OFFICE MEMO

TO: Paul Hutton	**DATE:** May 29, 2001
	SUBJECT: Relationships between EC, chloride, and bromide at Delta export locations
FROM: Bob Suits	

Relationships between EC and chloride and EC and bromide at Rock Slough, Los Vaqueros Intake, Clifton Court Forebay and DMC intake were developed in support of ongoing In-Delta Storage Project modeling efforts. These relationships, expressing EC as a function of either chloride or bromide are summarized in Table 1 with methodology following.

Table 1. EC, Chloride, and Bromide Relationships at Delta Export Locations

Contra Costa Canal

$EC_{\text{Old River at Rock Slough}} = 89.6 + 3.73\ (\text{Chloride}_{\text{Contra Costa Pumping Plant\#1}})$

$EC_{\text{Old River at Rock Slough}} = 118.7 + 1040.30\ (\text{Bromide}_{\text{Contra Costa Pumping Plant\#1}})$

Los Vaqueros Intake, Clifton Court Forebay, DMC Intake

EC = 160.6 + 3.66(Chloride)

EC = 189.2 + 1020.77 (Bromide)

Units: EC in uS/cm, chloride in mg/l, bromide in mg/l

I. EC at Old River at Rock Slough as a function of Chloride at Contra Costa Canal Pumping Plant # 1

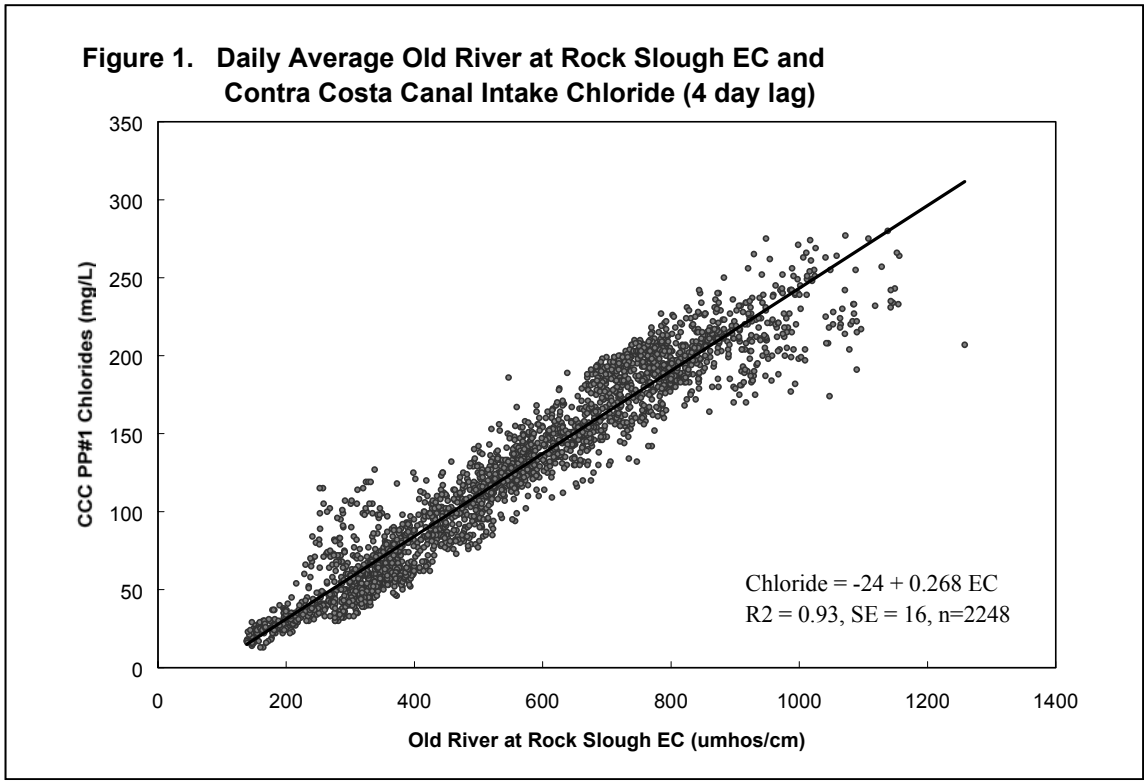
A regression between chloride at Contra Costa Canal Pumping Plant #1 and EC at Old River at Rock Slough was previously developed and reported in a memo from Aaron Miller to Tara Smith, dated January 2, 2001. The regression presented in that memo,

$$\text{Chloride}_{\text{Contra Costa Canal Pumping Plant \#1}} = -24 + 0.268\ (EC_{\text{Old River at Rock Slough}}) \qquad \text{(Eqn. 1)}$$

has a coefficient of determination of 0.93, a standard error of 16 mg/l, and 2,248 samples (Figure 1). Chloride and EC are in units of mg/l and uS/cm respectively. Used were EC data from Old River at Rock Slough collected by DWR's D-1485 Compliance Monitoring Program and chloride data at CCCPP#1 collected by Contra Costa Water District, all from the period of January 1967 through February 1995. To account for travel time, chloride data at CCCPP#1 were lagged 4 hours with respect to Old River at Rock Slough data before analysis was performed. Data collected during the unusual events of the San Andreas Island levee break of 1972 and the temporary barrier installations during the drought of 1976-1977 were not included in this analysis. EC and chloride concentrations were presented as daily average values.

Rewriting equation 1 in terms of EC as a function of chloride yields:

$EC_{\text{Old River at Rock Slough}} = 89.6 + 3.73\ (\text{Chloride}_{\text{Contra Costa Pumping Plant\#1}})$ (Eqn. 2)



II. EC and Chloride in Old River at Los Vaqueros Intake

EC and chloride grab sample data in or near Old River at several locations were examined to develop a relationship valid for the Los Vaqueros intake. Data collected by DWR's Municipal Water Quality Investigations Program at Old River at Highway 4, North Victoria Canal near Old River, Santa Fe - Bacon Island Cut near Old River, Rock Slough at Old River, and Old River at Bacon Island were examined along with data collected by the D1485 Water Quality Monitoring Program at Old River at Bacon Island (Figure 2). EC and chloride data from both programs usually were available from monthly or bimonthly surveys mainly from the 1990's. As shown in Figure 3, the relationship between EC and chloride at the Los Vaqueros intake site (Highway 4) is consistent with a general relationship spanning the reach from Old River at Highway 4 to the Bacon Island sampling site. The resulting regression from using all of the data is close to the regression derived from using only the data from Highway 4, and is valid over a larger range of data. The regression:

$EC = 160.6 + 3.66(\text{Chloride})$ (Eqn. 3)

has a coefficient of determination of 0.99, standard error of estimate of 35.7 uS/cm and sample size of 683. Chloride and EC are in units of mg/l and uS/cm respectively.

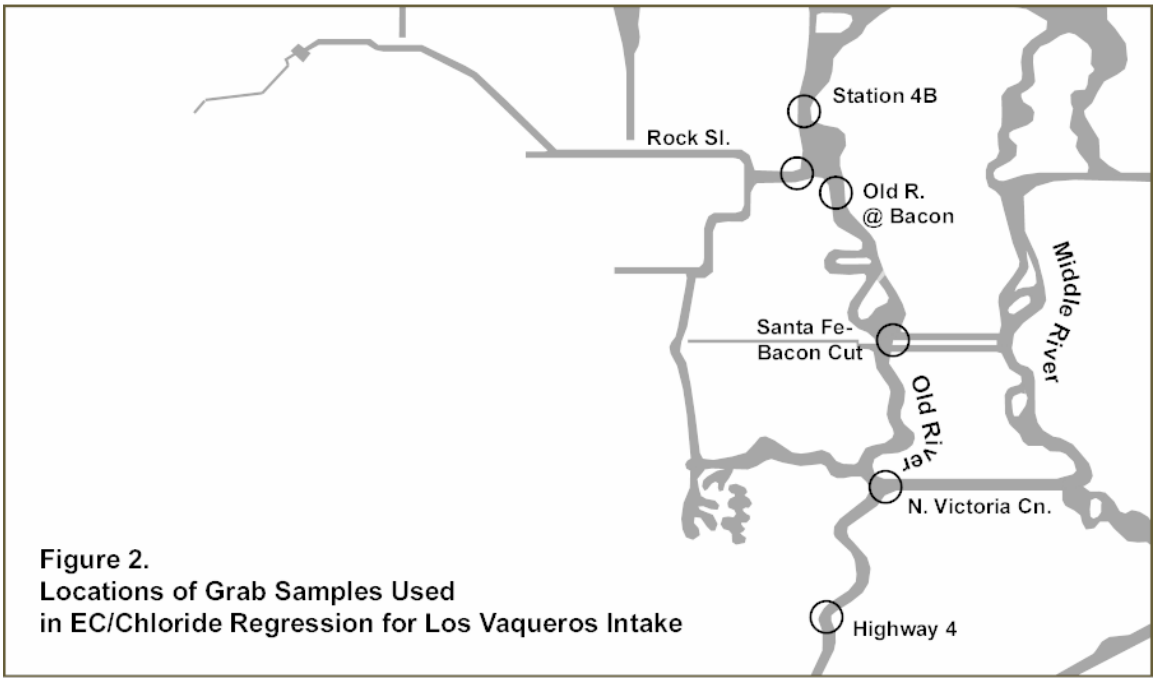
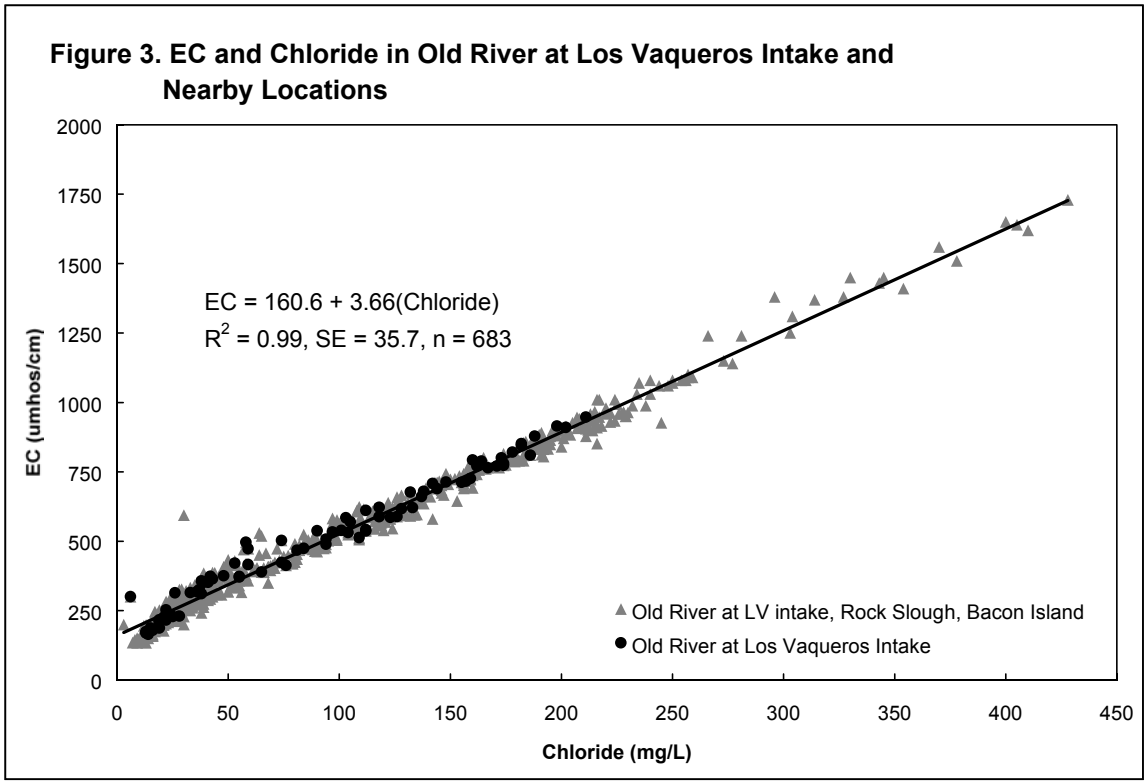


Figure 2.
Locations of Grab Samples Used
in EC/Chloride Regression for Los Vaqueros Intake

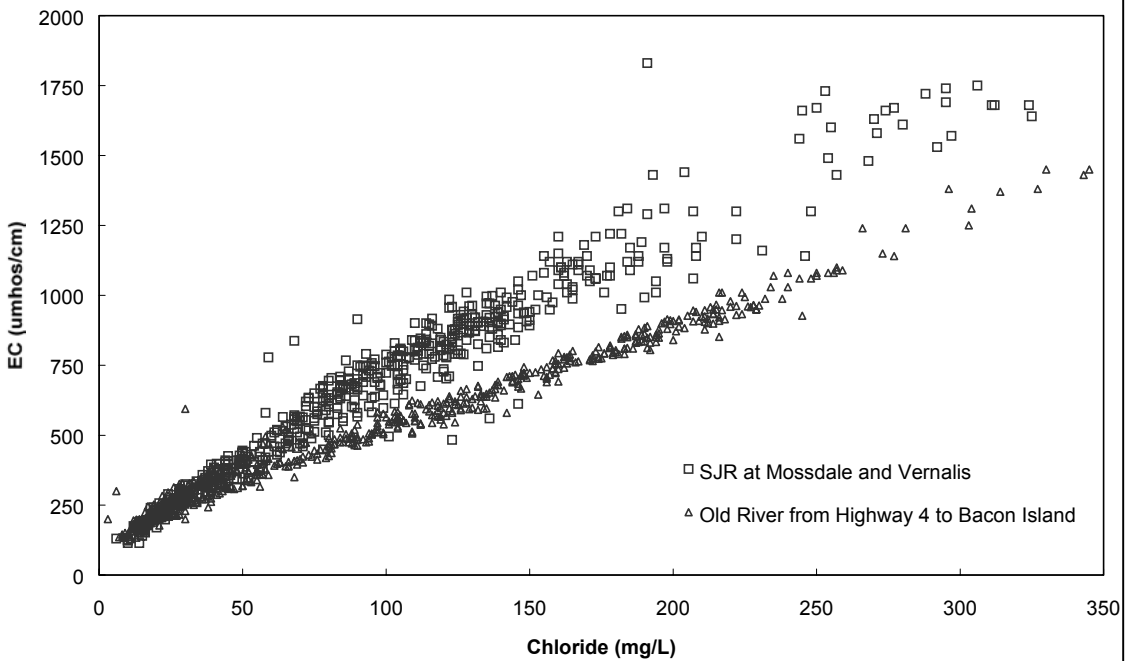


III. EC as a Function of Chloride at SWP and DMC Intakes

The relationship between EC and chloride in the vicinity of Clifton Court Forebay and DMC intakes in the south Delta is more complex than the one for the Los Vaqueros intake. In general, the relationship between EC and chloride in this area of the Delta depends upon whether the source of the water at the time of sampling is primarily the San Joaquin River or the Sacramento River. EC and chloride data from the San Joaquin River at Mossdale and Vernalis are plotted with data from Old River at Highway 4 to Bacon Island in Figure 4. For a

given chloride level, the corresponding EC will be higher in water originating in the San Joaquin River than water from the Sacramento River. Locations along Old River from Tracy Road to North Canal, including Clifton Court Forebay and DMC intakes, may experience EC to chloride ratios indicative of either San Joaquin River water or Sacramento River water, depending upon the Delta hydraulics when the sample was taken. Figures 5 and 6 show how DMC intake and Banks Pumping Plant samples compare to the trends displayed from samples taken from San Joaquin and Old rivers.

Figure 4. EC and Chloride Old River from Highway 4 to Bacon Island and San Joaquin River at Vernalis and Mossdale



The EC-chloride relationship at Banks Pumping Plant is generally similar to that seen from the Old River samples, however some samples indicate San Joaquin River may have been a significant source. The EC-chloride relationship at DMC intake is about evenly split between the two trends, indicating that the San Joaquin River may be a more significant source of water for the DMC than for Banks Pumping Plant. These figures also show the difficulty in using a single linear regression to express the relationship between EC and chloride here. Historic San Joaquin and Sacramento River inflows, SWP and CVP delta exports, Delta outflow, and channel depletions were briefly examined to assess the possibility of predicting the EC-chloride relationship at any given time. These cursory attempts to date haven't been successful and this issue for now is left for future investigation. For the purpose of converting standards written in chloride to standards in EC at SWP and DMC intakes, it is proposed that the equation developed above for Old River at Los Vaqueros intake be used:

$$EC = 160.6 + 3.66(\text{Chloride}) \qquad \text{(Eqn. 3)}$$

with EC in units of uS/cm and chloride in mg/l. When chloride is given, this equation will be effective most of the time in predicting EC at Banks Pumping Plant. It also provides conservative (lower) values of EC when converting standards from chloride to EC at both Banks Pumping Plant and DMC intake.

Figure 5. EC and Chloride at DMC Intake Compared to Old River from Hwy 4 to Bacon Is. and San Joaquin River

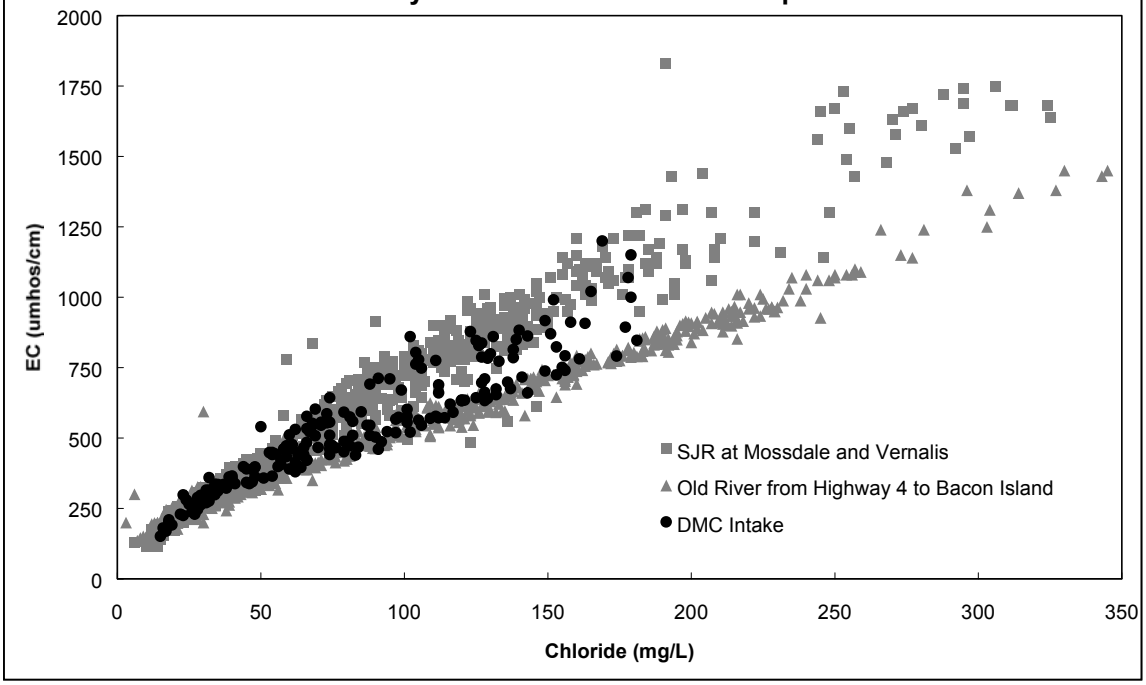
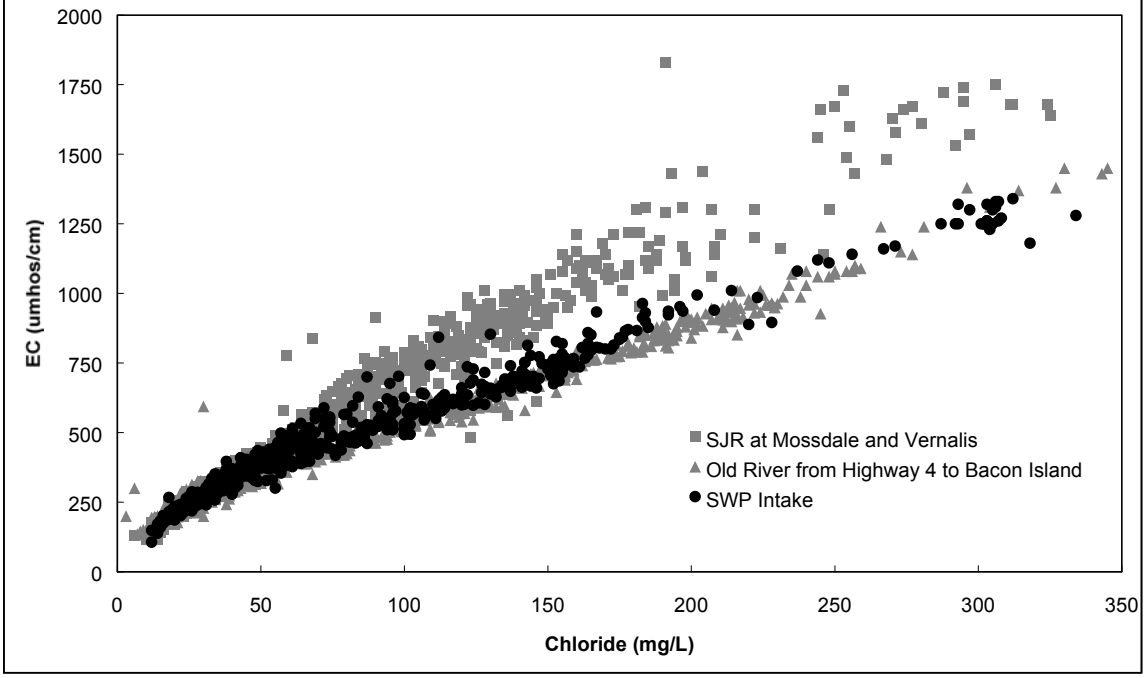


Figure 6. EC and Chloride at Banks Pumping Plant Compared to Old River from Hwy 4 to Bacon Is. and San Joaquin River



IV. Chloride as a Function of Bromide at Delta Exports

Grab samples collected by DWR's Municipal Water Quality Investigations Program and Operations and Maintenance Division were used to develop regressions between chloride and bromide at Old River at Rock Slough, Los Vaqueros intake, Clifton Court Forebay, and DMC intake. The data are mostly monthly or bimonthly samples from the 1990s and sample sites range from Old River upstream of the DMC intake to Old River downstream of Rock Slough (Figure 7). Location specific regressions were very similar, indicating that the relationship between chloride and bromide in the region is fairly uniform (Table 2). Therefore a single regression was generated from all of the data available for the sites shown in Figure 8:

Chloride = 7.8 + 278.9 (Bromide) (Eqn. 4)

With coefficient of determination of 0.96, standard error of 10.7 mg/l, and sample size of 1,094 grab samples. Chloride and bromide are in units of mg/l.

Table 2. Chloride as a Function of Bromide in Vicinity of Delta Export Locations

Old River at Rock Slough Vicinity
Chloride = 8.5 + 281.5 (Bromide) n = 262, SE = 10.9 mg/l, R2 = 0.94

Los Vaqueros Intake Vicinity
Chloride = 7.9 + 281.5 (Bromide) n = 394, SE = 9.9 mg/l, R2 = 0.95

DMC Intake Vicinity
Chloride = 6.0 + 278.1 (Bromide) n = 141, SE = 10.4 mg/l, R2 = 0.97

Banks Pumping Plant/Clifton Court Forebay Intake
Chloride = 7.2 + 277.9 (Bromide) n = 296, SE = 12.2 mg/l, R2 = 0.97

Chloride, bromide in mg/l

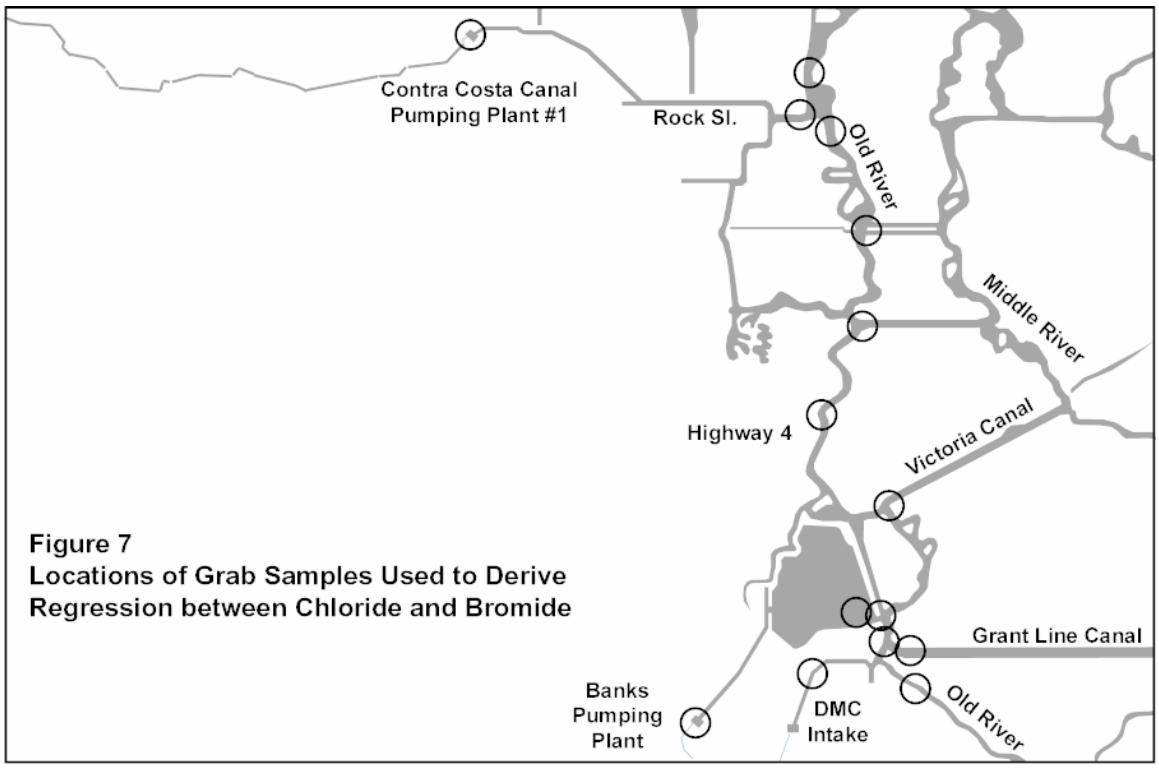
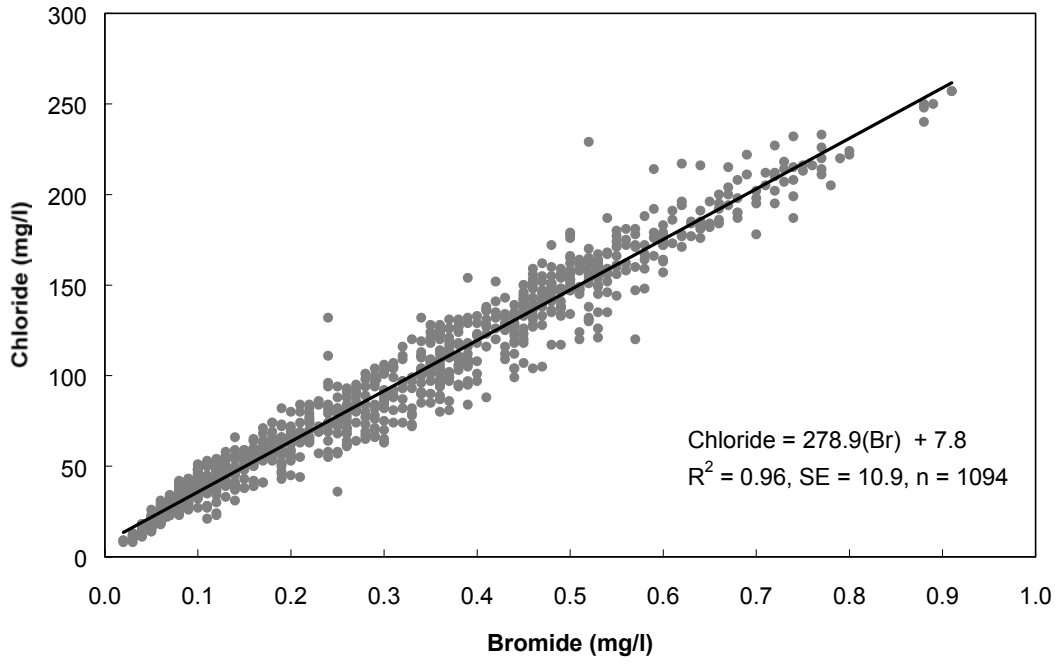


Figure 7
Locations of Grab Samples Used to Derive
Regression between Chloride and Bromide

Figure 8. Chloride and Bromide in the Vicinity of Delta Exports



V. EC at Old River at Rock Slough as a Function of Bromide at Contra Costa Canal Pumping Plant #1

Equation 4 was substituted into Equation 2 to yield:

$$EC_{\text{Old River at Rock Slough}} = 118.7 + 1040.30\ (\text{Bromide}_{\text{Contra Costa Pumping Plant\#1}}) \quad \text{(Eqn. 5)}$$

with EC in units of uS/cm and bromide in units of mg/l.

VI. EC as a Function of Bromide at Los Vaqueros Intake, Clifton Court Forebay, and DMC Intake

Equation 4 was substituted into Equation 3 to yield:

$$EC = 189.2 + 1020.77\ (\text{Bromide}) \quad \text{(Eqn. 6)}$$

with EC in units of uS/cm and bromide in units of mg/l.