**Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh**

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# Chapter 3
# DSM2 Dissolved Organic Carbon Boundary Condition Improvement

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# Contents



## Figures



## Tables

# 3 DSM2 Dissolved Organic Carbon Boundary Condition Improvement

## 3.1 Summary

The Municipal Water Quality Investigations (MWQI) group conducted a 15 month, biweekly sampling program to acquire representative dissolved organic carbon (DOC) data for the Yolo Bypass and the East Side Streams (Mokelumne, Cosumnes, and Calaveras Rivers).

Previously, little data for organic carbon concentrations was available for the East Side Streams and the Yolo Bypass near the Delta boundary. Historical Delta Simulation Model II (DSM2) simulations of DOC concentrations in the Delta relied on assumed boundary conditions based on surrogate data. The current sources of the surrogate data used for generating the East Side Streams and Yolo Bypass boundary conditions for DOC are the Sacramento and American Rivers, and the Delta Island Consumptive Use (DICU) model.

In this chapter, the DOC data collected from the East Side Streams and Yolo Bypass are summarized and comparisons are made between the collected data and the assumed boundary conditions of the DSM2. Based on these comparisons, the assumed boundary conditions for DOC concentrations may underestimate concentrations during high flows.

## 3.2 Methods

### 3.2.1 Sites

Samples were collected at (1) Shag Slough at the Liberty Island Bridge to represent the Yolo Bypass, (2) the Mokelumne River at Wimpy's Marina in Walnut Grove to represent both the Cosumnes and Mokelumne Rivers, and (3) the Calaveras River in Stockton (Figure 3-1). The corresponding DSM2 segment or node is listed by station in Table 3-1 as is the Water Data Library (WDL) station number.

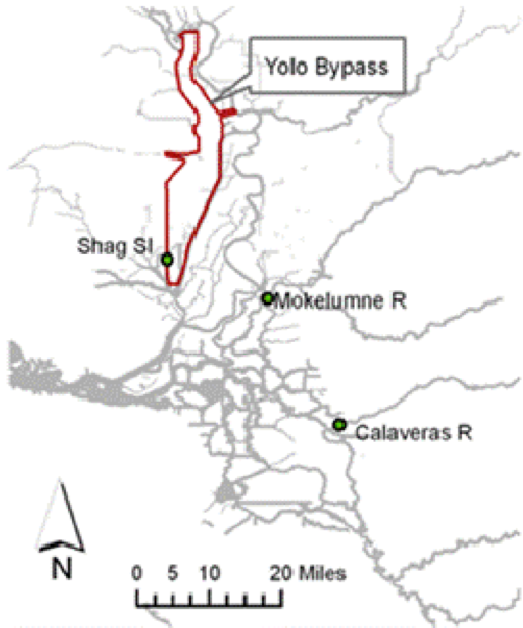



**Figure 3-1 Sampled Delta boundary stations**

**Table 3-1 Water Data Library station numbers and the corresponding DSM2 geometry by location**

| Location | WDL station number | DSM2 geometry |
|---|---|---|
| Shag Slough (Yolo Bypass) | B9S81841416 | Segment 401 |
| Mokelumne River | B9D81371295 | Segment 336 |
| Calaveras River | B9D75851208 | RCAL009 |

### 3.2.2 Sample Collection and Analysis

Grab samples were collected biweekly from December 2008 through March 2010. In the 2010 water year, additional samples were taken during significant storm flows to better capture the elevated DOC concentrations that typically coincide with storm flows. Storm flow event samples were collected after an estimated peak in storm flow. Bryte Laboratory conducted analyses for organic carbon concentrations using standard method 5310D, chemical oxidation, on an OIC 1010 analyzer. The dissolved fraction was the filtrate that passed through a 0.45 µm filter prior to analysis.

### 3.2.3 Comparisons

DOC concentrations from this study were compared to their respective assumed boundary condition for DOC concentrations used in DSM2 simulations. The DOC boundary conditions are outlined in the Department of Water Resources' Bay-Delta Office annual progress reports on DSM2 methodology (Suits 2002) (Pandey 2001).

*Yolo Bypass*

When flows in the Yolo Bypass are greater than 50 cfs, DSM2 assumes that Yolo Bypass DOC concentrations are equivalent to those of the Sacramento River. All samples collected from December 2008 through September 2009 occurred when Yolo Bypass flows were greater than 50 cfs. Dayflow data were not available for the Yolo Bypass for the October 2009 through March 2010 period when this report was authored; for this period, it was assumed that flows were greater than 50 cfs. Data collected from the Sacramento River at Hood (Hood) during the study interval were used to represent an assumed high-flow (> 50 cfs) boundary condition for DOC in the Yolo Bypass.

*Mokelumne and Cosumnes Rivers*

Based on visual examination, DOC concentrations from the Mokelumne River were divided into a high observed DOC group (> 4 mg/L) and a low observed DOC group (< 4 mg/L). All DOC concentrations greater than 4 mg/L were associated with high flows. The high observed DOC group was compared to the early winter high flow DOC boundary condition assumption of 3.95 mg/L. The low observed DOC group was compared to the assumed base flow boundary conditions of 1.74 mg/L for the wet season (November through May) and 1.66 mg/L for the dry season (June through October). Flow data for the Cosumnes River at Michigan Bar were used to represent flow in the Mokelumne River at Wimpy's Marina.

*Calaveras River*

The existing documentation on DSM2 methodology does not explicitly state the assumed boundary conditions for the Calaveras River; therefore, data for the Calaveras River were not compared to an assumed boundary condition. The collected DOC data are presented as a time series along with flow and precipitation data. Flow data used to represent Calaveras River were from the head of Mormon Slough. Outflow data for the New Hogan Reservoir were considered inappropriate because they did not capture the storm flow dynamics of the lower Calaveras River.

*Hydrological Data*

All rainfall data and flow data for the Cosumnes and Calaveras Rivers were obtained online from the California Data Exchange Center (http://cdec.water.ca.gov/). Flow data for the Yolo Bypass were obtained from Dayflow (http://www.water.ca.gov/dayflow/). Flow data are presented graphically as daily averages in thousand cfs. Rainfall data are presented as daily totals in inches.

## 3.3 Results

Descriptive statistics for DOC concentrations from the study locations are summarized in Table 3-2.

**Table 3-2 Statistics for DOC concentrations (mg/L) at boundary locations, Dec 2008—Mar 2010**

| Location | mg/L | | | | n |
|---|---|---|---|---|---|
| | Min | Max | Mean | Median | |
| Shag Slough (Yolo Bypass) | 3.3 | 9.7 | 5.6 | 4.9 | 35 |
| Mokelumne River | 1.3 | 9.4 | 3.0 | 2.2 | 38 |
| Calaveras River | 3.3 | 18.7 | 6.5 | 5.0 | 35 |

*Yolo Bypass*

Storm flow responses in DOC concentrations were evident in a time series plot with flow and rainfall (Figure 3-2). Throughout the study period, DOC concentrations at Shag Slough were consistently greater than at Hood. The difference in mean concentrations between the 2 stations was relatively large, 3.3 mg/L (Figure 3-3). The relative percent difference in means was 83%. Daily average Yolo Bypass flow was greater than 50 cfs on 97% of the days between December 11, 2008, and September 30, 2009.

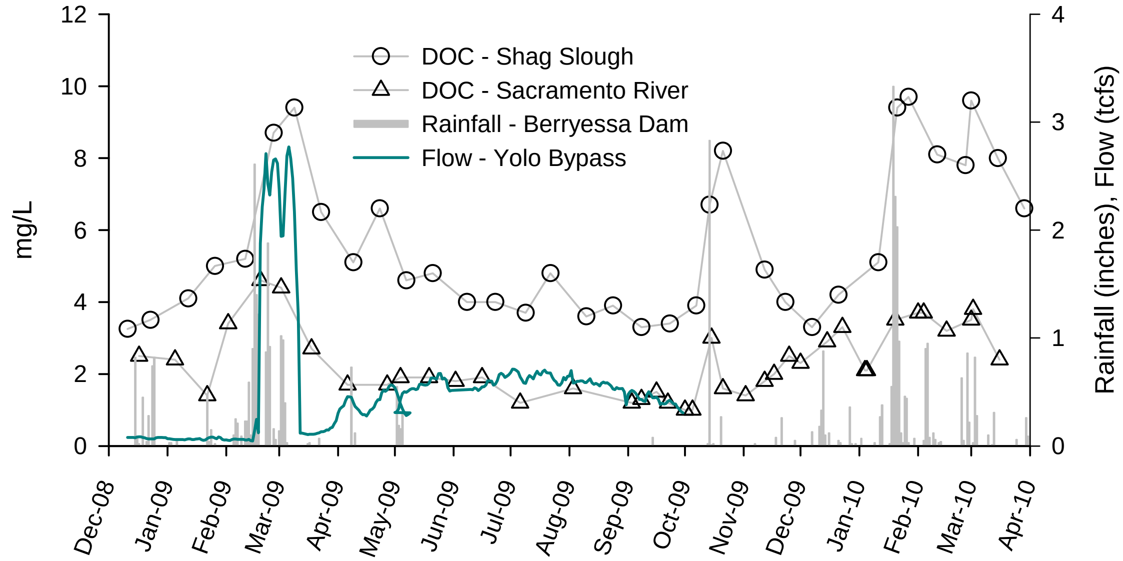
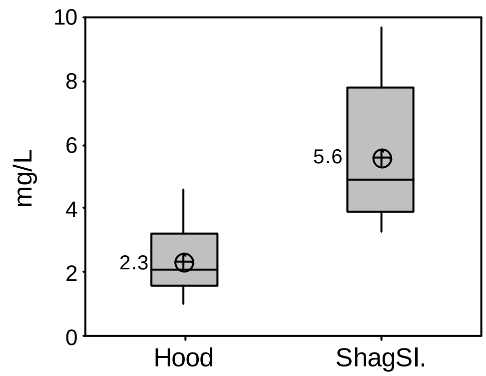



**Figure 3-2 Shag Slough DOC, Sacramento River DOC, Yolo Bypass flow, and rainfall**




**Crosshairs represent mean**

**Figure 3-3 DOC in the Sacramento River at Hood and Shag Slough, December 2008—March 2010**

*Mokelumne River*

The Mokelumne River DOC concentrations showed increases during storm flows that appeared to vary in the strength of the response (Figure 3-4). All DOC data over 4 mg/L were associated with increased flow and were grouped together as a high observed DOC group. All other values were grouped together to represent a low observed DOC group which includes concentrations that occurred during base flows and during low storm water flows. The mean of the high observed DOC group (6.07 mg/L) was 2.12 mg/L greater than the assumed early winter high flow boundary condition of 3.95 mg/L (Figure 3-5), a relative difference of 43%. The mean of the low observed DOC group (1.98 mg/L) was 0.32 mg/L and 0.24 mg/L greater than the assumed low flow boundary conditions for the dry season and wet season, respectively (Figure 3-6). These low flow differences were less than the 0.5 mg/L reporting limit of the analytical method for determining DOC concentrations (Calif. Dept. of Water Resources 2006).The relative percent difference between the assumed low flow DOC conditions and the mean of the observed low DOC group were less than 19%.

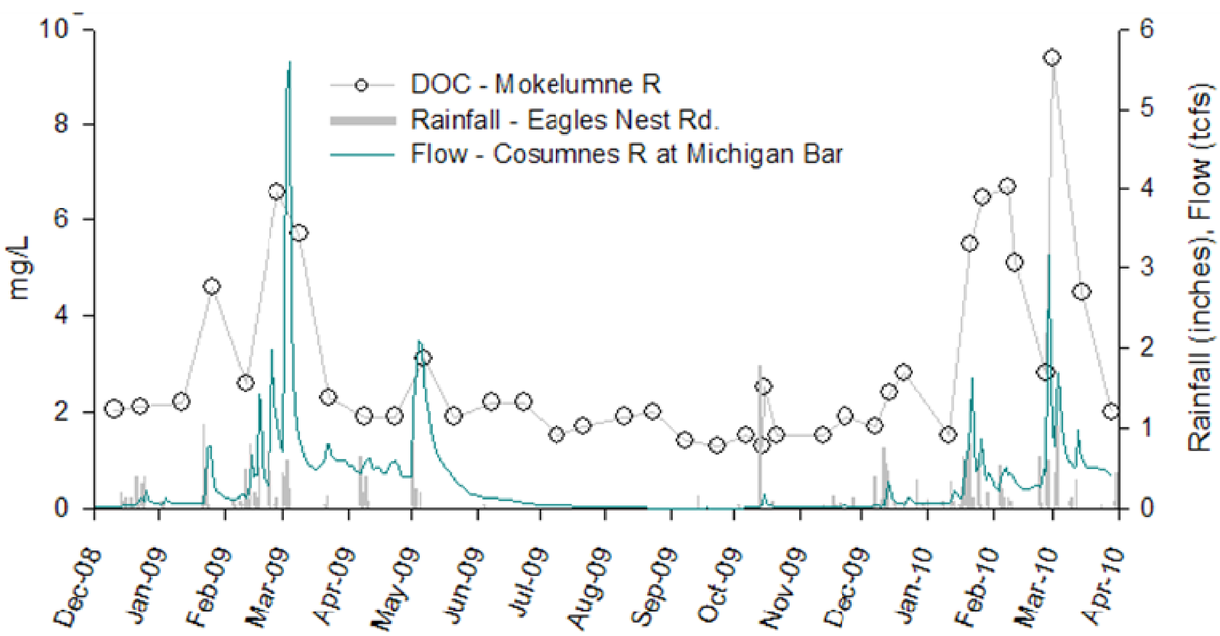



**Figure 3-4 Mokelumne River DOC, Cosumnes River flow, and rainfall**

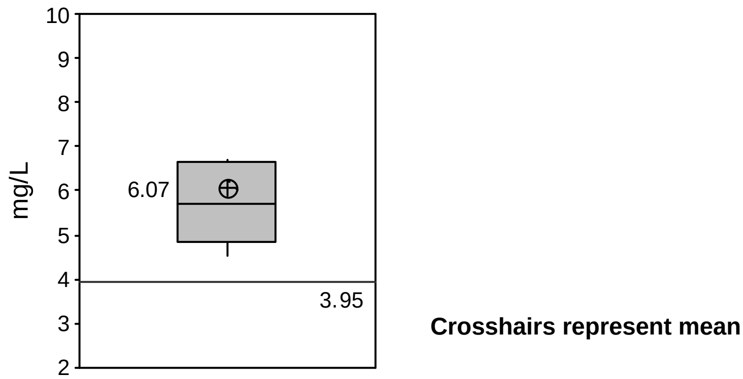



**Figure 3-5 Mokelumne River DOC > 4 mg/L and high flow boundary conditions**

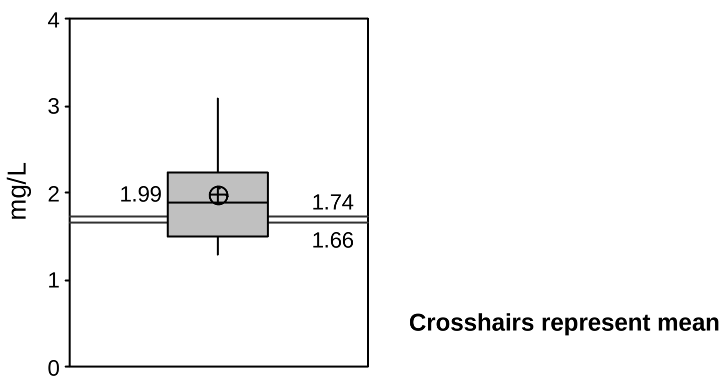



**Figure 3-6 Mokelumne River DOC < 4 mg/L and low flow boundary conditions**

*Calaveras River*

Figure 3-7 demonstrates the seasonality and the flow response behavior of DOC concentrations in the Calaveras River at Stockton.

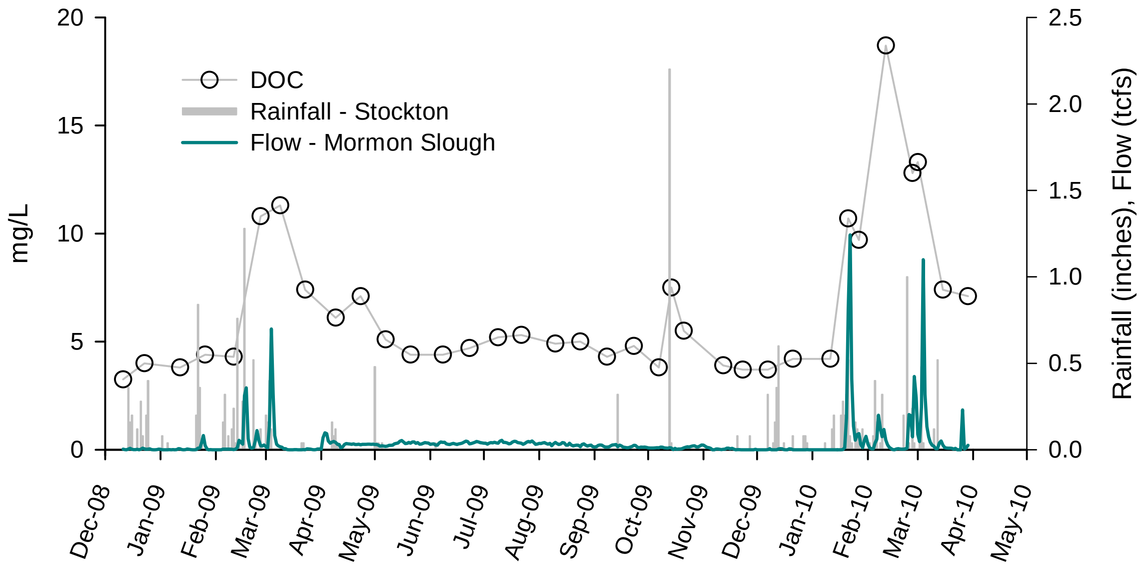



**Figure 3-7 Calaveras River DOC, Mormon Slough flow, and rainfall**

## 3.4 Discussion

**Land Use Influence**

The consistent difference in concentrations between the Hood and Shag Slough stations and the large relative difference (83%) in the means of the data are evidence that DOC data from Hood are not an adequate surrogate for DOC in the Yolo Bypass. The high DOC values of Shag Slough are likely due to the large areas of agricultural land in the watershed of the bypass, agriculture drainage into Shag Slough, and the wetlands of Liberty Island. Limited data suggest that storm flow from the waterways draining agriculture lands to the west of the Yolo Bypass have DOC concentration greater than 9 mg/L. A study in the predominately agricultural watershed of Willow Slough, a tributary of the Yolo Bypass, obtained a peak DOC concentration of 9.82 mg/L during storm water flow in February 2008 (Saraceno, et al. 2009). The DOC concentrations measured prior to the storm were between 2.3 mg/L and 2.7 mg/L (Saraceno, et al. 2009). Additionally, a sample of storm water from another predominately agricultural watershed tributary of the Yolo Bypass (Putah Creek at Mace Boulevard) had a DOC concentration of 9.5 mg/L on January 21, 2010. The elevated storm water DOC values from the agricultural watersheds of the tributary streams to the Yolo Bypass were close to those of the measured storm water values in Shag Slough (8.7 mg/L to 9.7 mg/L). Runoff from agriculture lands was likely the dominant factor for determining DOC concentrations in Shag Slough during storm water flows. Agricultural areas also appeared to have a strong influence during storm water flows in the Calaveras River. The Calaveras watershed downstream of the New Hogan Reservoir is predominately agricultural by area. Increased flows following rain events in Mormon Slough were not reflected in the outflow data for New Hogan Reservoir (data not shown) which demonstrates that runoff during this period was predominately from the watershed downstream of the New Hogan Dam or from tidal San Joaquin River water. Values for DOC in the Calaveras River during storm flows were greater than 7 mg/L.

Differences between the watersheds of the Mokelumne River and the American River were likely responsible for the large difference between the assumed DOC concentration for early winter high flow condition and the observed high DOC data. The boundary condition assumptions for the East Side Streams were developed from DOC data collected in the American River at the American River Treatment Plant Intake (Pandey 2001). The watershed upstream of the American River is predominately forested land and has very little influence from the lowland agriculture or wetlands. The upstream watershed of the Mokelumne River at Wimpy’s Marina by contrast has a strong presence of agriculture and wetlands in the lower reaches. It is this difference between the watersheds of the surrogate data and the actual Mokelumne River that is likely responsible for the underestimation of DOC concentrations during high flow conditions. The division of the observed data by visual examination likely entered some bias into the comparisons; however, it is unlikely that introduced bias accounted for the majority of the difference between groups. The differences between the mean of the low observed DOC group and the DOC boundary conditions for low flow were less than the reporting limit (0.5 mg/L) of the analytical method for determining DOC concentration. Simulations of DOC in the Mokelumne using the current boundary condition methodology would more often than not underestimate DOC during low flow conditions, yet the difference between actual and modeled concentrations is not likely to be of practical significance.

## 3.5 Conclusions

The results of this study demonstrate that current DSM2 assumptions for DOC concentrations at the Delta boundaries of the Mokelumne River and Yolo Bypass underestimate actual DOC concentrations during high flow conditions. The differences between the low flow DOC assumptions in the Mokelumne River and the mean of the values measured under low flow conditions are less than the reporting limit for laboratory analysis for DOC concentration.

## 3.6 References

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