Connecting the Dots:
Fish, Groundwater, and Weather

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BIOGRAPHICAL SKETCH

Tim Washburn is Agency Counsel for the Sacramento Area Flood Control Agency (SAFCA). He has been actively involved in river management efforts along the Lower American and Sacramento Rivers since SAFCA's formation in 1989. These efforts have included development and implementation of the current variable space flood control diagram for Folsom Dam and Reservoir, formation of the Lower American River Task Force, implementation of an innovative erosion control program along the Lower American River, and, most recently, completion of the Lower American River Corridor Management Program.

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The purpose of this paper is to connect the dots linking the three topics of this LAR Science Conference: forecasting of extreme flood events, groundwater management and fish and aquatic habitat. The discussion begins with a historical perspective on the events that have driven these topics to the top of the water resource planning and management agenda along the Lower American River. This perspective will lay the groundwork for assessing the substantive connections between the three topics and for outlining what the conference might accomplish with respect to pursuing these connections. The author is Agency Counsel for the Sacramento Area Flood Control Agency (SAFCA). The discussion reflects his experience over the past fifteen years in fashioning a strategic plan for managing the risk of flood damage in the heavily urbanized American River floodplain.

FLOOD CONTROL AND WEATHER FORECASTING

During the latter half of the 19th Century, the Sacramento River was the City of Sacramento's principal commercial/transportation link to the outside world. Thus, despite the discouraging floods of 1850, 1852, 1862, and 1867, it made sense for Sacramento's early settlers to locate the central city in the floodplain close to the river rather than retreat to high ground. Battling floods became a major local undertaking. Sacramento residents elevated their homes and businesses and sought protection behind crudely engineered levees along the east bank of the Sacramento River and the south bank of the American River.

The great Sacramento River floods of 1907 and 1909 initiated the modern era of flood control in the Sacramento Valley. These floods overwhelmed local defenses and made it clear that a comprehensive state/federal effort was needed to prevent the Valley from becoming a seasonal inland sea. This effort took shape in the Sacramento River Flood Control Project under the leadership of the California Reclamation Board and the U. S. Army Corps of Engineers (Corps). In Sacramento, the project commenced with the reclamation of the Natomas Basin. Construction of the Yolo and Sacramento Bypass systems quickly followed along with the extension of the levee system along the north side of the American River and around the City of North Sacramento east of Natomas. All of this work was completed by 1930.

The flood of 1937 and the nation's sustained appetite for federally funded public works cleared the way for Congressional approval of the Flood Control Act of 1944 calling for the Corps to construct a 350,000 acre-foot flood control dam on the American River near the town of Folsom. The American River Basin Development Act of 1949 increased the footprint of the project to a little over 1,000,000 acre-feet, added water supply and power generation as project purposes, and incorporated Folsom Dam and Reservoir into the Central Valley Project under the operation of

the U. S. Bureau of Reclamation. Based on the limited hydrologic record then available for the American River Basin, the Corps concluded that a seasonal reservation of 400,000 acre feet of reservoir storage for flood control combined with a sustained flood control release of 115,000 cubic feet per second would provide Sacramento with protection against the most severe storm that could be anticipated considering the meteorologic and hydrologic characteristics of the watershed. Such a storm was considered to have an annual risk of occurrence of less than 1/500.

Folsom Dam was effectively operational though not technically completed when the storm of December 1955 exceeded previous records for run-off volume and peak discharge along the American River and filled the empty reservoir in a matter of days. Despite this portent of a changing hydrology, the Corps proceeded with the last phase of American River levee construction, closing off an overflow basin on the north side of the river upstream of H Street. This levee work, completed in 1958, significantly narrowed the river channel and increased the community's reliance on reservoir storage. Unfortunately, Folsom Dam did not have an accommodating design. The dam's outlet works would not permit operators to quickly increase outflows at the beginning of a flood event. Sizeable releases from the dam could not be made until almost half of the reservoir storage space allocated to flood control was filled. At that point, the limited capacity of the new channel became a constraint. The consequences of these design limitations became clear in 1961 when the Corps reassessed the hydrology of the American River Basin and concluded that the new flood control system could only contain a flood with an annual risk of occurrence of about 1/125.

There have been three distinct public policy responses to this problem over the past 40 years. The multipurpose Auburn Dam project was authorized following the flood of 1964. The project proceeded into the mid-1970's before an earthquake near Oroville created concerns regarding the seismic safety of the thin arch design of the dam. Construction stopped until a blue ribbon panel concluded that with design modifications the new dam could be safely built and operated. This finding did not revive the project, however, because the new Republican administration elected in 1980 withdrew federal financial support for water development programs.

The record flood of 1986 produced a new Auburn Dam initiative. In order to avoid the disputes surrounding the multipurpose project, SAFCA advocated construction of an expandable flood control dam. This facility would have provided new reservoir storage capacity for flood control only, but without precluding the option of expanding the size of the dam and including water supply and power generation as project purposes in the future. In the meantime, SAFCA offered to work with water supply interests on ways to meet regional water demands without using the new dam for water conservation. This approach generated much support in the immediate aftermath of the 1986 flood when public safety was a commanding concern. Over time, however, this concern diminished and some environmental and water supply interests, for opposite reasons, concluded that SAFCA's flood control dam tilted the playing field against their competing visions for the Auburn site. This odd alliance killed the flood control dam on the floor of the U. S. House of Representatives in 1992.

The defeat of the flood control dam spawned the current flood risk management program that is based on redesigning, reconfiguring, and re-operating Folsom Dam. Using weather forecasts to guide flood control operations is a key element of this program. In a perfectly informed world,

we would keep Folsom Reservoir full of water at all times, emptying it only as needed to accommodate forecasted inflow to the reservoir. Unfortunately, we are not yet capable of such foresight. However, neither are we so blind that we must depend on a flood control operation that is keyed to measured inflow to the reservoir. The emerging forecast-based management strategy puts us somewhere between these two extremes. This strategy is keyed to forecasts of very large flood events producing either a peak discharge or three-day volume in excess of what we experienced in 1986 and 1997. It is assumed that the profile of such an event is reasonably unmistakable and observable at a distance from our watershed, i.e. a monster of this size is not likely to catch us by surprise. On the other hand, having been observed at a distance, there is no assurance that the monster will head directly for us. Thus, the management strategy calls for a calibrated response reflecting the best judgment of our sentinels as to the direction and pace of the monster's advance. It is assumed that the monster is unlikely to be nimble enough to threaten us with immanent harm, inducing us to discharge precious water supplies, only to dance off to a neighboring watershed without creating enough of a deluge for us to recover the supplies we have discharged.

Not only would the forecast-based management strategy enable us to better cope with the threat of monster storms invading our watershed, it would also enable us to more fully utilize our water conservation capacity when there is no immanent threat of such an invasion. Since such threats are relatively rare, especially in the late fall and early spring, we should be able to measurably improve system operations during these periods.

The forecast-based management strategy is heavily dependent on a series of ongoing operational and physical improvements to Folsom Dam. In order to react alertly and effectively to identified threats of harm, dam operators must be able to release large amounts of water from the reservoir even when the reservoir is less than half full. They will not have this capability until the work needed to enlarge the dam's low-level river outlets is completed. Moreover, the extent of any seasonal improvement in water conservation is linked to the dam's physical capacity to store water during normal flood operations. Within the next ten years, this capacity will be enlarged by modifying Folsom Dam's emergency spillway gates so as to allow floodwater to be temporarily stored in the "surcharge" space above the top of the water conservation pool. With Congressional approval, this "surcharge" space could be further enlarged by raising the top of the dam.

SURFACE AND GROUNDWATER SUPPLY

Historically, water has been supplied to urban and agricultural users in the Sacramento area either from diversions off the Sacramento and American Rivers or from pumping out of the large groundwater basin that lies beneath Sacramento County. Until recently, most of the growth in the County occurred either in the City of Sacramento or in areas of the County adjoining the north and south banks of the American River. For a variety of reasons, these areas have had reliable access to surface water supplies. However, as growth has moved into the northern and southern portions of the County away from the American River, the volume of groundwater pumping has increased, creating a risk of over-pumping. This risk was heightened during the

drought years of the mid-1970's. It became more serious as urban demand for water increased in the 1980's and early 1990's.

In 1994, the City and County of Sacramento convened the Sacramento Water Forum to address groundwater issues and develop a plan for meeting the surface water needs of the region. This diverse group of business and agricultural leaders, citizens groups, environmentalists, water managers and local governments focused on two coequal objectives: providing a reliable and safe water supply for the region's economic health and planned development to the year 2030, and preserving and the fishery, wildlife, recreational and aesthetic values of the Lower American River. More than six years of intense negotiations, including tens of thousands of hours of research, education and discussion produced the Memorandum of Understanding for the Water Forum Agreement (Agreement) signed by all of the participants. This Agreement contains seven elements or categories of complementary actions that are necessary to achieve the Water Forum's objectives:

- Increased surface water diversions;
- Actions to meet water needs while reducing surface water diversions in drier years;
- Improved pattern of fishery flow releases from Folsom Reservoir;
- Water conservation;
- Groundwater management; and
- Creation of an organizational structure to oversee, monitor and report on implementation of the agreement.

Guided by the Agreement, the City of Sacramento has expanded its existing water diversion facilities on the American River and on the Sacramento River south of the American. The City has also initiated planning and construction of a new diversion facility on the Sacramento River north of the American. Sacramento County along with the East Bay Municipal Utility District has initiated planning and construction of a new diversion facility on the Sacramento River near the town of Freeport. These facilities will create significant flexibility in accessing surface water when run-off conditions in the watershed permit.

With respect to groundwater, which is expected to provide about half of the region's water supplies, the Agreement contains recommendations regarding the average annual sustainable yield of each of the three sub-areas of the groundwater basin in Sacramento County. North of the American River, the north area sub-basin between the Sacramento River and Folsom Reservoir has a recommended annual sustainable yield of 131,000 acre-feet. The central area sub-basin between the American River and the Cosumnes River has a recommended annual sustainable yield of 273,000 acre-feet. The south (Galt) area sub-basin south of the Cosumnes River has an annual sustainable yield of 115,000 acre-feet.

In the north area, stakeholders have created the Sacramento Groundwater Authority (SGA) to manage the groundwater resources of the sub-basin in this area. The SGA has been very active in developing groundwater monitoring and data collection, coordinating groundwater quality protection, creating the physical and operational linkages necessary to promote integrated use of surface and groundwater supplies based on watershed run-off conditions, and developing a regional groundwater banking and exchange/surface water transfer program within the

framework of the Water Forum Agreement. In the central area, a stakeholder forum has been created to develop a comparable management program for this sub-basin. In developing this program, the forum will have to address the twin problems of over-pumping and groundwater contamination.

FISH AND AQUATIC HABITAT

Prior to the 20th Century, migratory salmon and steelhead had access to over 125 miles of habitat in the American River watershed. However, since the early 1900's, access has been impeded by dams constructed for debris containment, flood control and water diversion. Many of these dams had inadequate fish ladders or other means to permit fish passage. Construction of Folsom Dam in 1955 without fish passage facilities permanently confined the river's migratory fish to the lower 23 miles of the watershed. At the same time, the dam completely altered seasonal flow and temperature conditions in this reach of the river, making it only marginally habitable for salmon and steelhead. To compensate for the resulting impacts on these migratory fish, the Nimbus Fish Hatchery was constructed as part of the Folsom Dam project in an effort to maintain fish stocks through artificial means. Lastly, in connection with the project authorization, Reclamation adopted decision D-893 establishing a minimum daily flow standard for the lower river of 500 cfs between September 15 and December 31, and 250 cfs at all other times.

In time, it became clear that neither the adopted flow standard nor the physical design of the dam provided adequate conditions to sustain viable populations of salmon and steelhead in the lower river. River temperatures were consistently too high because the dam had no means to manage the limited cold water pool that formed in the reservoir each spring. The adopted flow standard was too low to ensure adequate spawning and rearing habitat. In order to improve cold water pool management, Reclamation installed a system of manually operated temperature control shutters on each of the dam's three hydropower intakes. Authorization of the multipurpose Auburn Dam led to a revised flow standard (D-1400) that called for flows as low as 250 cfs in months with very low reservoir storage and up to 3,000 cfs in months with high storage and projections of ample watershed run-off. This standard was tied to completion of the new dam but was used as a voluntary guideline to help maintain natural fish production in the lower River.

In the early 1970's, environmental interests backed by the County of Sacramento sued the East Bay Municipal Utility District (EBMUD) to prevent diversions from the lower river that would undermine the public trust values of the river. After an extensive examination of the issue, Judge Richard Hodge developed a series of "physical solution" flows designed to protect the river's fishery resources, riparian habitat values and recreational values. These flows were 2,000 cfs from mid-October through February, 3,000 cfs in March through June, and 1,750 cfs in July through October. Unfortunately, these physical solution flows did not specifically address water temperature conditions for over-summering steelhead or allow sufficient operational flexibility to adjust the specified flows based on water year type.

These problems were addressed in the Central Valley Project Improvement Act (CVPIA) passed by Congress in 1992. Declaring that fish and wildlife protection is a project purpose equal in

stature to water supply and power generation, the CVPIA contains a series of provisions to address past impacts to fish and wildlife resources. These provisions include the Anadromous Fish Restoration Program (AFRP) whose goal is to double the natural production of five anadromous fish species including salmon and steelhead in the Central Valley and Trinity River basins. This is to be accomplished by ensuring adequate river flows, improving physical habitat, and eliminating or reducing losses through water diversions. AFRP flow objectives for the lower American River have been developed for each month of the year and range between 500 cfs and 4,500 cfs depending on watershed run-off.

In order to coordinate this federal initiative with similar efforts affecting the State Water Project, a number of state and federal water management and regulatory agencies along with urban, agricultural and environmental interests have developed the CALFED Bay Delta Program. The Framework Agreement, signed in June 1994, identifies the primary areas of concern within the CALFED process (water quality, coordination of the federal and state water projects, and restoring the ecological health of the Bay Delta) and establishes the cooperative roles of the participating state and federal agencies.

At the local level, the Fisheries and In-stream Habitat Management Plan for the lower American River (FISH Plan) that was developed as part of the Water Forum Agreement serves as the vehicle for addressing the fish and wildlife concerns articulated in the CVPIA and CALFED. The principal goal of the FISH Plan is to increase and maintain viable populations of naturally spawning fall-run salmon and steelhead in the Lower American River. The Plan outlines a broad range of recommended actions to achieve this goal. These actions are tiered by priority and practicality. The top priorities are actions to improve river temperatures and flows, including mechanization of the temperature control shutters on the intakes to Folsom Dam's hydropower units, modifications to the diversion structure at the Nimbus Dam fish hatchery, reduction in the extent and frequency of flow fluctuations in the river, and approval of an updated flow standard for the Lower American River.

CONNECTING THE DOTS

There is a clearly discernable interdependence between the efforts described above to initiate a weather forecast-based strategy for operating Folsom Dam, improve management of the groundwater basin beneath Sacramento County, and preserve the fish and aquatic habitat values of the lower American River. The weather forecast-based strategy has the potential not only to reduce the risk of flood damages in the Sacramento floodplain, but also, when combined with physical improvements to the dam, to minimize flow fluctuations and improve water conservation efforts, especially in the late spring and early fall. These are critical periods for salmon and steelhead in the lower river. Improved water conservation during these periods could strengthen Folsom Reservoir's coldwater pool and increase the operational flexibility needed to meet in-stream flow requirements.

Roughly speaking, on an annual basis, the total volume of water available to consumers in Sacramento County from both surface and groundwater sources is about 1,000,000 acre-feet. Greater flexibility in reservoir operations would make it easier to promote an integrated approach

to managing this water supply. Assuming groundwater management is improved along the lines of the SGA program in the north area of Sacramento County, water customers could benefit from being connected into a combined surface and groundwater supply system that would permit adaptive management of water deliveries based on watershed run-off conditions. This would make the region's water supply more sustainable, increasing the likelihood that flood control requirements, consumer demands for water consumption, and resource management demands for adequate flows and temperatures could be effectively balanced.

CREATING A TEST BED

Marty Ralph of the National Oceanic and Atmospheric Administration (NOAA) likes to talk about creating a test bed for research and development of the physical tools and operational programs that will be needed to implement the forecast-based management strategy at Folsom Dam. A test bed is a kind of expanded laboratory that is designed to provide scientists, engineers, and policy makers with a structure for carrying out interrelated projects. The structure focuses on an identified practical problem and promotes association and activity among people with interests related to this problem leading to exchanges of information and ideas that generate breakthroughs that might not otherwise occur.

The LAR Science Conference could be a kind of test bed in the making. The conferees are mostly scientists, engineers and policy makers interested in reconfiguring and re-operating the existing water management infrastructure along the Lower American River so as to better balance the competing demands for flood control, water supply, and preservation of fish and aquatic habitat in the river. A considerable amount of activity is occurring in connection with three issues that are likely to significantly affect the manner in which a desirable balance is achieved: use of weather forecasting in reservoir operations, groundwater management, and fish and aquatic habitat management.

The purpose of the conference is to facilitate an exchange of information and ideas on these issues, encourage an understanding of their interconnectedness, and promote association and continued activity among the conferees. Although the Lower American River and its floodplain is a relatively confined area, it is well suited to support a substantial research and development effort. Over the next several decades the Central Valley is expected to absorb the lion's share of California's population growth. Sacramento is currently the largest urban settlement in the valley. Because of the unique topography and hydrology of the valley, all of these settlements are dam and reservoir dependent; all of them also rely on large groundwater basins; and all of them are struggling to preserve the valley's remnant fish and aquatic habitats. Because of the extraordinary investments in time and money that have been made in Sacramento over the last eight years in addressing these challenges, no other valley community is as far along in the process of developing an effective management response.

As reflected by this conference, an appropriately tailored, integrated water management program is beginning to emerge in Sacramento, but we have a long way to go. We would get there faster and provide even more effective leadership to others in the valley if we made better use of the test bed concept. In agreeing to organize this conference, California State University,

Sacramento has signaled its interest in helping to meet this need. It would appear that the University is well suited to the task. It is located right on the Lower American River. It has a diverse, interdisciplinary faculty and a large student population with a practical orientation. When not consumed by its teaching function, the University is capable of supporting the kind of applied research and development that lies at the core of the emerging water resource management program in Sacramento. Through its support for the Center for Collaborative Policy, the University has contributed to making significant advances in building capacity for citizen and agency collaboration in water policy development, a major community asset. Nevertheless, for a variety of reasons, the University has played a relatively minor role in the great volume of technical work that has supported this collaboration.

Hopefully, this is about to change. Each of the three topics of this conference offers substantial opportunities for data collection, research and practical problem solving. With a cadre of technically competent faculty members backed by a large pool of student investigators, the University could play a major role in pursuing these opportunities. This conference shows that considerable outside support would greet such an initiative, particularly if the topics are approached in an interdisciplinary and interconnected manner.