

Using Daily Electrical Conductivity (EC) Data for Evaluating Delta Outflow and Seawater Intrusion



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View from Mt Diablo looking north
towards the confluence of the
Sacramento and San Joaquin Rivers

Goal: Show potential value of a curated, publicly available dataset with displays of data on a daily time increment by providing an example related to seawater intrusion.

- Will consider interrelationship between Delta outflow, measurements of EC and X2, and equations for EC and X2 (X2 is the distance in river km from the Golden Gate to 2 ppt bottom Salinity)
- Value of daily data displays is to allow visualization of interrelationships between parameters to inform modeling, calculation, or statistical evaluations
- Based on past work, not meant to represent most recent work on this topic

DAYFLOW – a great example of a useful daily dataset, 2 parameters pertinent to this discussion

- Net Delta Outflow Estimate (QOUT) calculated from water budget
- Estimated X2

In Dayflow, X2 is estimated using the Autoregressive Lag Model:

$$X2(t) = 10.16 + 0.945 \cdot X2(t-1) - 1.487 \log(QOUT(t))$$

where

⇒ t = current day

⇒ t-1 = previous day

The relationship between X2 and Delta outflow can be used to translate X2 regulatory values to an outflow requirement. Delta outflow corresponding to X2 can be estimated using the inverse of the steady-state version the DAYFLOW equation. If X2 is not changing, X2 will equal the X2 of the previous day. The steady-state X2 equation can be rearranged to calculate the steady outflow corresponding to a measured or required X2:

1) $X2(\text{day}) = 10.16 + 0.945 * X2(\text{day-1}) - 1.487 * \log [\text{Outflow (cfs)}]$

2) $\text{Steady-state } X2 = 185 - 27 * \log [\text{Outflow (cfs)}]$

3) $\text{Steady Outflow (cfs)} = 10 ^ { [185 - X2 (\text{km})]/27}$

Effective or antecedent outflow (G) as described by CCWD:

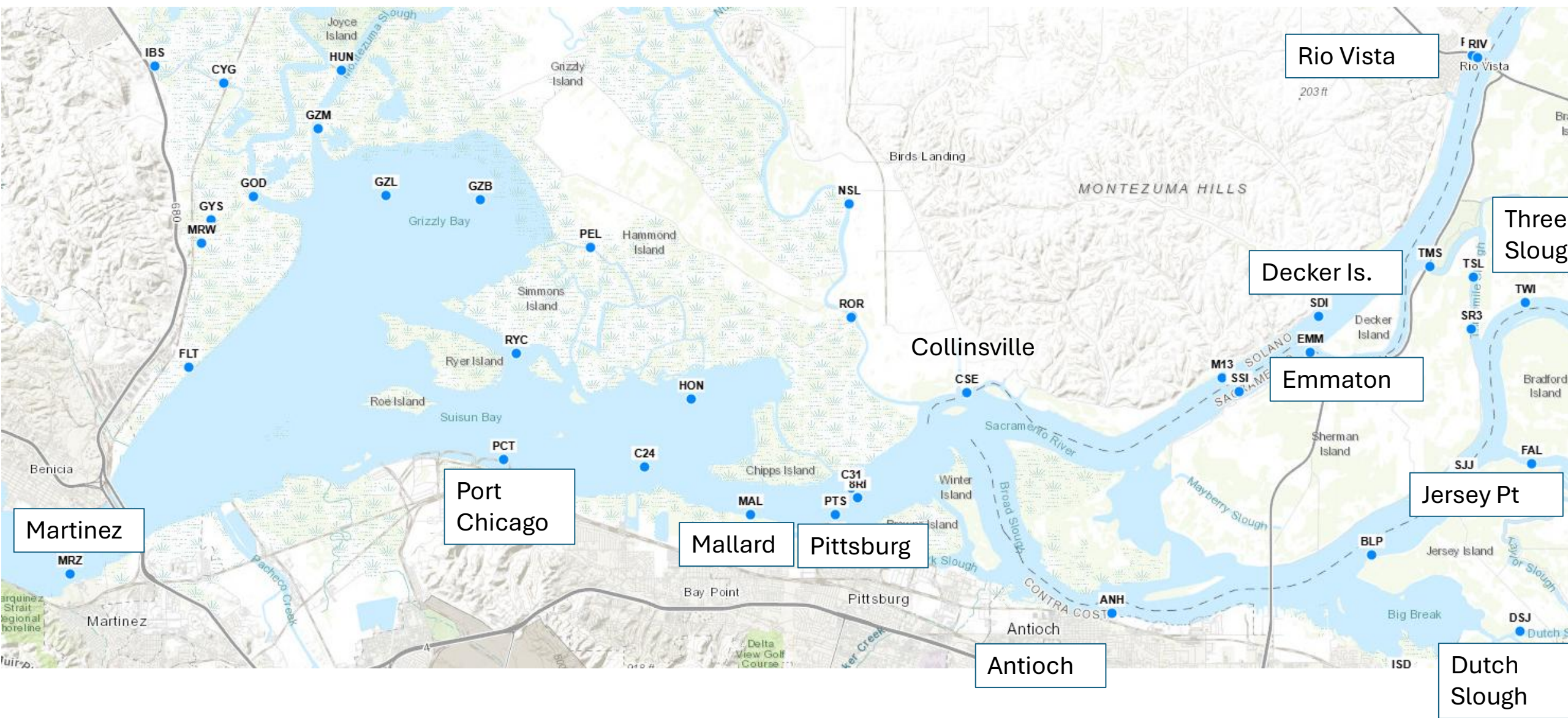
Effective outflow (G) equation:

$$G_d = \text{Outflow} / [1 + (\text{Outflow} / G_{d-1} - 1) * \exp (-\text{Outflow} / B)]$$

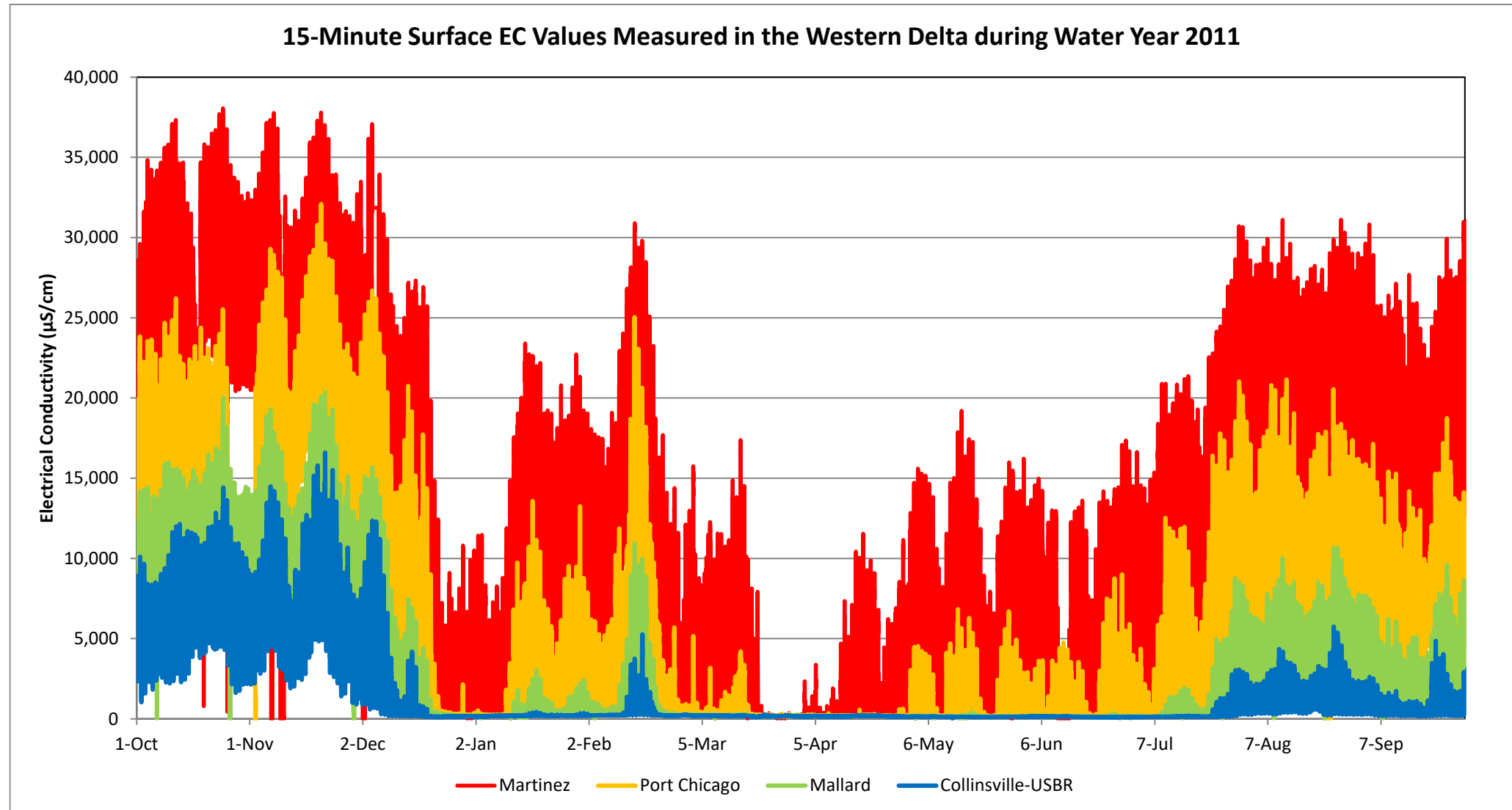
Accounts for past Delta outflow conditions that affect current EC values. Can be used in equation 2 to estimate current X2 and can be estimated by inserting an accurate X2 value into equation 3.

Other useful data for evaluating seawater intrusion

- EC top and bottom measurements for Martinez, Port Chicago, Mallard Island, Pittsburg, Collinsville, Antioch, Emmaton, Jersey Point, Decker Island, and Rio Vista
- USGS flow, stage, and velocity data for Rio Vista, Jersey Point, Dutch Slough, and Three Mile Slough
- And more – USGS monthly water quality boat survey

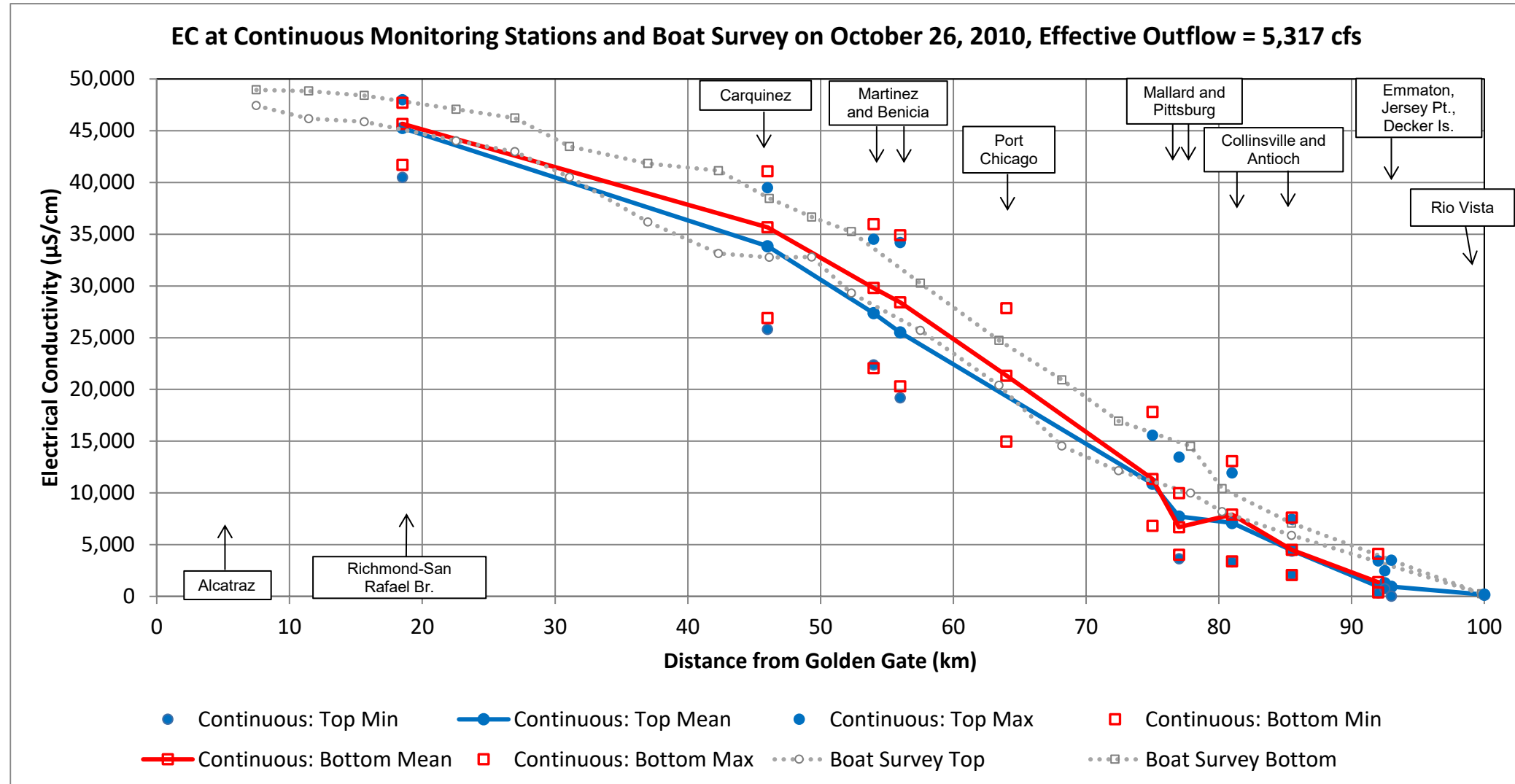


15-Minute or Hourly Data - how to integrate in daily data set (e.g., tidal excursion and min, mean, max of EC, flow, stage, velocity)

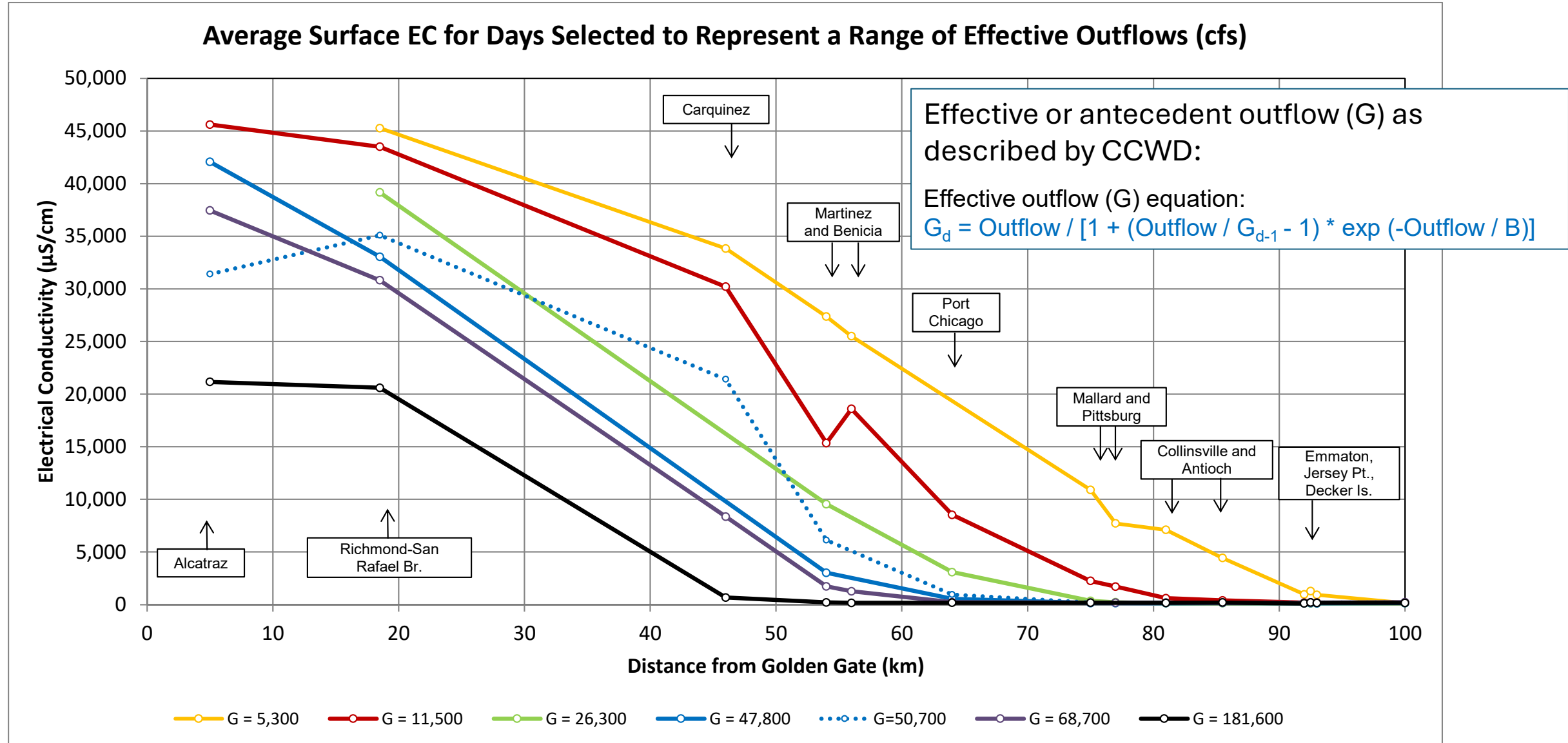


Integration of Data for One Day

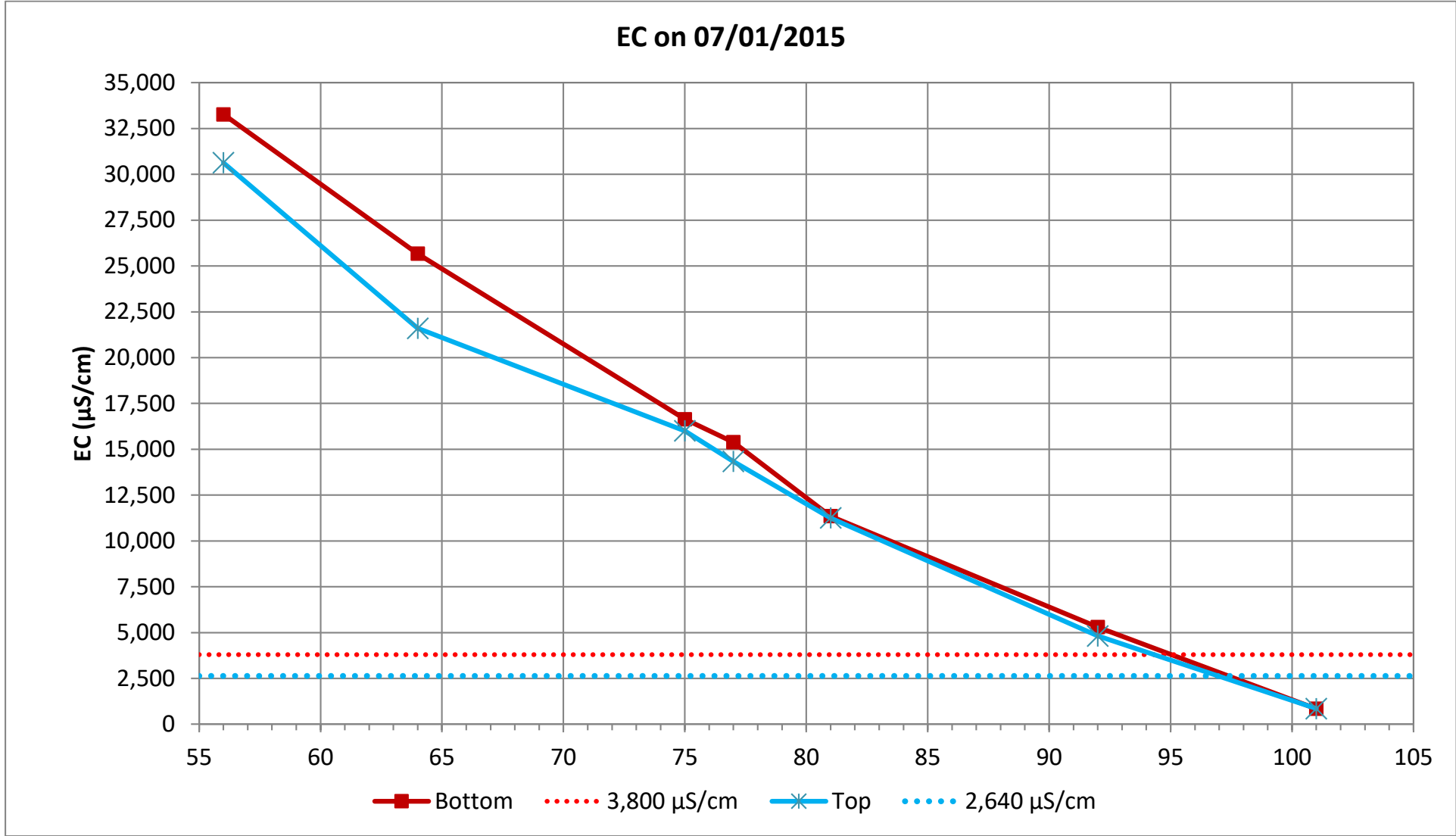
The daily range of EC values at a location is much greater than the vertical EC stratification.



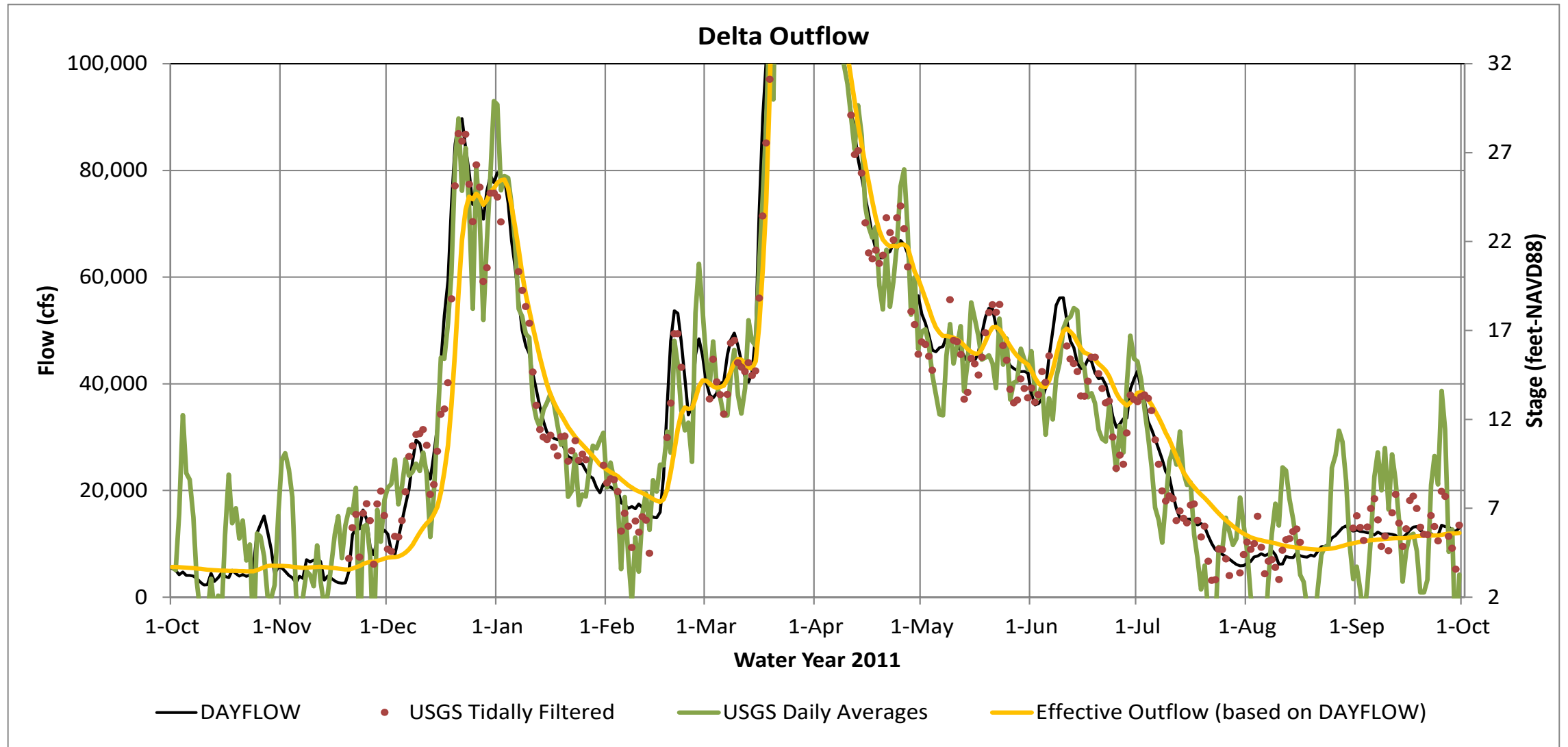
The salinity wedge is pushed downstream by higher outflow, but the salinity gradient remains less than 1,000 $\mu\text{S}/\text{cm}$ per kilometer.



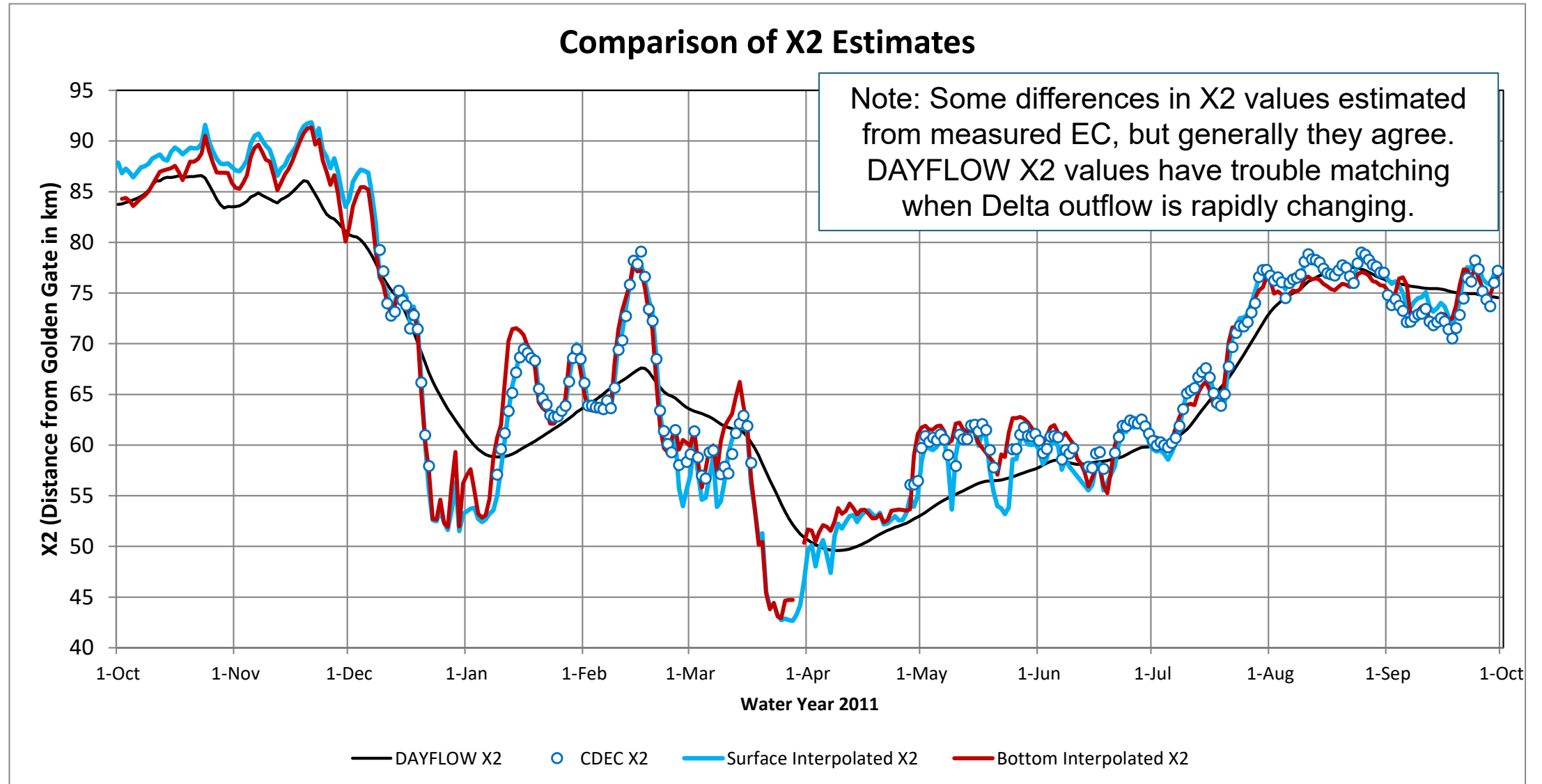
X2 can be interpolated from the bottom EC (3,800 $\mu\text{S}/\text{cm}$) or surface EC (assumed EC of 2,640 $\mu\text{S}/\text{cm}$)
The “measured” value may depend on the approach



DAYFLOW and USGS outflow estimates generally agree for WY 2011

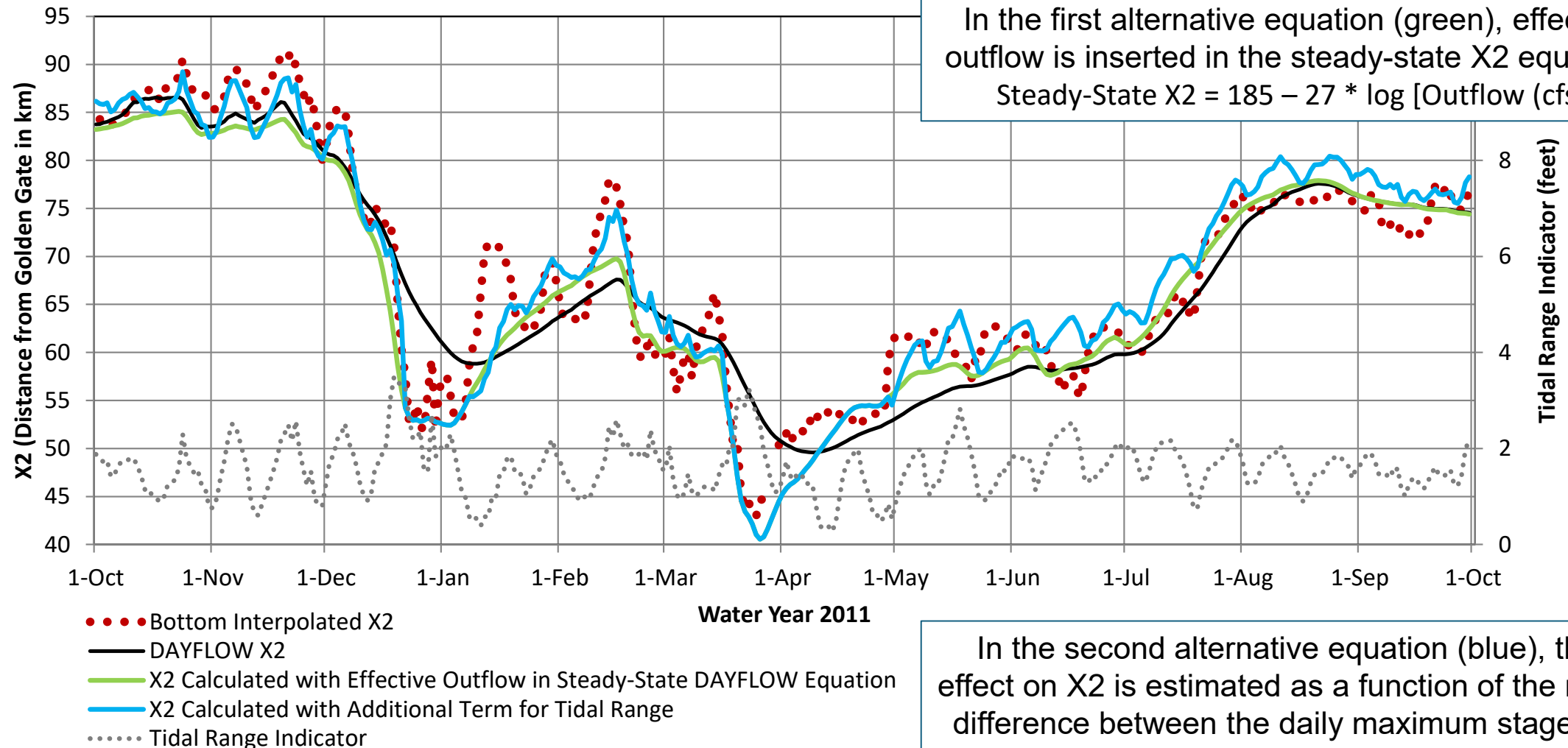


Viewing daily data can help improve calculations

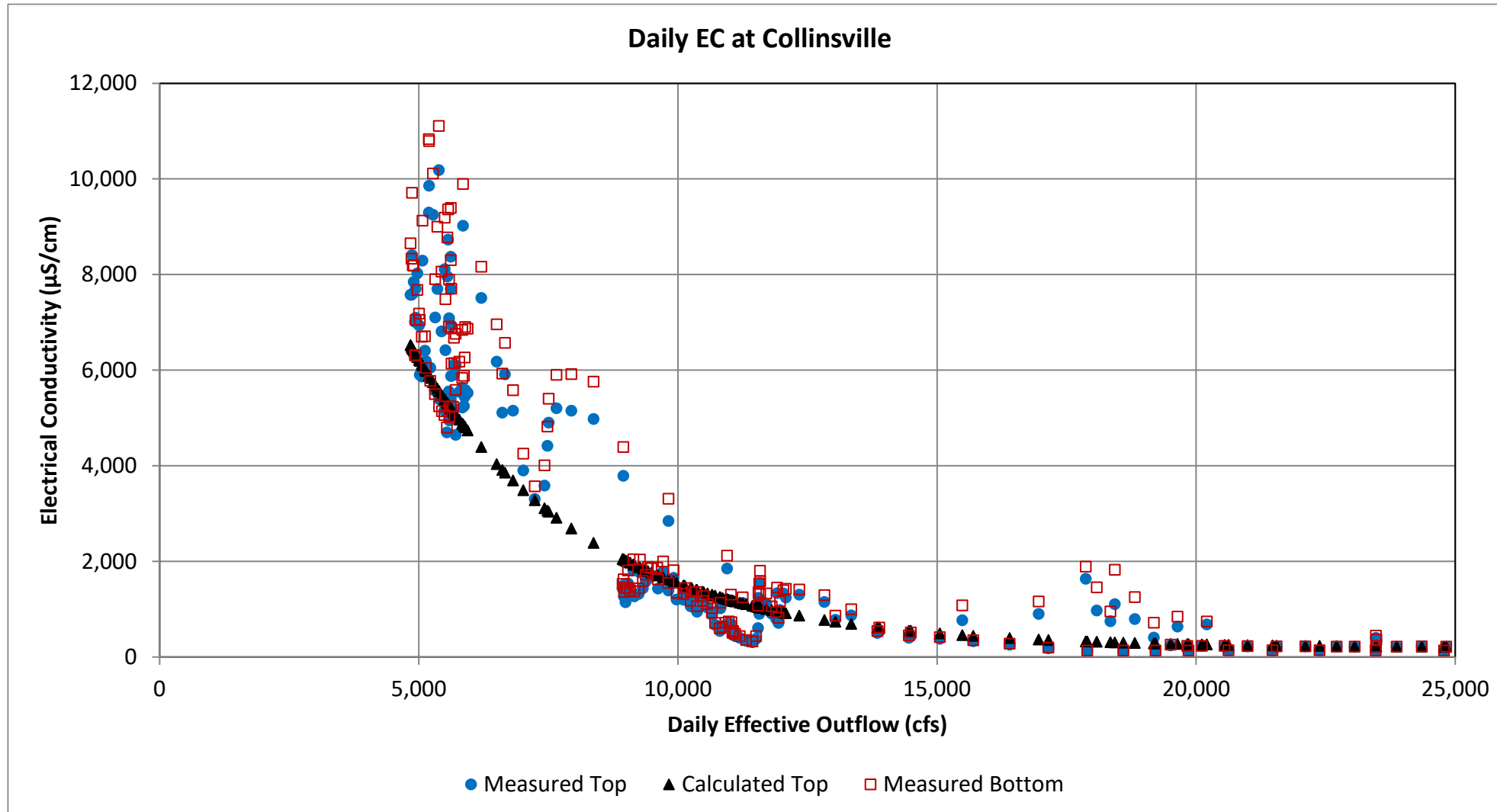


Two Alternative Equations Provide Better Performance at Estimating X2 during 2011

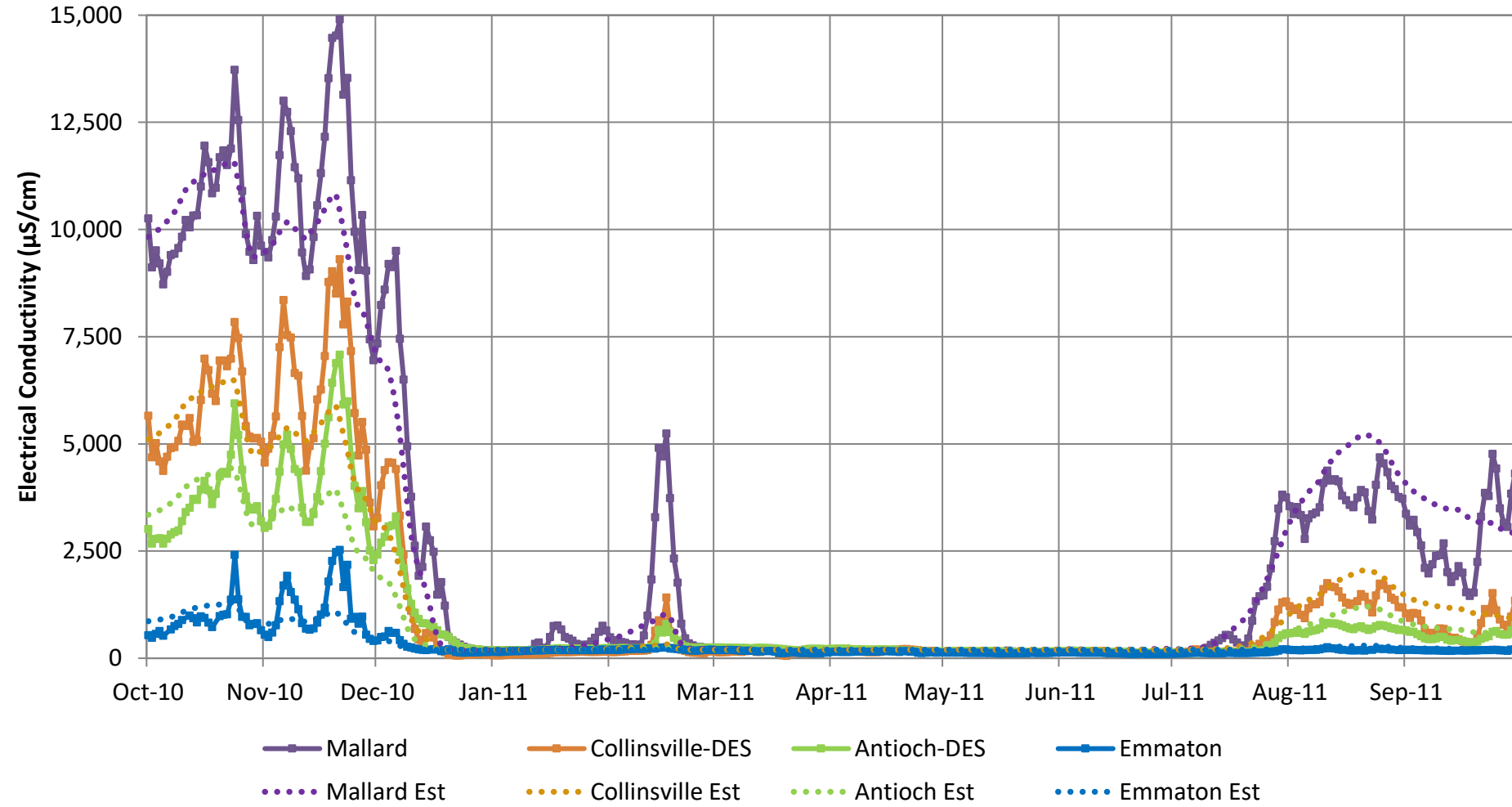
More Comparisons of X2 Estimates



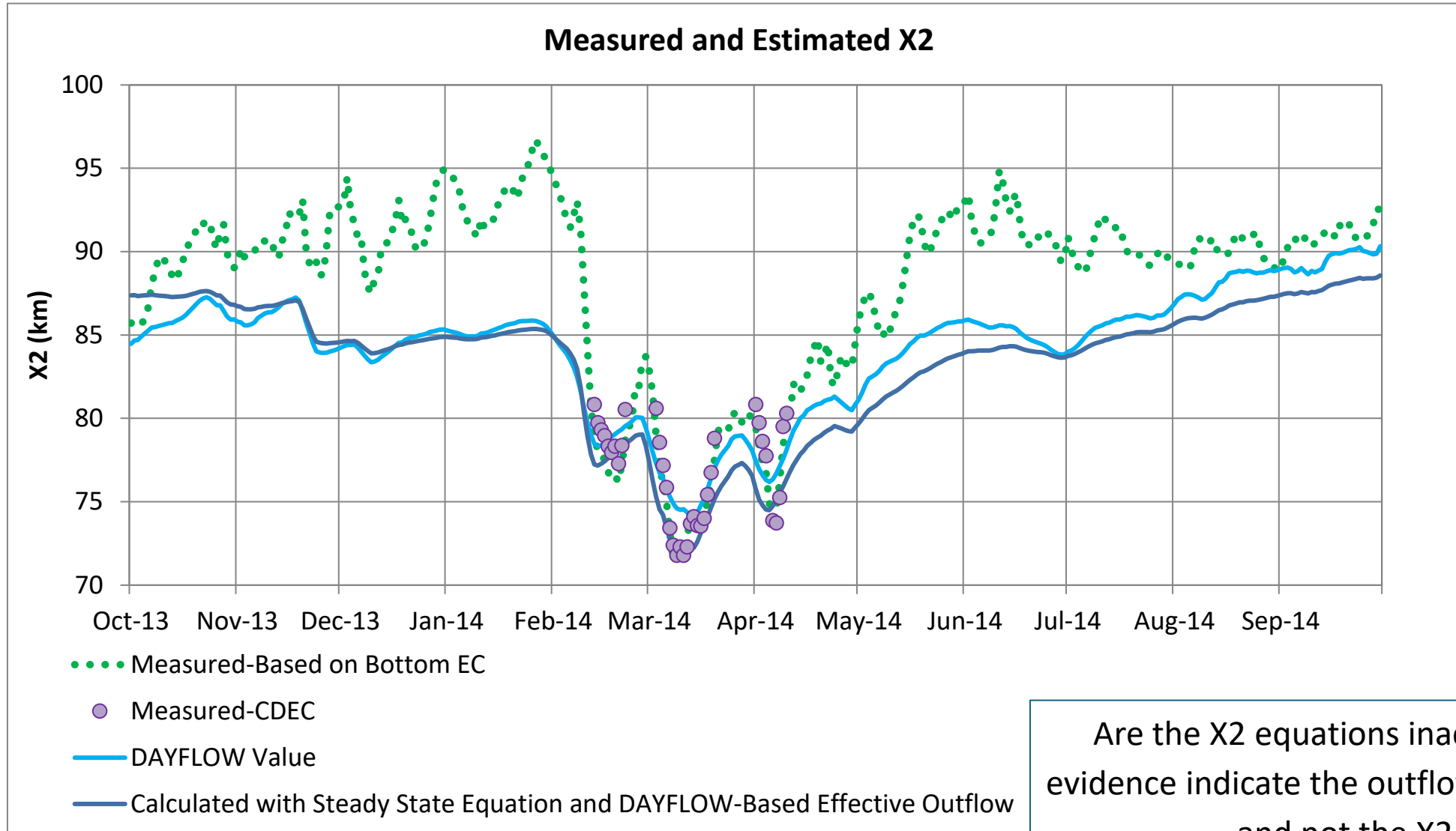
Effective outflow (G) was used to estimate the daily surface EC at 15 monitoring locations using negative exponential equations of the form:

$$EC = EC_{min} + EC_{max} * \exp(-coeff * G)$$


Western Delta Surface EC

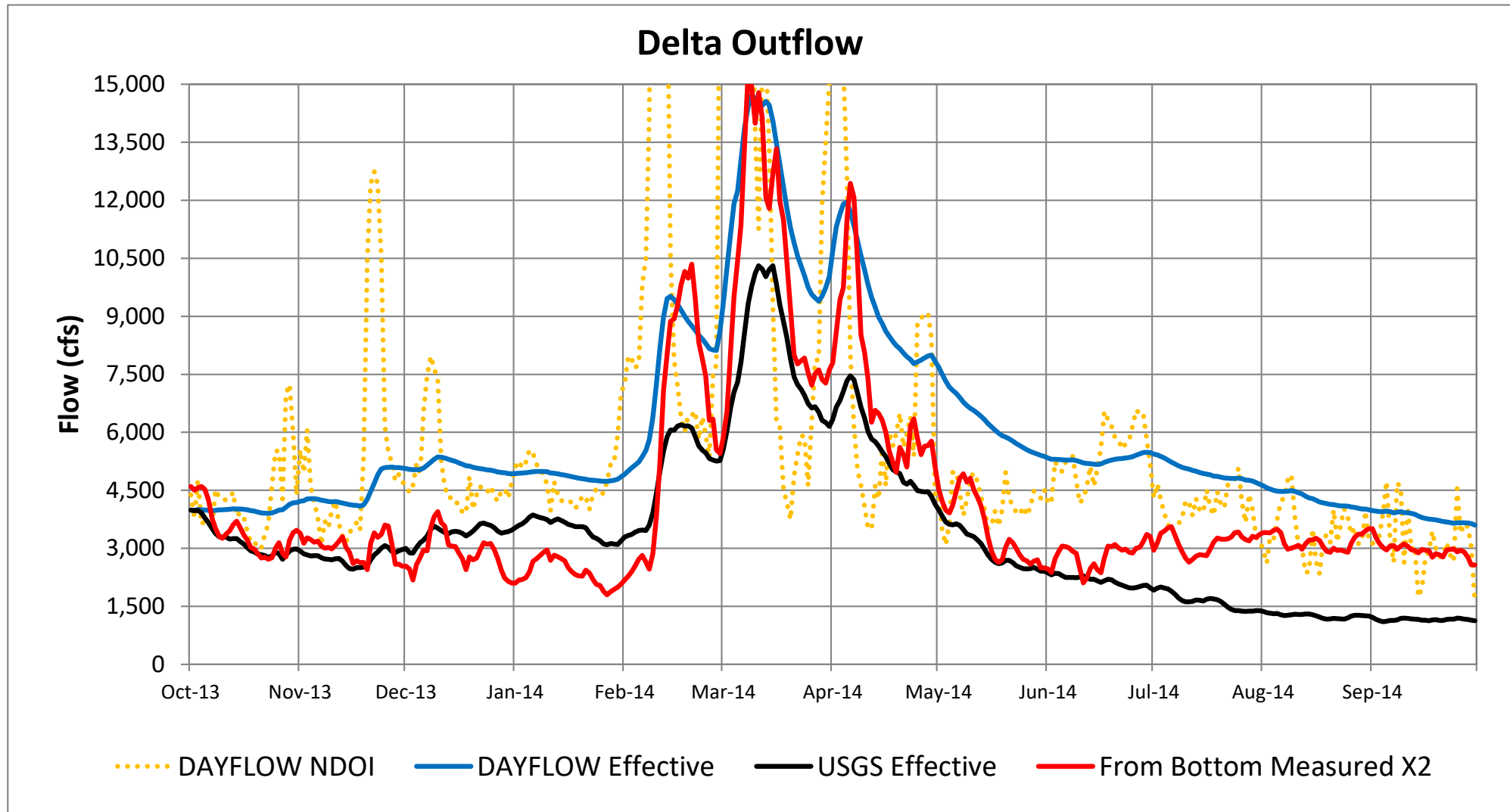


“Measured” WY 2014 X2 based on bottom EC was considerably higher than X2 calculated from DAYFLOW outflow, indicating that actual outflow was less than DAYFLOW water balance estimates

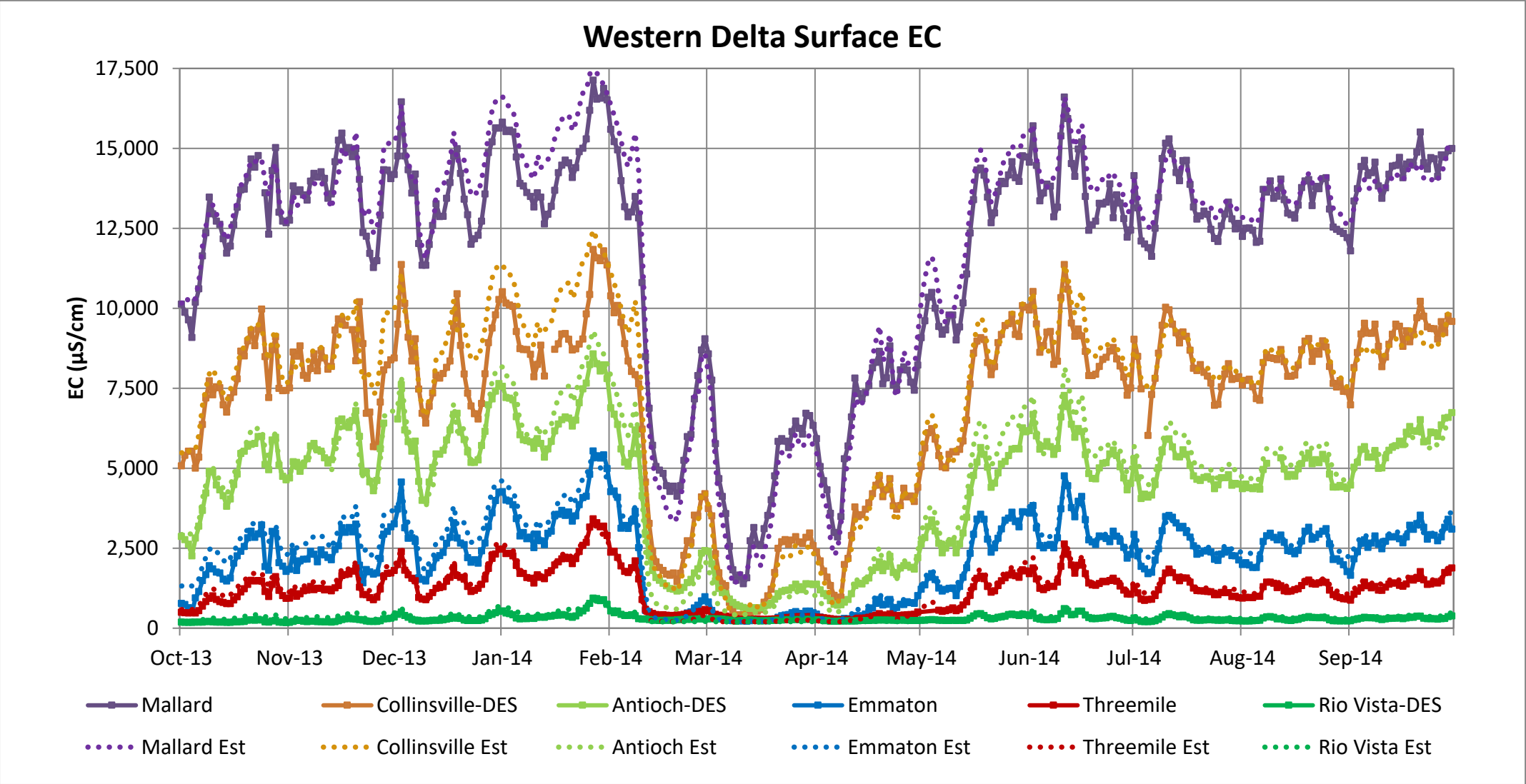


Are the X2 equations inaccurate? Two lines of evidence indicate the outflow estimate is inaccurate and not the X2 equations.

Effective Delta Outflow from Measured X2 (red) and Calculated from DAYFLOW (blue) and USGS Measured Daily Outflow (black) for WY 2014. The DAYFLOW estimates were higher and the USGS measurements were lower than the effective outflow from measured bottom X2.



Comparison of Measured EC with Calculated EC Using Negative Exponential EC-Outflow Relationships with Effective Outflow Estimated from Measured Bottom X2 for WY 2014. This confirms accuracy of the outflow based on measured X2.



Conclusions from viewing daily seawater intrusion data

- The autoregressive lag model used by DAYFLOW responds too slowly to large, rapid changes in Delta outflow
- Alternative equations may respond more quickly to changes in Delta outflow and could be improved by incorporation of a tidal term.
- Evaluation of “Measured” X2 compared to DAYFLOW X2 can indicate when DAYFLOW Delta outflow may be inaccurate.
- Effective outflow estimates calculated based on measured X2 may be more accurate than USGS- or DAYFLOW-based estimates of effective outflow.
- Evaluation of daily data can increase understanding of processes, indicate discrepancies, and suggest new or altered calculation methodologies.