CHAPTER 1.0 INTRODUCTION

The Central Valley, comprising the Sacramento and San Joaquin River watersheds, is a vital source of drinking water in California. Many Central Valley communities rely on water from the Sacramento and San Joaquin rivers or their tributaries. The Sacramento-San Joaquin Delta (hereafter referred to as the Delta) provides source water to more than 23 million people in the Southern California, Central Coast, and San Francisco Bay regions (CALFED Water Quality Program Plan, 2000). The tributaries of the Sacramento and San Joaquin rivers that originate in the Cascade Range and Sierra Nevada Mountains generally have high quality water; however, as the tributaries flow into lower elevations, they are affected by flows from urban, industrial, agricultural, and natural land uses as well as a highly managed water supply system.

The Central Valley Drinking Water Policy Workgroup is working with the Central Valley Regional Water Quality Control Board (Regional Board) to conduct the technical studies needed to develop a policy that will provide greater protection to drinking water supplies in the Central Valley. The policy is initially focused on five categories of constituents: organic carbon, nutrients (nitrogen and phosphorus), salinity, bromide, and pathogens and indicator organisms. This conceptual model report is focused on organic carbon.

For more than two decades organic carbon in source waters has been identified as a constituent of concern, in the Delta and elsewhere, primarily due to the formation of carcinogenic byproducts during disinfection at water treatment facilities. Drinking water is disinfected with chlorine or other chemicals to meet regulatory requirements to inactivate pathogens that may be present in the source water. Organic carbon, like several of the other identified constituents of concern, may originate from both natural and anthropogenic (human) sources, and the levels of organic carbon may play a beneficial role in ecosystem function.

A wide variety of chemical compounds are formed during the disinfection of source waters with chlorine in the presence of organic carbon and bromide. Of the many dozen disinfection byproduct compounds that have been detected (Cohn et al., 1999), trihalomethanes (THMs) and several haloacetic acids (HAAs) are currently regulated by the US EPA as part of the Stage 1 and Stage 2 Disinfectants and Disinfection Byproducts Rule (US EPA, 1998). These rules, in conjunction with the Interim Enhanced Surface Water Treatment Rule (IESWTR) and the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), are intended to provide protection from microbial pathogens while minimizing the human health risk due to disinfection byproducts. Table 1-1 lists the regulated THMs, the total concentrations of which cannot exceed 0.08 mg/l, and the five regulated HAAs (also abbreviated as HAA5), the total concentrations of which cannot exceed 0.06 mg/l (US EPA, 2001). Approximately 50% of the disinfection byproduct compounds in finished drinking water are unidentified (US EPA, 2003). The list of detected disinfection byproducts and knowledge of their human health impacts continues to grow, and it is conceivable that in future years the total allowable THM and HAA5 concentrations may decrease and the number of regulated compounds may increase.

Table 1-1.
Disinfection by-products of human health concern.

Trihalomethanes (Current EPA standard*: 0.08 mg/l):	
Chloroform	$CHCl_3$
Bromodichloromethane	$CHCl_2Br$
Dibromochloromethane	$CHClBr_2$
Bromoform	$CHBr_3$
Haloacetic acids (HAA5) (Current EPA standard*: 0.060 mg/l):	
Dibromoacetic acid	$CHBr_2CO_2H$
Dichlororoacetic acid	$CHCl_2CO_2H$
Monobromoacetic acid	CH_2BrCO_2H
Monochloroacetic acid	CH_2ClCO_2H
Trichloroacetic acid	CCl_3CO_2H
Bromate (BrO_3-); MCL = 0.010 mg/l	
Chorite (ClO_2-); MCL = 1.0 mg/l	

* 1998 Stage 1 Disinfectants and Disinfection Byproducts Final Rule; 2005 Stage 2 Disinfectants and Disinfection Byproducts Final Rule

A number of water suppliers that rely on the Delta as a source of drinking water have modified their treatment processes and are using ozone as the primary disinfectant to avoid the formation of trihalomethanes and haloacetic acids. However, organic carbon in the source water still impacts facilities using ozone because increased TOC increases the required ozone dosage. Higher levels of ozone in the presence of bromide can increase bromate concentrations. Drinking water suppliers that treat

Delta water with ozone already must take steps to ensure that bromate levels do not exceed the Maximum Contaminant Level (MCL) of 0.01 mg/l.

To protect the quality of Delta source waters, CALFED has proposed a total organic carbon target of 3 mg/l or an equivalent level of public health protection using a cost-effective combination of alternative source waters, source controls, and treatment technologies. In recent years, water at the Delta pumping plants has often exceeded this concentration target, particularly during the wet season (Department of Water Resources, 2005).

Although organic carbon is referred to as a single constituent, it is well known that it is comprised of a wide variety of chemical compounds, with numerous structural forms, and a range of reactivity, solubility, and molecular weights (Thurman, 1985). Inferring these details about an aquatic organic carbon sample is not straightforward, but studies have documented the importance of organic carbon quality in influencing the quantity of THMs that are formed during chlorine disinfection. Unfortunately, there is not sufficient information about the quality or characteristics of organic carbon from many sources in the Central Valley. This report is therefore focused on total organic carbon.

This report presents a conceptual model of organic carbon that summarizes current knowledge of the sources, transformation processes, and transport of organic carbon in the waters of the Central Valley and Delta. There have been previous descriptions of conceptual models for organic carbon in this region (MWQI, 1998; Brown, 2003). The work presented in this report expands upon the earlier efforts by using more recent data and covering a larger geographical area. The conceptual model is intended to form the basis for identifying data needed to better understand the sources of organic carbon, the relationship between drinking water concerns and ecosystem concerns, and the ability to control organic carbon in the Delta and its watersheds. This is important because organic carbon concentrations are currently problematic at some water supply intakes and anticipated changes in the Central Valley and Delta system may exacerbate the problem in the future. Anticipated changes include increases in developed land, population, and concomitant increases in water withdrawals (at new and existing locations) and wastewater and urban runoff discharges. The CALFED Program includes a number of ecosystem restoration activities in the Delta, including the restoration of tidal marshes, some of which have the potential to adversely affect organic carbon concentrations at the drinking water intakes. Changes to state and federal water management system are also being contemplated.

The contents of the chapters that follow are briefly summarized as follows:

- Chapter 2 presents a summary of the key processes associated with the production, consumption, decomposition, and transport of organic carbon in watersheds and receiving waters and an overview of the chemical forms of organic carbon and what is known about its relationship to disinfection byproduct formation.

- Chapter 3 summarizes the information on organic carbon-related parameters in the database developed by the Central Valley Drinking Water Policy Workgroup. Spatial and temporal trends in concentration data are presented. This database is the primary source of information for the development of this conceptual model. Additional sources of data used for this assessment are also identified.

- Using the data summarized in Chapter 3, Chapter 4 provides an estimate of the flows and organic carbon loads transported from the tributaries to the Delta in wet and dry years. Sources of organic carbon from key non-point and point sources are estimated on a unit basis (e.g., per unit area or per unit population) to compare stream loads to watershed inputs.

- Chapter 5 presents an estimate of the organic carbon concentrations and sources within the Delta boundaries. Loads internal to the Delta are presented along with tributary sources discussed in Chapter 4. The current approach to relate tributary loads and in-Delta sources to concentrations at major pump stations is also presented.

- Chapter 6 summarizes the uncertainty in the findings from the preceding chapters and identifies additional data and studies that are needed to better understand the sources and potential impacts of organic carbon in municipal supplies. Key findings of the analysis presented in this conceptual model are highlighted. Future trends in organic carbon supplies to the Delta and vicinity are also discussed.