

Delta Water Quality Issues

Another potential consequence of climate change and sea level rise in the Sacramento-San Joaquin region is the further eastward intrusion of saltwater into the Delta. The Bay-Delta system can be crudely divided into three sections based on water quality: 1) the freshwater Delta, 2) the dilute sea water of San Pablo Bay and the more saline San Francisco Bay, and 3) the brackish water of Suisun Bay. An estuarine environment like Suisun Bay, where freshwater mixes with saline oceanic waters, is critical to several aspects of resource management in the region. The planktonic richness of the Bay produces nursery conditions for striped bass and other species (Davoren, et al., 1983), but the system is quite sensitive to climatic inputs. During 1977, when Sacramento-San Joaquin river discharge dropped to a new record low (below 100 m³/sec), phytoplankton, zooplankton, and striped bass abundance were all significantly reduced (Nichols, et al., 1986). Rising sea level would likely force this null zone eastward into the Delta.

Withdrawals of freshwater from the southern Delta by the SWP and CVP further encourage the eastward-moving saltwater flux. When freshwater flow from the Sacramento River is low, SWP

pumping plants filling the California Aqueduct for water exports to southern California may cause reverse flows by drawing water from the San Joaquin River. Under such circumstances, water in the western Delta becomes brackish as it mixes with salty ocean water entering the Delta under tidal flow. It was this tidal flow, intensified by persistent onshore winds, that caused water supply allocation problems in the SWP during 1985 (as described above). Further eastward penetration of this brackish water would have obvious, serious consequences for the SWP and CVP and their respective contractors. Increased freshwater outflow from the Delta could help repel this intrusion. However, an increase of freshwater outflow would require the diversion of water from the southern Delta's pumping plants and the agricultural and urban interests they serve.

Institutions and Policies Arrayed for Water Quality Maintenance

As in the maintenance of the Delta levee system, responsibilities and interests in the repulsion of sea water from the Delta overlap among many different agencies and interest groups. This section discusses the commitments and responsibilities of the main players in this climate-sensitive issue.

State Water Resources Control Board (SWRCB). The SWRCB is arguably the pivotal agency involved in the issue of saltwater intrusion, as well as Bay-Delta water quality in general. The board, established by the state legislature in 1969, is divided into two statutory divisions: water rights and water quality.

The powers of the board are spelled out in the Porter-Cologne Water Quality Control Act. The board's water right authority is quite distinct and separate from its water quality authority. Its water right function is strictly a state responsibility, while its water quality control authority is pursuant to the Porter-Cologne Act as well as the Federal Water Pollution Control Act (PL 92-500).

California was one of the first western states to establish a permit system for the appropriation and diversion of water for beneficial use. That permitting process is now under the jurisdiction of the SWRCB. Permits specify a rate or quantity of water, the point of diversion, the uses to be made of the water, and the place of use. Generally, the user can divert the water and put it to any use, as long as the use is "reasonable" and not wasteful.

The two largest diversions of water from the Delta are, of course, the SWP and the CVP. The permits issued by the SWRCB for the SWP and CVP facilities are in accord with Water Right Decision 1485 (D-1485), adopted in August, 1978. D-1485 requires as a condition in the SWP and CVP permits the maintenance of water quality standards as adopted in the "Delta Plan", except for the southern Delta (these standards are listed in Table II of D-1485). The underlying principle of these standards is "that water quality in the Delta should be at least as good as those levels which would have been available had the state and federal projects not been constructed, as limited by the constitutional

mandate of reasonable use. The standards include adjustments in the levels of protection to reflect changes in hydrologic conditions" experienced under different types of weather conditions (State Water Resources Control Board, 1978, emphasis added). Thus, there is some possibility left for adjusting standards if climate conditions make them difficult or impossible to achieve.

When D-1485 was issued, the SWRCB stated it believed the level of protection afforded was "reasonable." However, the board also recognized the possible need to revise these standards in the future. In keeping open the possibility of future changes, "the board...recogniz[ed] the uncertainty associated with possible future project facilities and the need for additional information on the complex effects of project operations and varying water quality conditions in the Delta and Suisun Marsh". The Board also stated its intent "to reopen the hearing on this matter within eight years from the adoption date, depending upon the availability of additional information upon which to re-examine these standards." Those standards are currently (not in 1986, as originally intended) being reviewed at the Bay-Delta Hearing in Sacramento. This multiple-year process, which started in 1987, is aimed at developing new water quality objectives for the Bay-Delta estuary and the means for implementing them.

In summary, D-1485 requires that water quality standards in the Delta be satisfied prior to any export from the Delta to

other areas for any purpose. The decision, which binds the federal CVP to the permitting terms of the SWRCB, was issued by the U.S. Supreme Court in California v. United States on July 3, 1978. This decision declared that a state may impose any condition on control, appropriation, use, or distribution of water in a federal reclamation project that is not inconsistent with clear congressional directives on the project. Thus, in the event of rising sea level and possible further penetration of saline water into the Delta, the SWRCB is likely to be the agency responsible for maintaining or changing Delta water quality standards. There will be pressure from environmental groups, such as the Environmental Defense Fund, and resource management agencies, such as the California Department of Fish and Game, to maintain these standards as high as possible. On the other hand, CVP and SWP users and managers might seek a relaxation of the standards in order to extract water from the Delta, especially if runoff decreases, or as discussed in the section on water supply, the seasonality of runoff changes and some form of additional lower-basin or even below-delta storage is necessary.

San Francisco Bay Conservation and Development Commission (BCDC). The BCDC was established as a temporary state agency with the passage of the McAtter-Petris Act in 1965. The tasks of the BCDC were to prepare a plan for the long-term use of the bay and to regulate development in and around the bay while the plan was being prepared.

The San Francisco Bay Plan, completed in January 1969,

includes policies on issues ranging from ports to public access. In August, 1969, the act was amended to make BCDC a permanent agency, as well as to incorporate the plan's policies into state law. In 1977, the Suisun Marsh Protection Plan expanded the commission's authority to include the protection of Suisun Marsh.

The BCDC's responsibility in the Suisun Marsh Protection Plan includes at least an assessment role in the matter of saltwater intrusion. A recent BCDC report focused on several engineering steps for dealing with sea level rise: "Salt water intrusion will require additional structures and diversion canals to move freshwater from farther upstream into the marsh. Pumps will be required to drain many of the duck clubs as sea level rises." . However, the report suggested that "the outboard levees, constructed on compressible peat soils, will be subject to subsidence and overtopping from high water. Although it may be feasible from an engineering standpoint to protect the managed wetlands, the economic cost may be very high" (Moffat and Nichols, et al., 1987). It is not clear at this time, however, what final role the BCDC might play in policy response to either saltwater intrusion or even levee failure given future climate change.

Suisun Resource Conservation District (SRCD). The principal regulatory agency in matters pertaining to Suisun Marsh water management is the Suisun Resource Conservation District. The SRCD has primary local responsibility for "regulating and improving water management practices on privately owned lands

within the primary management area of the Suisun Marsh in conformity with Division 19 and the Suisun Marsh Protection Plan." These powers are conferred to the district in Section 9962, Chapter 12 of Division 9 of the California Public Resources Code.

The main concerns of the SRCD regarding rising sea level and climate change are typical of most Delta organizations: saltwater intrusion (coping with this problem is probably the district's main reason for existence) and levee failure. Also, most of the managed wetlands of Suisun Marsh are drained by gravity/tidal gates. Rising sea level would make such tidal gates useless and likely turn Suisun Marsh into a tidal wetland.

The SRCD is party to the "Suisun Marsh Preservation Agreement." Other signees are the DWR, Bureau of Reclamation, and the California Department of Fish and Game. Also known as the "Four Party Agreement," this document effectively binds these agencies to a set of mutually acceptable water quality standards. In short, it assures that the DWR and Bureau of Reclamation will supply carriage waters to the marsh to mitigate the adverse effects of SWP and CVP water use.

Water Delivery Agencies. As the managers of the two largest water delivery systems in the state, the U.S. Bureau of Reclamation and the California Department of Water Resources have a strong interest in possible sea level rise and its potential impact on Delta water quality; a significant increase in salinity levels in the southern Delta could render that water unacceptable

to SWP and CVP contractors. The agencies can combat increasing salinity levels principally in two ways: 1) increase releases of upstream carriage waters, or 2) reduce water withdrawals from the southern Delta. As both of these options decrease the amount of water available to users further south, neither is particularly desirable, especially in the SWP where supply and demand are more closely balanced than in the CVP. Yet, both agencies are obligated by D-1485 to meet water quality standards in the Delta and Suisun Bay, and their "Coordinated Operations Agreement" now specifies that they will share resources and facilities to meet carriage water needs.

Another possible impact of rising sea level is the inundation of the pumping plants and water supply systems operated by the bureau and the DWR. Such a crisis might very well crystallize pressure for decisive action aimed at either maintaining the Delta as currently configured or restructuring the water delivery system, perhaps through a circum-Delta canal.

Summary: Water Quality Will Be a Priority in Future Climate Adjustments

There are several possible responses to increasing saltwater intrusion into the Delta caused by climate change, including the key options listed in Table 4.

TABLE 4

OPTIONS FOR ADJUSTING WATER QUALITY MANAGEMENT TO CLIMATE CHANGE

- 1) **Inaction:** This would include plans to derive the maximum benefits from a new salty marsh/brackish ecosystem.
- 2) **Increase carriage flows:** Increasing the releases of upstream water stored by the CVP and SWP.
- 3) **Reduce withdrawals,** especially those of the CVP and SWP, in the Southern Delta.
- 4) **Enlarge channels and waterways:** This would have the effect of increasing Delta flows, as well as reducing reverse flows during dry periods.
- 5) **Construct an isolated channel:** Such a canal would route water from the Sacramento River, around the Delta periphery, and directly to the export pumps near Tracy. Such a project; the "Peripheral Canal", was proposed in 1982 and soundly rejected by voters, especially Northern Californians.

First, it may be reasonable under certain circumstances to surrender to a more brackish Delta and plan to obtain the most benefits from this change (the "inaction" option). This would probably lead to a larger extent of Suisun Marsh-like environment, with benefits ranging from increased wildlife habitat, recreational opportunities, and possibly even commercial fisheries.

The release of carriage flows is one of the principal ways in which saltwater intrusion is presently combatted. However, there is little water which could be dedicated to such an increase without affecting CVP and SWP users. Thus, option 2 would likely require large additions to upstream storage and transport capacity. This option faces many barriers: large capital expenditures during a period in which federal support for water development is declining, the reduction of acceptable sites on which to construct large storage facilities, and increasing pressure (especially from environmental groups) to prevent new on-stream storage facilities.

Reduced water withdrawal for export to southern California (option 3) has an obvious implication especially for the SWP: the project may not meet current and projected contract demand unless new sources of water can be found or efficiency can be dramatically increased, as discussed in the supply section above.

The various project improvements outlined in the latest update of the state's water plan, especially those which would improve the transfer of water across the Delta (including

dredging of existing channels, channel enlargement, and new connecting channels) would not directly repel encroaching saltwater, but would help maintain better southern Delta water quality by feeding the southern Delta pumping plants more efficiently. Thus, it may take some pressure off of both carriage water requirements and raw water needs in the major delivery systems.

The fifth option, construction of an isolated canal to carry water from the Sacramento River directly to the southern Delta pumping plants, is not likely to be implemented in the near future because it would fall prey to the same environmental concerns that recently killed the Peripheral Canal proposal. However, if the Delta were to be threatened with conversion into a saline inland sea, such an alternative might be reconsidered.

The diversity of interests surrounding the Delta suggests that policies responding to climate impacts will be hotly debated. The large water delivery agencies are reluctant to increase carriage flows or reduce withdrawals. Options such as the enlargement of Delta channels or construction of an "isolated canal" are extremely controversial, though the latest state plans for these actions have elicited less criticism than most water managers expected. The salinity control plan, which should eventually emerge from the Bay-Delta Hearing, will be central to the choice of future options.

Delta water requirements will continue to be a key response policy issue in California water supply in the short- and long-

term. A combination of natural Delta degradation and subsidence, sea level rise, and runoff changes suggested in the larger EPA study, would require significant changes in water management over the next few decades. Currently, however, it appears that most of the policy options favor maintaining the existing system as long as possible rather than adjusting to climate change.

CONCLUSIONS: WATER RESOURCE MANAGEMENT POLICY IMPLICATIONS
OF CLIMATE CHANGE IN THE CALIFORNIA STUDY AREA

This analysis describes the key water resource management policies and practices that would be stressed by climate change in the California case study area. The three focuses--water supply/flood control, Delta island maintenance, and Delta water quality--are related and interactive. For example, changes in supply or flood control policy affect the ability to maintain water quality. Thus, the full range of agencies and interest groups listed in Table 1, and a wide range of resource management policies, will come into play as the region adjusts to future climate changes. Although the goal of this research was to examine current policies, their climate sensitivities, and the range of options for adjusting policy in each area, the foregoing discussion points to a few speculative prospects for future adjustment.

Prospects for Policy Adjustment in Water Supply and Flood Control

Water development trends in California could be characterized as actually quite predictable. Although economists have speculated on the emergence of "water markets" and a greater private role in large-scale water development, the latest manifesto from the state, its 1987 "Future" publication (California Department of Water Resources, 1987a), outlines a plan for somewhat smaller developments that generally move the system further along the previous development direction marked by public financing and management and improved physical facilities. The report offers a set of scaled-down physical improvements for increasing firm yield by 1 to 2 maf over the next two decades. Included in this package are improvements in existing transfer facilities in the Delta, development of off-stream storage at the Los Banos Grandes reservoir, water banking in aquifers (such as the Kern Water Bank, a large groundwater storage project), and plans for the Los Angeles area to receive more Colorado River water, thus taking some pressure off of northern California supplies.

In short, expected demand will be met by increasing facilities and new sources or storage, although future management will probably be more open to increased levels of risk of occasionally failing to meet peak demand (a variable risk policy). By maintaining a closer relationship between supply and demand (i.e., less "excess capacity"), the system will continue to be sensitive to climate fluctuations, and managers will have

to improve their fine-tuning of allocation rules. Calls for improved seasonal climate forecasting in the 1987 report illustrate the perceived need to better anticipate climate shocks.

Flood management in the basin is undergoing a major review by the USACE in light of apparently increased flood potential. After the 1986 floods, it was suggested that the proposed Auburn Dam was needed more for flood control than for water supply, and recent discussions have focussed on an Auburn Dam built as a "dry dam" (what is typically called a "detention dam" in flood control planning) used only to hold peak flood waters and then release them as downstream conditions permit (Sacramento Bee, March 4, 1988). Thus, the dam would not create a large on-stream reservoir. If current flood safety levels are to be maintained in the basin, some further tightening of operating rules--or additional flood storage--will be needed. Water management in the area will certainly be affected by the findings of the flood system review now underway.

There is, however, one event in the recent policy history of the area that portends a flexibility in adjusting to environmental uncertainty: the coordinated operations of the SWP and CVP. Water systems in the U.S. have tended to operate independently, each assuring its own firm yield by developing independent supplies and storage. However, the tightening relationship between demand and supply in northern California, and differences in the capacity of the two systems, yielded a new

joint operating policy that could act as a model for increasing the flexibility of water systems elsewhere and for effecting further adjustment in the region.

Indeed, the SWP/CVP Coordinated Operations Agreement (COA) represents, in many ways, a public policy response to climate sensitivity--that is, it creates a mechanism for absorbing future climate changes, as it better distributes the "absorptive capacity" or excess capacity in the system. The chief goal of the COA was to share responsibility for passing through the water necessary to meet state-imposed Delta water quality criteria. This carriage water requirement has been growing since Decision-1485 (discussed in detail above) mandated that water operators permit enough water to pass on to the Delta to fight saltwater intrusion. The increase has been due to a greater frequency of dry years in the basin since the mid-1970s, as well as degradation of the Delta's island-levee system. Chiefly by virtue of its larger excess capacity, the CVP takes up the slack in SWP carriage water deliveries, and thus helps the SWP meet user requests when Delta requirements are high, runoff is low, or both. Most accounts suggest that the COA has helped the SWP avoid shortages in the past few dry years (1986-87 was another "critically dry" year in northern California). The COA clearly represents the kind of new, but simple and low-cost, institutional relationship and policy tool that can help resource agencies absorb some climate change without drastic crisis responses or a rush to develop new physical facilities.

Furthermore, the 1987 water plan update suggests that further coordination, perhaps even state management of both systems, is being considered.

Other than the COA, however, there is little evidence that less traditional adjustments, like the development of water marketing, will emerge in the near future.

Prospects for Adjusting Delta Island Land Use

The maintenance of the system of Delta islands and levees (or employment of the "strategic inundation" strategy) in the face of sea level rise will not as easily yield to incremental, operational adjustments as will supply and flood control. Indeed, Delta maintenance will be a costly policy even without sea level rise or reduced freshwater flows. In the face of either or both of these future climate trends, though, the public investment to protect the Delta islands could escalate dramatically. In the DWR's 1982 Delta Levee Investigation, then-DWR director Ronald Robie estimated "a complete rehabilitation of the Delta levee system would cost a staggering \$3.4 billion." (California Department of Water Resources, 1982)

The levee system is not in good condition, as evidenced by the 24 levee failures since 1980. The islands of the Delta, most of which are well below sea level, continue to subside as the Delta's peat soils erode and decompose. Nevertheless, short-term maintenance of the levee system, although very expensive, is viewed as quite feasible by most responsible agencies and other

interests. There is a widespread attitude that because of the Delta's critical importance to California's water supply system and, subsequently, the entire state, its short-term maintenance is perhaps economically justifiable. In the long-term (i.e., greater than 50 years), however, maintenance of the levees is questioned even by some groups that support their rehabilitation now.

Despite the legislature's recognition that "it may not be economically justifiable to maintain all the Delta's islands," there is an increasing potential for huge financial commitment to the maintenance of the Delta island system, especially in the face of rising sea level. Rising sea level will increase the failure of levees and promote the intrusion of saltwater into the Delta. The possible disappearance of a freshwater Delta in the long run would drastically alter the character of the state's water supply system. Ideas such as the Peripheral Canal (which reappeared as an "isolated canal" in the state's 1987 water futures assessment--California Department of Water Resources, 1987a), soundly rejected by the voters in 1982, may not seem far-fetched in the face of Delta inundation.

Prospects for Water Quality Maintenance

Any decrease in managed water supplies (or even marked changes in the seasonality of runoff) in the Sacramento-San Joaquin basin will further worsen Delta water quality unless the major delivery systems can provide more carriage water. Right

now it appears that regulatory water requirements will take precedence over deliveries to users, though this is by no means assured in the face of cumulative climate change. It may be, however, that the large body of regulatory policy aimed at protecting water quality--which is not matched in water supply--may win out in future conflict for water that becomes more scarce due to climate change. However, it is not prudent to speculate on prospects for this issue until the Bay-Delta Hearings end. New attitudes, policy tools, and institutions may then emerge.

The Need for Integrated Policy Solutions

The proliferation of interests and institutions focused on what is, essentially, a connected constellation of climate-sensitive policy issues in Northern California, suggests that near-future climate change could elicit a disjointed policy response. Yet, the climate problem could also create new ties between resource management areas. For example, the coordinated operations agreement between the SWP and CVP represents a major policy adjustment to environmental uncertainty (e.g., variable and likely increasing requirements for carriage water to maintain Delta quality, and short-term climate fluctuations) that could act as a policy model for adjusting to other impacts of climate change. Indeed, additional interagency cooperation has been proposed in the state's latest water planning document, but no strategy has yet emerged to offer an integrated response to the interacting problems of supply, flooding, quality, and Delta

protection, which could be exacerbated by almost any nontrivial climate change.

The old standard for integrated resource management policy in an area was the concept of watershed planning. Perhaps, given the emerging threat of climate change, there has come a need to incorporate climate-sensitive resource management practices.

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