Conceptual Model For
SALINITY IN THE CENTRAL VALLEY AND SACRAMENTO-SAN JOAQUIN DELTA

Prepared for
Central Valley Drinking Water Policy Workgroup

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LIST OF ACRONYMS & ABBREVIATIONS

µg/L	Micrograms per Liter
µS/cm	Microsiemens per centimeter
CALFED	CALFED Bay-Delta Program
CCWD	Contra Costa Water District
CDEC	CDEC
cfs	Cubic Feet per Second
CUWA	California Urban Water Agencies
CVP	Central Valley Project
CVRWQCB	Regional Water Quality Control Board, Central Valley Region
DCC	Delta Cross Channel
DRERIP	Delta Regional Ecosystem Restoration Implementation Plan
DSM2	Delta Simulation Model 2
DWR	Department of Water Resources
EC	Electrical Conductivity
MCL	Maximum Contaminant Level
mg/L	Milligrams per Liter
ROD	CALFED Bay-Delta Program, Programmatic Record of Decision
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAF	Thousand Acre-Feet
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
USBR	United States Bureau of Reclamation
USGS	United States Geological Survey

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INTRODUCTION

"The value of water is determined by its potential uses. In turn, the uses that can be made of water are determined by its quality."

– CALFED Water Quality Program Plan, July 2000.

Salinity, the amount of dissolved salts in water, is a basic measure of the quality of water. People and the vast majority of the world's land animals and plants need an adequate supply of fresh water to survive. Water with too high a salt concentration tastes bad, can be harmful to health, reduces plant growth, can be corrosive, and limits our ability to recycle water or recharge groundwater. Salinity is expensive to treat and is often the characteristic of water that compels us to discharge it rather than reuse it. Some of the component constituents of salinity, bromide for example, may be even more problematic than salinity itself. Bromide can be converted into carcinogenic disinfection byproducts in the drinking water treatment process.

While dissolved salts naturally increase in a watershed from the source in snow or rain, water quality is significantly degraded as it passes through the Central Valley and Delta on its way to the points where it is diverted for municipal and agricultural uses. High quality water from Sierra Nevada streams generally has a total dissolved solids (TDS) concentration (one measure of salinity) of less than 100 mg/L[1]. Drinking water taken from the Delta typically has a TDS of from 150 mg/L to 300 mg/L but may be more than 500[2]. The reasons for these differences in water supply salinity and what can be anticipated for Delta salinity in the future is the subject of this report.

The primary source of salinity in Delta water is the ocean itself. The Delta is the upstream part of the San Francisco Bay – Sacramento-San Joaquin Delta and Estuary, the largest estuary on the west coast of the United States. It is natural for estuaries to have a gradation in salinity from completely fresh water to the salinity of the ocean. In fact this salinity gradation is a defining characteristic of estuaries. This mixing of seawater and fresh water is the result of tidal water movement and other complex hydrodynamic processes. By volume, only a small fraction of the water that makes it to the export pumps in the central and southwestern Delta is seawater but that tiny fraction has a

[1] Average total dissolved solids reported in East Bay Municipal Utility Districts annual water quality report for 2004 was 97 mg/L. This is mostly Mokelumne River water diverted at Pardee Reservoir. _http://www.ebmud.com/water_&_environment/water_quality/annual_report/2004_wq_report.pdf. Average total dissolved solids concentration reported I the San Francisco Public Utilities Commission annual water quality report for 2004 was 101 mg/L. The primary source is the Tuolumne River at Hetch Hetchy Reservoir http://sfwater.org/detail.cfm/MSC_ID/51/MTO_ID/63/MC_ID/10/C_ID/2525/holdSession/1.

[2] Contra Costa Water District annual report for 2004 http://www.ccwater.com/files/AWQR04.pdf and DWR presentation on SWP water quality http://wwwomwq.water.ca.gov/PublicationsPage/Documents/SWP WQ talk_files/frame.htm.

profound effect on the concentration of salts. Seasonally, seawater mixing into the Delta can increase salinity by more than 40% at the diversion points.

The remaining significant sources of salinity are drainage from irrigated agriculture and managed wetlands in the San Joaquin Valley, the Sacramento Valley, and the Delta. This includes subsurface drainage, return flows, and runoff. The high salinities from these sources are the result of several processes including concentration of salts in the applied water through evapotranspiration, leaching of natural salts from soils, and agricultural chemical addition. Evapotranspiration is a combination of simple evaporation from water surfaces and soils and transpiration by plants. This is complicated in the San Joaquin River by the use of Delta water for irrigation that carries some seawater salinity. Some of this seawater salinity finds its way into agricultural drainage, into the San Joaquin River and back to the Delta. Municipal wastewater discharges, industrial discharges, urban runoff, and natural leaching of minerals also contribute salts to the system but these sources are minor compared to the contributions from seawater intrusion, irrigated agriculture, and managed wetlands.

This report examines the state of knowledge about the causes of salinity increase in the system and opportunities to improve the Delta as a source of municipal and agricultural water supply. It begins with background information about salinity, its measurement, and its impacts. Following that, we present observed salinity in the Bay-Delta system. The conceptual models section, the core of this report, then seeks to explain the forces and processes (drivers) that cause the salinity patterns we observe. The computational models section introduces some of the tools available to assist with salinity management and planning. The last chapter explores the implications of the conceptual model for monitoring and management of salinity.

PURPOSE AND SCOPE

This conceptual model was prepared as part of the Central Valley Drinking Water Policy development project, a major CALFED Bay-Delta Program Record of Decision (ROD) action. This is an effort to clarify and enhance the regulatory policies of the Central Valley Regional Water Quality Control Board (CVRWQCB) with respect to protection of the municipal water supply beneficial use. This conceptual model will help to identify information gaps and potential measures for monitoring progress towards water quality improvement.

The conceptual model will address salinity sources and impacts throughout the CALFED solution area (Figure 1) with respect to municipal water supply.

Figure 1: CALFED Program solution area.

The focus will be on the Delta and the San Joaquin Valley but will extend to the Sacramento River watershed and those areas of the State that receive Delta water as needed.

It will not address the importance of salinity to ecosystem function in the Bay-Delta system in anything more than a cursory way. Salinity and its implication for the Bay-Delta ecosystem is well covered in Kimmerer 2004 and other publications. Likewise, this report will not go into any depth on agricultural water quality issues. For an overview of the effects of salinity and associated constituents on agriculture and other beneficial uses, see the Central Valley Regional Water Quality Control Board San Joaquin River salinity TMDL report (*Regional Water Quality Control Board 2002)*.

There is a long record of Delta salinity measurements. Much of the recent data is from permanent continuous electrical conductivity (EC) monitoring stations. Figure 2 shows the current Department of Water Resources (DWR) Delta monitoring stations.

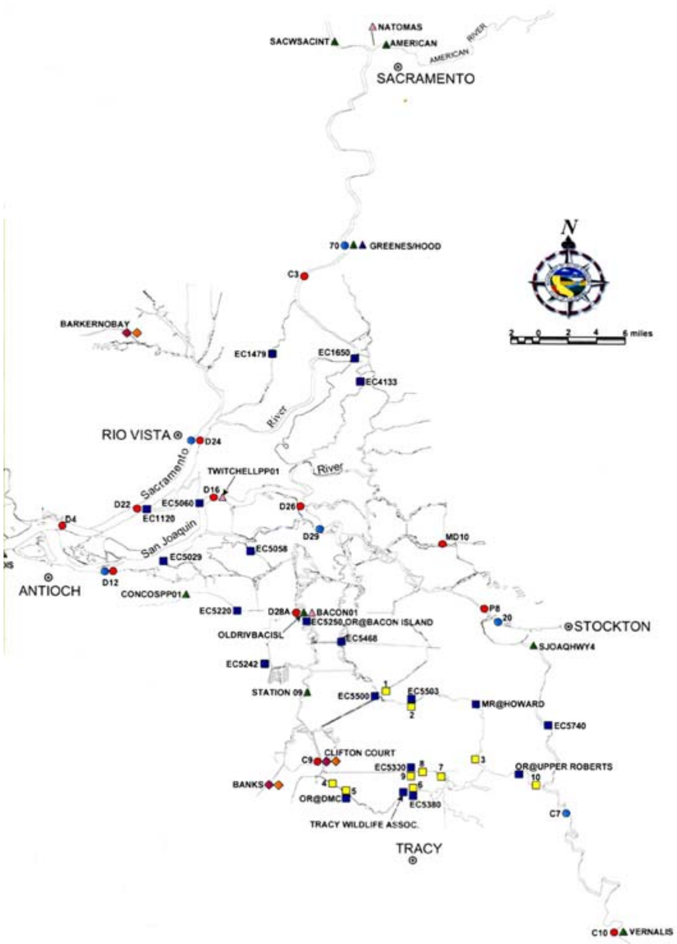

Figure 2: Department of Water Resources monitoring stations in the Delta.

There is also an extensive amount of grab sample data available. Salinity is the most extensively monitored water quality constituent in the system. Naturally, operation of the system has changed over the years placing the emphasis on more recent data (1975-present) but early data can also be instructive. For example, the historic extent of seawater intrusion in the Delta, discussed later, illustrates the profound effect of the Federal and State water projects on Delta salinity.