Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh

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Chapter 6
Calculation of Clifton Court Forebay Inflow and Re-rating the Forebay Gates

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Contents

6 Rating Clifton Court 6-1
6.1 SUMMARY 6-1
6.2 CLIFTON COURT FOREBAY 6-1
6.3 PROJECT DATA 6-3
6.4 PRIOR GATE RATINGS 6-4
6.5 DYNAMIC RESPONSE TO RADIAL GATES 6-5
6.6 THE NEW RATING 6-6
6.7 SYNTHESIZING HEIGHTS 6-8
6.8 VALIDATION THROUGH FLOW BALANCE 6-9
6.9 DSM2 EXPERIMENTS WITH FULL AND LIMITED DATA 6-16
6.10 OLD VERSUS NEW RATING 6-16
6.11 DATA GRANULARITY 6-19
6.12 BANKS DATA GRANULARITY 6-21
6.13 GATE TIMING: SCHEDULED PRIORITY 3 VERSUS HISTORICAL 6-21
6.14 CONCLUSION 6-22
6.15 REFERENCES 6-23

Figures

Figure 6-1 Location and Aerial View of Clifton Court Gates (adapted from Wilde 2006) 6-1
Figure 6-2 Priority 3 Gate Schedule (adapted from Wilde 2006) 6-2
Figure 6-3 Average Clifton Court Radial Gate Height over Three Recent Years 6-3
Figure 6-4 Comparison of Daily Gate Flow Calculations from DAYFLOW (SLP is Gate Inflow) with Daily Averages of Flows Reported Based on the Hills Equation 6-5
Figure 6-5 Components of Flow Balance Used to Calibrate the Gate Rating 6-9
Figure 6-6 Water Levels (top), SWP Exports (middle) and Gate Heights (bottom) at Clifton Court in Winter 2004-2005 6-10
Figure 6-7 Water Levels (top), SWP Exports (middle) and Gate Heights (bottom) at Clifton Court in 2008 6-11
Figure 6-8 2004-5 Forebay Water Level Fluctuations and Gate Flows from the New Rating Compared with Field Data Utilizing Instantaneous Gate Height and Pumping Data and the Simple Mass Balance Model 6-12
Figure 6-9 Rating Validation in 2008 Under Low Flows and "Sipping" Gate Operations, Including Clifton Court Water Levels (top), Daily Flows (middle), and Gate Heights (bottom) 6-13
Figure 6-10 Close-up of Intratidal Water Level Fluctuations in the 2008 Mass Balance Experiment 6-14

Figure 6-11 Forebay Water Level Fluctuations and Gate Flows from the DSM2 Gate Rating and Simple Mass Balance Model 6-15

Figure 6-12 Fitted Versus Observed Values for the ADCP Data 6-16

Figure 6-13 Water Level and Flow Results for DSM2 Experiment with Old (R1) and New (R2) Rating 6-17

Figure 6-14 Clifton Court Electrical Conductivity (EC) under Old and New Ratings with Instantaneous Gate and Pumping Data 6-18

Figure 6-15 Old River at Tracy Bridge Water Levels Under Old and New Ratings with Instantaneous Gate and Pumping Data 6-18

Figure 6-16 Clifton Court Water Elevations with Different Quality and Granularity of Gate Height Data..... 6-19

Figure 6-17 Clifton Court EC with Different Quality and Granularity of Gate Height Data 6-20

Figure 6-18 Old River at Tracy Bridge Water Elevations with Different Quality and Granularity of Gate Height Data 6-20

Figure 6-19 Clifton Court Water Levels with New Rating, Instantaneous Gate Heights and Two Granularities of Banks Pumping Data, Instantaneous (full) and Daily 6-21

Figure 6-20 Comparison of Scheduled Timing and Actual Historical Gate Timing using DSM2 with the Prior Rating and Gates Treated as Always Open/Closed 6-22

Tables

Table 6-1 Parameter Fits for Coefficients and Comments from Drought Modeling 6-8

6 Rating Clifton Court

6.1 Summary

With the help of staff at California Department of Water Resources (DWR) Operations and Maintenance (O&M), Delta Field Division (DFD), and North Central Region Office (NCRO), the Delta Modeling Section has developed a new rating for the Clifton Court radial gates — a formula for estimating flow into the forebay based on gate heights and water levels inside and outside the gates. The new rating is suitable for operational and modeling purposes.

Clifton Court Forebay (CCFB) is included explicitly in our models, DSM2 and SCHISM. In addition to presenting the new rating, we describe DSM2 modeling experiments that show the role the gates play in the local balance and where modeling error tends to manifest. Although our main results are obtained with detailed gate data and pumping data, we also address situations, such as planning scenarios, where detailed time series of gate heights and exports are not available.

The main potential impact of the work presented here is on water levels in the forebay, where the Clifton Court gate characterization and modeling practices have an enormous impact on results. There are more minor impacts as well on exterior water levels in the South Delta, on high tide, on water quality, and residence time in the forebay.

6.2 Clifton Court Forebay

The intake structure to Clifton Court is comprised of five 20’ x 20’ radial gates along Old River. Figure 6-1 shows the location and configuration of the gates. These gates are operated over the tidal cycle to reduce approach velocities, prevent scour in adjacent channels, and minimize water-level fluctuation in the South Delta. When a large head differential exists between the outside and the inside of the gates, instantaneous flows into the forebay can reach 15,000-20,000 cubic feet per second (cfs).

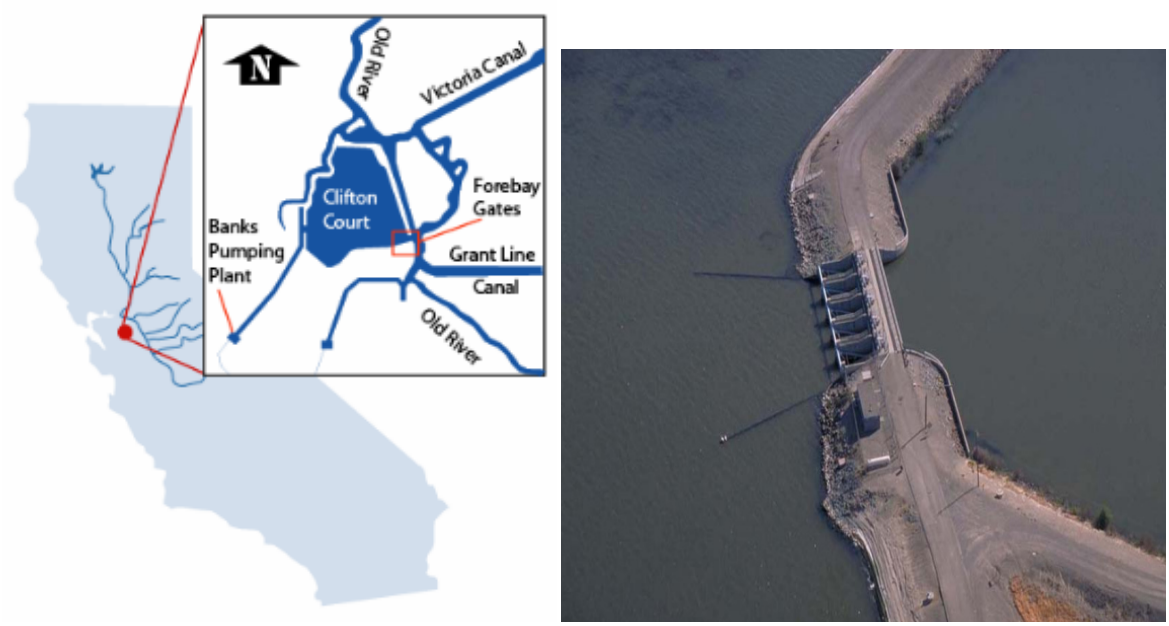

Figure 6-1 Location and Aerial View of Clifton Court Gates (adapted from Wilde 2006)

Generally, operators open all five gates in tandem, but a gate(s) may be independently operated strategically or during maintenance. The daily opening and closing of gates depends on the scheduled State Water Project (SWP) export allotment, timing, amplitude of the local tides, and storage availability in the forebay. Gate operations are constrained by water level concerns in the South Delta for local agricultural irrigators. The criteria for the gate operation are defined in the O&M Standing Operating Order PC 200.7-A (California Department of Water Resources 1989) with respect to agreements with the South Delta Water Agency. The most common operation of the CCFB intake gates is what is commonly termed Priority 3: "Intake gates open 1 hour after the low-low tide, close 2 hours after the high-low tide, reopen 1 hour before the high-high tide, and close 2 hours before the low-low tide." This is shown in Figure 6-2. Some ambiguities in this schedule occur during crossover neap tides when tidal energy is low and the pattern of high and low tides does not follow its usual patterns. These issues are resolved by O&M using conservative scheduling. An important aspect of the Priority schedule is that this is the *potentially* open period. In practice, the gates are closed immediately after the day's allotment is fulfilled, a point that is not included in planning scenarios.

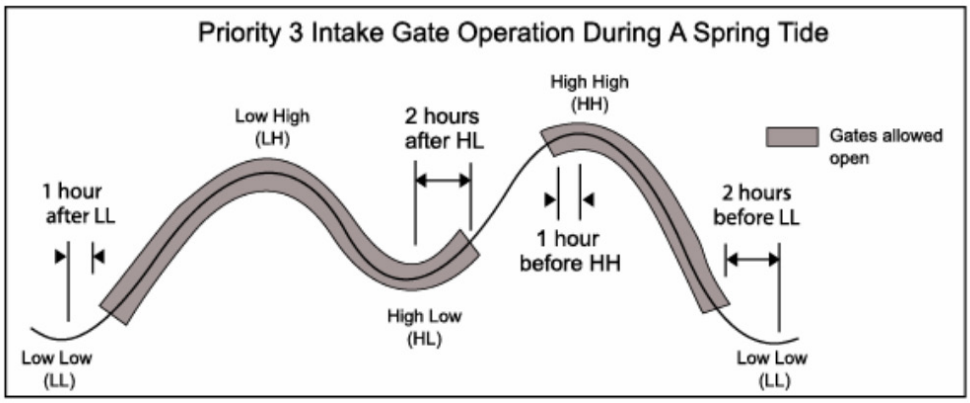

Figure 6-2 Priority 3 Gate Schedule (adapted from Wilde 2006)

In addition to issues of timing, there are two main operational strategies associated with how high the gates are lifted during each open period. For part of the year, Clifton Court gates are operated in a mostly fully open (~15 ft.) or closed fashion and are closed once the day's allotment has been satisfied. Since 2009, operators have followed a *sipping* strategy for part of the year to reduce velocity under the hypothesis that this will increase fish survival. Under the sipping regime, the gates are open to a smaller height for a longer period. Figure 6-3 shows the average Clifton Court radial gate height from April 2009 to April 2012 and illustrates the difference and seasonality Sipping requires greater effort and uncertainty. According to operators, it is still unclear whether this will become a permanent strategy.

Rather than being driven by the tidal calendar, the Harvey O. Banks pumping plant (Banks) follows a 24-hour daily schedule driven by diurnal variation in electricity prices. In addition, recently some emphasis has been placed on consistency in order to reduce stress on equipment. During periods when exports are relatively high, conveyance and cavitation considerations dictate that water levels in the forebay do not get too low. An elevation of -2 ft. sea level (datum assumed to be National Geodetic Vertical Datum of 1929 [NGVD]) is the level used as a cavitation warning. At the same time, the challenge of taking in the daily allotment of water through the gates during low energy tides favors low water levels, and the forebay is allowed to be drawn down more during weak neap periods for this reason. In the absence of these special considerations, one rule of thumb employed

by operators is to try to bring water levels to-0.5 ft. mean sea level every day at midnight and lower during weak neap periods.

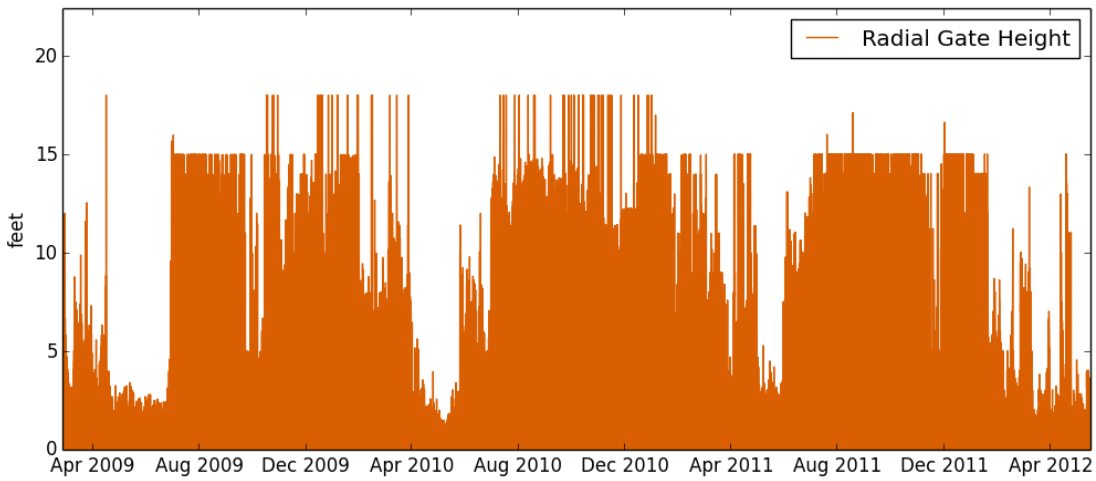

Figure 6-3 Average Clifton Court Radial Gate Height over Three Recent Years

6.3 Project Data

To develop a rating, upstream and downstream water levels are required. Upstream stage is taken from the NCRO station 95340, Old River, at Clifton Court Ferry, which is the reference used by operators for the exterior water levels. Interior water levels are observed at a station just south of the gates wing walls, and are fairly well isolated from the dynamics of the gate and far from drawdown near the pumps. Interior water levels are not distributed in real time.

For fitting the new rating, we used flow data from several boat-mounted (downward-looking) Acoustic Doppler Current Profiler (ADCP) campaigns at the intake channel just outside the forebay. Four collections were made by NCRO in 2004-2005, two in 2012, and one by Cathy Ruhl of the U.S. Geological Survey in 2008. While our data set has more variety than any of its predecessors, the ADCP datasets span mostly periods of small-medium gate heights. We sought to get data from more large gate openings, but in late 2012 the winter sipping season was declared two days before our proposed outing, and in late 2013, one of the gates fell off its hinges the week before our second attempt. Because of these mishaps, in part, one of our validation periods, using a flow balance, emphasizes a 2004-2005 period with large openings.

Several other datasets are sometimes described in association with the Clifton Court gates. The first is the daily value available from the DAYFLOW program and on the California Data Exchange Center (CDEC) as the Clifton Court station identified as CLC. This gate flow is inferred from a daily mass balance that includes Banks flow, Byron-Bethany Irrigation District (BBID) exports, and changes in volume in the forebay. The second is an hourly or instantaneous flow stored in DWR operational databases at hourly or finer intervals at least as far back as 2004. This second “flow” is really a computation based on the Hills Equation, a rating known to be very inaccurate. The gates have never been fitted with a continuous flow monitoring device, although a pilot effort was made in

2004 to establish an ADCP flow station just upstream of the gates in the intake of this channel. This year, plans for that station have been revived, and observations may begin as early as this fall.

Hourly or more frequently timed records of gate heights exist in scattered form over several DWR databases, most recently in the DWR Control Systems Branch Information Server (Wonderware). We collated the data across sources for the period covered by this project, which goes back to December 2004. There are also large gaps in the record. Often the calculated gate flow, as well as upstream and downstream water levels, were recorded even when the gate height was not. In these cases, the Hills Equations can be inverted to reverse engineer, although imperfectly, a gate height from water levels and flow. In addition to these gate height records, historical opening and closing times at the CCFB gates have been included in the DSM2 historical input datasets for many years. Only the timing is included in this dataset, but it is by far the most lengthy and widely disseminated record of gate openings.

As with gate flow, Harvey O Banks flow and BBID exports (CDEC stations identified as HRO and BBI) are widely distributed in daily averaged form. Instantaneous data is not directly recorded. The Banks pumps are equipped with flow instruments, but they are rarely functional. Instead, DFD calculates pumping volumes using the capacity of each pumping unit and the start/stop times of the units. The calculation is subject to some transient error at startup, variations caused by upstream and downstream conditions, and assumptions concerning the design and age of the impellors. We encountered three sets of pumping ratings used by different groups in DWR, though the difference among them was only a few percentages. It is this calculation, summarized as a daily total using a spreadsheet, that is reported on CDEC as station HRO. Although the method seems like it implies the creation and integration of a fine time-scale-flow-time series, that actually is not the case — operators are primarily concerned with volumes, and a time series of flows is not produced.

DWR does, on the other hand, create an approximate instantaneous time series of Banks flows on a monthly basis using stored start/stop times as part of the service rate report, which is delivered to contractors. It is mostly from this effort that we learned how to calculate Banks pumping on a fine time scale, although we used the pump ratings for each unit given to us by DFD, which are slightly different. We are able to compute a flow that matches the daily averaged CDEC calculation fairly accurately for periods after 2004. In principle, a detailed time series of exports could be constructed going farther back, but this would require significant researching of archived records using the Operations and Control Office MAPPER software or even paper records.

6.4 Prior Gate Ratings

One of the original operational ratings for the Clifton Court gates was devised by Edward Hills in 1988, based on a few dozen observations with hand-held velocity meters with gate heights in the common range of the day, 12-15 ft. There were no examples of the much lower gate heights (3-10 ft.) that are common nowadays. An optimistic skill assessment of the Hills Equation was published by Le (2004), but this validation was based on a misunderstanding concerning quantities stored in DWR databases and essentially just compared two versions of the same calculation. We have found to the contrary that the Hills rating performs poorly even in its design range, with sustained errors of thousands of cubic feet per second (or 30-40 percent) common over a wide range of flows. Figure 6-4 shows a comparison of daily averaged Hills Equation flow with daily DAYFLOW estimates based on daily flow balances, which are thought to be fairly accurate. Significant overestimation

and underestimation are evident. Importantly, as far as we know, **DWR does not rely on flows from the Hills Equation for any critical operational or regulatory purpose**.

The second gate rating that was of interest to us is the one in DSM2. DSM2 used a submerged gate equation to model the forebay gates. The traditional DSM2 gate coefficient has some minor difficulty reproducing Clifton Court water levels when used with realistic gate heights. But the potential performance is hampered by overly simple modeling assumptions made concerning gate heights. For instance, in historical modeling, gates are presumed to be fully closed or open. We will demonstrate it is not possible to model water levels accurately during the sipping season under this constraint.

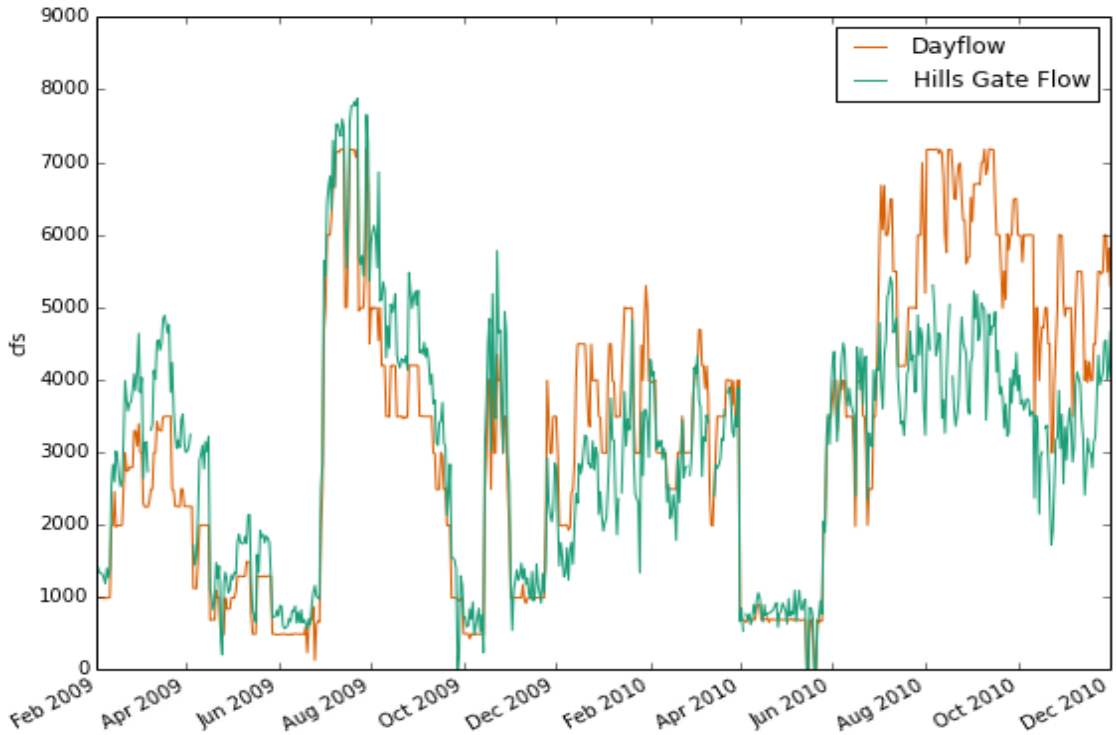

Figure 6-4 Comparison of Daily Gate Flow Calculations from DAYFLOW (SLP is Gate Inflow) with Daily Averages of Flows Reported Based on the Hills Equation

6.5 Dynamic Response to Radial Gates

The sensitivity of a model to gate ratings depends on the use to which the rating is put. A rating can be used offline to produce an estimate of flow boundary conditions. This is particularly likely to be the case for a model that includes just the Delta or just Clifton Court. Alternatively, the gate can be embedded within the model and used to dynamically couple the two sides of the gate as it is in SCHISM and DSM2.

MacWilliams and Gross (2013) studied residence time in Clifton Court using the UnTRIM model. Their study was an isolated model of the forebay using gate flows based on the Hills Equations and historical gate heights and water elevations to force the boundary. Encountering the inaccuracy of the Hills formula described in this chapter, they proposed a two-step procedure to estimate gate flows, using the Hills Equation, for disaggregation of the daily pattern of flows and daily historical CDEC values to re-scale the flows to the correct daily total volume. In principle, their technique can be used to transfer flows between the Delta and forebay, and we tried this during the calibration of the 3D model SCHISM. For us,

it turned out to be a high quality but brittle solution for long-term simulations of the coupled system. A small (e.g., 2-5 cfs) systematic discrepancy between Banks pumping and the gate flow will fill the forebay during just a few months.

When the Clifton Court gate is embedded in a model that allows water levels to respond dynamically, approximation error manifests more in the interior water level of the forebay than in the flow. Although Figure 6-1 implies persistent errors of thousands of cubic feet per second, a surplus or deficit this size is unsustainable, because it would overtop or drain the forebay within a few days. In a dynamic model, forebay water levels respond and provide the negative feedback needed to maintain stability. For instance, if inflow through the gates is overestimated, water levels go up in Clifton Court and act through the gate rating to reduce the influx. Long-term flows in such a model can be accurate and robust, matching exports. Even short-term variations in flows and water levels can be surprisingly good depending on how gate heights are approximated. Even so, water levels within the forebay drift unrealistically. We will demonstrate this phenomenon below when we consider DSM2 modeling results.

6.6 The New Rating

In selecting a formula for the gate, we considered a variety of parameterizations of varying complexity, ranging from the submerged gate equation used in DSM2 to the energy-momentum method of Clemmens (2004) and Wahl and Clemmens (2005).

The impetus for considering the energy-momentum method was the possibility that Clifton Court operates in the “partially submerged” regime. This is a region of flow that is hard to characterize with the typical (energy-only) equations due to complex tail water control from inside the reservoir. Acting on reviewer comments, MacWilliams and Gross (2013) suggested one reason for the failure of the Hills Equations under modern flows, where both sides of the gate are deeply submerged, is that they were calibrated with data almost solely in the partially submerged regime, which was common in 1988, and that is why the calibration does not extrapolate well to submerged flow, which was common in 2008. We have some doubts concerning this explanation. First, the foibles of the Hills rating extend across a wide range of flows, including ones similar to those under which it was calibrated. Second, conditions in Clifton Court are rarely partially submerged based on the usual criteria. The U.S. Army Corps of Engineers (Hydrologic Engineering Centers River Analysis System [HEC-RAS]) criterion for partial submergence is a ratio of downstream tail water to upstream head of 0.67-0.80. This ratio is rarely, if ever, satisfied at the CCFB. The sill is deep and both sides of the gate are too constrained by sea level and cavitation constraints for the depths to become very different from one another. We have surveyed several years of data, and it seems the ratio is often in the 0.85-0.95 range, which is typical of fully submerged conditions. We do not consider this matter resolved; certainly, anyone experimenting with a hypothetical scenario involving lower-than-historical water levels in the CCFB would need to reconsider the comments in Wahl and Clemmens (2005) concerning submergence.

Eventually we settled on a modified form of the submerged gate equation [1].

$$Q = nCA\sqrt{(2g)(z_{up} - z_{down})} \quad [1]$$

Where

Q is the gate flow,

n is the number of gates operating (with non-zero heights),

C is the dimensionless state-dependent gate coefficient described below,

g is gravity,

z_{up} is the stage upstream of the forebay (assessed by DFD at Clifton Court Ferry),

z_{down} is stage inside the forebay,

z_{sill} is the bottom elevation where the flow pours over, and

A is the average area of the gates in operation, based on width W, and limited from above either by the free surface or by the average height G of gates that are open, $A = \min(G, z_{up} - z_{sill})$.

As expressed above, this formulation has the same form as in DSM2. Inspired by a parameterization in Wahl (2013), we made the gate coefficient linearly dependent on the ratio of gate height to upstream depth from the sill located at -15.5 ft. NGVD (-13.2 ft. North American Vertical Datum of 1988 [NAVD])[2], [3].

$$C = d + sR \quad [2]$$

$$R = \min\left(\frac{G}{z_{up} - z_{sill}}, 1.0\right) \quad [3]$$

Where d and s are parameters.

We used linear least squares to fit the coefficient conditional on the data, excluding a small number of observations taken when the gates were in the process of lifting or closing rapidly. The standard error of the fit is 400 cfs, although the residuals seem to scale as a fraction at about 5 percent of gate flow magnitude so that higher flows have higher residuals. Since 5 percent would represent acceptable accuracy for the ADCP flows, overall the fit is roughly on par with the accuracy of the measurements used to derive it. The reported coefficient of determination, R^2, of all our fits is well over 0.95. We do not wish to publish a specific value in light of the serial correlation of the residuals and a small amount of sample dependence of the statistic.

The original formula suggested in Wahl (2004) involved a quadratic rather than a linear formula, and we had hoped including a quadratic term might improve the handling of a wide range of gate heights. We tested this hypothesis using leave-out-5 cross-validation. Even though the quadratic coefficient makes

the rating look better in most fits, cross-validation rejects the extra coefficient. The coefficients given in Table 6-1 are appropriate under a wide range of conditions.

Coefficient	Value	Comment
d	0.67	Range 0.67-0.75
s	0.67	Range 0.6 – 0.8

Table 6-1 Parameter Fits for Coefficients and Comments from Drought Modeling

Our rating does not assign individual coefficients to the five Clifton Court Gates. We felt the gates have not been operated independently in enough configurations to infer the individual character of a gate from historical data. Also, this per-gate effect would be easily conflated with that of relative location within the row of gates. For instance, Gate #2 might be on the outside of the set of open gates one day when Gate #1 is closed for maintenance, but then Gate #2 would be on the inside the next day when Gate #1 comes back online. If specific gate coefficients are assigned in the future, we hope they will be properly tested against the null hypothesis that the individual gates should be treated the same.

6.7 Synthesizing Heights

The new rating requires more access to data and more preparation. At the very least, Clifton Court gate heights are needed at fairly short time intervals, and subtidal water level variation at the outside of Clifton Court will affect results (i.e., astronomical forecasts may not represent difficult minima). Large errors in forebay water levels are introduced in planning studies when modelers assume that the gates are fully open (Priority 3), at the times when they are designated to be open.

Some approximations are possible, though. For historical periods, when explicit gate heights or Banks pumping data are not available, we have had some luck converting target gate flows to gate heights using the following method.

1. Obtain daily gate flow from DAYFLOW (SWP) or CDEC (CLC) or the planning scenario and distribute this volume evenly over the period the gate is open, which is part of the DSM2 standard inputs and usually comprises a subset of the Priority 3 period.
2. Determine a gate height, G, for all five gates by inverting this simplified rating based on gate heights only.

$$Q = aG + bG^2,$$

where $a = 1100\ \mathrm{ft}^2/\mathrm{s}$ and $\mathrm{b} = -16.8\ \mathrm{ft/s}$.

We will demonstrate the effectiveness of this synthetic gate height in section 6.8 below. So far, this formula is more accurate for historical modeling than for planning because it assumes we know the flow at the gate and how this flow is different from the daily exports. This difference is driven by strategies that are difficult to mimic for planning.

In the first half of 2015, exports were low and a new gate operation became common – operating a single gate briefly, Priority 1, (Le 2004) and at a significant height. The above formula predicts a gate height that is too small under these conditions. Imposing a minimum opening of 1-2 feet is sufficient to

stabilize the water balance. Correcting for a change in period and a single gate is expected to be more accurate, but we have not tested this assumption.

6.8 Validation through Flow Balance

Although we performed our calibration against ADCP observations, we also wanted to validate the fit using a mass balance around Clifton Court. Figure 6-5 shows the domain of our conceptual model. Exterior water levels, gate heights, and exports (SWP plus BBID) were based on observations. Interior water level is the state variable we integrated and compared with observed values. We ignored wind and evaporation.

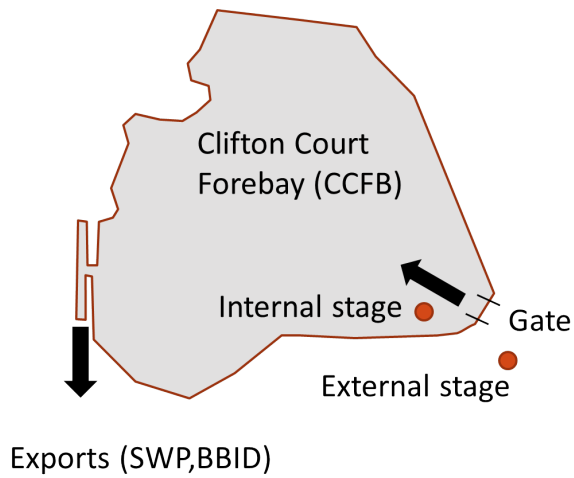

Figure 6-5 Components of Flow Balance Used to Calibrate the Gate Rating

To capture a more comprehensive set of gate operations, two periods were used for validation using this model. The first was winter 2004-2005, a period in which the gates were often fully open. The second was March-December 2008, a period where sipping was more common. Water levels and flows are shown for the 2004-2005 and 2008 periods in Figure 6-6 and Figure 6-7, respectively. Results of the water balance validation are shown in Figure 6-8 and Figure 6-9 with a shorter length zoomed view of the 2008 case in Figure 6-10. Figure 6-11 shows the forebay water level fluctuations and gate flows from the DSM2 gate rating and simple mass balance model for 2004-2005. Figure 6-12, a scatter plot, also shows the flow results from the new rating as compared to the ADCP observed data. The new rating performs well in both periods, capturing most of the trend and short-term variation in water levels. The fit is slightly high in 2008, and we noticed that this was again true when doing drought modeling in 2014 with SCHISM. This may be due to the rating, a physical factor such as evaporation, or different relative error in Banks flows at low volumes.

For the sake of comparison without the complication of model error, we also applied the DSM2 gate rating to the 2004-2005 hydrology, but using our simple mass balance model as the context rather than DSM2. The main difference is that upstream stage is pegged to historical observations without the model error from DSM2, which in this area is typically a small exaggeration of tidal range. Water levels are consistently biased downward by 1 ft. or more for large gate heights in order to coax more water through the gate (the coefficient is lower than the new fit). Other aspects of the fit, including flow through the gate, are acceptable. This result is in keeping with modeling results we will show in the next section on DSM2 experiments.

Although the ADCP fit and flow-balance based validation were two distinct exercises, the two agreed well.

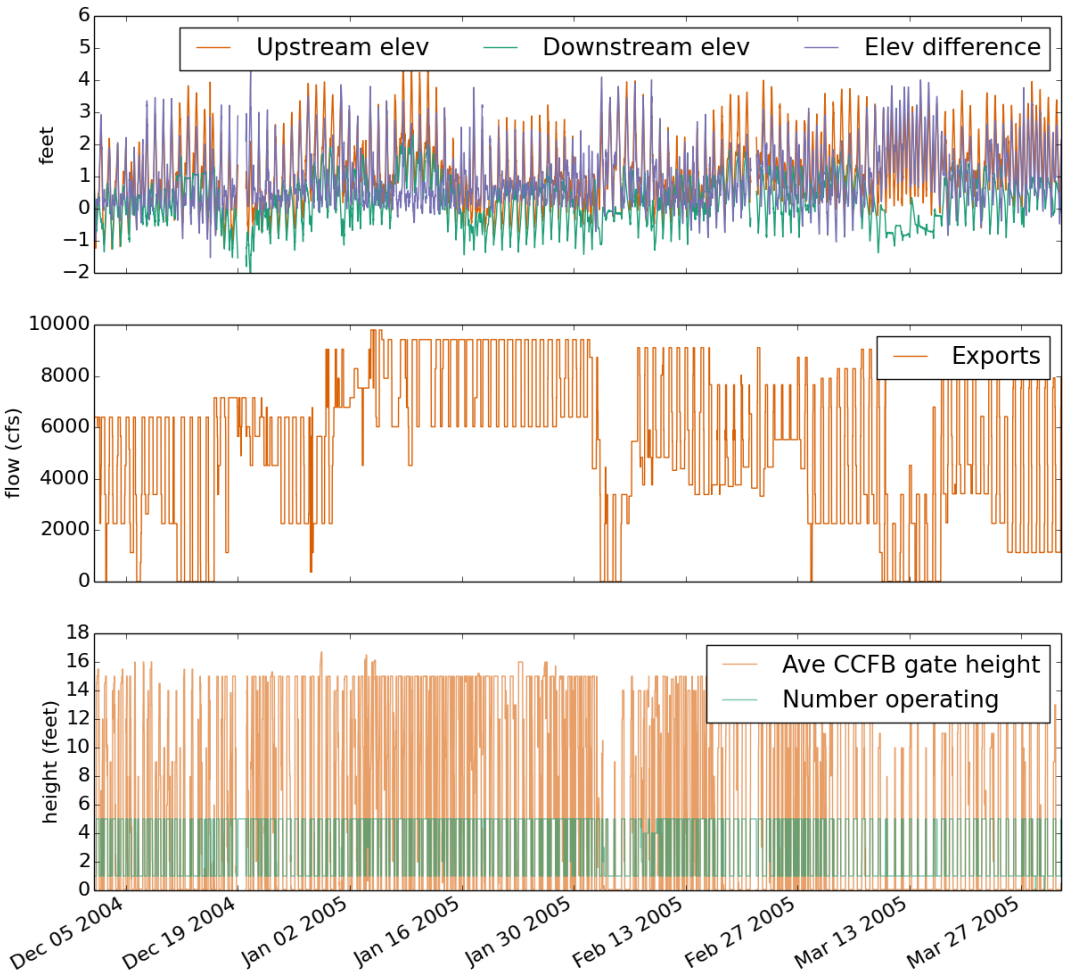

Figure 6-6 Water Levels (top), SWP Exports (middle) and Gate Heights (bottom) at Clifton Court in Winter 2004-2005

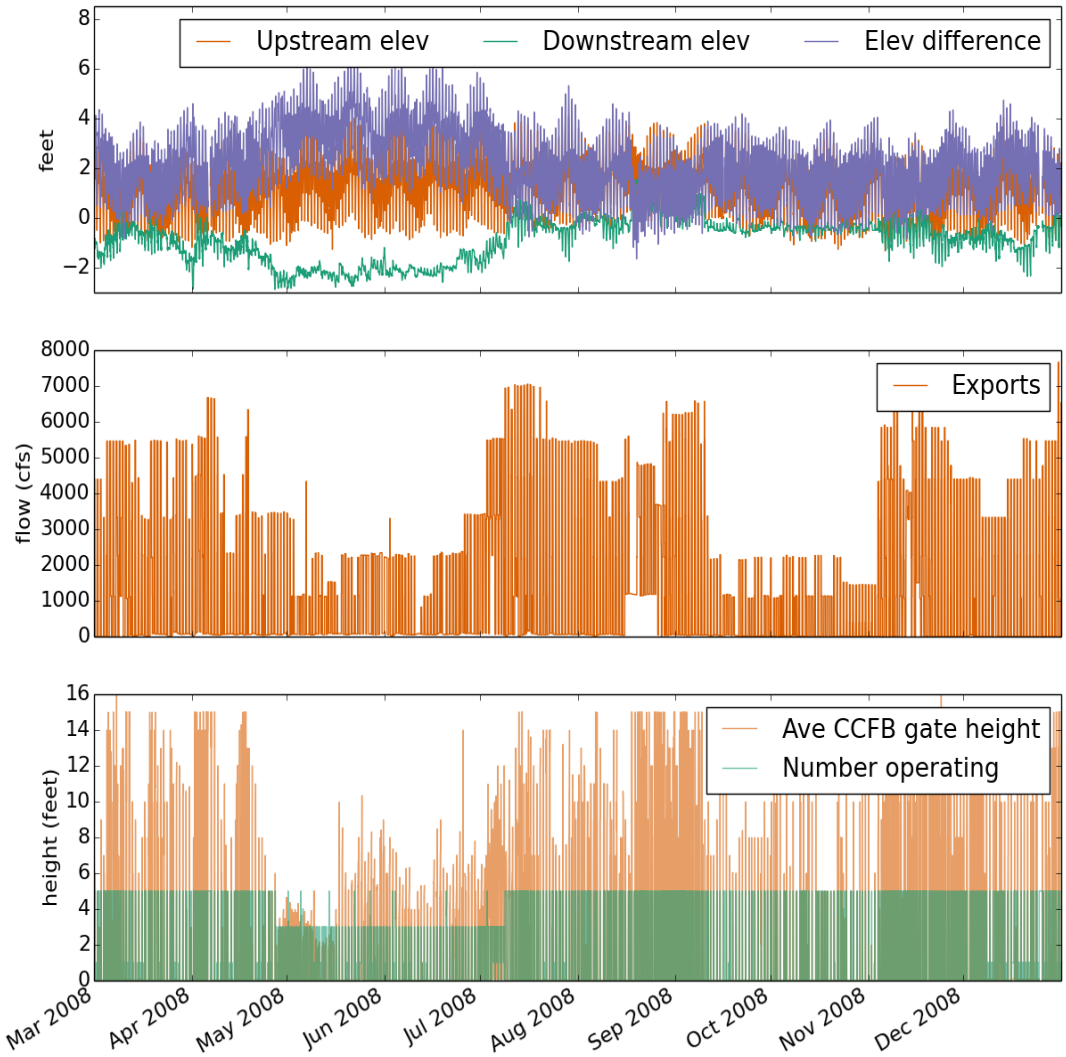

Figure 6-7 Water Levels (top), SWP Exports (middle) and Gate Heights (bottom) at Clifton Court in 2008

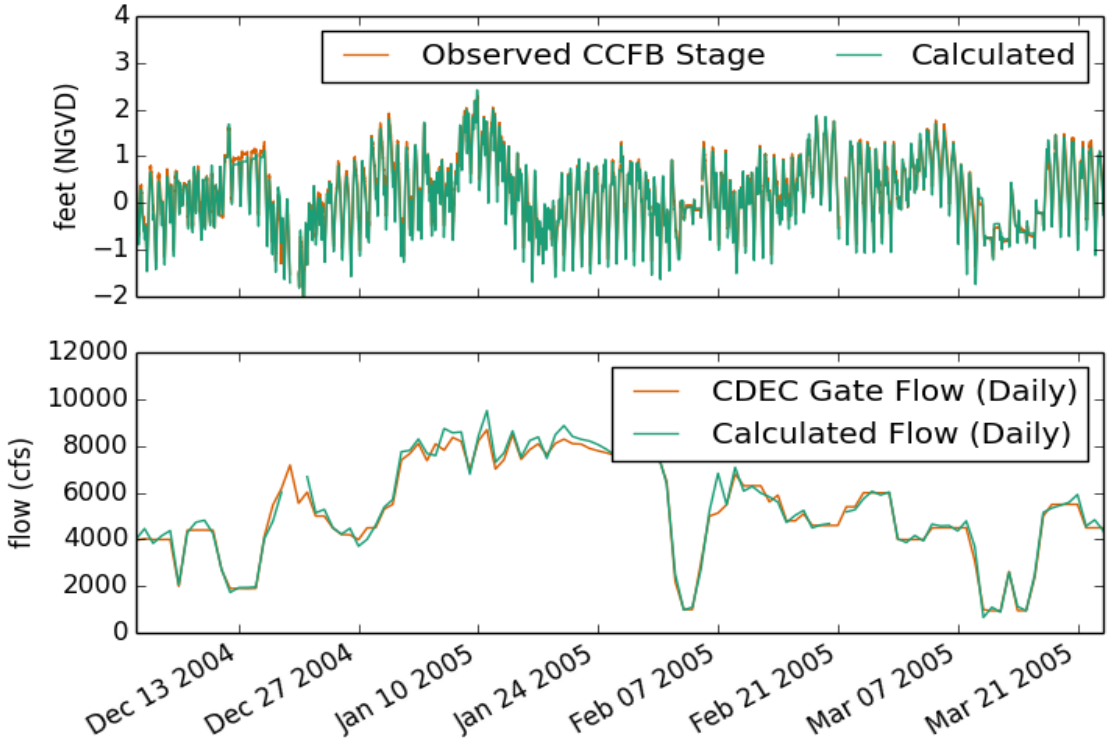

Figure 6-8 2004-5 Forebay Water Level Fluctuations and Gate Flows from the New Rating Compared with Field Data Utilizing Instantaneous Gate Height and Pumping Data and the Simple Mass Balance Model

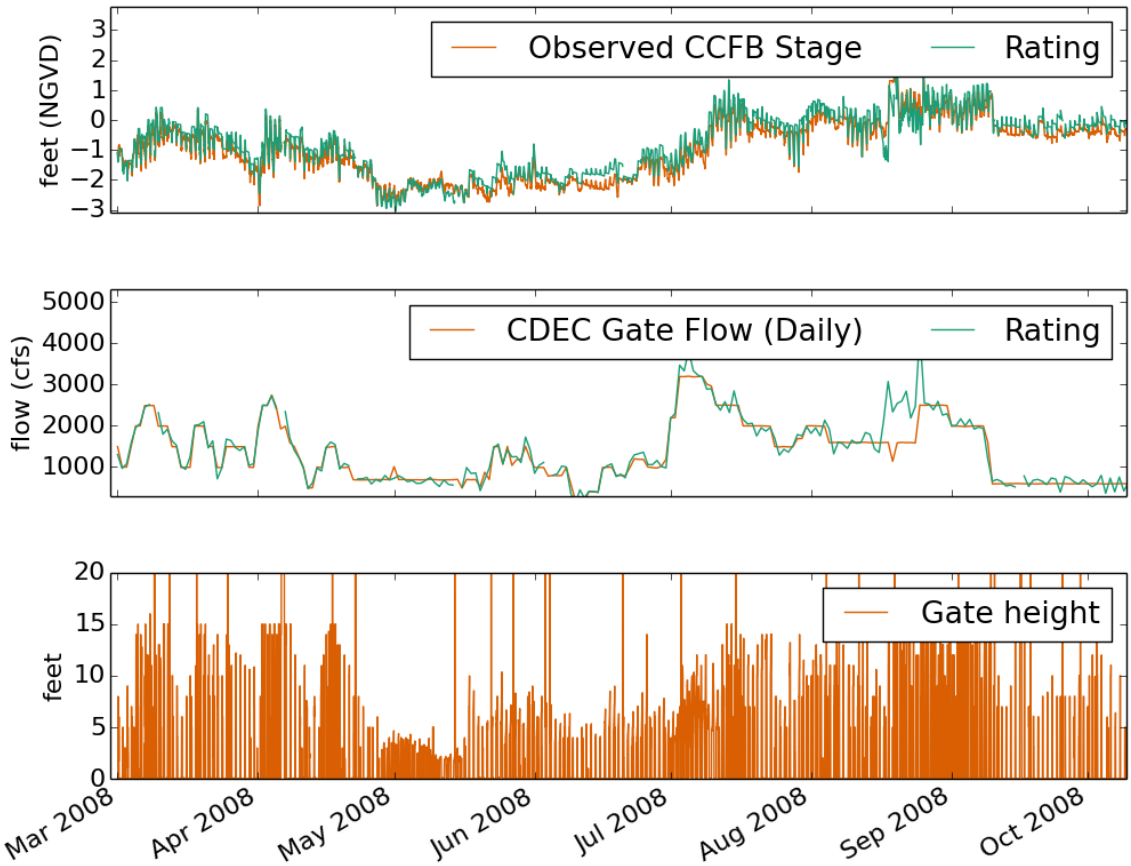

Figure 6-9 Rating Validation in 2008 Under Low Flows and "Sipping" Gate Operations, Including Clifton Court Water Levels (top), Daily Flows (middle), and Gate Heights (bottom)

Note:The slight positive bias indicates that the coefficient is slightly too high for these flows.

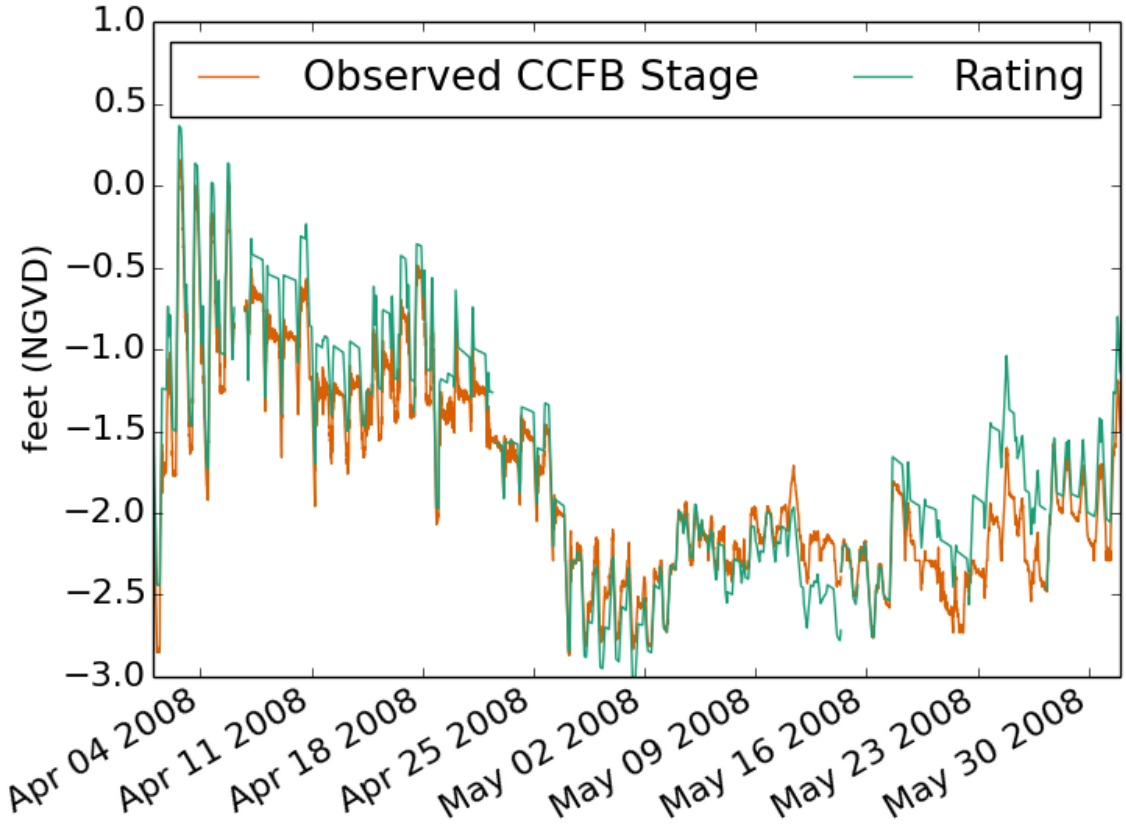

Figure 6-10 Close-up of Intratidal Water Level Fluctuations in the 2008 Mass Balance Experiment

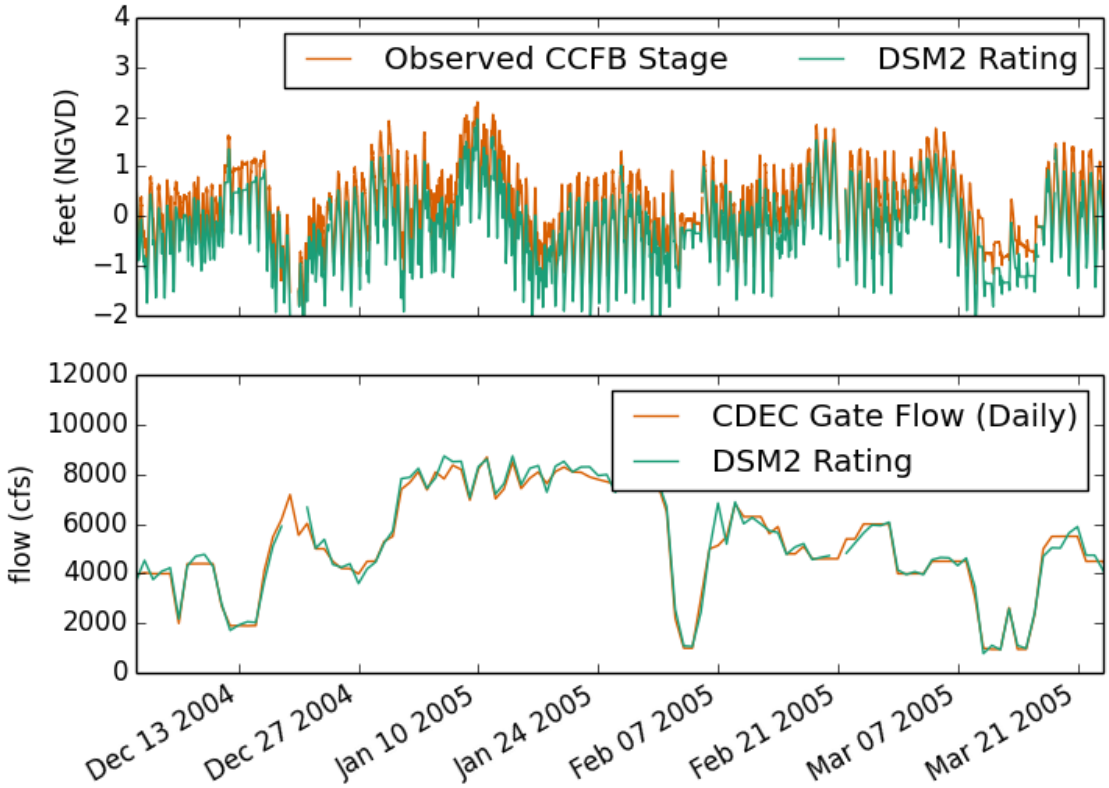

Figure 6-11 Forebay Water Level Fluctuations and Gate Flows from the DSM2 Gate Rating and Simple Mass Balance Model

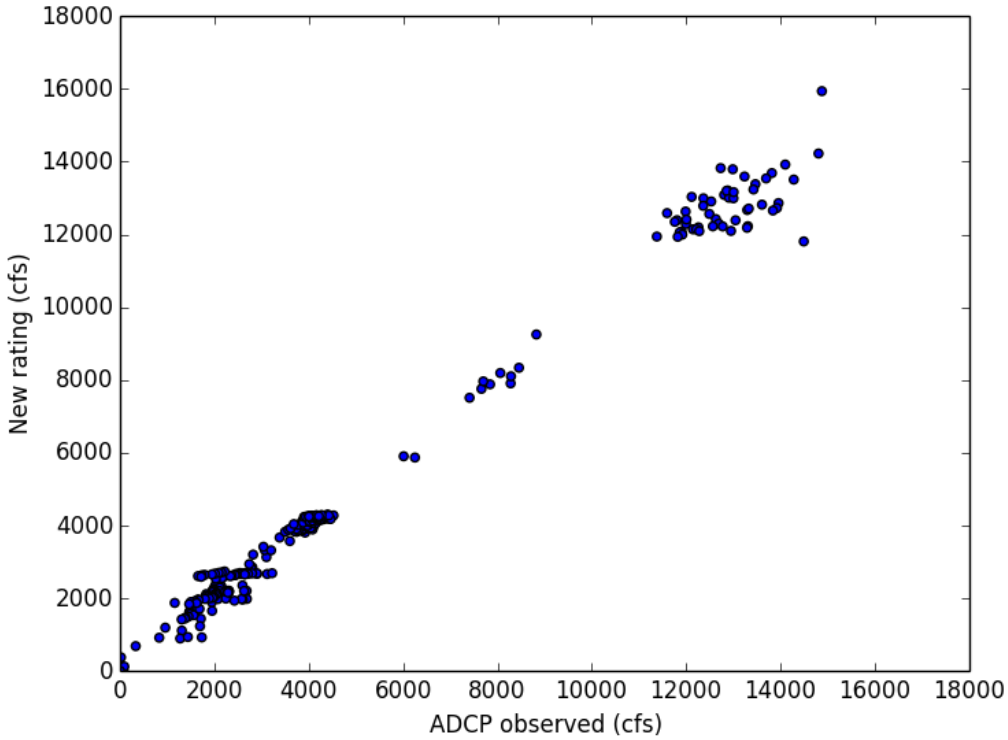

Figure 6-12 Fitted Versus Observed Values for the ADCP Data

6.9 DSM2 Experiments with Full and Limited Data

The gate rating presented here is sufficiently accurate and appears to be robust when tested in isolation. Typical errors in flow for the rating are 5-10 percent, and any tendency for Clifton Court water levels to wander appears to be self-correcting.

This section adds the additional complication of a model. We show how the gate formulation interacts with the DSM2 model. Since the costs of preparation are not insignificant, we sought also to confirm how important this might be on dynamics throughout the South Delta, and to see how important fine time scale data is to the modeling of the region.

6.10 Old versus New Rating

Our main experiment is intended to isolate the performance of the new rating while holding data granularity the same. The cases all use instantaneous Banks pumping and gate height data. The two cases are:

R1: DSM2 original rating.

R2: New rating.

Figure 6-13 shows the water level and flow results for both ratings, with interior water levels compared with observations. During May, the old rating has a clear bias, and we note that it is in a different direction than Figure 6-9, which is common during sipping operations. Figure 6-14 shows the corresponding water quality results. Although residence time is probably affected significantly by the change in water levels, the effect on concentration is negligible. The same is true for Old River stage at

Tracy Road Bridge (Figure 6-15). Clearly, Clifton Court water levels are the only DSM2 variable affected by the change.

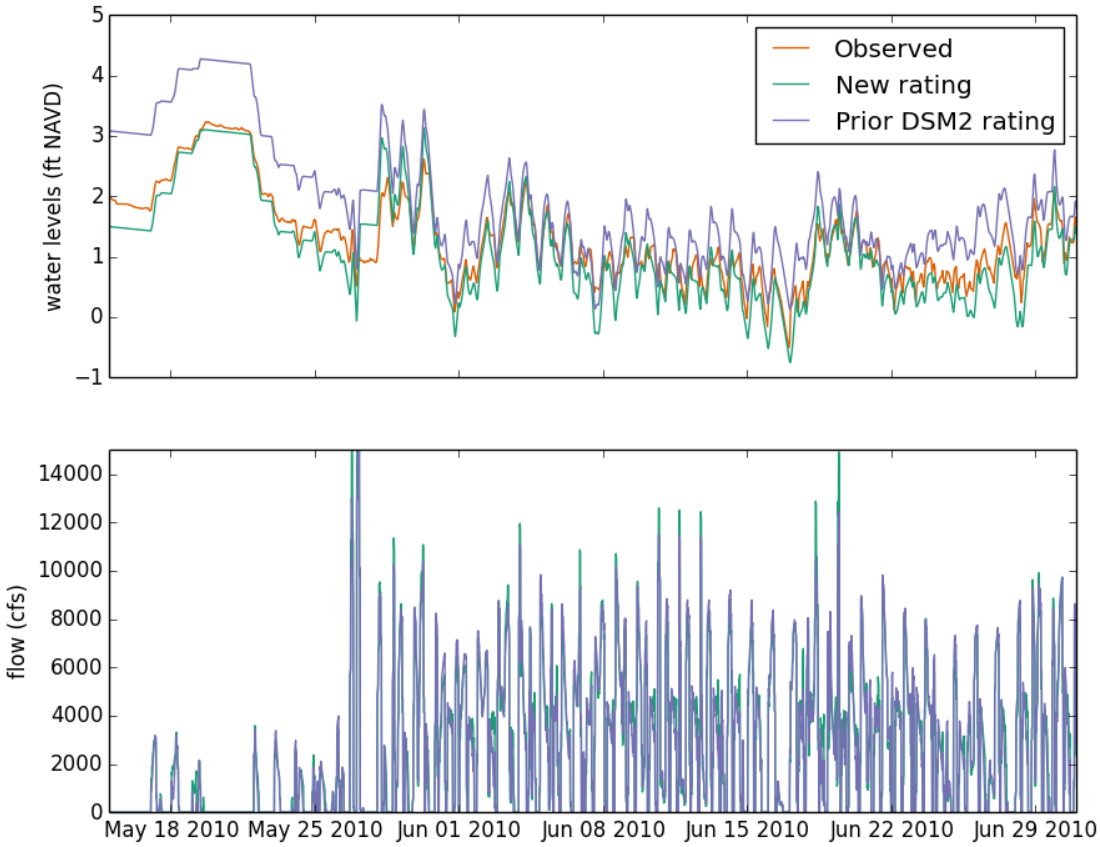

Figure 6-13 Water Level and Flow Results for DSM2 Experiment with Old (R1) and New (R2) Rating

Figure 6-14 Clifton Court Electrical Conductivity (EC) under Old and New Ratings with Instantaneous Gate and Pumping Data

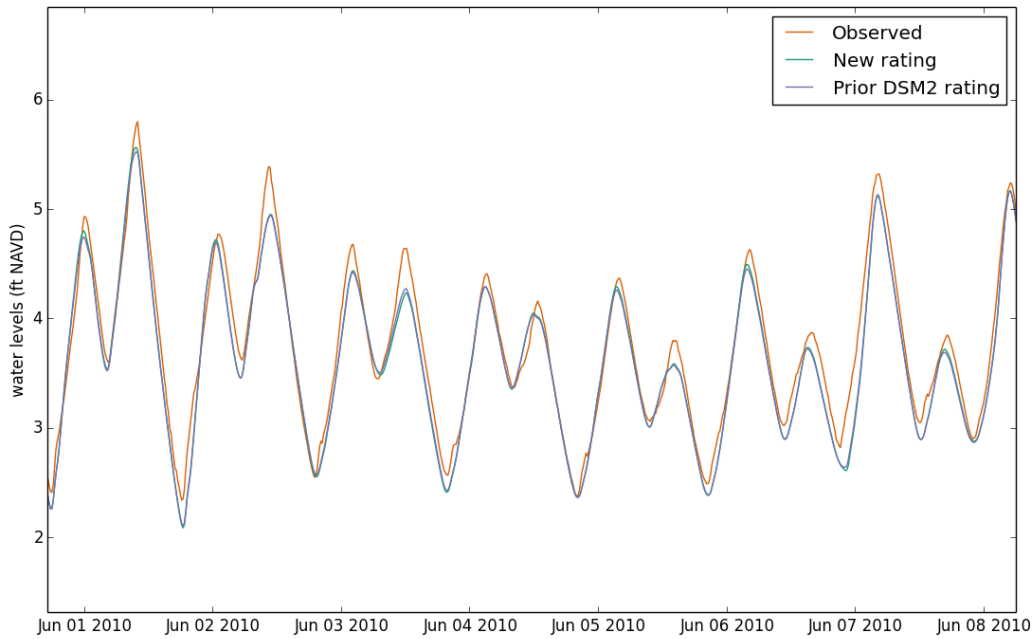

Figure 6-15 Old River at Tracy Bridge Water Levels Under Old and New Ratings with Instantaneous Gate and Pumping Data

6.11 Data Granularity

Our second group of experiments isolates the effect of holding data granularity constant while holding the new rating fixed. Variations we attempted are as follows.

C1 (Planning Priority 3): Gates are assumed to be fully open or closed over full possible Priority 3 period.

C2 (DSM2 historical): Gates are assumed to be fully open or closed. Timing is historical and instantaneous.

C3: Gate heights are synthesized from daily gate allotment (section 6.7, "Synthesizing Heights").

C4: Instantaneous gate heights (10 minutes or less, except during filled gaps).

Results are shown in Figures 6-16, 6-17, and 6-18. The most striking water level results are in Figure 6-16 and show that the water levels for the Priority 3 case (C1) are very high and unfortunately represent the practice in planning DSM2 runs. The 2 ft. errors shown in the figure are not exceptional. In the next section we will show errors as significant as 5 feet. The higher interior water levels occur because of the feedback mechanism we noted before; the reservoir fills up to compensate for the exaggerated high gate heights. Flows are somewhat disorganized and incorrectly timed, though on average, of course, they match exports.

Figure 6-17 shows Electrical Conductivity (EC) for the different quality and granularity of gate height data. EC results are similar except in June 2009 and April 2010. Figure 6-18 shows the water level impacts of the gate height data on a location upstream at Old River and Tracy Road Bridge.

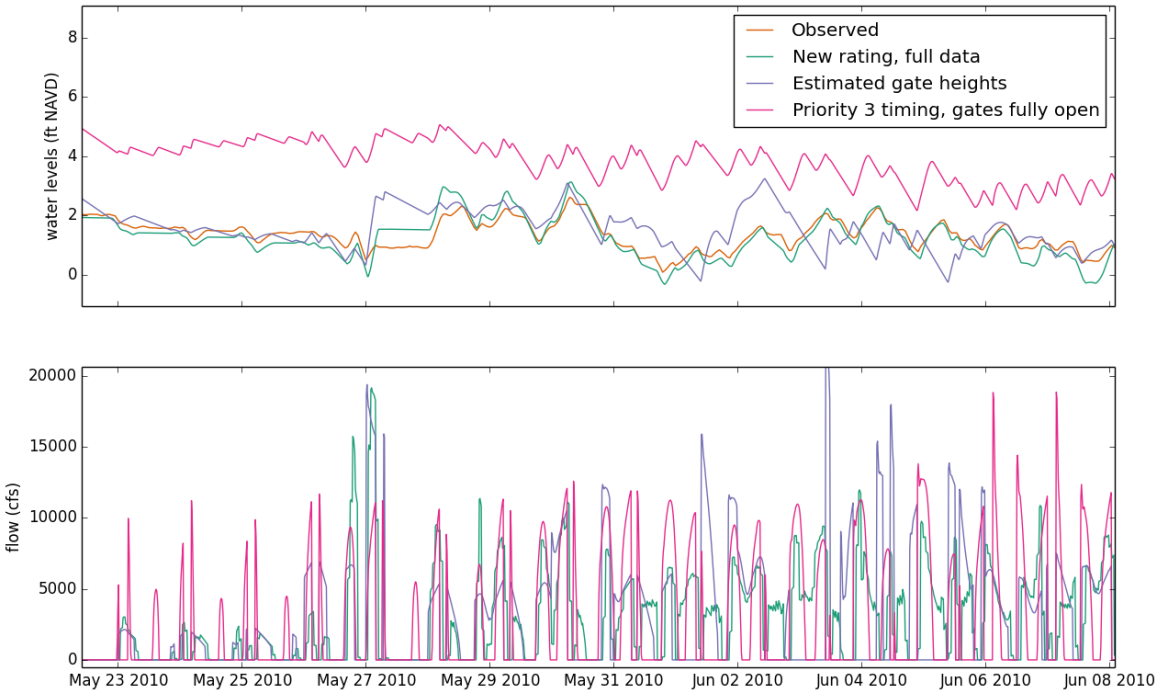

Figure 6-16 Clifton Court Water Elevations with Different Quality and Granularity of Gate Height Data

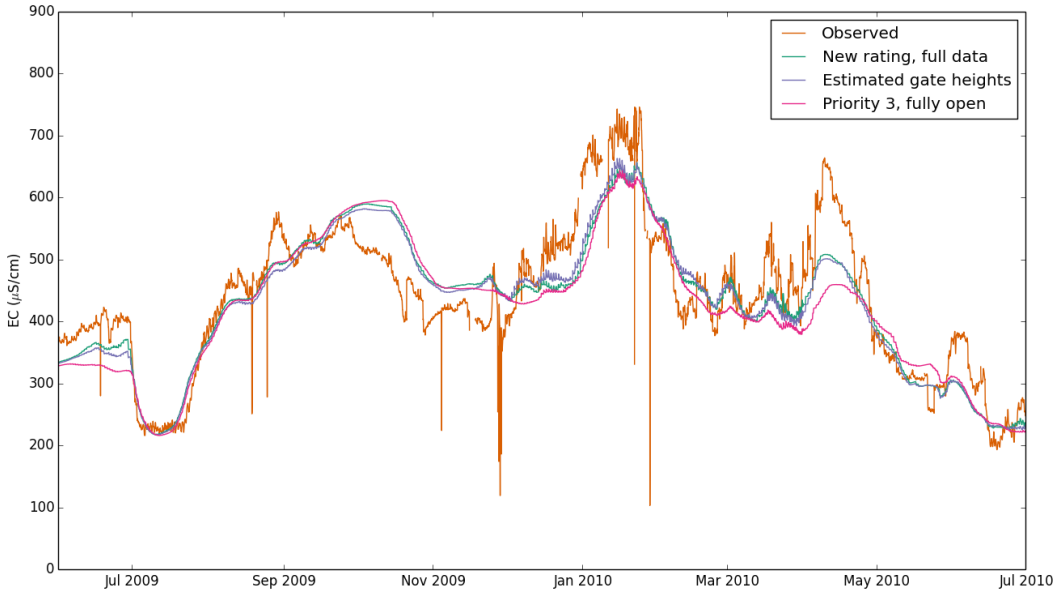

Figure 6-17 Clifton Court EC with Different Quality and Granularity of Gate Height Data

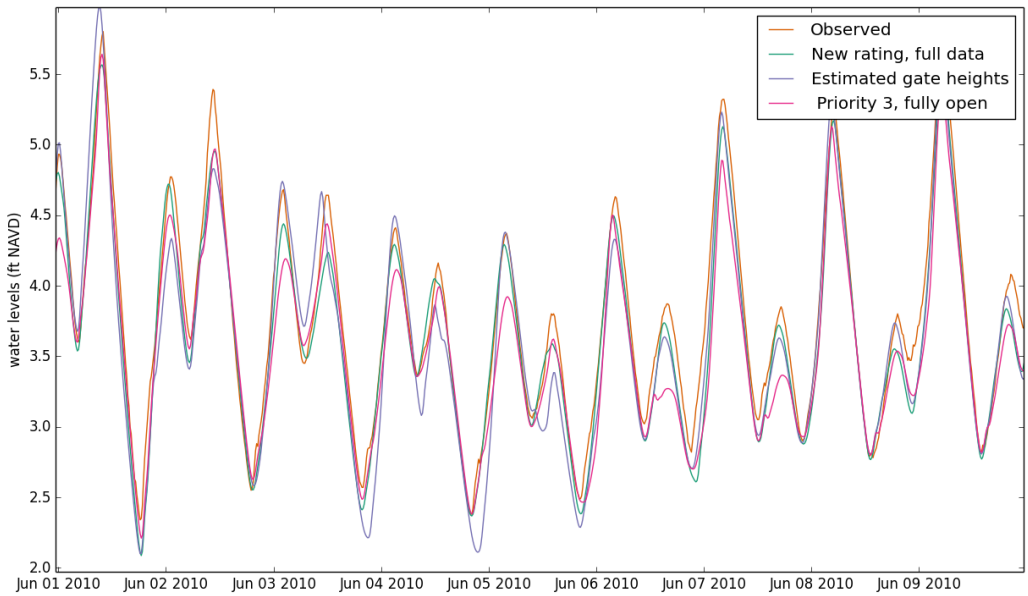

Figure 6-18 Old River at Tracy Bridge Water Elevations with Different Quality and Granularity of Gate Height Data

6.12 Banks Data Granularity

We tested the granularity of Banks (SWP) pumping data using the new rating and instantaneous gate heights:

B1: Banks pumping data is available instantaneously.

B2: Daily Banks pumping data.

Results for these two cases are shown in Figure 6-19. Our impression looking over years of data is that, in general, detailed Banks pumping information is only sporadically helpful in modeling with DSM2. This is a fortunate result in that detailed Banks pumping data is very inconvenient to acquire compared with other measurements. For detailed circulation near the pumps with SCHISM or another 3D model, such as UnTRIM, pumping would be required in more detail, of course.

6.13 Gate Timing: Scheduled Priority 3 versus Historical

In a planning run, gates are often held open for the entire Priority 3 period, whereas in the field, gates are closed as soon as the day's allotment is achieved. Using the original DSM2 rating and fully open gates, we looked at what difference this makes in water levels. The result is shown in Figure 6-20. Both answers are erratic, with maximum errors of water surface up to 5 feet. This is true of all the cases with the gates raised fully open. The historical timing does not seem to be beneficial. The result with historical timing seems to be almost exactly the same most of the time with huge unrealistic swings. One reason the historical timing might not be helpful is that it is supposed to represent fulfillment of the day's allotment. When the gate is fully open, that fulfillment is probably achieved much earlier than in the field and so the historical timing no longer satisfies this interpretation.

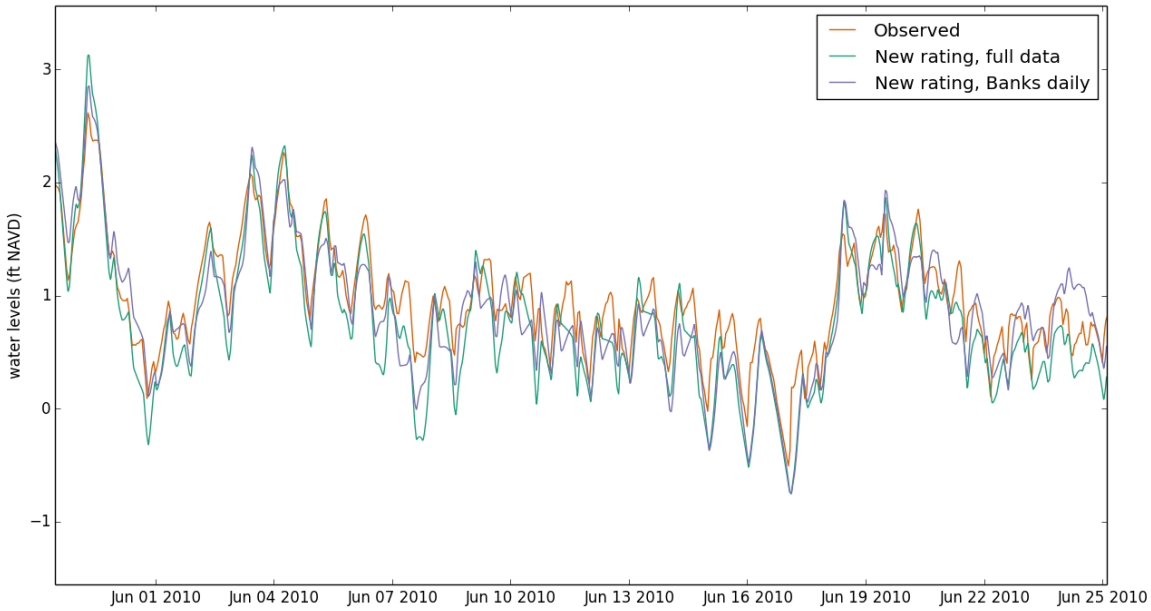

Figure 6-19 Clifton Court Water Levels with New Rating, Instantaneous Gate Heights and Two Granularities of Banks Pumping Data, Instantaneous (full) and Daily

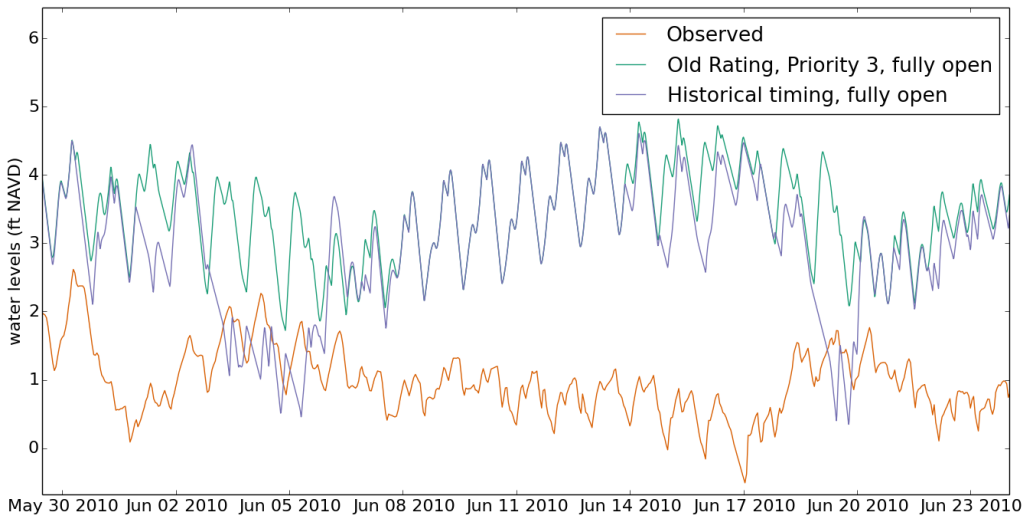

Figure 6-20 Comparison of Scheduled Timing and Actual Historical Gate Timing using DSM2 with the Prior Rating and Gates Treated as Always Open/Closed

6.14 Conclusion

The authors have calibrated a rating that we believe can be successfully applied in operational scheduling and modeling applications. The new rating has a standard error of 400 cfs, or 5 percent, under a fairly wide variety of conditions, and this accuracy can be re-evaluated in a few years as the new Clifton Court intake flow station comes online. Accuracy is much better than the rating curve currently on hand at DFD, and it is somewhat better than the one in DSM2. The new rating is being offered as part of a revised version of DSM2, and is part of the standard package for the 3D Bay-Delta SCHISM model.

Model practices may be at least as important as the rating. Modelers often treat the Clifton Court gates as always being open or closed, and this assumption is enough to cause a large bias in water level results inside the forebay regardless of which gate equation is used. Since the increase in water levels can cause a 30-50 percent change in depth, this would also affect residence time. Furthermore, in the SCHISM model, it changes estimates of local velocity. Most other variables are very robust, including exterior stage and water quality on both sides of the gate.

Modelers often have to proceed with imperfect information when modeling the forebay. Detailed time series of Banks pumping and gate heights are not available for many periods and in planning scenarios. Daily time series are the norm for pumping and timing-without-heights is the norm for gate operations. For most DSM2 applications, gate heights are the component that is really crucial. Given a daily gate flow/allotment and Priority 3 timing, we have provided a formula for estimating gate height that requires no detailed tidal information and reduces most of the objectionable error in water levels. Detailed Banks pumping data is of secondary importance. Instantaneous pumping is required for 2D model or 3D model calculations near pumps or for assessing circulation in the forebay. Consequently, it is not required to produce gross residence time for the forebay or for 1D model studies where focus is on the South Delta or points downstream.

6.15 References

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