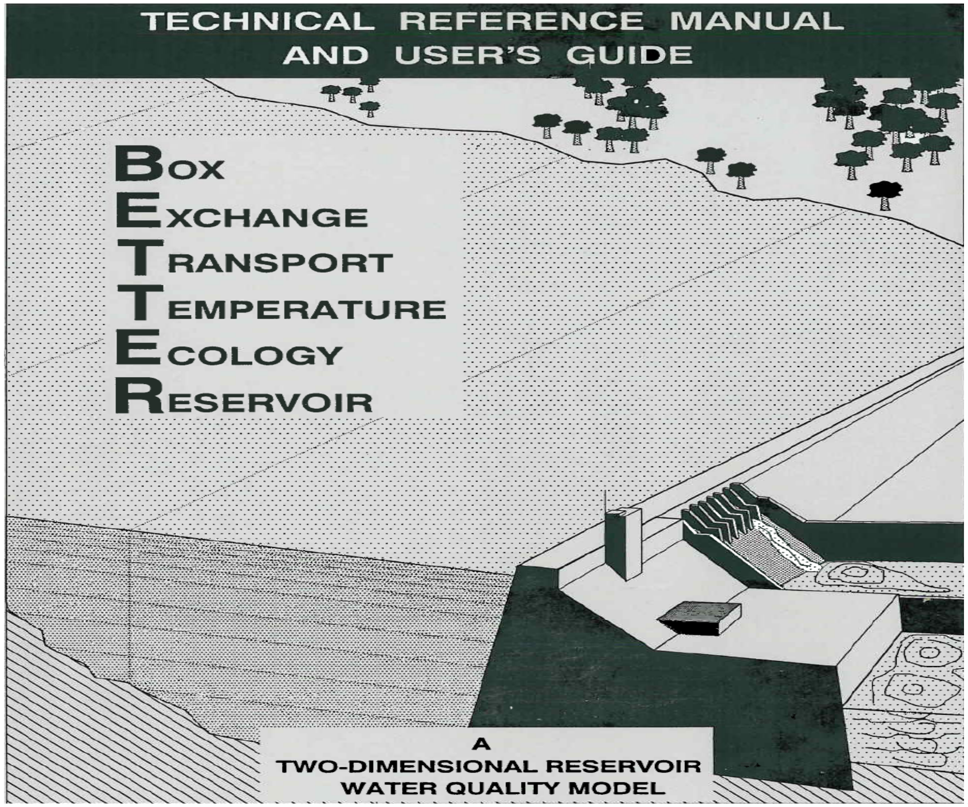


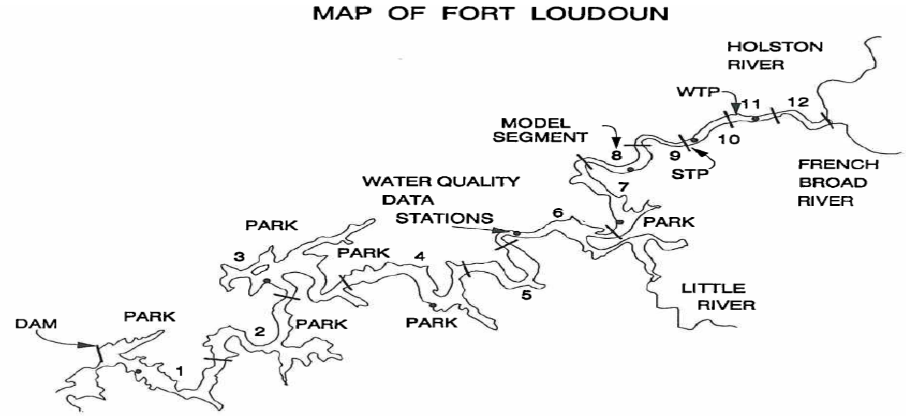


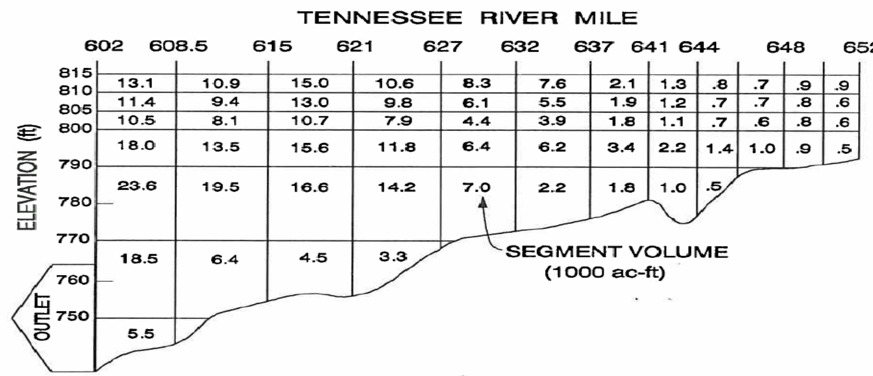


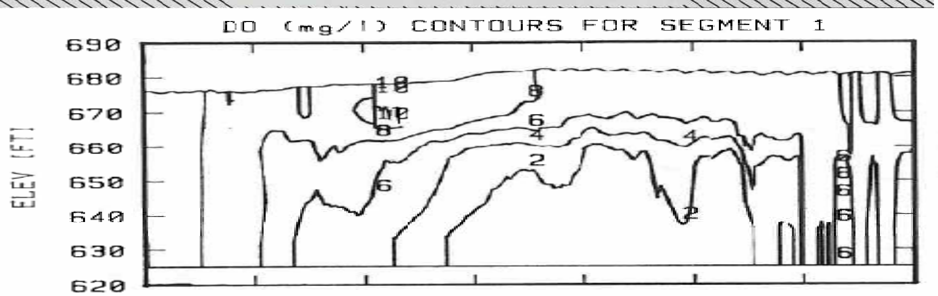
Reservoir Water Quality Modeling

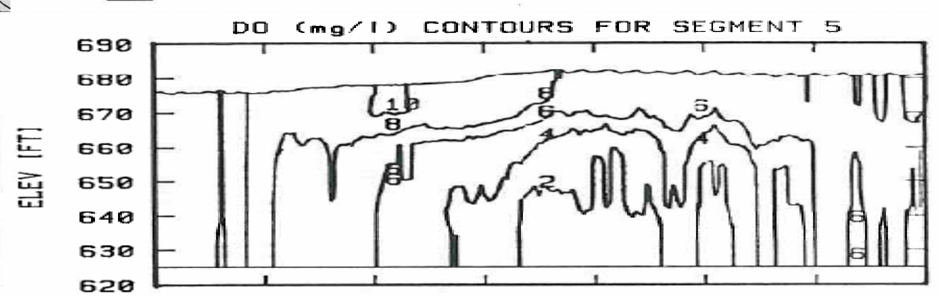
- Seasonal stratified temperature and DO depletion
- Algae growth with SS settling/light effects
- Inflow placement effects on travel time and nutrients
- Aeration (turbine venting, O_2 diffuser, Garton- pump)
- BETTER Model- seasonal simulation with daily time-step using layered boxes with 2-D graphs
- Normandy Reservoir storm event sampling/modeling
- Applied to 20 Reservoirs at TVA, COE, BOR (and Lewiston and New Exchequer)
- "We should have a model for every reservoir"

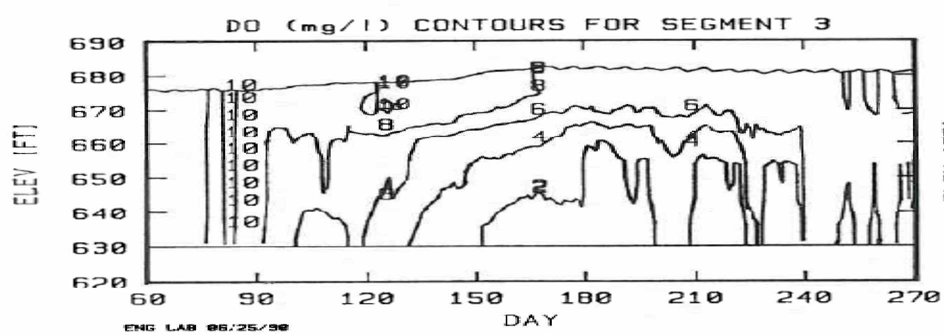

TECHNICAL REFERENCE MANUAL
AND USER'S GUIDE
BOX
EXCHANGE
TRANSPORT
TEMPERATURE
ECOLOGY
RESERVOIR
A
TWO-DIMENSIONAL RESERVOIR
WATER QUALITY MODEL

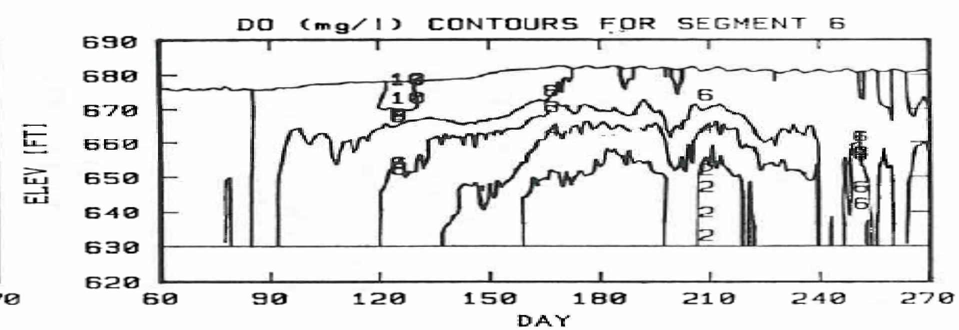

MAP OF FORT LOUDOUN
HOLSTON RIVER
WTP
MODEL SEGMENT
FRENCH BROAD RIVER
STP
WATER QUALITY DATA STATIONS
PARK
LITTLE RIVER
DAM


TENNESSEE RIVER MILE
602 608.5 615 621 627 632 637 641 644 648 652
ELEVATION (ft)
OUTLET
SEGMENT VOLUME
(1000 ac-ft)


DO (mg/l) CONTOURS FOR SEGMENT 1
ELEV (FT)


DO (mg/l) CONTOURS FOR SEGMENT 5
ELEV (FT)


DO (mg/l) CONTOURS FOR SEGMENT 3
ELEV (FT)
DAY
ENG LAB 06/25/90


DO (mg/l) CONTOURS FOR SEGMENT 6
ELEV (FT)
DAY

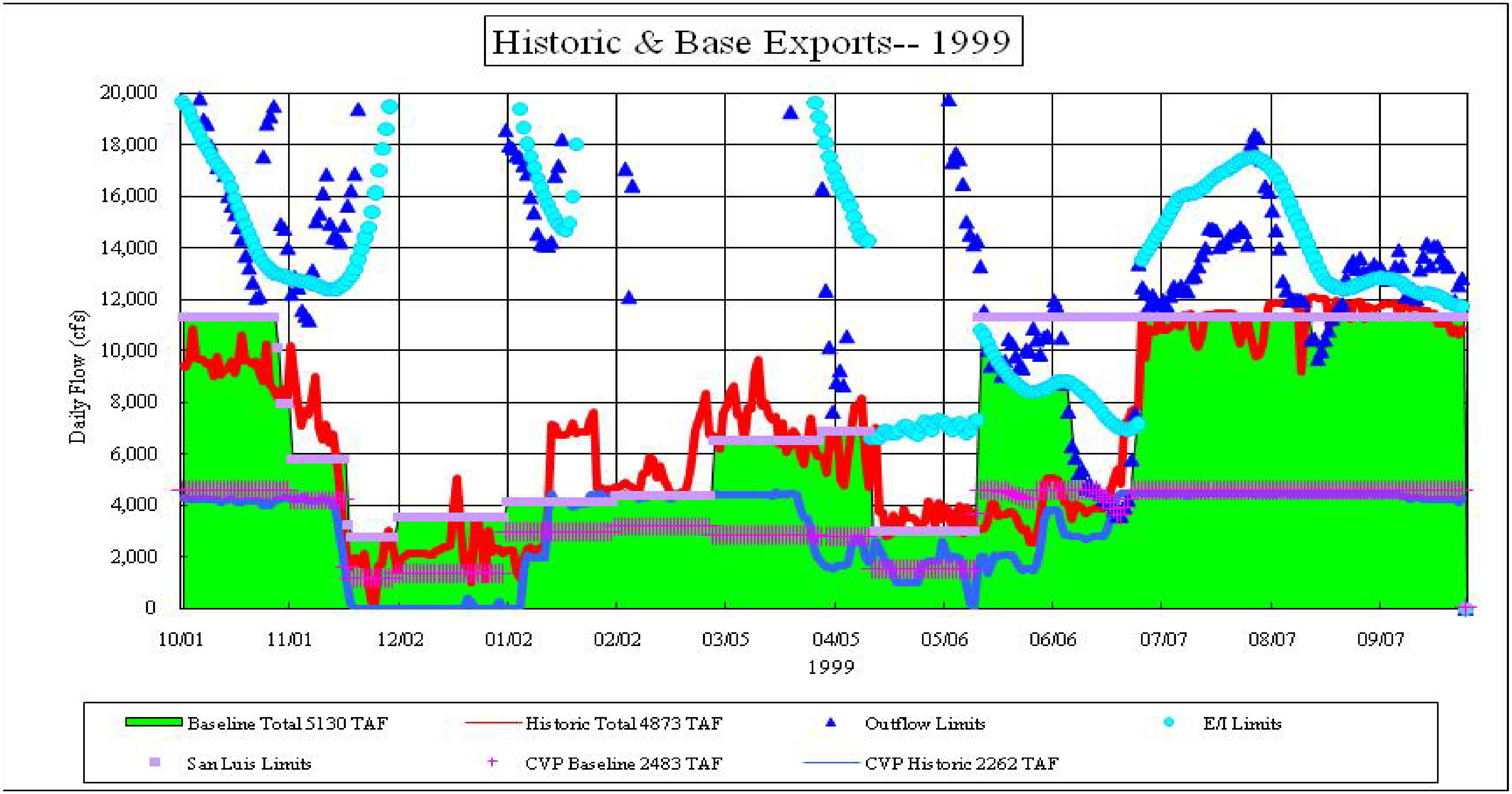
California Water and Environmental Impact Assessments

- "Models are perfect tools for impact assessments"
- Mono Lake Diversions- Los Angeles Aqueduct Monthly Program (Fortran and Lotus spreadsheet)
- Delta Wetlands -Delta SOS monthly adjustments of DWRSIM and Daily SOS spreadsheet models
- Guadalupe River- JSATEMP model of daily stream temperature using CIMIS data for hourly heat budget
- Sacramento Wastewater Treatment- CWFATE Constructed Wetlands fate and transport of nutrients and metals
- "A new model each month would be a good way to work"

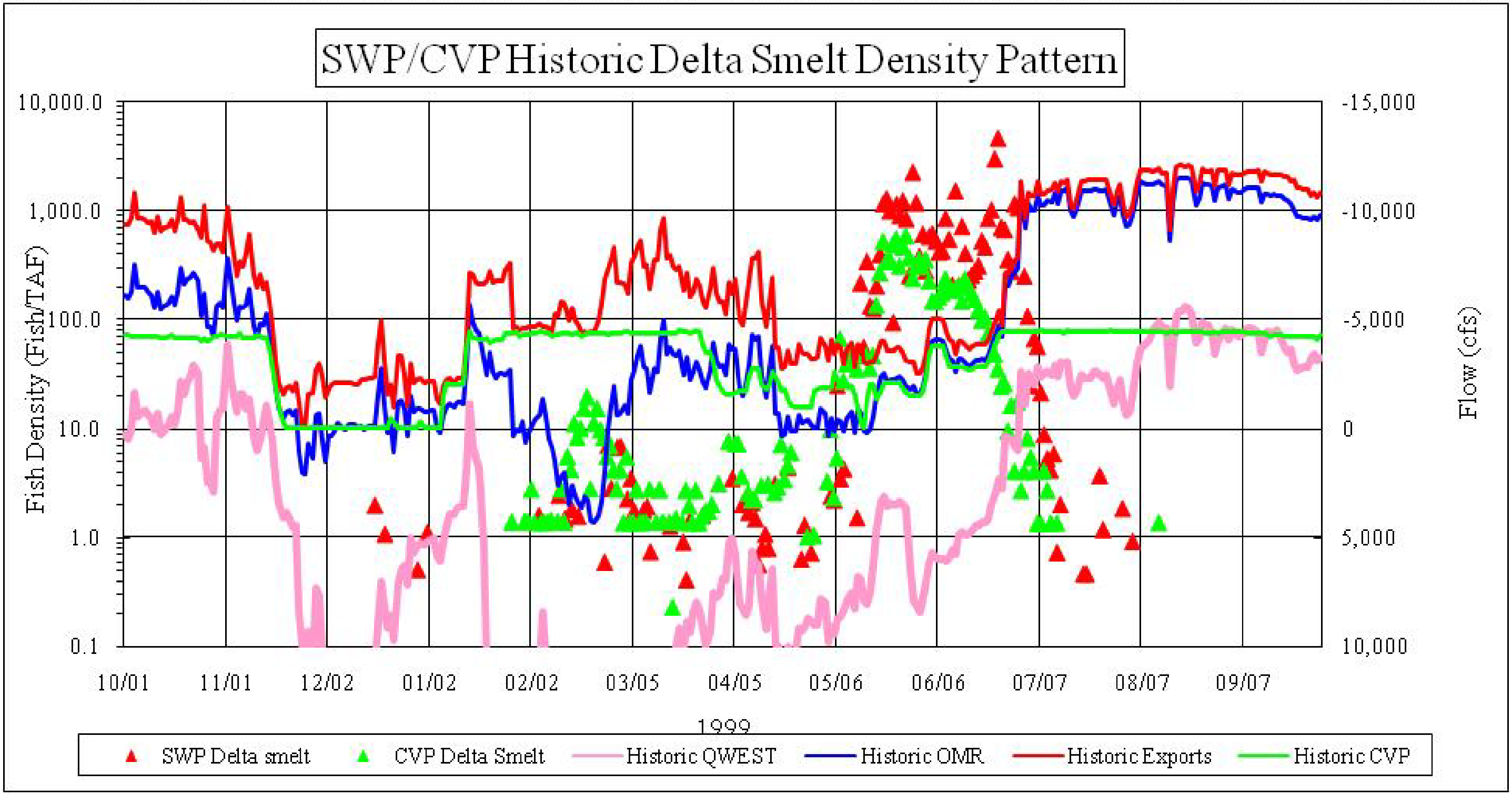
Delta Operations and Protections Simulation Modeling for the EWA

- DAYFLOW with channel flow splits and gates with adjustable objectives for outflow, X2, E/I, and QWEST
- Daily CVP and SWP fish salvage density (fish/taf)
- Interactive "gaming forum" with water managers and fish protection agencies (MAs and PAs) for decision-making and tracking of fish protection actions/results
- Projector display of data and model results
- Modeler Stress "Our modeling-mistakes and missing features- were immediately revealed to everyone"

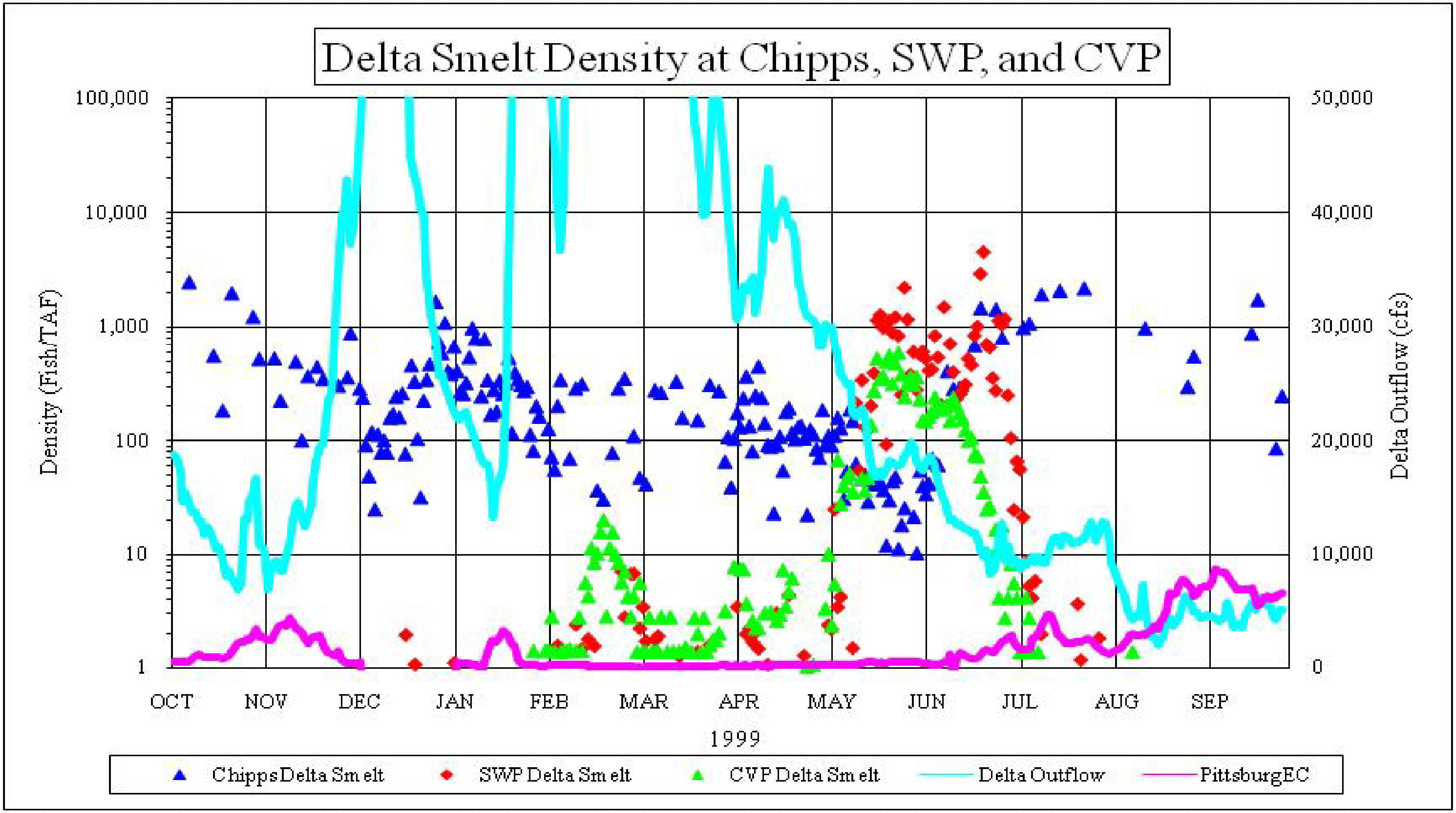
EWA Modeling for CALFED- Combining Daily Delta Flows and Salvage Fish Densities



Daily Fish Salvage Density Reveals Delta Fish Movement Patterns and Entrainment Events



“All Trawls and Surveys should be integrated and interpreted with fish movement models”

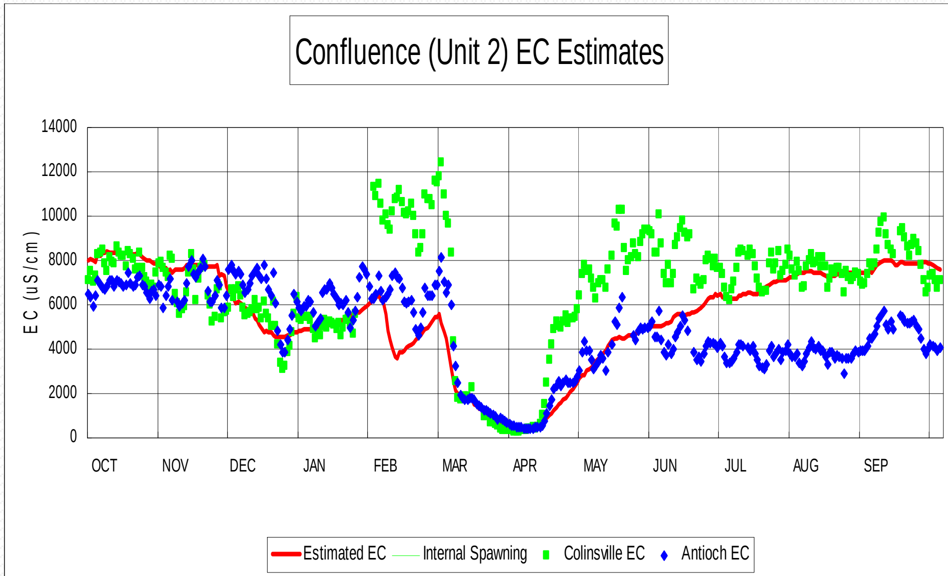


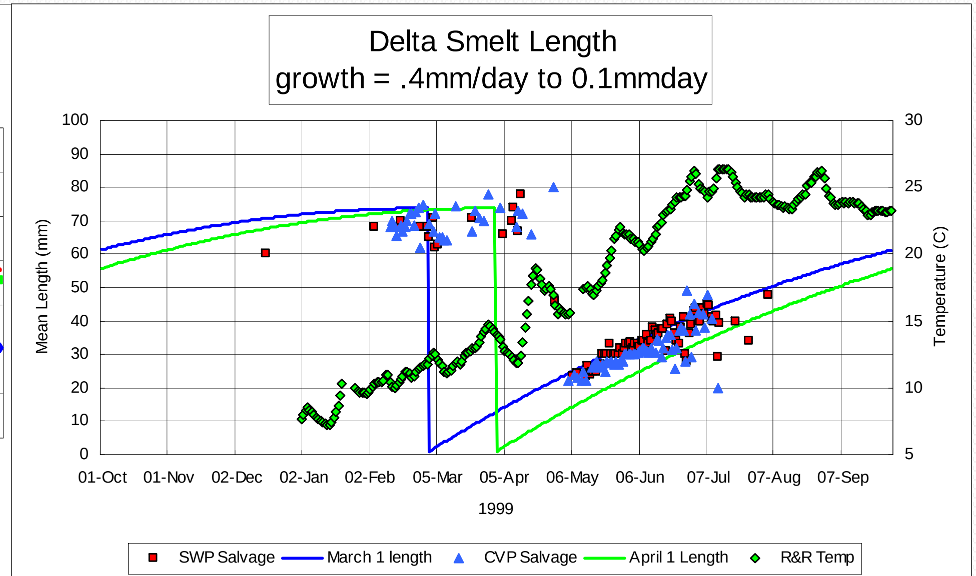
Delta Fish Modeling Opportunities

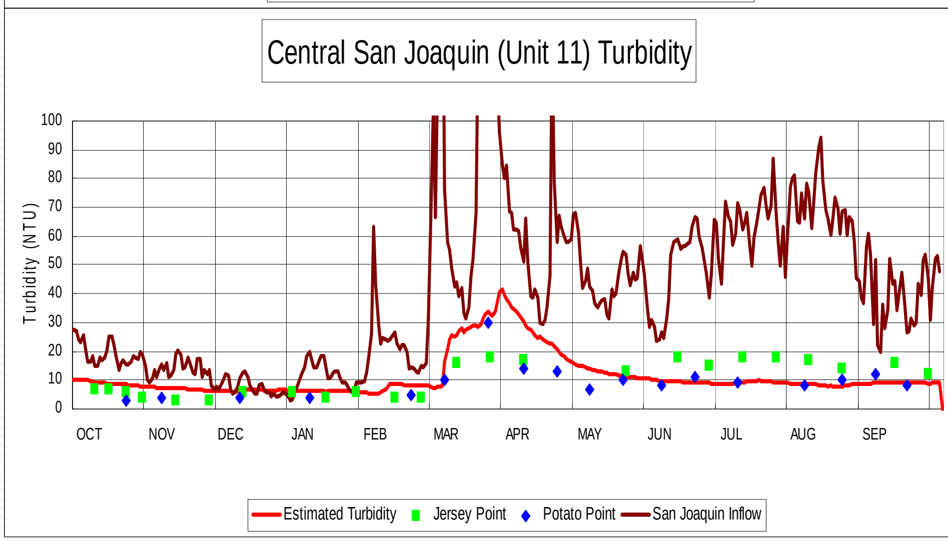
- "San Joaquin River daily flows, temperatures, and fish habitat simulations" FWUA and NRDC 2001
- "Battle Creek Daily Flows, Temperatures and Fish Habitat Evaluation" BOR 2003
- "Methods for Assessment of Fish Entrainment in SWP and CVP Exports" SDIP EIS/EIR Appendix J 2005
- "A possible Approach for Integrating Delta Aquatic Species Survey Data" CALFED Science Conference 2006
- "Evaluation of Fish Protection from Installation of the Head of Old River Temporary Barrier" CVPIA 2007
- "Evaluation of Delta Smelt Entrainment Events in 1995-2007" CALFED Science Conference 2008

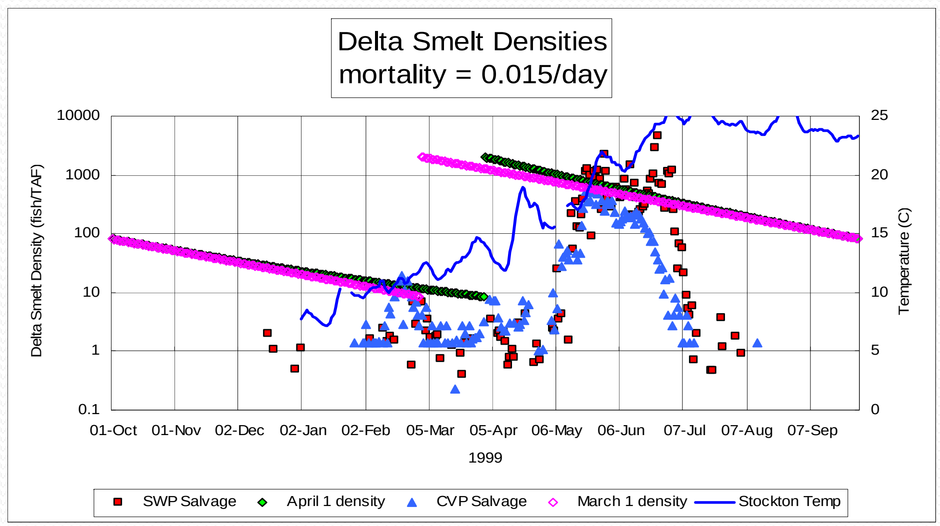
DeltaMOVE

“movement of organisms vulnerable to entrainment”





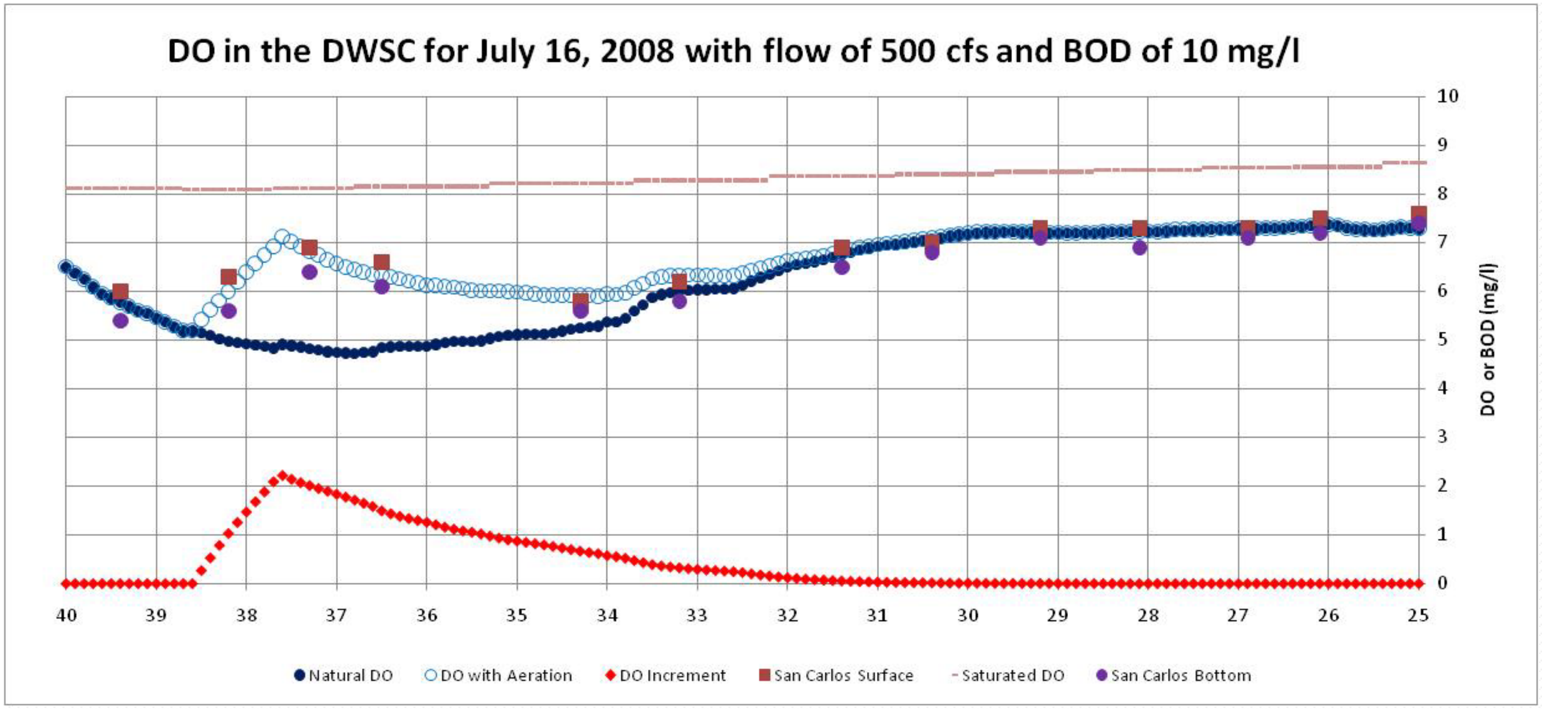




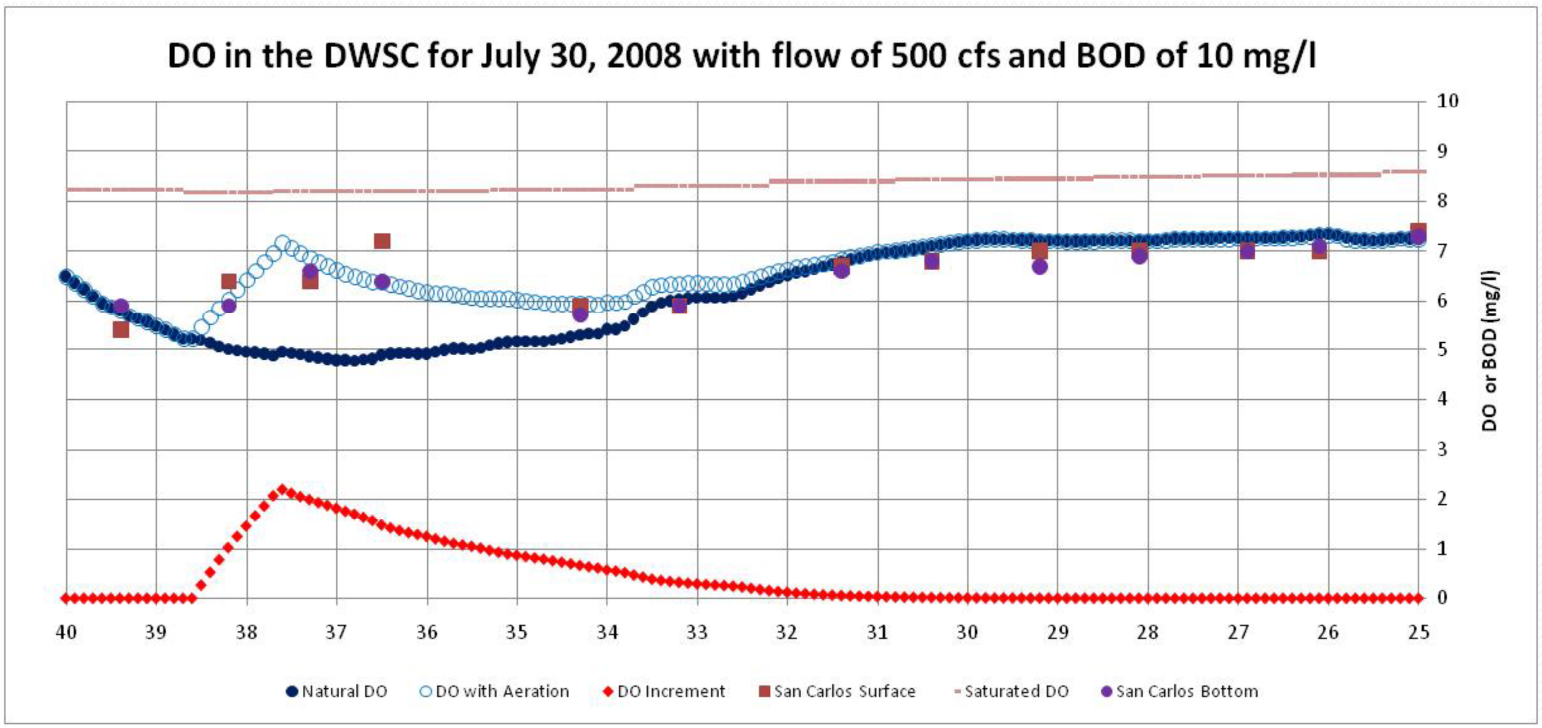
Stockton Deep Water Ship Channel DO and the SJR DO TMDL –Measurements and Models

- San Carlos ship surveys
- Mossdale and RRI water quality monitors
- USGS Garwood tidal flows
- Stockton RWCF Effluent and River Surveys
- CALFED studies in DWSC and SJR upstream
- DWR DO probes for Aeration demonstration

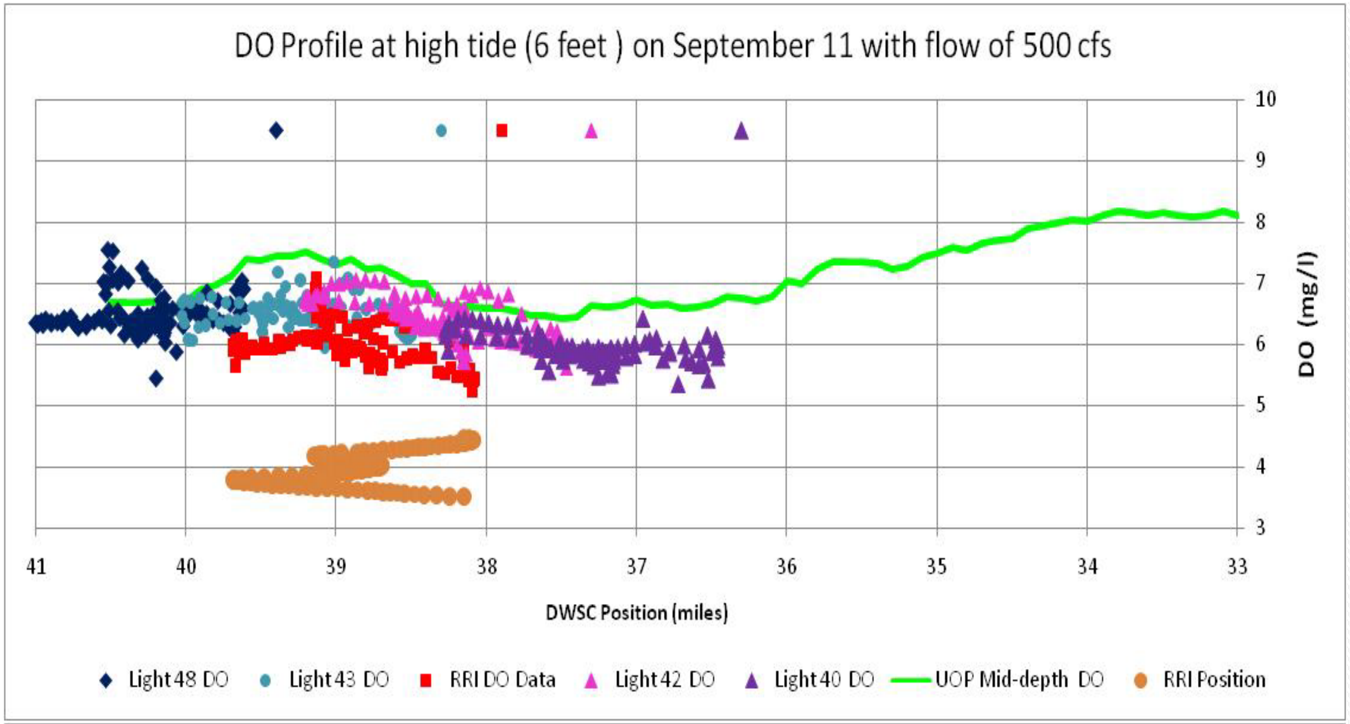
- RMA tidal and WQ
- Systech Water Quality
- DSM2 Hydro and Qual
- HydroQual 3D
- DWSC DO-BOD Profile
- DO Increment model
- SJR DO TMDL Accounting Procedures



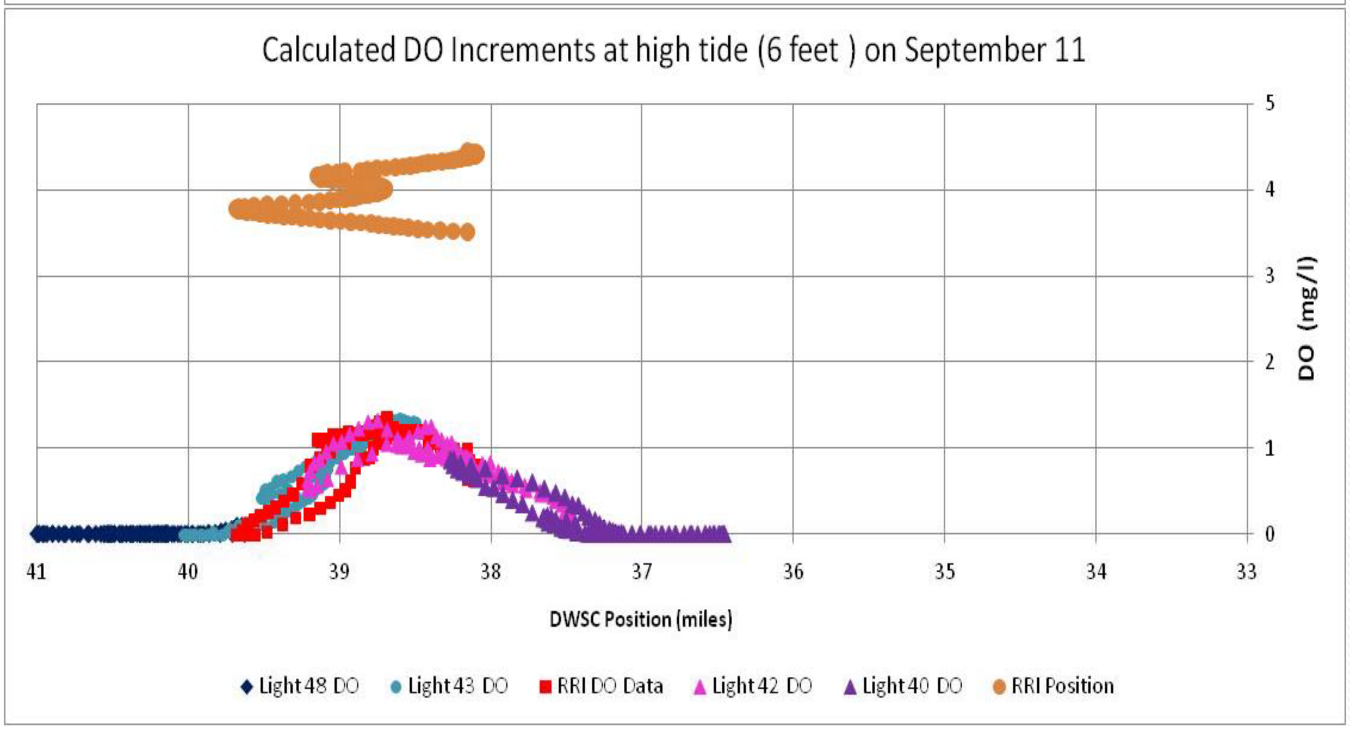
DO-BOD modeling requires flow, inflow DO & BOD, Temp, BOD decay and reaeration rates.



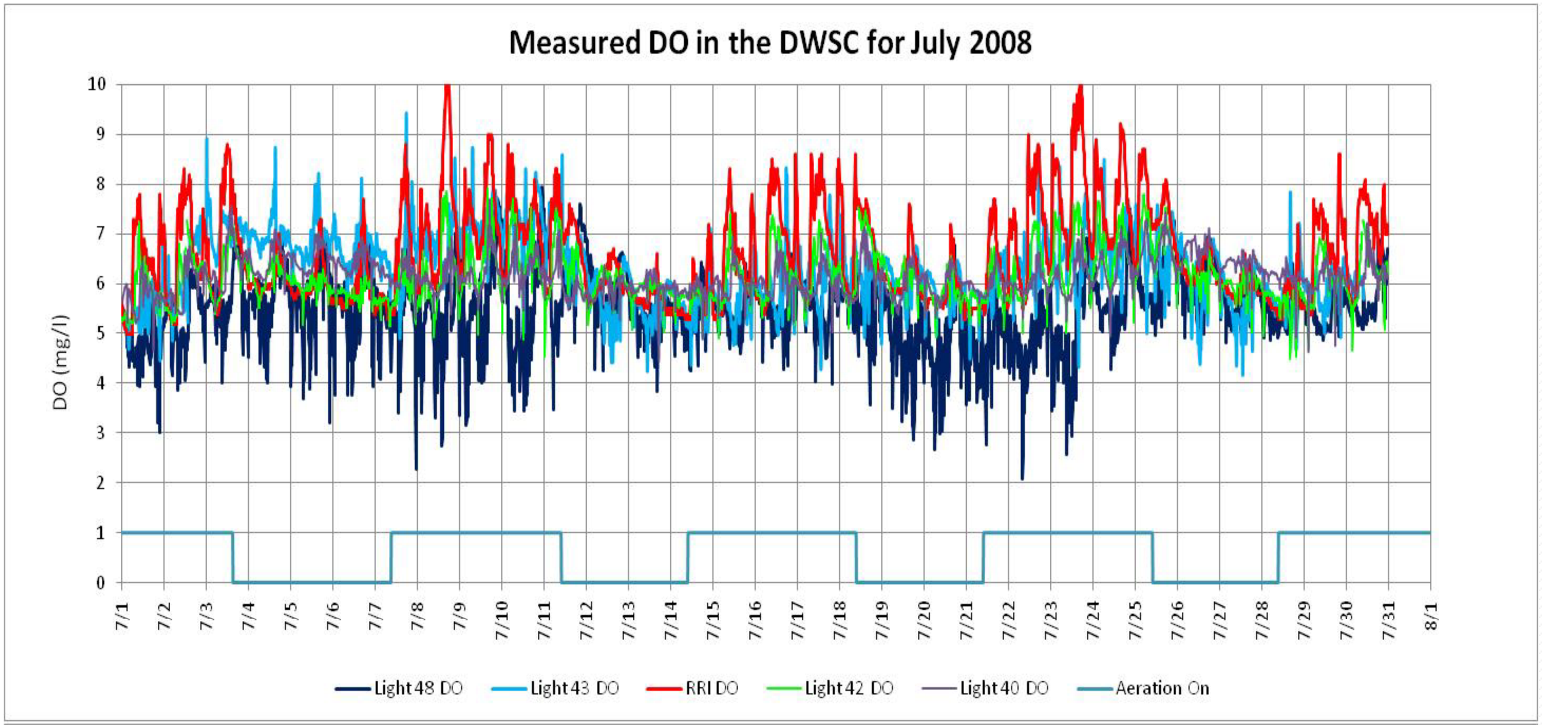
The DO deficit is proportional to the BOD: Ratio = Reaeration/ Decay rate



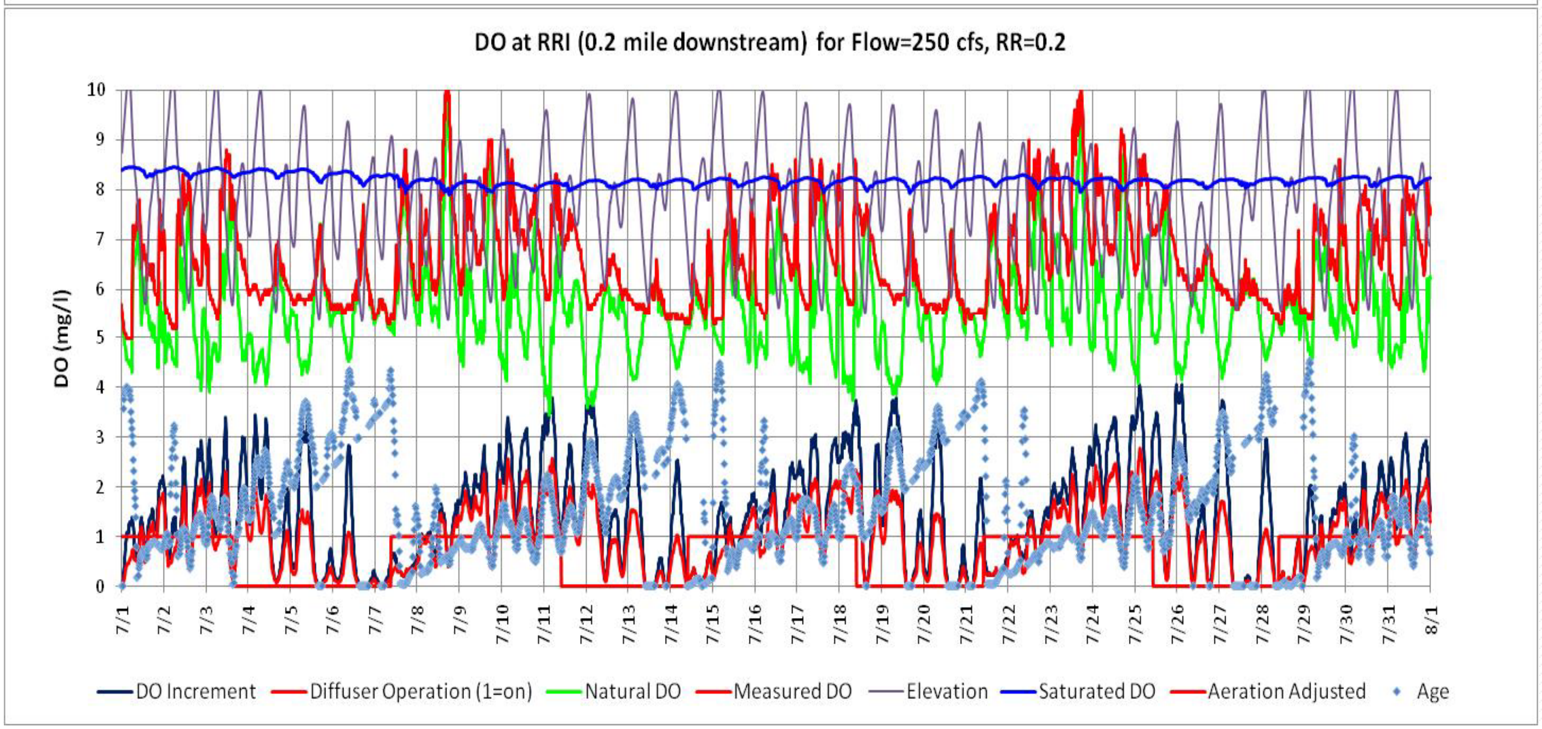
UOP DO Survey and high-tide DO Profile from monitoring stations on Sept 11, 2009



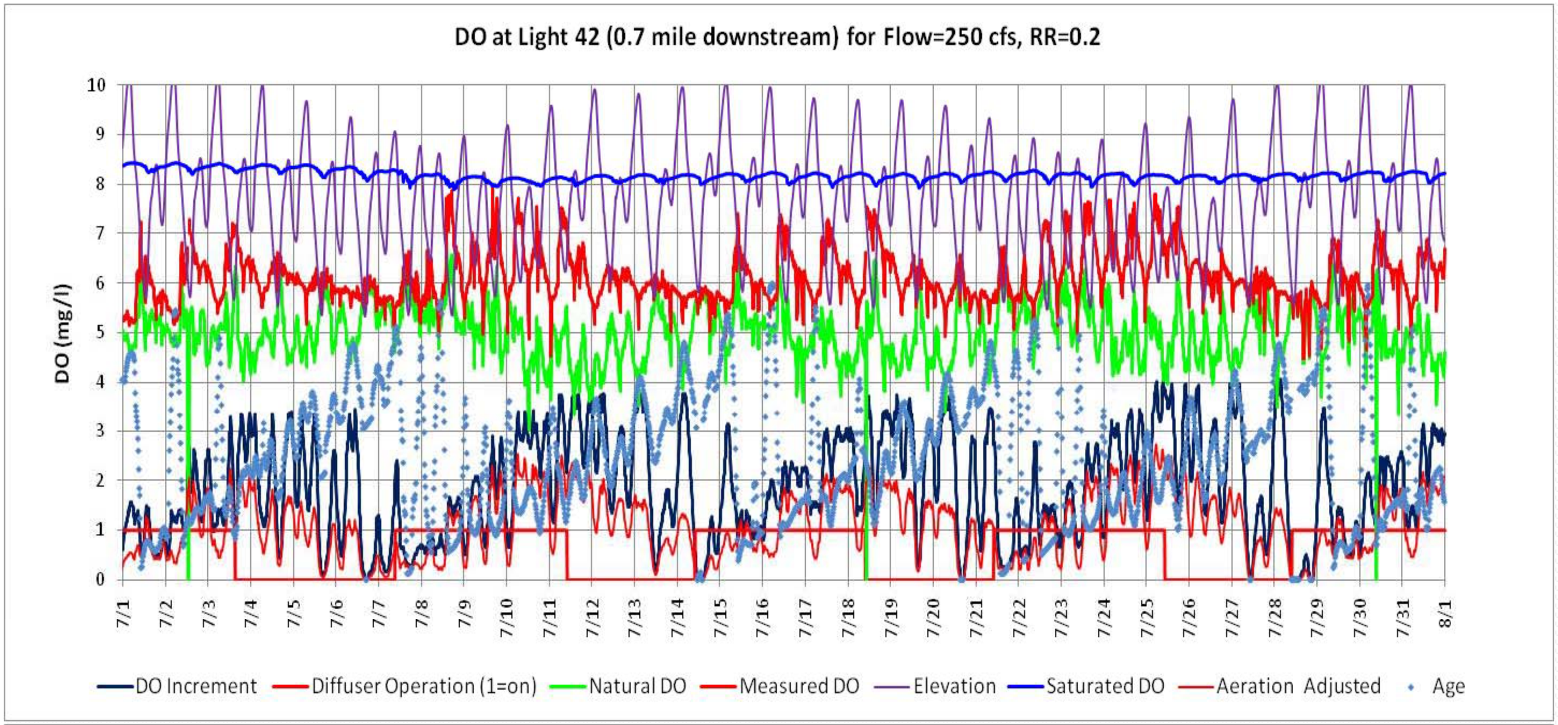
"DO Increment Model" estimated distribution of added DO on Sept 11, 2009 at high tide



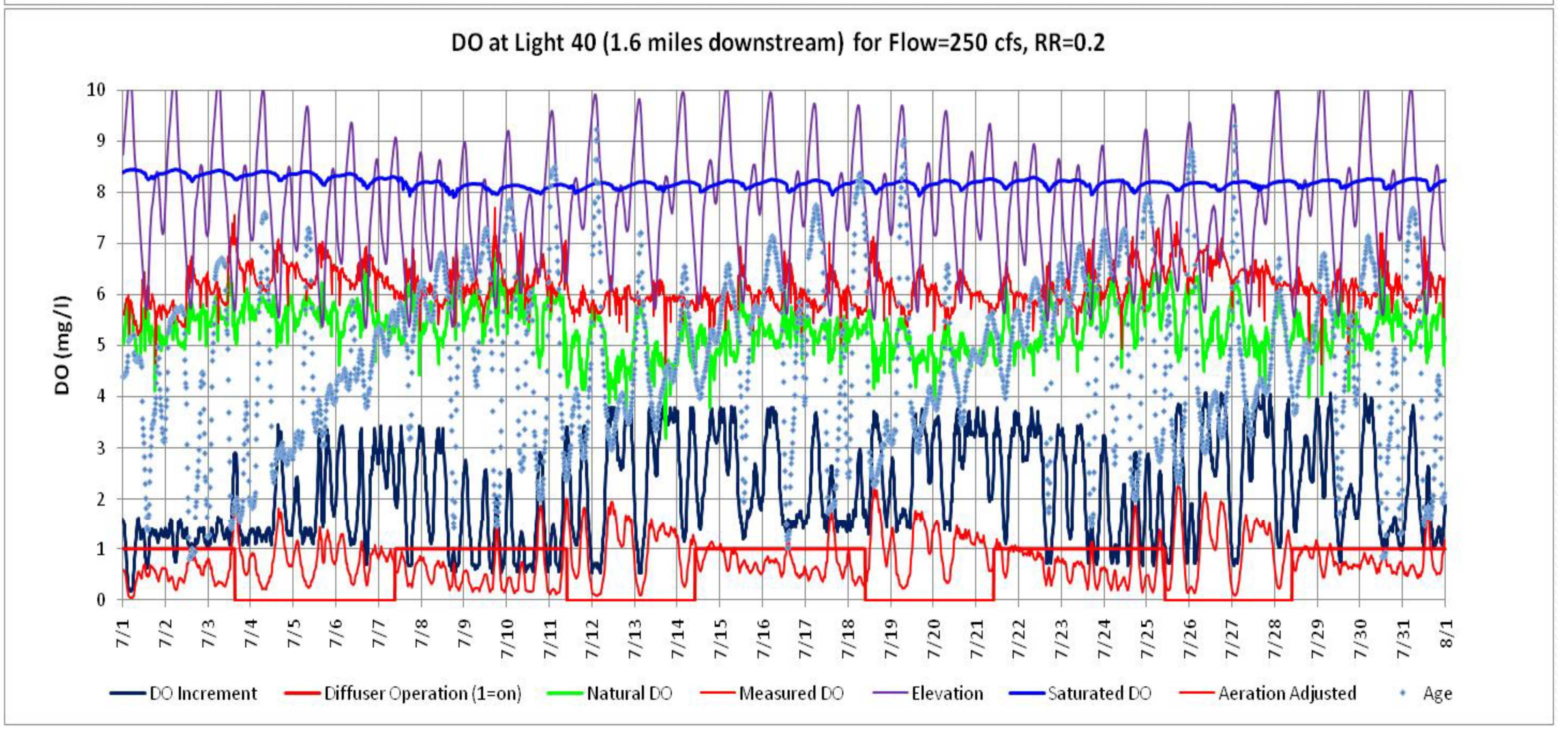
Can you tell how much DO is from the Aeration Facility?



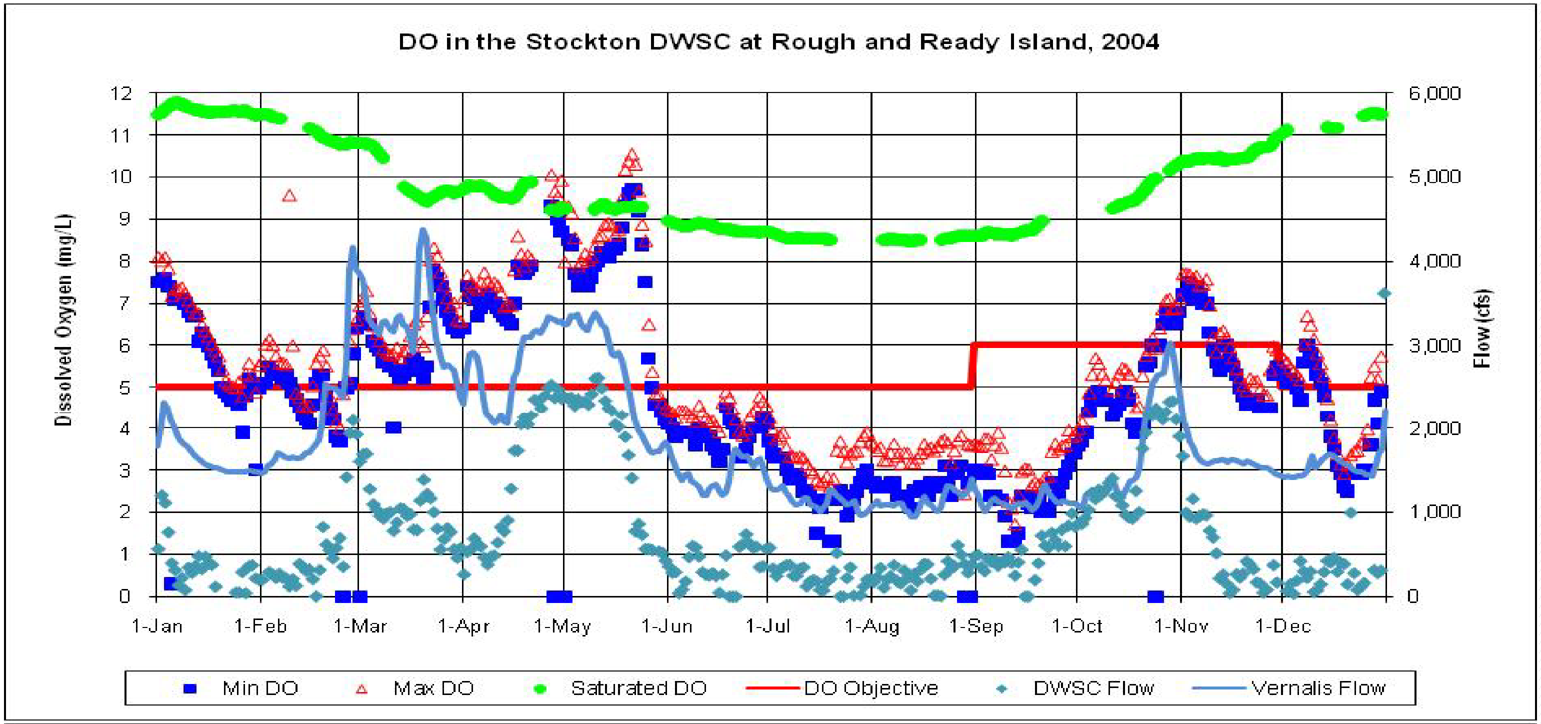
The DO Increment Model may be able to estimate the natural DO.

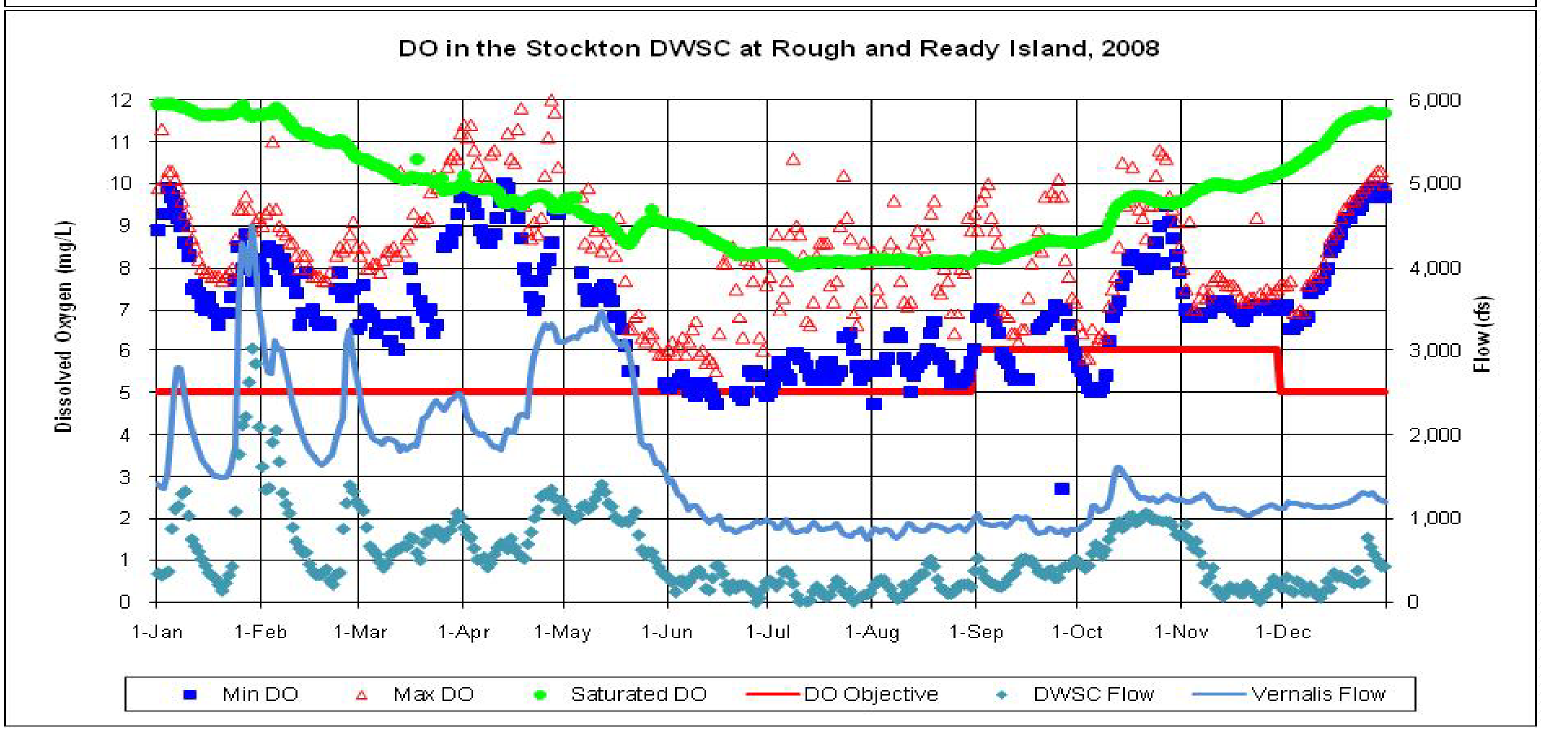


The greatest DO increments are estimated at Light 42



The DO increments at Light 40 are largest at low tide.

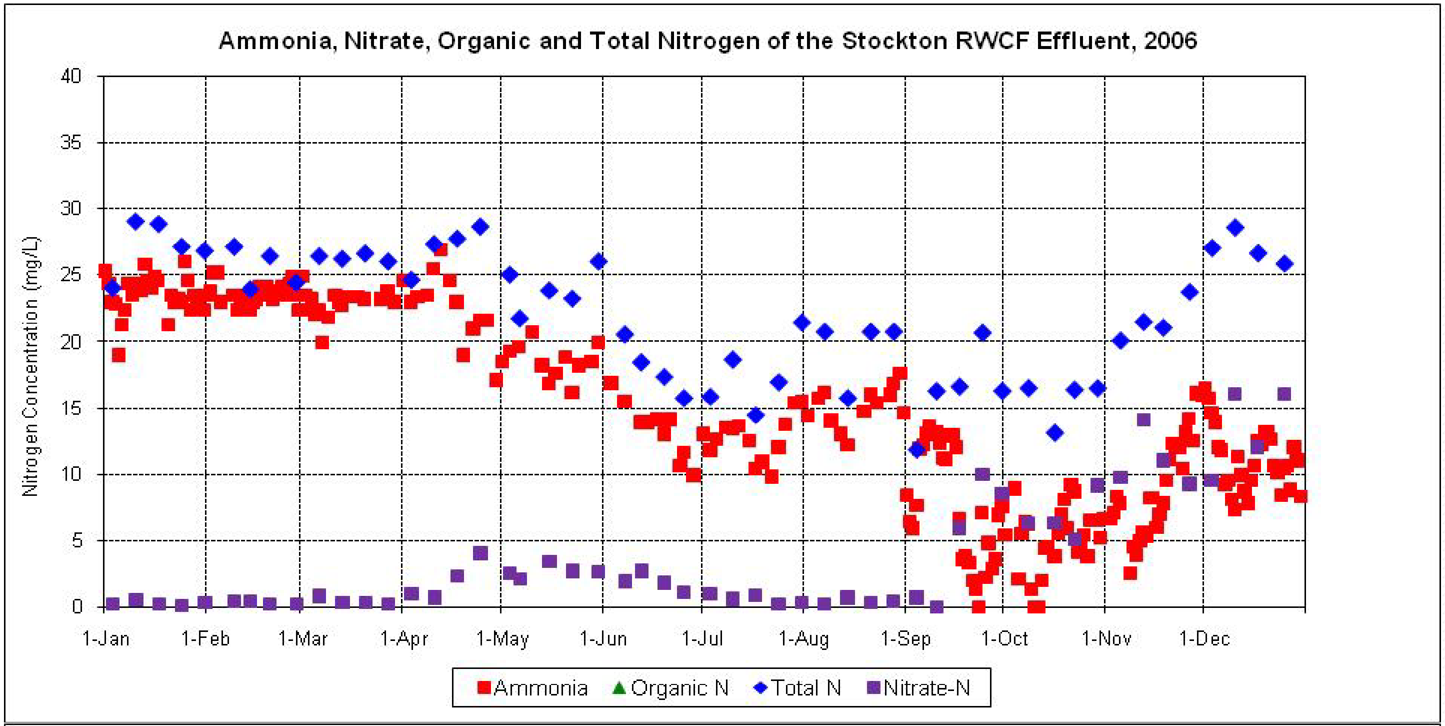




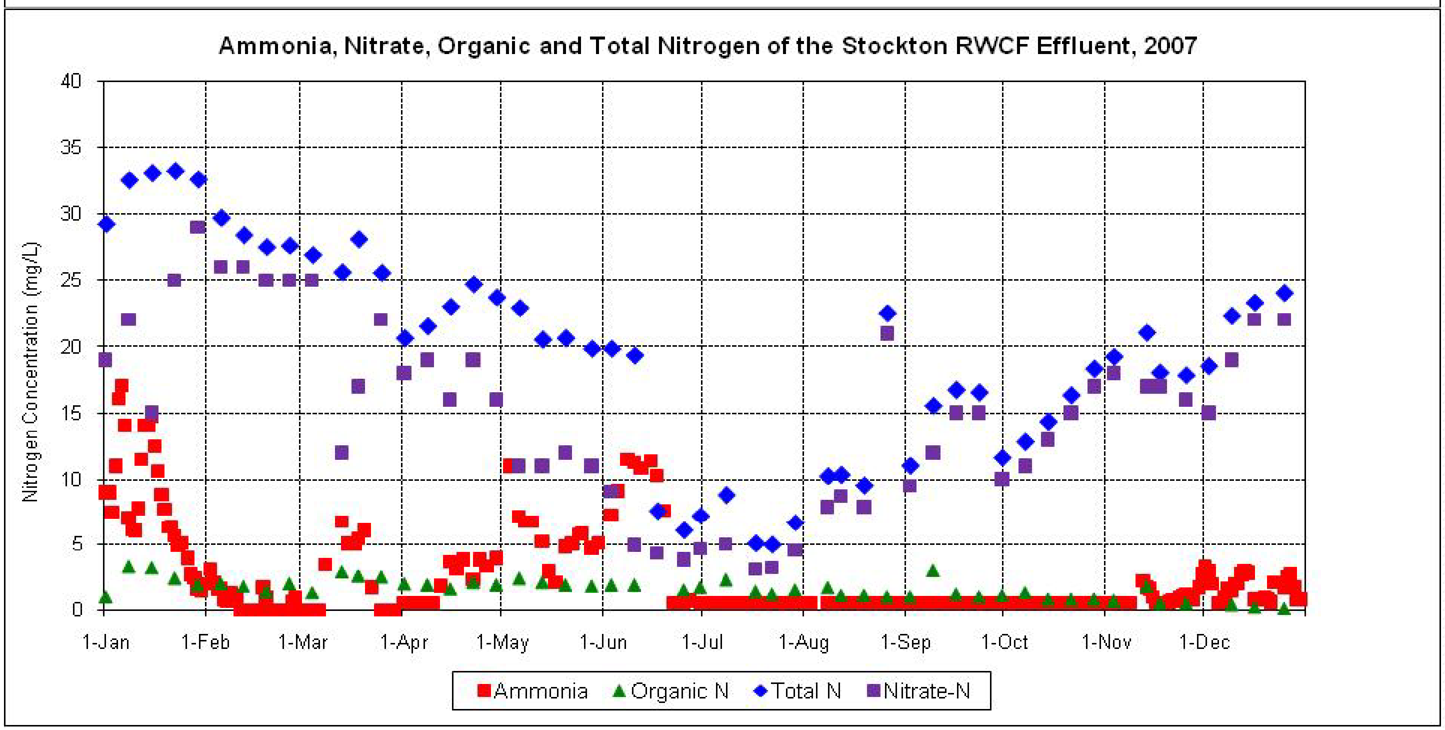
Q. The flows in 2004 and 2008 were similar. Why was the DO in 2008 higher than in 2004?

A. The City of Stockton's RWCF nitrification bio-towers began operation in 2007.

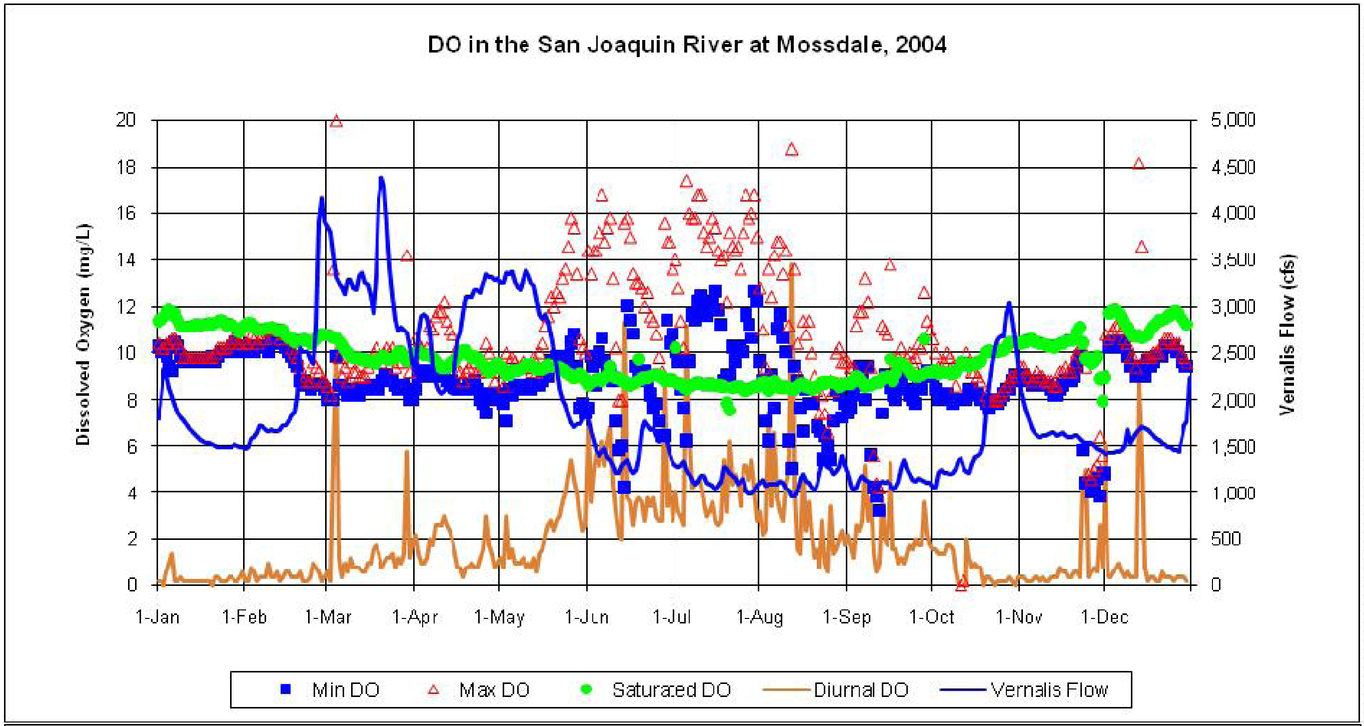
Q. Did the DO models predict this big effect?

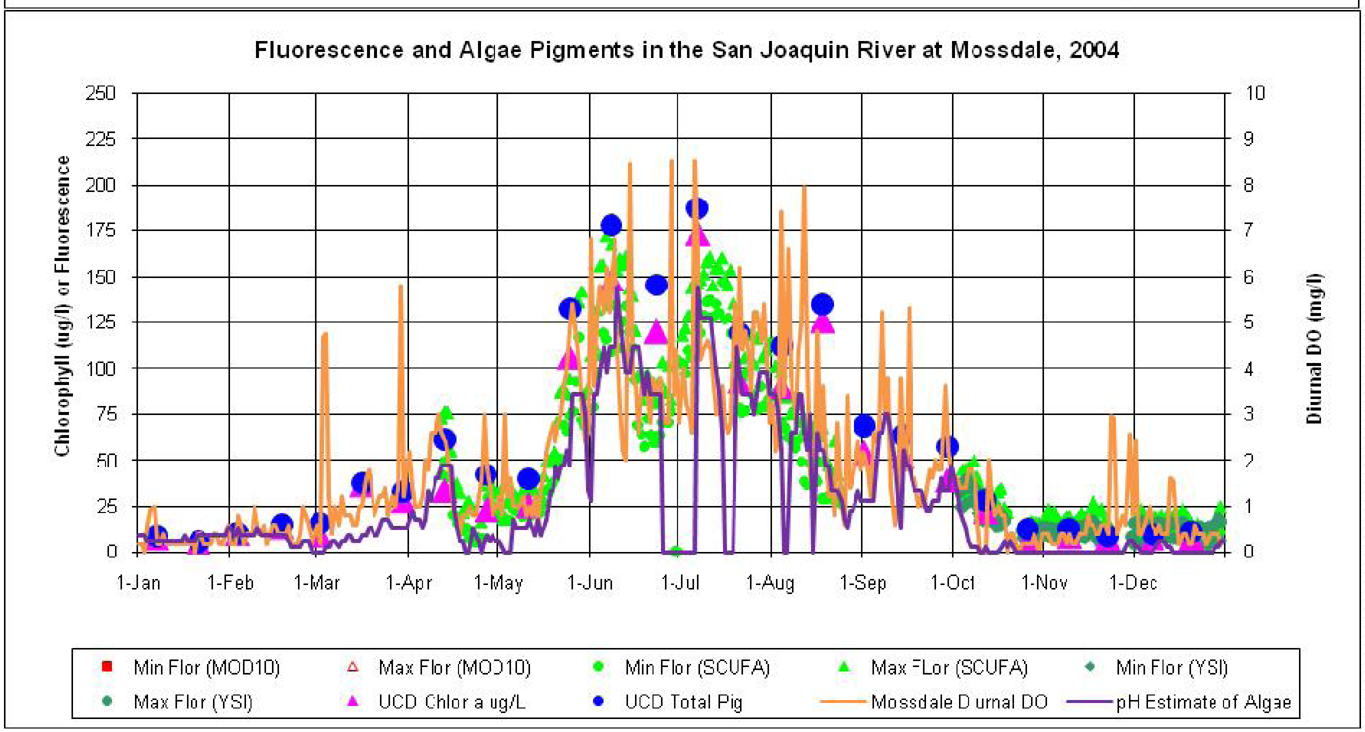


The RWCF CBOD concentration is relatively low (5-10 mg/l). The maximum ammonia-N concentration was about 25 mg/l through 2006



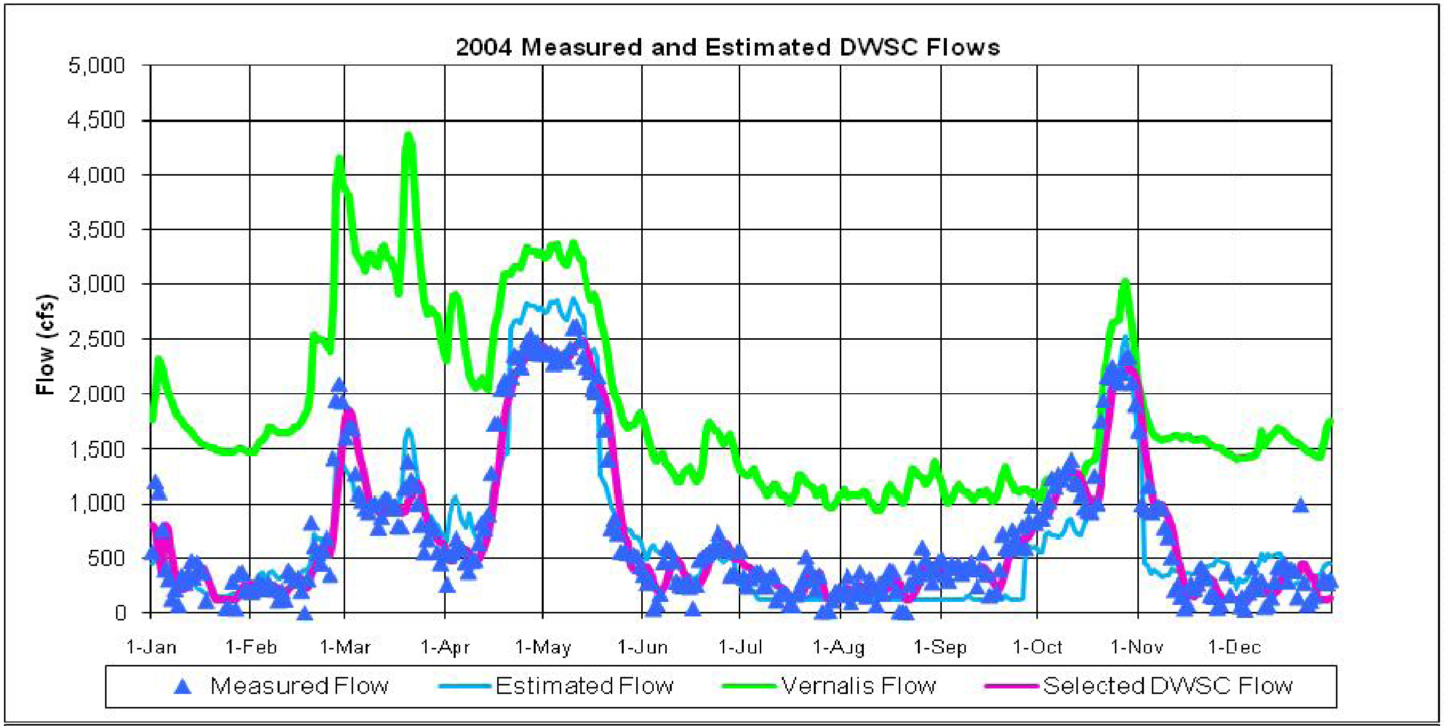
The RWCF nitrification facility has converted all of the ammonia-N to nitrate-N since 2007. The nitrate-N represents the ammonia that was eliminated (credit).



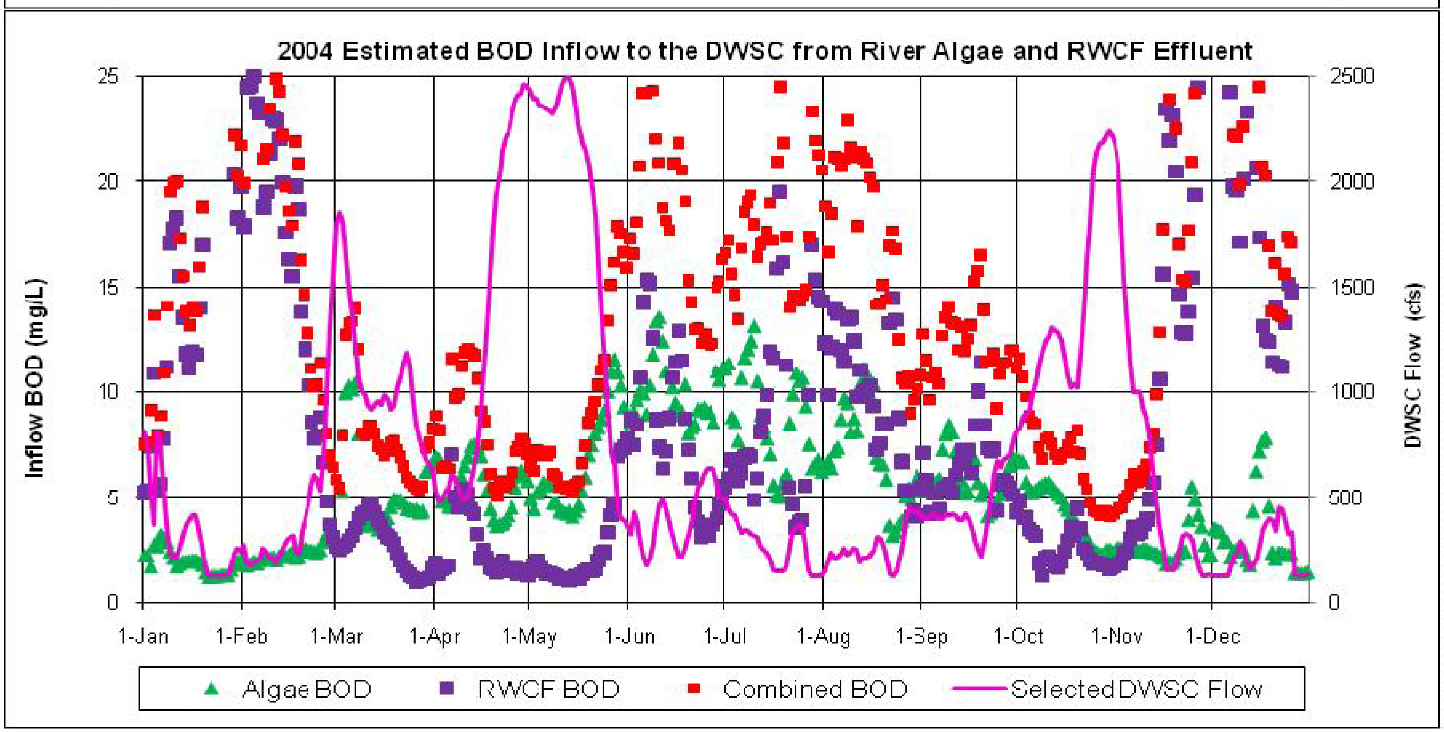


The daily DO range at Mossdale appears to be correlated to the algae biomass and pigment concentration (and fluorescence).

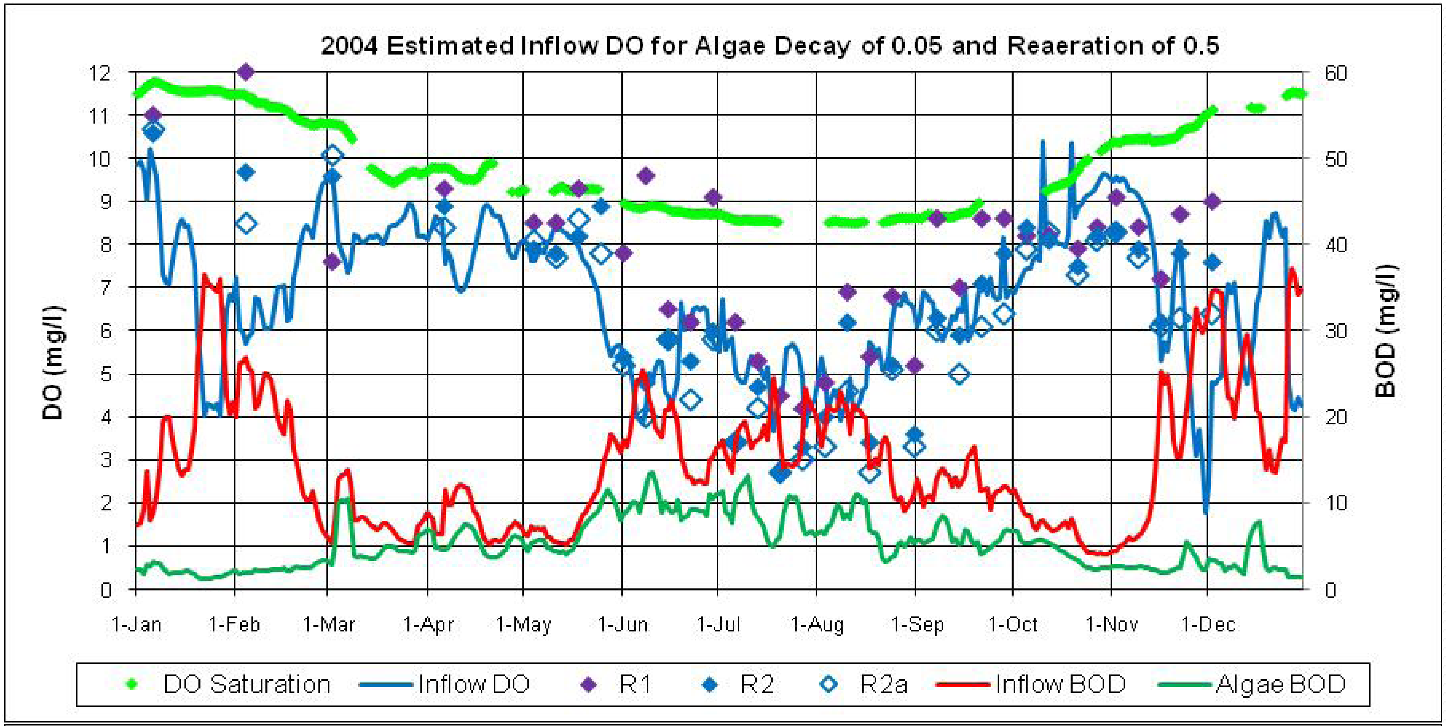
UC Davis data suggest that 1 mg/l daily DO range is equivalent to about 25 µg/l of algae pigment and 2.5 mg/l of BOD.



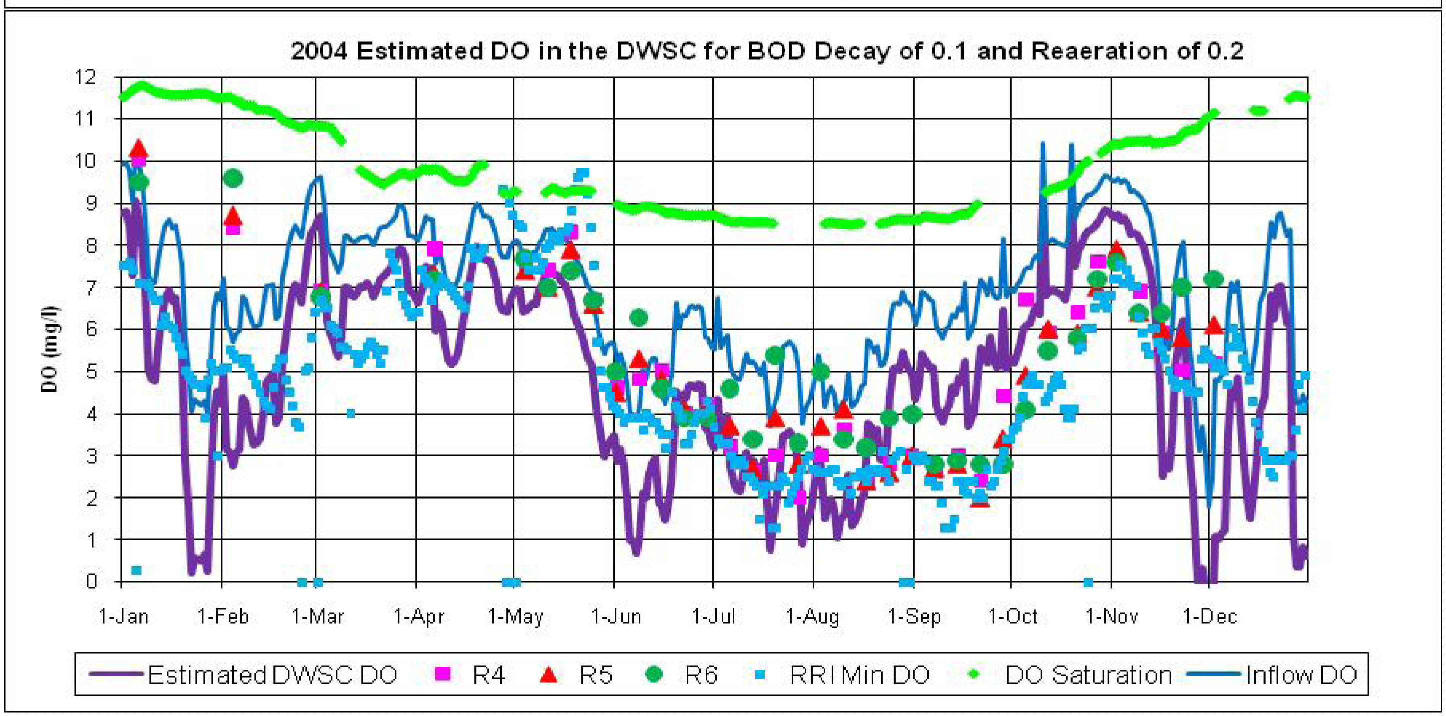
SJR Flow is important for river algae; DWSC flow is important for transporting algae to the DWSC and for dilution of the RWCF effluent



Algae BOD and RWCF BOD are both high during low flows in the summer. Ammonia BOD can be high in the winter with low flows



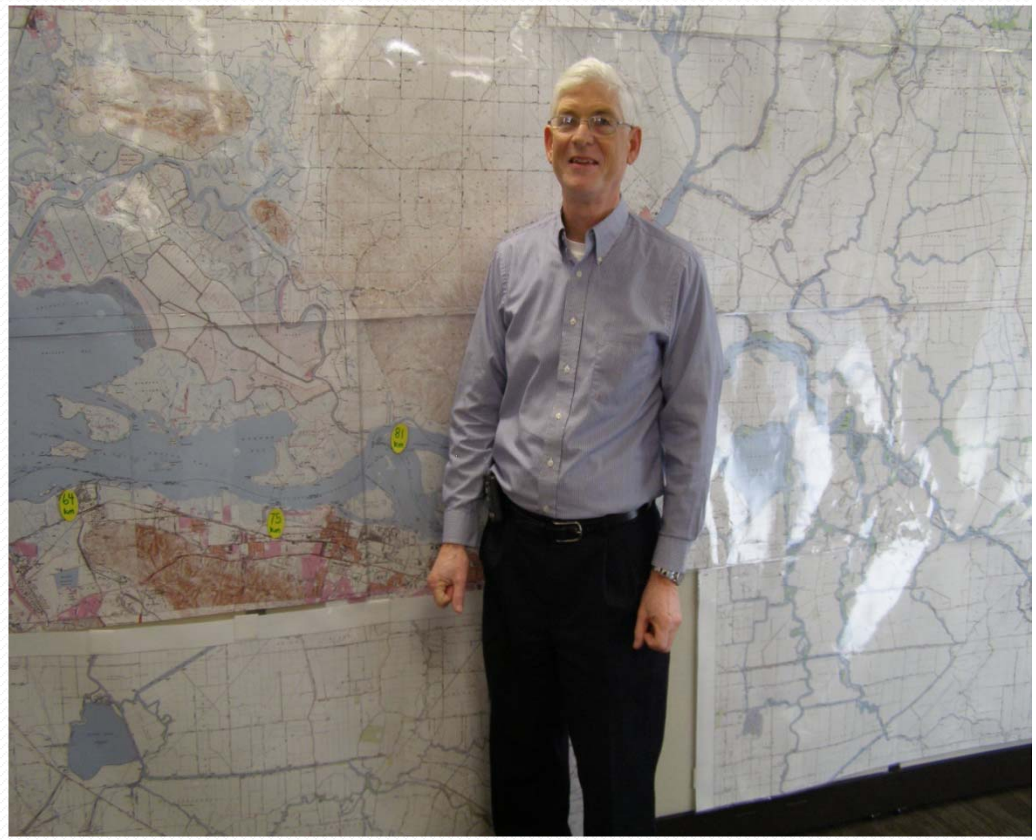
Estimated inflow BOD (from river algae and diluted RWCF effluent and estimated inflow DO both look promising.



The estimates of inflow DO and 5-day (minimum) DO with a BOD decay of 0.1 per day appear to match the daily minimum DWSC DO data at RRI

“The highlight of my working year is coming to Asilomar and talking with you!”

- We talk the same languages (data, equations, relationships, graphs)
- We share “new views” of the world with each other
- We understand that we know very little about water or fish or …
- We think and share and work together too help protect and manage California’s natural and developed water resources



“I am ready for 20 more years of daily modeling with you!”