

The Bay Institute (TBI) has thoroughly investigated natural and unimpaired flows in the Bay-Delta-River system over the last two decades. Our 1998 publication, *From the Sierra to the Sea, The Ecological History of the San Francisco Bay-Delta Watershed* [1] (STS), was partially funded by public water agencies and others who provided exhaustive technical review on Delta outflow and salinity [2]. Some key findings from that work and subsequent analysis relevant to the deliberations on Delta outflow include:

1. Natural Delta outflow is not the same as unimpaired Delta outflow because vegetation conversion, levee building, and elimination of flood basin storage altered the flow pattern and may have reduced the annual volume of outflow by up to 15% compared to the unimpaired estimate. The unimpaired runoff at the rim stations (valley/foothill boundary) is a satisfactory representation of the pattern and magnitude of natural flow below the major dams (STS P. 2-14) for the reasons described below.
2. Natural Delta outflow is not the same as pre-development hydrology but is calculated as the water balance of the rim station unimpaired flow and estimates of Central Valley precipitation and evapotranspiration (ET) along with the estimated pre-development vegetation types and acreage. TBI's 1998 estimate of the mean annual natural Delta outflow was 23 million acre-feet (MAF) or about 85% of the unimpaired flow – far greater than the approximately 15 MAF/YR (slightly more than half of the unimpaired flow) estimated by the State Water Contractors for the natural outflow and the computed average actual Delta outflow. USGS [3] calculated an outflow of 24 MAF/YR with a “pre-development” groundwater budget using the rim station unimpaired runoff (see STS P. 2-71 and 2-72 for other estimates of natural outflow, including 19th century estimates). The variation in these different estimates is primarily attributable to the values assigned to the areal extent of different vegetation types and their ET rates.
3. Given the altered hydroscape, the unimpaired runoff is the best indicator of the hydroclimate since 1922, and can be used in comparison

with actual runoff as to indicate hydrological alterations to the watershed over time, particularly on an annual and seasonal basis for Delta outflow, and on a monthly time step for the rivers below the dams. That is how we used it in our presentation to your panel and previously, to the State Water Board.

4. While important for a number of reasons, exploration of differences between natural and unimpaired issue does not resolve the questions:

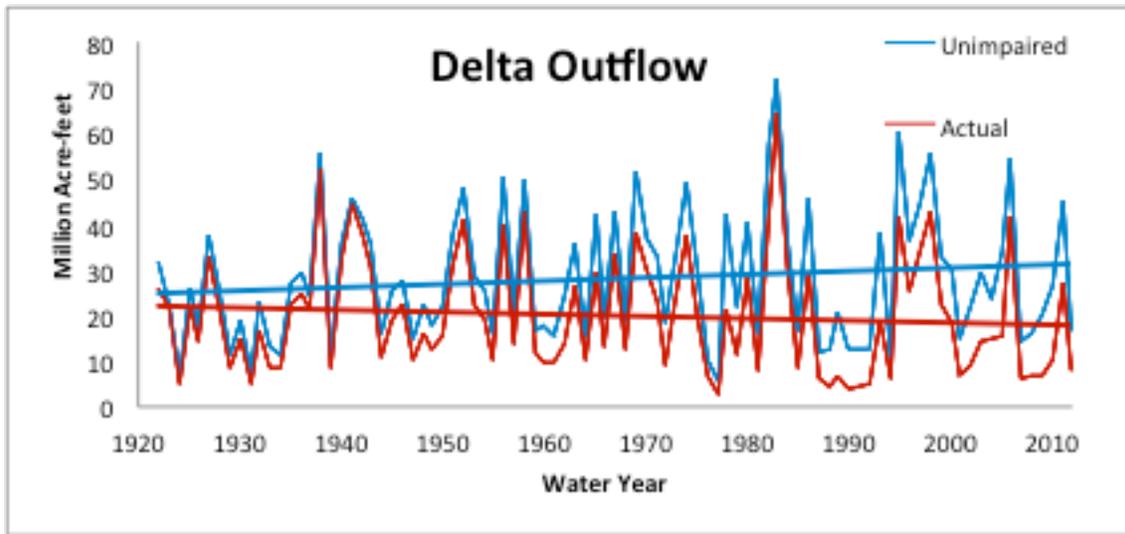
How should Delta outflow be manipulated to address species declines that occurred in the altered 20th century estuarine ecosystem?

How should information about relationships between outflow and biological response observed in this later period be incorporated into protective flow regimes?

More relevant to these issues is the change in actual Delta outflow as the hydroscape was significantly altered in the 20th century by large dams and water transfer projects. The effects of these alterations can be discerned by comparing the computed Delta outflow in the 1922-43 pre-project period (prior to the construction of Shasta and Friant Dams and Federal Delta export facilities), with that of the 1968-2010 post-project period (after the completion of the State Water Project dams and export facilities). When all but the “wet” year types are examined, annual Delta outflow is 30% to 60% less than comparable years of the pre-project period, with even greater percentage reductions in spring outflows in drier year types (STS P. 4-6, Figure IV-C on P.4-5). Exclusion of “wet” year types from this analysis is reasonable because flows during wet years often dwarf the capacity of the built system and can include flood control reservoir releases.

If one includes all years, the mean annual Delta outflow during the post-project period was about 15% less than the pre-project period, however, the mean Central Valley runoff increased 17% in the post-project vs. the pre-project period; so the net effect of human diversions during the post-project period is, obviously, greater than 15%. The driest 11-year period in the 20th century – the 1924-34 pre-project period- had about half the runoff of the 1995-2005 11-year period.

Perhaps more importantly, we have little data on the abundance and population dynamics of fish and wildlife species during the pre-project period, which makes studying the impact of increasing diversions in that period challenging. Again, we believe the relevant questions are about the effect of freshwater flow rates given the landscape we have, and that was the point of our analyses.



5. We agree with the State Water Contractors that additional work can and should be done to explore changes in flow and salinity over time. TBI's offers in 2012 and 2013 of the services of Peter Vorster, our staff hydrologist and the co-author of the Sierra to the Sea report, to the SWC to provide guidance and review of their work on natural and unimpaired flow, were not accepted. It now appears that the SWC's investigation has suffered from excluding such critical expertise from their efforts and overlooking previous work on the issue.

[1] <http://bay.org/publications/from-the-sierra-to-the-sea-the-ecological-history-of-the-san-francisco-bay-delta-waters>

[2] Dr. Phyllis Fox, the primary reviewer of the outflow and salinity sections, is currently engaged by the State Water Contractors in their current work on unimpaired and natural flows.

[3] Williamson, A. K., D. E. Prudic, and L. A. Swain. 1989. Ground-Water Flow in the Central Valley, California. USGS Professional Paper 1401-D.