A Century of Salt Water Barriers in the Delta

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June 5, 2015 edition

Since the late 19th century, California's basic plan for water resource development has been to export water from the Sacramento River and the Delta to the San Joaquin Valley and southern California. Unfortunately, this basic plan ignores the reality that the Delta is the very definition of an *estuary*: it is where fresh water from the Central Valley's rivers meets salt water from tidal flow to the Delta from San Francisco Bay. Productive ecosystems have thrived in the Delta for millenia prior to California statehood.

But for nearly a century now, engineers and others have frequently referred to the Delta as posing a "salt menace," a "salinity problem" with just two solutions: either maintain a predetermined stream flow from the Delta to Suisun Bay to hydraulically wall out the tide, or use physical barriers to separate saline from fresh water into the Delta. While readily admitting that the "salt menace" results from reduced inflows from the Delta's major tributary rivers, the state of California uses salt water barriers as a technological fix to address the symptoms of the salinity problem, rather than the root causes.

Given complex Delta geography, these two main solutions led to many proposals to dam up parts of San Francisco Bay, Carquinez Strait, or the waterway between Chipps Island in eastern Suisun Bay and the City of Antioch, or to use large amounts of water—referred to as "carriage water"—to hold the tide literally at bay. These proposals would create a large reservoir in which river inflow to the Delta would collect and, at least theoretically, then after moving from north to south across the Delta be available for export.

As shown in the chronology below, the state of California decided by the early 1930s that it made more economic and environmental sense to use continuous stream flow as a hydraulic barrier (rather than build a physical barrier and convert the Delta and Suisun Bay into stagnant reservoirs). This is the principle of "through-Delta conveyance" that the the California Department of Water Resources (DWR) and the US Bureau of Reclamation use today to move their upstream reservoir supplies across the Delta for export to the San Joaquin Valley and southern California.

Damming of the Bay-Delta estuary with a physical salt water barrier is no longer under serious consideration for good ecological, economic, transportation, navigation, and water quality reasons. But in the late 1950s and early 1960s, numerous studies of the flow of water into and through the Delta were done that revealed several existing channel pathways or "Trans-Delta" canals (as DWR called it in the 1957 *California Water Plan*) to convey water from the lower Sacramento River at Walnut Grove all the way to the south Delta pumps.

As a result, DWR considers various kinds of physical barriers (like rock barriers, Obermeyer dams, and fixed radial operable gates associated with boat locks and fish passages) still potentially useful at a local scale *within the hydraulic barrier* that now exists.

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Since the early 1960s, DWR has installed temporary barriers to close the head of Old River to help migrating salmon and steelhead in the mainstem of the San Joaquin River and avoid dangers at the south Delta pumps.

Since the 1976-1977 drought, DWR has used temporary barriers to limit tidal salt water and push flows from Sutter Slough to the Sacramento River in 1976, through the Delta Cross Channel and Georgiana Slough into the Central Delta where the south Delta pumps can draw the fresher water for export. They also installed barriers in 1977 to reduce salinity at Dutch Slough, Rock Slough, Indian Slough, and two others proposed were not installed: one at west False River and at Fisherman's Cut at the San Joaquin River.

The Suisun Marsh Salinity Control Gates on Montezuma Slough, installed by DWR in 1988, operates to manage salinity in the marsh on the tidal cycle. Its gates open on ebb tides to let fresh water in from Delta outflow and close on the flood tide to hold that fresher water in the marsh while blocking tidal salt water. The gates were deemed necessary, however, because Delta outflows (and inflows) themselves were too low. Tidal flows, left uncontrolled, would have converted the Marsh to a salt water ecosystem, which would have been bad for fish, other aquatic species, and migratory waterfowl.

Through its experience with the Suisun Marsh Salinity Control Gates, DWR learned how operable gates could be used to make small but significant changes in how water flows in a complicated hydraulic environment. In the CalFED Bay-Delta Program of the late 1990s into 2000, four operable gates were proposed for helping manage conveyance of export flows to the pumps. Those proposed gates came under close public scrutiny between 2006 and 2010, but so far have been neither approved nor installed, in part due to concerns for salmon and steelhead.

Barriers played roles in both the recent Bay Delta Conservation Plan and in the state's "emergency" response to drought. As Alternative 9 in the Bay Delta Conservation Plan Environmental Impact Report/Statement (Figure 3-16), DWR provided a variation on its *Bulletin 60* presentations of the Biemond Plan and a "Junction Point Barriers" plan. The 2013 "Through Delta/Separate Corridors" alternative would isolate a "Water Supply Corridor" along Middle River from a "River-Estuary Habitat Corridor" through which fish migration could proceed untroubled by reverse flows in Old River. "Operable barriers" would be used to separate the two corridors.

Between 2001 and 2010, DWR and the Bureau, and many consultants, studied alternatives for ecosystem restoration, water quality, and recreation at Franks Tract, and other Delta open water bodies—including barriers and operable gates. They conceived the "Franks Tract Project" about 2006, since if the state and federal water systems lose control of Delta salinity, Franks Tract is where that battle would be lost. From their studies, including holding public meetings and taking public comments on the project in 2008, they initially concluded that an operable gate located somewhere on Three Mile Slough between the San Joaquin and Sacramento Rivers, or closure of west False River would be the best physical barrier options for reducing Delta export salinity levels. In fact, DWR staff concluded in 2007 that the False River structure performed the best during critically dry years. DWR's web site as of today says: "The Franks Tract Project has been

delayed." Restore the Delta is attempting to verify whether the Bureau of Reclamation has taken over the project and will be issuing a feasibility report and environmental report soon.

But the False River barrier is back on track. In early 2014 and again in January 2015, DWR proposed barriers for north and central Delta channels to block tidal flow to the Delta and reduce the need for upstream reservoir releases. By the end of May, DWR settled on completing just the False River barrier near the San Joaquin River.

With state and federal reservoir storage low and cold water needed for temperature management for spawning salmon runs in the upper Sacramento and Stanislaus river areas, barriers in Delta channels have been a staple response of the state of California to its water management problems, with insufficient regard for the Delta's integrity as an estuary.

Restore the Delta has attempted to provide as comprehensive a guide to the chronology and literature of Delta salt water barriers. We hope you find it useful.

Attachments: Delta Barrier Concept Events Chronology, and Delta Barriers Bibliography.

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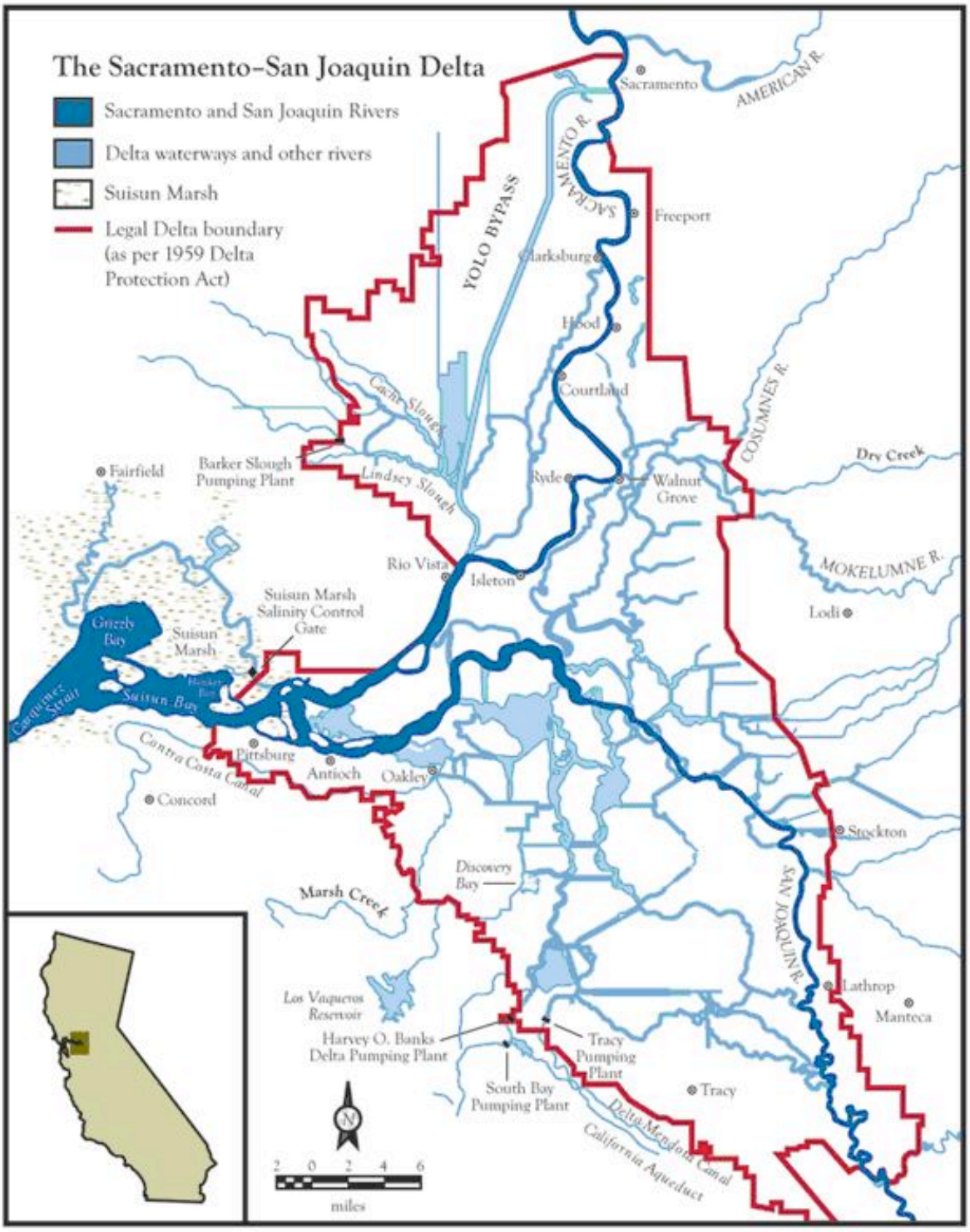

Delta Stewardship Council.

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Year	Delta Barrier Concept Events
1916	State Water Commission begins to study salinity in the Delta, just as rice cultivation in the Sacramento Valley begins.
1920	Upstream Sacramento Valley diversions for rice cultivation deplete Delta inflow and cause tidal salt water to move into the Delta. Town of Antioch with Delta farmers' support sues upstream rice irrigators for greater Sacramento River inflow. *Town of Antioch v. Williams Irrigation District* decided in 1922 against Antioch.
1923	California Department of Public Works (DPW) releases a conceptual state water plan (*Bulletin 4*) showing Suisun Bay as a reservoir, and an aqueduct diverting from it up Walnut Creek to Contra Costa, Alameda, and Santa Clara counties.
1923	Sacramento Valley Development Association requests that the US Bureau of Reclamation study salt water dam project across San Francisco Bay at Point Richmond, or other possible locations for a salt water barrier.
1924	Drought year led potentially renewed conflict but was headed off by a Sacramento River Problems Conference and cooperation between upstream irrigators and Delta farmers. Civil engineer T.H. Means tells the conference "If we build a tight dam preventing the upflow of [tidal] current, we affectively [*sic*] stop all salt water flowing upstream. We may accomplish the same thing by emptying a volume of water inte the Rivers which will keep the salt water back." (*Proceedings of the Sacramento River Problems Conference*, January 1924, p. 107.)
1927	US Bureau of Reclamation authors "Report on Salt Water Barriers" with 16 preliminary designs.
1928	Means report on *Salt Water Problems* found a physical salt water barrier in Carquinez Strait "can be solved permanently and cheaper than by any other solution that has been suggested." (Means Report, p. 69.)
1929	DPW issues *Bulletin 22* on salt water barriers in two volumes (analyses and drawings) that concludes, "Not only will it protect the delta and industrial plants along the shores of the bay, but its conservation of a large part of the fresh water required to act as a natural barrier against invasions of salt water under present conditions. Without the barrier, salinity conditions will become more acute unless mountain storage is provided to be released during periods of low river discharge to act as a natural barrier against invasions of salt water." Sites studied included where the Richmond-San Rafael and Benecia-Martinez bridges are now located.

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Year	Delta Barrier Concept Events
1931	DPW issues *Bulletin 27: Variation and Control of Salinity in the Delta*, concluding, first, that "supplemental water supplies required for control of salinity by stream flow could be developed and furnished from mountain storage reservoirs proposed in the State Water Plan." Second, it concluded that "control of salinity by stream flow into the delta would adequately protect the delta from saline invasion and remove the present salinity menace, assure ample and dependable irrigation supplies for the entire delta, provide a source of fresh water supply...suitable for industrial, municipal and agricultural use in the upper bay region, reduce the salinity of water in Suisun Bay..., and bring about salinity conditions approaching the equivalent of those which would have occurred in the same years with natural stream flow unimpaired by upstream irrigation and storage diversions." (*Bulletin 27*, pp. 44-45.)
1934	State engineer Edward Hyatt claims that Kennett Reservoir (now Shasta Lake) with a capacity of 3 million acre-feet will create enough storage to control floods and "meet the needs of domestic water supply, irrigation, navigation, and control of salinity." It would eliminate "the existing shortage of water along the [Sacramento] river, and [provide] sufficient fresh water in the delta area to prevent encroachment of walt water. It will also eliminate larger scale litigation between the delta region and the upper Sacramento Valley, which threatens to ruin one or the other." (*Civil Engineering*, September.)
1935	State engineer Hyatt further claims that a hydraulic salt water barrier via fresh water flow "would have capital and annual costs less than half those required for a plan of equivalent scope and service with a salt water barrier. The adopted plan for control of salinity by stream flow is an important feature of the Central Valley Project of California." A barrier structure would hinder navigation through the Golden Gate and inside San Francisco Bay from the loss of scouring tidal flows; cause delays from lock operations for commercial navigation; would "offer an obstruction to the free migration of fish and would substantially reduce the shallow brackish-water areas essential as a feeding ground for young fish fry and for adjult striped bass and shad"; and create a problem for disposal of sewage and industrial waste which would "seriously curtail [the barrier lake's]use as a source of fresh water supply." (*Civil Engineering*, September.)
1944	US Bureau of Reclamation engineers second-guess *Bulletin 27* flow needs as overly optimistic to achieve 100 parts per thousand with 3,300 cubic feet per second in the dry season at Antioch. (Jackson and Paterson, p. 49.)
1946	Reber Plan to build two major dams and a fresh water ship channel, creating supposed fresh water lakes in San Pablo Bay and southern San Francisco Bay. Plan faced overwhelming opposition because it would cause severe dislocations to Bay region industry, high costs, water pollution, and navigation problems.
1949	US Bureau of Reclamation selects an operable gate system for a new Delta Cross Channel at Walnut Grove from the Sacramento River to Snodgrass Slough, a site that guaranteed better water quality in case of saline intrusion upstream in the Delta. The DCC gates, when open, would enable better quality Sacramento River water to enter the central Delta fro delivery to the Tracy pumping plant of the Central Valley Project in the south Delta.

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1951	Consultant to the State Assembly (named Savage) concluded the Reber Plan was physically infeasible, neither functionally nor economically feasible, and would not produce desired results, and should be given no more consideration. (Jackson and Paterson, pp. 67-68.)
1952	California Water Project Authority mandated to study barriers for the San Francisco Bay system led by Raymond A. Hill and Cornelius Biemond (a Dutch hydraulic engineer). (Jackson and Paterson, p. 68.)
1952 to 1959	The Bureau's operating plan for the Central Valley Project makes no commitment to control tidal salinity beyond what is needed to protect export water quality from the Tracy pumping plant in the south Delta. (Jackson and Paterson, pp. 50-52.)
1954	Biemond found that in dry years, water quality behind barriers would worsen, flood discharges would be insufficient to flush salinity from Suisun Bay, and that water quality impounded by barriers "would probably not meet accepted standards of quality." (Jackson and Paterson, p. 68.)
1955	Two reports by Water Project Authority completed on a range of barrier concepts, including Reber and Savage plans. Reports each criticized all the schemes, though they each recommended further study of Biemond's suggestion to use "dams or 'control structures' on the Sacramento River above Rio Vista to regulate the river and divert water into a closed cross-Delta canal leading to" export pumps in the south Delta. DWR recommended also study of a Chipps Island barrier at east end of Suisun Bay. Common to all the criticisms were findings of increased siltation in the reservoirs, flood control problems, impacts on fish, uncertainty about potential bridge use for transportation, and water pollution from domestic and industrial sources. A joint military report also rejected any alleged national defense advantages. (Jackson and Paterson, p. 69.)
1957	DWR releases *Bulletin 3: State Water Plan* which proposed a "Trans-Delta system" to move an estimated 18.3 million acre-feet of water through the Delta to central and southern California and the Bay Area, using an isolated canal through the Delta and control structures based partly on the Biemond Plan. (Note that the highest recent Delta exports in 2011, a wet year, were just 6.7 million acre-feet.) "As unregulated flows of the Sacramento and San Joaquin Rivers are reduced in the future by increased upstream storage developments for local use and export of water, it will become necessary to segregate and prevent commingling, during transit, the imported and locally developed waters of high quality with the drainage and flushing waters of poor quality which occur in and drain to the Delta. Segregation of these waters would be accomplished by facilities of the Biemond Plan. Controlled releases of water to Suisun Bay for salinity repulsion would be reduced." (*Bulletin 3*, p. 186.)

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1957	DWR releases *Bulletin 60* in which it states two basic principles for repelling sea water from the Delta: either maintain a predetermined stream flow from the Delta to Suisun Bay, or use physical barriers to separate saline water from fresh flowing through the Delta. *Bulletin 60* studied the Biemond Plan, a "Junction Barriers" concept, and the Chipps Island Barrier. The first two plans isolated Sacramento River water from tidal saline waters, while the Chipps Island plan would combine water quality with navigation locks and a fish way.
1960	DWR releases Bulletin 76, presenting the Chipps Island barrier, first but acknowledges its pollutant disposal issues, followed by alternatives that rely on a complex array of barriers and channel closures that would use existing channels to isolate Sacramento River water. A "comprehensive Delta water project" would consolidate and isolate the path by which Sacramento water moved through eastern Delta channels to Middle River for the south Delta pumps (now planned to include what is now Banks Pumping Plant). Consistent elements of each alternative included control structures on Steamboat Slough, at Ryde on the Sacramento, and at Holland Cut, while Fishermans Cut and Miner Slough would be closed off. The bulletin acknowledged that "average water levels in South Delta channels would be lowered slightly." (*Bulletin 76*, p. 34-40.)
1960, October	John Reber, the Reber Plan author, died in October.
1963	US Army Corps of Engineers releases its studies of Reber and Savage plans and the Chipps Island barrier project, and concluded these plans were "infeasible" due to water quaity, mosquito control, and only "momentary" fresh water storage benefits (since huge losses expected from evaporation, fish ladders, evapotranspiration, and lockage). The lakes would shrink in a matter of years to below mean sea level. The barriers would have to be opened again just to restore navigation, the Corps concluded. (Jackson and Paterson, p. 70.)
1963, Fall	First temporary barrier at Head of Old River to keep fall run Chinook salmon from straying into Old River toward the Tracy Pumping Plant. San Joaquin River fall-run salmon runs had averaged 40,000 fish between 1953 and 1960, but 1961 fell to 2,400 and there were less than 600 in 1962, due apparently to severe depletion of dissolved oxygen in the mainstem San Joaquin River. Delta exports were also recirculated via the Newman Wasteway to augment San Joaquin River flows that fall. The first barrier used at the head of Old River was an old Army barge. The benefit to fish that year was "disappointing," according to DWR. (*Bulletin 132-76*, p. 68.)
1976	Sutter Slough closed with a rock barrier from September 1, 1976, to December 3, 1976 near its junction with Sacramento River, to increase flow in that river to shift more water through the Delta Cross Channel and Georgiana Slough. Project had adverse effects on juvenile salmon outmigrating. It was discontinued when salinity at Emmaton reached critical levels. DWR estimated the water savings this barrier provided at 60,000 acre-feet. (*Bulletin 132-77*.)

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1977	Six barriers installed as “dry year facilities” by DWR in the second year of drought. Rock and Indian Slough barriers were installed to lower chloride concentrations at Contra Costa Water District’s Middle River pumping plant. Dutch Slough barrier was installed to decrease salinity intrusion past Bethel Island and Holland Tract. Barriers on Old and San Joaquin Rivers were installed to increase water levels and improve circulation. And the temporary Head of Old River barrier was installed to enhance migration success of salmon and steelhead. DWR estimated the water savings from these barriers at 240, 000 acre-feet that year.
1977	Legislature passes Suisun Marsh Protection Act, AB 1717, implementing the Suisun Marsh Protection Plan, which includes water quality criteria and provision of supplemental water supplies to maintain them. DWR acknowledges that upstream water use reduced outflow from the Delta, thus increasing salinity in the Marsh.
1979 to 1980	Initial facilities for improving circulation in Suisun Marsh constructed and completed, including the Roaring River Distribution System and the Morrow Island Distribution System.
1988	Suisun Marsh Salinity Control Gates installed and began operation, consisting of a boat lock, three radial operable gates and flashboards. The gates control salinity by restricting flow of higher salinity water from Grizzly Bay into Montezuma Slough during incoming tides and retaining lower salinity Sacramento River water from the previous ebb tide. Operation lowers salinity in Suisun Marsh channels and net movement of water is from west to east as a result
1995 to 2000	CalFED Bay-Delta Program develops as part of its conveyance and storage alternatives a system of south Delta operable gates, three for managing water flow near Banks and Jones pumping plants, and an operable gate system to replace the Head of Old River temporary barrier. The operable barriers were included in the CalFED Record of Decision, August 2000.
2001	CalFED receives a grant application from several consultants to study flooded island management to benefit water quality, ecosystem restoration, and recreation uses. The grant would turn into the “Flooded Island Studies.”
2005 to 2010	DWR organizes and oversees the Flooded Island Studies, and from them conceives with the Bureau of Reclamation the Franks Tract Project, with two leading barrier alternatives: an operable gate positioned somewhere along Three Mile Slough between the Sacramento and San Joaquin Rivers, and a barrier closing off False River. A barrier closure of False River was found to be the best alternative during drought years when Delta inflow is low. Both yield significant improvements in water quality for Delta exports through salinity reduction. After a CEQA and NEPA process was begun, the project is currently in limbo—except that a barrier at False River has been put in place to deal with low Delta inflow and low state and federal upstream storage.
2006	DWR and the Bureau release the South Delta Improvement Program Action Specific Implementation Plan for the operable gate systems called for in the CalFED Record of Decision. The project was shelved about 2010, in part because of concerns about their effects on migrating salmon.

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2013	Bay Delta Conservation Plan Environmental Impact Statement/Report contained Alternative 9, the Through Delta Alternative, which relied on a series of gates, siphons and channel closures to isolate diversions from the Sacramento River to reach the south Delta pumps with improved export water quality.
2015	DWR applies to State Water Board and Army Corps of Engineers for a ten-year "program permit" to install three temporary rock barriers: at Steamboat Slough near the Sacramento River confluence, along Sutter (later Miner) Slough, and at the western end of False River near the San Joaquin River. The program permit would allow DWR to install these barriers three out of the next ten years. DWR later withdrew the application, opting instead to just install the False River barrier this year.

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