

GATES AND BARRIERS IN THE DELTA

A Report to the State Water Resources Control Board
and
the Delta Stewardship Council

by

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INTRODUCTION

While previous Delta Watermaster reports have dealt mainly with water rights and water supply issues, Water Code section 85230 (d) specifies that reports shall also be submitted on water quality issues and conveyance operations. The use of barriers and gates in the Delta addresses both of these topics.

The Sacramento-San Joaquin Delta (Delta) was reclaimed from a large tidal marsh area and has been altered through the construction of a complex levee system. The result is a Delta that consists of many islands and tracts divided by a system of natural and artificial waterways. Superimposed on this island-levee-water way system is the operation of the two major water projects, the State Water Project and the federal Central Valley Project (Projects). Operation of the Projects, including how water is conveyed through the Delta to the southern export pumps, has resulted in both water quality issues and issues regarding protection of the ecosystem. Water quality issues include both protection of beneficial uses in the Delta and ensuring adequate water quality for export water. Conveyance operations have also affected the timing of seawater intrusion extending eastward in the Delta. Operations can impact the ecosystem, mainly threatening fisheries, in other ways because the same water corridors used to convey water south are used by the fish. Problems of fish migrating to the supply corridors have contributed to major declines in fish populations.

The installation of barriers and gates on Delta waterways as a method to address water quality issues and to keep fish away from the export pumps is the subject of this report. Topics that will be covered include: gate and barrier projects that are already in place, the possibility of modifying or reoperating such structures, additional projects that have been studied; and projects that are only at the "idea" stage.¹

No matter which conveyance projects come out of the Bay Delta Conservation Plan (BDCP) process, gates and barriers can play a role both in addressing water quality issues and in keeping fish out of the water supply corridors.

¹ These are existing barrier structures, such as weirs located North of the Delta on the Sacramento River and structures in the Yolo Bypass, that can impede fish passage and strand fish. Modification to those structures, such as construction of notches and fish ladders, could improve fish passage by improving connectivity between the Sacramento River, the Yolo Bypass, and the entrance of the Delta. Since such projects are mainly concerned with removing or minimizing barriers to fish migration, they will not be examined in this project. Rather this report focuses on projects in the legal Delta that are specifically designed to improve water quality and/or keep fish away from the export pumps.

GATES AND BARRIERS

A. In General

The Delta's size and hydraulic complexity provides many potential opportunities for flow modifications to achieve water quality benefits and benefit to fisheries. Gates and barriers can be used to alter the hydrodynamics of a waterway. They can range from simple temporary rock and earth barriers to sophisticated operable gates. The simple designs can include culverts containing tidal flap gates and portage facilities to allow for boating traffic. The more sophisticated designs can operate on a daily or even an hourly basis to coincide with tidal events and can include boat locks to allow boat traffic to pass.

B. The Tides

There are 3 major hydrodynamic factors affecting the Delta: tidal flows, river flows, and export operations. Of these, tidal flows are by far the dominant factor. Since one of the main purposes of gates and barriers in the Delta is to improve water quality by regulating tidal flow, a basic understanding of the tidal cycle becomes relevant. Tides are the rise and fall of sea levels caused by the combined effects of the gravitational forces exerted mostly by the Moon and somewhat by the Sun, together with the rotation of the Earth. There are two high (flood) tides each day and two low (ebb) tides. High tides in the Delta occur largely when the Moon faces the Delta and when it is on the opposite side of the Earth. The high tides are a little over 12 hours apart. Conversely, low tides occur when the Moon is 90 degrees from the Delta. The time difference between a high and low tide is a little over 6 hours and there are 2 high tides and 2 low tides in a 24-hour-plus period.

The difference in height between high and low tides varies in a 2-week cycle. Approximately twice a month, when either a new Moon or a full Moon forms a line with the Earth and the Sun, the tidal forces are intensified. At such times, the tide's range is at its maximum, and it is called a spring tide. The opposite effect, where the Sun's tidal force partially cancels that of the Moon's tidal force, is called a neap tide.

Other, more minor factors affecting tidal heights are the changing distances separating the Moon and Earth, the tilt of the Earth, the plane of the Earth and Moon's orbit, and the slope of the shoreline and ocean floor in a given area. When most or all of the various effects align together to increase tidal influence, an event called a King or Super Tide occurs.

Since tides have an obvious impact on the Delta's waterways, operating gates and barriers to coincide with tidal cycles improves their utility.

C. Existing Gate and Barriers Programs

1. Northern Delta and Suisun Marsh

The Sacramento –San Joaquin Delta Reform Act of 2009 defines the Delta to include the Suisun Marsh (Water Code sec. 85058). The Suisun Marsh, located north and west of the Delta, is a large brackish marsh subject to tidal ebb and flow. There are several sloughs traversing the marsh. One of the largest, Montezuma Slough, is open at both ends. The flood tide current is larger and stronger than its ebb current because of the way the openings are configured. This creates a net west-to-east flow during times when Delta outflow is high. The result is more saline water flowing eastward from the

San Francisco Bay tidal estuary. To address this situation, the State Water Board's Decision D-1485 set salinity standards for Suisun Marsh from October to May to preserve that area's beneficial uses. The Suisun Marsh Salinity Control Gates were completed and began operating in 1989 during high periods of Delta outflow in response to the standards. The Gates, located on the eastern side of Suisun Marsh in Montezuma Slough, provide lower salinity water to manmade wetlands in the marsh. The facility consists of a boat lock, series of three radial gates, and flashboards. The gates control salinity by restricting flow of higher salinity water from the west during flood tides and retaining lower salinity Sacramento River water from the previous ebb tide. Operation of the gates in this fashion lowers salinity in Suisun Marsh channels and results in a net movement of water from east to west. By decreasing salinity levels, waterfowl food, plant abundance and diversity is increased. The Gates have proved to be effective in lowering salinity levels. Extensive monitoring and studies have demonstrated that salinity levels are lowered by operation of the gates and that habitat has improved.

2. Central Delta

The major gate/barrier feature of the Central Delta is the Delta Cross Channel (DCC) Gate structure. While the Suisun Marsh Gates' purpose is water quality improvement, the Delta Cross Channel's main purpose is to provide a water supply corridor for Project water to flow south to the export pumps. It has an additional purpose of providing a means to separate the water supply corridor to the export pumps from the fish corridor on the Sacramento River. The Delta Cross Channel Gates control the use of an artificial diversion channel on the Sacramento River about 30 miles south of Sacramento that diverts water from the river into a branch of the Mokelumne River. When the gates are open, fresh water is drawn from the Sacramento River into the interior of the Delta. With the gates open, the channel provides a short-cut for freshwater flow to the interior of the Delta and for export in the south. When closed, the gates prevent salmon and other threatened species from being diverted from the migratory routes in the Sacramento River. Pursuant to State Water Board Decision D-1641 the gates must be closed for fish protection during selected periods in the year when river flows are higher. The DCC consists of two large gates that are normally operated together. They are not automated, not separately operated, and must be open and closed manually.

There are 4 seasons of DCC operation:

- Feb 1 – May 20: Gates closed for protection of Sacramento River salmon
- May 21 – June 15: Gates are closed for 14 of these 20 days
- June 16 – Oct 31: Gates are generally open
- Nov 1 – Jan 31: Gates may be closed up to 45 days to protect migrant fish and for flood control protection.

3. Southern Delta

The major existing gate/barrier system in the South Delta is the South Delta Temporary Barriers Project. This project consists of three rock barriers constructed each year during the irrigation season to improve water levels for local agriculture and a fish barrier constructed at the head of Old River (HOR) in the spring and, possibly, the fall. The objectives of the project are 1) to reduce fisheries impacts by improving fishery

conditions and 2) to increase water levels and improve circulation patterns in the Southern Delta area for local agricultural diversions.

Water levels and water circulation in the South Delta have improved with the agricultural barrier installation although there are persistently high salinity levels at times.² Migration conditions for salmon have generally improved when the HOR barrier is installed, although there are indications that fish predation has minimized these improvements. Presently the barriers are temporary in nature and are constructed and removed each year. Operational and design changes have been made in recent years to improve water circulation and reduce water quality problems by increasing the height of some of the barriers and changing the way the culvert flap gates operate.

The HOR fish barrier has been in place most years in the fall and many years during the spring (when flows permit). While the HOR barrier operates to keep fish out of Old River and away from the export pumps, recent studies indicate that the fish being diverted to the San Joaquin River are suffering high predation rates. Thus the effectiveness of HOR in improving fishery conditions is in doubt. The remaining three barriers, called agricultural barriers because they are intended to improve water levels for agricultural users in the South Delta, are usually installed between April 1 and November 30 of each season. Culverts with flap gates are incorporated into the barriers. While the flap gates normally operate to open and close with tidal cycles, the flaps can be tied open to promote better circulation and improve water quality when conditions are appropriate. The height of the Middle River barrier has recently been increased to induce better flows and possibly improve water quality upstream of the barrier.

D. Non-Physical Barriers

An alternative means for separating fish from water supply corridors or less-preferred migration corridors is the use of non-physical barriers. One such barrier that has been studied on a pilot basis is a Non-Physical Barrier (NPB) that has utilized a Bio-Acoustic Fish Fence (BAFF) in its design. This system uses a combination of fish-annoying sound from underwater speakers, air bubbles, and strobe lights, to deter fish from passing the barrier while allowing water to pass through. This technology has been employed at two pilot locations: at the head of Old River in the South Delta and at the Georgiana Slough's divergence with the Sacramento River near Walnut Grove. At the Georgiana Slough location, a pilot study was conducted in 2011 and 2012 to estimate the effectiveness of an existing BAFF system in successfully deterring fish from entering the Slough and encouraging them to use the Sacramento River. During the 2011 study period, the NPB reduced the percentage of tagged fish entering the Slough from 22.1% to 7.4 %. These results are obviously promising for the future use of NPB's, although predator control remains an issue.

E. Reoperation and Modification of Existing Gates/Barriers Projects

It may be feasible to modify or change the operation of existing gates and barriers to provide greater water quality or fishery benefits. For the Delta Cross Channel, improved operation could include widening the gate structures, doing supplemental dredging to increase the

² Factors other than tidal flow also affect salinity levels, including local agricultural runoff and other discharges from sloughs that feed into larger watercourses.

conveyance of high quality water to the Central Delta, and/or automating the gates to allow quicker opening and closing. Operable gates could provide additional fishery protection through a more sophisticated closure program based on tidal cycles.

The South Delta temporary barriers could also be replaced with permanent operable gates.³ These gates are part of the South Delta Improvements Program which is on hold indefinitely pending completion of certain south Delta fish studies and further fish agency approvals. Such gates would provide quicker response times and the flexibility to operate in conjunction with the tidal cycle to more effectively achieve fishery benefits and water quality improvements.

F. Additional Gate Programs

There are many other areas within the Delta's complex hydraulic system where the installation of small scale salinity barriers could be used to regulate tidal flow to both protect fisheries and improve water quality.

1. Franks Tract Project

Franks Tract is a flooded island located in the Central Delta. It is approximately 3,300 acres in size. Franks Tract is connected tidally to the San Joaquin River via False River. During low flow conditions, higher salinity water enters Frank Tract on the flood tide while fresh water flows back during ebb tide. Because of the configuration of the waterways, net flows are west to east which increases salinity conditions. Franks Tract also provides a corridor for fish such that they can more easily be drawn toward the export pumps.

Both the Department of Water Resources and Bureau of Reclamation have conducted studies to evaluate the feasibility of modifying the hydrodynamic conditions near Franks Tract to improve Delta water quality and protect fishery resources. Gates could be installed and operated in concert with tidal events. Studies have shown that such gates would limit the entry of higher salinity water into Franks Tract and could be operated to encourage the movement of fish species of concern away from the Central and South Delta to areas that provide more favorable habitat conditions.

2. Two – Gates Project

The Two-Gates Project is a proposed demonstration project that would install and operate removable, portable gate structures at 2 key central Delta locations to test the ability of the structures to improve delta smelt protection by keeping them away from the South Delta export pumps. The project would be used to test whether, through operation of the gates, movement of delta smelt into the South Delta pumping area can be controlled. Local and environmental opposition to the Two-Gates Projects has caused the project to be shelved pending further review of the science supporting it and the impact of the proposed locations on boating access.

³ Currently, fish agencies have not recommended that the temporary barriers be made permanent.

3. Delta Corridors Project

The Delta Corridors Project is a proposed conveyance alternative to the isolated conveyance option. Its main features are to separate San Joaquin River flows from the export pumps, creation of a more direct corridor for water to reach to the export pumps, and use of barriers and screens to keep fish out of the water supply corridors.

Regarding the latter, several gates are proposed at locations on Old River, Middle River, Mokelumne River, and San Joaquin River to provide greater separation between Delta channels that fish use and channels that convey water for export. A smaller, version of this approach, called the Through-Delta Improvement project, is also being evaluated.

4. Western Seawater Barrier

One proposal was studied decades ago but has received little attention since: the construction of a major seawater barrier to the west of the Delta near Chipps Island. This old proposal studied a permanent rock barrier that would have prevented salinity intrusion on high tides into the Delta and would have created a freshwater Delta behind the barrier. Recently however, a different type of seawater barrier project received some attention. Dutch Engineers suggested the feasibility of a large operable barrier similar to the Maeslant Storm Surge Barrier that protects Rotterdam in the Netherlands. The Maeslant Barrier is an operable gate structure that is larger in size than a Sherman Island Gate Barrier would be. It was completed in 1997. Except for annual testing, it remains open unless needed to prevent major flooding. The Maeslant Barrier has only been closed once due to a storm in 2007. A Chipps Island gate structure could provide a similar benefit in California. There are several potential catastrophic events that could threaten the water supply of the Delta, including major flooding, Delta island failure, and seawater surges in the future associated with climate change and King tides. In such events, a gate system could be closed to prevent major seawater intrusions in the Delta. It may also be possible to operate the gates on a seasonal basis to provide water quality benefits. However, considering that both Sacramento River and San Joaquin River are major navigation routes, seasonal operations would be a challenge. The costs of such a facility would be large. The Maeslant Storm surge barrier cost \$700 million dollars to construct. The cost to build a Chipps Island gate structure would most likely be much higher than \$700 million dollars. However, it is estimated that the Maeslant barrier saved many times that amount when closed in 2007 to prevent major flooding.

G. Boating and Navigation Concerns

Boating and navigation concerns should be considered during the study and evaluation of present and future gate/barrier projects. Existing projects have incorporated boat locks (Suisun Marsh) or portable portage programs (South Delta Temporary Barriers Project).

Projects should not be put in popular waterways unless boating access is provided. Mitigation measures could include recreation facilities and boat ramps and/or locks. Projects should be chosen that do not restrict boating by closing waterways for significant periods. Use of non-physical barriers should be considered as an alternative.

H. Funding

Funding for projects is always problematic. One potential funding source is the use of bond funds. The 2009 Water Bond could be used if it is ever put before the voters and enacted. Another option is SB42 (Wolk) which was introduced as a bill on December 11, 2012. It would provide funding for a wide variety of Delta water related activities and could be a funding source for future Gate Projects.

CONCLUSIONS

1. Gates and barriers can serve a useful purpose.
2. They have demonstrable benefits in improving water quality and in protecting fisheries.
3. The potential for increased predation at gate and barrier facilities is a concern that must be addressed.
4. Adding small scale projects could be beneficial regardless of which major conveyance option is implemented. Such projects should be considered as early-action items provided a funding source is available. The Franks Tract Project appears to be a good candidate.
5. Use of non-physical barriers should be considered.
6. A large-scale western operable gate project should be furthered studied.
7. Location of specific projects should be prioritized and based on the following factors:
 - 1) Projects that can serve dual purposes of improving water quality and affording fish protection.
 - 2) Locations in areas where boating traffic would not be unduly affected or where boat locks or other portage options can be made available.