

# CALFED WATER QUALITY

## LOADING ANALYSIS

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*Prepared for*



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Sacramento, CA

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## PRELIMINARY LOADING ANALYSIS

### INTRODUCTION AND PURPOSE

The purpose of the analysis is to estimate the loads of various pollutants discharged to water bodies within different portions of the CALFED study area. The pollutants of interest are the key contaminants identified by the CALFED advisory committees. Load estimates were made for four regions, the Sacramento River Basin, the San Joaquin River Basin, the Delta, and the Bay Region. The Sacramento River Basin estimates were further subdivided into loads generated above and below the three major dams, Shasta, Oroville and Nimbus.

In a later task in the CALFED program, the load estimates will be used to determine the relative importance of different pollutant sources and the effectiveness of potential control measures. For example, it may be determined that municipal and industrial wastewater treatment plants contribute less than 5% of the copper discharges to the Delta. It is apparent from the loading estimate described above for copper that additional measures to reduce copper from this source are unlikely to greatly affect copper concentrations in the Delta.

### ANALYTICAL APPROACH AND ORGANIZATION OF INFORMATION

Considerable information on pollutants discharged to the Sacramento River Basin, the San Joaquin River Basin, the Delta, and the Bay Region and pollutant concentrations in various water bodies is available but it is not found in a single depository. Developing a comprehensive picture of pollutant loadings involves compilation of potentially-relevant data from published and unpublished sources, review of the data by the consultant team and, in many cases, further manipulation of the data into the form of load estimates.

Pollutant load estimates are difficult to make for large geographical areas because data is always limited and many assumptions have to be made. The approach used here was to try to make fairly complete load estimates for the various contaminants even if fairly gross assumptions have to be made. The load estimates will then be progressively refined as additional data is acquired and analyses completed.

The following analytical report includes a number of separate sections addressing each key contaminant. Each section consists of a tabular and graphical summary of loading data and a series of notes. The notes describe the data sources and any analyses undertaken by the consultant team to produce the load estimates.

Two approaches to load estimation were used and their results compared in the tabular and graphical summaries. The first approach was to estimate the load attributable to each major source and then to sum the loads up to provide a total basin load. Major contaminant source

categories include agricultural stormwater runoff and subsurface drainage, mine drainage, municipal and industrial wastewater discharges and urban stormwater runoff. The second approach was to estimate the total pollutant emission from a basin by calculating the load contained in water exiting the basin at its downstream end. The loads calculated using the two approaches are not directly comparable because some of the pollutants discharged to waterways in a basin may be stored in sediments and biota or transformed into other substances, as a consequence of chemical reactions and biological activity.

## LIMITATIONS

Because of the many assumptions and simplifications involved in the load estimates the results need to be used with caution. The more important assumptions and simplifications are noted below.

### Year-to-year variations

Most contaminant sources are affected by meteorological conditions. The total contaminant loads from agricultural and urban runoff depend on the volume of runoff which can vary widely from year-to-year. Mine drainage loads are similarly weather-dependent. Waste loads associated with municipal and industrial wastewater discharges are less affected by weather; the same may be true for waste loads in agricultural subsurface drainage which probably depend more on irrigation rates than precipitation.

Because the data available to characterize contaminant loads is limited it was not separately compiled for different meteorological conditions. Ideally, loads should be separately estimated for wet, normal, dry and very dry years. Instead data from different years, representing different meteorological conditions were compiled to produce a single load estimate that may approximate "typical" conditions.

### Seasonality of loadings

Most contaminant emissions vary seasonally. The initial load estimates contained in this report were made on an annual basis. If the available data allows, later refinement of the load estimates will seek to account for seasonality.

### Background loads

The load estimates do not attempt to account for background loads. Many substances regarded as contaminants occur at low concentrations in waters uninfluenced by human activities. This is the case for metals and trace elements, salts, naturally-occurring organic substances and plant nutrients. It is not so for synthetic organic including pesticides.

The lack of allowance for background loads probably does not greatly affect load estimates for relatively concentrated waste streams. If, for example, a city draws water from a river, uses it for municipal supply and discharges it back to the river after wastewater treatment then the phosphorus load attributable to the municipal wastewater discharge is the load contained in the effluent less the background load contained in the source water. In this case, the background phosphorus concentration might be 0.05 mg/l while the concentration of phosphorus in the wastewater effluent would be 5 or 10 mg/l. The phosphorus load would be similar whether or not the background concentration is allowed for.

Lack of an adjustment for background loads can have a greater effect on loads attributable to dilute, but high-volume, waste streams. For example, copper concentrations in agricultural runoff may be estimated to be 0.01 mg/l while copper concentrations in runoff from non-agricultural lands with similar soil chemistry characteristics may be 0.005 mg/l. Not accounting for the background concentration in the load calculations would result in an overestimation of loads attributable to agricultural runoff by a factor of 2.

CONSTITUENT SELECTION TABLE											
Ecological/Human Health											
Type	Constituent	303(d) List					Drinking Water	Agricultural Water	Industrial	Recreational	LOADING LIST
		Delta	Sacramento Basin	San Joaquin Basin	Bay Region	Sacramento R. (above dams)					
Metals	As										
	Cd										
	Cr										
	Cu										
	Hg										
	Pb										
	Zn										
Trace El.	selenium										
	boron										
Organics	TOC										
	DOC										
	THM										
	THMFP										
	TFPC										
Pesticides	DDT										
	carbofuran										
	chlordane (A)										
	chlorpyrifos										
	diazinon										
	toxaphene (A)										
Salts	PCBs										
	endosulfan (A)										
	TDS										
Biotic	salinity										
	SAR										
	bromide										
	chloride										
Nutrients	pathogens										
	nitrate										
	phosphorous										
Other	ammonia										
	DO										
	turbidity										
	temperature										
	unk. toxicity										
	pH										
	alkalinity										
sediment.											

**SOURCE SELECTION TABLE**

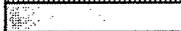
Type	Constituent	M&I									
		Agricultural	Mine Drainage	Wastewater (POTW)	Urban Runoff	Flow Regulation	Dams	Dairies	Construction	On-site Disposal	Marinas
Metals	As										
	Cd										
	Cr										
	Cu										
	Hg										
	Pb										
	Ni										
Zn											
Trace El.	selenium										
	boron										
Organics	TOC										
	DOC										
	THM										
	THMFP										
	TFPC										
	chlorpyrifos										
Pesticides	DDT										
	carbofuran										
	chlordane (A)										
	diazinon										
	toxaphene (A)										
	PCBs										
endosulfan (A)											
Salts	TDS										
	salinity										
	SAR										
	bromide										
	chloride										
Biotic	pathogens										
	viruses										
Nutrients	nitrate										
	phosphorous										
	ammonia										
Other	DO										
	turbidity										
	temperature										
	unk. toxicity										
	pH										
	alkalinity										
	sediment.										

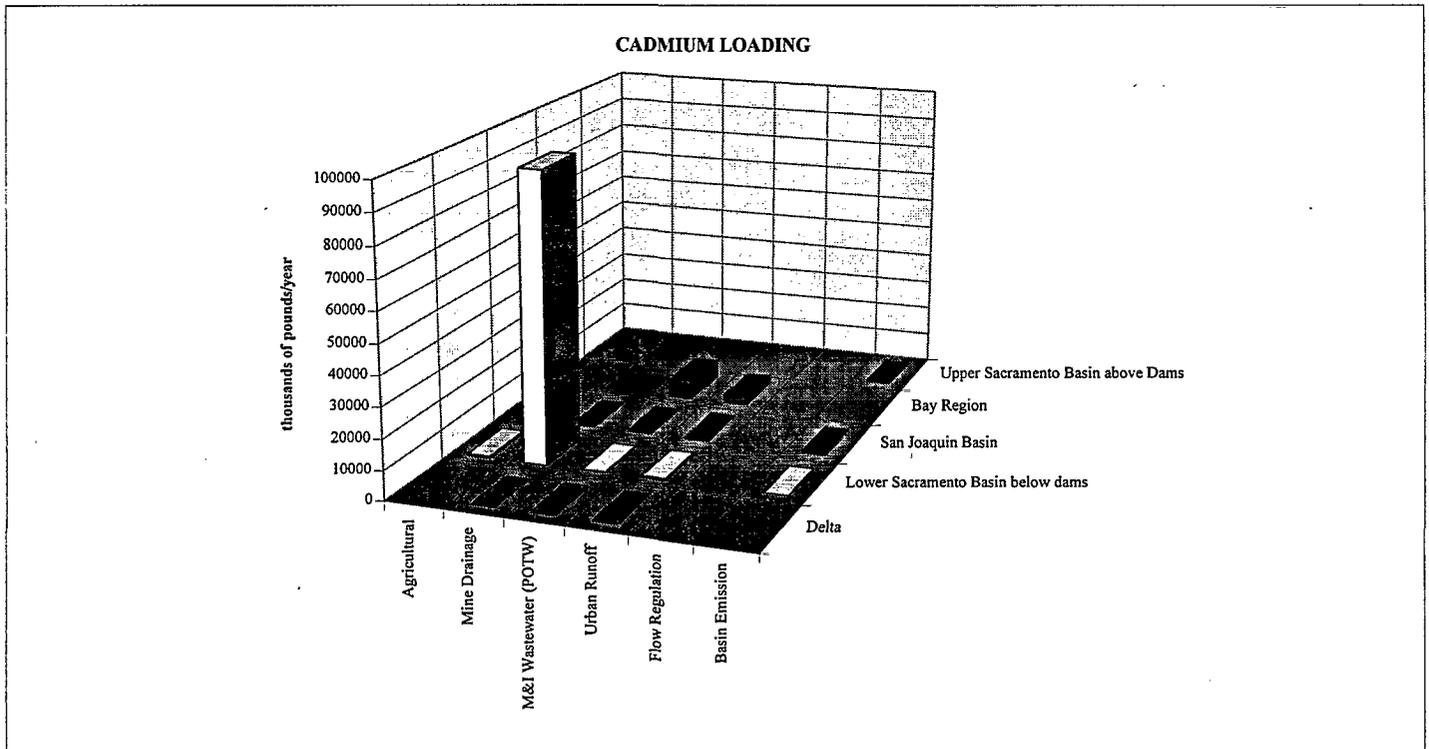
CADMIUM LOADING TABLE										
Cadmium Loading (pounds/year)										
Source	Delta	Note	Lower Sacramento Basin below dams	Note	San Joaquin Basin	Note	Bay Region	Note	Upper Sacramento Basin above Dams	Note
Agricultural			655	<i>d</i>						
Mine Drainage	36	<i>a</i>	96,000	<i>e</i>	36	<i>i</i>				
M&I Wastewater (POTW)	154	<i>b</i>	270	<i>f</i>	202	<i>j</i>	6394	<i>m</i>		
Urban Runoff	136	<i>c</i>	582	<i>g</i>	191	<i>k</i>	2535	<i>n</i>		
Flow Regulation										
Total Load	326		97,507		429		8929			
Basin Emission			11	<i>h</i>	2	<i>l</i>			200	<i>o</i>

Note: Letters listed in italics under the Note column provide the background and references associated with the accompanying load

 Data available; flow and concentration data available; load calculations required.

 Further literature review required.

 - Source does not contribute significant load of constituent in this watershed.



## Cadmium Loading Notes

a. The original data for the load estimate was obtained from "A mass loading assessment of major point and non-point sources discharging to surface waters in the Central Valley, California, 1985" prepared by the RWQCB Central Valley Region in 1988. Flow and load data was compiled for four inactive mines including Iron Mountain, Newton, New Idria and Afterthought Mines. Only mines that drain to the Sacramento River or its tributaries below Shasta, Oroville and Nimbus Dams were considered. Eighty-five percent of the load was from Iron Mountain. A later report by Central Valley RWQCB prepared in 1989 and entitled "A mass loading assessment of major point and non-point sources in the Sacramento Valley, California, 1985" estimated that the earlier mine drainage estimate only represented 25% of the total. A further review of the two RWQCB documents was made by Woodward-Clyde in light of information contained in a 1992 report by the Central Valley Board entitled "Inactive mine drainage in the Sacramento Valley". Data in this report suggests that mine drainage represents about 50% of the total cadmium load from inactive mines. The 50% estimate was used to scale up the loads originally calculated by RWQCB. The loads calculated in the 1988 RWQCB were segregated into the three geographical areas, delta, San Joaquin Basin and Sacramento Basin below dams.

b. The original data for the load estimate was obtained from "A mass loading assessment of major point and non-point sources discharging to surface waters in the Central Valley, California, 1985" prepared by the RWQCB Central Valley Region in 1988. Flow and load data was compiled from several NPDES dischargers who have been monitoring copper, including the largest in the Central Valley the Sacramento Regional County Sewer District. Woodward-Clyde divided the results into two geographical areas, the delta and the Sacramento Basin. A later report by Central Valley RWQCB prepared in 1989 and entitled "A mass loading assessment of major point and non-point sources in the Sacramento Valley, California, 1985" estimated that the earlier M and I estimate only represented 50% of the total. This percentage was used to scale up the loads.

c. The original data for the load estimate was obtained from "A mass loading assessment of major point and non-point sources discharging to surface waters in the Central Valley, California, 1985" prepared by the RWQCB Central Valley Region in 1988. Urban runoff estimates were made for 19 large cities in the Central Valley. Flow data was calculated using rainfall data for cities, urban acreage and a runoff factor of 0.3. Quality data for the city of Sacramento was used for all cities. A later report by Central Valley RWQCB prepared in 1989 and entitled "A mass loading assessment of major point and non-point sources in the Sacramento Valley, California, 1985" estimated that the earlier urban runoff estimate only represented 35% of the total. A further review of the original data by Woodward-Clyde concluded that the original estimate probably captured 70% of the load, because all major urban areas were included in the calculations. The 70% figure was used to scale up the original estimates. The data allowed separation of the loads into three geographical areas, the delta, San Joaquin Basin and the Sacramento Basin.

d. The original data for the load estimate was obtained from "A mass loading assessment of major point and non-point sources discharging to surface waters in the Central Valley, California, 1985" prepared by the RWQCB Central Valley Region in 1988. Flow and concentration information was compiled for the major drains in the Sacramento Basin, including Sacramento Slough, Colusa Basin Drain, RD1000, RD108 and Natomas East Main Drain. A later report by Central Valley RWQCB prepared in 1989 and entitled "A mass loading assessment of major point and non-point sources in

## Cadmium Loading Notes

the Sacramento Valley, California, 1985” estimated that the earlier agricultural runoff estimate only represented 80% of the total. This percentage was used to scale up the estimates.

e. See note a for explanation.

f. See note b for explanation.

g. See note c for explanation.

h. Concentration data is from EarthInfo USGS Quality of Water databases on CD-ROM (EarthInfo, 1996). Flow data is from USGS Water Data Reports for the years in which concentration data was available. For the Sacramento River concentration and flow data used in the load calculation is from Freeport. For the San Joaquin River concentration and flow data used in the load calculation is from Vernalis.

Loads were calculated for each day data were available. For the period of record the average daily load was calculated from all the daily values. The annual load for the period of record is the product of the average daily load multiplied times the number of seconds in a year. The resulting value was converted to an average annual value by dividing the annual load for the period of record by the average daily flow over the period of record and then multiplying the result times the long term daily average flow rate.

average annual load = ((average daily load \* number of seconds in a year) / average daily flow over the period of record)\* long term daily average flow rate.

i. See Note a for explanation.

j. See Note b for explanation.

k. See Note c for explanation.

l. See Note h for explanation.

m. Reported in Table 19 of “State of the Estuary: A report on conditions and problems in San Francisco Bay/Sacramento-San Joaquin Delta Estuary’ San Francisco Estuary Project, 1992. Middle of range of values used .

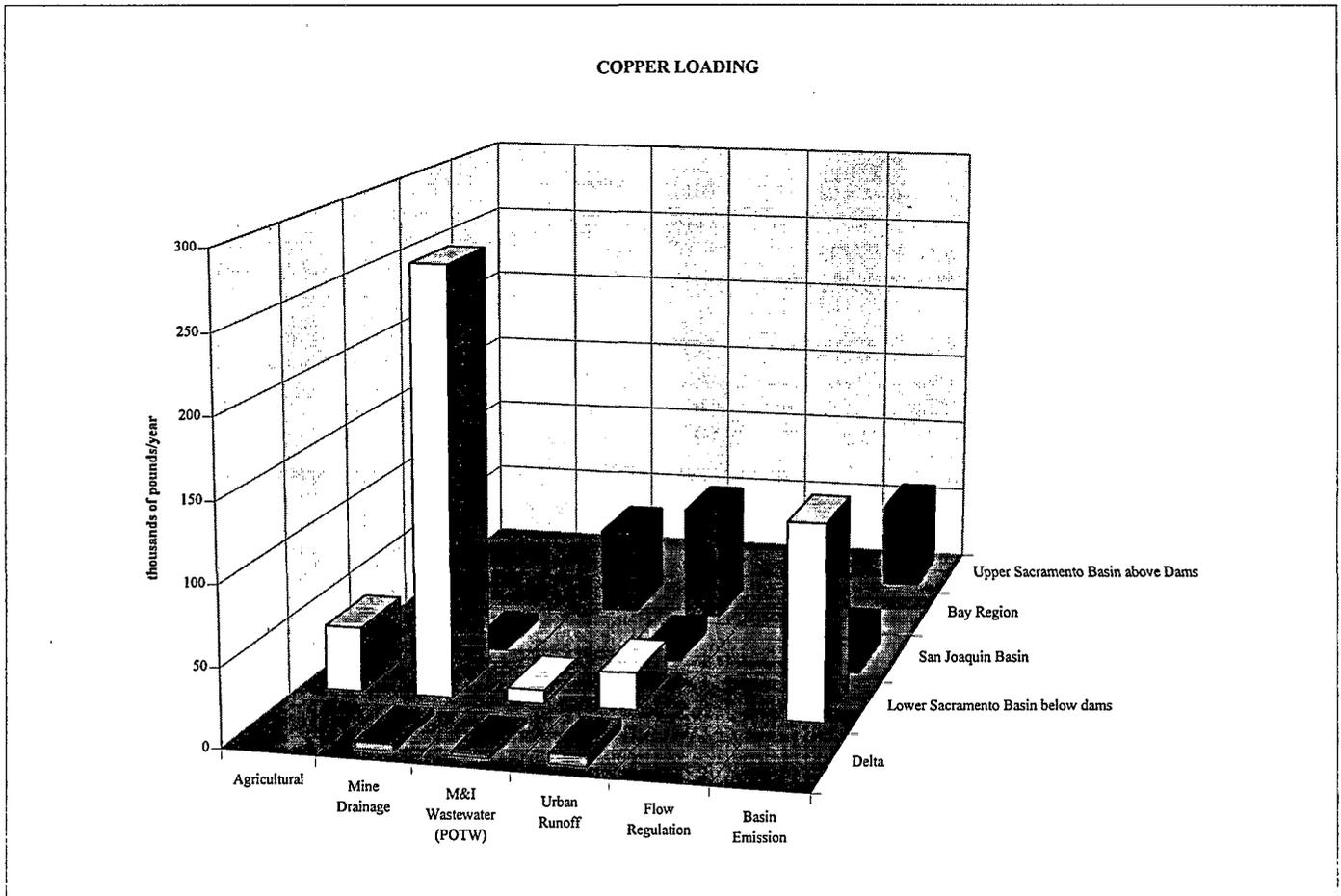
n. See Note mc for explanation.

o. Total emission from upper Sacramento Basin was calculated using flow and concentration data for releases from Shasta, Oroville and Nimbus Dams. Reported in “A mass loading assessment of major point and non-point sources discharging to surface waters in the Central Valley, California, 1985” prepared by the RWQCB Central Valley Region in 1988.

COPPER LOADING TABLE										
Copper Loading (thousands of pounds/year)										
Source	Delta	Note	Lower Sacramento Basin below dams	Note	San Joaquin Basin	Note	Bay Region	Note	Upper Sacramento Basin above Dams	Note
Agricultural			41	<i>e</i>						
Mine Drainage	4	<i>a</i>	274	<i>f</i>	4	<i>j</i>				
M&I Wastewater (POTW)	2	<i>b</i>	9	<i>g</i>			55	<i>m</i>		
Urban Runoff	6	<i>c</i>	24	<i>h</i>	9	<i>k</i>	73	<i>n</i>		
Flow Regulation										
Total Load	12		348		13		128			
Basin Emission		<i>d</i>	124	<i>i</i>	22	<i>l</i>			56	<i>o</i>

Note: Letters listed in italics under the Note column provide the background and references associated with the accompanying load

-  - Data available; flow and concentration data available; load calculations required.
-  - Further literature review required.
-  - Source does not contribute significant load of constituent in this watershed.



## Copper Loading Notes

a. The original data for the load estimate was obtained from "A mass loading assessment of major point and non-point sources discharging to surface waters in the Central Valley, California, 1985" prepared by the RWQCB Central Valley Region in 1988. Flow and load data was compiled for four inactive mines including Iron Mountain, Newton, New Idria and Afterthought Mines. Only mines that drain to the Sacramento River or its tributaries below Shasta, Oroville and Nimbus Dams were considered. Ninety-five percent of the load was from Iron Mountain. A later report by Central Valley RWQCB prepared in 1989 and entitled "A mass loading assessment of major point and non-point sources in the Sacramento Valley, California, 1985" estimated that the earlier mine drainage estimate only represented 25% of the total. A further review of the two RWQCB documents was made by Woodward-Clyde in light of information contained in a 1992 report by the Central Valley Board entitled "Inactive mine drainage in the Sacramento Valley". Data in this report suggests that Iron Mountain represents about 50% of the total copper load from inactive mines. The 50% estimate was used to scale up the loads originally calculated by RWQCB. The loads calculated in the 1988 RWQCB were segregated into the three geographical areas, delta, San Joaquin Basin and Sacramento Basin below dams.

b. The original data for the load estimate was obtained from "A mass loading assessment of major point and non-point sources discharging to surface waters in the Central Valley, California, 1985" prepared by the RWQCB Central Valley Region in 1988. Flow and load data was compiled from several NPDES dischargers who have been monitoring copper, including the largest in the Central Valley the Sacramento Regional County Sewer District. Woodward-Clyde divided the results into two geographical areas, the delta and the Sacramento Basin. A later report by Central Valley RWQCB prepared in 1989 and entitled "A mass loading assessment of major point and non-point sources in the Sacramento Valley, California, 1985" estimated that the earlier M and I estimate only represented 50% of the total. This percentage was used to scale up the loads.

c. The original data for the load estimate was obtained from "A mass loading assessment of major point and non-point sources discharging to surface waters in the Central Valley, California, 1985" prepared by the RWQCB Central Valley Region in 1988. Urban runoff estimates were made for 19 large cities in the Central Valley. Flow data was calculated using rainfall data for cities, urban acreage and a runoff factor of 0.3. Quality data for the city of Sacramento was used for all cities. A later report by Central Valley RWQCB prepared in 1989 and entitled "A mass loading assessment of major point and non-point sources in the Sacramento Valley, California, 1985" estimated that the earlier urban runoff estimate only represented 35% of the total. A further review of the original data by Woodward-Clyde concluded that the original estimate probably captured 70% of the load, because all major urban areas were included in the calculations. The 70% figure was used to scale up the original estimates. The data allowed separation of the loads into three geographical areas, the delta, San Joaquin Basin and the Sacramento Basin.

d. Copper concentrations are available from various sampling locations within the Delta and at the San Joaquin River inflow to the Delta. Most of this data can be found at the Interagency Ecological Program web site. Work is in progress to acquire matching discharge data and calculate loads.

## Copper Loading Notes

e. The original data for the load estimate was obtained from "A mass loading assessment of major point and non-point sources discharging to surface waters in the Central Valley, California, 1985" prepared by the RWQCB Central Valley Region in 1988. Flow and concentration information was compiled for the major drains in the Sacramento Basin, including Sacramento Slough, Colusa Basin Drain, RD1000, RD108 and Natomas East Main Drain. A later report by Central Valley RWQCB prepared in 1989 and entitled "A mass loading assessment of major point and non-point sources in the Sacramento Valley, California, 1985" estimated that the earlier agricultural runoff estimate only represented 80% of the total. This percentage was used to scale up the estimates.

f. See Note a for explanation.

g. See Note b for explanation.

h. See Note c for explanation.

i. Concentration data is from EarthInfo USGS Quality of Water databases on CD-ROM (EarthInfo, 1996). Flow data is from USGS Water Data Reports for the years in which concentration data was available. For the Sacramento River concentration and flow data used in the load calculation is from Freeport. For the San Joaquin River concentration and flow data used in the load calculation is from Vernalis.

Loads were calculated for each day data were available. For the period of record the average daily load was calculated from all the daily values. The annual load for the period of record is the product of the average daily load multiplied times the number of seconds in a year. The resulting value was converted to an average annual value by dividing the annual load for the period of record by the average daily flow over the period of record and then multiplying the result times the long term daily average flow rate.

average annual load = ((average daily load \* number of seconds in a year) / average daily flow over the period of record)\* long term daily average flow rate

j. See Note a for explanation.

k. See Note c for explanation.

l. See Note i for explanation.

m. Reported in Table 19 of "State of the Estuary: A report on conditions and problems in San Francisco Bay/Sacramento-San Joaquin Delta Estuary' San Francisco Estuary Project, 1992. Middle of range of values used .

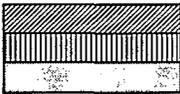
## Copper Loading Notes

n. See Note m for explanation.

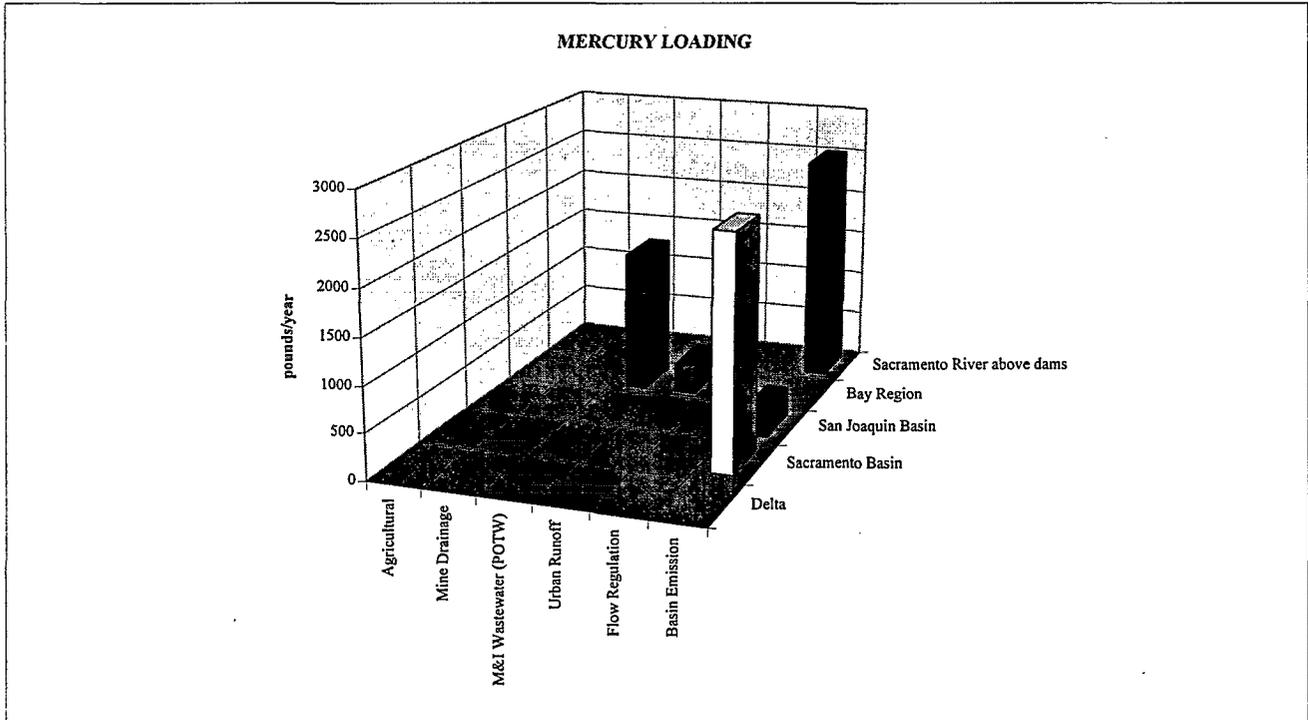
o. Total emission from upper Sacramento Basin was calculated using flow and concentration data for releases from Shasta, Oroville and Nimbus Dams. Reported in "A mass loading assessment of major point and non-point sources discharging to surface waters in the Central Valley, California, 1985" prepared by the RWQCB Central Valley Region in 1988.

MERCURY LOADING TABLE										
Source	Mercury Loading (pounds/year)									
	Delta	Note	Sacramento Basin	Note	San Joaquin Basin	Note	Bay Region	Note	Sacramento River above dams	Note
Agricultural	▨		▨		▨		▨		▨	
Mine Drainage	▨		▨		▨		▨		▨	
M&I Wastewater (POTW)	▨		▨		▨		1543	<i>c</i>	▨	
Urban Runoff	▨		▨		▨		330	<i>d</i>	▨	
Flow Regulation	▨		▨		▨		▨		▨	
Total Load	▨		▨		▨		1873		▨	
Basin Emission	▨		2530	<i>a</i>	328	<i>b</i>	▨		2500	<i>e</i>

Note: Letters listed in italics under the Note column provide the background and references associated with the accompanying load



- Data available; flow and concentration data available; load calculations required.
- Further literature review required.
- Source does not contribute significant load of constituent in this watershed.



## Mercury Loading Notes

a. Concentration data is from EarthInfo USGS Quality of Water databases on CD-ROM (EarthInfo, 1996). Flow data is from USGS Water Data Reports for the years in which concentration data was available. For the Sacramento River concentration and flow data used in the load calculation is from Freeport. For the San Joaquin River concentration and flow data used in the load calculation is from Vernalis.

Loads were calculated for each day data were available. For the period of record the average daily load was calculated from all the daily values. The annual load for the period of record is the product of the average daily load multiplied times the number of seconds in a year. The resulting value was converted to an average annual value by dividing the annual load for the period of record by the average daily flow over the period of record and then multiplying the result times the long term daily average flow rate.

average annual load = ((average daily load \* number of seconds in a year) / average daily flow over the period of record)\* long term daily average flow rate

b. See Note a for explanation.

c. Reported in Table 19 of "State of the Estuary: A report on conditions and problems in San Francisco Bay/Sacramento-San Joaquin Delta Estuary" San Francisco Estuary Project, 1992. Middle of range of values used .

d. See Note c for explanation.

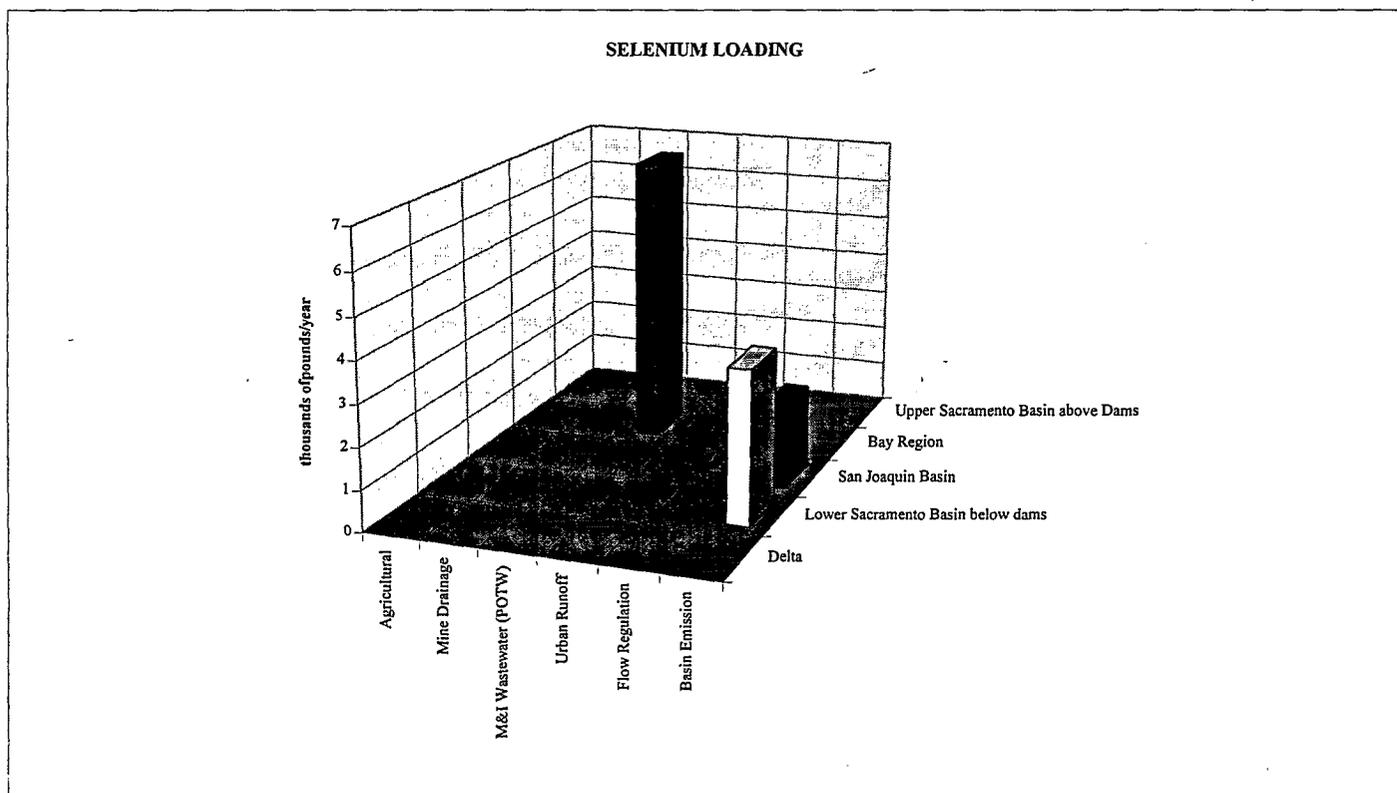
e. Emission was calculated using flow and concentration data for release from Shasta Dam. No similar data was available for Oroville and Nimbus Dams so this is probably an underestimate. Reported in "A mass loading assessment of major point and non-point sources discharging to surface waters in the Central Valley, California, 1985" prepared by the RWQCB Central Valley Region in 1988. The emission is the product of a large flow and a small concentration, probably based on limited data. Consequently, a small error in concentration can greatly effect the emission rate.

### SELENIUM LOADING TABLE - 1

Selenium Loading (thousands of pounds/year)										
Source	Delta	Note	Lower Sacramento Basin below dams	Note	San Joaquin Basin	Note	Bay Region	Note	Upper Sacramento Basin above Dams	Note
Agricultural										
Mine Drainage										
M&I Wastewater (POTW)							7	<i>c</i>		
Urban Runoff										
Flow Regulation										
Total Load							7			
Basin Emission			4	<i>a</i>	2	<i>b</i>				

Note: Letters listed in italics under the Note column provide the background and references associated with the accompanying load

- Data available; flow and concentration data available; load calculations required.
- Further literature review required.
- Source does not contribute significant load of constituent in this watershed.



## SELENIUM TABLE - 2

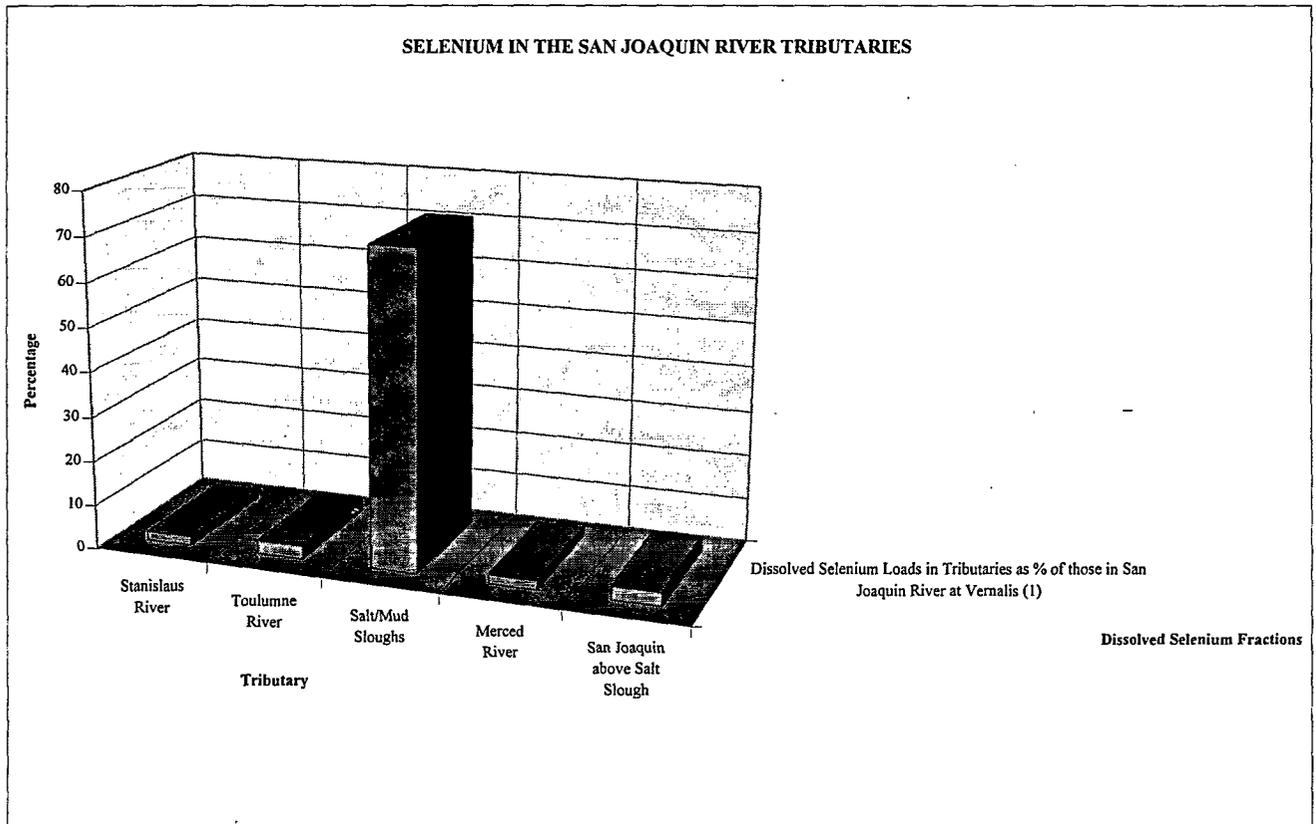
### Selenium in the San Joaquin River Tributaries

Tributary	Dissolved Selenium Loads in Tributaries as % of those in San Joaquin River at Vernalis (1)
Stanislaus River	2
Toulumne River	3
Salt/Mud Sloughs	71
Merced River	2
San Joaquin above Salt Slough Confluence	3

**Notes:**

(1) Values obtained from the U.S. Geological Survey Water Resources Investigation Report 88-4186.

The dissolved selenium loads for the tributaries to the San Joaquin River do not add up to 100% of the loads in the San Joaquin River at Vernalis because some of the load at Vernalis most likely can be attributed to sources within the river, such as selenium delivered to the San Joaquin River from sources other than the listed tributaries.



## Selenium Loading Notes

a. Concentration data is from EarthInfo USGS Quality of Water databases on CD-ROM (EarthInfo, 1996). Flow data is from USGS Water Data Reports for the years in which concentration data was available. For the Sacramento River concentration and flow data used in the load calculation is from Freeport. For the San Joaquin River concentration and flow data used in the load calculation is from Vernalis.

Loads were calculated for each day data were available. For the period of record the average daily load was calculated from all the daily values. The annual load for the period of record is the product of the average daily load multiplied times the number of seconds in a year. The resulting value was converted to an average annual value by dividing the annual load for the period of record by the average daily flow over the period of record and then multiplying the result times the long term daily average flow rate.

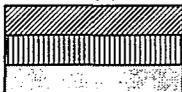
average annual load = ((average daily load \* number of seconds in a year) / average daily flow over the period of record) \* long term daily average flow rate

b. See Note a for explanation.

c. Selenium loads to San Francisco Bay are reported in "Mass Emissions Reduction Strategy for Selenium" prepared by San Francisco Bay RWQCB in 1992. The loads are estimated as 7.1 kg/day from oil refineries, 2.2 kg/day from municipal wastewater treatment plants and 2 kg/day from riverine sources under average flow conditions. No selenium was detected in samples of municipal wastewater. The RWQCB assumed that it was present in municipal wastewater at the detection limit used in the analyses and thus calculated 2.2 kg/day. The RWQCB noted this was a probable overstatement. It is worth noting that the estimated load to the bay from riverine sources (1,600 lbs/yr) is much lower than the sum of the Sacramento and San Joaquin River inputs to the Bay-Delta system (11,000 lbs/yr reported in "State of the Estuary: A report on conditions and problems in San Francisco Bay/Sacramento-San Joaquin Delta Estuary" San Francisco Estuary Project, 1992. Perhaps, this is attributable chemical reactions and biological uptake in the Delta.

ZINC LOADING TABLE										
Zinc Loading (thousands of pounds/year)										
Source	Delta	Note	Lower Sacramento Basin below dams	Note	San Joaquin Basin	Note	Bay Region	Note	Upper Sacramento Basin above Dams	Note
Agricultural			88	<i>c</i>						
Mine Drainage	116	<i>a</i>	930	<i>d</i>	116	<i>h</i>				
M&I Wastewater (POTW)	2	<i>b</i>	34	<i>e</i>						
Urban Runoff			131	<i>f</i>						
Flow Regulation										
Total Load	118		1183		116					
Basin Emission			255	<i>g</i>	69	<i>i</i>	279	<i>j</i>		

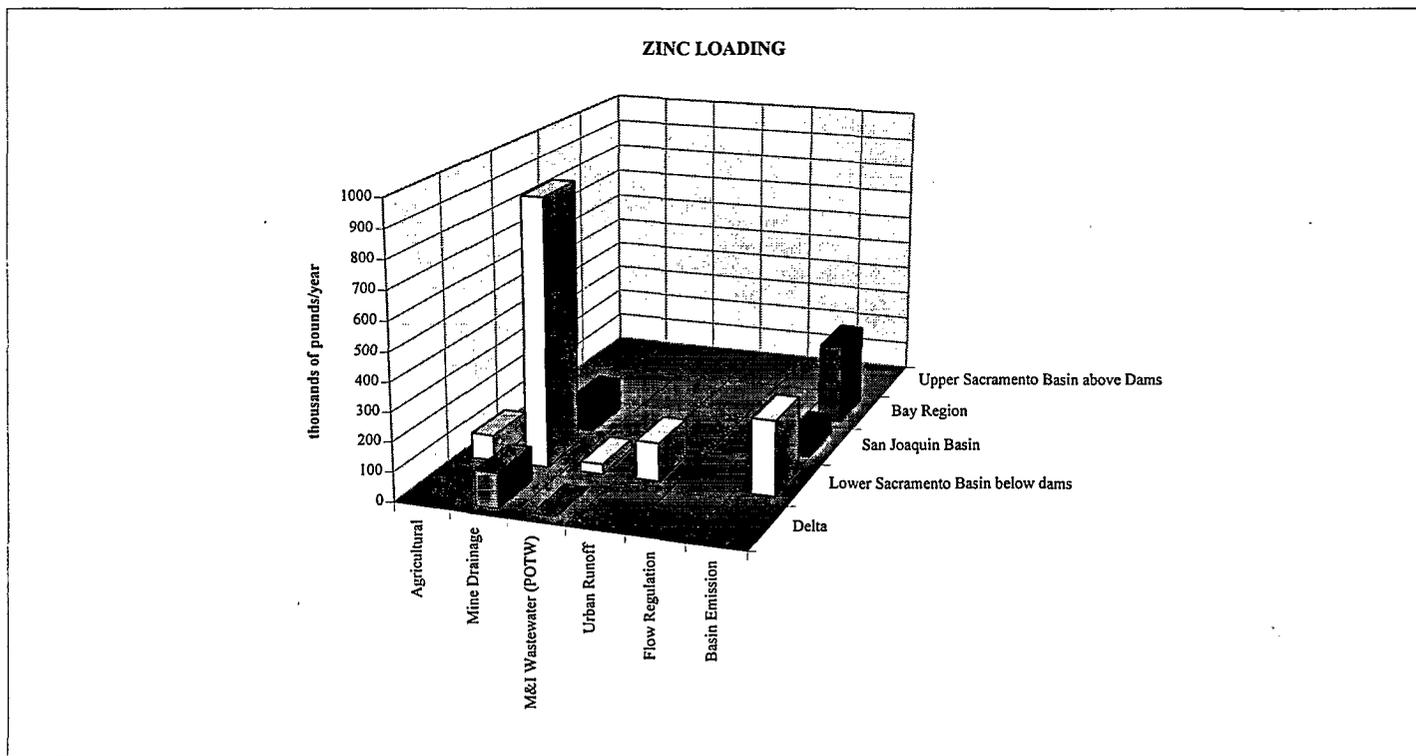
Note: Letters listed in italics under the Note column provide the background and references associated with the accompanying load



Diagonal lines: Data available; flow and concentration data available; load calculations required.

Vertical lines: Further literature review required.

Stippling: - Source does not contribute significant load of constituent in this watershed.



## Zinc Loading Notes

a. The original data for the load estimate was obtained from "A mass loading assessment of major point and non-point sources discharging to surface waters in the Central Valley, California, 1985" prepared by the RWQCB Central Valley Region in 1988. Flow and load data was compiled for four inactive mines including Iron Mountain, Newton, New Idria and Afterthought Mines. Only mines that drain to the Sacramento River or its tributaries below Shasta, Oroville and Nimbus Dams were considered. Eighty-five percent of the load was from Iron Mountain. A later report by Central Valley RWQCB prepared in 1989 and entitled "A mass loading assessment of major point and non-point sources in the Sacramento Valley, California, 1985" estimated that the earlier mine drainage estimate only represented 25% of the total. A further review of the two RWQCB documents was made by Woodward-Clyde in light of information contained in a 1992 report by the Central Valley Board entitled "Inactive mine drainage in the Sacramento Valley". Data in this report suggests that mine drainage represents about 50% of the total zinc load from inactive mines. The 50% estimate was used to scale up the loads originally calculated by RWQCB. The loads calculated in the 1988 RWQCB were segregated into the three geographical areas, delta, San Joaquin Basin and Sacramento Basin below dams.

b. The original data for the load estimate was obtained from "A mass loading assessment of major point and non-point sources discharging to surface waters in the Central Valley, California, 1985" prepared by the RWQCB Central Valley Region in 1988. Flow and load data was compiled from several NPDES dischargers who have been monitoring copper, including the largest in the Central Valley the Sacramento Regional County Sewer District. Woodward-Clyde divided the results into two geographical areas, the delta and the Sacramento Basin. A later report by Central Valley RWQCB prepared in 1989 and entitled "A mass loading assessment of major point and non-point sources in the Sacramento Valley, California, 1985" estimated that the earlier M and I estimate only represented 50% of the total. This percentage was used to scale up the loads.

c. Loads were taken from "A mass loading assessment of major point and non-point sources discharging to surface waters in the Central Valley, California, 1985" prepared by the RWQCB Central Valley Region in 1989.

d. See note a for explanation.

e. See note c for explanation.

f. See note c for explanation.

g. Concentration data is from EarthInfo USGS Quality of Water databases on CD-ROM (EarthInfo, 1996). Flow data is from USGS Water Data Reports for the years in which concentration data was available. For the Sacramento River concentration and flow data used in the load calculation is from Freeport. For the San Joaquin River concentration and flow data used in the load calculation is from Vernalis.

Loads were calculated for each day data were available. For the period of record the average daily load was calculated from all the daily values. The annual load for the period of record is

the product of the average daily load multiplied times the number of seconds in a year. The resulting value was converted to an average annual value by dividing the annual load for the period of record by the average daily flow over the period of record and then multiplying the result times the long term daily average flow rate.

average annual load = ((average daily load \* number of seconds in a year) / average daily flow over the period of record)\* long term daily average flow rate.

h. See note a for explanation.

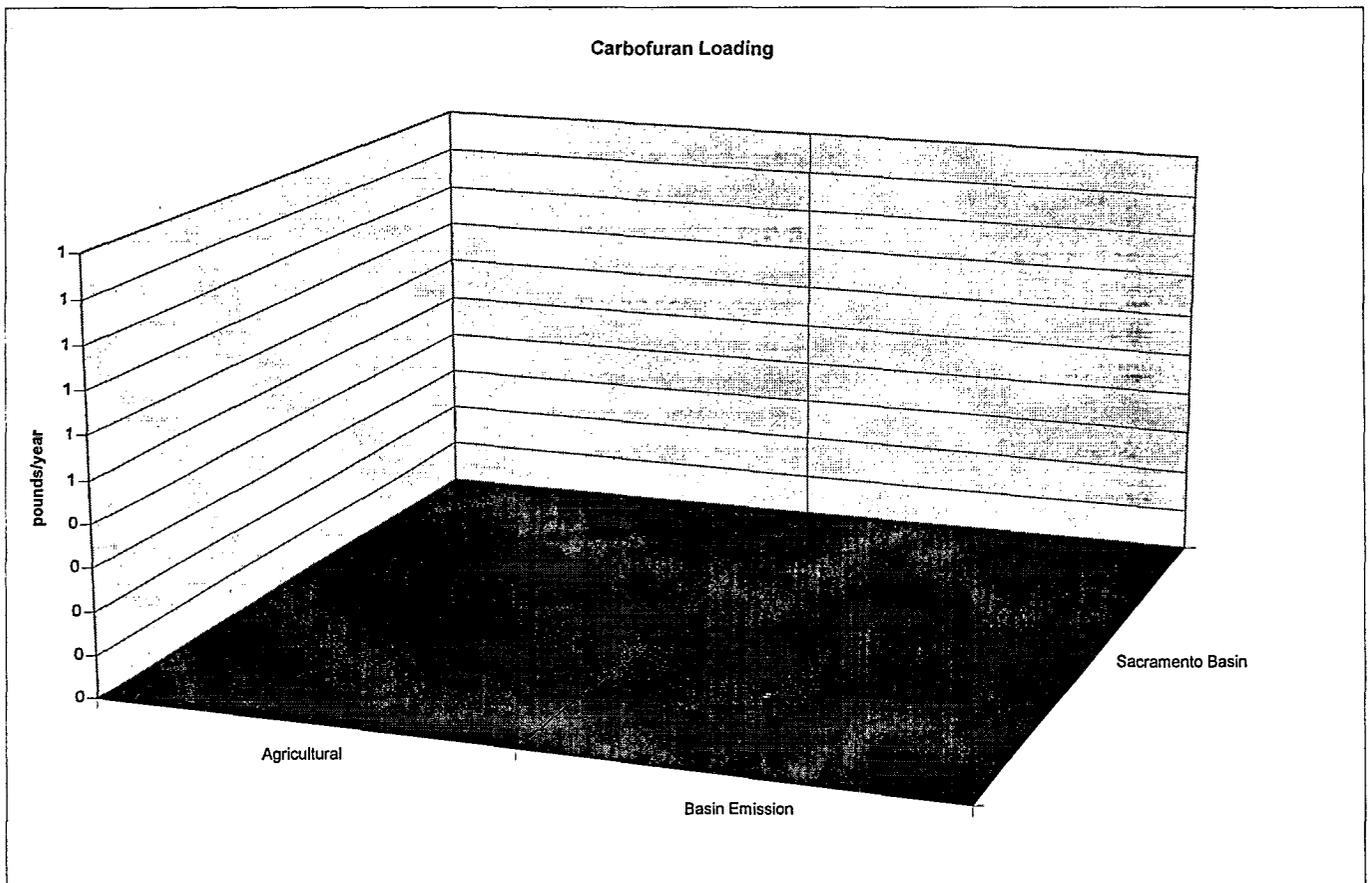
i. See note g for explanation.

j. Estimate of Bay Region loads were made by adding estimated pollutant loads of Contra Costa, Alameda and Santa Clara Counties. This value probably underestimates the total contribution of zinc by the Bay Region.

CARBOFURAN LOADING TABLE		
	Carbofuran (pounds/year)	
Source	Sacramento Basin	Note
Agricultural		<i>a</i>
Total Load		
Basin Emission		<i>b</i>
Total Load		

Note: Letters listed in italics under the Note column provide the background and references associated with the accompanying load

- Data available; flow and concentration data available; load calculations required.



## Carbofuran Loading Notes

### General Notes

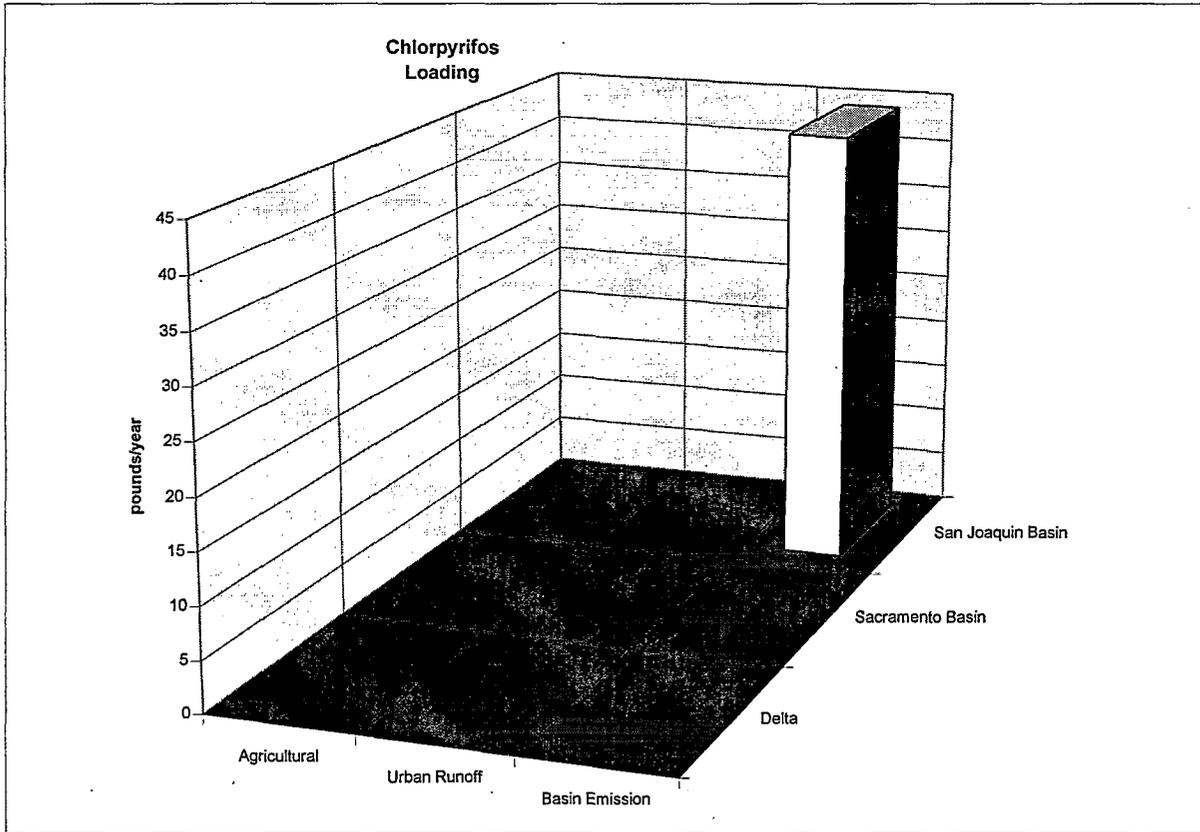
- Applied to alfalfa fields in March and to rice fields from April through June.
- a. Several studies report carbofuran concentrations detected in the Sacramento River at various locations (USGS, 1995, Open File Report 95-110); (Crepeau et. al.); (Department of Fish and Game, Rice Pesticide Concentrations in the Sacramento River and Associated Agricultural Drains); (Department of Water Resources, August 1989). Discharge data is available for many of the locations where carbofuran was sampled. Load calculations are in progress.
- b. See Note a for explanation.

CHLORPYRIFOS LOADING TABLE						
Source	Chlorpyrifos Loading (pounds/year)					
	Delta	Note	Sacramento Basin	Note	San Joaquin Basin	Note
Agricultural						
Urban Runoff						
Total Load						
Basin Emission					44	<i>a</i>

Note: Letters listed in italics under the Note column provide the background and references associated with the accompanying load



- Data available; flow and concentration data available; load calculations required.
- Further literature review required.
- Source does not contribute significant load of constituent in this watershed.



## Chlorpyrifos Loading Notes

### General Notes

- Applied to almond orchards in January and February and again in May through August.
- Applied to alfalfa fields in March.
- Particle bound compound.

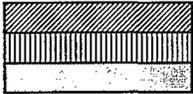
a. Concentration data is from EarthInfo USGS Quality of Water databases on CD-ROM (EarthInfo, 1996). Flow data is from USGS Water Data Reports for the years in which concentration data was available. For the Sacramento River concentration and flow data used in the load calculation is from Freeport. For the San Joaquin River concentration and flow data used in the load calculation is from Vernalis.

Loads were calculated for each day data were available. For the period of record the average daily load was calculated from all the daily values. The annual load for the period of record is the product of the average daily load multiplied times the number of seconds in a year. The resulting value was converted to an average annual value by dividing the annual load for the period of record by the average daily flow over the period of record and then multiplying the result times the long term daily average flow rate.

average annual load = ((average daily load \* number of seconds in a year) / average daily flow over the period of record)\* long term daily average flow rate.

DIAZINON LOADING TABLE						
Diazinon Loading ( pounds/year)						
Source	Delta	Note	Sacramento Basin	Note	San Joaquin Basin	Note
Agricultural						
Urban Runoff		<i>a</i>		<i>b</i>		
Total Load						
Basin Emission			319	<i>c</i>	116	<i>d</i>

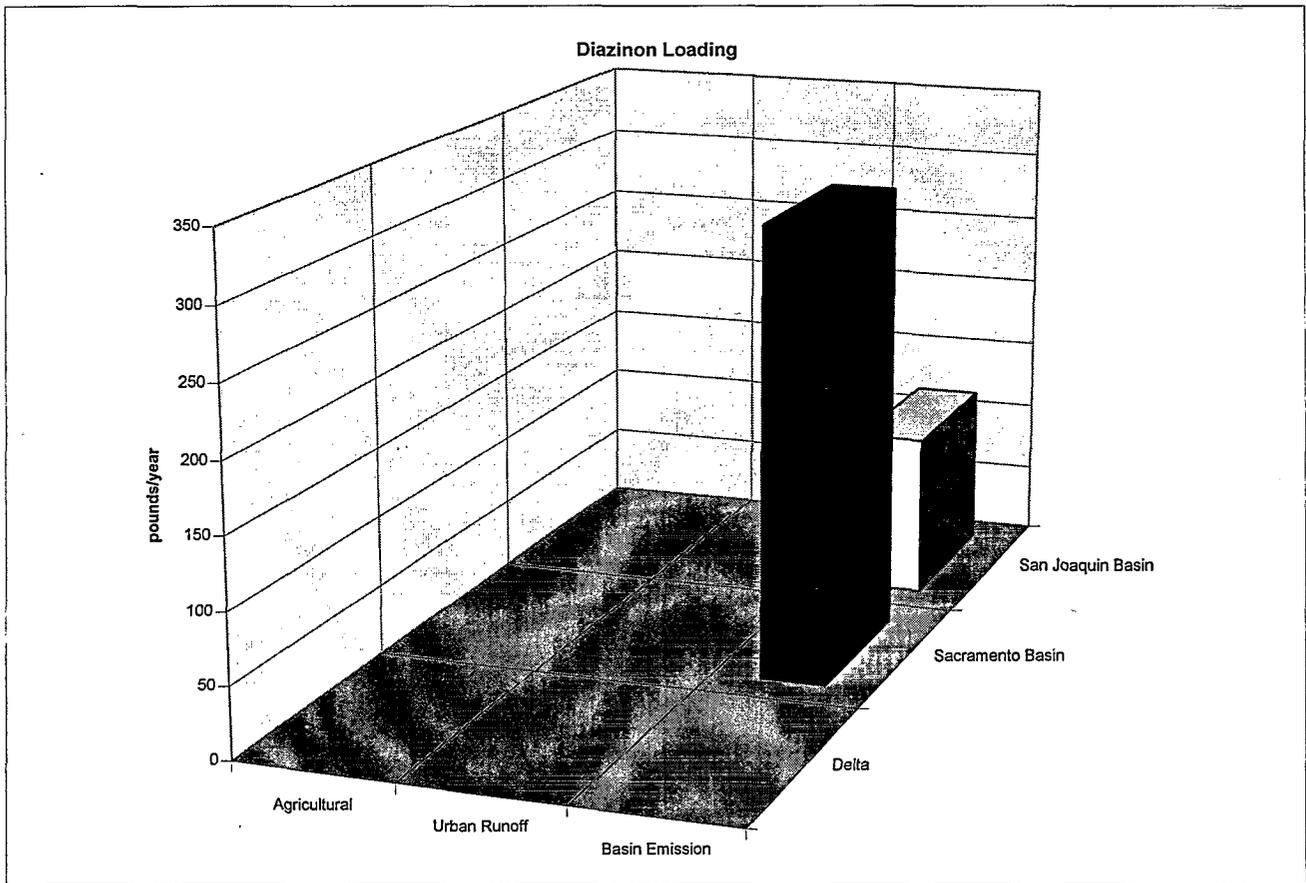
Note: Letters listed in italics under the Note column provide the background and references associated with the accompanying load



- Data available; flow and concentration data available; load calculations required.

- Further literature review required.

- Source does not contribute significant load of constituent in this watershed.



## Diazinon Loading Notes

### General Notes

- Applied to almond orchards in January and February and again in May through August.
- Applied to alfalfa fields in March.

a. One study (Conner, 1996) reports diazinon concentrations in urban runoff from the cities of Stockton and Sacramento and the San Francisco Bay Area. The concentration from the City of Stockton could be used to calculate a load for the Delta. However, further investigation is required to determine if discharge data can be matched to the sampling events and locations.

b. See Note a for explanation.

c. Loads were estimated based on measured diazinon concentrations and measured streamflows. Diazinon concentrations in the San Joaquin River at Vernalis were obtained from The USGS WATSTOR database and the USGS Open File Report 95-110. Diazinon data in the Sacramento River at Sacramento were obtained from the USGS Open File Report 95-110. Flows in the Sacramento River are from the USGS gage at Freeport (#11447650).

d. Flows in the San Joaquin River are from the USGS gage at Vernalis (#11303500). At Vernalis loads were estimated for years 1991, 1993, and 1994. The average is reported in the table. At Sacramento loads were estimated for 1993 and 1994 and the average reported. Note, the estimated diazinon load at Sacramento includes urban runoff from Sacramento and surrounding areas in addition to agricultural runoff. Non-detect data was not included in the loads analysis.

DISSOLVED ORGANIC CARBON (DOC) LOADING TABLE										
Dissolved Organic Carbon (DOC) Loading (thousands of pounds/year)										
Source	Delta	Note	Lower Sacramento Basin below dams	Note	San Joaquin Basin	Note	Bay Region	Note	Upper Sacramento Basin above Dams	Note
Agricultural	▨		15,558	<i>a</i>	▨		▨		▨	
Mine Drainage	▨		▨		▨		▨		▨	
M&I Wastewater (POTW)	▨		▨		▨		▨		▨	
Urban Runoff	▨		▨		▨		▨		▨	
Flow Regulation	▨		▨		▨		▨		▨	
Total Load			15,558							
Basin Emission	▨		24,380	<i>b</i>	7,100	<i>c</i>	▨		▨	

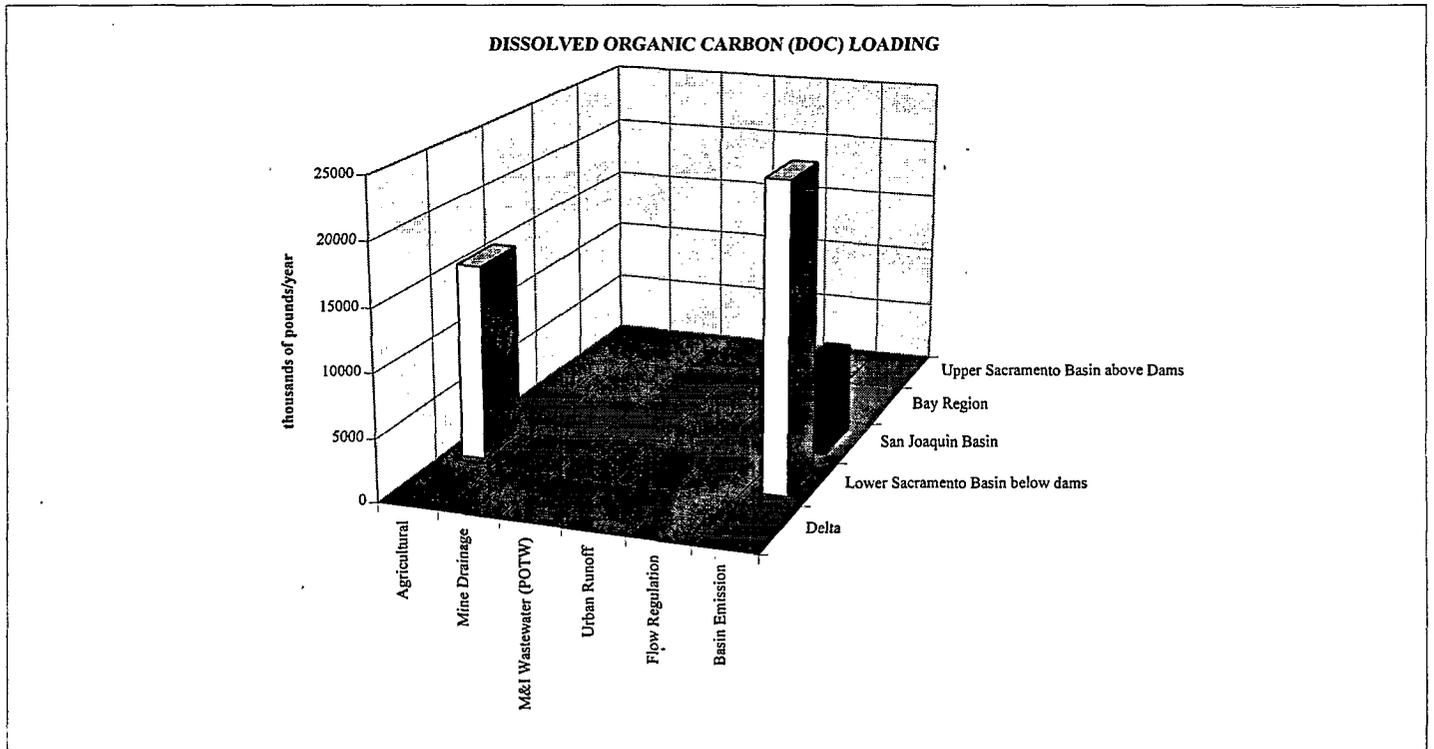
Note: Letters listed in italics under the Note column provide the background and references associated with the accompanying load



▨ Data available; flow and concentration data available; load calculations required.

▨ Further literature review required.

▨ - Source does not contribute significant load of constituent in this watershed.



## Dissolved Organic Carbon (DOC) Loading Notes

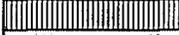
a. Load data was obtained from the "Study of Drinking Water Quality in Delta Tributaries" from the California Urban Water Agencies, April 1995 Report. The data estimated using Figure 4-1 which shows total loads of DOC and TOC and percentages for various contributing sources. The total in pounds per day in the Sacramento River at Greene's Landing is 310,000 lbs/day, 13.75 % of that is from agriculture. The data were evaluated using two techniques. One involves constructing and evaluating time-series plots for rainfall, flow, concentration and load allowing for a direct and detailed examination of seasonal and historical patterns and allow for a direct and detailed examination of periods when concentrations are high. The second technique included combining data from different sets of conditions/types of seasonal periods to average loads.

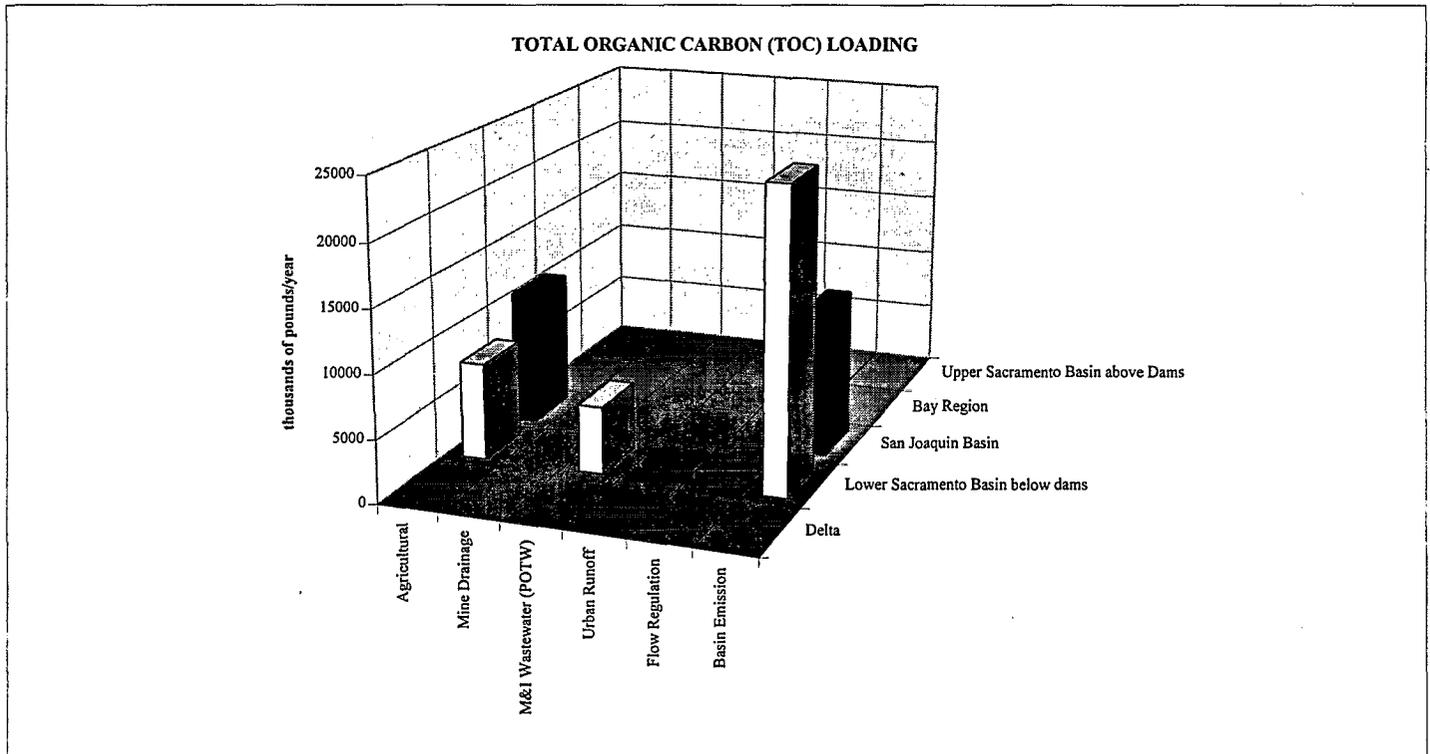
b. The "Study of Drinking Water Quality in Delta Tributaries", California Urban Water Agencies, April 1995 shows a 1.1 mg/L increase in DOC concentrations from agricultural drainage by comparing Inflow, Observed and Predicted DOC Five Years (1987-91) of Monthly Average DOC data. No flow data was supplied, therefore, no load calculations can be performed until further literature review has been performed.

c. A single sample reported in the Study of Drinking Water Quality in Delta Tributaries. California Urban Water Agencies, April 1995, was collected in 1989 (4.4-500mg/l) for urban runoff in Sacramento. No flow data available for this sample. Further data search must be performed to obtain additional TOC data information for load calculations.

TOTAL ORGANIC CARBON (TOC) LOADING TABLE										
Total Organic Carbon (TOC) Loading (thousands of pounds/year)										
Source	Delta	Note	Lower Sacramento Basin below dams	Note	San Joaquin Basin	Note	Bay Region	Note	Upper Sacramento Basin above Dams	Note
Agricultural			7706	<i>a</i>	10,764	<i>d</i>				
Mine Drainage										
M&I Wastewater (POTW)			5375	<i>b</i>						
Urban Runoff										
Flow Regulation										
Total Load			13,081		10,764					
Basin Emission			24,130	<i>c</i>	11,710	<i>e</i>				

Note: Letters listed in italics under the Note column provide the background and references associated with the accompanying load

-  Data available; flow and concentration data available; load calculations required.
-  Further literature review required.
-  - Source does not contribute significant load of constituent in this watershed.



## Total Organic Carbon (TOC) Loading Notes

a. Load concentrations to the mud and salt sloughs from agriculture in the Sacramento Area were reported in the "Study of Drinking Water Quality in Delta Tributaries". (California Urban Water Agencies, 1995). The value was obtained from Appendix D, Table D-7. The value used here is the highest value from the Table and in Wet year/wet season. The annual load was calculated assuming an average of 30,850 lb/day and 365 days in the wet season as defined in the study.

b. Load data was obtained from the "Study of Drinking Water Quality in Delta Tributaries" from the California Urban Water Agencies, April 1995 Report. The data estimated using Figure 4-1 which shows total loads of DOC and TOC and percentages for various contributing sources. The total in pounds per day in the Sacramento River at Greene's Landing is 310,000 lbs/day, 4.75 % of that is from agriculture. The data were evaluated using two techniques. one involves constructing and evaluating time-series plots for rainfall, flow, concentration and load allowing for a direct and detailed examination of seasonal and historical patterns and allow for a direct and detailed examination of periods when concentrations are high. The second technique included combining data from different sets of conditions/types of seasonal periods to average loads.

c. Concentration data was received from Ray Tom of the Department of Water Resources. Concentration data was collected at Green's Landing for the Sacramento River and Vernalis for the San Joaquin River. Flow data is from USGS Water Data Reports for the years in which concentration data was available.

Loads were calculated for each day data were available. For the period of record the average daily load was calculated from all the daily values. The annual load for the period of record is the product of the average daily load multiplied times the number of seconds in a year. The resulting value was converted to an average annual value by dividing the annual load for the period of record by the average daily flow over the period of record and then multiplying the result times the long term daily average flow rate.

average annual load = ((average daily load \* number of seconds in a year) / average daily flow over the period of record) \* long term daily average flow rate

d. Load data was obtained from the "Study of Drinking Water Quality in Delta Tributaries" from the California Urban Water Agencies, April 1995 Report. The data estimated using Figure 4-1 which shows total loads of DOC and TOC and percentages for various contributing sources. The total in pounds per day in the San Joaquin River at Vernalis is 47,950 lbs/day, 61.51 % of that is from agriculture. The data were evaluated using two techniques. One involves constructing and evaluating time-series plots for rainfall, flow, concentration and load allowing for a direct and detailed examination of seasonal and historical patterns and allow for a direct and detailed examination of periods when concentrations are high. The second technique included combining data from different sets of conditions/types of seasonal periods to average loads.

Additional sampling has been conducted by the Department of Pesticide Regulations along the San Joaquin River. Sampling occurred periodically from March of 1991 through February of 1993. It can be assumed that these samples are being collected to estimate contaminants from

agriculture. Concentration and flow data are available for values collected in the San Joaquin River. Further Investigation on the locations of these monitoring stations and surrounding landuse will be performed prior to load calculations.

e. Concentration data is from EarthInfo USGS Quality of Water databases on CD-ROM (EarthInfo, 1996). Flow data is from USGS Water Data Reports for the years in which concentration data was available. For the Sacramento River concentration and flow data used in the load calculation is from Freeport. For the San Joaquin River concentration and flow data used in the load calculation is from Vernalis.

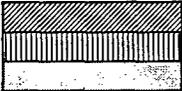
Loads were calculated for each day data were available. For the period of record the average daily load was calculated from all the daily values. The annual load for the period of record is the product of the average daily load multiplied times the number of seconds in a year. The resulting value was converted to an average annual value by dividing the annual load for the period of record by the average daily flow over the period of record and then multiplying the result times the long term daily average flow rate.

The load was calculated using the equation in note c.

TOTAL DISSOLVED SOLIDS (TDS) LOADING TABLE										
Total Dissolved Solids (TDS) Loading (thousands of pounds/year)										
Source	Delta	Note	Lower Sacramento Basin below dams	Note	San Joaquin Basin	Note	Bay Region	Note	Upper Sacramento Basin above Dams	Note
Agricultural			2,651,000	<i>a</i>	2,171,000	<i>e</i>				
Mine Drainage										
M&I Wastewater (POTW)			296,000	<i>b</i>						
Urban Runoff			42,330	<i>c</i>	296	<i>f</i>				
Flow Regulation										
Total Load			2,989,330		2,171,296					
Basin Emission			901,300	<i>d</i>	722,500	<i>g</i>				

: All numbers are rounded to significant 4 digits

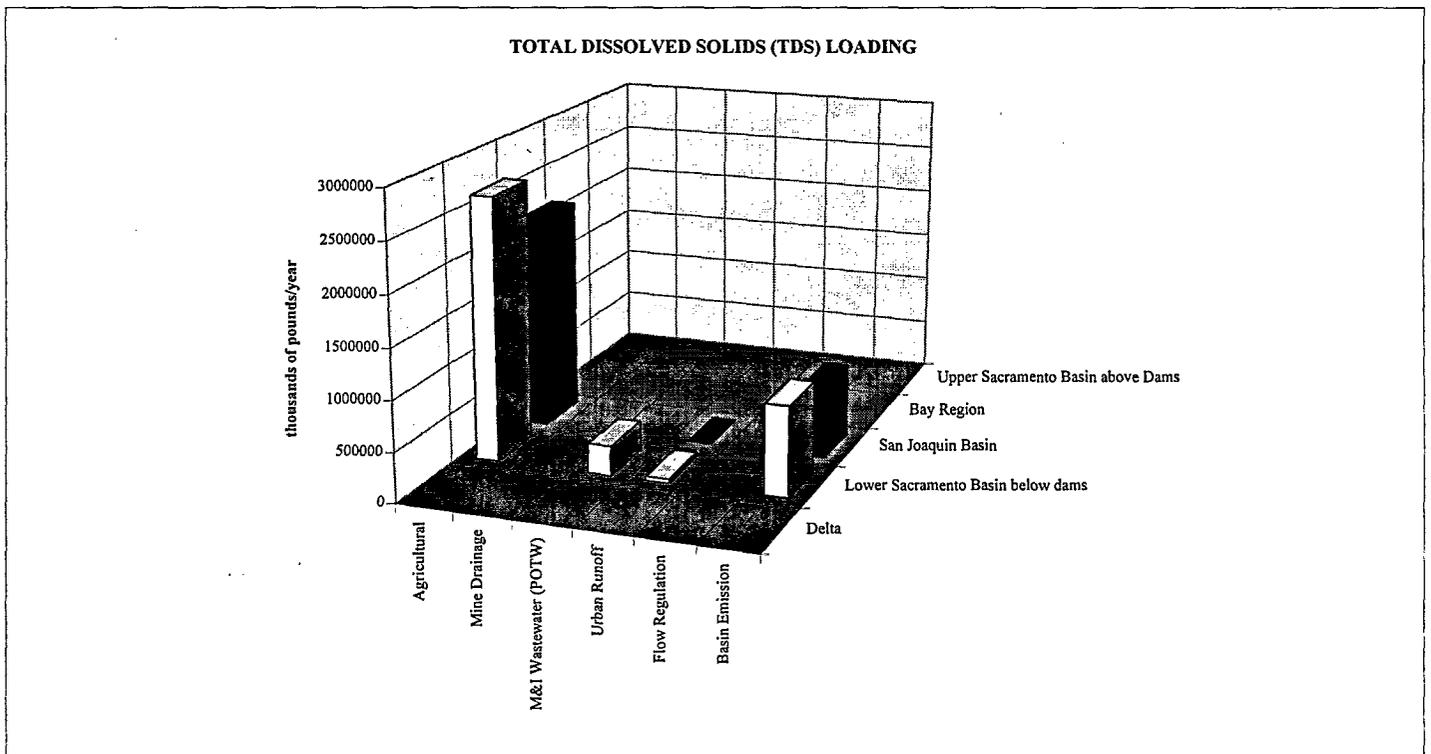
Note: Letters listed in italics under the Note column provide the background and references associated with the accompanying load



Data available; flow and concentration data available; load calculations required.

Further literature review required.

- Source does not contribute significant load of constituent in this watershed.



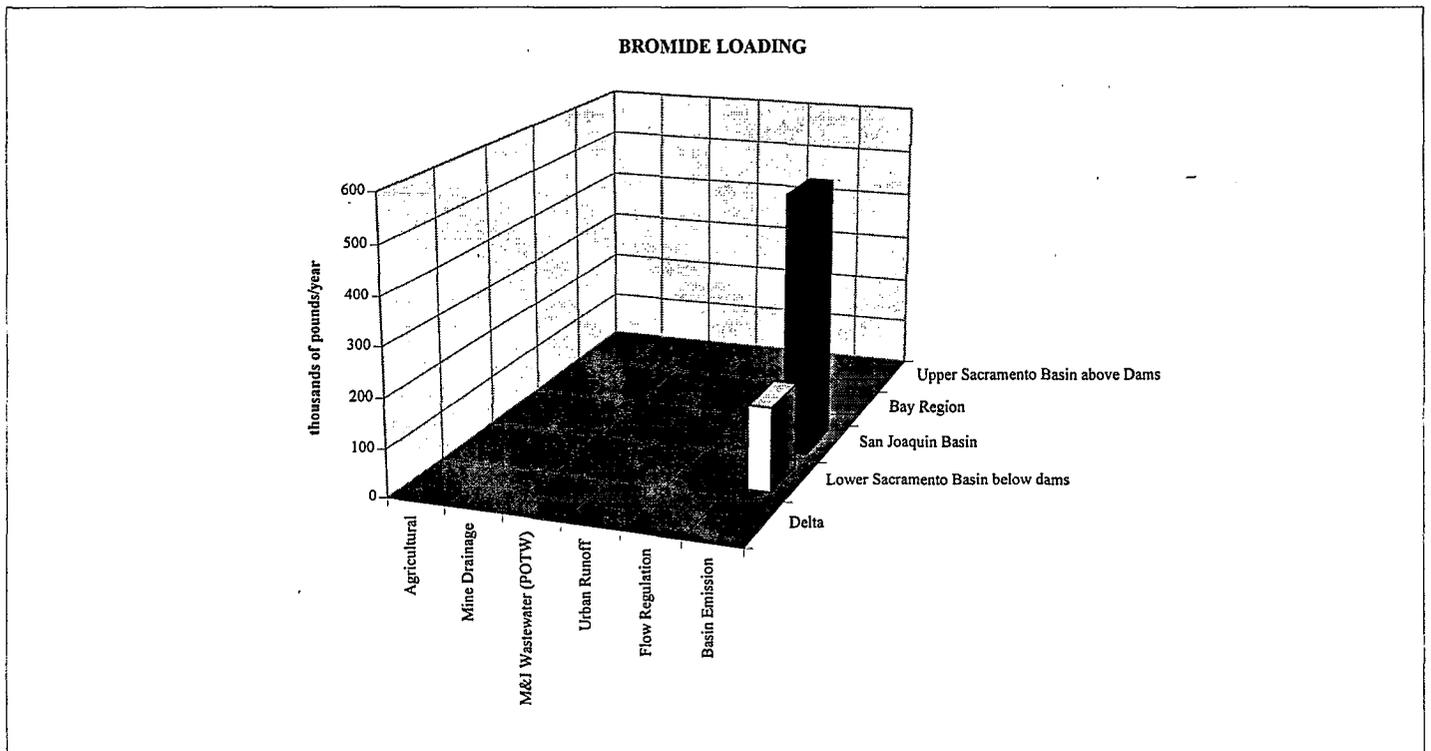
## Total Dissolved Solids (TDS) Loading Notes

- a. One study on drinking water quality in Delta tributaries calculated the relative proportions of TDS loads in the Sacramento River at Greene's Landing (California Urban Water Agencies, 1995). The load was subdivided into the following five categories: other sources, Sacramento Regional Wastewater Treatment Plant, Sacramento Combined Sewer Overflow, urban runoff, and the Sacramento Slough and Colusa Basin Drain. The load from Sacramento Slough and Colusa Basin Drain is assumed to be drainage from rice fields and therefore represents the agricultural load for the Lower Sacramento Basin.. The study calculated loads for both wet and dry years. The table contains an average for both years.
- b. The portion of the load attributed to the Sacramento Regional Wastewater Treatment Plant in the drinking water study referenced in note represents a load from the area serviced by the plant. The load in the table does not represent a total load form all POTW's in the Lower Sacramento River Basin. The load value in the table is an average of wet and dry year loads.
- c. The TDS concentration was developed from a continuous simulation analysis as a sum of the loads from wet weather, dry season and inter-storm loads (Larry Walker & Associates, 1996).
- d. Concentration data was received from Ray Tom of the Department of Water Resources. Concentrations data was collected at Green's Landing for the Sacramento River and Vernalis for the San Joaquin River. Flow data is from USGS Water Data Reports for the years in which concentration data was available.
- Loads were calculated for each day data were available. For the period of record the average daily load was calculated from all the daily values. The annual load for the period of record is the product of the average daily load multiplied times the number of seconds in a year. The resulting value was converted to an average annual value by dividing the annual load for the period of record by the average daily flow over the period of record and then multiplying the result times the long term daily average flow rate.
- $$\text{average annual load} = ((\text{average daily load} * \text{number of seconds in a year}) / \text{average daily flow over the period of record}) * \text{long term daily average flow rate}$$
- e. The study referenced in note a above also calculated loads for the San Joaquin River at Vernalis. The load was subdivided into contributions from Mud and Salt Sloughs and other sources. The load from Mud and Salt Sloughs is assumed to be agricultural drainage. The load value in the table is an average of wet and dry year loads.
- f. One study (Fresno Metropolitan Flood Control District, 1995) estimated the annual pollutant loads, summing the loads from the San Joaquin River, Dry Creek and Bidon Canal.
- g. See explanation for note d.

BROMIDE LOADING TABLE										
Bromide Loading (pounds/year)										
Source	Delta	Note	Lower Sacramento Basin below dams	Note	San Joaquin Basin	Note	Bay Region	Note	Upper Sacramento Basin above Dams	Note
Agricultural	▨		▨		▨		▨		▨	
Mine Drainage	▨		▨		▨		▨		▨	
M&I Wastewater (POTW)	▨		▨		▨		▨		▨	
Urban Runoff	▨		▨		▨		▨		▨	
Flow Regulation	▨		▨		▨		▨		▨	
Total Load										
Basin Emission	▨		172	<i>a</i>	535	<i>b</i>	▨		▨	

Note: Letters listed in italics under the Note column provide the background and references associated with the accompanying load

- ▨ Data available; flow and concentration data available; load calculations required.
- ▨ Further literature review required.
- ▨ - Source does not contribute significant load of constituent in this watershed.



## Bromide Loading Notes

a. Concentration data was received from Ray Tom of the Department of Water Resources. Concentrations data was collected at Green's Landing for the Sacramento River and Vernalis for the San Joaquin River. Flow data is from USGS Water Data Reports for the years in which concentration data was available.

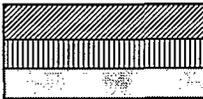
Loads were calculated for each day data were available. For the period of record the average daily load was calculated from all the daily values. The annual load for the period of record is the product of the average daily load multiplied times the number of seconds in a year. The resulting value was converted to an average annual value by dividing the annual load for the period of record by the average daily flow over the period of record and then multiplying the result times the long term daily average flow rate.

average annual load = ((average daily load \* number of seconds in a year) / average daily flow over the period of record)\* long term daily average flow rate

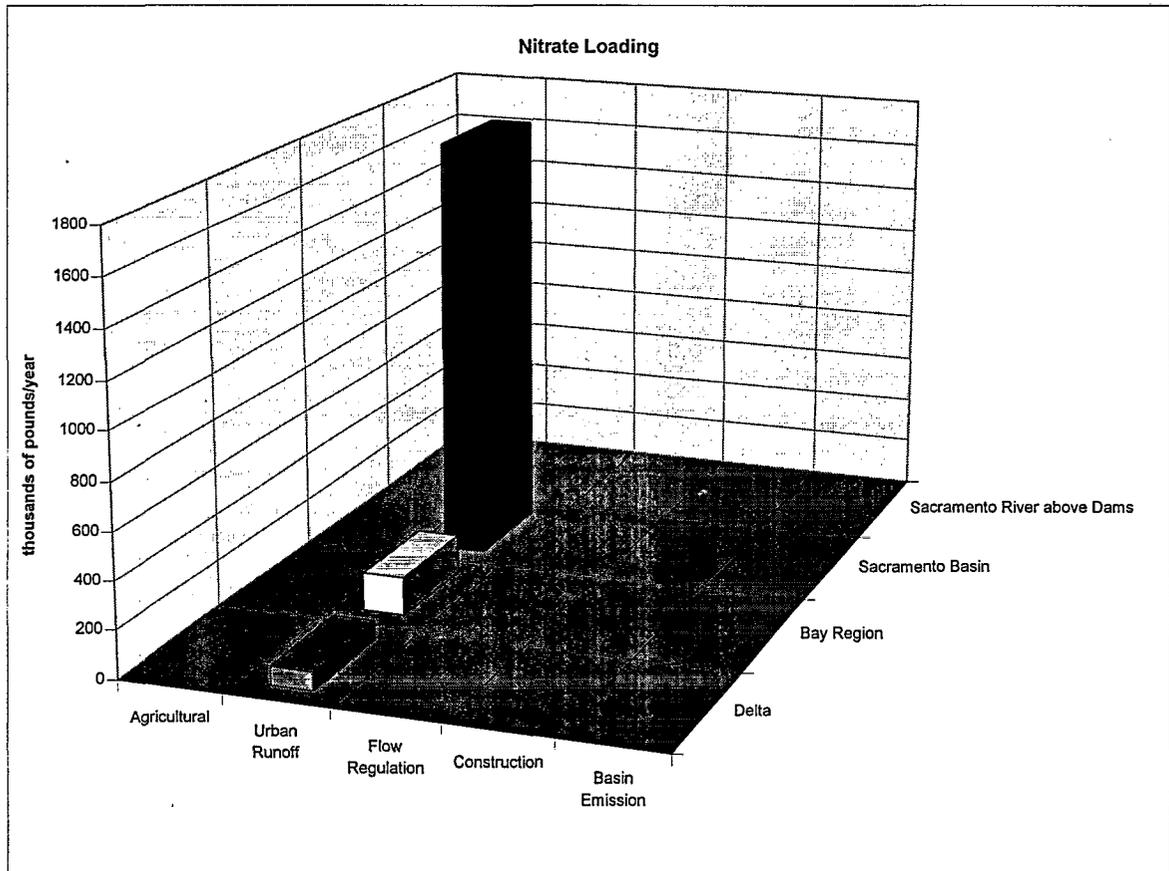
b. See note a for explanation.

NITRATE LOADING TABLE								
Nitrate Loading (thousands of pounds/year)								
Source	Delta	Note	Bay Region	Note	Sacramento Basin	Note	Sacramento River above Dams	Note
Agricultural								
Urban Runoff	77	<i>a</i>	166	<i>b</i>	1790	<i>c</i>		
Flow Regulation								
Construction								
Total Load	77		166		1790			
Basin Emission								

Note: Letters listed in italics under the Note column provide the background and references associated with the accompanying load



- Data available; flow and concentration data available; load calculations required.
- Further literature review required.
- Source does not contribute significant load of constituent in this watershed.



## Nitrate Loading Notes

a. Nitrate loads were calculated by Woodward-Clyde for the Contra Costa Clean Water Program (Contra Costa Clean Water Program, 1994). The loads assessment model is based upon a relationship between rainfall quantities, runoff pollutant concentrations, and the relationship between pollutant loads and land use. The loads assessment model contains the following assumptions:

- Uniform precipitation between isohyets
- Constant runoff coefficient based upon land use
- Runoff water quality was constant for each land use
- Isohyets based on average annual precipitation

The reported load in the loading table is from Figure 4-1 of the report (Contra Costa Clean Water Program, 1994).

b. See Note a for explanation.

c. Nitrate loads were calculated for the Sacramento NPDES Stormwater Discharge Characterization Program (Larry Walker & Associates). Loads were initially calculated in 1992 using the following methodology:

- Regression models were developed showing the relationship of urban runoff pollutant discharge factors.
- The regression equations were then used as input to a continuous simulation model for Sacramento urban runoff mass loading over a 58 year period.
- The model was refined in 1996, using the updated database of urban runoff monitoring data available from the Sacramento NPDES Stormwater Monitoring Program. The load reported in the loading table is from Table 15 of the report (Larry Walker & Associates).

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INTERNET SEARCH RESULTS

RESULTS INTERNET SEARCH	ADDRESS	RELEVANT SUBJECT/CATEGORIES	REVIEW RESULTS
WATER QUALITY DATA SACRAMENTO & SAN JOAQUIN BASIN			
RESOURCE/AGENCY/DEPARTMENT	ADDRESS	RELEVANT SUBJECT/CATEGORIES	REVIEW RESULTS
Department of Water Resources/Division of Flood Management	<a href="http://cdwr.water.ca.gov">http://cdwr.water.ca.gov</a>	Current & Historical Data Single & Group Stations	Retrieved daily data for April for Freeport station, no monthly data available, Error messages for historical data
Interagency Ecological Program	<a href="http://www.iiep.ca.gov">http://www.iiep.ca.gov</a>	IEP Long Term Monitoring Data Discrete Water Quality Sampling DAYFLOW (estimates of net freshwater flow)	Retrieved Discrete Sampling Data for Metals, Pesticides and Water Quality & DAYFLOW data for 1984 - 1995
USGS/Water Resources of California	<a href="http://water.wr.usgs.gov/">http://water.wr.usgs.gov/</a>	Pesticides in the Hydrologic System National Assessment Sacramento River Basin/USGS National Water Quality Assessment Pesticide Links	Retrieved Summaries from NAWQA Pesticide Studies & Bibliography Retrieved NAWQA Study Areas, no access to Sacramento River Basin study No significant results from following pesticide links
California Department of Water Resources	<a href="http://www.dwr.water.ca.gov/">http://www.dwr.water.ca.gov/</a>	Water Conditions California Water Conditions State Water Project	Retrieved Summary Report for Apr. 16 with flow data for various stations No relevant information from CA Water Info page Link to Operations Control Office Home Page, see below
State Water Project/Operations Control Office	<a href="http://www.water.ca.gov/">http://www.water.ca.gov/</a>	SWP Operational Reports Bay Delta Standards Delta Hydrology and Quality Conditions Delta Environmental Compliance Reports	Retrieved monthly summary of water operations- flows for the month- for March 97 Winter-Run and Delta Smelt ESA biological opinions Retrieved data for the past 30 days No access possible
State Water Resources Control Board	<a href="http://www.swrceb.ca.gov/">http://www.swrceb.ca.gov/</a>	Plans, Policies, Staff Reports, Publications Links to other sites	Retrieved list of staff reports and publications No significant results
California Environmental Resources Evaluation System	<a href="http://ceres.ca.gov/">http://ceres.ca.gov/</a>	Web Search by geographic area, theme, data type	Did a search with no significant results
California Department of Fish and Game Bay Delta and Special Projects Division	<a href="http://www.dfg.ca.gov/">http://www.dfg.ca.gov/</a>	Bay Delta Monitoring	Only description of monitoring program, no data
CALFED/Bay-Delta Program	<a href="http://calfed.ca.gov/">http://calfed.ca.gov/</a>	Phase I Final Report, Current Phase II Alternative	No relevant information
California Rivers Assessment (CARA)	<a href="http://randevor.das.ucdavis.edu/cara">http://randevor.das.ucdavis.edu/cara</a>	Information by River Basin	Retrieved information for Sacramento Basin, only maps, no data