A rationale for using fingerprints to develop conversions between conductance and other constituents in Delta waters.

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18 Aug 2020

We regularly need to convert modeled conductance to other constituents. While this has been limited to estimating chloride and bromide at Delta export locations (as documented in a few memos), an authoritative document that is more ambitious is needed: *a method for converting from conductance to additional constituents and for throughout the Delta.*

An approach to accomplish this has been previously presented as follows:

1. Develop regressions between EC and various constituents at Delta boundaries, including for island drainage.
2. Using **DSM2-generated volumetric fingerprints**, develop regressions based on observed EC and observed constituent in grab samples for:
    a. Each specific location data is available
    b. **Small regions** in the Delta for which regressions are similar (approximately 12)
    c. **A singular Delta-wide regression**.

3. Generate regressions as under item (2) above **using DSM2-generated EC fingerprints**.

Repeat (2) and (3) above using DSM2-simulated EC instead of sampled EC.

This following information uses the example of **calcium** and conductance to present several issues with developing regressions and a rationale for this approach.

Background

The data available to develop regressions are grab samples taken throughout the Delta over many years. From a particular grab sample, multiple constituents are usually measured. This noncontinuous data is available from **DWR's Water Data Library** and in some cases date back to the 1950s and 1960s.

Depending upon the constituent and location in the Delta, **a conversion from conductance to another constituent will depend upon the source of the water**. **This is because regressions at Delta boundary sources can vary**. One example is the relationship between calcium and conductance. The correlation between calcium and conductance in the west Delta is very different than in inflow from the Sacramento, San Joaquin and Mokelumne rivers (Figure 1).

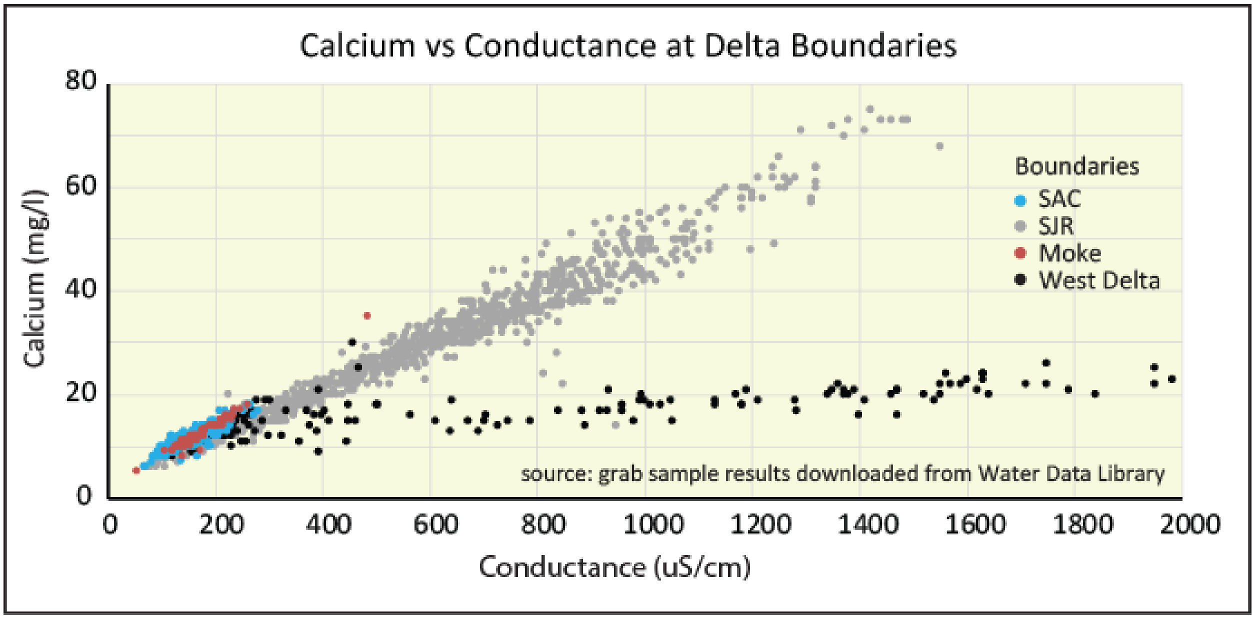

Figure 1. Calcium and conductance from grab samples taken in the west Delta, Sacramento River Inflow, San Joaquin River inflow and Mokelumne River inflow.

A closer look at calcium and conductance for low values corresponding to large Delta outflow shows that as conductance falls below about 300 uS/cm, the relationship between conductance and calcium takes on the characteristics of Sacramento River water (Figure 2). This trend is repeated for all constituents. **When the Sacramento River inflow gets sufficiently high, the water in the west Delta, at least to Mallard Island, reproduce the characteristics of Sacramento River water at the upstream Delta boundary**.

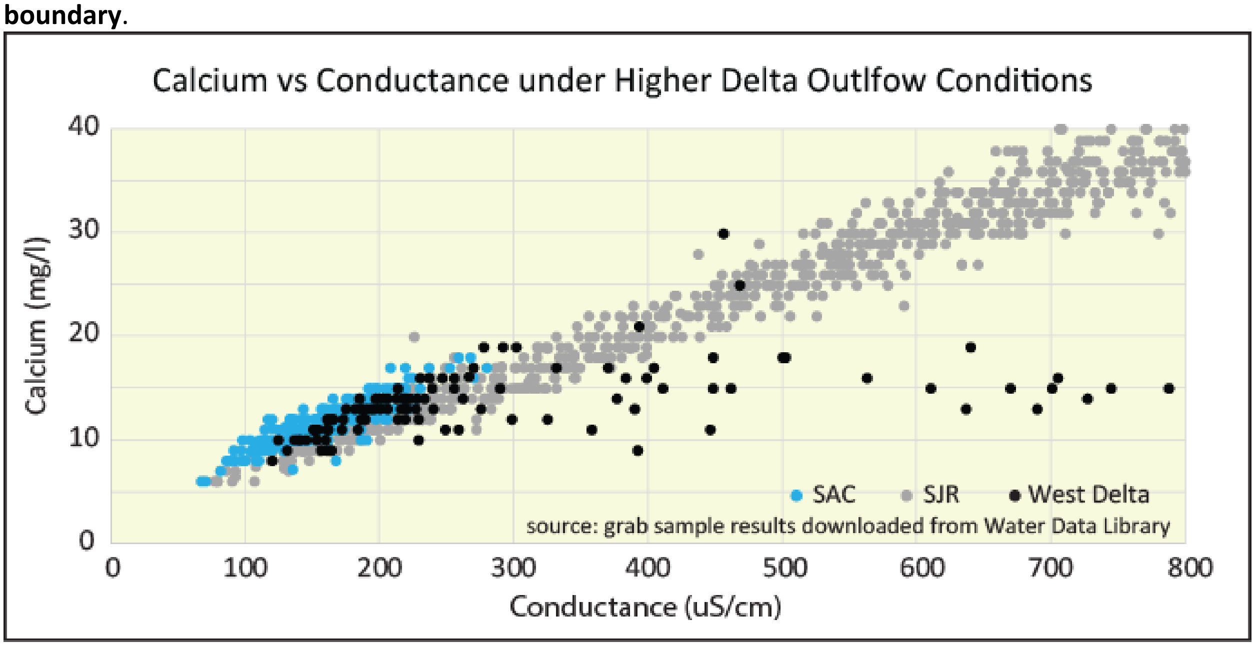

Figure 2. Conductance and calcium from grab samples from the west Delta, Sacramento River inflow and San Joaquin River inflow.

The differences in relationships between conductance and calcium in the water at Delta boundaries suggest that **the relationship between conductance and calcium at any location in the Delta could depend upon the makeup of the source waters there.**

This is shown in the relationship between conductance and calcium in Old River at Bacon Island (Figure 3). The conductance and calcium relationship in Old River at Bacon Island tends to follow either the west Delta data or the Sacramento and San Joaquin data, with some falling somewhere in between the two. For a conductance value of 1000 uS/cm, the dissolved calcium in the water in Old River at Bacon Island can range from about 20 mg/l to 50 mg/l, evidently depending upon how much of the water came from what source.

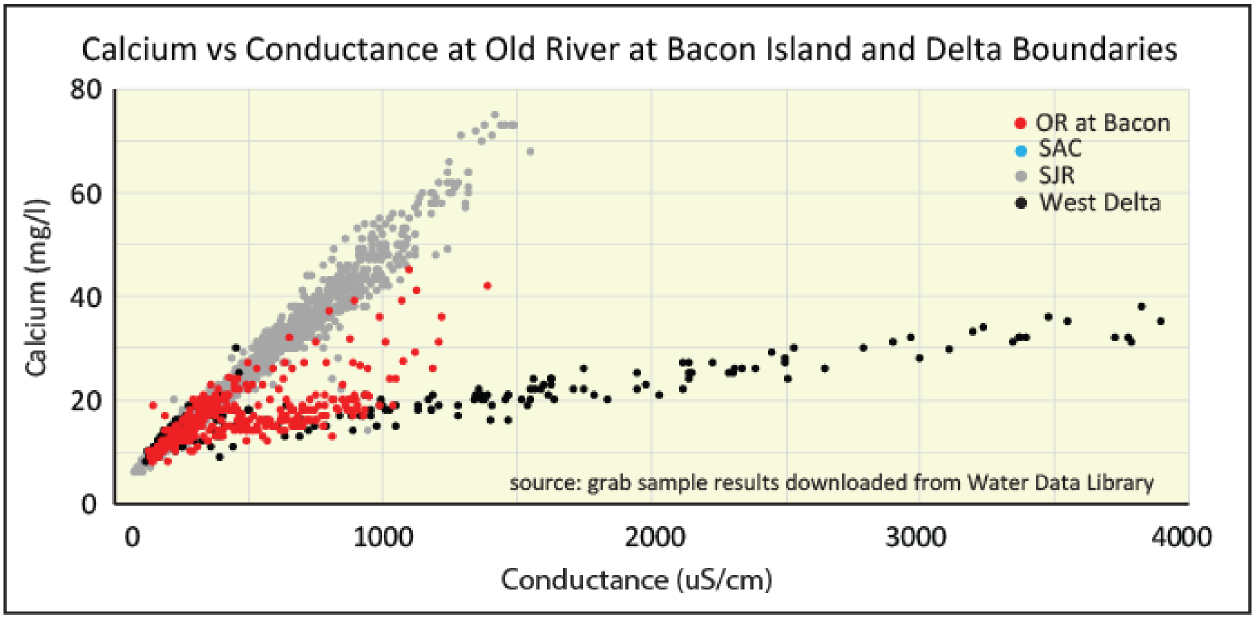

Figure 3. Conductance and calcium from grab samples in Old River at Bacon Island compared to those from Sacramento River Inflow, San Joaquin River inflow and the west Delta channels.

This behavior between conductance and calcium is seen in the other constituents. **As shown in Figure 4, the source of water in Old River at Bacon Island changes over time in response to changing Delta inflows, exports and barrier operations.** The same is true throughout the Delta network of channels. For this reason, an approach for developing conversions between conductance and other constituents has been proposed which use simulated fingerprints and conductance and grab sample data to estimate the constituent of interest.

Currently, DSM2 fingerprints are estimated for 5 sources:
1-Sacramento River (including Yolo Bypass),
2- San Joaquin River,
3-East side inflow (Cosumnes and Mokelumne Rivers),
4- west Delta
5-island drainage/runoff.
Grab samples for some locations for some constituents are **not available**. In such cases, the regression for Sacramento River inflow can be used for East side inflow and the San Joaquin River inflow regression can be used for island drainage.

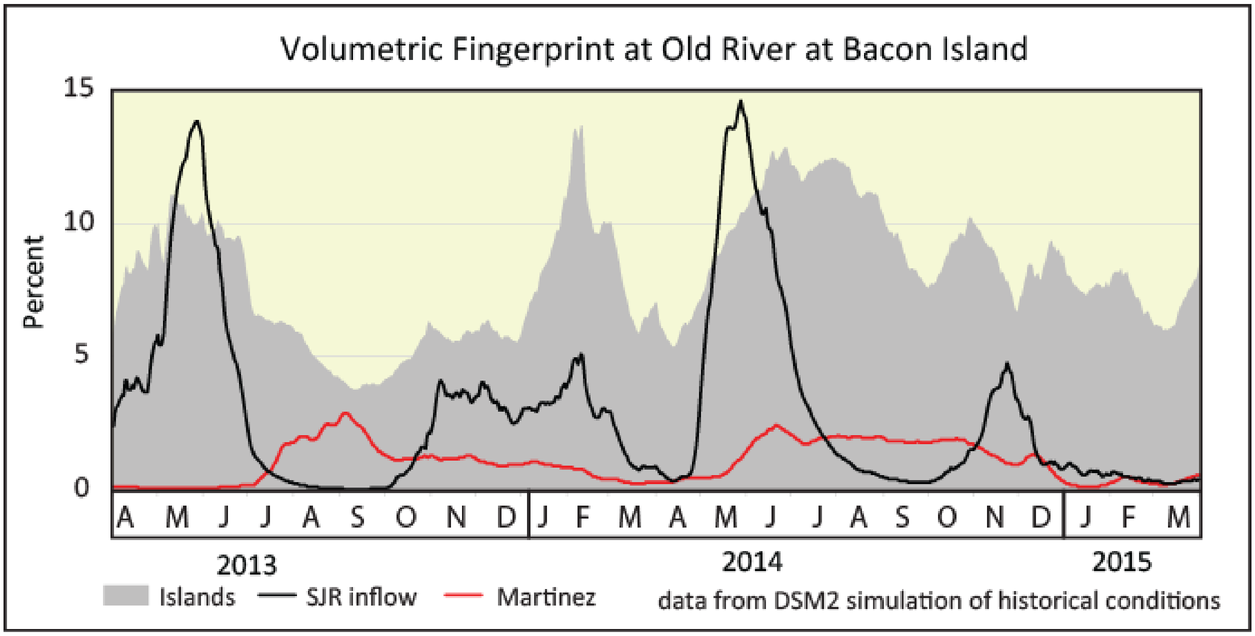

Figure 4. Varying source of water at Old River at Bacon Island from April 2013 through March 2015.

Drainage from Delta islands

Since **island drainage** can be a **significant contributor** of the makeup of water in certain areas of the Delta during the irrigation season, regressions are needed for this boundary condition. Grab samples of island drainage were taken for a special MWQI study in the 1990s. The results are accessible from the Water Data Library under project name "Ag Drains." Figure 5 shows calcium and conductance for all grab sample results available, except for those from Clifton Court Tract.

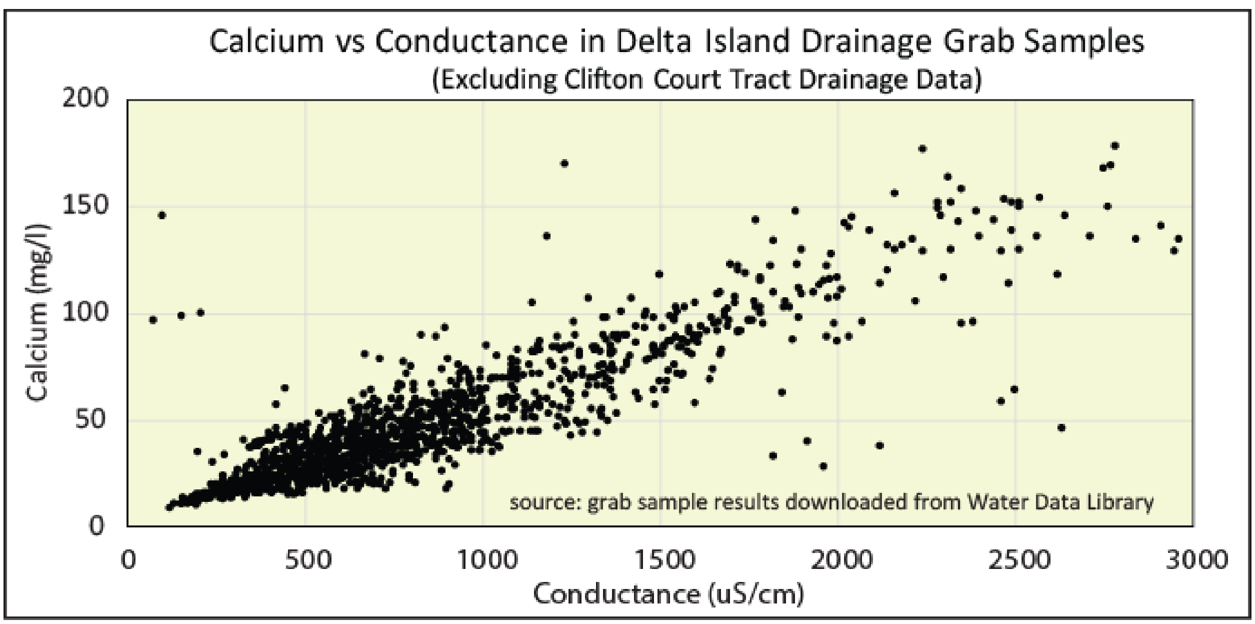

Figure 5. Conductance and calcium from grab sample taken from Delta island drainage channels.

While regressions between constituents at the Delta boundaries are usually fairly strong, there can be a lot of spread in the data from island drainage. This is because the relationship between conductance and calcium can vary by island. As an example, Figure 6 shows conductance and calcium from the drainage from Bouldin and Twitchell islands.

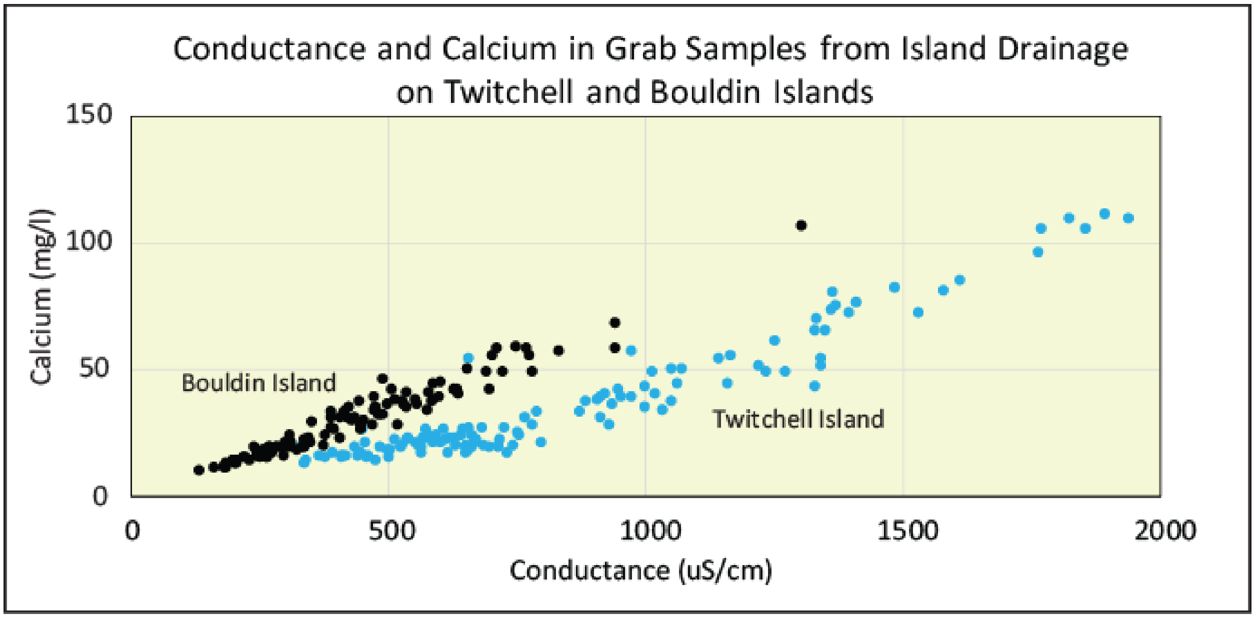

Figure 6. The relationship between calcium and conductance in island drainage on two Delta islands.

The variation in drainage calcium to conductance relationship is not simply due to varying source of applied water to the island. Figure 7 compares island drain water on Jersey Island to San Joaquin River water at Jersey Point. The relationship between calcium and conductance is clearly different for the entire range of conductance sampled.

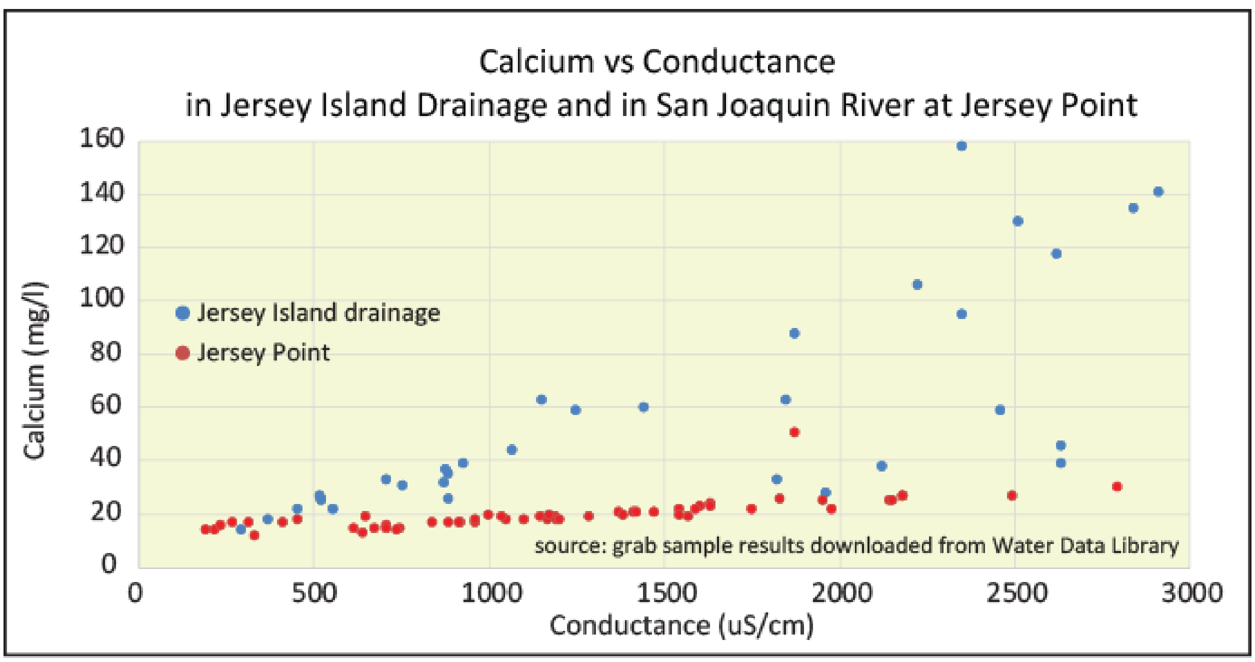

Figure 7. Relationship between calcium and conductance in Jersey Island drainage and at Jersey Point.

The drainage from Clifton Court Tract has its own unique characteristics. As show in Figure 8, the relationship between calcium and conductance in drainage water here falls in between the general relationship for drainage water from other Delta islands and that for the Sacramento River at Mallard Island (west Delta). Studies of the south Delta channels have suggested that highly saline groundwater in the south Delta can show up in island drainage. This may explain the data from Clifton Court Tract.

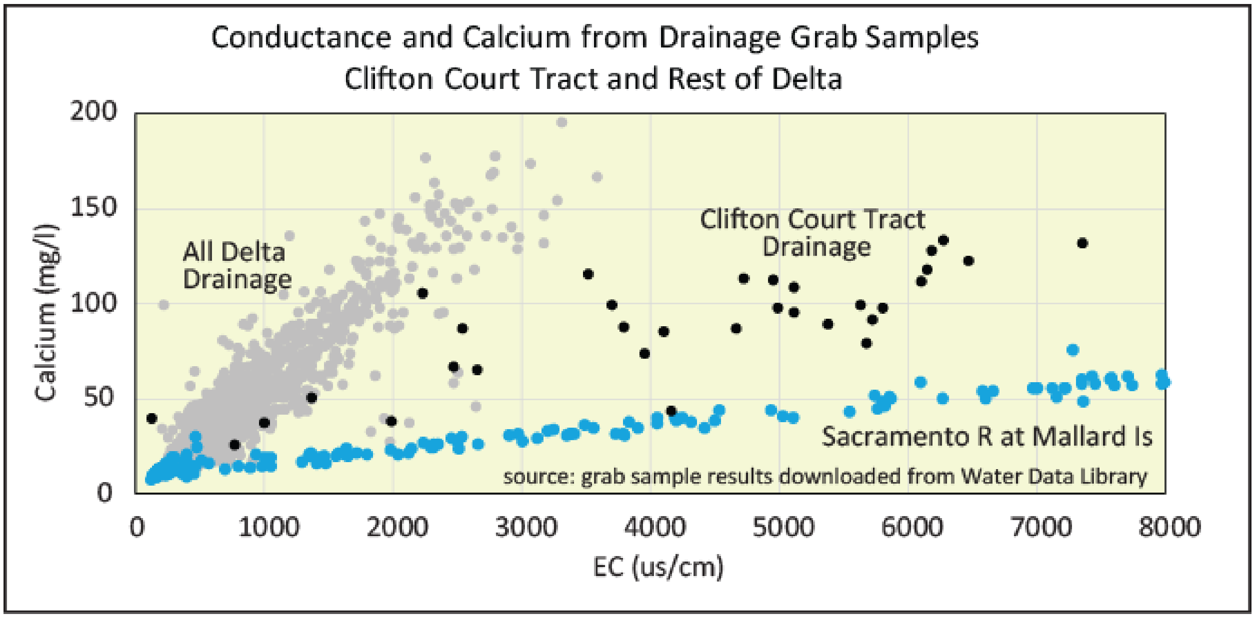

Figure 8. Calcium and conductance in grab samples of island drainage and in the Sacramento River at Mallard Island.

If other constituents show large differences in relationships to conductance between different islands, breaking up the island drainage fingerprint component into two or three groups may be beneficial.

Regressions for Delta regions

For most constituents, grab samples exist for many locations in the Delta. In the past, work by Siqing Liu showed that the relationship between conductance and other constituents, while varying by location in the Delta, can be grouped to form persistent regions. Figure 9 shows the regions for conductance and bromide. Stations not included in groups had no available data. The correlation between conductance and any given constituent at Vernalis persists down the San Joaquin River to Rindge Tract.

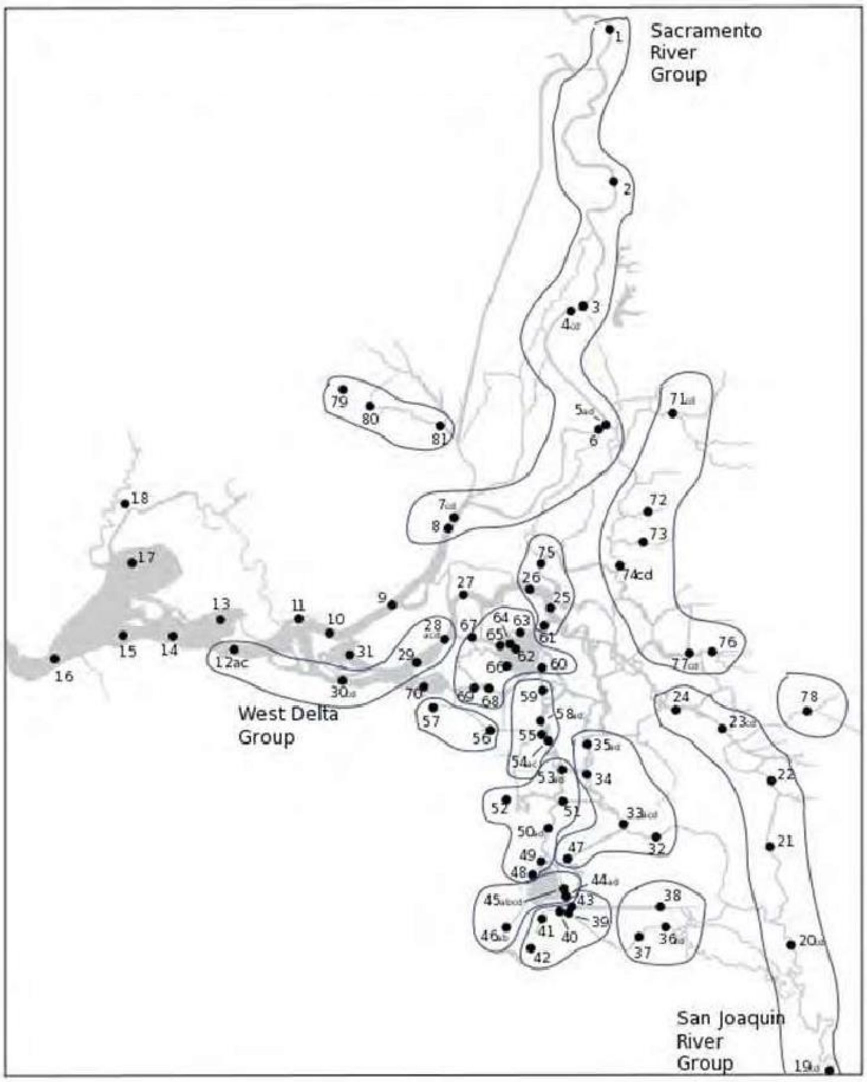

Figure 9. Groupings for common regressions between conductance and bromide.

The stations on the Sacramento River show the same correlations down to Rio Vista. To demonstrate the presence of groups of stations showing the same relationship between constituents, calcium and conductance obtained from grab samples is presented in groupings in Figures 10 through 14. Three groups are shown: a San Joaquin River Group, a Clifton Court Forebay Group and a Jones Pumping Plant Group. The San Joaquin River Group is used to compare the different groups. The Clifton Court Forebay Group and the Jones Pumping Plants show similar relationships, but there is a difference. Some constituents other than calcium show significantly different regressions at the Sacramento River and the San Joaquin River inflows. When this occurs, the differences between the Clifton Court Forebay and Jones Pumping Plant groups is more pronounced.

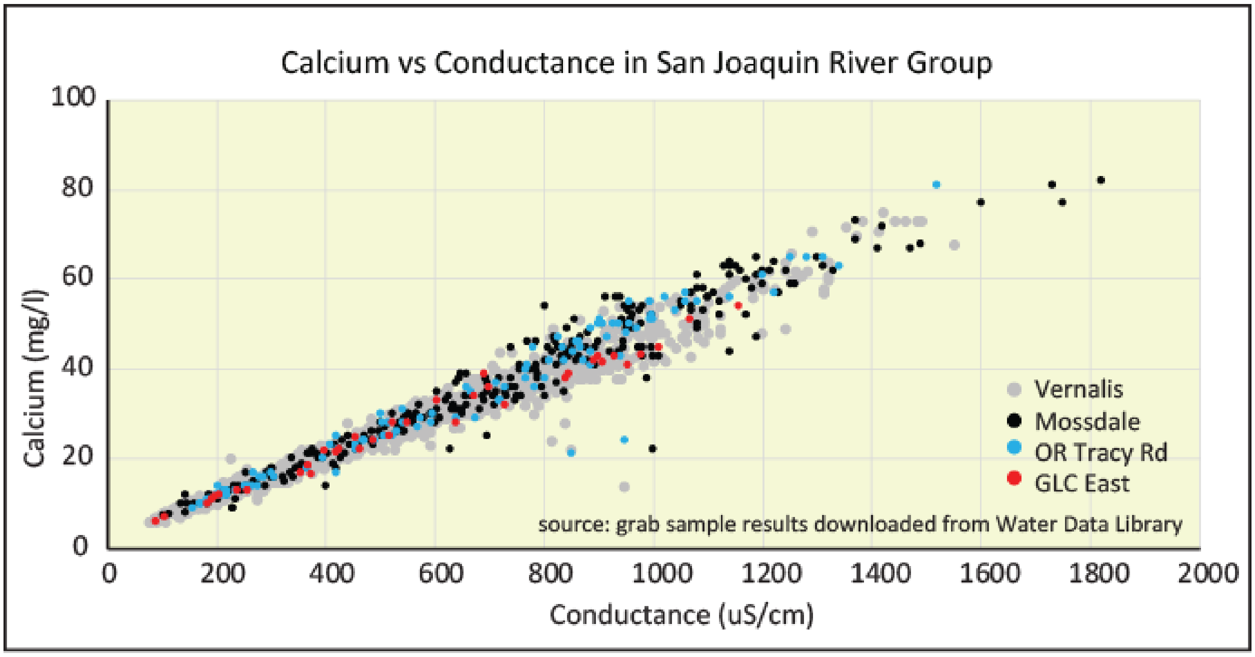

Figure 10. Calcium versus conductance in grab samples at Vernalis, Mossdale, Old River at Tracy Road and the east end of Grant Line Canal.

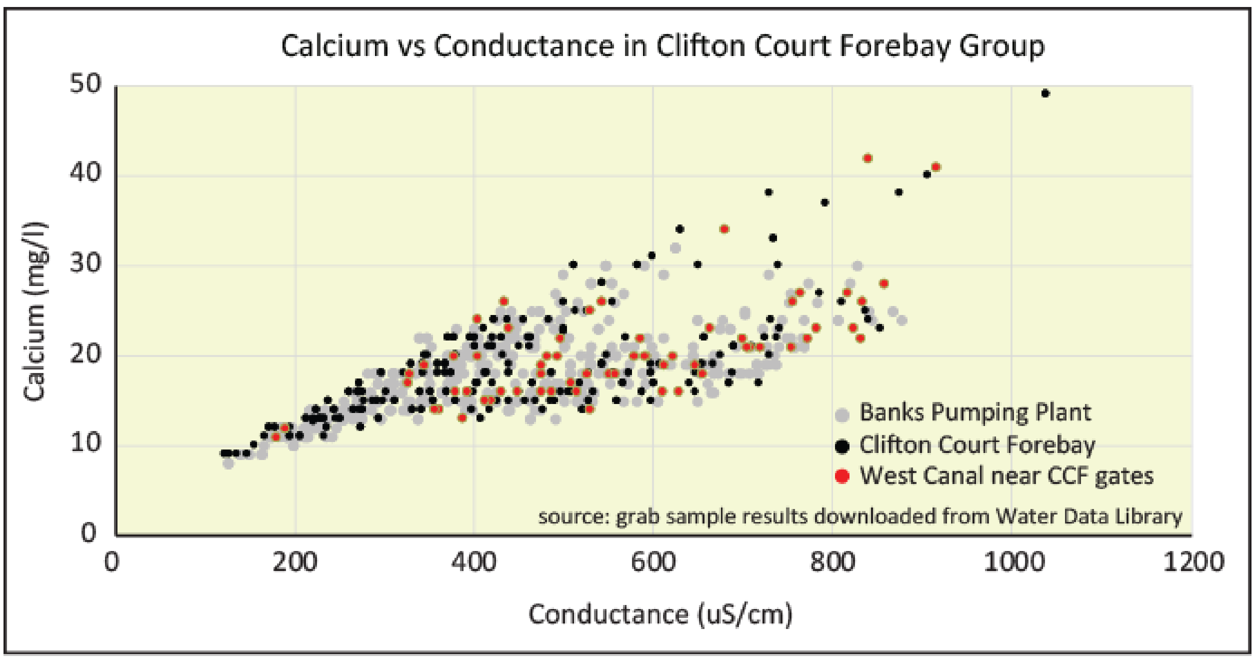

Figure 11. Calcium versus conductance in grab samples at Banks Pumping Plant, Clifton Court Forebay and West Canal near Clifton Court Forebay intake gates.

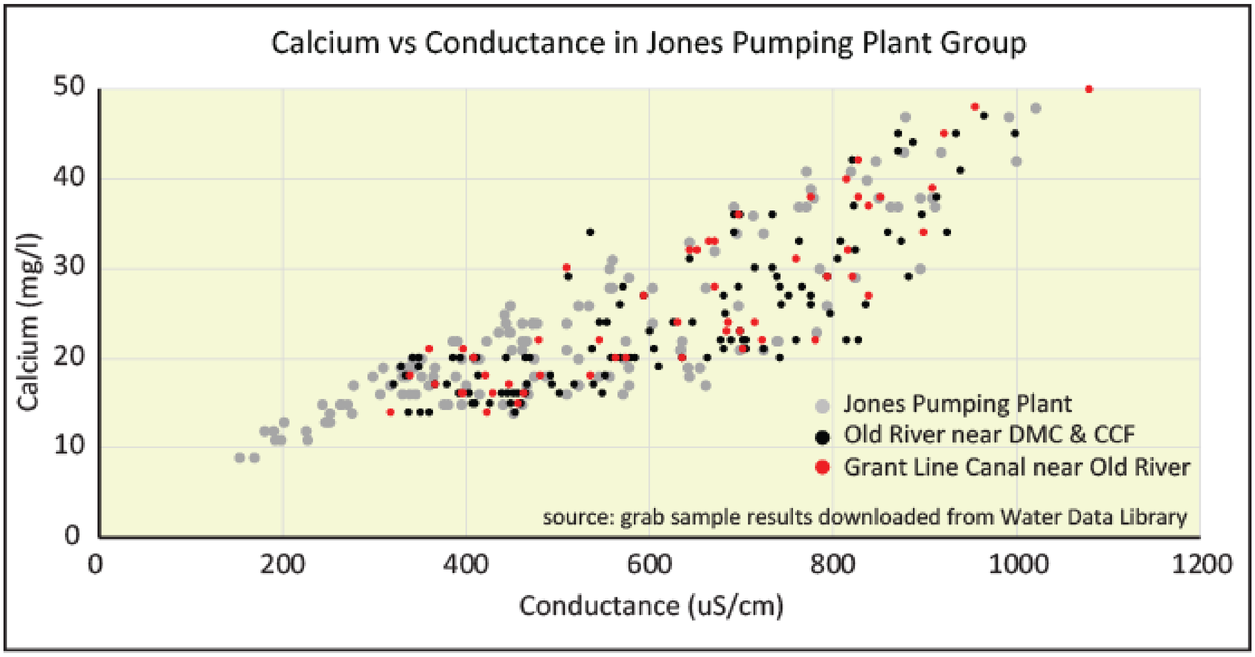

Figure 12. Calcium versus conductance in grab samples at Jones Pumping Plant, Old River near DMC and CCF and Grant Line Canal near Old River.

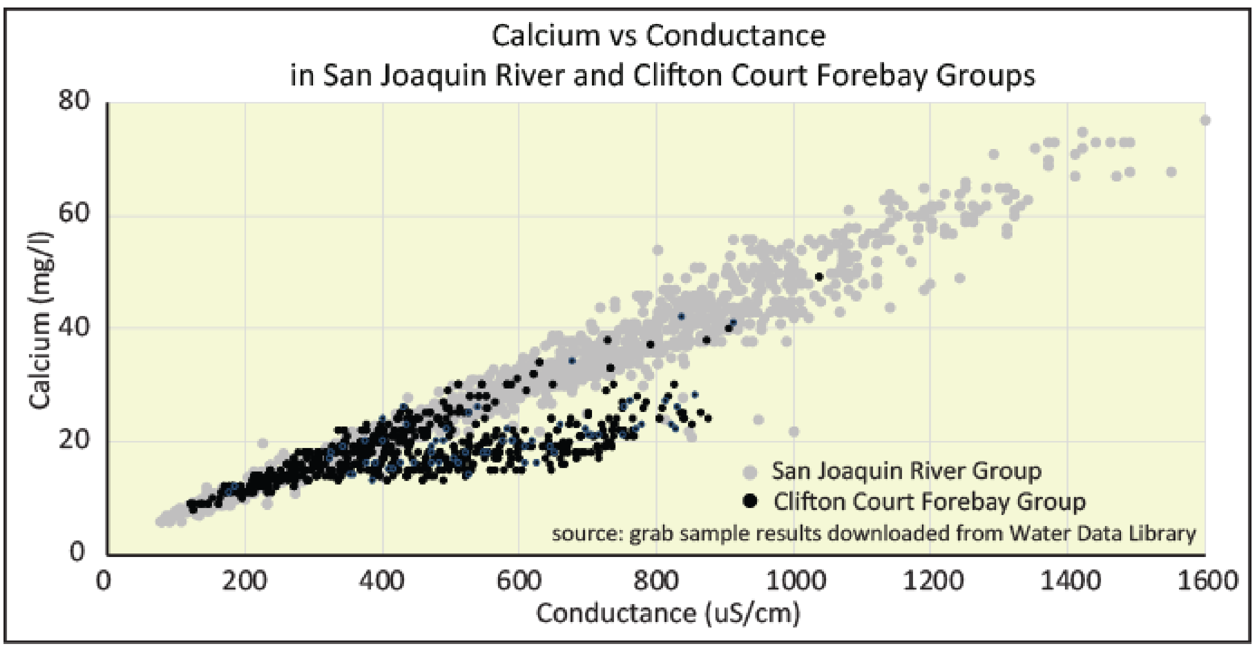

Figure 13. Calcium versus conductance in grab samples comparing relationship within San Joaquin River Group to that within the Clifton Court Forebay Group.

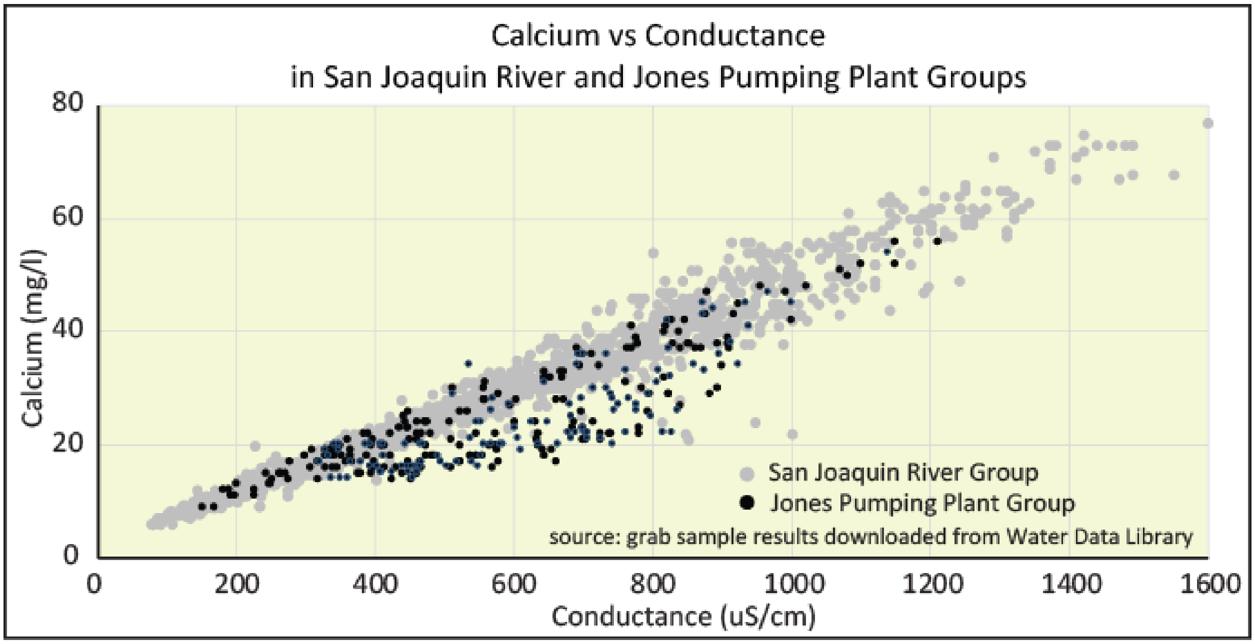

Figure 14. Calcium versus conductance in grab samples comparing relationship within San Joaquin River Group to that within the Jones Pumping Plant Group.

Siqing developed meaningful regressions based on EC fingerprints for three levels of detail: a regression for each individual location grab samples exist, a regression for each of the identified regions, and a single Delta-wide regression. **As expected, the site-specific regressions were significantly better than the single Delta-wide regressions. However, the regressions for the regions were as meaningful as the site-specific ones. This indicated that we should be able to convert from conductance to another constituent throughout the Delta given simulated conductance and fingerprints.**

Time period and the relationships between constituents.

Past work indicated that relationships between constituents may have changed over time. It's reasonable to assume that land practices have changed upstream of the Delta, particularly for land draining into the San Joaquin River above Vernalis. Figure 15 shows chloride and conductance from grab samples at the San Joaquin River at Mossdale Bridge. The data has been partitioned into two groups: a group of older grab samples of 1952 to 1971 and a newer group of grab samples from 1972 to 1997. There is a clear difference between the groups. Something apparently changed. Further exploration may be fruitful concerning using grab samples to indicate changing Delta conditions that aren't revealed in conductance alone.

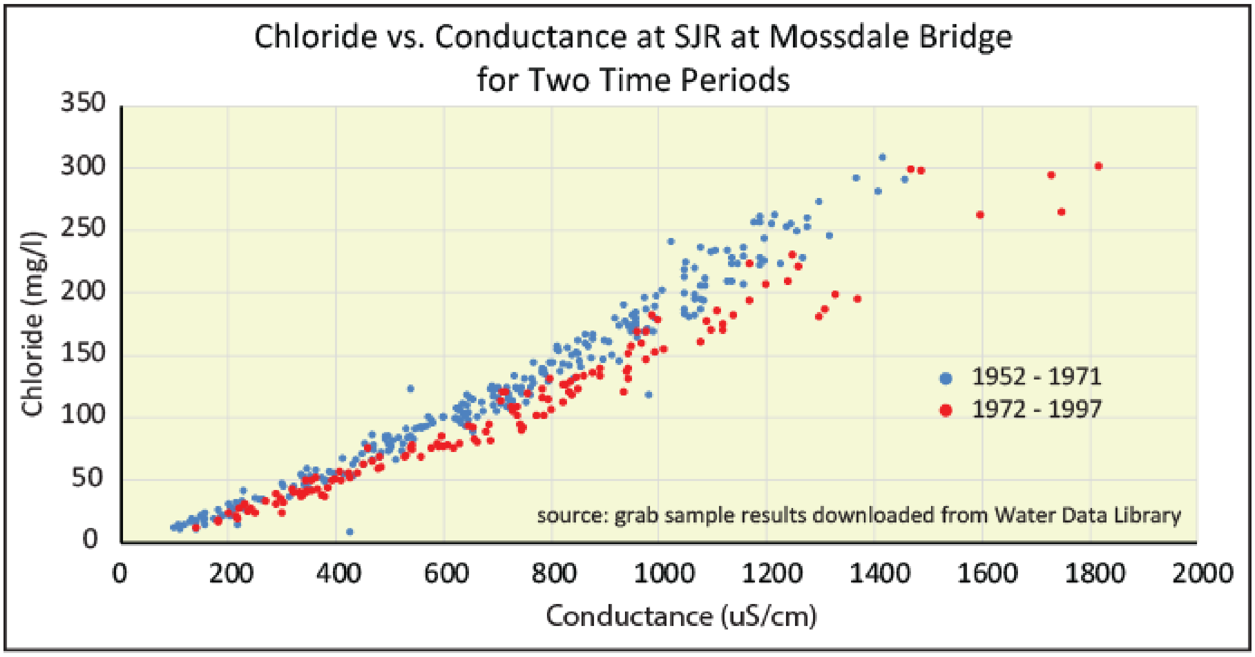

Figure 15. Chloride and conductance at San Joaquin River at Mossdale Bridge based on grab samples separated into two groups by date.

Summary

We should be able to generate meaningful Delta-wide conversions from conductance to various constituents using regressions based on grab sample data and modeled fingerprints. Siqing's previous work with EC fingerprints has proven this.

This effort may reveal **persistent zones of mixing** in the Delta as well as indicating the extent of influence of Delta inflows on the makeup of source water. This could enhance our understanding of "**Delta circulation patterns**", a long-stated goal but which has been difficult to operationalize.

There may be substantial benefit from **breaking island drainage up into subgroups** for fingerprinting if we see consistent correlation differences among the islands. Study of this might focus on the **south Delta** where island drainage can strongly influence channel water quality.

Time-varying correlations between conductance and other constituents at Delta boundaries may be an indication of **changing upstream land practices** and may merit further investigations.