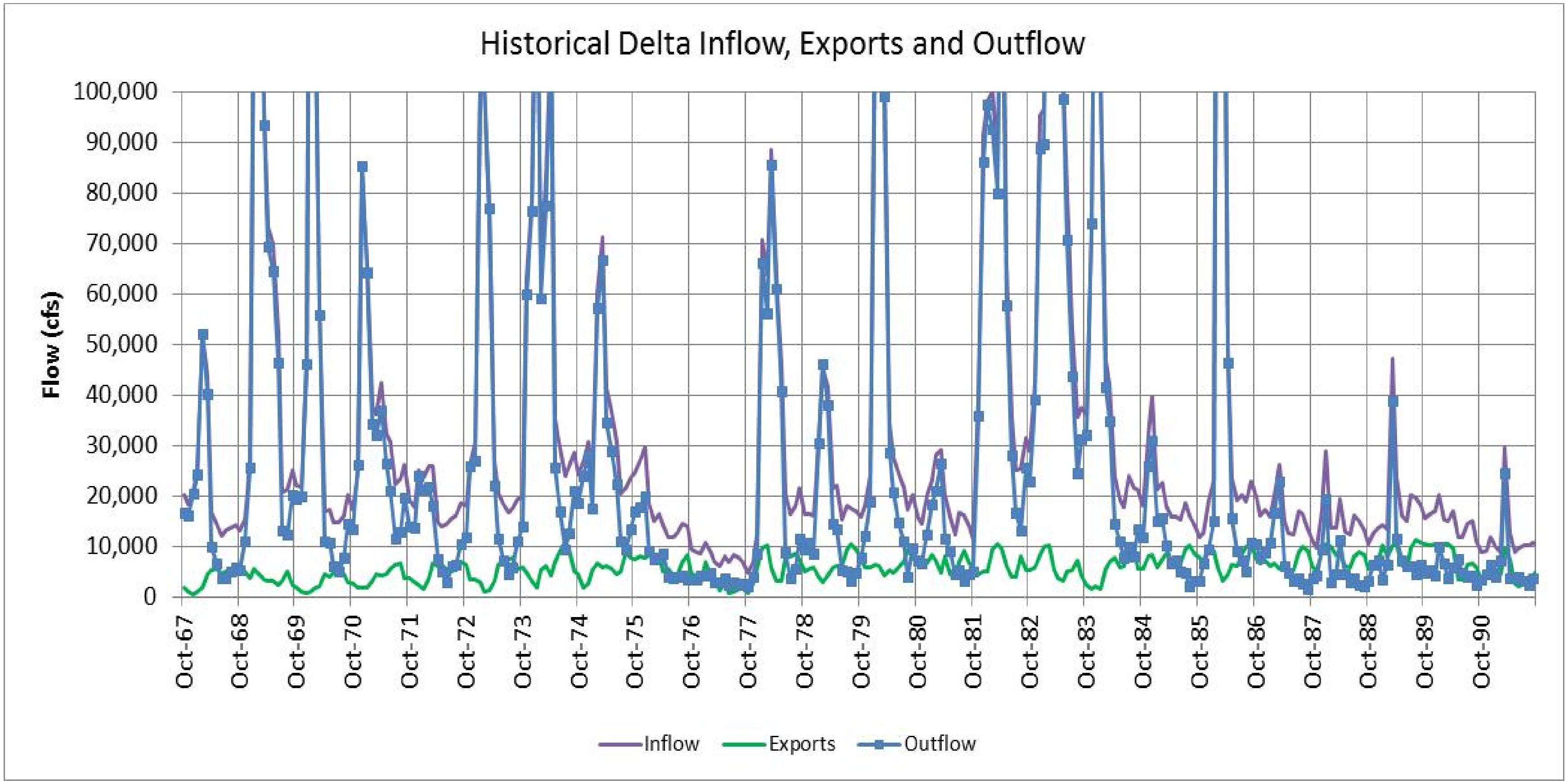
Effects of SWRCB Bay-Delta Water Quality Control Plan Objectives on Delta Water Supply

Introduction

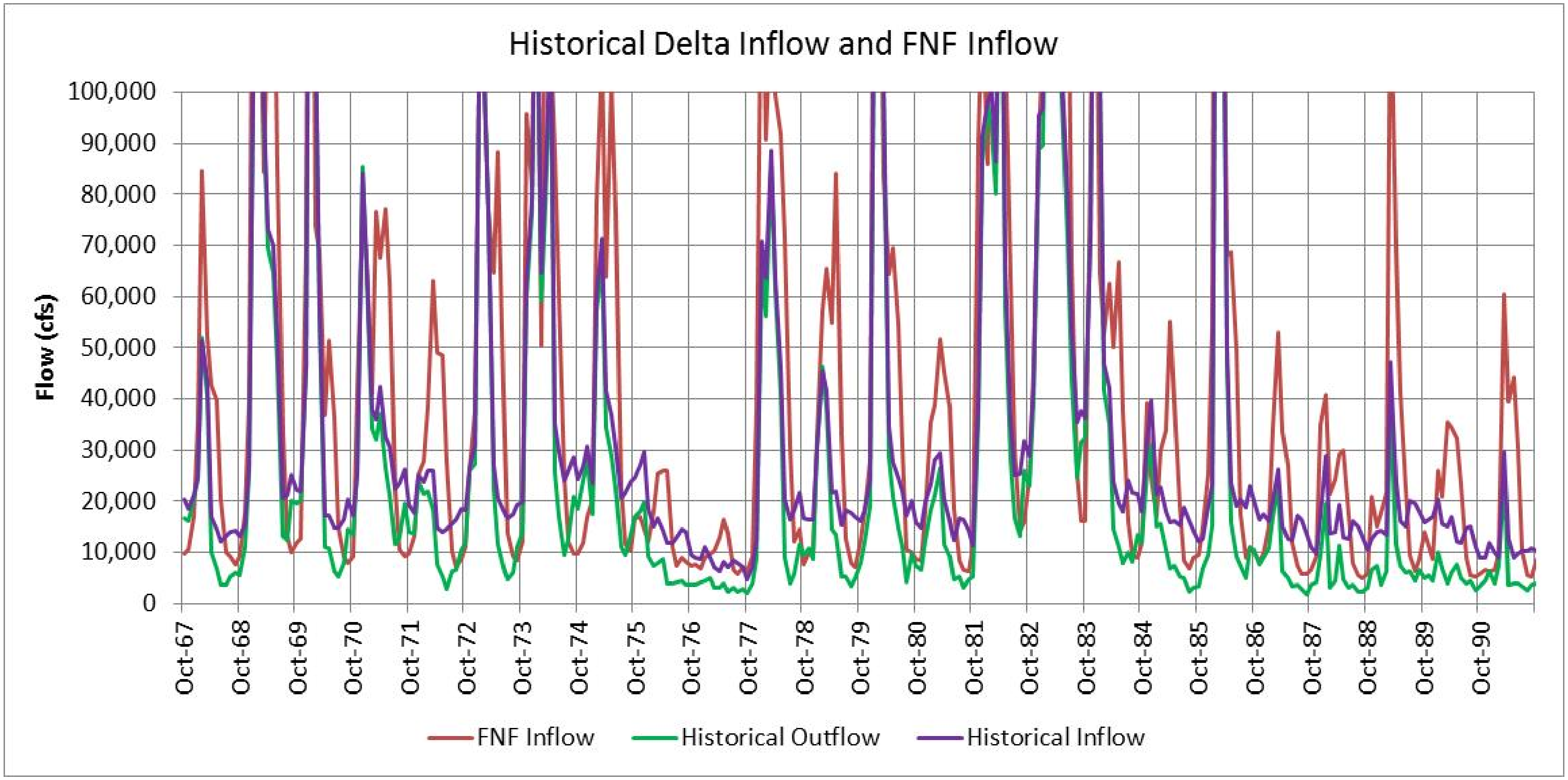
This report provides an overview of the existing Delta objectives and describes the incremental effects of each objective on reducing the water supply that can be exported from the Delta for south-of-Delta beneficial uses (e.g., agriculture, urban, and wildlife refuges). The Delta objectives are developed by SWRCB to protect water quality for beneficial uses (i.e., salinity control) or to protect fish and wildlife uses of the Bay-Delta aquatic habitat and to reduce entrainment of juvenile fish at the exports. A monthly water supply analysis tool (Delta-DEAL, an Excel spreadsheet) was developed to identify and evaluate the incremental effects of existing and revised objectives. The monthly spreadsheet includes several graphs which illustrate the effects of various monthly outflow and export objectives applied to the historical Delta inflows (obtained from DAYFLOW) for 1968-2015. This document provides an introduction to the basic factors controlling Delta water supply: the hydrology (i.e., rainfall, snowpack and runoff); the water facilities (CVP and SWP pumps, canals and reservoirs, water demands); and the Delta objectives (i.e., rules that control outflow or limit export pumping). This report shows some of the graphs with paragraphs below each graph describing the monthly results and comparisons. There are three basic sections:

1) The maximum possible Delta water supply each year is controlled by the monthly Delta inflows and the full contract demands, as well as the existing CVP and SWP Delta Facilities: the CVP and SWP export pumps, the DMC and CA canals, and the San Luis Reservoir.
2) The effects of the D-1641 objectives, as well as the Fall X2 outflow requirements and the Old and Middle River (OMR) export limits on Delta water supply are described, by showing the incremental effects (reductions) from these outflow requirements and export limits.
3) The likely effects of new north Delta intakes on Delta exports are evaluated, for a range of possible intake capacities. The existing D-1641 outflow objectives limit the maximum Delta exports in many months and the north Delta intakes would not allow increased exports in these months. The north Delta intakes would allow increased exports in months when the E/I ratio or OMR restrictions are limiting south Delta exports but the increase in exports would depend on the inflows and the OMR limits, which are conditional, as well as the north Delta intake capacity.

The original draft of this report and the Delta-DEAL spreadsheet were prepared by Russ Brown while at ICF International in December 2016.



This graph shows the historical monthly Delta inflow, water supply exports (CVP & SWP), and Delta outflow for the first half of the study period, WY 1968-1991. There were a few months when Delta inflow (and outflow) was greater than 100,000 cfs, and a few months when Delta inflow was less than 10,000 cfs, but most Delta inflows ranged from 10,000 cfs to 100,000 cfs. Monthly Delta exports generally varied from 5,000 cfs to 10,000 cfs (the export capacity until 1987). Delta outflows were less than 5,000 cfs in several months of most years (3,000 cfs is the minimum outflow in D-1641). Because the CVP and SWP export pumping capacity is now about 15,000 cfs, the monthly exports must be less than 15,000 cfs. The maximum monthly Delta depletion (i.e. evaporation and crop use) is about 5,000 cfs, so the maximum difference between Delta inflow and Delta outflow could be about 20,000 cfs.



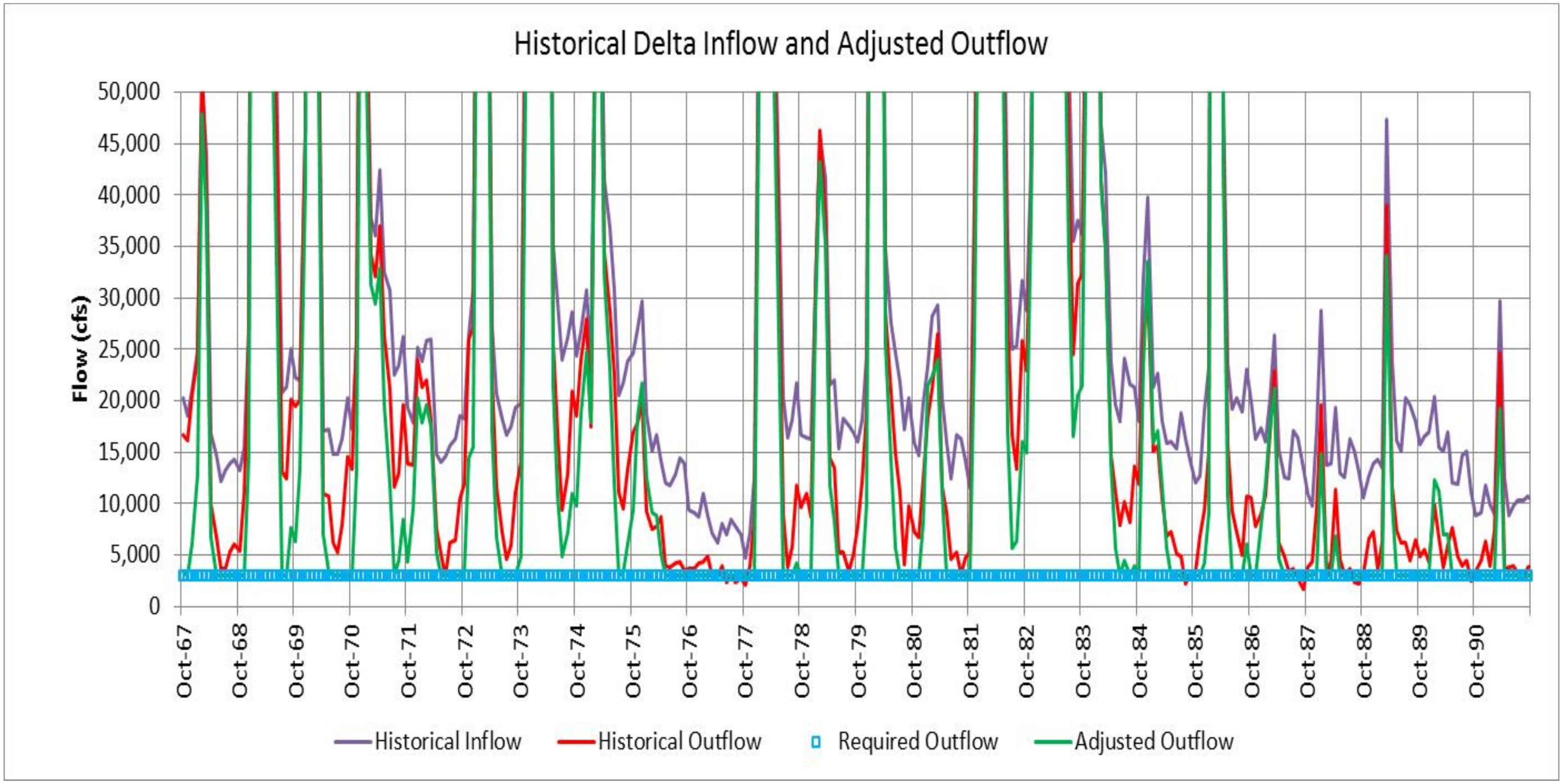
The full natural flow (FNF) or unimpaired runoff (red line) from the Central Valley rivers and tributaries can be compared to the historical Delta inflow (purple line) to identify months when upstream storage or diversions reduced the FNF Delta inflow, and months when releases from upstream reservoirs increased the FNF Delta inflow (e.g., fall months). The minimum monthly FNF inflows each year were usually 5,000 cfs to 10,000 cfs, whereas the minimum Delta outflows (green line) were about 3,000 cfs. Because there is limited upstream storage capacity, much of the FNF runoff in wet years flowed to the Delta. The available upstream storage below the maximum flood control levels in November-March were filled, but any additional runoff was released; some of the snowmelt in April-June can be stored, but excess snowmelt is released from the reservoirs. For this report, we will assume that historical upstream reservoir operations remain the same; the historical Delta inflow will be used to explore the incremental effects of Delta objectives on CVP and SWP exports.

Existing CVP and SWP Delta Facilities and Maximum Possible Delta Water Supply (Exports)

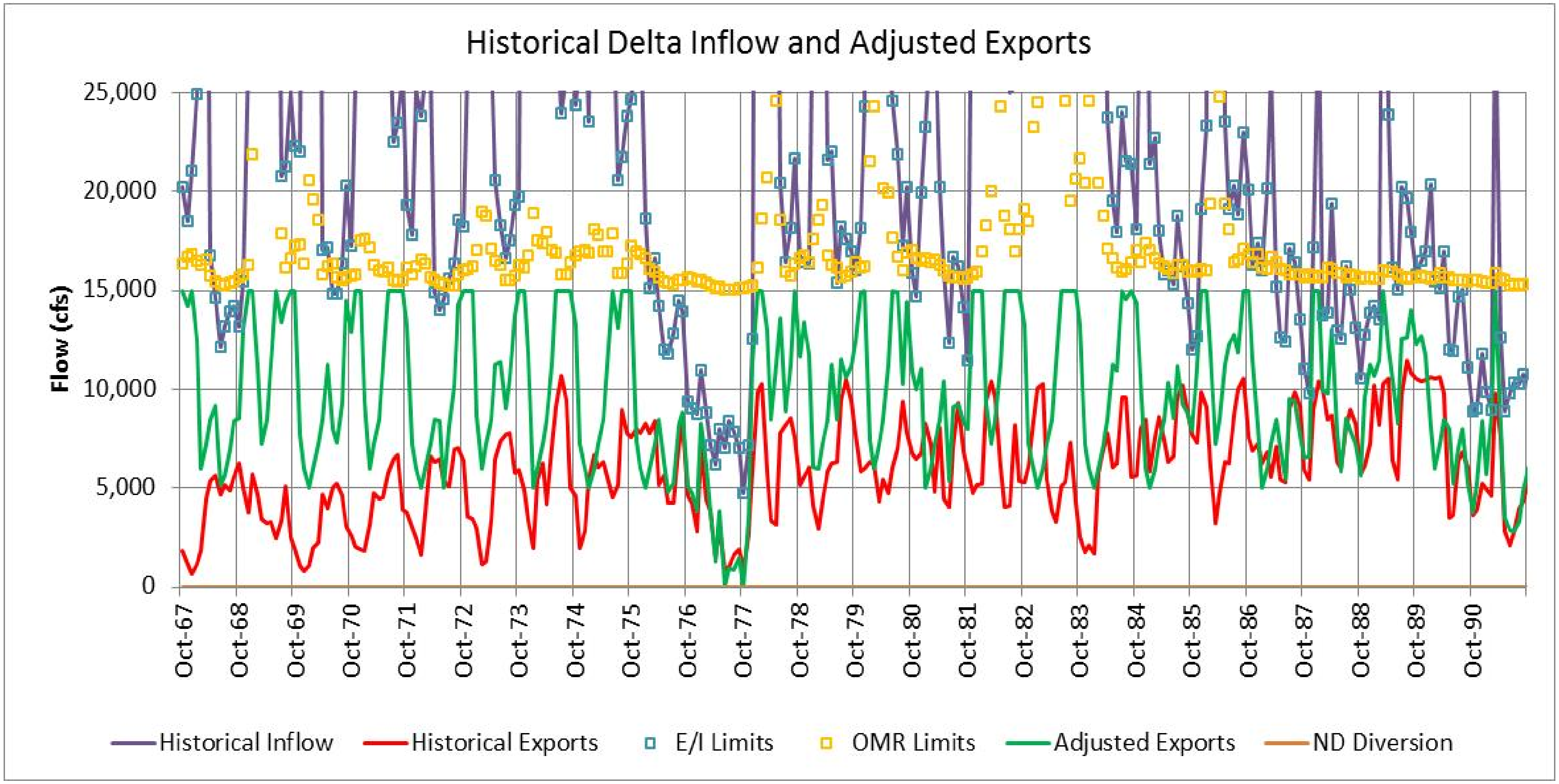
The CVP pumping capacity to the Delta Mendota Canal is about 5,000 cfs with recent renovations of the electrical motors and pumps. The SWP pumping capacity to the California Aqueduct is about 10,000 cfs, so the combined pumping capacity is about 15,000 cfs (30 taf per day). The San Luis Reservoir storage capacity is about 2,000 taf, and this is extremely valuable for seasonal storage of Delta exports during the October-March period when agricultural water demands are low. San Luis Reservoir is shared by CVP and SWP with about 1,000 taf for each. The historical monthly south-of-Delta water deliveries were estimated from the historical exports and changes in San Luis Reservoir storage. The annual demand was assumed to be 7,500 taf with a strong seasonal pattern of 5,000 cfs in January and 18,500 cfs in July. The Delta water supply goal is to provide 7,500 taf/yr of export pumping every year, while allowing full water use in the Delta (Delta diversions and depletions) and maintaining sufficient Delta outflow to control seawater intrusion (i.e., salinity objectives) for beneficial uses in the Delta and for the exports.

If the CVP and SWP export pumps were at full capacity each month, the annual exports could be 10,860 taf, which is higher than the annual demands (7,500 taf). However, there are many months when the Delta inflows were less than 15,000 cfs, so maximum pumping was not possible. Two other factors limit export pumping. Some of the Delta inflow is used for existing diversions in the Delta for drinking water (e.g., CCWD, North Bay aqueduct, Stockton), agricultural water supply and evaporation); and some of the inflow is needed for minimum Delta outflow to control seawater intrusion. The estimated Delta diversions and evaporation uses are about 2,000 taf/yr (from DAYFLOW) , and although precipitation in the Delta provides an average of 1,000 taf/yr, most of this precipitation is in the winter months when the evaporation and Delta diversions are low, so Delta inflow must provide the majority of the Delta depletions (about 1,500 taf/yr). The minimum Delta outflow needed to control seawater intrusion is about 3,000 cfs, which requires a minimum of 2,175 taf/yr. Therefore, at least 3,000 taf/yr of the Delta inflow is required for minimum outflow and Delta diversions and depletions. During July, the maximum Delta depletion is estimated as 4,500 cfs and minimum Delta outflow is 3,000 cfs, so about 7,500 cfs of Delta inflow is required in July before any export pumping is possible.

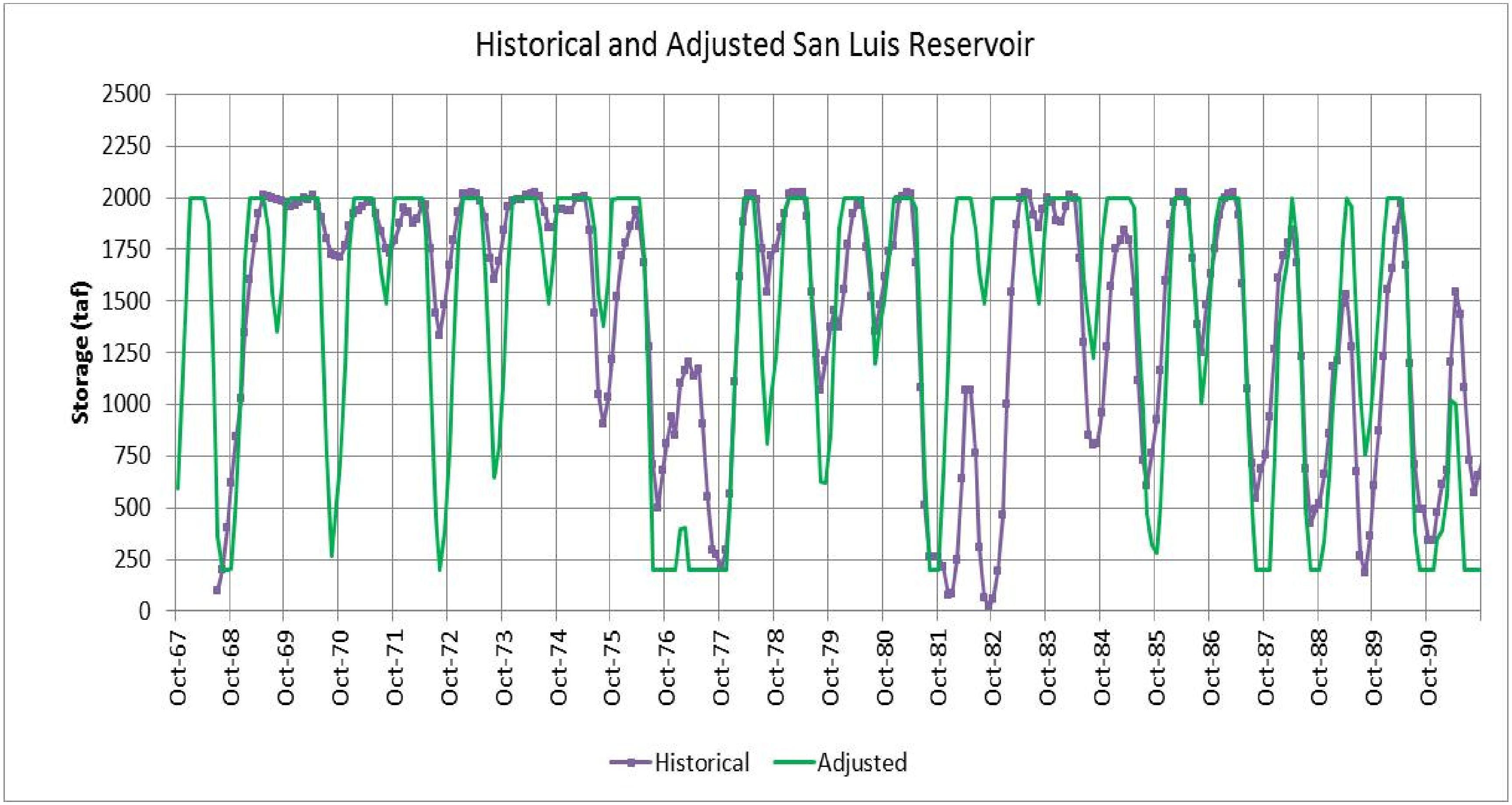
The maximum possible Delta exports were calculated for each year with the historical monthly inflows and Delta depletions and with a specified minimum outflow of 3,000 cfs in all months and full Delta export capacity of 15,000 cfs. The monthly exports may be constrained by the monthly inflow, the export capacity, the monthly water supply demands, and the available San Luis Reservoir storage capacity. This will be considered the maximum water supply case, and will be used to compare the effects of other objectives or limits (i.e., constraints). For reference, the average annual historical Delta inflow for WY 1968-2015 was 23,914 taf, but this varied from 8,222 taf in 1977 to 95,397 taf in 1983. The average annual exports calculated for 1968-2015 (48 years) for the maximum water supply case were 6,981 taf/yr, about 93% of full demands (7,500 taf) and about 29% of average Delta inflows (about 24,000 taf).



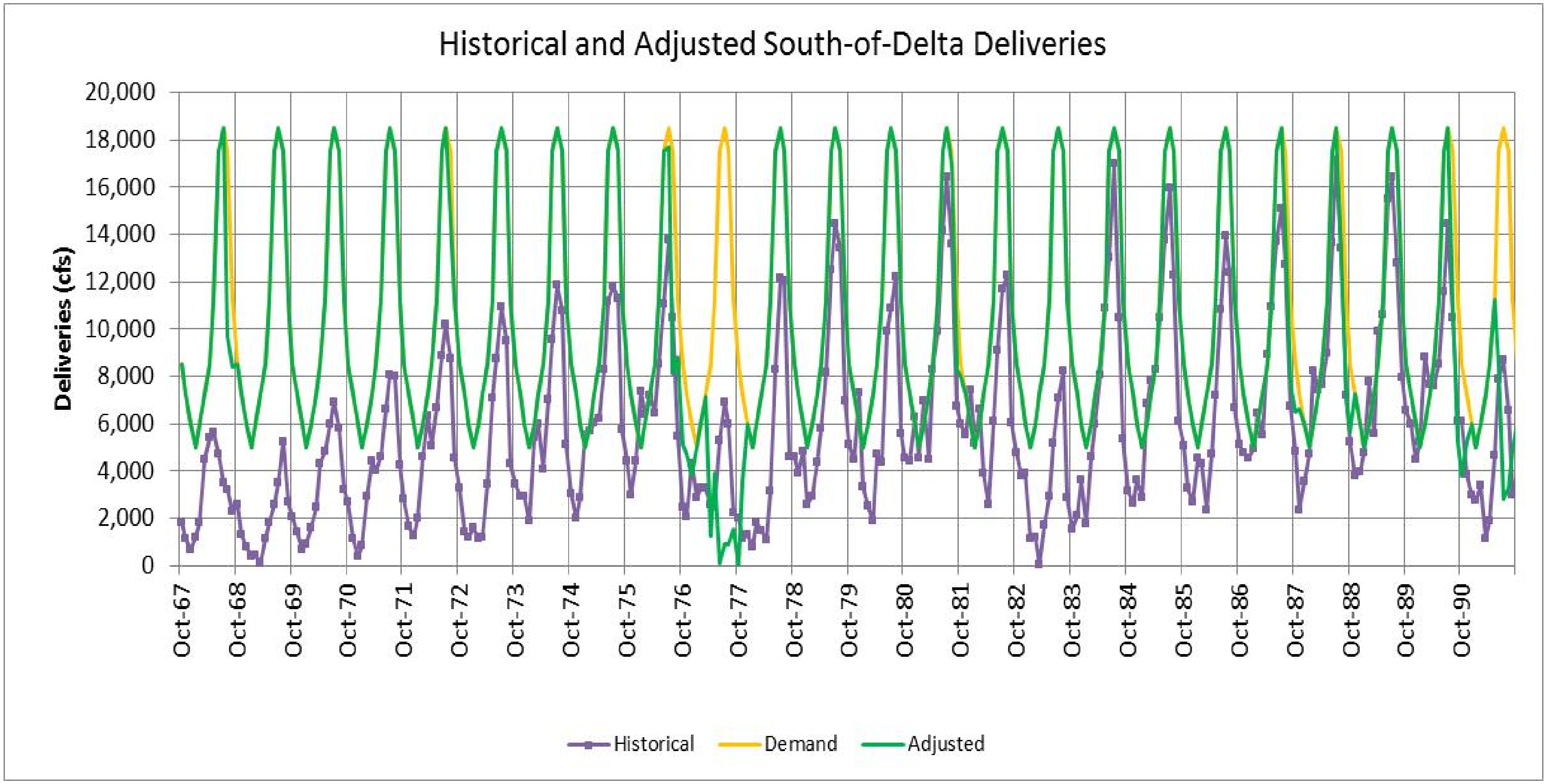
This graph shows the monthly Delta inflow (purple line) and the historical Delta outflow (red line) as well as the adjusted Delta outflow (green line) for the maximum water supply case. Some of the inflow was used for the 3,000 cfs minimum required Delta outflow (bright blue boxes) and some of the inflow was needed for the monthly Delta depletions (i.e., 1,000 cfs to 4,500 cfs), but any additional inflow was exported, to a maximum of 15,000 cfs, unless San Luis Reservoir was filled and full monthly demands were delivered. The calculated outflows were almost always less than the historical outflows; the reductions in outflow for the maximum water supply case were most apparent when the inflow was less than 25,000 cfs. The reduced outflow would have allowed increased seawater intrusion (i.e., higher salinity) if the adjusted outflow was less than 10,000 cfs; whereas changes in outflow that remain above 10,000 cfs would cause only small changes in salinity within the Delta (upstream of Collinsville).



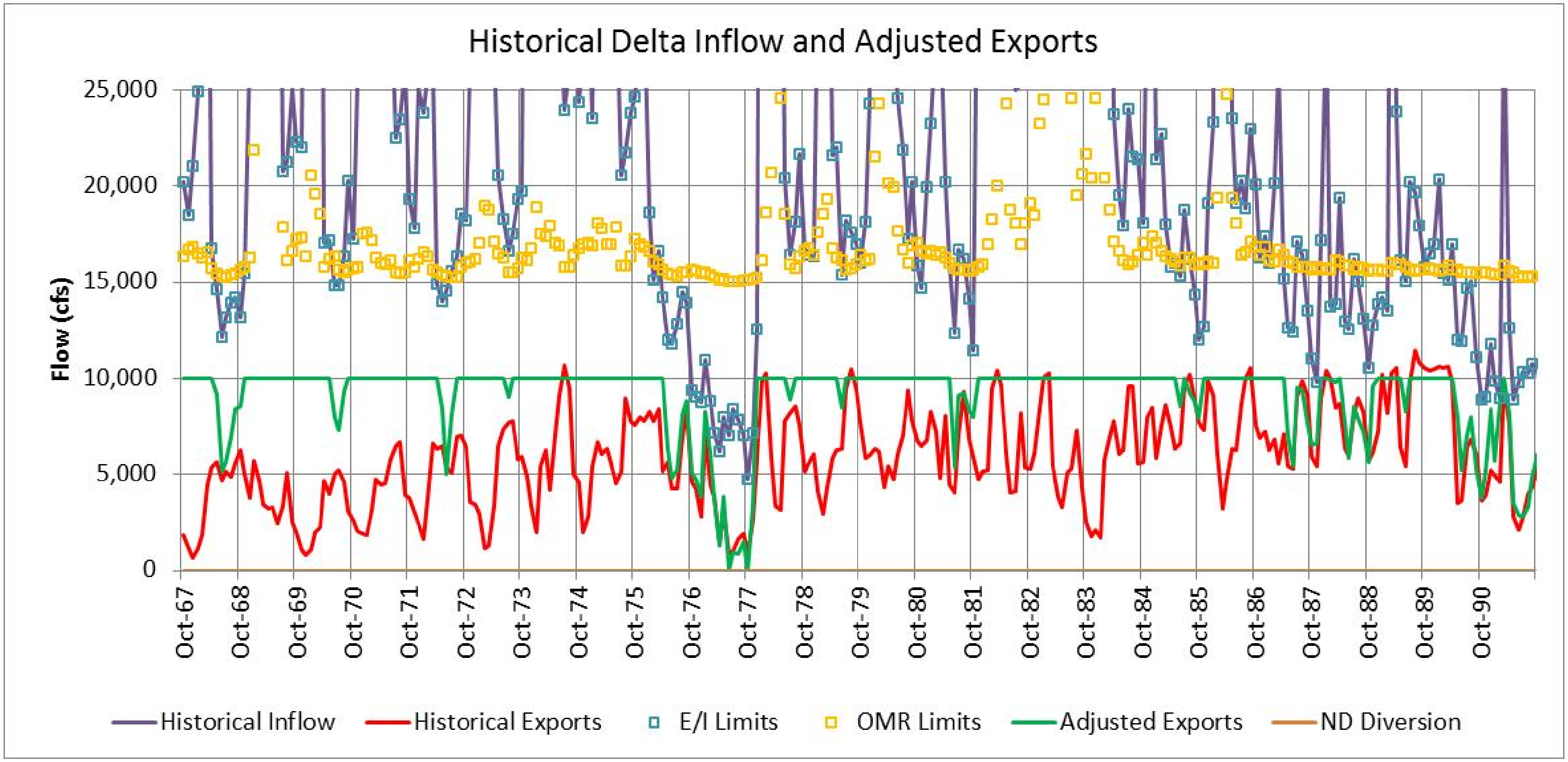
This graph shows the historical inflows (purple line) and the historical exports (red line), as well as the adjusted exports (green line) for the maximum water supply case. The historical exports were increased in almost every month, and were increased to 15,000 cfs for at least a month in most years. The combined CVP and SWP pumping capacity was only 10,000 cfs until 1987, when SWP installed additional pumping capacity. The calculations indicate that exports of 15,000 cfs would be possible in almost every year, and that a substantial portion of the exports were obtained with this increased capacity (monthly exports between 10,000 cfs and 15,000 cfs). The average annual calculated exports were 6,981 taf and the calculated exports were similar to the historical exports in the dry periods of 1976-1977 and 1990-1991. A higher pumping capacity (15,000 cfs) may increase the maximum possible exports in some dry years by allowing higher exports in a few months.



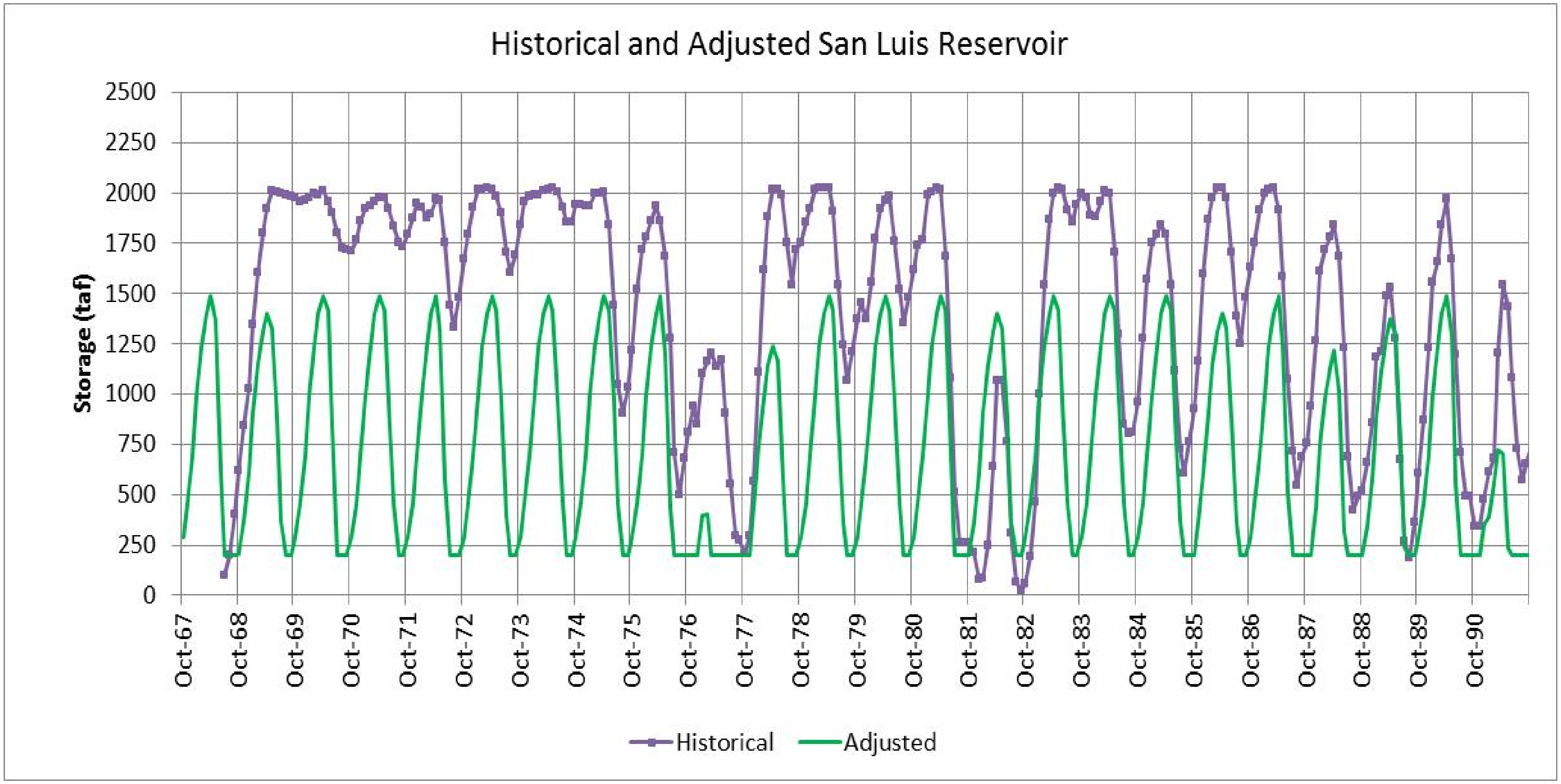
This graph shows the historical combined CVP and SWP San Luis Reservoir storage (purple line) and the calculated San Luis Reservoir storage (green line) for the maximum water supply case. The calculated storage was quite variable in most years, filling to capacity in the October-March period and then being drawn-down to the minimum specified storage (200 taf) to help provide the higher water supply demands in the summer months (i.e., exports plus San Luis Reservoir releases). The seasonal San Luis Reservoir storage patterns were similar to the historical storage pattern in several years (e.g., 1983-1991) because the calculated maximum exports were similar to the historical exports. The seasonal storage available in San Luis Reservoir (1,800 taf) was well matched with the seasonal demands (7,500 taf) and the maximum pumping capacity (10,860 taf). The existing CVP and SWP facilities operate effectively with the full range of Delta inflows and maximum water demands.



This graph shows the historical monthly water supply deliveries (purple line) compared to the assumed monthly water supply demands (gold line) and the calculated deliveries (green line) for the maximum water supply case. The monthly calculated water deliveries matched the maximum demands in most years, and were much higher than the historical water deliveries, especially in the first ten years when SWP deliveries were increasing; the calculated deliveries were lowest in the 1976-1977 and 1990-1991 dry periods. The highest historical water delivery shown on this graph for WY 1968-1991 was 5,500 taf in 1985. Most of the calculated annual deliveries met the full demands (7,500 taf), and the lowest annual deliveries shown on this graph were 2,437 in 1977 and 4,374 taf in 1991.



This graph shows the historical exports (red line) and the calculated exports with a minimum outflow of 3,000 cfs and a reduced pumping capacity of 10,000 cfs. The maximum annual exports with 10,000 cfs capacity would be about 7,250 taf, slightly less than the full demands. The average annual exports with 10,000 cfs pumping capacity was 6,546 taf, 435 taf less than the maximum water supply case with 15,000 cfs. Increasing the capacity by 5,000 cfs (3,620 taf/yr) allowed the calculated average exports to increase by 435 taf/yr (12% of the increased capacity). The Delta-DEAL spreadsheet was used to compare other export capacities. A pumping capacity of 5,000 cfs would provide a maximum average water supply of 3,515 taf (47% of full demands), a capacity of 7,500 cfs would provide 5,118 taf (68% of full demands), a capacity of 10,000 cfs would provide 6,546 taf (87% of full demands), a capacity of 12,500 cfs would provide 6,945 taf (92.5% of demands), and a capacity of 15,000 cfs would provide 6,981 taf (93% of demands). The water supply benefits (i.e., increased % of demands) for pumping capacity increments decreased rapidly above 12,500 cfs.



This graph shows the historical San Luis Reservoir storage (purple lines) and the calculated storage with a reduced pumping capacity of 10,000 cfs. San Luis Reservoir filled and drained in response to the monthly pumping and water demands and the maximum San Luis Reservoir storage was 1,500 taf in April of each year. This reduced pumping capacity case illustrates that the CVP and SWP facilities have been designed to work together to meet the combined seasonal water demands. Changing the export capacity, or the San Luis Reservoir storage capacity, or the water supply demands will have effects on the Delta water supply capability (e.g., maximum exports) and reliability (e.g., average and minimum exports).

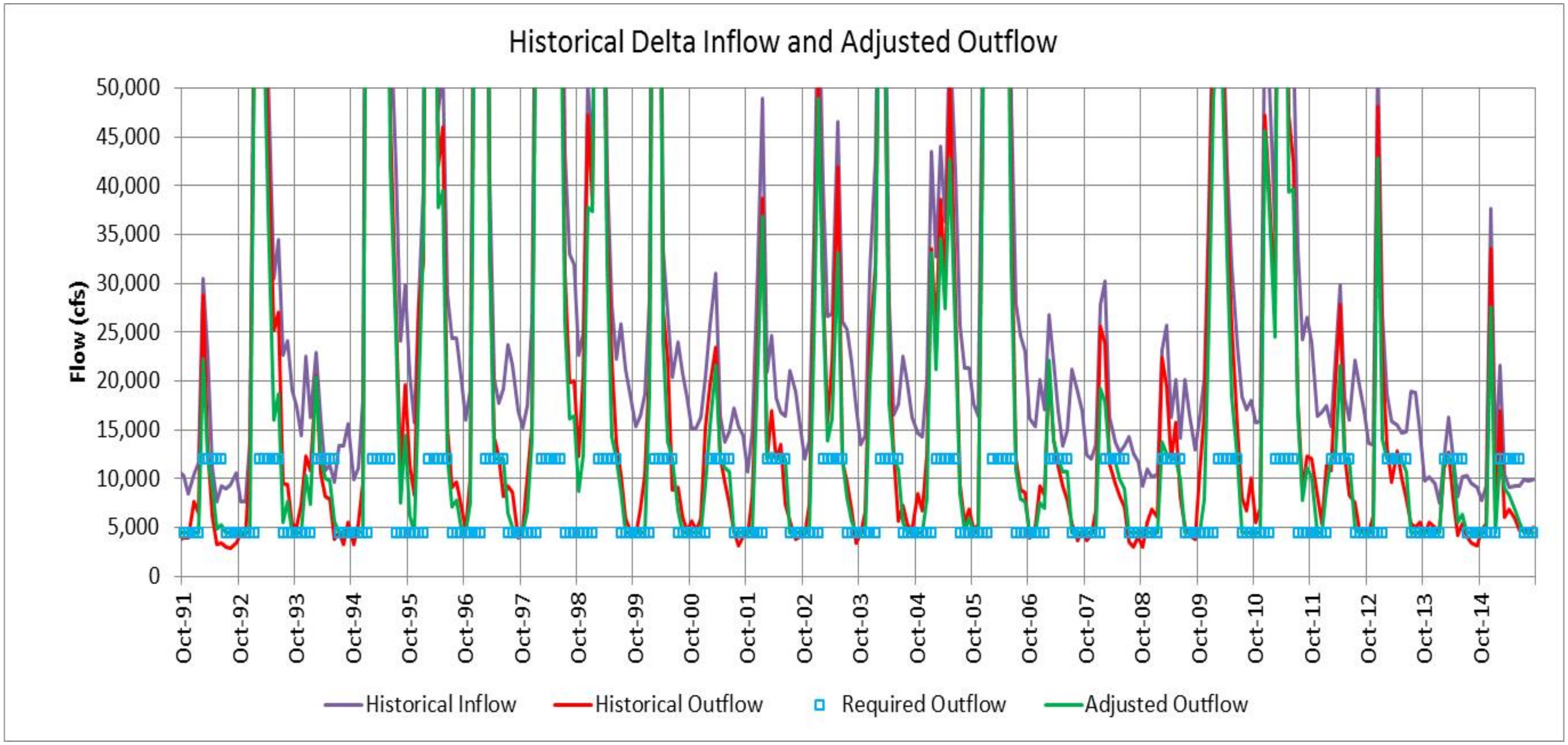
Effects of D-1641 Objectives and Biological Opinion Restrictions

This section describes the incremental water supply effects of the basic D-1641 objectives. The required Delta outflow is regulated by minimum monthly outflows, X2 (salinity gradient location) in the months of February-June, and maximum monthly salinity (EC) requirements at various locations in the Delta. For each month, the highest outflow objective will control the Delta operations. The D-1641 objectives vary with water year type, an index that includes the current year's runoff and the previous year's runoff. Because the runoff index is not reliably known until March, the first 6 months of each water year use the prior year's runoff index. The year-type variations in the monthly outflow objectives were not included in the Delta-DEAL spreadsheet; specified monthly minimum outflows were applied to every year.

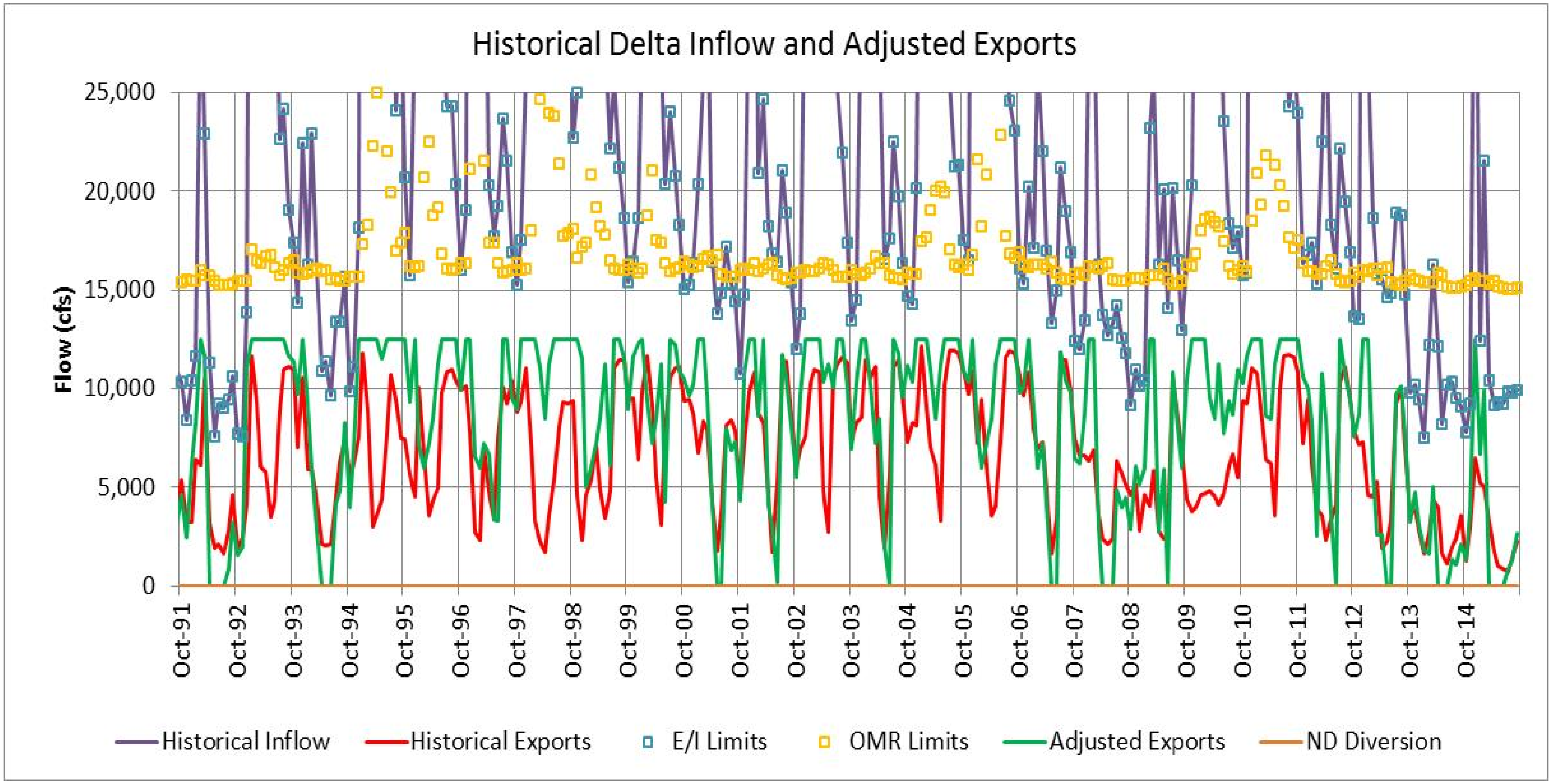
Several minimum outflows were compared to demonstrate the incremental effects of outflow requirements on Delta water supply. For example, constant outflows of 4,500 cfs, 6,000 cfs and 7,500 cfs were compared to determine the incremental effects of higher outflow objectives. The D-1641 X2 objectives were approximated with a 7,500 cfs or 12,000 cfs outflow requirement in February-June with a 3,000 cfs or 4,500 cfs requirement in July-January. The primary D-1641 export limits are the monthly export/inflow (E/I) ratios, which are 35% during February-June (X2 months) and 65% for July-January. Although not included in D-1641, the export capacity is currently limited to about 12,500 cfs (based on USACE restrictions on CCF diversions).

Here are some results from the Delta-DEAL spreadsheet model, with the export capacity reduced to 12,500 cfs. With a minimum outflow of 3,000 cfs the average annual exports were 6,945 taf (92.5% of demand). Increasing the minimum outflow to 4,500 cfs in every month reduced the average annual exports to 6,664 taf (89% of demand). Increasing the minimum outflow to 6,000 cfs reduced the average annual exports to 6,320 taf (84% of demand), and increasing the outflow to 7,500 cfs reduced the average annual exports to 5,922 taf (79% of demand). An outflow of 9,000 cfs reduced the average annual exports to 5,462 taf (73% of demands), an outflow of 10,500 cfs reduced the average annual exports to 5,003 taf (66% of demands), and an outflow of 12,000 cfs reduced the average annual exports to 4,523 taf (60% of demands). The D-1641 outflow requirements can be approximated as 7,500 cfs in February to June (X2) and 3,000 cfs in July-January; this case reduced the average annual exports to 6,624 taf (88% of demands). A higher approximation of the D-1641 outflow objectives would be 12,000 cfs in February-June (X2) and 4,500 cfs in July-February; this case reduced the average annual exports to 6,042 taf (80% of demands).

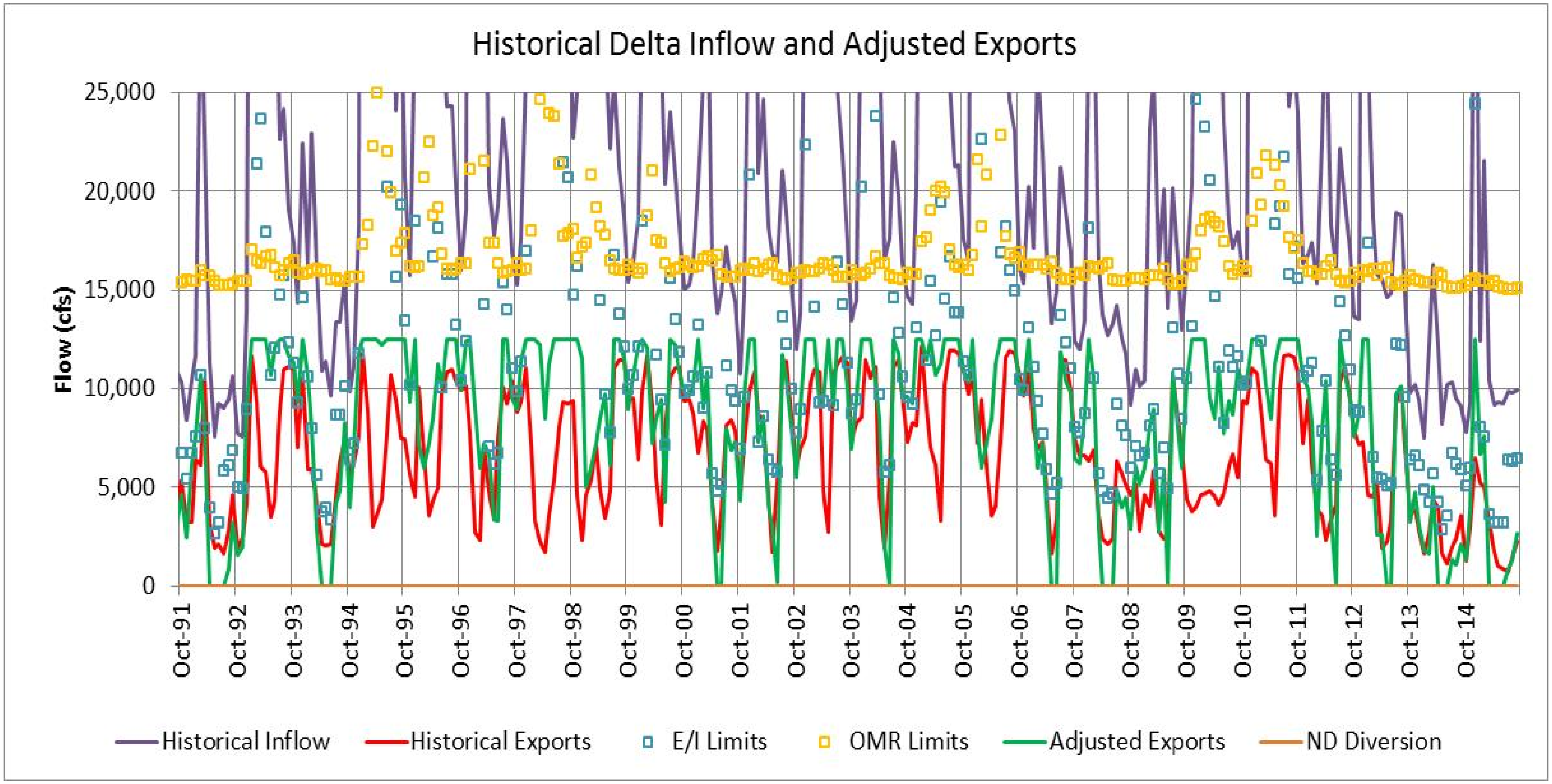
The USFWS reverse OMR flow restrictions on exports from January-June can be approximated with a maximum of 5,000 cfs, but can be reduced to 2,500 cfs or less by the USFWS smelt working group based on fish distribution and turbidity monitoring. The USFWS Fall X2 requirements in above normal and wet years (40% of years) can be approximated as 7,500 cfs outflow in September-October following above normal years and 12,000 cfs in September-October following wet years. Here are a series of graphs illustrating the effects of these D-1641 objectives and fish protections on exports and outflow.



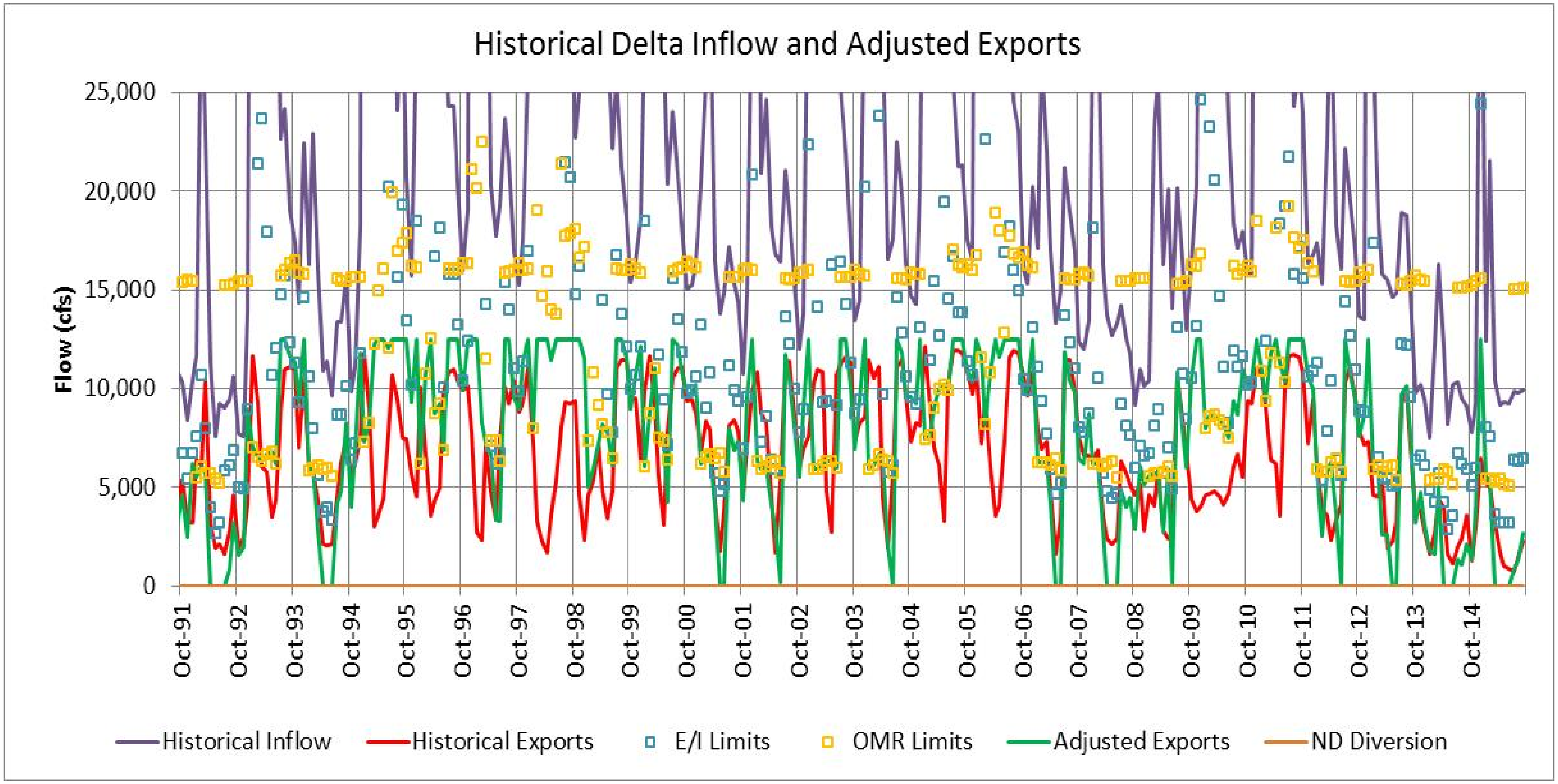
This graph shows the historical inflows (purple line) and historical outflows (red line) with the calculated outflow for WY 1992-2015, the second half of the study period. The required Delta outflow was 12,000 cfs in February-June (X2 months) and 4,500 cfs in July-January, which was the higher approximation of the D-1641 outflow and X2 objectives. Most of the salinity objectives are satisfied with an outflow of 4,500 cfs. The 4,500 cfs outflow in the summer and fall was higher than the historical outflows in some months of some years. The outflow of 12,000 cfs in February-June (X2) was higher than the historical outflows in a few months of several years, but the outflows were much higher than 12,000 cfs in February-June of most years. There were a few years when the inflows in May and June were not sufficient to provide 12,000 cfs of outflow. The actual X2 objectives are reduced when the previous month's runoff was low, but the minimum X2 outflow of 7,100 cfs may be hard to meet when Delta inflows are low. The E/I objectives are the most adaptive objectives because they vary directly with the Delta inflow.



This graph shows the historical inflow and exports (red line) compared to the calculated exports for WY 1992-2015, with the higher approximation of D-1641 outflow and X2 objectives. The calculated exports were 12,500 cfs (specified capacity) for several months in most years. The calculated exports were similar to the historical exports during most of this period, suggesting the approximated D-1641 outflow and X2 objectives were reasonably close to the actual D-1641 objectives. The calculated average annual exports were 6,042 taf (80.5% of demands), about 900 taf less than the average exports of 6,945 taf (92.5% of demand) with 3,000 cfs minimum outflow. The average annual exports with the lower approximation of D-1641 outflow and X2 objectives (7,500 cfs in February-June, 3,000 cfs in July-January) were 6,624 taf, about 320 taf less than average exports with 3,000 cfs outflow. The 1,500 cfs additional outflow in July-January (630 taf) and the 5,000 cfs additional outflow in February-June (1,500 taf) reduced average exports by about 580 taf.



This graph shows the historical inflows (purple line) and historical exports (red line) compared to the calculated exports with the higher approximation of D-1641 outflow and X2 objectives, and with D-1641 E/I objectives (35% in February-June; 65% in other months). The allowable exports with D-1641 E/I objectives (blue boxes) sometimes limited the exports, but most of the E/I limits were greater than the calculated exports with the approximated D-1641 outflow and X2 objectives. Adding the E/I objectives to the higher approximation of D-1641 outflow and X2 objectives reduced the average annual exports by about 75 taf, from 6,042 taf to 5,968 (79% of demands). Adding the D-1641 E/I objectives to the lower approximation of D-1641 outflow and X2 objectives reduced the average annual exports by about 167 taf, from 6,624 taf to 6,457 (86% of demands). The E/I objectives did not often limit the exports; the exports were usually limited by the Delta outflow and X2 objectives.



This graph shows the historical inflows (purple line) and historical exports (red line) compared to the calculated exports with the higher approximation of D-1641 outflow and X2 objectives, the D-1641 E/I objectives and the USFWS OMR reverse flow restrictions on exports approximated as January-June reverse OMR flow of 5,000 cfs. The assumed OMR reverse flow limits (gold boxes) often limited exports, and reduced the average annual exports by about 443 taf, from 5,968 taf to 5,525 (74% of demands). Adding the assumed OMR reverse flow limits to the lower approximation of D-1641 outflow objectives reduced the average annual exports by about 431 taf, from 6,457 taf to 6,026 (80% of demands). If the OMR reverse flow limits were 2,500 cfs in January-June of every year, the average annual exports were reduced by an additional 470 taf from the higher outflow objectives and 575 taf for the lower approximation of outflow objectives. The reverse OMR limits have a large effect on average Delta exports.

Summary of Effects of D-1641 Objectives and Fish Protection Measures

Beginning with the maximum Delta water supply case, with an export capacity of 15,000 cfs, a minimum outflow of 3,000 cfs, and a full demand of 7,500 taf, the effects of the various D-1641 objectives were evaluated with the Delta-DEAL spreadsheet model of monthly Delta outflows and exports with specified monthly objectives. Although the actual D-1641 objectives are adaptive, depending on runoff or water year type, the objectives are approximated in Delta-DEAL with a set of monthly outflow requirements and export limits applied to every year in the 1968-2015 sequence. The following incremental changes in Delta water supply were calculated:

1) The maximum average Delta water supply, with 15,000 cfs pumping capacity and 3,000 cfs outflow, was 6,981 taf (93% of 7,500 taf demand). The full water supply was pumped in many years but the average water supply was reduced by low flow years.

2) The effects of export pumping capacity on Delta water supply, with 3,000 cfs minimum outflow, were evaluated with the following results:

Pumping Capacity (cfs)	Outflow (cfs)	Average Exports (taf)	Export Increment (taf)	Percentage of Demands
15,000	3,000	6,981		93%
12,500	3,000	6,945	-36	93%
10,000	3,000	6,546	-399	87%
7,500	3,000	5,118	-1,428	68%
5,000	3,000	3,514	-1,604	47%

3) The effects of required minimum outflow on Delta exports, with 12,500 cfs pumping capacity, were evaluated with the following results:

Pumping Capacity (cfs)	Outflow (cfs)	Average Exports (taf)	Export Increment (taf)	Percentage of Demands
12,500	3,000	6,945		93%
12,500	4,500	6,664	-281	89%
12,500	6,000	6,320	-344	84%
12,500	7,500	5,922	-398	79%
12,500	9,000	5,462	-460	73%
12,500	10,500	5,003	-459	66%
12,500	12,000	4,523	-480	60%

4) The D-1641 outflow and X2 objectives were approximated with lower objectives (7,500 cfs in February-June; 3,000 cfs in other months) and higher objectives (12,000 cfs in February-June; 4,500 cfs in other months). The average exports with the lower objectives was 6,624 taf (86% of demand), a reduction of 321 taf (for the 4,500 cfs higher outflows in February-June) from the 3,000 cfs minimum outflow case. The average exports with the higher objectives was 6,042 taf (80% of demand), a reduction of 622 taf (for the 7,500 cfs higher outflows in February-June) from the 4,500 cfs minimum outflow case.

5) The effects of the D-1641 E/I objectives were relatively small; exports were generally limited by the D-1641 outflow and X2 objectives. The E/I objective with the higher X2 objectives reduced the exports by about 74 taf. The E/I objective with the lower X2 objectives reduced the exports by about 167 taf.

6) The USFWS OMR reverse flow limits for January-June are adaptive, based on fish distribution and turbidity monitoring. If the OMR limits were 5,000 cfs for January-June, the exports would be reduced by about 431 taf for the lower X2 objectives, and the exports would be reduced by about 443 taf for the higher outflow and X2 estimate. If the OMR limits were 2,500 cfs for January-June the exports would be reduced by an additional 470 taf for the higher outflow objectives and by an additional 575 taf for the lower outflow objectives. The OMR reverse flow limits have a large effect on average exports.

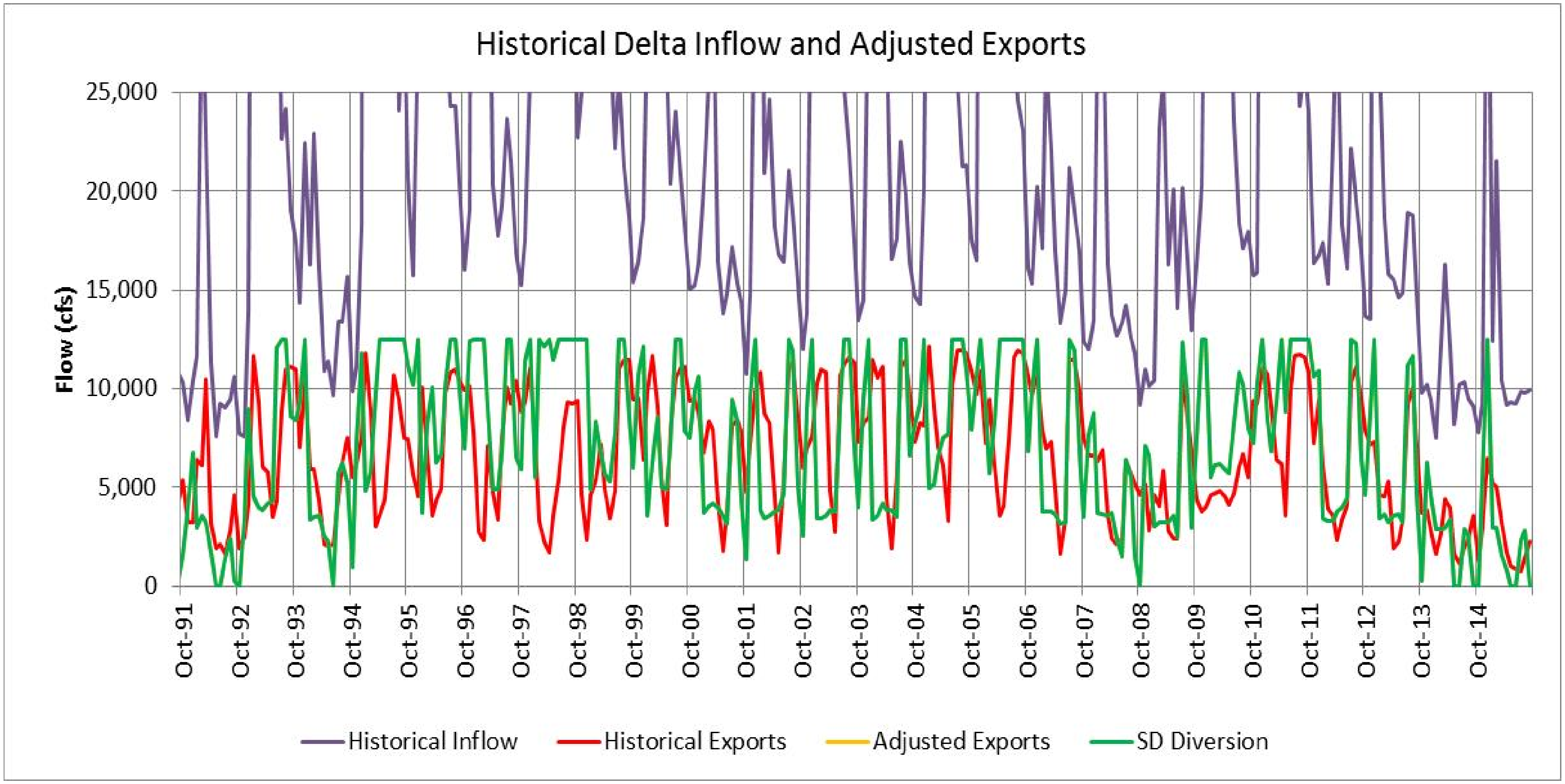
The DWR CALSIM model was used to calculate the average Delta exports for Existing Conditions (including D-1641 and OMR restrictions) for the BDCP and WaterFix EIR/EIS evaluations. The average annual CVP and SWP exports for WY 1922-2003 was 5,144 taf. This was very similar to the average exports calculated with the Delta-DEAL spreadsheet for 1968-2015 of 5,055 taf with the higher estimate of D-1641 outflow and X2 objectives and with OMR limits of 2,500 cfs. This suggests that the Delta-DEAL spreadsheet calculations were similar to the CALSIM model results.

Evaluating Effects of New Delta Facilities on Delta Exports

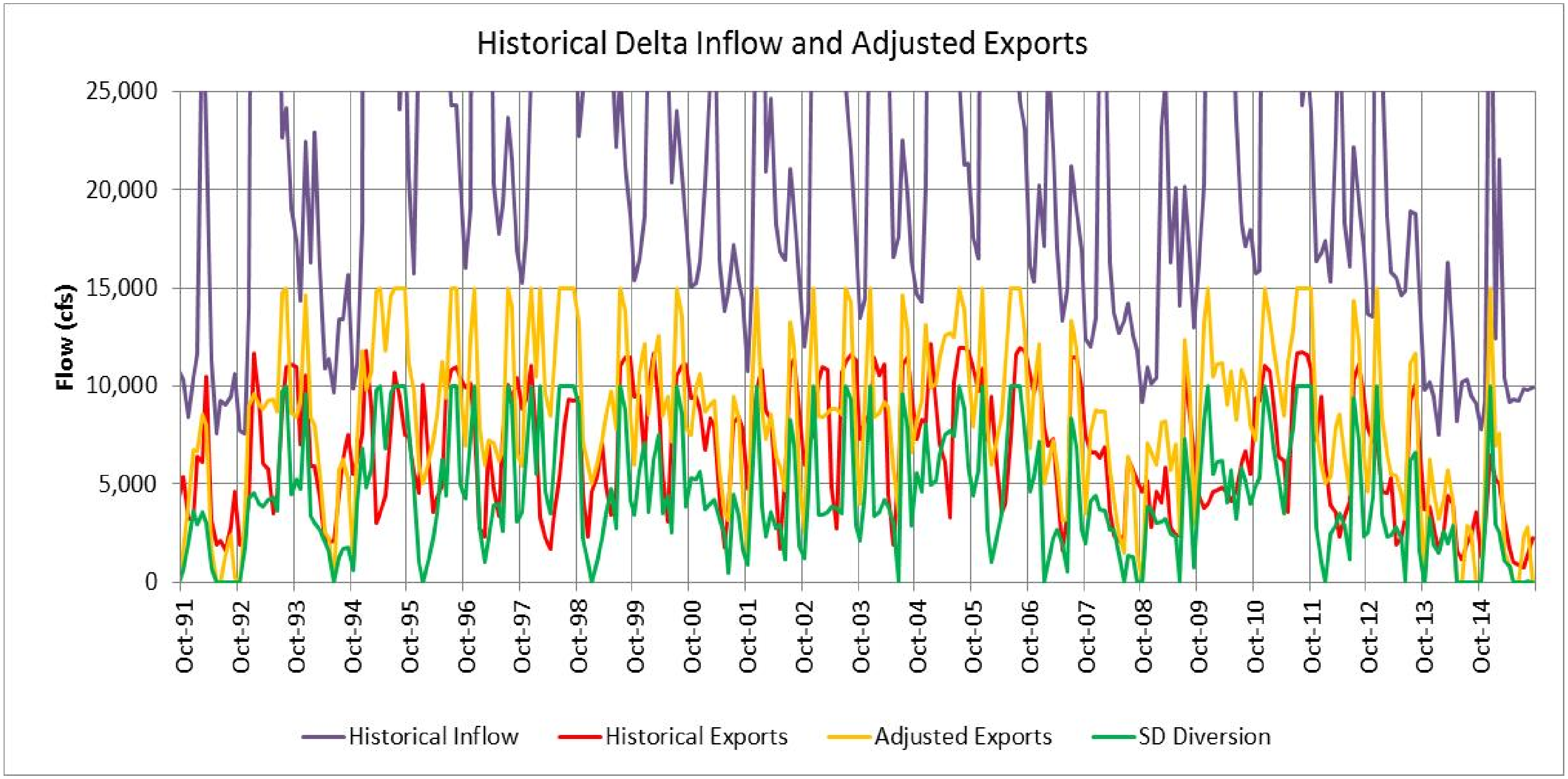
The combination of the D-1641 objectives and the fish protections included in the 2008 USFWS BO and the 2009 NMFS BO have reduced the average Delta water supply (exports) to about 5,000 taf (67% of demands). There is considerable interest in construction of new Delta facilities that would improve fish habitat and fish survival and also increase exports. The most familiar example is north Delta intakes with fish-screens that would allow diversions from the Sacramento River that would reduce the reverse OMR flows and reduce entrainment of fish at the south Delta intakes. Diversions at the north Delta intakes could reduce the entrainment of migrating fish (e.g., Chinook and steelhead) and reduce the upstream movement and entrainment of estuarine fish (e.g., delta smelt and longfin smelt) at the south Delta intakes. The diversion capacity of the north Delta intakes was increased from 2,500 cfs to 10,000 cfs to estimate the potential increases from the average Delta exports. The effects of a north Delta intake(s) were evaluated for OMR reverse flow limits of 2,500 cfs, with the following results:

North Delta Capacity (cfs)	North Delta Diversions (taf)	South Delta Diversion (taf)	Percent Reduction in South Delta Exports	Total Exports (taf)	Incremental Change in Total Exports (taf)	Percent of Demand
0	0	5,223		5,223		70%
2,500	1,673	4,213	-19%	5,886	663	78%
5,000	3,154	3,007	-42%	6,126	240	82%
7,500	4,245	1,979	-62%	6,224	98	83%
10,000	4,940	1,316	-75%	6,255	31	83%

The average annual exports of 5,223 taf were increased to 5,886 taf (78% of demands) with a 2,500 cfs intake, to 6,126 taf (82% of demands) with a 5,000 cfs intake, to 6,224 taf (83% of demand) with a 7,500 cfs intake, and to 6,255 taf (83% of demand) with a 10,000 cfs intake. The largest water supply increments were achieved with the 2,500 cfs and 5,000 cfs north Delta intakes; little additional water supply was achieved with a 7,500 cfs intake and almost no additional benefits were achieved with a 10,000 cfs intake. A 5,000 cfs capacity north Delta intake would appear to provide the majority of the water supply benefits.



This graph shows the historical inflows and historical exports (red line) for WY 1992-2015 with the calculated exports (green line) for the reference case that included a pumping capacity of 12,500 cfs, the lower estimate of D-1641 outflow and X2 objectives, 2,500 cfs OMR reverse flow limits in January-June, and the lower estimate of the Fall X2 protection (7,500 cfs in September and October). The calculated average annual exports for this reference case were 5,223 taf (70% of demands). The north Delta intake capacity was increased from 2,500 cfs to 10,000 cfs to determine the water supply benefits as well as the reduced south Delta diversions that would likely provide reduced fish entrainment benefits. A 2,500 cfs capacity would increase total exports to 5,886 taf (78% of demand); a 5,000 cfs capacity would increase total exports to 6,126 (82% of demand); a 7,500 cfs capacity would increase total exports to 6,224 taf (83% of demand); and a 10,000 cfs intake would increase exports to 6,255 taf (83% of demand).



This graph shows the historical inflow and historical exports (red line) compared to the south Delta diversions (green line) and total exports (gold line) using new north Delta intakes with a capacity of 5,000 cfs. The average annual total exports were increased from 5,223 taf (70% of demand) for the reference case to 6,126 taf (82% of demand). The north Delta intake bypass flow rules control the fraction of the Sacramento River water diverted at the north Delta intake. The bypass flow was the minimum Delta outflow and the diversion fraction was 75% of the Sacramento River water above the bypass flow. The calculated average annual north Delta diversions were 3,154 taf, so the north Delta intake was operated at 87% of capacity. The south delta exports were reduced from 5,223 taf to 3,007 taf (42% reduction), providing considerable benefits from reduced entrainment of migrating and estuarine fish.