Recalibration of DSM1 (Suisun Marsh Version)

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In November 1996, the CALFED Bay-Delta Program asked the DWR Suisun Marsh Branch to recalibrate the Delta Simulation Model in response to concerns that it was not adequately calibrated with available flow data. An effort is ongoing to create a new public domain one-dimensional delta model, calibrated to the flow data. The purpose of the recalibration is to address concerns about DSM1 while, in coordination with the Interagency Program's Delta Model Project Work Team, continuing progress toward a new Delta model. As the need for modeling CALFED alternatives approached, it was intended that all the available models would be evaluated and the best model would be used for EIR alternatives evaluation.

Two versions of the Delta Simulation Model (DSM1) have emerged. The State Water Project Planning Office uses a version optimized for delta planning, and the Environmental Services Office uses a version optimized for Suisun Marsh planning and forecasting. A goal of the recalibration was to obtain improvements amenable to both versions.

At the outset, five objectives were identified for recalibrating the Delta Simulation Model.

- Facilitate an open discussion by providing full disclosure of the calibration process and opportunity for comment from interested parties.
- Update the model channel descriptions based on a recently developed bathymetry database.
- Improve the flow calibration based on recent flow data collected by the USGS.
- Improve the salinity transport calibration based on salinity monitoring data.
- Merge calibration and geometry improvements to the SWP Planning Office version of DSM1.

A final report has been completed and submitted to CALFED covering each objective in detail. In addition, the report discusses limitations of the model, bathymetry data, and flow data, and contains recommendations for further data collection and model development. The report is available from the CALFED Bay-Delta Program. Following is a brief summary of the report.

Outreach on Recalibration Progress

The catalyst for the recalibration effort originated primarily from agency personnel outside of DWR who are involved with hydrodynamics data collection and numerical modeling of the bay/delta system. Since the intent of CALFED staff is to be responsive to concerns regarding the efficacy of analysis tools, an emphasis on outreach about recalibration methodology and progress was considered essential.

Also, there is a wealth of modeling and field experience within the larger community of bay/delta scientists and engineers. By providing easy access to recalibration results and opportunity for constructive feedback, we believe that the outcome of this effort was improved.

In general, a level of confidence was established among modelers and non-modelers alike in the ability of the recalibrated model to provide reasonably accurate results for evaluating proposed alternatives. By providing an open atmosphere for monitoring and feedback, the credibility of the recalibration process was enhanced.

Outreach for DSM1 recalibration was specifically accomplished using three approaches: First, an *ad hoc* multi-agency recalibration team was created to peer review the geometry reevaluation and recalibration process. Second, an email reflector was established to facilitate updates and open discussion on recalibration issues (dsm1cal@water.ca.gov). Third, a Web site was established to share recalibration progress through plots, meta data, and background documents. Over 3,000 plots of field data and model flow, stage, and salinity results are available for viewing in time sequenced order. The Web site is available from the IEP home page at www.iep.water.ca.gov.

DSM1 Geometry Revision

The objective of the geometry revision project was to update channel geometry descriptions by applying a systematic approach and using the best available bathymetry data.

Before the revision, DSM1 channel geometry was determined primarily from National Oceanographic and Atmospheric Administration navigation charts, which contain scattered point estimates of channel depth relative to local mean lower low water level. Limited field cross section data were also used. It has long been suspected that the overall volume of the delta represented by the previous geometry could be significantly in error. Further, evidence was building within the bay/delta modeling community that model performance could be improved with increased geometry accuracy.

In response to the perceived need, the DWR Modeling Support Branch developed a bathymetry database from sources of channel bathymetry data including DWR, USGS, NOAA, and USCOE. All data were identified by source agency and year of collection and converted to a common horizontal (UTM Zone 10) and vertical (NGVD, Golden Gate) datum. In addition, a contract was let to a private consultant to create a Bathymetry Data Display software package capable of providing plan and down-channel views of the data, along with measurements of channel characteristics including segment length, cross-sectional area, top-width, wetted perimeter, and volume. The bathymetry database, and the BDD program were used extensively in the geometry revision process.

A total of 558 channels were revised by virtually "surveying" more than 1,000 cross sections. The total length of channels in the DSM1 grid remained nearly the same, but total volume of the system below NGVD mean lower low water was reduced by about 22%.

Although the geometry revision project is considered fundamental to the success of the DSM1 recalibration effort, it is also a valuable product in its own right. It represents the culmination of efforts by the DWR Modeling Support Branch and Suisun Marsh Planning Section to organize and integrate more than 400,000 data points from multiple agencies into a consistent format, to develop specialized software making it possible to analyze and manipulate the data, and to represent the field bathymetry data as cross sections amenable to DSM1 model input. The results are useful beyond DSM1 to other activities requiring bay/delta channel geometry information. As such, stand-alone documentation of the geometry revision has been prepared on CD-ROM and is available upon request.

DSM1 Suisun Marsh Version Hydrodynamics Recalibration

This project was motivated by a growing concern that the DSM1 model was not adequately calibrated with recent USGS flow data. As such, the hydrodynamics recalibration effort comprised the heart of the overall recalibration project.

The primary goal in the choice of hydrodynamics calibration periods was to exercise the model under a range of flows and structural/operational conditions. A constraint on choosing the calibration period was the need to match the periods to times when flow data were available. Three historical periods of 10-14 days in May 1988, January 1993, and May 1994 were chosen for the hydrodynamics calibration. The three periods represent a diversity of rim flow hydrology, structural configuration, and operational scenario.

In its simplest form, the calibration process attempts to match model flow, velocity, and water level time-series output to field data. For each calibration period, the known historical Golden Gate boundary tide, river inflows, agricultural depletions, precipitation, water project exports, and structural configurations are input to the model. Repeated model runs are made with incremental adjustments to model coefficients controlling the magnitude of channel friction until an adequate match is achieved between field and model flow, velocity, and water level data.

The hydrodynamics calibration parameter, called Manning's n, accounts for channel bed friction under conditions of uniform flow. The equations underlying the DSM1 model allow for non-uniform, unsteady flows. Therefore, lumped into Manning's n are all physical factors not explicitly included in the governing equations, along with all errors in the geometrical description of the system, and all errors in the input hydrology and structural configuration data. An example of physical factors not included in the equations is the baroclinic pressure gradient between regions of relatively salty and fresh water. An example of errors in the geometrical description of the system is the requirement for cross section uniformity along the length of each channel in the model grid. Finally, input data errors are exemplified by the uncertain nature of agricultural diversion and drainage magnitude, timing, and distribution.

More than 50 hydrodynamics calibration runs were conducted. To organize and document the process, an automated input system was developed. Manning's n changes in a given group were made in a "meta file" to centralize and simplify the procedure. The meta file was, in turn, used as input to a preprocessing program that automatically modified the directory structure, moved files, generated a run-time batch file, and distributed the group Manning's n changes to the member channels of the group. The meta file also included space for logging the run number, date, and changes made in each run. This provided a living history and complete documentation of decisions made during the calibration.

In general, the calibration proceeded from the west (at the Golden Gate) to the east into the delta and up the Sacramento and San Joaquin rivers. The goal was to propagate tidal energy, as represented by wave phasing and amplitude, as accurately as possible. Of particular importance upon entering the delta was balancing the division of tidal energy between the lower San Joaquin and Sacramento rivers. In this regard, the intervening influence of the connecting channels, Broad Slough, Sherman Lake, and Threemile Slough was evident.

Decisions about how to proceed at each step of the calibration were made by visual comparison of 15-minute time-series field data and model output for 27 flow and 42 stage monitoring locations. In addition, scatter plots of field versus model stage were produced along with regression statistics as a systematic measure of goodness-of-fit. Finally, 24.75-hour average flows were produced for locations with continuous field flow data.

Figure 1 is an example of the final hydrodynamics calibration results for several western delta locations for the May 1988 calibration period. The calibration Web site contains plots for all three calibration periods and all calibration trials. Outputs include 15-minute flow and stage plots, 1-hour salinity plots, stage scatter plots, tidally averaged flow plots, and index acceleration plots.

Many trends and tendencies were observed during the recalibration process. Some observations on the importance of Threemile Slough are offered here. The CALFED report contains additional observations, and the DSM1 calibration email reflector remains available for comments.

Threemile Slough has long been considered a key hydrodynamic connection between the lower Sacramento and San Joaquin rivers, yet there is little specific understanding of how it works. The slough conducts large tidal flows, especially on flood tides, because the flood wave arrives sooner at the Sacramento side than the San Joaquin side. This exchange of tidal flow on the flood tide accounts for most of the net flux of water from the Sacramento River to the San Joaquin River through Threemile Slough.

Similarly, Sherman Lake and Broad Slough play an unknown but likely important role in Sacramento-San Joaquin hydrodynamic connectivity.

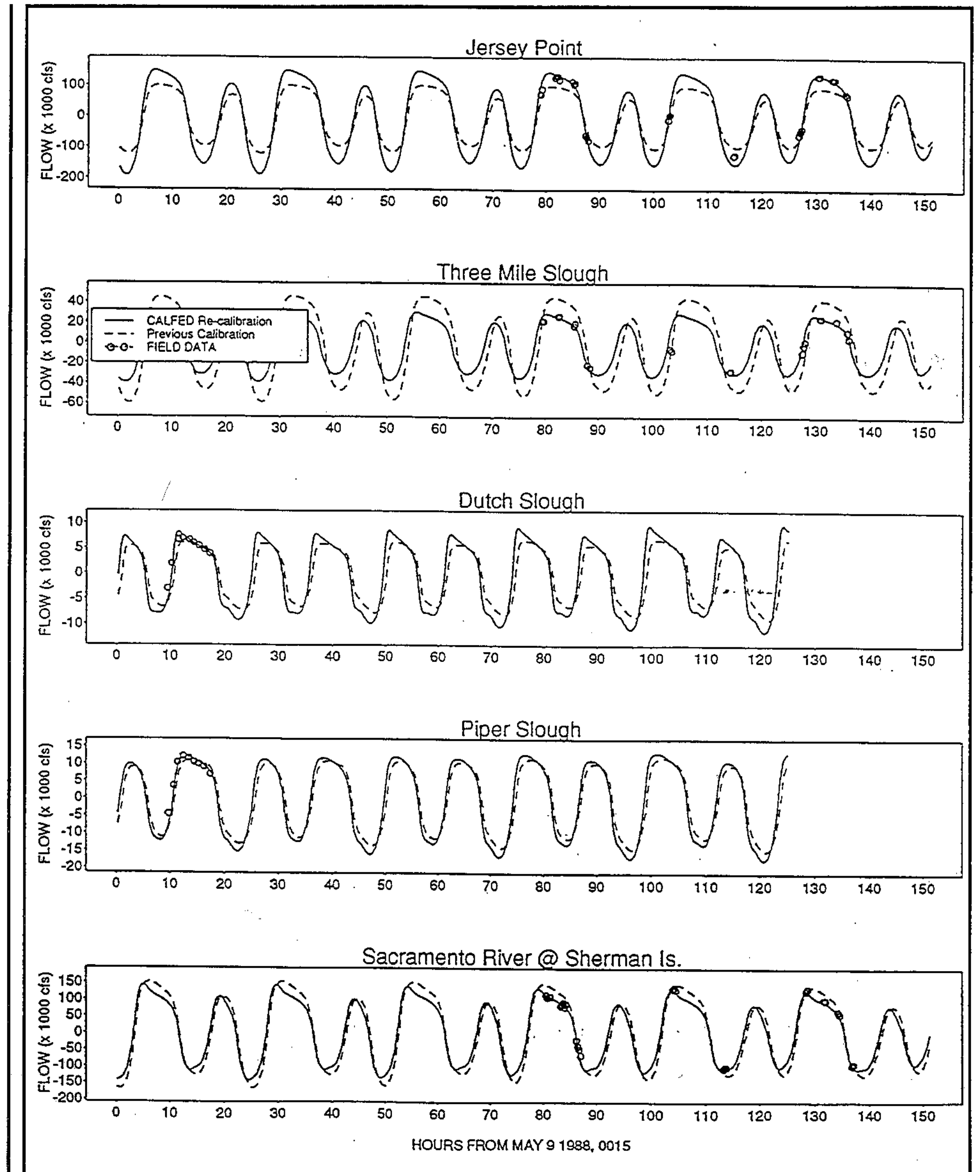

Figure 1
CALFED DSM1 RECALIBRATION VS. PREVIOUS CALIBRATION, MAY 9-15, 1988

However, bathymetry information is uncertain for both areas, and little is known about the geometry of Sherman Lake river connections. Several sensitivity runs indicated that modifications to Sherman Lake and Broad Slough bathymetry had a significant effect on regional flow patterns.

Recalibration of the DSM1 Salinity Module

The focus of the recalibration effort was to improve the hydrodynamics response of the DSM1 model using the latest USGS flow data. Since the salinity transport capability of the model is part and parcel of the flow field response, the transport coefficients of the model also required adjustment. The salinity module was calibrated, although additional work will be done soon in the Suisun Marsh region and results will be reported in the future.

Recommendations

The recalibration effort represents a significant improvement in accuracy of the DSM1 model. However, numerical modeling of complex hydrodynamic systems can always be improved as numerical formulations advance and field data are collected. We suggest that an interagency modeling team should be maintained to provide peer review of agency modeling efforts and guide resource allocation decisions intended for model improvements. The Delta Model Project Work Team is currently serving this role.

Based on experience gained during the recalibration effort, we recommend that the project work team consider the following actions.

Monitor Connection Channels between the Sacramento and San Joaquin Rivers

Tidal flow and salinity in the western delta is sensitive to the geometry of Threemile Slough, Sherman Lake, and Broad Slough. Recently, much attention has been given to Threemile Slough geometry and flow measurement. Sensitivity analysis on the relatively uncertain geometry of Sherman Lake and Broad Slough indicates that these connections are important energy and mixing conduits. Emphasis should be put on these locations in future bathymetric and flow measurement surveys.

Measure Franks Tract Geometry

Due to its size and central location, Franks Tract may play an important role in buffering flow and salinity in the central delta. Field data suggest that tidal day average salinity concentrations are rather level in the area just east and south of Franks Tract. Sensitivity analysis with the model suggests that modifying Franks Tract geometry, especially with regard to the geometry of openings in Franks Tract levees, has a significant impact on area salinity. Franks Tract geometry should be emphasized in future bathymetric surveys.

Use Sacramento River Boundary Salinity

Future calibrations would benefit from obtaining historical salinity data for the upstream boundary. It may be necessary to use Greens Landing as a surrogate, because salinity data at Sacramento are not routinely collected. In this calibration, a constant 100 parts per million TDS was assumed. Salinity at Steamboat Slough and Walnut Grove indicates that Sacramento salinity can vary between about 80 and 130 mg/L TDS. We believe that this would improve results in the northern delta, and some insight into source water contributions would be available for stations farther downstream.

Compare Cross Section Average and Point Salinity Data

The annual report to SWRCB by the Delta Modeling Section of the DWR SWP Planning Office suggests there should be an investigation of cross section salinity variability compared to the routinely collected point measurement. As an example, the San Andreas salinity monitoring station consistently records lower salinity than models predict. Since the data are collected one meter below the surface near the shore of a shoaled area, and the Mokelumne River joins the San Joaquin River just upstream, it is possible that the cross section average salinity computed by the model would consistently deviate from the point salinity data.

Collect Accurate Clifton Court Forebay Gate Operations Data

The intake structure at Clifton Court Forebay consists of six radial gates operated on a tidal basis to pump water into the forebay. Gate operation times are input to the model. Currently, gate operation data are collected as date and time of gate opening or closing. In reality, the six gates are operated independently to regulate flow into the forebay. We suggest that gate operation data be collected independently for each radial gate. The model would require some modification to handle the more complex operation. However, given the importance of this structure to water levels and export opportunities, accurate simulation is essential.

Resurvey the Delta

The bathymetry database used for the geometry revision is extensive, containing more than 400,000 point coordinates. However, much of the data is outdated, some collected 60 years ago. Although a moveable bed is a physical feature of the system, a more up-to-date dataset would improve model accuracy. Experience of various modeling groups working on the bay/delta system indicates that accurate geometry is an essential precursor of accurate models. An effort to resurvey Suisun Bay is being considered by USGS. An extension of this effort to the Sacramento-San Joaquin Delta, Suisun Marsh, and San Francisco Bay should also be considered.

New Salvage Data Management Biologist at DFG

Jane Arnold will take over Scott Barrow's old position on October 13th. Scott transferred to the Ocean Salmon Program in the DFG Marine Resources Division headquarters in Sacramento to expand his experience and return to marine-oriented biology. We wish him well. Jane came from the Young Fish Investigations Program at the DFG Bay-Delta Division, where she ran the Midwater Trawl Survey under Lee Miller's supervision and gained considerable SAS and PC database experience that will be useful in her new position. We welcome Jane and congratulate her on her promotion to Associate Biologist.