Memorandum Report

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Subject: California Aqueduct Water Quality Modeling Results for Proof of Concept Water Quality Forecast

Model simulations of O'Neill Forebay and the California Aqueduct were conducted as part of a proof of concept water quality forecasting effort of the Real Time Data and Forecasting (RTDF) Steering Committee under the Municipal Water Quality Investigations Program. This report presents the methodology, assumptions, and results of these simulations.

Background

The RTDF Project seeks to provide and enhance information regarding State Water Project (SWP) water quality. As part of this effort, the Steering Committee is investigating methods to develop and provide forecasts of SWP water quality. The Proof of Concept water quality forecast was initiated as a first step to demonstrate a forecast of water quality at various locations along the California Aqueduct and to assess the feasibility and potential usefulness of such forecasts. Previous model simulations performed by DWR's Delta Modeling Section produced simulated Delta water quality conditions under several forecasts of 1998 hydrologic conditions as well as a simulation based on historic 1998 hydrologic conditions. The model simulations described in this report build on the Delta modeling results to extend the forecasts to locations on the California Aqueduct.

Water Allocation Forecasts

Three water allocation forecasts for 1998 were used and provided the hydrologic conditions and operating assumptions needed to develop the water quality forecasts. These water allocation forecasts are provided to SWP contractors periodically during the year to keep SWP contractors updated regarding SWP supply conditions and delivery capability as water supply conditions develop and change. The January, March, and May water allocation forecasts at the 50% exceedance level were selected in order to investigate how water quality forecasts may vary depending on how early or late the forecast is made during the precipitation season.

In addition, historic hydrologic conditions and SWP and Central Valley Project (CVP) operations for 1998 were used to develop a simulation for comparison with the above three water allocation forecasts. Tables 1 and 2 show SWP and CVP Operation Summaries for the four scenarios (Historic conditions and the January, March and May forecasts)

Table 1. SWP Operations Summary for 1998

SWP Operations Summary for 1998
(all values in TAF)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Historical Simulation												
Exports	197	7	14	2	43	129	213	263	266	295	129	128
So. of Delta Deliveries												
Total	121	6	38	28	48	116	259	377	200	140	74	90
South of O'Neill	117	6	37	26	40	103	244	363	190	135	69	83
January Forecast												
Exports	204	168	180	180	120	90	373	390	380	200	320	392
So. of Delta Deliveries												
Total	130	148	170	233	303	443	507	438	236	168	156	131
South of O'Neill	115	133	153	224	292	431	494	426	224	157	148	124
March Forecast												
Exports	-	-	57	180	120	90	373	390	380	170	214	290
So. of Delta Deliveries												
Total	-	-	43	222	290	453	506	450	220	192	142	116
South of O'Neill	-	-	36	214	278	424	476	435	207	180	133	110
May Forecast												
Exports	-	-	-	-	25	220	386	384	350	360	200	123
So. of Delta Deliveries												
Total	-	-	-	-	282	375	478	435	247	174	151	130
South of O'Neill	-	-	-	-	276	368	461	418	231	157	136	117

Assumptions and Methodology

Delta modeling yielded water quality at Clifton Court and the Delta Mendota Canal (DMC) intake for the four scenarios. The water quality simulations produced estimates for three constituents: EC, TDS and bromide. Figure 1 shows the simulated historical and forecasted EC, TDS, and bromide at the SWP intake for 1998. Figure 2 shows the simulated historical and forecasted EC, TDS, and bromide at the DMC intake for 1998. This data was used as water quality input data to the model for the Banks and Tracy Pumping Plants respectively.

The O'Neill/San Luis model was used to simulate blending of water in O'Neill Forebay and to produce an estimate of water quality at the O'Neill Forebay outlet to the California Aqueduct. Inflows to O'Neill Forebay can come from three potential sources: inflows from the California Aqueduct, inflows from the DMC through O'Neill Pumping Plant, and releases from San Luis reservoir. The California Aqueduct Model was sued to simulate water quality in the California Aqueduct downstream of O'Neill Forebay.

Table 2. CVP Operations Summary for 1998

CVP Operations Summary for 1998
(all values in TAF)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Historical Simulation												
Exports	243	164	127	86	143	170	250	269	259	270	127	16
Total Deliveries	108	8	97	96	98	173	385	392	259	132	61	98
CA Aq. Deliveries	69	2	65	67	63	122	264	148	64	34	20	74
January Forecast												
Exports	260	235	260	203	170	240	276	276	262	335	240	248
Total Deliveries	140	180	113	223	294	395	467	415	202	166	83	83
CA Aq. Deliveries	100	120	40	60	90	150	180	160	20	45	20	40
March Forecast												
Exports	-	-	99	185	170	240	276	276	262	335	240	248
Total Deliveries	-	-	97	182	310	453	557	559	292	105	102	70
CA Aq. Deliveries	-	-	50	90	140	200	285	295	100	20	20	50
May Forecast												
Exports	-	-	-	-	178	260	275	280	294	292	270	280
Total Deliveries	-	-	-	-	219	359	564	479	260	155	141	121
CA Aq. Deliveries	-	-	-	-	130	210	270	200	62	62	60	100

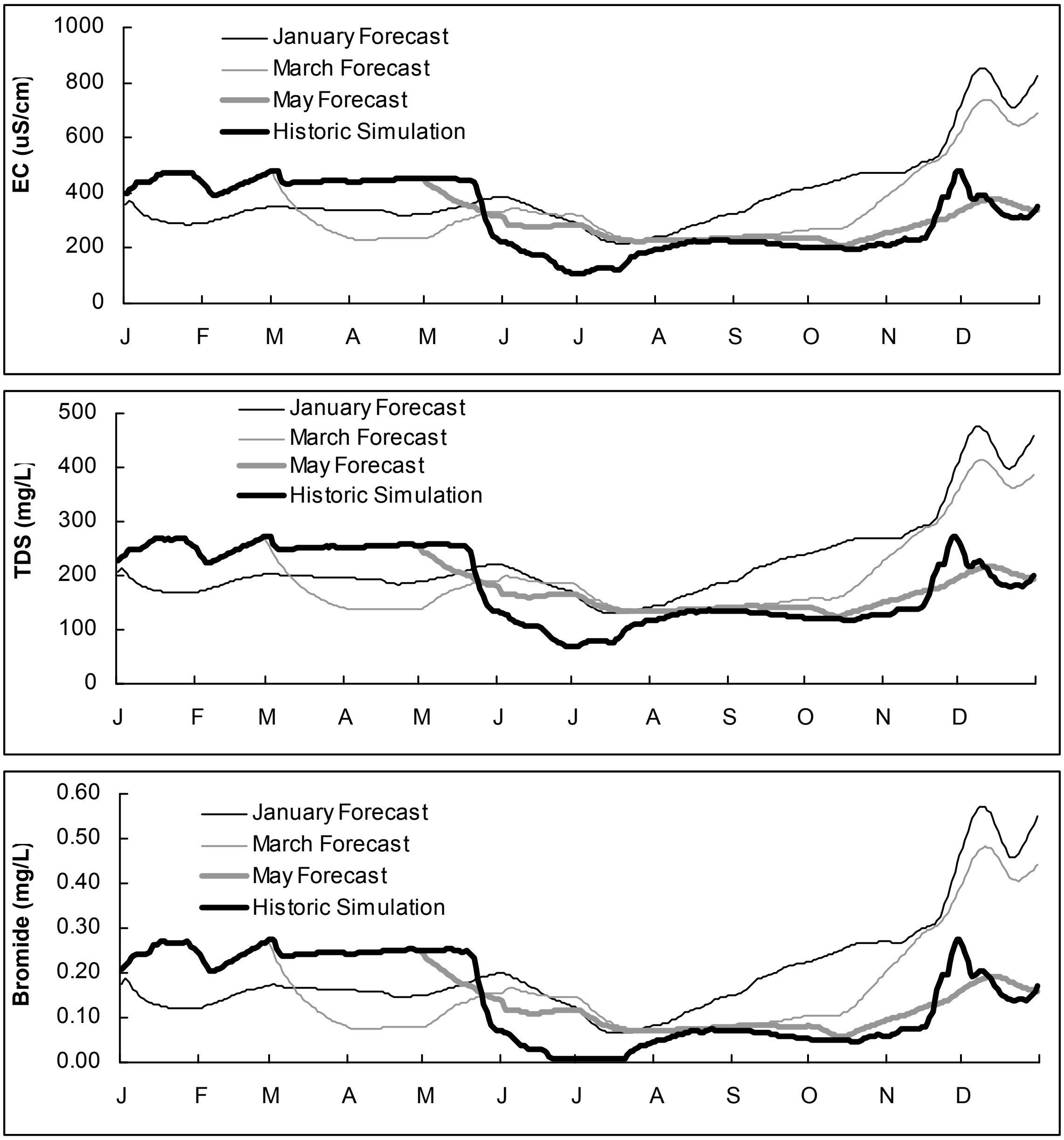
Developing SWP and CVP Modeling Inputs

The above-mentioned models require various inputs. Key inputs include all diversions or deliveries along the aqueduct, inflows to O'Neill Forebay, releases or pumping from O'Neill Forebay, and releases from San Luis reservoir to meet CVP San Felipe demands. Also, the volume, delivery pattern, and location (specified by milepost) for all demands or diversions is required input for the Aqueduct model.

The 1998 water allocation forecasts do not specify most of the required input data. For example, in the forecasts, all SWP south of Delta demands are lumped and treated as a single demand point. Operations and flows at O’Neill Forebay and San Luis Reservoir are not specified. Therefore, various assumptions were made and a methodology was developed to produce the required inputs from the forecasts. In some areas, a reasonable estimate of project operations can inferred from other available information. In addition, delivery locations and patterns along the aqueduct had to be assumed based on known information and best estimates.

In developing the input data and making assumptions, priority was given to achieving an overall water balance, i.e. total Delta exports minus deliveries and losses must equal any change in reservoir storage. In some cases, operational values specified in the water allocation forecasts appeared to be erroneous and adjustments had to be made to respect physical limits. For example, in some cases monthly aqueduct deliveries were adjusted to avoid a situation where total diversion from a section of the aqueduct during a month exceeded total inflows. The aqueduct pool heights and volume of water stored

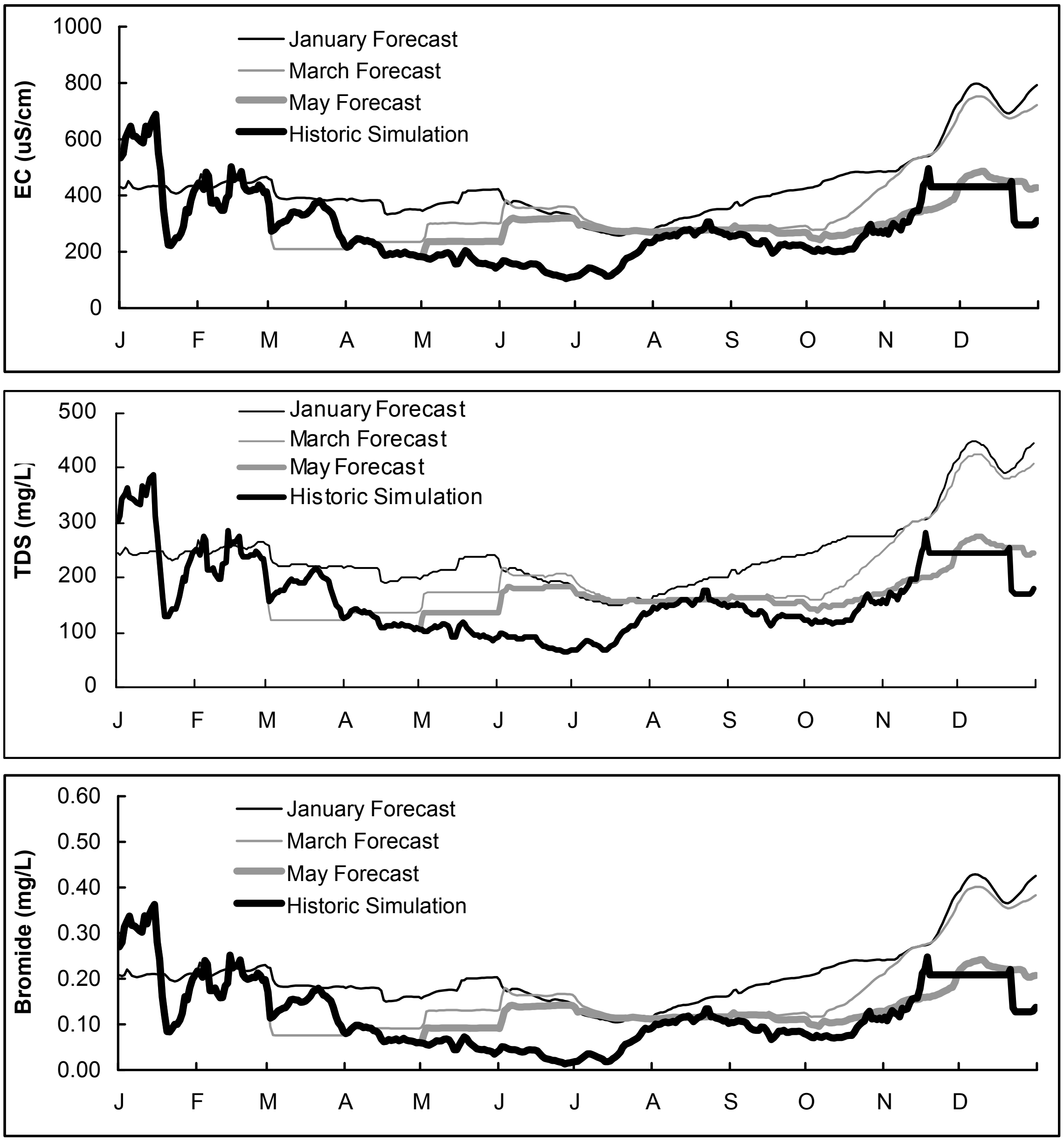
Figure 1. Simulated historical and forecasted EC, TDS, and bromide at the SWP intake for 1998.



in the aqueduct was held constant for all model simulations. Also, reservoir storage was required to stay within the range of physical limits. The developed set of operational information used for model input was compared where possible with operations specified in the water allocation forecasts such as San Luis Reservoir and total project deliveries. The sources of the apparent mismatch or error in the water allocation forecasts that made these adjustments necessary was not determined, but the adjustments were generally not large and are not thought to appreciably change the model results obtained.

Both the O'Neill/San Luis model and the California Aqueduct model were operated on a daily time step, therefore all flow and delivery volumes, which are specified as monthly volumes in the forecasts, had to be converted to daily quantities. Uniform flow was assumed, so the flow on any day equals the monthly flow divided by the number of days in the month.

Figure 2. Simulated historical and forecasted EC, TDS, and bromide at the DMC intake for 1998.



Results

Three locations on the California Aqueduct were selected for reporting the water quality results from the model simulations: O'Neill Outlet, Check 41 (just upstream of the bifurcation and the beginning of the West Branch), and Check 66 (just upstream of Mojave Siphon Powerplant and the inlet works to Silverwood Lake). Figure 3 shows the EC, DS, and bromide at O'Neill Outlet for the four scenarios. Figures 4 and 5 show the same information at Check 41 and Check 66 respectively.

Figure 3. Simulated and historical forecasted EC, TDS, and bromide at O'Neill Outlet for 1998.

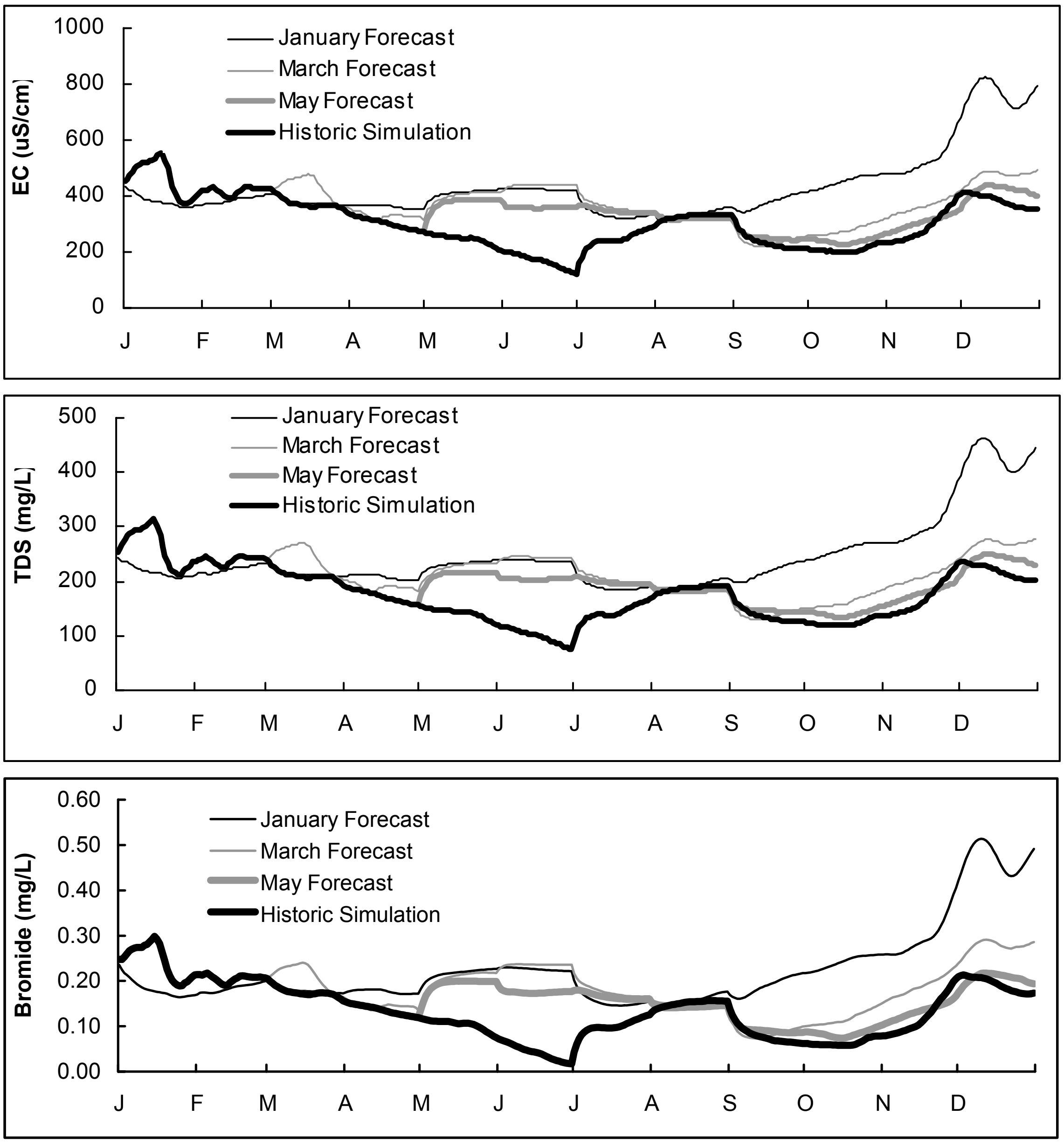
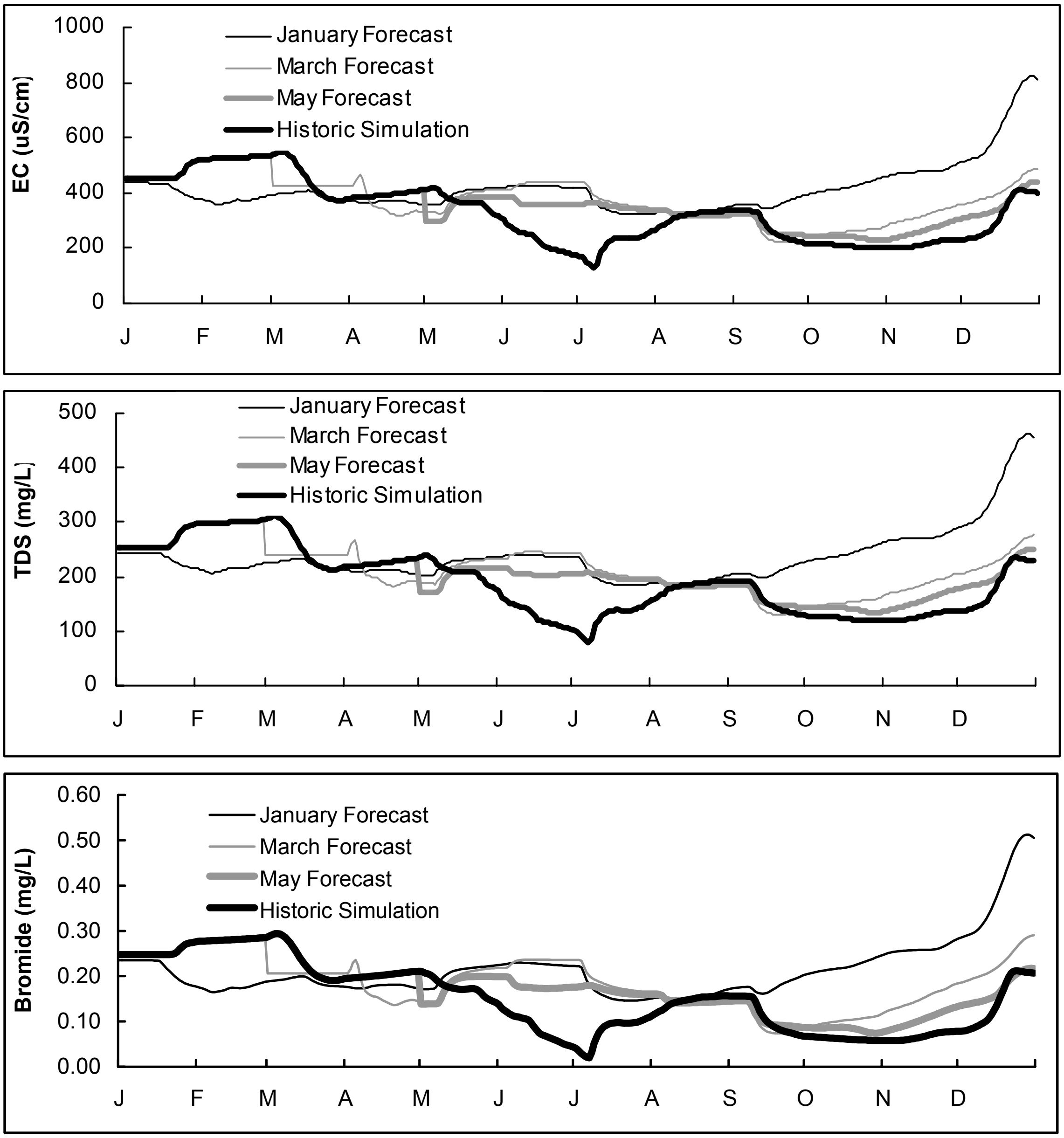


Figure 4 Simulated and historical forecasted EC, TDS, and bromide at Check 41 for 1998.

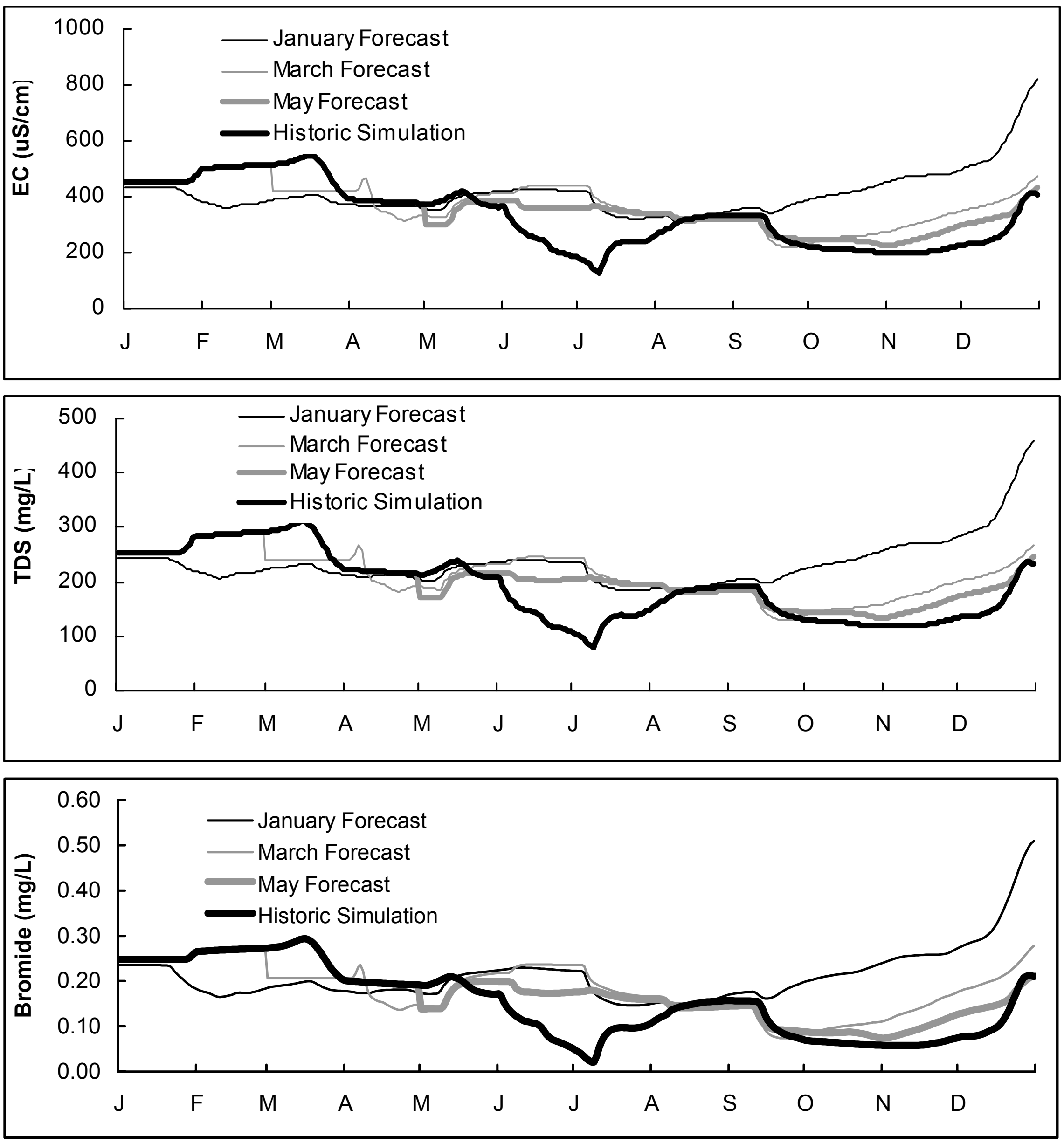


Discussion

Results at downstream locations along the aqueduct generally follow the trend of water quality from the Delta model simulation at the SWP intake, and to a lesser degree the DMC intake. CVP deliveries to the Dos Amigos Unit occur in the state/federal joint use portion of the aqueduct between O'Neill Outlet and approximately milepost 172 near Kettleman City. With the exception of a relatively minor amount of water that is wheeled by the SWP at Banks, most CVP exports occur at Tracy. Water to meet CVP Dos Amigos Unit deliveries must be pumped from the DMC into O'Neill Forebay. Thus, mixing of considerable volumes of water from different sources (Banks, Tracy, or San Luis Reservoir) occurs in O'Neill Forebay, which directly affects results downstream.

1998 was a very wet year. SWP and CVP actual deliveries and Delta exports were less that projected by any of the three forecasts. This results in less flow in the aqueduct, which may result in delay in observing a water quality trend downstream compared with the January, March, and May forecasts.

Figure 5 Simulated and historical forecasted EC, TDS, and bromide at Check 66 for 1998.



Appendix

Notes on Forecasts & Operational Data Used

Forecasts:

The following forecasts provided the input data for the models. These forecasts are sometimes referred to as the 'DCO Spreadsheet' and were provided by Loi Tran of DWR. They either directly provided the operational data, or in some cases, indirectly provided the data by inference from given data. A partial summary of the data in these forecasts (filename: dcostudies98_page3.xls) was provided by John Leahigh and was used for the DSM2 simulations.

January 1998:	filename: d98w0121.xls	Jan-Sep: 50% exceedance, Oct-Dec: 75%
March 1998:	filename: d98w0309.xls	Jan-Sep: 50% exceedance, Oct-Dec: 90%
May 1998:	filename: d98w0521.xls	Jan-Sep: 50% exceedance, Oct-Dec: 90%

Each forecast either directly provided the operational data, or in some cases, indirectly provided the data by inference from given data. A partial summary of the data in these forecasts (filename: dcostudies98_page3.xls) was provided by John Leahigh and was used for the DSM2 simulations.

Operational Data Used

Some of the key operational data used as input or to derive input for the model simulations is identified below. Other information may have been used or referred to for checking purposes:

Delta Export Pumping:
Tracy Exports (CVP), CVP Banks Exports, SWP Banks Exports

Actual Storages to Date:
CVP San Luis, SWP San Luis

San Luis Reservoir Estimate:
CVP Gross Demand, SWP Gross Demand, CVP Storage, SWP Storage

SWC Demand South of the Delta:
Total Deliveries, Transportation Losses, Del Valle Storage Change, Southern Reservoir Storage Change

Operational Data Used - (continued)

SWP Losses (evap & seepage):
Aqueduct, Southern Reservoirs

Other Delivery/Adjustment:
O'Neill Exchange

US Demand South of the Delta:
Delta Mendota Canal, Cross Valley Canal, Dos Amigos, San Felipe

Reservoir Losses:
San Luis Total