Public Comment
2016 Bay-Delta Plan Amendment & SED
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# ANALYSIS AND COMMENTS ON BAY-DELTA PLAN AMENDMENT SUBSTITUTE ENVIRONMENTAL DOCUMENT

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## Introduction:

These comments address phase 1 of the Bay-Delta Plan Amendment, which concerns the San Joaquin side of the Delta, often referred to as the Southern Delta. The focus of the analyses are the Plan objectives of water quality and protections of the Delta environment. The Delta environmental protection efforts are particularly concerned with depletion of endangered species strongly related to the induction of reverse flows due to export pumping. This analysis addresses the flow conditions in the South Delta and their relationship to San Joaquin import flows and export flow by the projects.

Flows at Vernalis are generally accepted as the best measure of net flows from the San Joaquin River into the Delta. A perusal of the quantitative data clearly shows that Vernalis flows are most often significantly less than Delta exports. Although the exports are justified as the harvesting of unappropriated flows of the Sacramento River entering the Delta, it is hard to escape the obvious observation that Vernalis flows will be the first to be pumped. Since export flows dominate over Vernalis flows, the bulk of the export flows must be made up by the transmigration of Sacramento flows across Delta which because of Delta hydraulic considerations cause those flows to migrate generally to the South Delta entering below the export pumps, hence the reverse flows.

Because Vernalis flows contribute little or nothing to fresh water flows in the South Delta, they can do little to alleviate salinity problems in the South Delta. This is especially true when export pumps are in a position which will scavenge most of the Vernalis flows before they reach the downstream parts of the South Delta. This necessarily leaves the burden of salinity control to the flows that come from the Sacramento River.

In the analysis that follows we demonstrate why the Vernalis flows tend to be very inadequate most of the time, how the San Joaquin, Tuolumne, Merced, and the Stanislaus river operations allow little flow to reach the Delta, and why fall-early winter flows are very indicative of the magnitude of spring flows and a better predictor of those flows than the existing Water Year Type indicator used in operations. We also present findings on the relationship between Old River, Vernalis, and Export flows **which strongly suggest that to meet the objectives of the amended Bay-Delta Plan, either export flows must be curtailed very significantly or Vernalis flows must be increased significantly or some combination of those two operational changes.**

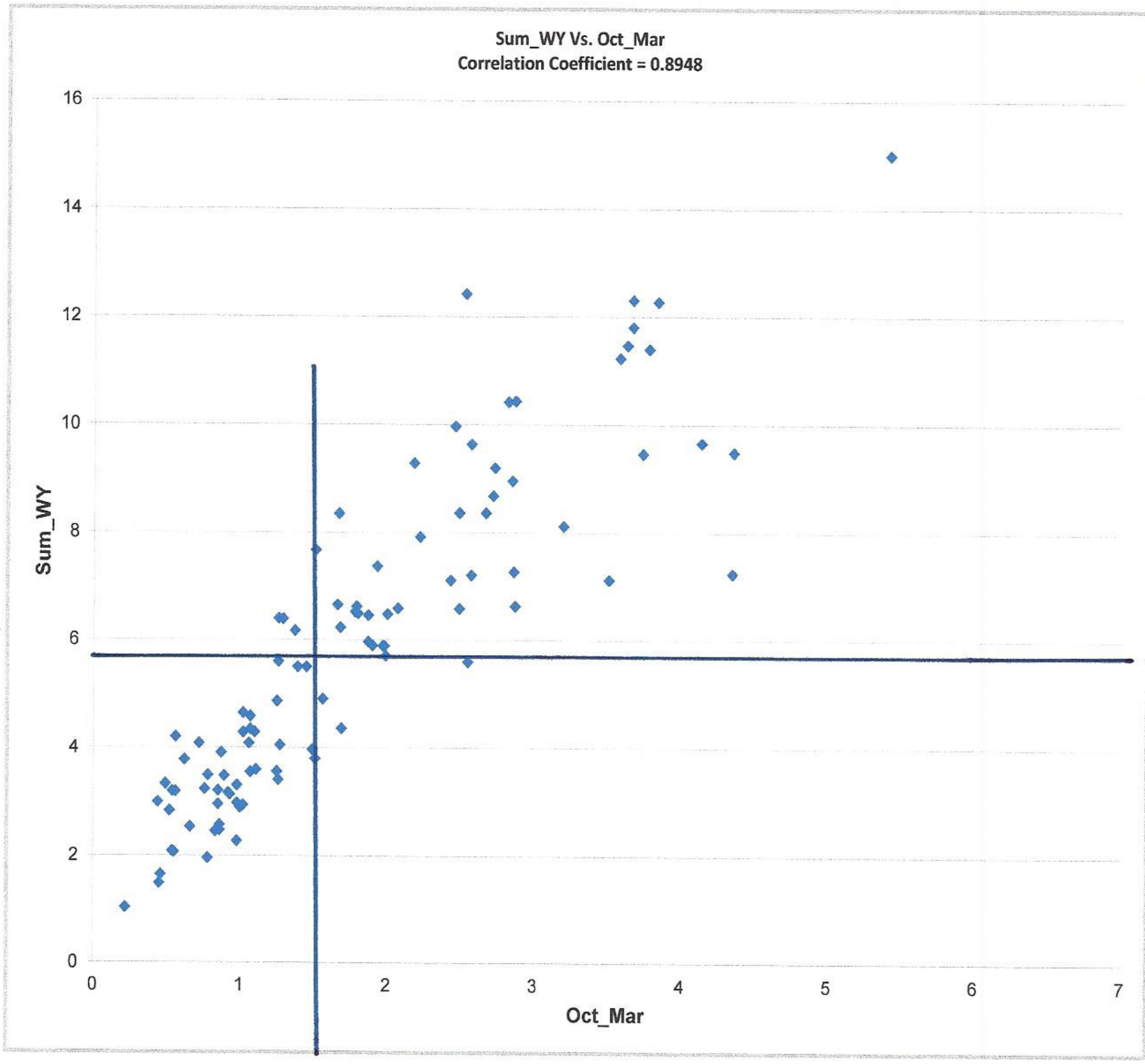
## Analysis:

In a similar study (Testimony given at SWRCB on the DWR petition to change the point of diversion on the Sacramento River, November, 2016) of the Sacramento River and its watershed we investigated the fundamental character of the hydrology of that watershed in terms of its runoff distribution. It was found that the distribution of annual runoff over a 100-year record was definitely bi-modal; that is, about 56% of the years were below average and 46% were above average with very few years near the average. The investigation further found that if cumulative runoff by the end of January of a water year was less than about 4.0 million acre-ft (as measured by the 4-river index) the ensuing year was very likely to be dry as well. It was found that the Water Year Type index (derived from the 4-river index) had no scientific merit because it relied on runoff in the previous water year, which relationship could not be confirmed statistically. The same type investigation was performed on the San Joaquin water shed using that basin's 4-river index.

The investigation revealed pretty much the same conclusions. Although the San Joaquin basin runoff was not bi-modal, it was highly skewed to the dry side and presented the same early indication of a dry water year. Figure 1 presents a scatter plot of the total 4-river index versus the cumulative runoff through the end of March. (About 25% of the basin runoff occurs before the end of March). If that cumulative runoff is less than 1.6 million acre-ft it is very likely that the ensuing year will be less than average. As was the case in the Sacramento watershed, the average again bisects the runoff record in roughly equal numbers of dry and wet years with not many years near average. All of this is made clear in Figure 1.

**Figure 1**

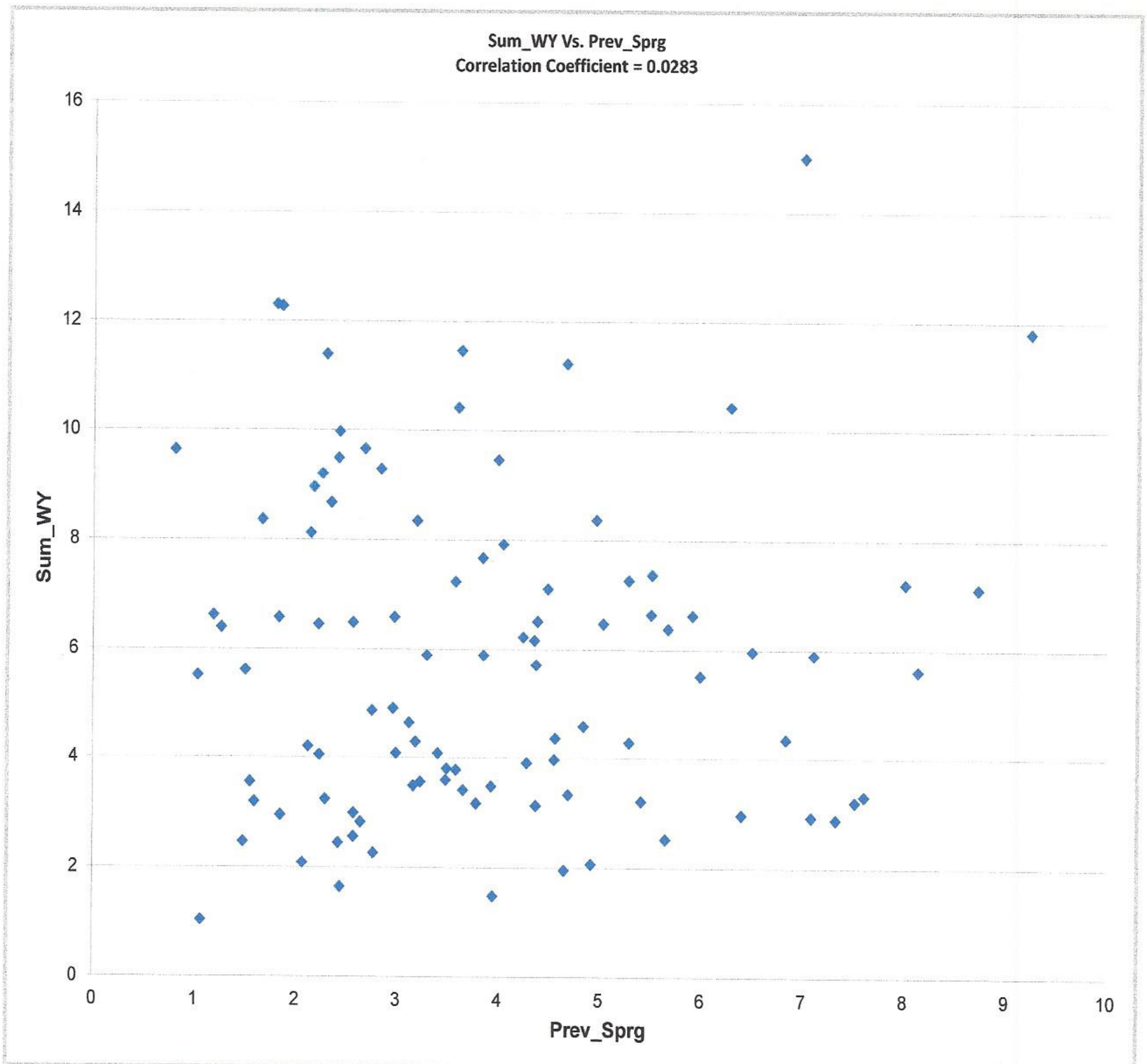
**Scatterplot of Total Annual Runoff vs. Oct.-Mar. Runoff (MAF)**



An examination was also made of whether or not the previous water year had any influence on the ensuing water year. The correlation of the total runoff for the ensuing water year against the previous water year's spring runoff (which constitutes about 75% of a water year runoff) was found to be statistically insignificant, which means that any use of the present Water Year Type index to guide hydrologic operations is without merit. Figure 2 presents the results of the correlation analysis. The correlation coefficient is -0.0283 which signifies there is very little probability of a true relationship.

**Figure 2**

**Regression Result for WY Total Runoff vs. Previous Apr-Jul Runoff**



The next investigation sought to determine why Vernalis flows are chronically low. In drought episodes they are low year after year. Figure 2-7 from South Delta Water Quality studies (page 2-10 and here reproduced as Figure 3) shows that no significant runoff occurs below Friant Dam except in the exceptionally wet years of 2005 and 2006. The figure, which presents the unimpaired runoff at Friant and the corresponding runoff below Friant, demonstrates well the difficulty. The text accompanying the figure states that for all the years from 1999 to 2008 except for years 2005 and 2006 the average runoff below Friant was 125 cfs. This compares to an unimpaired flow over the same period that is generally 5000 cfs or more. Corresponding runoff records for the Tuolumne and Stanislaus indicated the same pattern. These rivers are so highly regulated for water diversions little water is released into the main stem of the San Joaquin. Figure 4 compares the Vernalis flows ("column C" in the figure) with the sum of the San Joaquin, Tuolumne, and the Stanislaus ("column A" in the figure) (the Merced River flows could not be retrieved easily from the CDEC data base). As shown in the Figure, the Vernalis flows are about one-half to three-quarters greater than the sum of the Tuolumne, Stanislaus, and San Joaquin flows. The difference has to be explained by the regulated releases from the Merced and all the flows from the minor unregulated streams between Vernalis and the San Joaquin. Some of the differences may be explained by measurement errors.

**Figure 3**

**Plot of Monthly Flows Above and Below Friant**
**(cfs)**
(Reproduction of Figure 2-7 from South Delta Water Quality studies)

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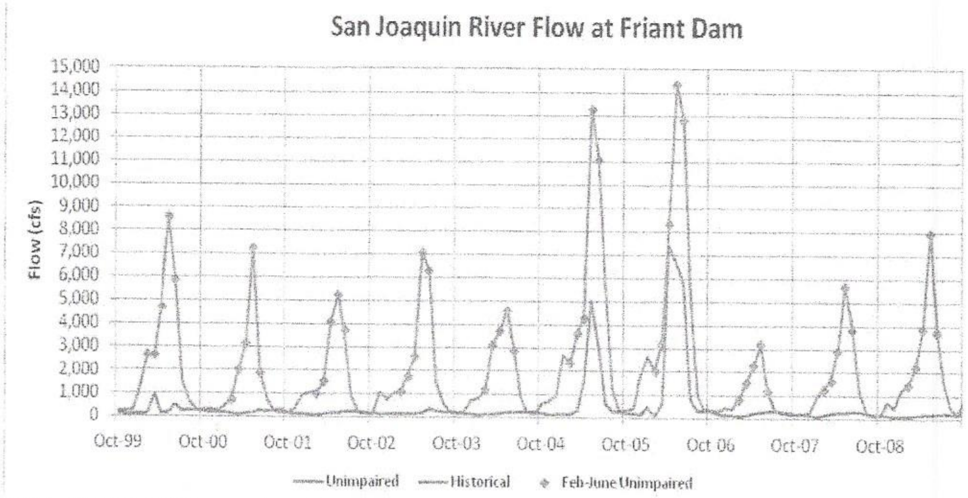



**Figure 2-7. Monthly Unimpaired and Historical San Joaquin River Flows at Friant Dam for Water Years 2000–2009 (cfs = cubic feet per second)**

### 2.2.4 Hydrology

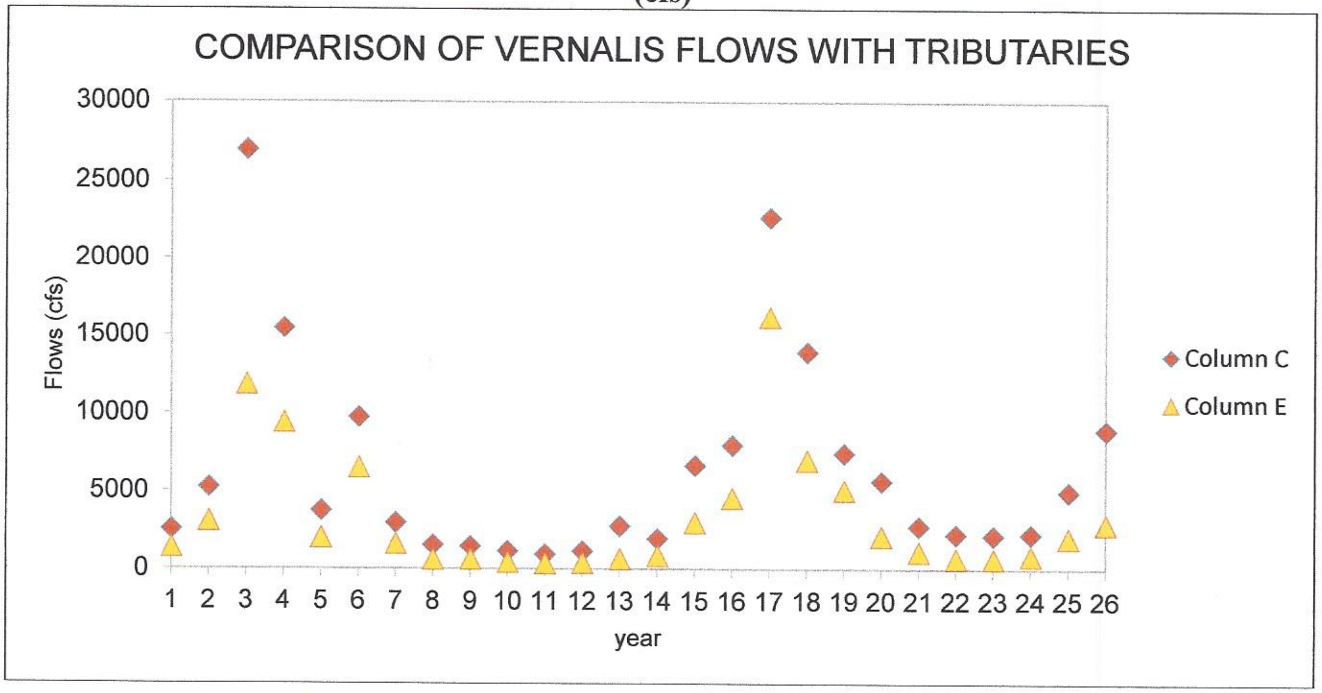
The average annual unimpaired flow for the Upper SJR at Friant Dam f om 1984 through 2009 was 1,702 TAF. This represents approximately 28 percent of the unimpaired flow on the SJR at Vernalis. Most of this water is seasonally stored in upstream reservoirs and in Millerton Lake and diverted to the Friant-Kern and Madera Canals for irrigation. Historically, during high flow years, there are considerable flood control releases from Friant Dam. The historical monthly flows on the Upper SJR at Friant Dam were less than 125 cfs in all months, except when releases were made for flood control purposes. From 1984 through 2009, Friant Dam releases averaged 420 TAF per year (TAF /y), or approximately 25 percent of the unimpaired flow.

As an example of these historical releases, Figure 2-7 shows the monthly unimpaired flow and the historical flow below Friant Dam for the recent 10-year period of water years 2000 through 2009.12 The average Friant Dam release for this period was approximately 20 percent of the unimpaired flow. Often, however, releases were less than 20 percent of the unimpaired flow, with flood control releases providing the majority of the flow below Friant Dam.

[12] A water year begins in October of the previous year. For example, water year 2000 begins in October, 1999.

**Figure 4**

**Plot Of Vernalis and the Sum of SJ, T, and Stan
Sum D,F,F,M Flows Over Period 1981-2006
(cfs)**




The Tuolumne and San Joaquin watersheds are about equal while the Stanislaus is about 60% to 70% of either of those. Between them they provide about 85% of the 4-river Index and the Merced provides another 10% so that the 4-river Index captures about 95% of the unimpaired flow. **Clearly, if it is desired to increase flows significantly at Vernalis as part of a plan to improve Delta health, it will be necessary to release more flow from these rivers into the main stem of the San Joaquin.**

One of the main concerns with Delta operations are the reverse flows that occur in Old and Middle rivers during heavy pumping at the export pumps. Old and Middle rivers are part of the San Joaquin river system on the south side of the Delta. The primary flows into and out of the Delta are the Sacramento River on the North Delta, the San Joaquin into the South Delta, export pumping from the South Delta, and outflows to the Bay system at the Western Delta. The flow at Vernalis is the best measure of San Joaquin flows into the Delta; Freeport is the best measure of Sacramento flows into the North Delta; and export flows are those pumped from the South Delta by the CVP at Tracy and the SWP at Clifton Court forebay. Table 1 presents those flows for the period 1981 to 2006. Using the data presented in Table 1 we examined through regression analyses several possible relationships between the flows at Vernalis and Sacramento River and Old and Middle river.

By far the best result was obtained with "OldRiverFlow" regressed against "Excess", which is the difference between Vernalis and Exports. When Exports are greater than Vernalis flows the result is entered as a negative. Figure 5 presents the results of that regression.

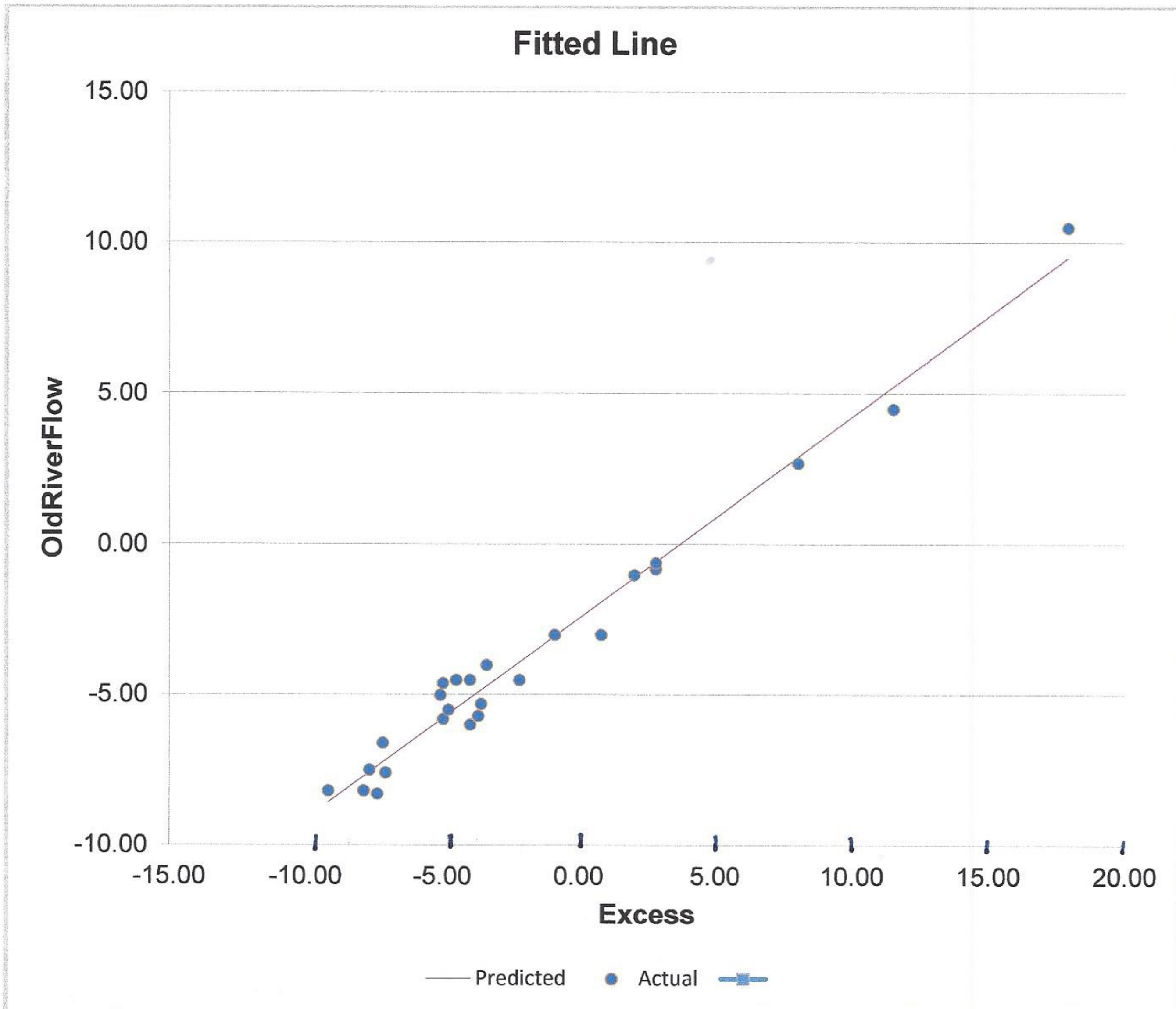
**Table 1**

**Flows Into and Out of the Delta Plus Old-Middle River Flows**
(1981 - 2006)

| Year | Old river flow kcfs | export flow kcfs | vernalis flow kcfs | Vernails - Export | sac r flow kcfs |
|---|---|---|---|---|---|
| Year | OldRiverFlow | Export | Vernails | Excess | Sac |
| 1981 | -4.5 | 6.6 | 2.6 | -4.0 | 23 |
| 1982 | -4.5 | 7.5 | 5.3 | -2.2 | 63 |
| 1983 | 0.3 | 8.3 | 27 | 18.7 | 66 |
| 1984 | 4.5 | 4 | 15.5 | 11.5 | 49 |
| 1985 | -5.7 | 7.5 | 3.8 | -3.7 | 20 |
| 1986 | -0.8 | 7 | 9.8 | 2.8 | 45 |
| 1987 | -4 | 6.4 | 3 | -3.4 | 16 |
| 1988 | -7.5 | 9.3 | 1.6 | -7.7 | 16 |
| 1989 | -6.6 | 8.7 | 1.5 | -7.2 | 20 |
| 1990 | -8.2 | 10.4 | 1.2 | -9.2 | 15 |
| 1991 | -4.6 | 6 | 1 | -5.0 | 13 |
| 1992 | -5 | 6.3 | 1.2 | -5.1 | 17 |
| 1993 | -5.5 | 7.6 | 2.8 | -4.8 | 40 |
| 1994 | -4.5 | 6.5 | 2 | -4.5 | 17 |
| 1995 | -3 | 7.6 | 6.7 | -0.9 | 52 |
| 1996 | -1 | 6 | 8 | 2.0 | 47 |
| 1997 | 10.5 | 4.8 | 22.7 | 17.9 | 57 |
| 1998 | 2.7 | 6 | 14 | 8.0 | 55 |
| 1999 | -0.6 | 4.7 | 7.5 | 2.8 | 51 |
| 2000 | -5.3 | 9.3 | 5.7 | -3.6 | 41 |
| 2001 | -5.8 | 7.8 | 2.8 | -5.0 | 19 |
| 2002 | -7.6 | 9.4 | 2.3 | -7.1 | 26 |
| 2003 | -8.3 | 9.6 | 2.2 | -7.4 | 35 |
| 2004 | -8.2 | 10.2 | 2.3 | -7.9 | 39 |
| 2005 | -6 | 9 | 5 | -4.0 | 27 |
| 2006 | -3 | 8.2 | 9 | 0.8 | 55 |

**Figure 5**

**Regression Line for Old River vs. Excess Flows**
(1981 - 2006)
(All flows in kcfs)




One data point 1983 has been deleted in this regression analysis. 1983 was an extremely wet year, in fact a record El Nino year. Why it appears as an outlier needs further investigation. It is possible for instance in such a year that the hydraulic gradients throughout the Delta are changed dramatically during such an event. Opening the Yolo Bypass as is done for extreme events may help explain the departure.

**The result shown in Figure 5 is unequivocal. The strong dependence on the Excess (Vernalis -Export) flows shows the importance of Vernalis flows and reduced exports if reverse flows in Old River are to be avoided.** No dependence of Old River reverse flows on the magnitude of Sacramento River flows could be discovered. This result should not be surprising given the close proximity of the

San Joaquin River, the export pumps, and Old River. The Vernalis flows in the San Joaquin are the first to scavenged by the Export pumps and given that they are insufficient to support the level of export flows gives rise to the induced reverse flows in Old River.

**Concluding Comments**

Recent studies by DWR have apparently been directed to the objective of managing salts in the South Delta by means of carefully selected barriers and salt reduction in the flows from Vernalis. As helpful as these may be it is difficult to understand how effective they can be given that there is insufficient flow entering the South Delta from Vernalis, which we have shown in the above presentation. If there is to be significant reduction in salts entering the pumps, our conclusion is that there has to be greater flows released from all the San Joaquin tributaries. This will require changes primarily in the operations at Friant, New Don Pedro, New Melones, and New Exchequer dams. Such changes will provide the most efficient way to achieve objectives in the South Delta.