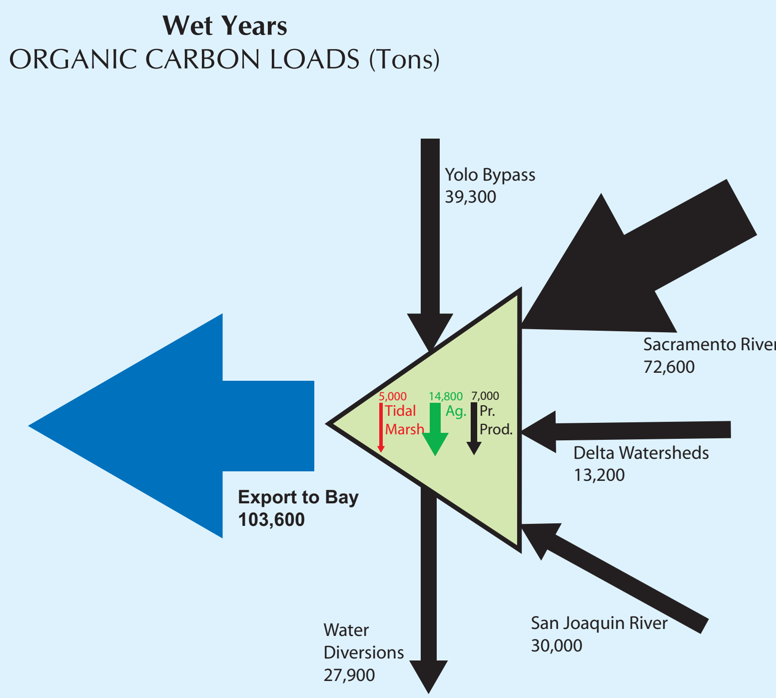
Conceptual Model For

Organic Carbon in the Central Valley and Sacramento–San Joaquin Delta

Final Report
April 14, 2006



Prepared for:

US Environmental Protection Agency, Region IX

Central Valley Drinking Water Policy Workgroup

Prepared by:

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Prepared by

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LIST OF ACRONYMS & ABBREVIATIONS

CDF FRAP	California Department of Forestry and Fire Protection Fire and Resource Assessment Program
cfs	Cubic feet per second
CVDWPWG	Central Valley Drinking Water Policy Workgroup
DICU	Delta Island Consumptive Use
DOC	Dissolved organic carbon
DSM2	Delta Simulation Model, Version II
DFG	Department of Fish and Game
DWR	Department of Water Resources
EPA	Environmental Protection Agency
GIS	Geographic Information System
HAA	Haloacetic acid
IESWTR	Interim Enhanced Surface Water Treatment Rule
LT2ESWTR	Long Term 2 Enhanced Surface Water Treatment Rule
MCL	Maximum contaminant level
mg/l	Milligrams per liter
MGD	Million gallons per day
MWQI	Municipal Water Quality Investigations
NEMDC	Natomas East Main Drainage Canal
POC	Particulate organic carbon
THM	Trihalomethane
THMFP	Trihalomethane formation potential
TOC	Total organic carbon
USGS	United States Geological Survey
UVA254	UV absorbance at 254 nm
WY	Water year

EXECUTIVE SUMMARY

This report presents a conceptual model of organic carbon for the Central Valley and the Sacramento-San Joaquin Delta. The conceptual model was based on previously collected data from a variety of sources and can be used to direct future investigations to improve understanding of organic carbon-related sources, transformations, impacts, and management.

Organic carbon in the dissolved form (DOC) is the form considered to be more likely to react during chlorination and form disinfectant byproduct compounds. DOC is generally less bioavailable to the base of the web compared with particulate organic carbon and/or organic carbon freshly derived from primary production. Thus, early data suggest that efforts in the Central Valley and Delta to control or manage DOC levels for drinking water quality are less likely to have direct adverse effects on the food web, although this is a subject that needs to be studied further. There is general agreement in the literature that THM formation is correlated to TOC concentrations, although the relationship is more complex when specific structural characteristics of DOC are compared with THM formation potential. A commonly used measure of DOC aromaticity, specific ultraviolet absorbance (SUVA) at 254 nm, was found to be poorly correlated to THM formation in Delta waters. Characterization of organic matter through sophisticated analytical tools such as stable isotope signatures and NMR-spectroscopy is an active area of research; published information that was available at this time, however, is limited to a small number of locations near the Delta, and with limited temporal resolution. The data are indicative of a contribution due to in-Delta primary production, although the variability of this contribution as a function of time is not known. There is limited knowledge on the relative propensity of different sources to form THMs, although it appears that Delta island drainage is somewhat less reactive than tributary sources.

Organic carbon concentrations across the Central Valley were estimated by averaging time series data at many sampling locations and are represented schematically in Figure ES-1. In general, most of the organic carbon is present in the dissolved form. The data show substantially higher concentrations in the San Joaquin River basin compared with the Sacramento River basin, especially in the upper reaches of the Sacramento River basin. Across seasons, the San Joaquin and Sacramento River concentrations exhibit contrasting behavior: in the Sacramento River, the highest concentrations are observed in the wet months, whereas in the San Joaquin River, the highest concentrations are observed in the dry months. The latter is a consequence of the significant contribution of agricultural drainage to total flows in the San Joaquin River in the dry season.

Organic carbon loads at various locations were estimated using historical monthly average flow data and average monthly concentrations of organic carbon at different stations (Figure ES-2). Tributary loads were found to vary significantly between wet and dry years, with loads from the Sacramento River Basin exceeding the San Joaquin River loads by a factor of two. Current estimates for in-Delta contribution of organic carbon show that annual loads of organic carbon from the tributaries are substantially greater than the best estimates of in-Delta production. However, in dry years these may be a significant fraction of the total loads. The organic carbon export in aqueducts is relatively uniform from year to year, particularly when compared with the tributary loads. The export of organic carbon in the aqueducts is slightly larger than the average internal Delta production (Figure ES-3).

The loads transported in streams were compared to the organic carbon export rates from different land uses. Export rates of organic carbon (mass of carbon exported per unit area per year) were computed for key land uses: urban land, agricultural land, wetlands, and natural areas (including forests, shrubland, and rangeland). The calculated total watershed exports matched well with the stream loads at key locations (such as Sacramento River at Hood/Greene's Landing and San Joaquin River at Vernalis) although not at all locations considered. Theses differences highlight the need for greater data collection, both to characterize stream loads and to quantify terrestrial export rates in selected watersheds. Export rates, as currently approximated, could be improved through focused flow and concentration data collection in small, relatively homogenous watersheds.

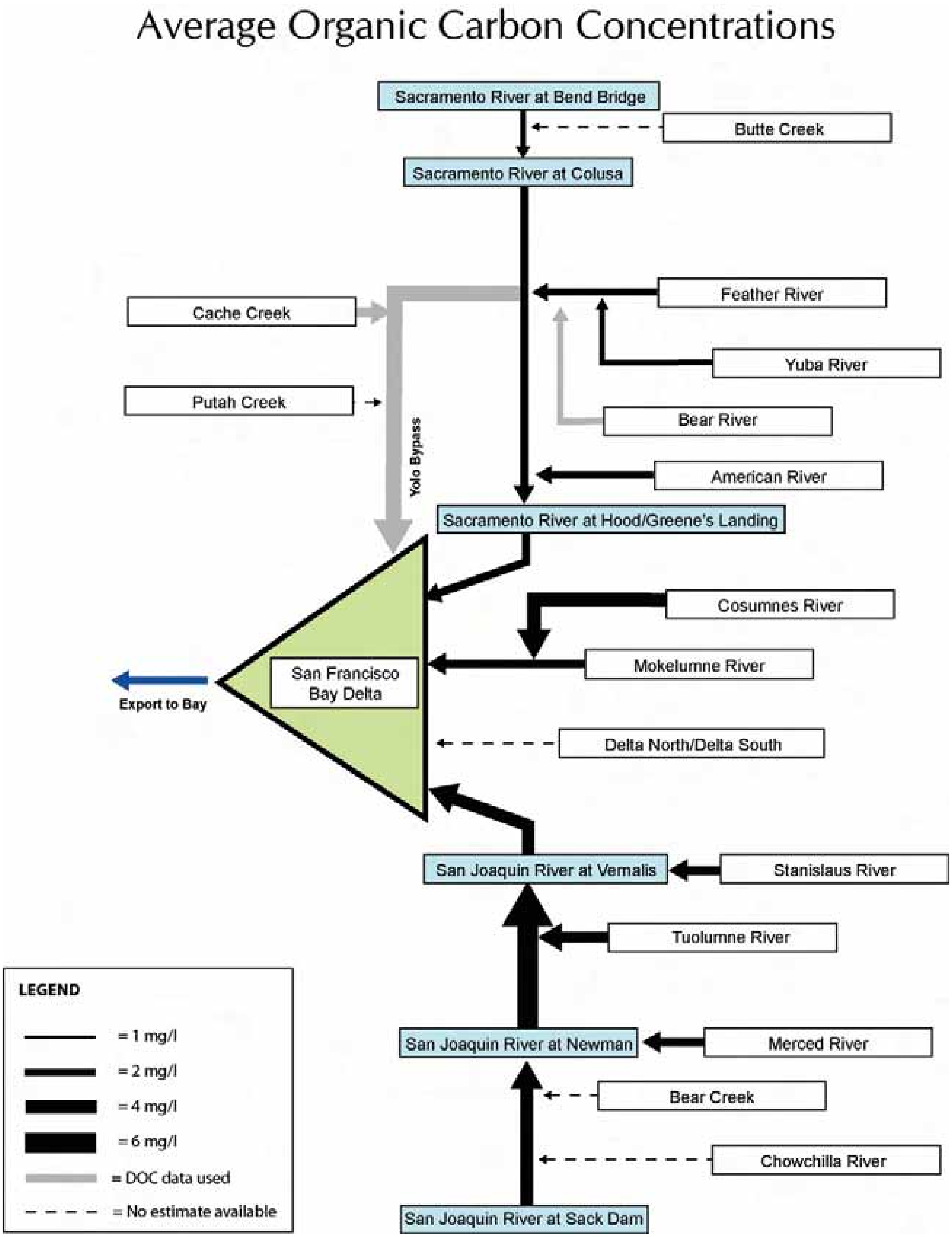

Figure ES-1. Average concentrations of organic carbon (mostly as TOC except where indicated) in the Central Valley and Delta.

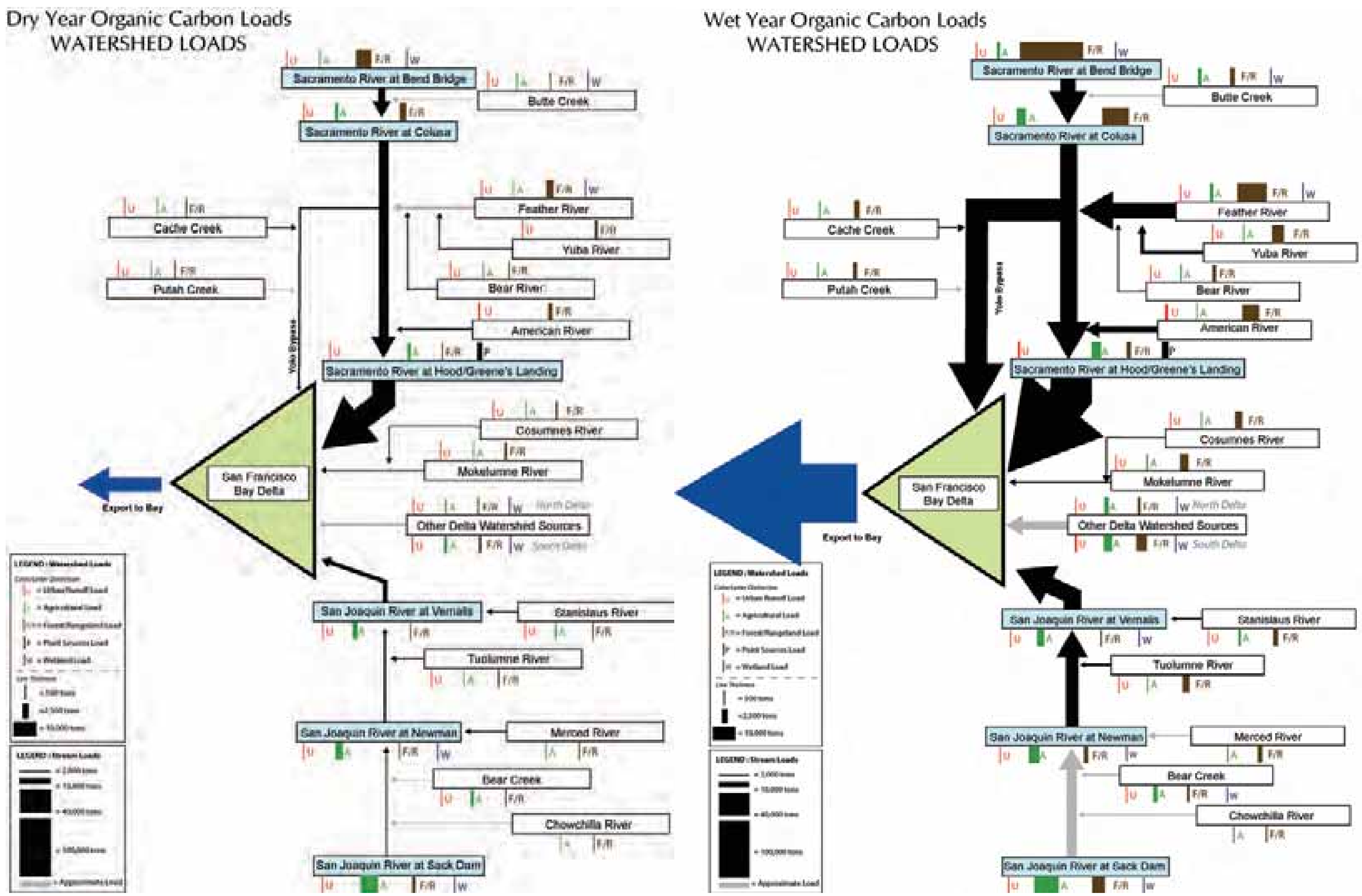

Figure ES-2. **Watershed and outflow loads for the Central Valley and Delta for average dry and wet years. Arrow thicknesses are proportional to stream loads; bars on the boxes are proportional to the loading from watershed sources.**

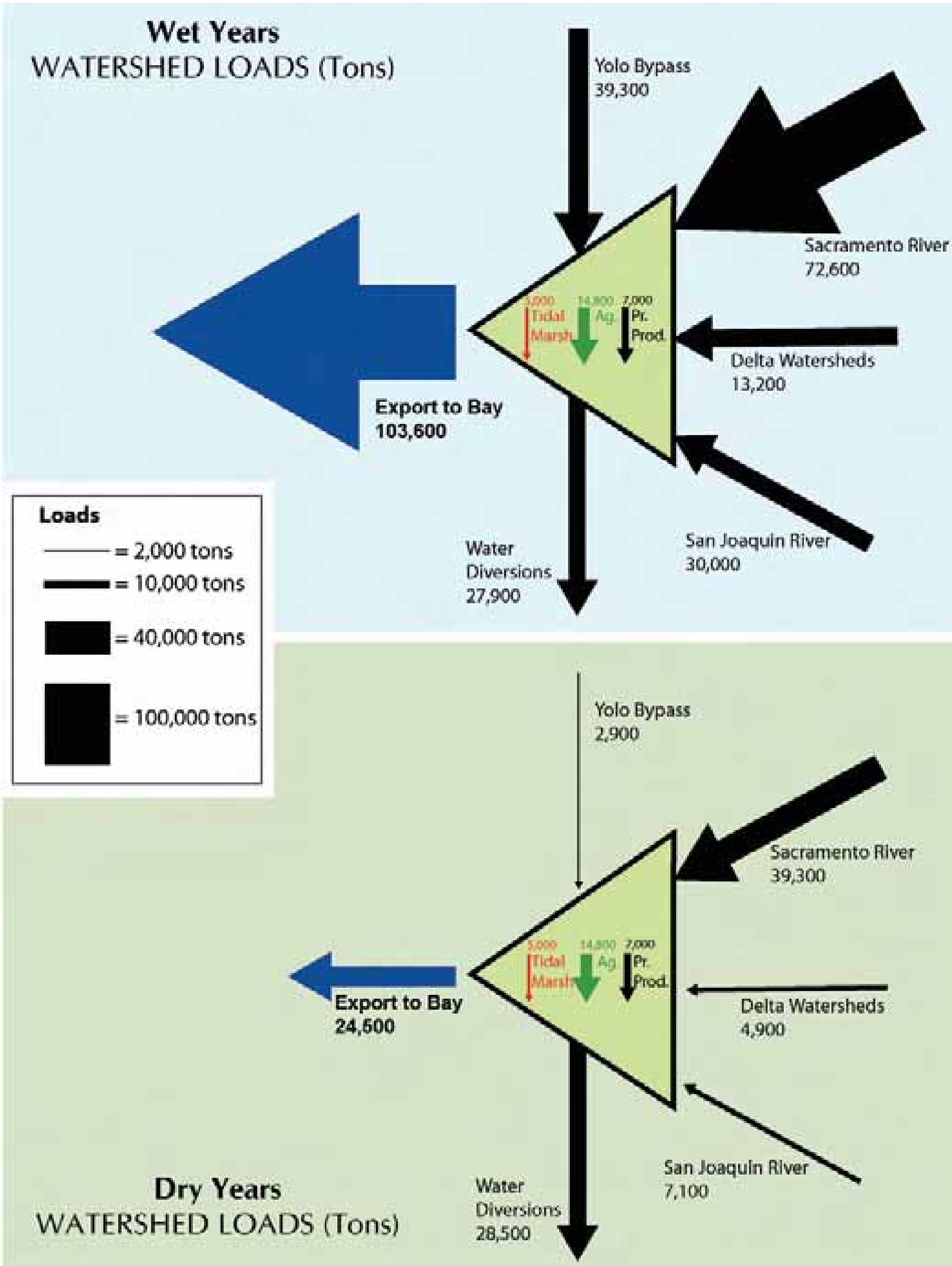

Figure ES-3. **The major tributary loads shown in Figure ES-2, along with the internal loads from in-Delta sources and exports from the Delta into San Francisco Bay and into the water diversions.**

The concentrations at the Banks Pumping Plant, and at other diversions in the Delta, are due to a complex mixture of the Sacramento River, the San Joaquin River, and in-Delta sources. The contribution of various sources to organic carbon concentrations at the intakes is best estimated through modeling. California Department of Water Resources' Delta Simulation Model (DSM2) was found to be the best tool for this task. This model is well calibrated and widely used for water flow and water quality applications throughout the Delta. The model is routinely used by DWR staff to evaluate the effect of specific scenarios on concentrations at various intakes. Ongoing work, termed fingerprinting, for example, shows the contribution of different sources to water volume and DOC concentrations at key intakes over time. A similar mechanistic model of the tributaries may need to be developed if impacts at stations outside the Delta need to be studied.

The conceptual model also identified data gaps and recommended improved cataloging of data from existing monitoring and research projects and additional field data collection. The broad areas where data collection is recommended includes characterization of export rates from different land uses, improved representation of agricultural drains, the contribution of Delta Island drainage and tidal marshes, quantification of reservoir exports of organic carbon, and improved quantification of wastewater sources. Recommendations for data collection were provided here as suggestions; the actual extent of additional data to be collected will depend on available time and resources.

Looking to the future, it appears that gradual changes in potential organic carbon sources (increased urban land and/or increased wastewater sources) are unlikely to be as large as the natural year-to-year variability in loads currently exhibited in the Delta. However, the role of anthropogenic organic carbon sources and the ecological impacts of substantial water withdrawals from the Delta, can all become highly significant during dry and critically dry years. Consideration of such extreme conditions should be a focus of future modeling work. In addition to the processes during dry years, future study of organic carbon should consider other factors. These include potential changes in Delta tidal marsh area due to restoration, changes in the regulations with lower standards for existing disinfection byproducts, or the addition of new compounds to the regulations, and the likelihood of catastrophic events such as levee failures.