

On University of California, Davis Letterhead

June 26, 2000

Dr. P. W. Lehman
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Department of Water Resources
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Dear Peggy:

It was a pleasure to meet with you and the other study participants and peer reviewers to discuss the CALFED San Joaquin Dissolved Oxygen Study. As requested I have reviewed the reports and work plans you have provided, and have prepared the enclosed summaries of my reflections on the study. I hope they will be useful in your planning for the next phases of the study.

As you will note, I have enclosed some general comments on the project, and also the evaluation I previously provided on Dr. Litton's studies of sediment oxygen demands. I've corrected a few typos in the latter and added a brief conclusion.

I would still like to review Carl's model in greater depth, but will need a copy of its documentation. I am concerned that the model may need some significant improvements in order to serve as a useful tool in evaluation of future strategies for DO management.

Please let me know if I can be of further assistance.

Sincerely,

Gerald T. Orlob
Professor Emeritus
Civil and Environmental Engineering

SAN JOAQUIN RIVER TMDL STUDY PEER REVIEW

MEETING OF JUNE 20-21, 2000

G. T. Orlob, PhD, PE
Peer Review Panelist

Scope and Intent of Review

The following comments are based on presentations made by project participants in the San Joaquin River TMDL Study, supported by draft reports on study activities to date. They are intended to be constructive, suggestive of topics in need of clarification in draft reports or that might need to be addressed in future field and laboratory investigations. The reviewer accepts full responsibility for his comments, including errors or misinterpretations.

This portion of the review generally follows the sequence of discussions in the peer review meetings of June 20-21, 2000 supplemented by draft progress reports. A draft summary report "Sediment Oxygen Demand, Sediment Deposition Rates and Biochemical Oxygen Demand Kinetics" that was reviewed in preparation for the meetings is attached. Comments are as follows:

Scope and Intent of the Project

It appears that the "project" has two major goals and several minor goals. The first major goal is to characterize quantitatively the fundamental physical, chemical and biological properties of the hydrologic/hydrodynamic system in order to ascertain the system's response to specific compliance measures, e.g., reductions in TMDLs. The second major goal is to determine how to use this knowledge of system behavior in order to determine the net reduction in TMDLs that would have to be achieved by future adaptive management alternatives to assure compliance with dissolved oxygen standards for the San Joaquin River in the reach encompassing the Stockton Deep Water Ship Canal and turning basin. Additionally, a number of specific research goals would have to be reached in support of quantitative description of the system, e.g., kinetic coefficients required for modeling.

Quantifying System Behavior

The San Joaquin River in the vicinity of Stockton, specifically the reach extending from Mossdale to Prisoner's Point, including the Port of Stockton deep water turning basin, is influenced hydrodynamically by both tides and runoff from the basin upstream of Vernalis. It is an unsteady system, experiencing large fluctuations in velocity and water level over the tidal cycle and significant variations in net flow, both in the upstream and downstream directions. At times of low net inflow from the basin upstream the net flow passing Stockton may actually be landward. These fluctuations in hydrodynamic properties of the river strongly influence mixing processes that in turn determine the distribution of oxygen demanding substances.

Also, while the system experiences large variations in hydraulic properties along the principal axis

of flow, there are significant variations in water quality both longitudinally and vertically that influence its hydrodynamic behavior. Although lateral variations in water properties are probably not of great significance in estimation of DO, both longitudinal and vertical distributions of hydrodynamic and water quality properties are prime considerations. In this reviewer's opinion the system should be characterized as vertically stratified, i.e., as two-dimensional. Preliminary evidence from the field supports this argument. Significant vertical variations are evident in dissolved oxygen, suspended sediment, dissolved and particulate organics, SOD, light intensity, salinity, and fluid density. More detailed spatial and temporal quantification is needed.

Boundary Conditions

Aside from the hydrodynamics of the system, transport and distribution of oxygen demanding substances are strongly influenced by the magnitudes and locations of sources and sinks of water entering and leaving the main channel of the river. Unfortunately, many of these cannot be directly monitored, such as those associated with irrigated agriculture along the river. The significance of these should be assessed in future sensitivity analysis using appropriate modeling of hydrologic fluxes and mass balances. A specific concern expressed by another peer reviewer is the role of seepage through levees along the river channels, both in water balance and nutrient loading of the system. DWR can provide useful information on locations of diversions and drainage returns and some estimates of amounts.

It should be appreciated that field observations to date have been under abnormal hydrologic conditions, i.e., high runoff from the San Joaquin basin upstream, several times greater than recorded in recent drought years at the Vernalis gage. Thus, water quality observations at these times are likely not representative of the most stressful conditions likely to be experienced.

Modeling the System

It is important to acknowledge *a priori* that no model is an exact replica of the system and that any model's principal role, once it has been calibrated against field observations, is one of discriminating between alternatives. The process of applying the model in the assessment of TMDL management alternatives for the San Joaquin River requires the establishment of a credible data base from field observations. In this case careful description of vertical as well as longitudinal variations in the flow field and affected water quality parameters is required.

The modeling process should include calibration against the most credible data set, sensitivity testing of important model coefficients and assumptions, e.g., numerical analysis assumptions, and validation against an independent set of field data. Caution should be exercised to assure that the data sets correspond to conditions most likely to represent reasonable tests of feasible TMDL management options.

The model should be updated to provide the best possible characterization of vertical distributions of parameters and variables that may affect dissolved oxygen balances. Specific attention should be given to vertical variability in DO, SS, turbidity, light intensity, and phytoplankton, and other constituents that are not uniformly distributed in the water column. The trade-off between empirical representations of

reaeration fluxes and sediment oxygen demand should be addressed by sensitivity testing or by direct measurement of benthic oxygen demand. In the absence of direct measurements of oxygen fluxes at the water surface and the bottom, calibration of the model may be largely a matter of adjusting uncertain coefficients. Field studies should include some direct measurements of SOD.

The model presently being used is a successor of the Link-Node models developed originally in the 1960s by WRE (Water Resources Engineers) in connection with San Francisco Bay-Delta Water Quality Management studies. It has since been adapted by Systech for study of the Stockton Ship Canal, incorporating some new routines intended primarily to overcome a basic deficiency in numerical solution of the advection-dispersion equation in the water quality module. Numerical mixing that was inherent in the original model is now suppressed by adding a negative correction term to the equation. This numerical adjustment, although convenient, is not consistent with the hydrodynamics of the system which requires that dispersive mechanisms be related to local turbulence and advective transport be cast in a Lagrangian framework, i.e., in a moving coordinate system. A more hydrodynamically correct model that has these attributes is DWRDSM-Qual, developed by H. Rajbhandari for DWR. It has been adapted to the Delta system, but is not yet fully calibrated.

Conclusion

The San Joaquin River System in the vicinity of the Stockton Ship Canal and turning basin is fundamentally unsteady, driven hydrodynamically by tidal action imposed at the downstream boundary and hydrologic fluxes introduced at the upstream boundary and along the main channel. Water quality characteristics are also unsteady, variable on a diurnal and tidal cycle basis, but also in accord with seasonal hydrology. There is a need, already being partially addressed in this project, to define more closely the physical, chemical and biological properties of the system as they vary both spatially and temporally. This effort should be intensified in the interest of providing a sound basis for modeling.

From the modeling viewpoint, the system is best characterized as two-dimensional and unsteady. Important gradients in hydrodynamics and water quality occur along the principal axis of flow and in the vertical. The model needs to be further calibrated, validated and tested for sensitivities of coefficients and other assumed properties of the system, particularly as concerns the vertical distributions of water column characteristics that are treated in the model. The dispersive properties of the system, as they are approximated numerically in the model, should be critically assessed.

REVIEW OF DRAFT SUMMARY REPORT

SEDIMENT OXYGEN DEMAND, SEDIMENT DEPOSITION RATES BIOCHEMICAL OXYGEN DEMAND KINETICS

Prepared by

G. T. Orlob, Ph.D, PE
Peer Review Panelist

Scope and Intent of Review

The following comments are based on a draft report which is subject to future revision. They are intended to be constructive, suggestive of topics in need of clarification, either in the context of the report or in the course of future research and investigation. The reviewer takes full responsibility for his comments.

The review addresses issues as they are presented in the draft report, beginning with Executive Summary as page 1 and concluding with References as page 38.

Page 1

1. "Combined these measurements provide..." or "In combination these measurements provide..."
2. A reference should be cited for the so-called DWSC, if there is one
3. What is intended by "lateral variability of DO? Does this comment suggest that the DWSC is in reality a three-dimensional water body and that estimates of SOD require more detailed characterization of the hydrodynamics of this system?
4. Also, due to tidal action and water project operation the system is unsteady, i.e., steady state assumptions may be inappropriate. "Assuming steady-state conditions where the SOD is equal to the rate at which oxygen utilizing matter is settled multiplied by its associated oxygen demand.'

Page 2

1. Sediment resuspension is a dynamic process which may impose an immediate oxygen demand.
2. What is meant by "over-trapping"?
3. The abiotic demand will be exerted immediately following resuspension whereas the demand associated with microbial decomposition of organic matter may require a much longer period.
4. Actually, these demands are exerted continuously from the initiation of resuspension.

Page 5

1. Model calibration is a critical process that requires quantitative evaluation (formulation) of mixing and sediment suspension processes.
2. What are the hydrodynamic conditions that must be favorable to estimate the SOD from profiles? Does this imply that only steady state conditions are appropriate for this estimation? If so, we may be missing the most important dynamic parts of the suspension and resuspension processes.

Page 6

1. The legend identifying monitoring locations is incomplete.

2. Stations upstream of Stockton in the San Joaquin river are conspicuous by their absence. Data at such locations will be essential for establishing boundary conditions for modeling.

Page 7

1. Is the reason that no water samples were taken in November a consequence of the time required to do this while recording DO profiles? Why not employ a continuously recording DO probe?
2. What is the “upper limit of possible SOD values”?
3. Domination of near-sediment DO levels by tidal flows reinforces the notion that the system is highly dynamic and three-dimensional.

Page 8

1. Figure 2 could be made more general by contrasting DO profiles (perhaps actual observations) over a more explicit period of time than the beginning and end of the slack tide event. The slack period is too poorly defined to serve as basis for estimation of SOD.
2. By accident Figure 4 which is referenced in the text is not a depiction of DO profiles but rather a display of pH observations. The figure does, however, provide some interesting information, e.g., lower pH values near the bottom (possibly related to anoxia deeper in the sediments) and higher pH values near the surface in a few profiles (possibly related to photosynthesis).

Page 9

1. Figure 3. It would be useful also to have profiles of temperature, DO saturation and salinity for this period of observation.

Page 10

1. Figure 4. Again, this figure shows pH profiles rather than DO profiles as intended.

Page 11

1. This is an interesting figure that suggests a period of significant vertical mixing evidenced in the nearly uniform DO values top to bottom and tidally related oscillations (especially in the lower 15 feet or so) during the HL tidal period.

Page 12

1. Reference is made to high DO concentrations in the San Joaquin River, but no data are given. Conditions in the San Joaquin may well dominate those of the DWSC, especially during the later months of the year when flows from upstream sources are much increased, over conditions earlier in the year when DO conditions might be most critical. The recorded flow at Vernalis on November 6, 1999 was about 2473 cfs, significantly above the minimum of about 500 cfs that may be experienced during some critical drought periods. It is important to recognize also that diversions for agriculture along the reach between Vernalis and the DWSC may actually cause reversal of flow directions in the vicinity of the DWSC.
2. Where are the “relatively high DO concentrations measured in the San Joaquin River...”
3. “hydrodynamics and spatial variability of DO concentrations appeared to strongly mask SOD effects on water column profiles.” It is acknowledged that “reliable estimates of SOD were not possible with the profile presented..”
4. The configuration of sediment traps should be described with sketches. How were these traps oriented in the water column and with respect to the flow?

Page 13

1. The procedure for estimation of SOD conforms to standard practice.

Page 14

1. Units for trapping rates should be stated explicitly in Table 2 and elsewhere grams/square meter/hour?
2. Depth of water column should be stated.

Page 15

1. 84,490? What is this number?

Page 16

1. Data Indicate that between Channel Pt and Light 45 ????? is significant...

Page 17

1. "The data suggest that the microbial population was not acclimated to degrade the volatile organic fraction of the sediment.

Page 18

1. Agreed that the approach to estimate SOD is limited. The approach fails to account for both spatial and temporal variations in the hydrodynamic regime that in turn determine the fate of suspended, deposited and resuspended sediments.

Page 19

1. Although not stated, it is assumed that all reaction rate coefficients were referenced at a standard temperature, e.g., 20 degrees C. This should be indicated where these rate coefficients are cited.

Page 20

1. Were samples analyzed for DO actually filtered to remove SS before analysis? Were samples containing sediment agitated during incubation?

Page 21

1. What is meant by "shallow"? What are the dimensions of a typical core?

Page 24

1. Tidal flows in the San Joaquin do tend to increase on the average toward the ocean but this does not mean that velocities also increase proportionately, since the channel geometries also change. In general, maximum velocities of the order of 2-3 fps are reached in most channels. Occasionally local velocities up to 4 fps can be observed. These are sufficient to result in periodic scouring with intermediate low velocity periods when deposition can occur. In recent years sediment deposition in the Southern Delta has greatly modified channel geometries, velocities and deposition rates. It can be expected that water quality and ecological factors will also be modified.

Pages 25-29

1. Overall, laboratory procedures and interpretations conform to standard practice. Agreed that NBOD results are still questionable. This may be troublesome in modeling, particularly where oxidation of ammonia is a likely process impacting DO balance. Ammonia may not be a factor in well-oxidized effluents from waste water treatment facilities. However, it could result from decomposition of benthic organics. I [it] could account for depression of DO in the water column

near the sediment-water interface.

Pages 30-37

1. Laboratory results plotted and tabulated. Satisfactory

References

1. Add specific references to model documentation and application.