Resource Management Associates
4171 Suisun Valley Rd., Suite J
Fairfield, California 94534
Phone: 707.864.2950, FAX: 707.864.3064, WEB: www.rmanet.com

RMA Turbidity and Adult Delta Smelt Behavioral Model Covering the Forecast Period Dec. 08 – 27, 2011

Date:	December 14, 2011
To:	Chuching Wang, Senior Engineer, Metropolitan Water District Paul Hutton, Senior Engineer, Metropolitan Water District
From:	Marianne Guerin, Senior Water Resources Specialist Steve Andrews, Water Resources Engineer
Subject:	Results of Recent Forecasting Work

Background

This document provides a summary of the first forecast for WY2012 prepared by RMA on December 08, 2011. The forecast was developed using the RMA models for hydrodynamics, salinity, and turbidity and particle tracking using the Adult Delta Smelt Behavioral model. Figures are provided to document the results of the modeling with a focus on turbidity.

Because the funding for this project was delayed for several weeks past the initially agreed-upon start date, there was insufficient time to develop all of the preparatory materials needed for the model forecast simulations. MWD staff was informed that due to this delay, RMA would not be able to supply all of the agreed forecast simulations for the first few forecast weeks. Instead, priority is being given to developing those simulations deemed most critical to advancing interactions with 34North and the development of the Bay-Delta Live website.

Boundary Condition Development and Simulation Timing

Model BCs (Boundary Conditions) for the forecast model were prepared using several sources for historical and forecast conditions including: CNRFC flow data and predictions, CDEC and USGS data, and DWR-supplied model inputs and results from their flow and salinity forecasts.

BC for this forecast period were prepared using these data sources, and using professional judgment where necessary to resolve data discrepancies and to piece the data together for reasonable BC.

The RMA modeled period was November 01, 2011 to December 27, 2011 for flow, salinity and turbidity. DWR Operations and Maintenance (O&M) group provided RMA with BC they used in the DSM2 HYDRO and QUAL/salinity models for a combined historical and forecast period November 26, 2011 through December 27, 2011 – the three week DWR forecast period was December 06 – 27, 2011. Additional flow, turbidity and EC data was downloaded for the period December 06 – 07, 2011 from the CDEC, CNRFC and USGS websites to fill-in historical conditions in the RMA forecast models.

Historical and forecast BC for flow, turbidity and salinity were developed from sources as summarized in Table 1 through Table 3 below. Stage and export BC were compiled solely from DWR O&M sources.

Due to a difference in the way CNRFC and CDEC data bases approach the one hour time shift for Daylight Savings Time, CNRFC data was shifted back one hour to match the CDEC convention. Note that the DWR and RMA models follow the convention used by the CDEC downloadable data, which implements time shifts specified by Daylight Savings Time. Due to low turbidity at the model boundaries, forecast turbidity was modeled as a constant.

WARMF Model

The WARMF model forecast output was delivered to RMA, but was not implemented for this forecast period. Because the funding for this project was delayed for several weeks past the initially agreed-upon start date, there was insufficient time to develop all of the preparatory materials needed for the turbidity and salinity simulations using the WARMF-supplied BC. MWD staff was informed that, due to this delay, RMA would not be able to supply all of the agreed forecast simulations for the first few forecast weeks, including WARMF-based simulations.

Flow and Turbidity Model Results

Boundary inflow was low during this period as there have been no recent rain events, and turbidity measurements indicate suspended sediment loading from the watersheds is very low. Depending on time and location within the Delta, measured turbidity was instead partly due to resuspension of sediments due to tidal action and/or wind events. Turbidity was low throughout the Delta, ranging from about 5 - 25 NTU in the raw data. Turbidity data was noisy at many locations, which was particularly evident as turbidity values were so low.

These types of conditions - low boundary inflow and low watershed sediment loading with in-Delta turbidity due to sediment resuspension - are outside the current turbidity model design as turbidity is being modeled not suspended sediment. Additionally, the turbidity model calibration was optimized for high flow conditions with substantial loading from the watersheds, conditions that are hypothesized to lead to movement of delta smelt into the interior of the Delta as they follow flow and turbidity cues.

Flow and turbidity BC are illustrated in Figure 1 through Figure 5, while Figure 6 through Figure 10 illustrate export levels and Old+Middle River flows. Using information supplied by O&M for historical and forecast State (SWP) and Federal (CVP) exports, Figure 6 illustrates that daily-averaged exports decreased from a maximum of ~13,000 cfs in early November to ~ 2,000 cfs by the end of November, then increased to ~12,000 cfs starting in early December through the end of the forecast period as both SWP and CVP exports levels increased. Figure 8 and Figure 9 are plots of Old River and Middle River flows and daily-averaged flows, respectively, while Figure 10 illustrates the combined Old+Middle River flow criterion (3-day center-weighted average) compared with CDEC data.

Figure 11 is a comparison of model output and data at the three compliance locations, and Figure 12 is a similar plot in the SWP export area. Note that Figure 12 is a comparison of data inside Clifton Court Forebay with model output at the entrance to the Forebay. For these two figures, data were cleaned (noisy values removed) and missing data filled with linear approximation. The cleaned and filled data were also daily averaged for comparison with daily-averaged model output.

Turbidity was below compliance values (12 NTU) at two of these three locations. At Holland Cut, the turbidity went above the compliance value for several days in early December, almost certainly due to a wind event (see Figure 13 for wind data at a nearby CIMIS station).

Figure 14 and Figure 15 illustrate the progression of the main turbidity boundary conditions at Freeport and Vernalis down the Sacramento and San Joaquin Rivers, respectively.

Figure 17 through Figure 22 are plots of model output compared with raw CDEC turbidity data at several in-Delta locations - these locations can be found on a map of the Delta in Figure 23. The turbidity model captured the very low measured turbidity in the south and central Delta (see, for example Figure 21 and Figure 22). In November, modeled turbidity is lower than CDEC data along the

Sacramento River mainstem at Rio Vista and downstream at Decker Island (Figure 17 and Figure 18, respectively). This is likely due to sediment resuspension due to tidal influences from the regions near Suisun Bay contributing to the turbidity measurement, as the sediments reach these locations under these low Sacramento River flow conditions. The wind event in early December also contributed to the turbidity signal, which was not captured by the turbidity model.

Adult Delta Smelt Particle Tracking Model Results

See Figure 24 through Figure 29 for turbidity contour plots and particle tracking model results. The Delta Smelt behavioral model was run November 01 to December 27th - 50,000 particles were inserted on November 01. Figure 25 through Figure 28 show contour plots of RMA-modeled turbidity (left plot) with particle tracking model results (right plot). These plots illustrate that just prior to and during the forecast period, modeled turbidity in the Delta was very low. The delta smelt behavioral model results illustrate that the distribution of the particles is centered along the Sacramento River and the region at the confluence with the San Joaquin River with only a few particles straying into the central Delta. Although a few of these particles eventually reached the export locations (Figure 29) by the end of the simulation, the percentages are low indicating these particle counts are insignificant.

MWD Training

Model input files and results were provided to Chuching Wang for remote access on the RMA intranet.

List of Acronyms:
WY ~ Water Year
SWP ~ State Water Project
CCFB ~ Clifton Court Forebay
CNRFC ~ California-Nevada River Forecasting Center
CDEC ~ California Data Exchange Center
CIMIS ~ California Irrigation Management System

CDEC Stations:
FPT ~ Freeport
RYI ~ Cache Sl. at Ryer Island
SMR ~ South Fork Mokelumne River
MRZ ~ Martinez
VNS ~ Vernalis

DSM2 Boundary Locations:
RMKL070 ~ Mokelumne River
RCSM075 ~ Cosumnes River
RCAL009 ~ Calaveras River
RSAN112 ~ San Joaquin River
BYOLO040 ~ Yolo Bypass
RSAC054 ~ Martinez

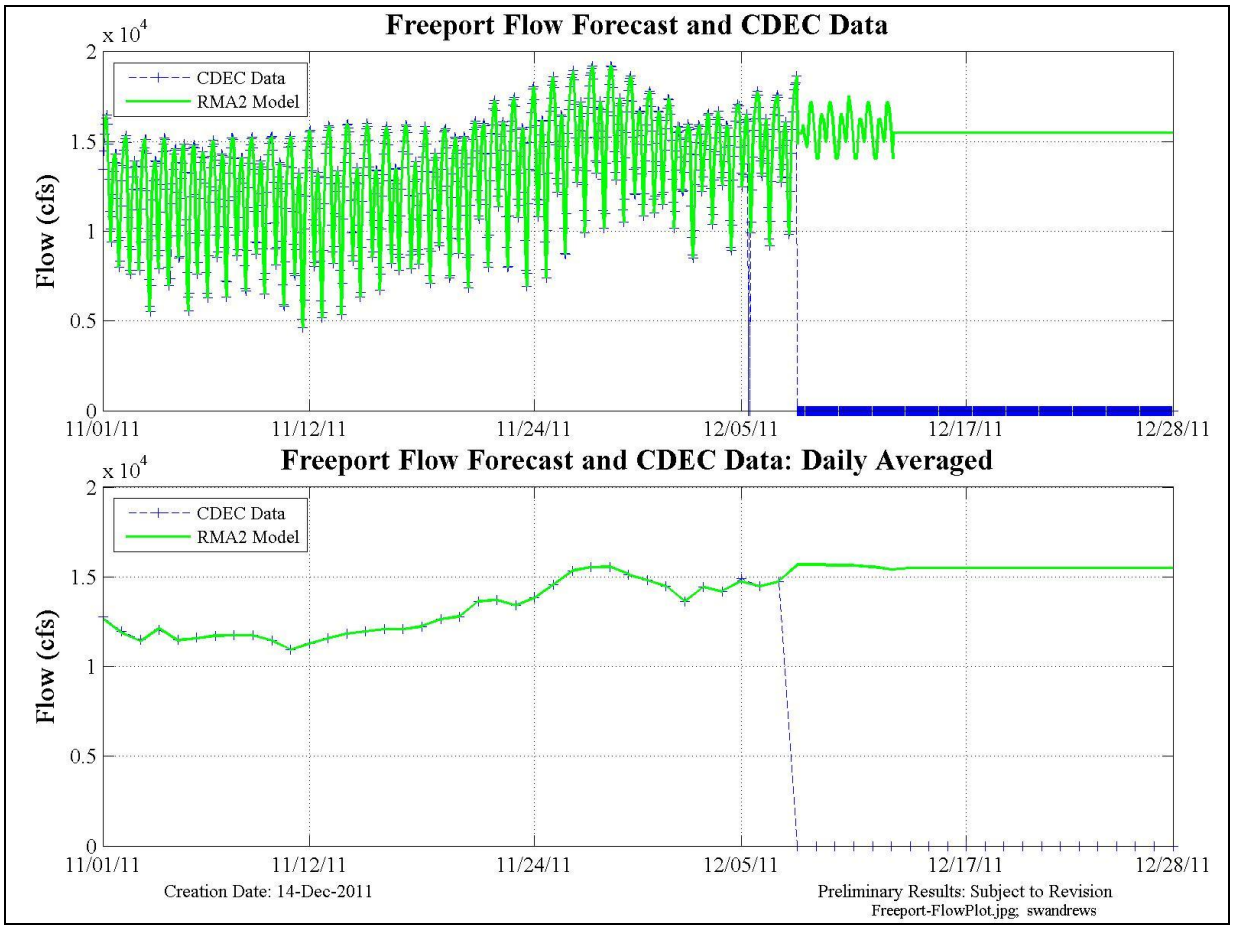

Figure 1 Freeport flow BC was compiled using CDEC data, CNRFC forecast and then extended as a constant. Note y-axis unit is cfs*10,000. Zero values indicate the end of data (blue).

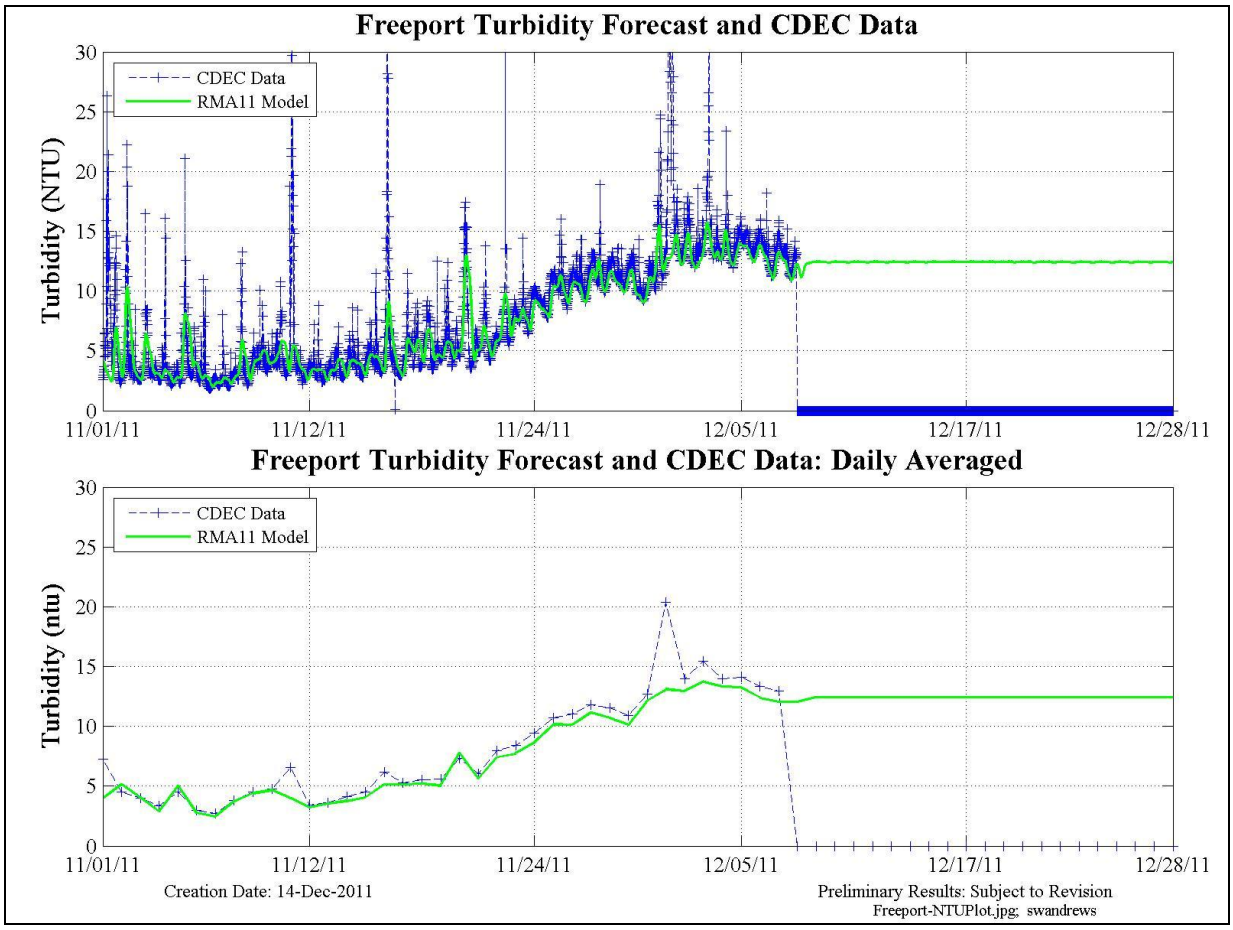

Figure 2 Freeport turbidity BC was compiled using CDEC data, and then extended as a constant. Zero values indicate the end of data (blue).

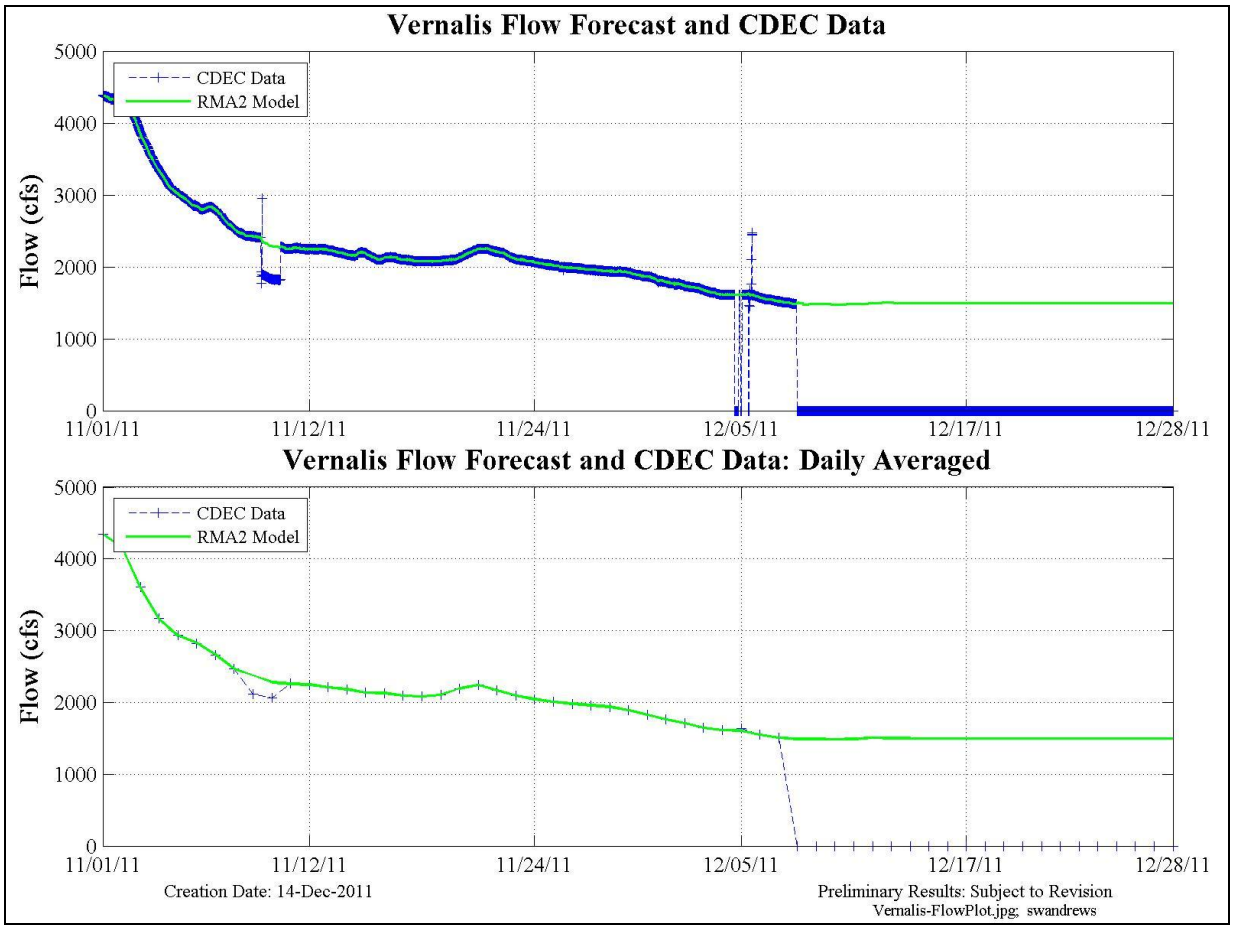

Figure 3 Vernalis flow BC was compiled using CDEC data and DWR forecast flow. Zero values indicate the end of data (blue).

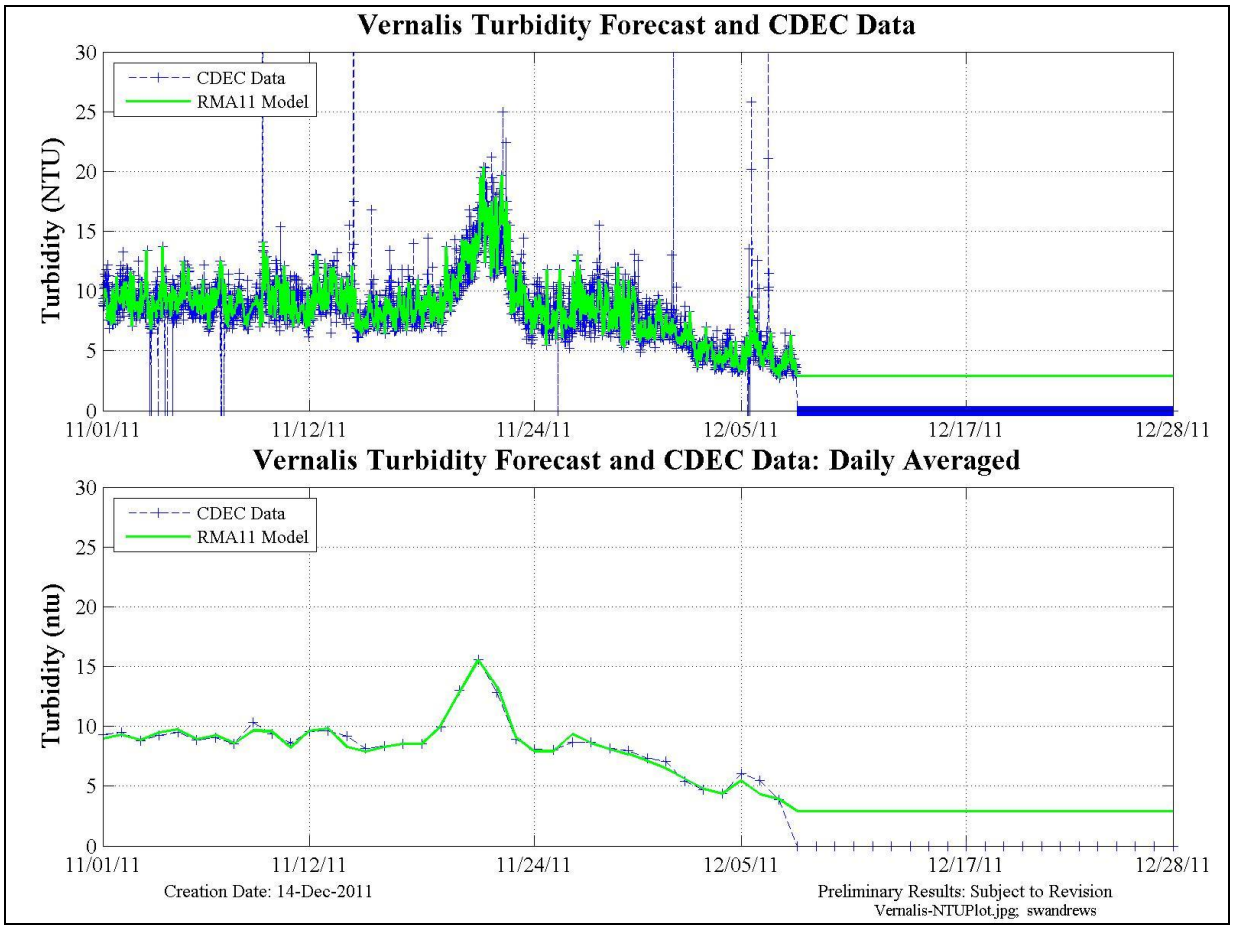

Figure 4 Vernalis turbidity BC was compiled using CDEC data, then extended as a constant. Zero values indicate the end of data (blue).

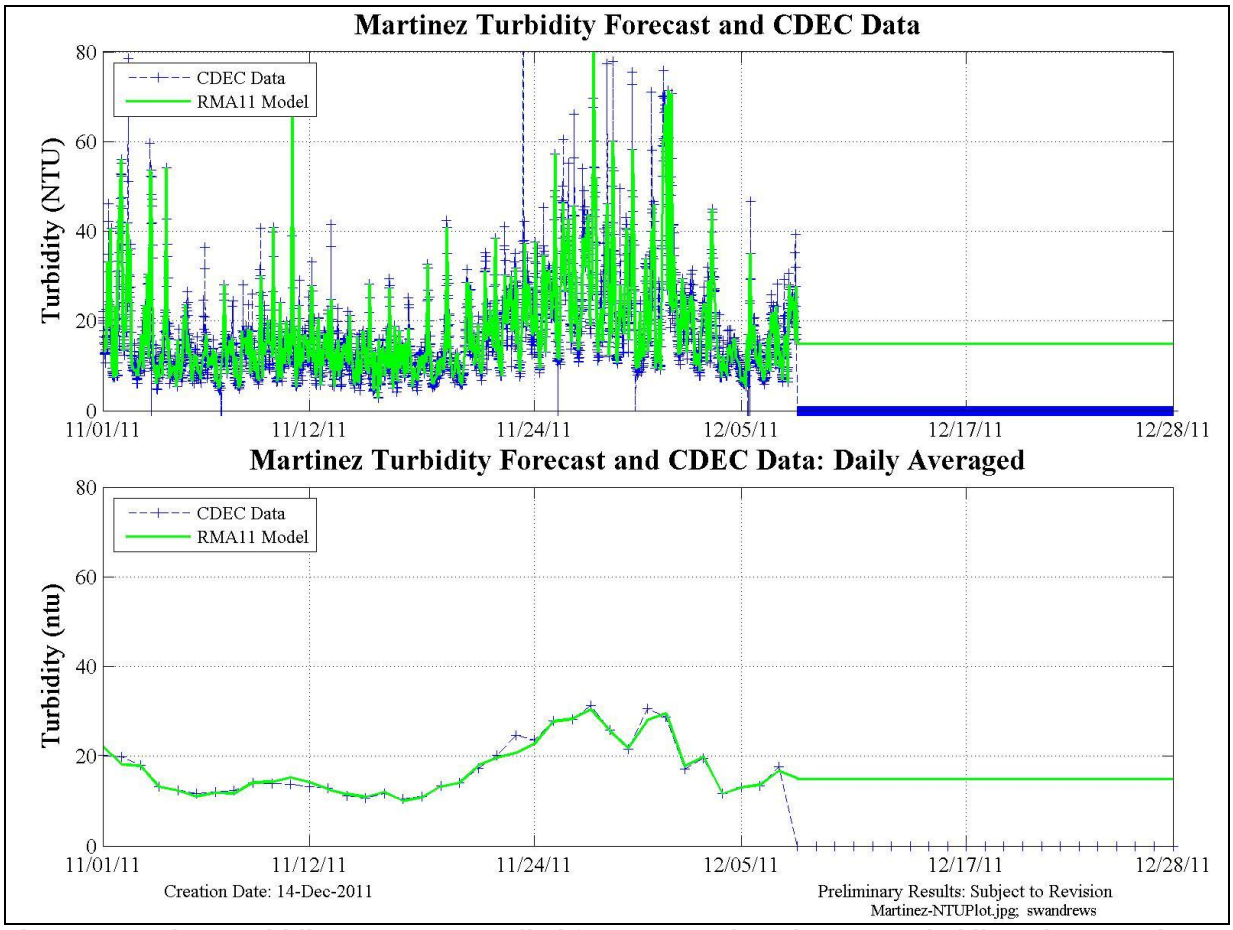

Figure 5 Martinez turbidity BC was compiled from CDEC data then extended linearly to a value of 15 NTU. Zero values indicate the end of data (blue).

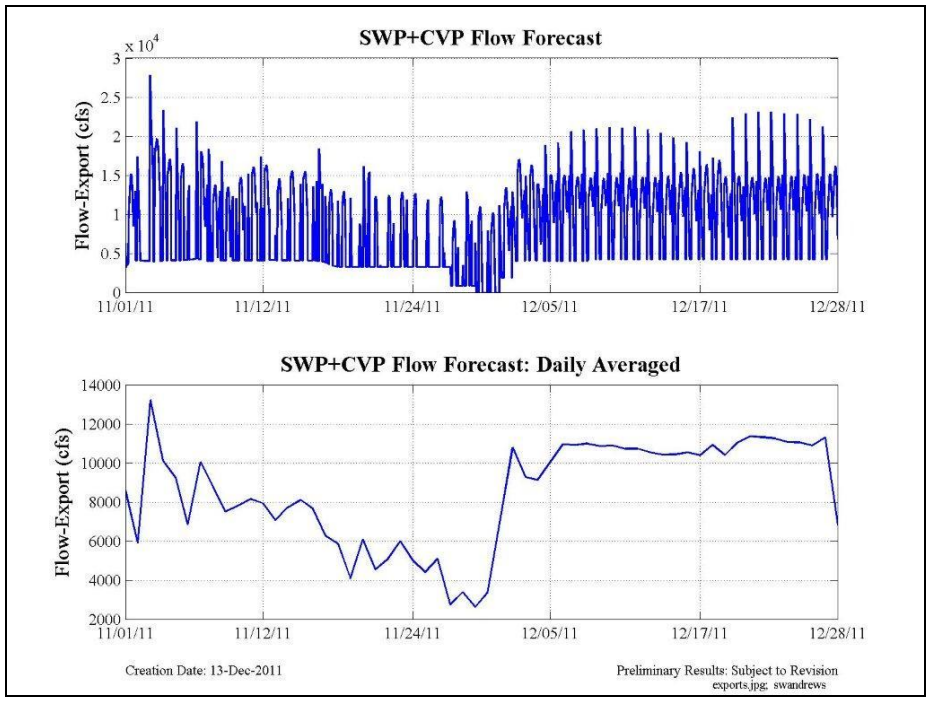

Figure 6 The plots illustrate modeled combined exports at the SWP plus CVP export locations. Both 15-min model output (upper) and daily-averaged (lower) plots are shown.

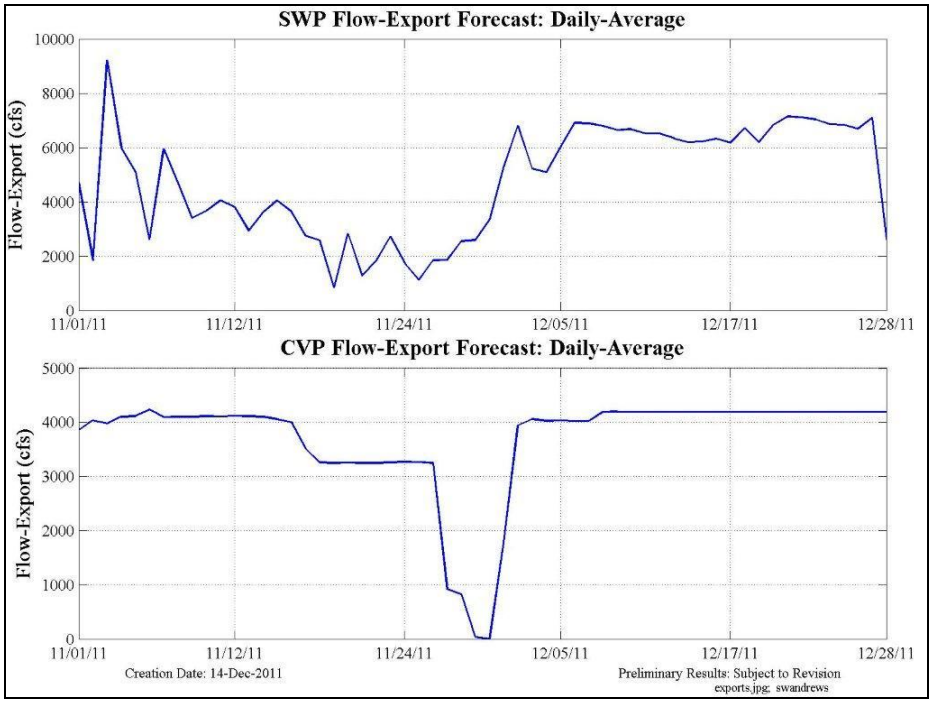

Figure 7 The plots illustrate modeled daily-averaged exports at the SWP (upper plot) and CVP (lower plot) export locations.

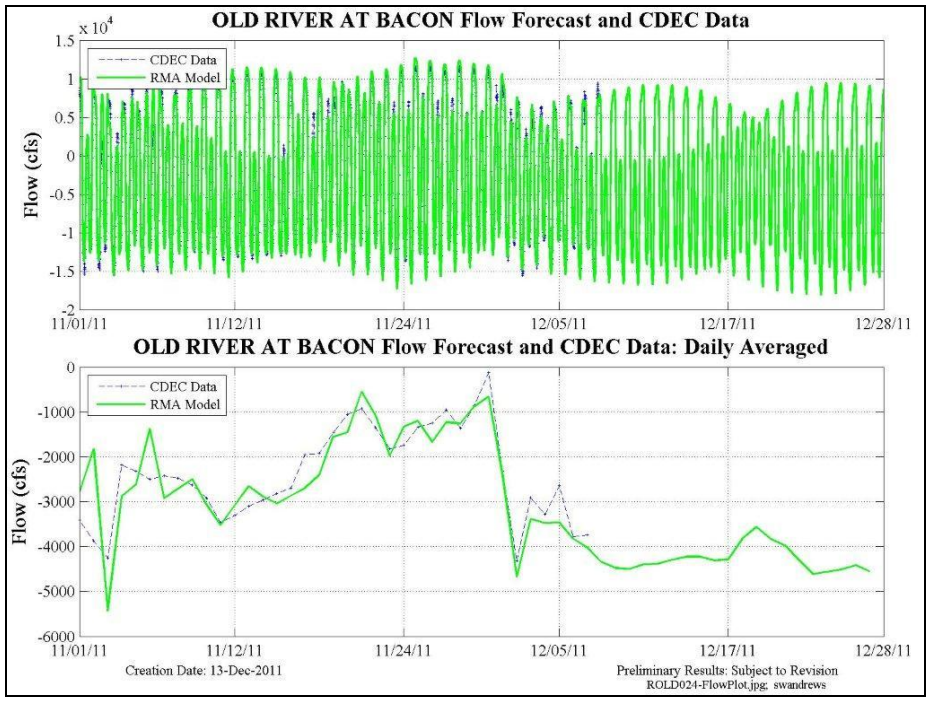

Figure 8 Model flow forecast output t and raw CDEC data at Old River at Bacon (ROLD024) location. Both 15-min (upper) and daily averaged (lower) plots are shown.

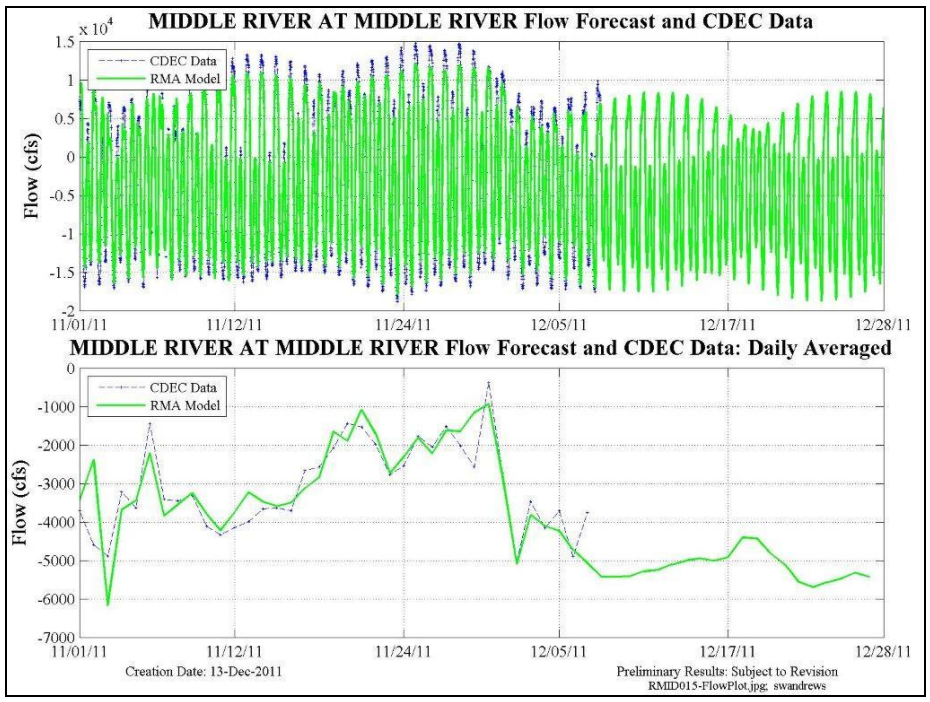

Figure 9 Model flow forecast output and raw CDEC data the Middle River-at-Middle (RMID015) location. Both 15-min (upper) and daily averaged (lower) plots are shown.

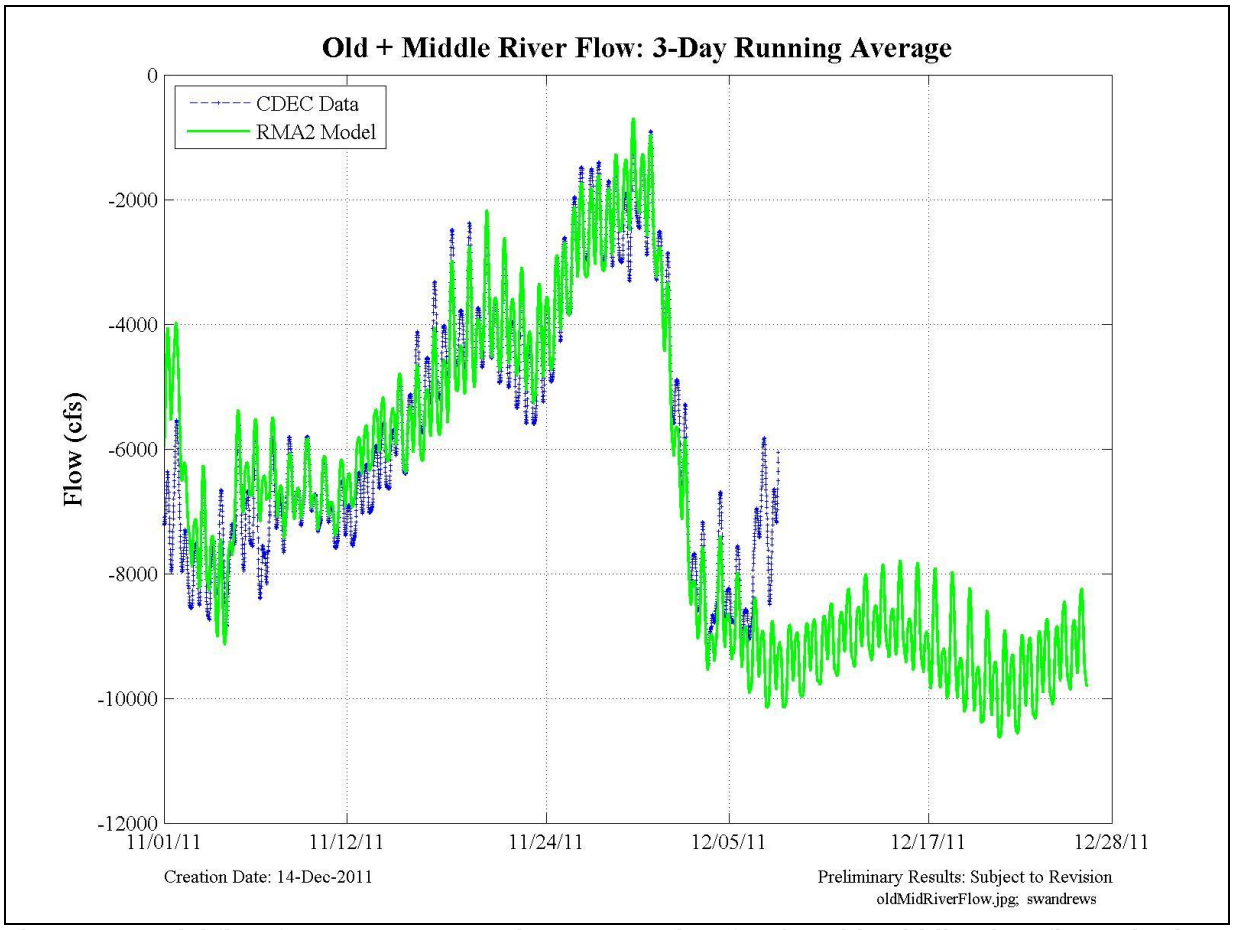

Figure 10 Model flow forecast output and raw CDEC data for the Old+Middle River flow criterion for three-day running-average flow.

Table 1 Boundary condition development for flow for this forecast period.

December 8, 2011	Historical DWR BC	Definition Historical Flow	Definition Forecast Flow	Comment
BC Location				
Yolo Bypass	Not used	Hourly CDEC LIS stage, cleaned+filled, converted flow	Hourly CNRFC forecast (Yolo at Lisbon) for 5 days, Daily DSM2 BYOLO040 after	Stage-discharge rating table from CNRFC, CNRFC data shifted 1hr back in time to match CDEC/DSM2 convention
Sacramento River at Freeport	Not used	Hourly CDEC FPT, cleaned+filled	Hourly CNRFC forecast (Sac R at I St.) for 5 days, Daily DSM2 RSAC155 after	CNRFC data shifted 1hr back in time to match CDEC/DSM2 convention
Mokelumne River	Daily DSM2 RMKL070, converted to hourly	Not used	Daily DSM2 RMKL070, converted to hourly	
Cosumnes River	Not used	Hourly CNRFC Cosumnes-McConnell, cleaned+filled	Hourly CNRFC forecast (Cosumnes R at McCon) for 5 days, Daily DSM2 RCSM075 after	CNRFC data shifted 1hr back in time to match CDEC/DSM2 convention
Calaveras River	Not used	Hourly CDEC MRS, cleaned+filled	Daily DSM2 RCAL009, converted to hourly	
San Joaquin River at Vernalis	Not used	Hourly CDEC VNS, cleaned+filled	Hourly CNRFC forecast (SJ R at Vernalis) for 5 days, Daily DSM2 RSAN112 after	CNRFC data shifted 1hr back in time to match CDEC/DSM2 convention
Stage - Martinez	Not used	15min CDEC MRZ, cleaned+filled	15min DSM2 RSAC054 (hydro.dss)	

Table 2 Boundary condition development for turbidity for this forecast period.

December 8, 2011	Definition Historical NTU	Definition Forecast NTU	Comment
BC Location			
Yolo Bypass	15min CDEC RYI, cleaned+filled, hourly averaged	extend as constant	
Sacramento River at Freeport	15min CDEC FPT, cleaned+filled, hourly averaged	extend as constant	Shifted 15hrs back in time (optimal shift for low Sac flow)
Mokelumne River	15min CDEC SMR, cleaned+filled, daily averaged then converted to hourly	extend as constant	Daily-avg to remove tidal variation
Cosumnes River	15min CDEC SMR, cleaned+filled, daily averaged then converted to hourly	extend as constant	Daily-avg to remove tidal variation
Calaveras River	15min CDEC RRI, cleaned+filled, hourly averaged	extend as constant	
San Joaquin River at Vernalis	15min CDEC SJR, cleaned+filled, hourly averaged	extend as constant	
Martinez	15min CDEC MRZ, cleaned+filled, hourly averaged	extend as constant	

Table 3 Boundary condition development for EC for this forecast period.

December 8, 2011	Historical DWR BC	Definition Historical EC	Definition Forecast EC	Comment
BC Location				
Yolo Bypass	Not used	15min CDEC RYI, cleaned+filled, hourly averaged	extend as constant	
Sacramento River at Freeport	Not used	15min CDEC FPT, cleaned+filled, hourly averaged	extend as constant	Shift back 15 hrs
Mokelumne River	Not used	15min CDEC SMR, cleaned+filled, daily averaged then converted to hourly	extend as constant	Daily-avg to remove tidal variation
Cosumnes River	Not used	15min CDEC SMR, cleaned+filled, daily averaged then converted to hourly	extend as constant	Daily-avg to remove tidal variation
Calaveras River	Not used	15min CDEC RRI, cleaned+filled, hourly averaged	extend as constant	tidal variation not removed
San Joaquin River at Vernalis	Not used	15min CDEC SJR, cleaned+filled, hourly averaged	extend as constant	
Martinez	Not used	15min CDEC MRZ, cleaned+filled, hourly averaged	DWR forecast (quality.dss)	

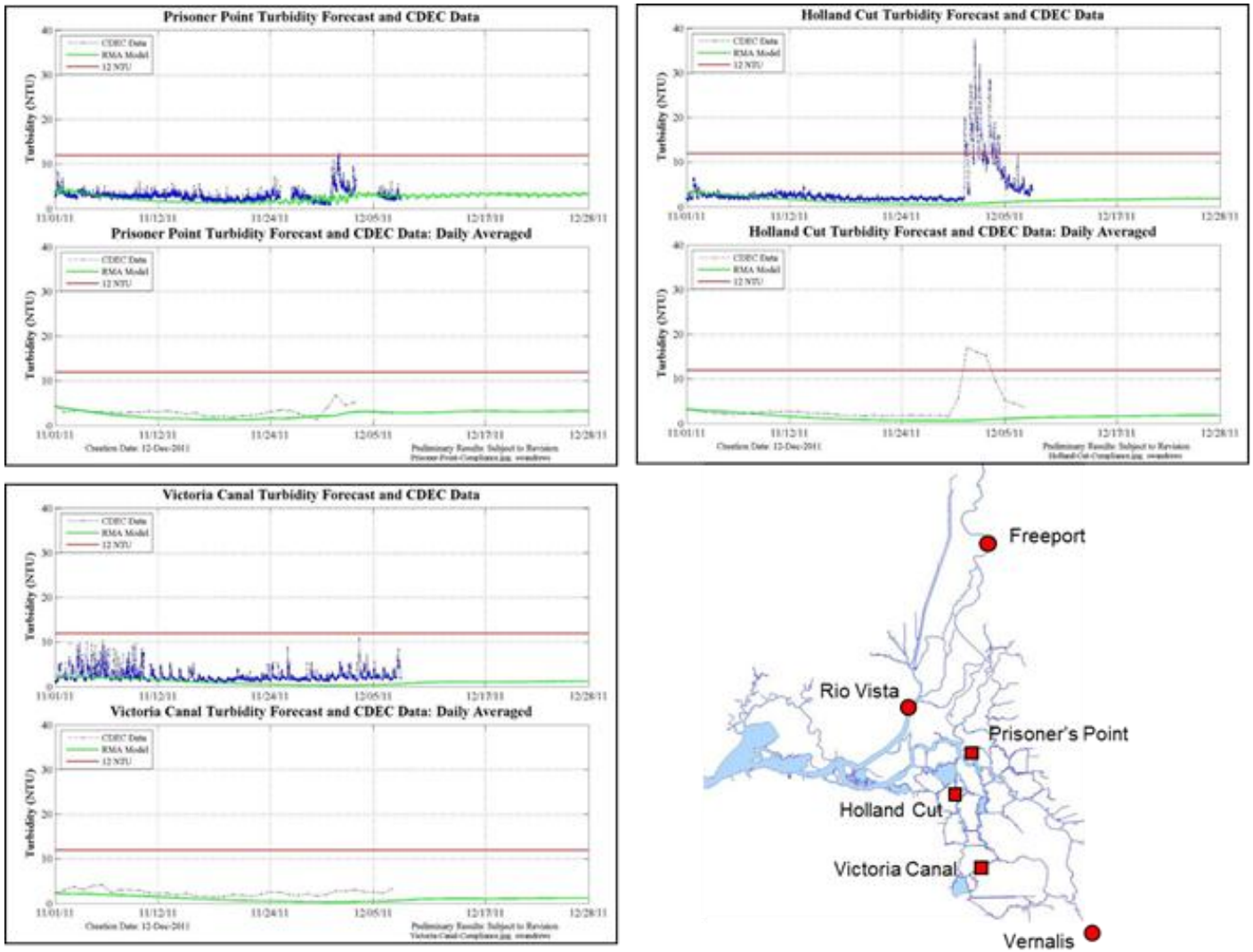

Figure 11 Modeled turbidity and data (cleaned and filled) at the three compliance locations. Both 15-min model output and data and daily averaged plots are shown. Red line illustrates the 12-NTU compliance value.

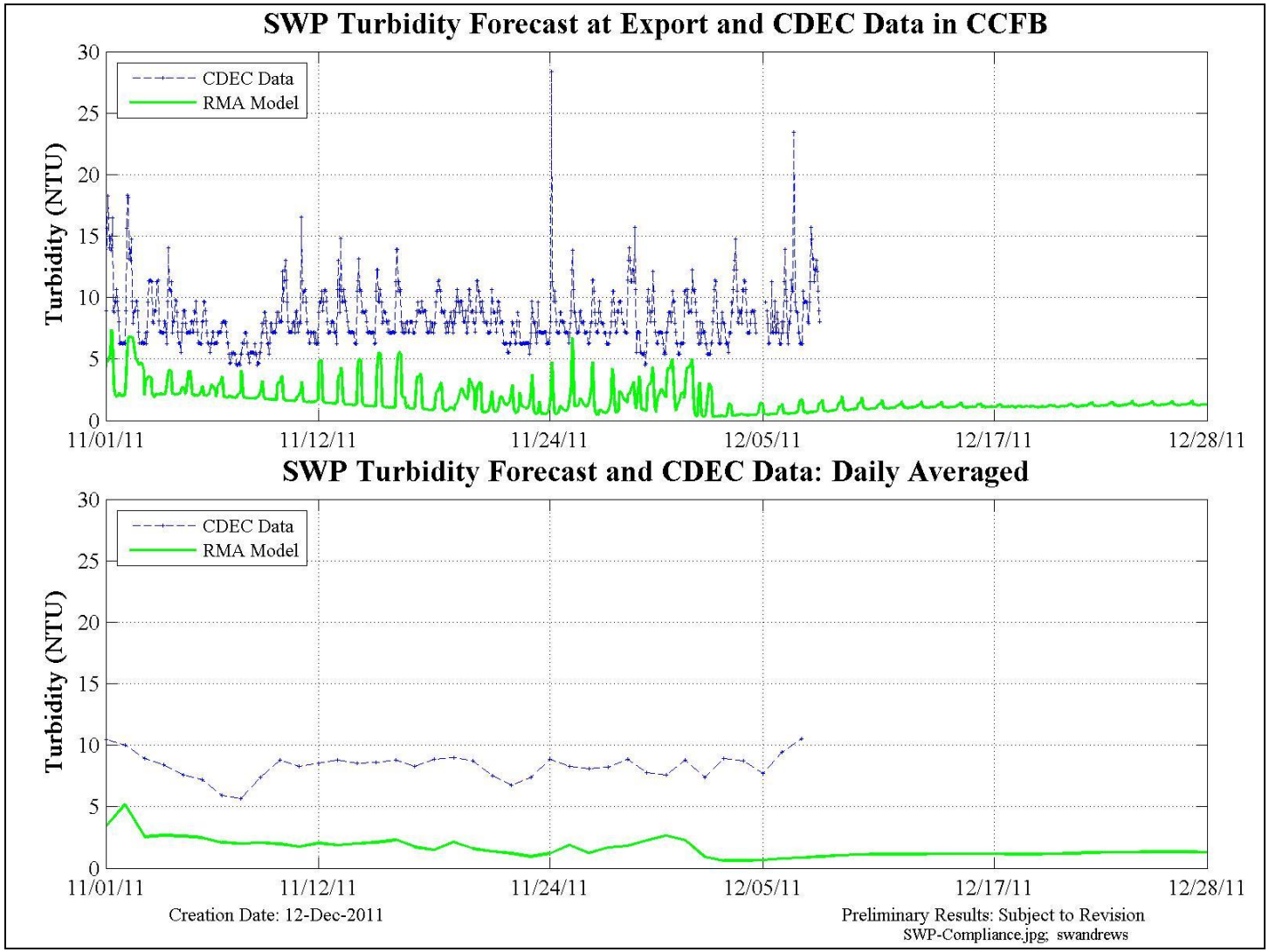

Figure 12 Plots compare model output at the SWP export location with data gathered inside Clifton Court Forebay. Both 15-min model output and daily averaged plots are shown.

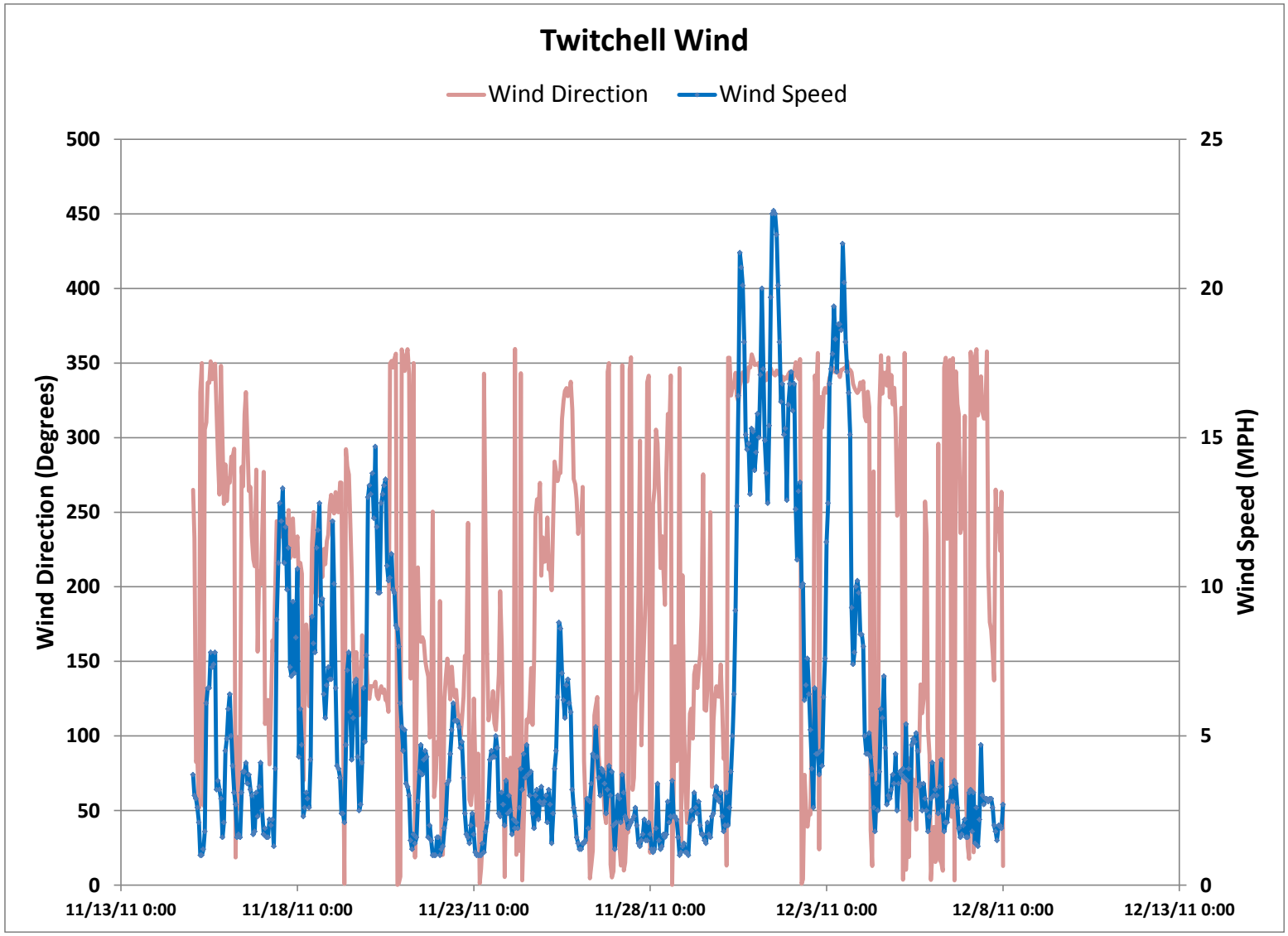

Figure 13 CIMIS data at Twitchell Island station indicates that there was a wind event in the Delta in early December 2011.

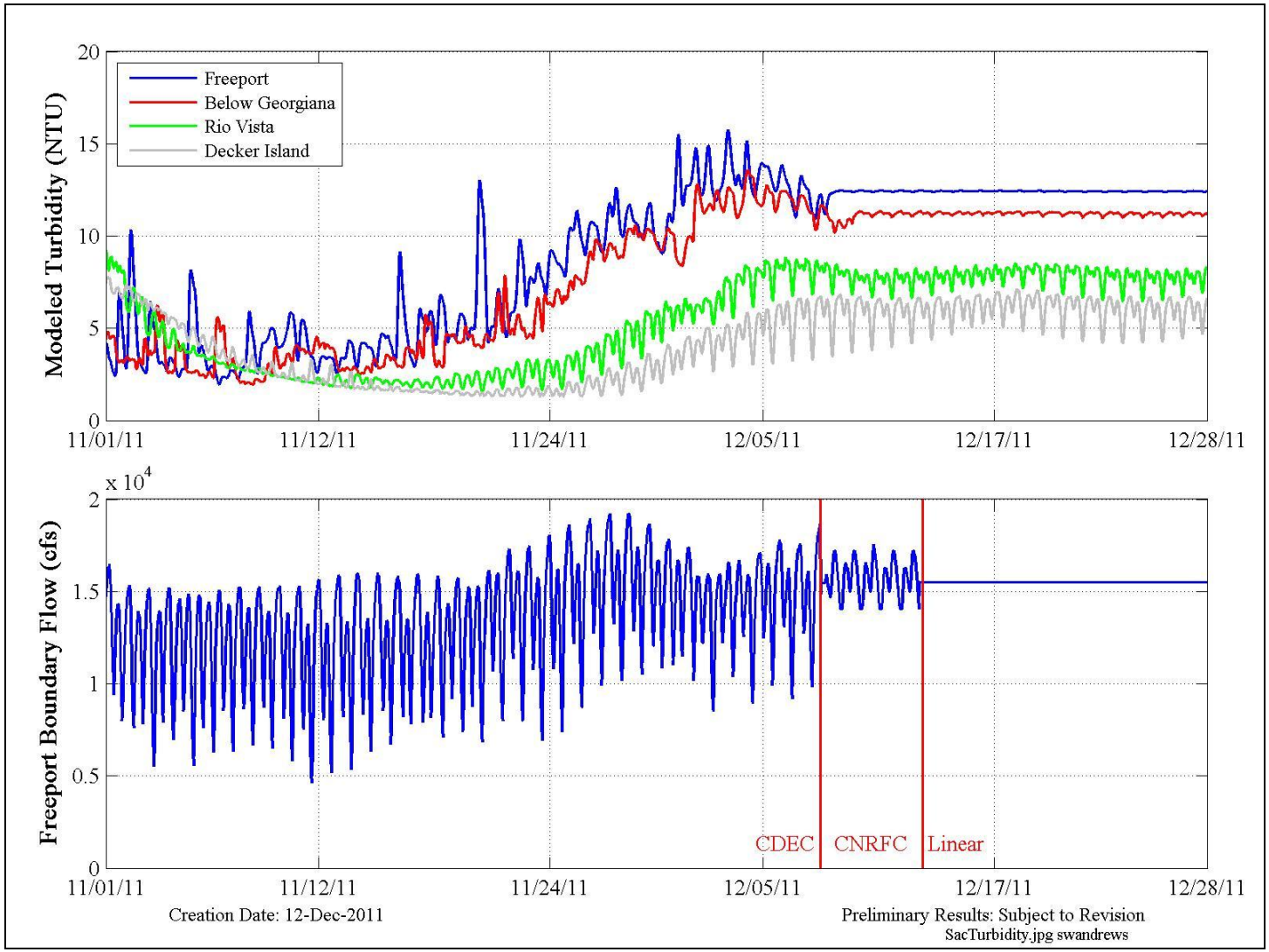

Figure 14 Freeport turbidity boundary condition progression down the Sacramento R. (upper plot) along with the flow boundary (lower plot) used during the historical and forecast periods. Forecast began on Dec. 08, 2011.

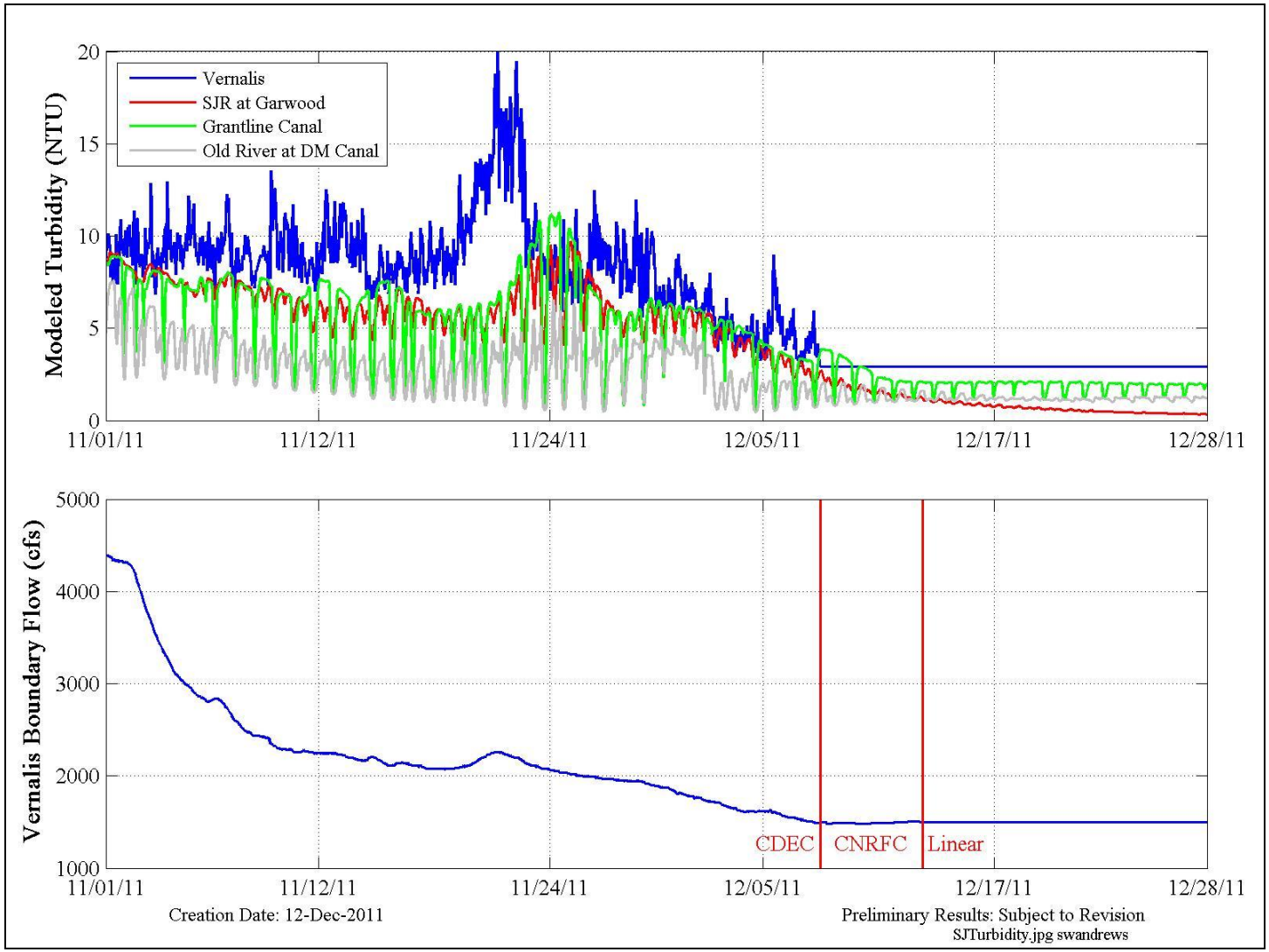

Figure 15 Progression of the turbidity boundary condition from Vernalis down the San Joaquin R to Garwood, and down Old River. Vernalis flow forecast periods indicated by red lines (upper plot). Flow boundary conditions at Vernalis are shown in the lower plot.

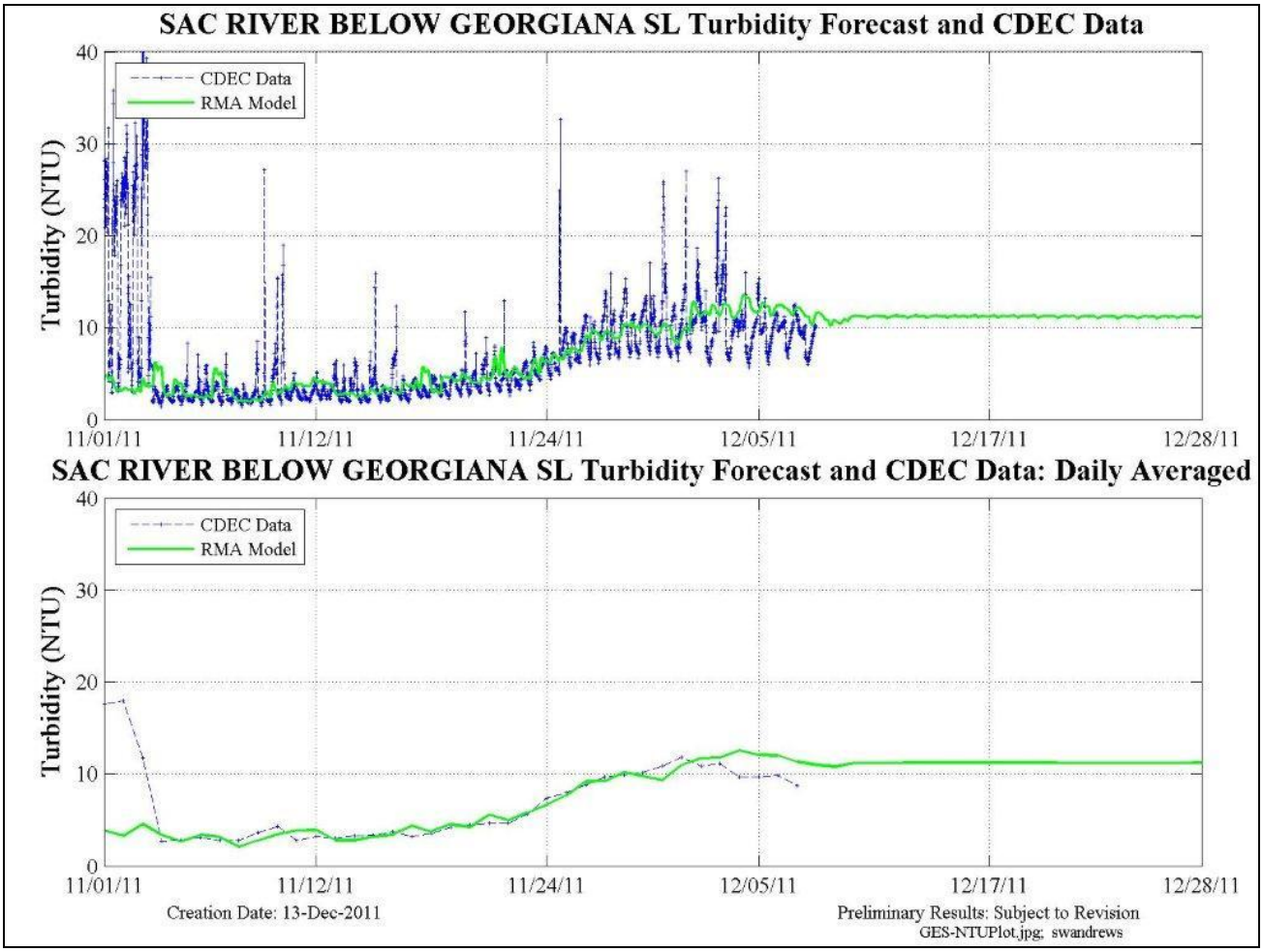

Figure 16 Model forecast and raw CDEC data at Sac. River Below Georgiana Sl. Both 15-min (upper) and daily averaged (lower) plots are shown.

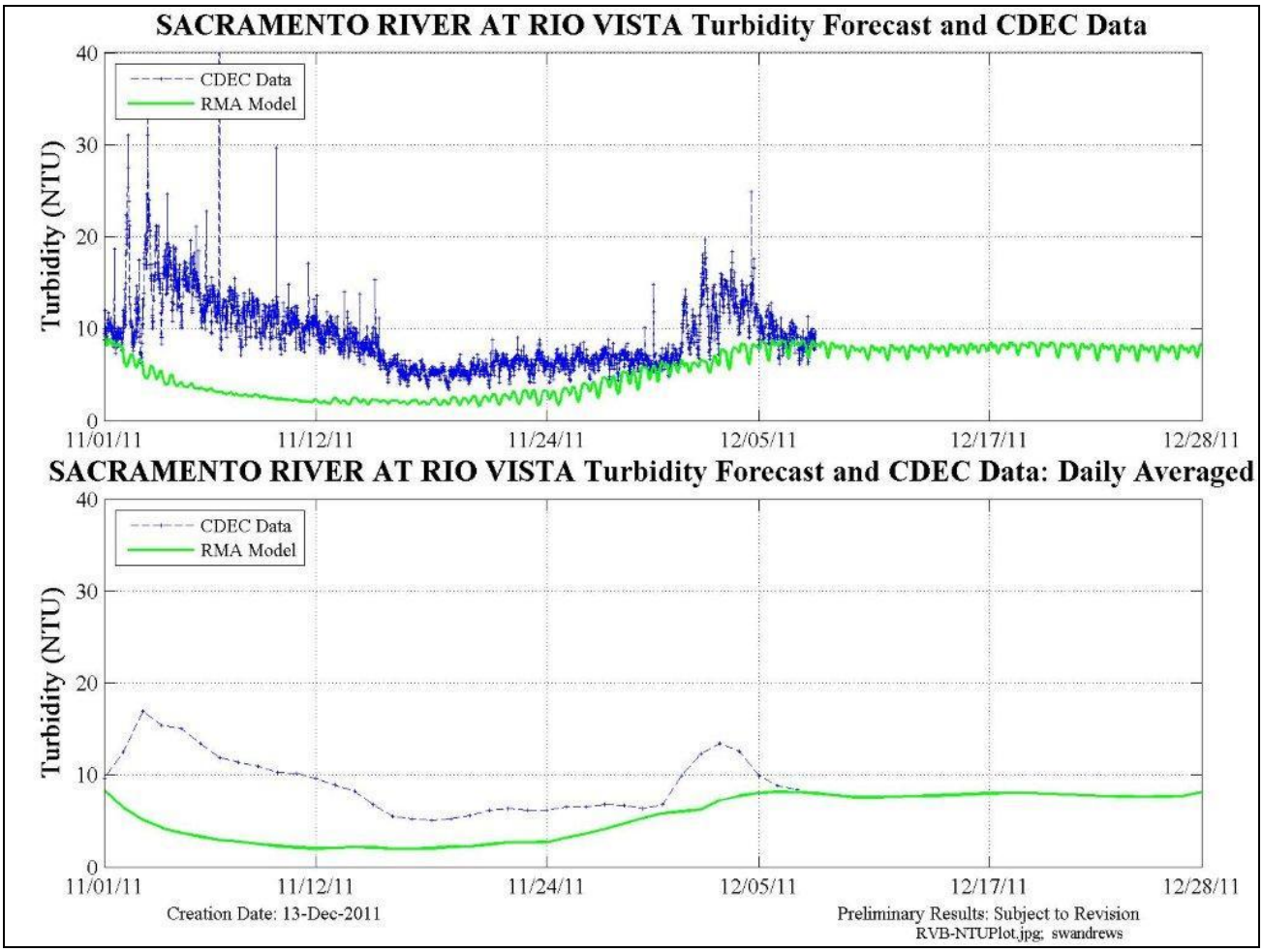

Figure 17 Model forecast and raw CDEC data at Rio Vista. Both 15-min (upper) and daily averaged (lower) plots are shown.

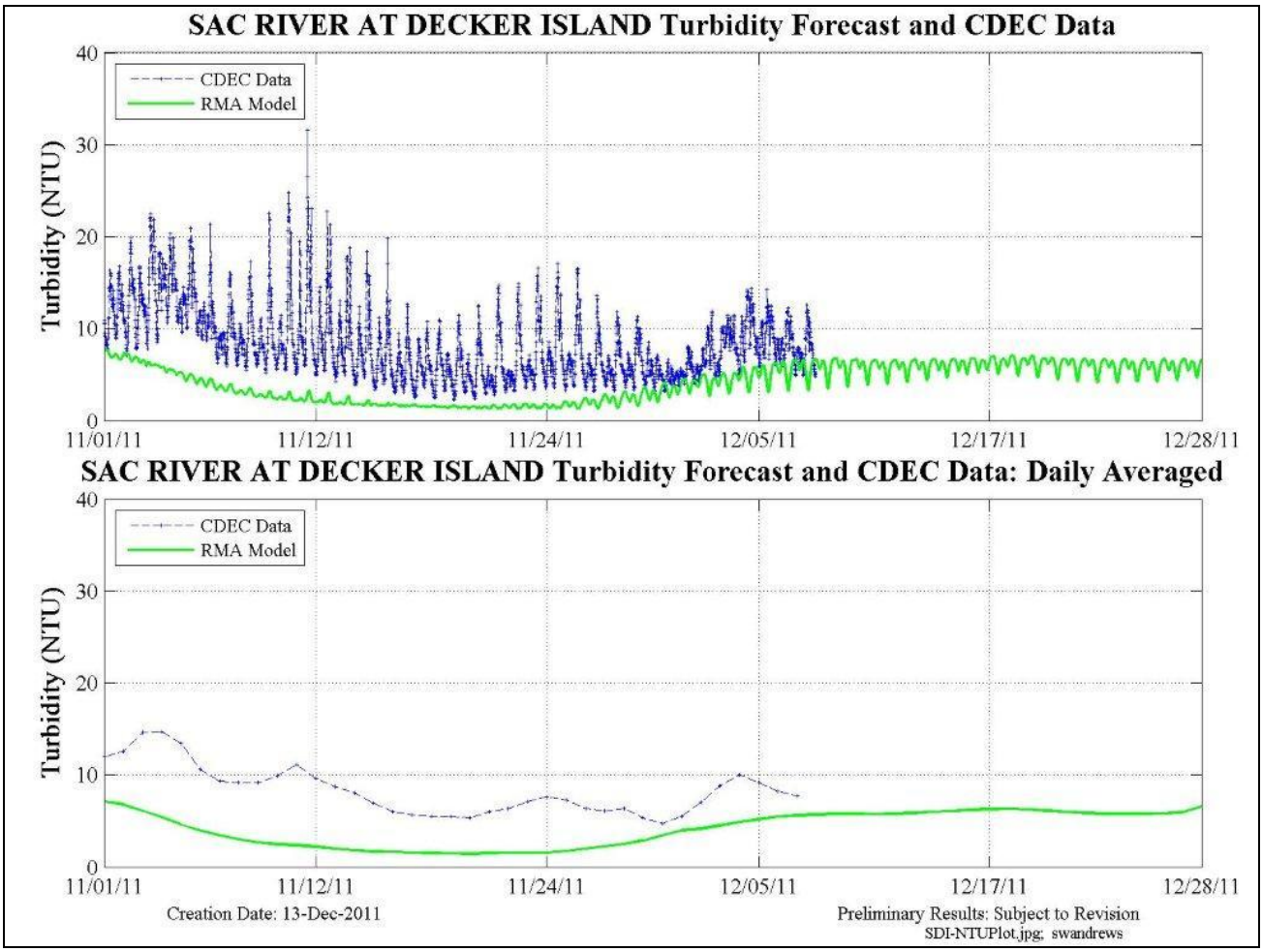

Figure 18 Model forecast and raw CDEC data at Decker Island. Both 15-min (upper) and daily averaged (lower) plots are shown.

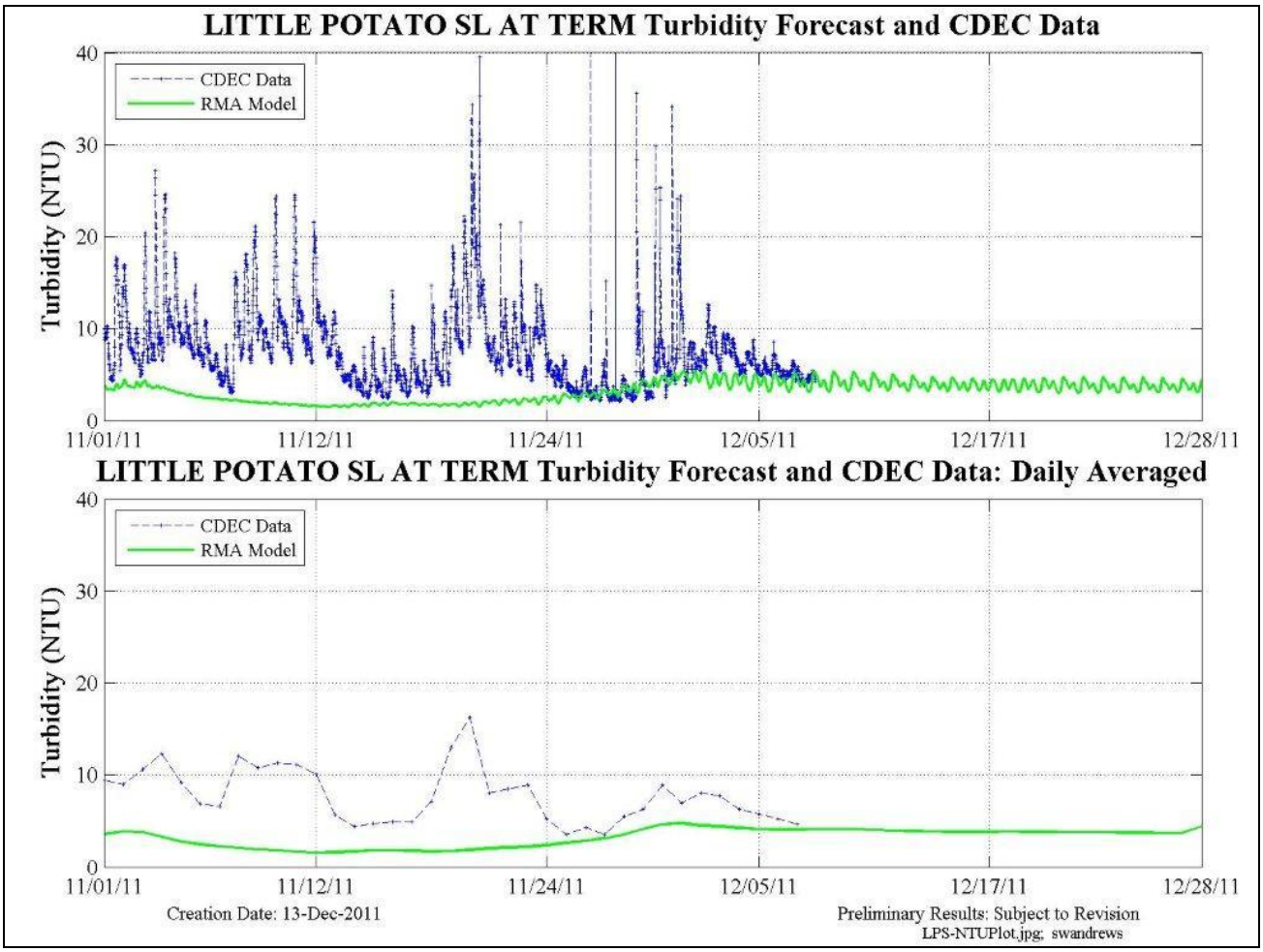

Figure 19 Model forecast and raw CDEC data at Little Potato Slough at Terminous. Both 15-min (upper) and daily averaged (lower) plots are shown.

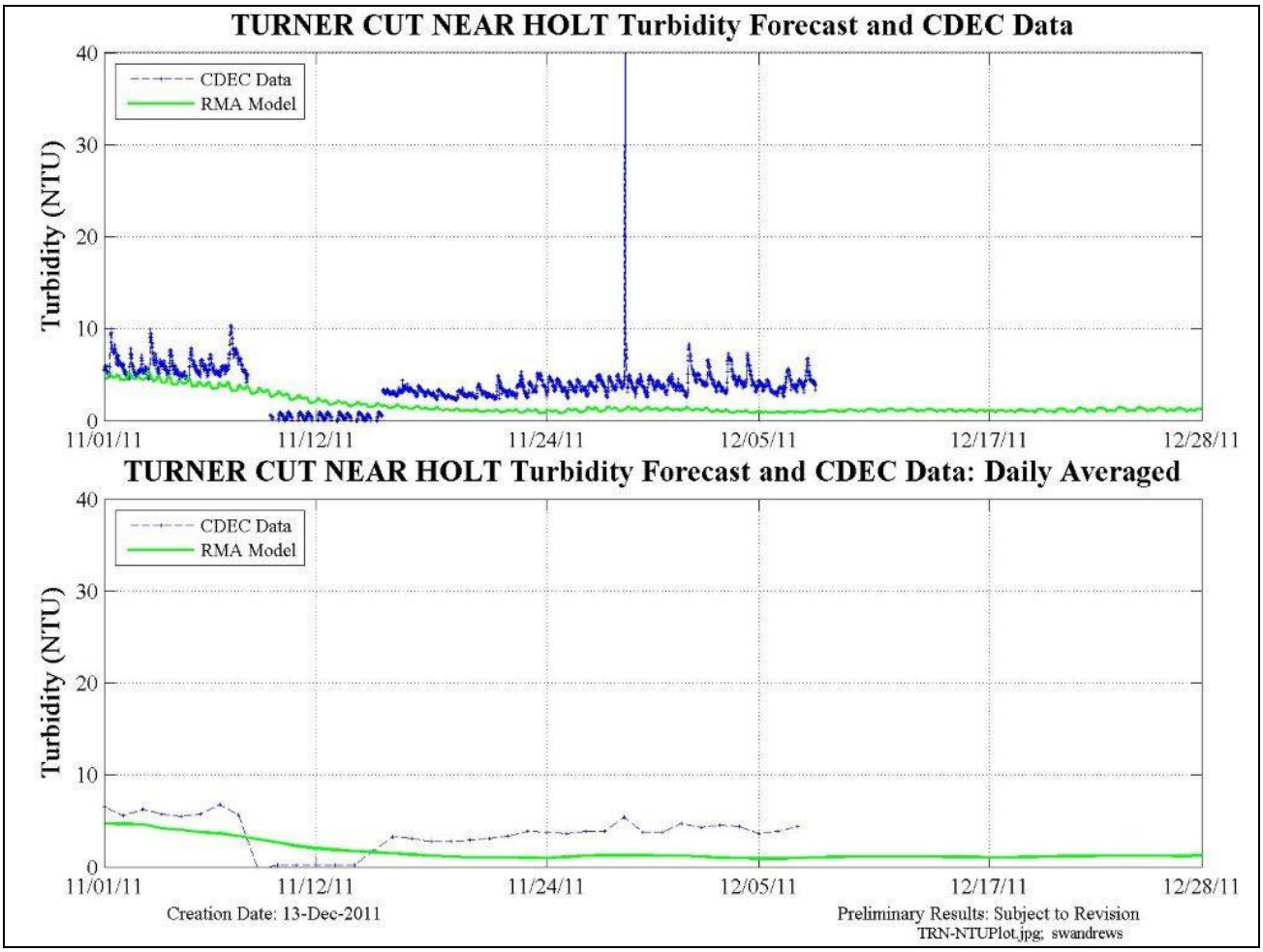

Figure 20 Model forecast and raw CDEC data at Turner Cut near Holt. Both 15-min (upper) and daily averaged (lower) plots are shown.

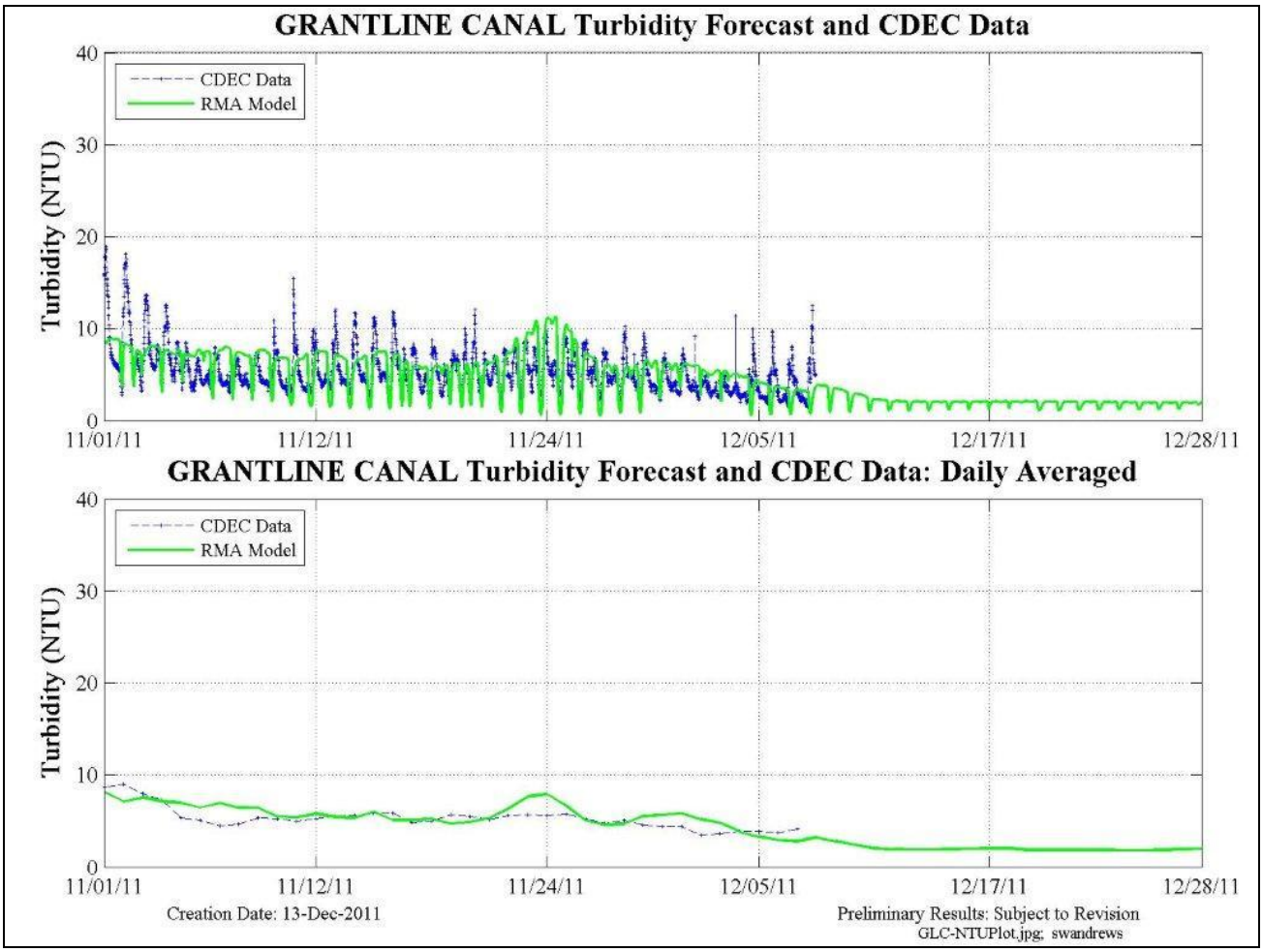

Figure 21 Model forecast and raw CDEC data at Grant Line. Both 15-min (upper) and daily averaged (lower) plots are shown.

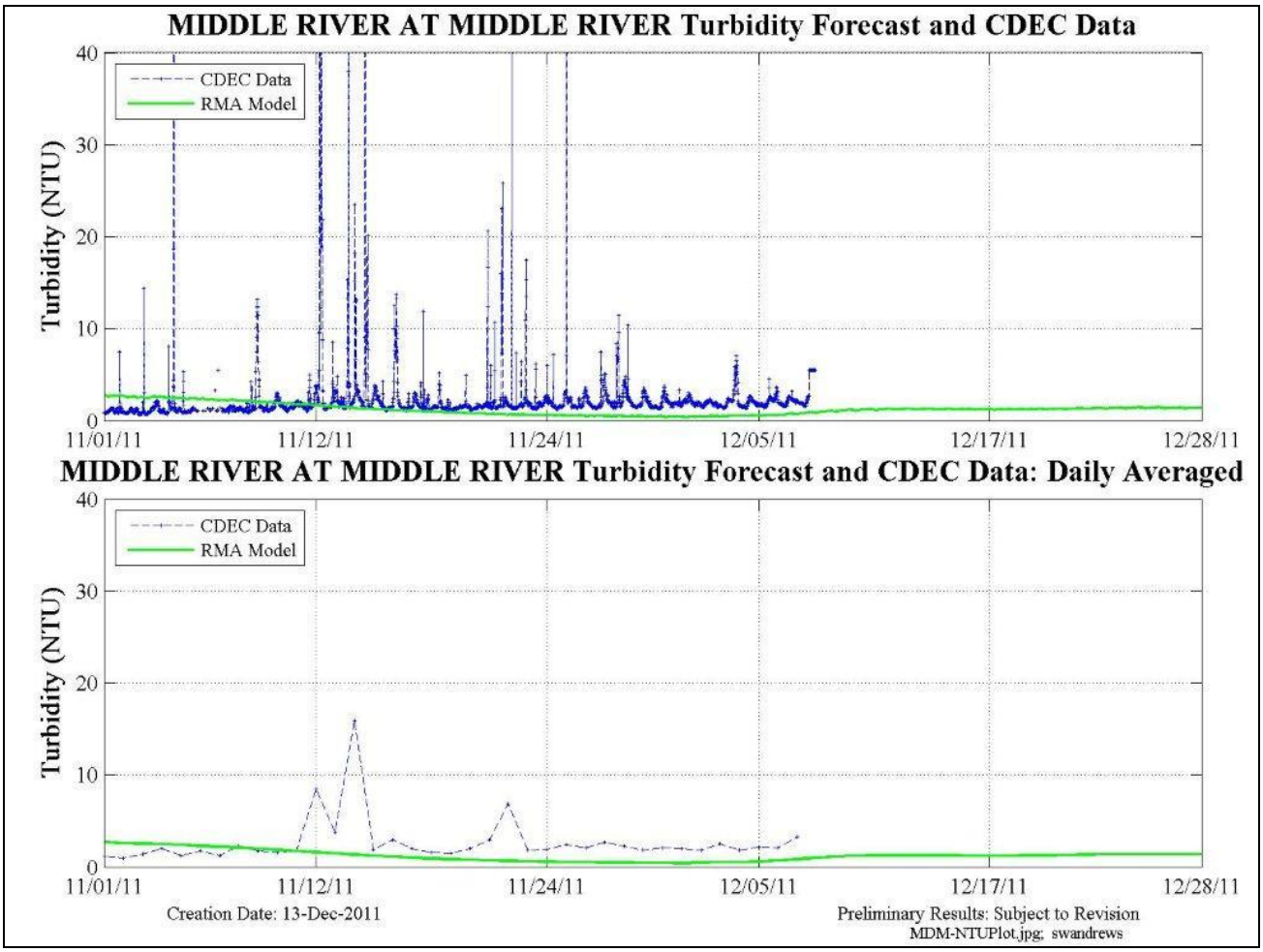

Figure 22 Model forecast and raw CDEC data at Middle R. at Middle R. Both 15-min (upper) and daily averaged (lower) plots are shown.

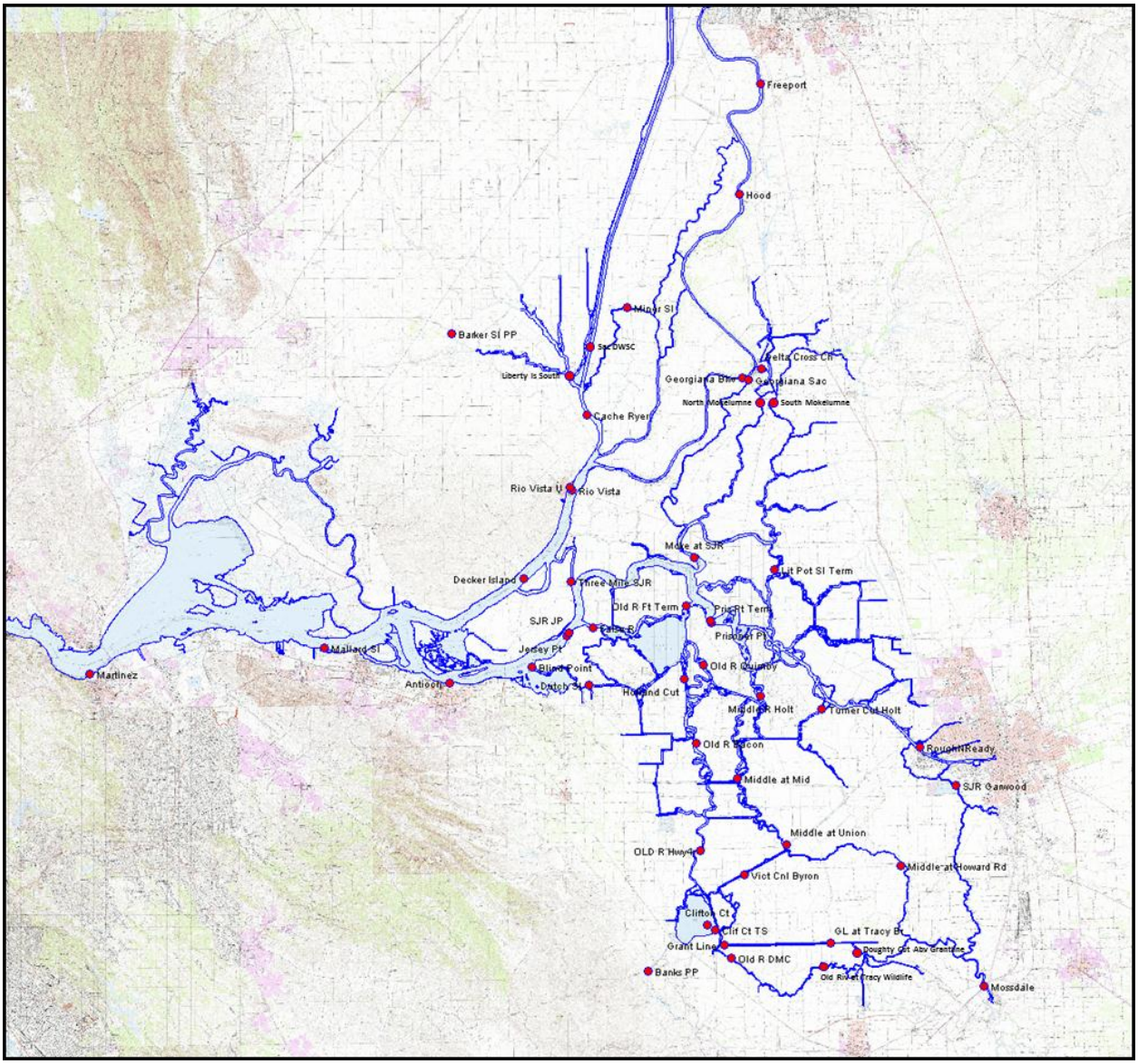

Figure 23 Figure illustrating model output and data collection locations.

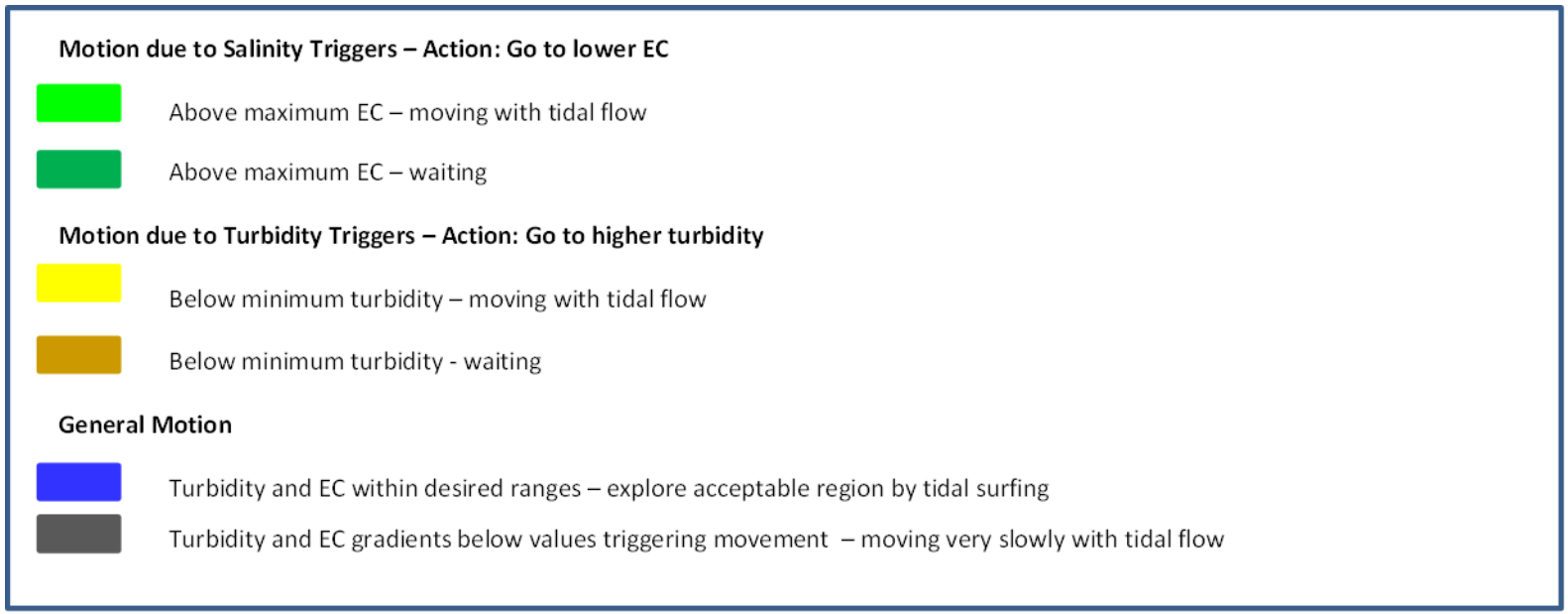

Figure 24 Particles in the Adult Delta Smelt particle tracking model are color-coded by the triggers influencing their behavior during the simulation. Use this figure to interpret the simplified color scale in the next three figures.

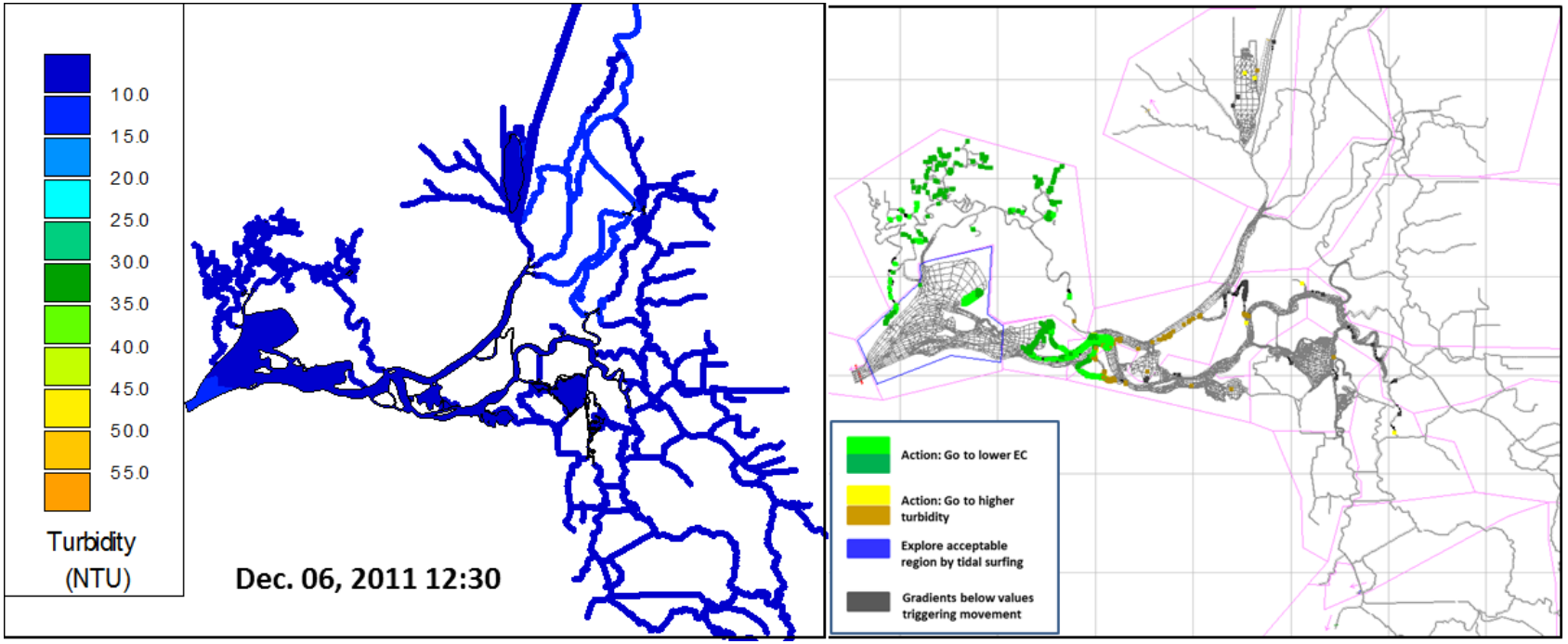

Figure 25 Turbidity contours and particle locations in the RMA model grid on Dec. 06, 2011.

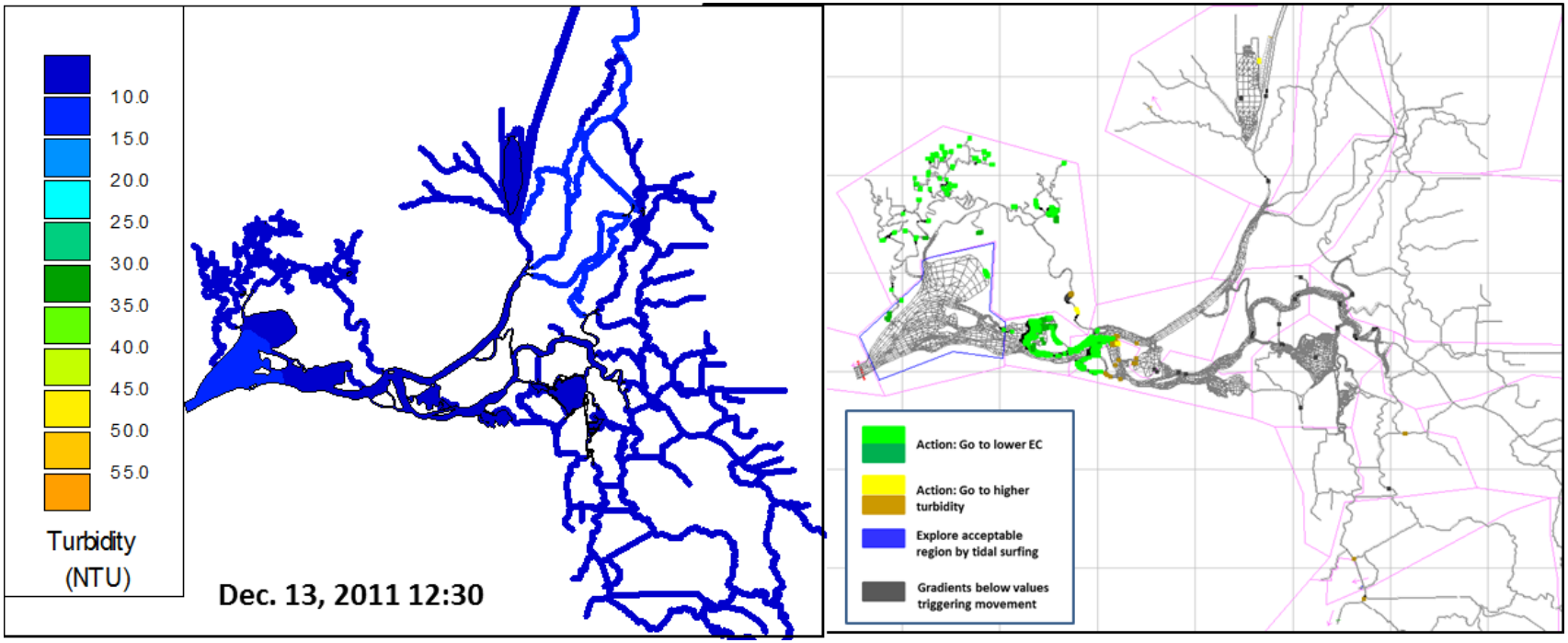

Figure 26 Turbidity contours and particle location in the RMA model grid on Dec. 13, 2011.

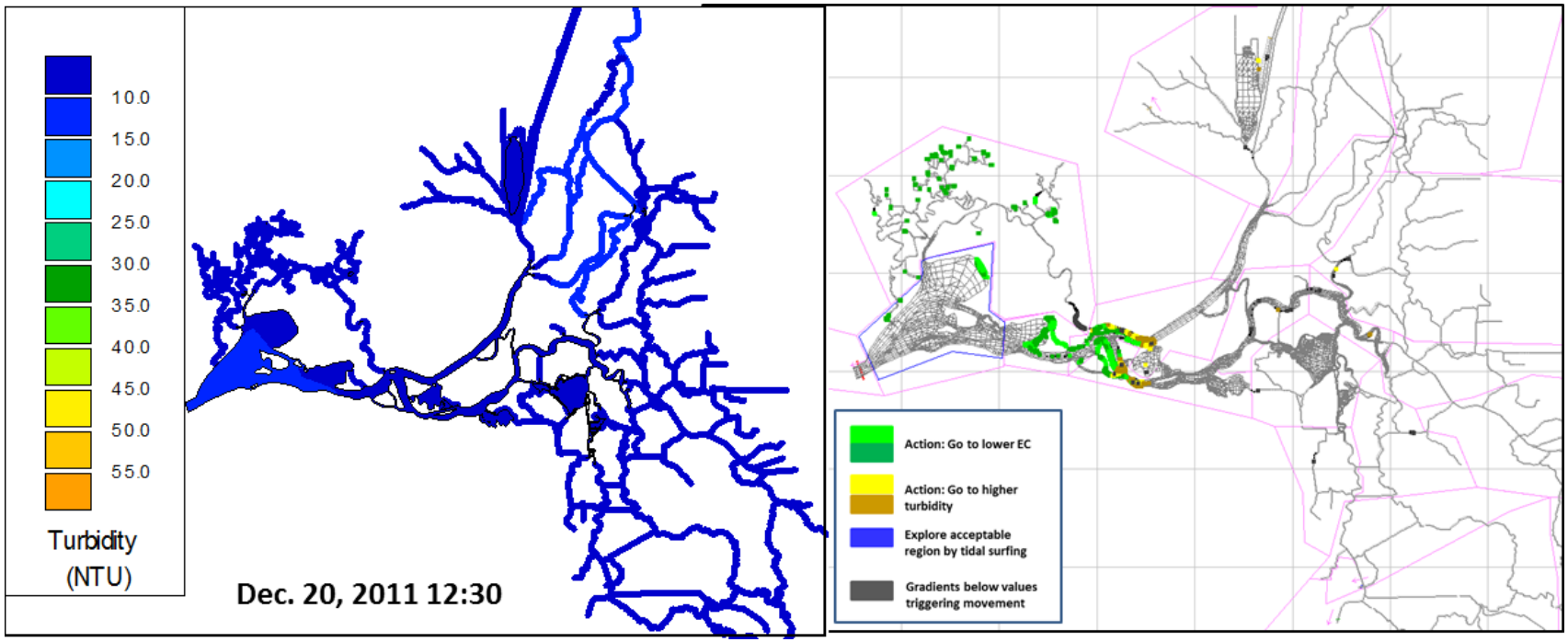

Figure 27 Turbidity contours and particle location in the RMA model grid on Dec. 20, 2011.

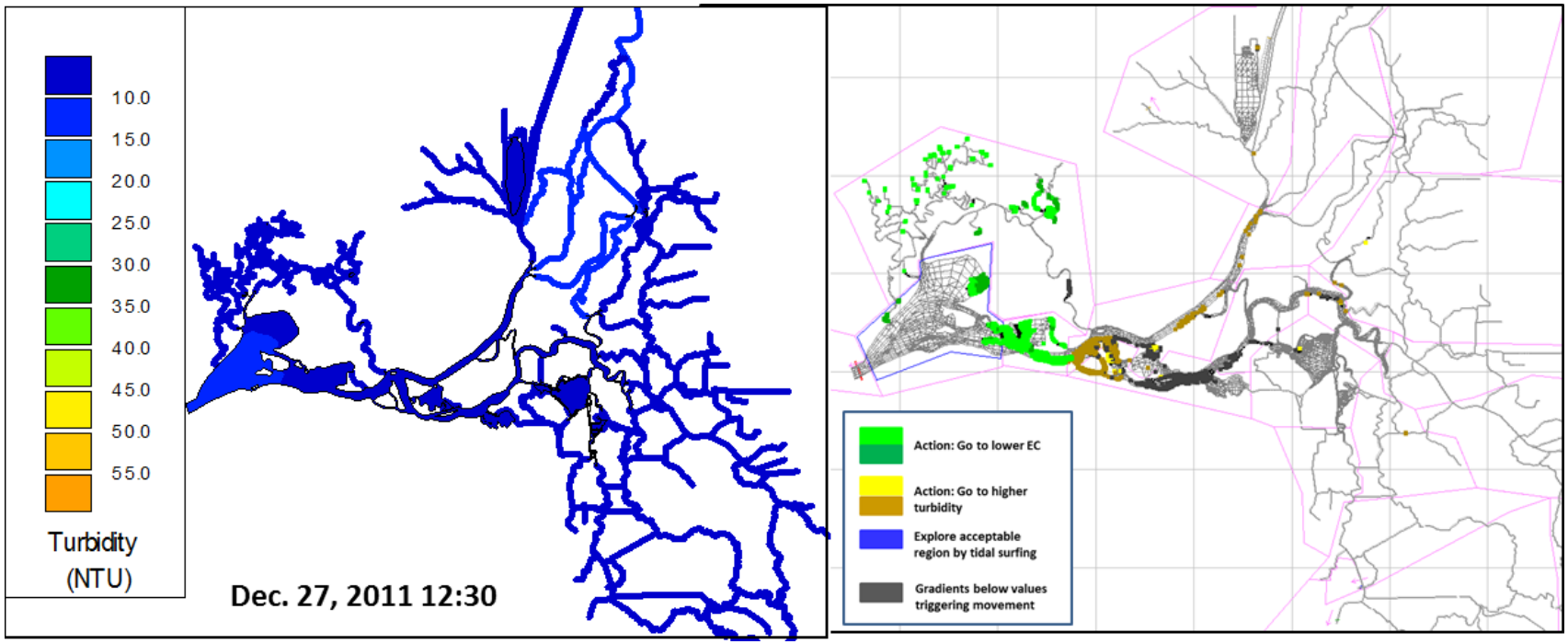

Figure 28 Turbidity contours and particle location in the RMA model grid on Dec. 27, 2011.

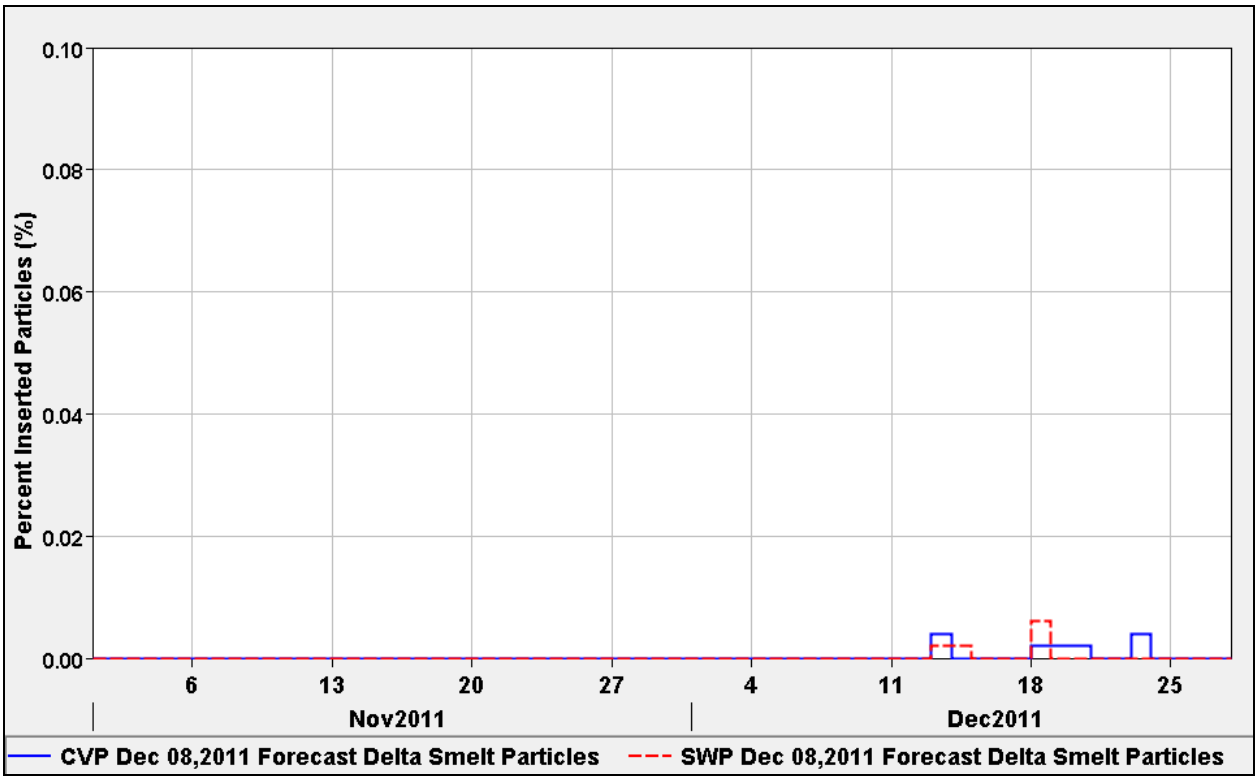

Figure 29 Adult delta smelt behavioral model particle tracking results at the CVP and SWP export locations.