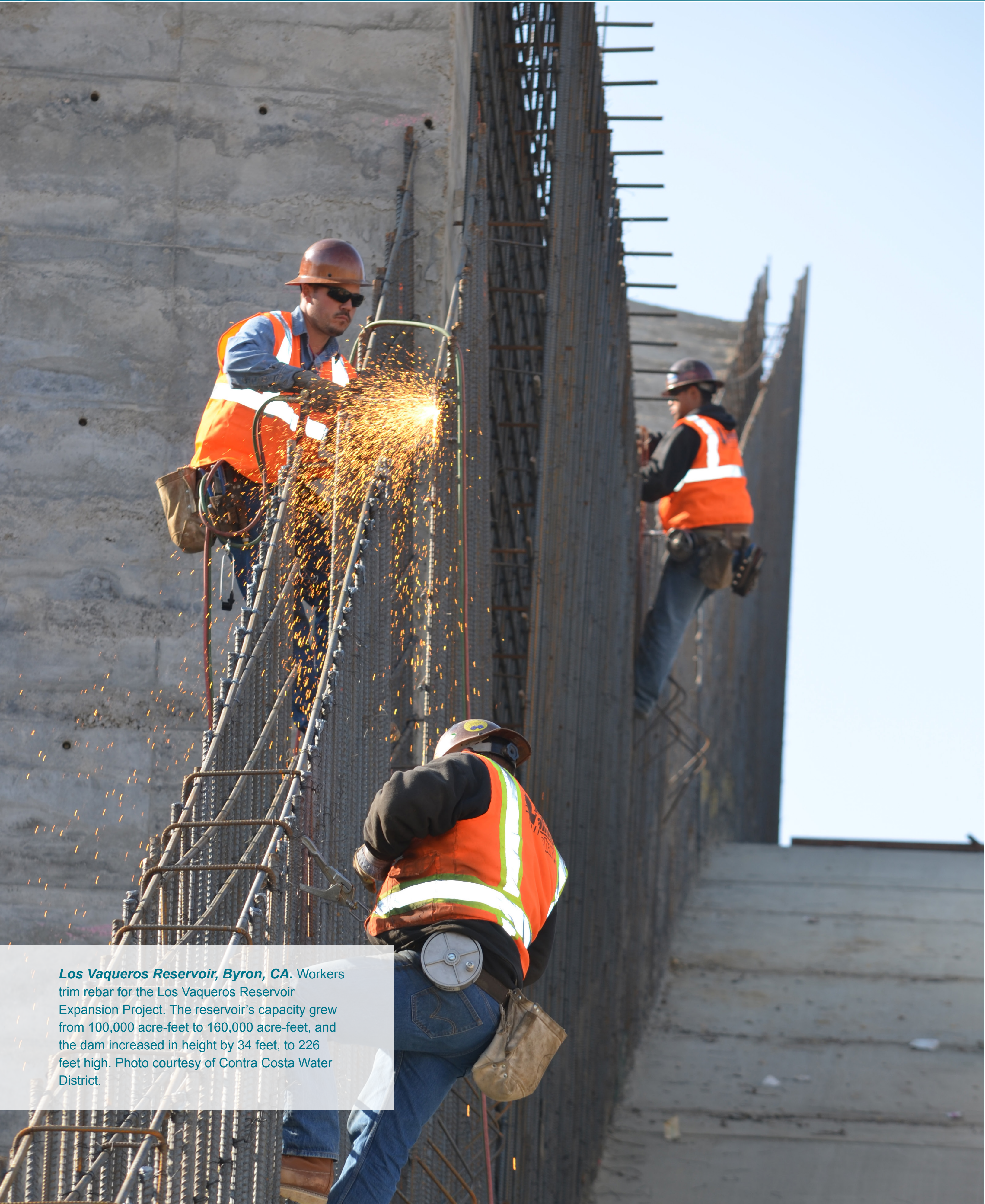
VOLUME 3 - RESOURCE MANAGEMENT STRATEGIES

CHAPTER 14

Surface Storage — Regional/Local



Los Vaqueros Reservoir, Byron, CA. Workers trim rebar for the Los Vaqueros Reservoir Expansion Project. The reservoir's capacity grew from 100,000 acre-feet to 160,000 acre-feet, and the dam increased in height by 34 feet, to 226 feet high. Photo courtesy of Contra Costa Water District.

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Chapter 14. Surface Storage — Regional/Local

Surface storage is the term for the use of human-made, above-ground reservoirs to collect water for later release when needed. Surface storage has played a key role in California where the quantity, timing, and location of water demand frequently does not match the natural water supply availability. Many California water agencies rely on surface storage as a part of their water distribution systems. Reservoirs also play an important role in flood control and hydropower generation throughout California.

In addition, surface storage is often necessary to implement, or can maximize the benefits from, other water management strategies, such as water transfers, conjunctive water management of surface and groundwater (see Chapter 9, "Conjunctive Management and Groundwater"), and conveyance improvements. Some reservoirs contribute to water deliveries across several regions of the state while others provide only relatively local water deliveries. There are two general categories of surface storage reservoirs: (1) those formed by damming an active, natural river; and (2) those called offstream reservoirs, which require a human-made diversion or pumping of water from a river into storage.

Additional surface storage benefits can be developed by enlarging a dam and releasing the water it stores behind it, reoperating the releases from a dam (see Chapter 7, "System Reoperation"), or modifying existing reservoirs. Smaller reservoirs typically store water only annually in the winter for supply use in summer, while larger reservoirs hold extra water over several years (known as carryover storage) as a reserve for droughts or other emergency supplies. In recent decades, reservoir operations have been most affected by the need to meet environmental regulations for the protection of affected fish species. Today, multiple-purpose surface storage projects balancing water supply, flood protection, hydropower production, water quality, recreation, and ecosystem needs are the norm.

The information in this chapter focuses on regional and local surface storage alternatives but does not include the major surface storage investigations of the State and federal CALFED Bay-Delta Program (CALFED), which are described separately in Chapter 13, "Surface Storage — CALFED."

Surface Storage in California

California has nearly 200 surface storage reservoirs greater than 10,000 acre-feet (af) with a combined storage capacity of more than 41 million af. These were tabulated in chronological order within Volume 4 of *California Water Plan Update 2009,* "Reference Guide," under the topic "Infrastructure" (California Department of Water Resources 2009). In addition, there are many more reservoirs smaller than 10,000 af that are used to provide for a wide range of water uses, such as stabilizing water delivery to customers or providing a backup supply for emergency needs.

Most of California's reservoirs were constructed more than 40 years ago; the number of new reservoirs built has steadily declined since the 1960s. Only six new water supply reservoirs were constructed in California in the 1980s and 1990s, and only three have been completed since 2000. Examples of recently completed surface storage projects servicing local or regional areas include:

- The U.S. Bureau of Reclamation's Warren H. Brock Storage Reservoir, located on the north side of the All-American Canal in Imperial County and completed in 2010.
- San Diego County Water Authority's Olivenhain Reservoir, completed in 2003.
- Metropolitan Water District of Southern California's Diamond Valley Reservoir, completed in 2000.
- The U.S. Army Corps of Engineers' and Orange County Flood Control District's Seven Oaks Reservoir, completed in 1999.
- Contra Costa Water District's Los Vaqueros Reservoir, completed in 1998.

The primary benefits of these new reservoirs include water supply reliability against catastrophic events and droughts, operational flexibility to meet peak summer water demands, water quality improvement, flood control, hydropower, and capturing excess flows.

A few enlargements of existing surface storage reservoirs have been completed since 2000 to meet anticipated future needs. Examples include the 60,000 af expansion of Los Vaqueros Reservoir by Contra Costa Water District completed in 2012; the 24,000 af expansion of Topaz Lake Reservoir on the California-Nevada border in 2008 to increase flood control; the 152,000 af enlargement of San Vicente Reservoir in San Diego County in 2006; and the 42,000 af expansion of Lake Kaweah reservoir in 2004 for flood protection and agricultural water supply.

Some surface storage is used to provide flood control benefits and to facilitate capture of stormwater for recharge of downstream groundwater basin(s) used for local water supply. Water conservation pools have been established by U.S. Army Corps of Engineers (USACE) at Seven Oaks Dam and Prado Dam on the Santa Ana River. Captured water is released slowly for groundwater recharge and use by downstream water managers. The Los Angeles County Flood Control District also holds water behind many local dams for subsequent release and spreading to recharge groundwater. The Southern California Water Committee Stormwater Task Force has initiated discussions with USACE to determine if additional stormwater could be captured at the federal flood control reservoirs for water supply purposes. Some water agencies also use their surface storage for imported water deliveries for groundwater recharge. Accumulation of sediment in flood control reservoirs has reduced capacity for both flood management and stormwater conservation. (See Chapter 26, "Sediment Management," for more information on sediment management.)

Some surface storage has decreased across the state due to the removal of smaller, older, obsolete dams, primarily for the purpose of improving fish habitat and passage upstream. The California Department of Water Resources' (DWR's) Fish Passage Improvement Program, within the FloodSAFE Environmental Stewardship and Statewide Resources Office (FESSRO), maintains a list of dams removed for fish passage purposes. DWR's June 2005 Bulletin 250, *Fish Passage Improvement: An Element of CALFED's Ecosystem Restoration Program*, describes structures removed to improve fish passage in California. One of the reasons that removal of existing dams is feasible is that newer, more efficient alternatives now serve the projects' original purposes for water deliveries or hydropower generation. In early 2010, a package of agreements was signed by many local stakeholder groups, three tribes, PacifiCorp (an electric power company), California, Oregon, and the federal government. This is leading to the removal of four hydroelectric dams on the Klamath River in Oregon and California. The removal will improve fish passage and possibly bring about a major fisheries restoration.

Throughout the past three decades, new regulations and legislation have required many reservoirs to be operated in a more environmentally friendly manner to improve downstream riverine habitats and fisheries. Specifically, many existing reservoirs have been reoperated to achieve ecosystem and river recreation benefits beyond the original project objectives.

As the competing water demands for agricultural, urban, and environmental needs have increased, the operational flexibility of California's various surface water systems has decreased. Today's water system managers face a complex array of competing demands on the use of limited reservoir storage, which potentially results in more water reductions during droughts.

The relative need for additional local surface storage development may be greatest in California's interior mountainous areas, such as the Cascades and the Sierra Nevada. Although much of the water used throughout the state originates in the mountains, these locations generally possess limited groundwater supplies, are particularly vulnerable to the impacts of climate change on hydrology, and have a shorter list of water management strategies available to meet local needs. This is largely due to geographic, hydrogeologic, or hydrologic limitations. Of these few strategies, new surface storage or enlargement of existing reservoir storage may hold the greatest potential for achieving local supply reliability objectives. Local surface storage development options also could include the reoperation of existing reservoirs through the development of water sharing or purchasing agreements with the downstream owners of existing reservoirs.

Potential Benefits

Many of California's reservoirs were originally built for one or two primary purposes, such as agricultural and municipal consumptive water use, flood control, or hydropower. However, over time the number of benefits asked of surface storage has generally expanded to include the following:

- Water quality management.
- Ecosystem management.
- Sediment transport management.
- River and lake recreation.
- Emergency water supply.
- System operational flexibility.
- Flexible hydropower — the conversion and storage of wind and solar energy as hydropower.

The presence of new surface storage allows water managers the flexibility to implement water management strategies more easily and more efficiently or to implement strategies simply not available without storage. Storage helps solve the temporal problem that occurs when the availability of water and the demand for water do not occur at the same time. Often regional conservation efforts are ineffective if any water conserved cannot be stored for later use. For example taking into consideration percolation rates and geology, surface reservoir capacity can store and carry over stormwater captured in wet years for gradual release into spreading grounds or retention basins to help replenish groundwater.

Storage allows water transfers between regions to occur at any time, not just when the water is needed for immediate use. In addition, water transfers early in the water year are generally less expensive, because of less demand, than transfers later in the water year. Surface storage is needed to enable and improve the effectiveness of conjunctive water management strategies by controlling the timing and volume of water ultimately conveyed for storage in groundwater basins.

Dealing with climate change impacts is a key concern for California's water purveyors. Climate change projections foresee more extreme weather, such as floods and droughts. More importantly, warming temperatures are expected to raise the snowfall elevation, causing more winter precipitation in the Sierra Nevada to occur as rainfall and creating larger and earlier runoff events. In addition, several million acre-feet (maf) of natural snowpack storage could be lost. By expanding surface storage capacity, water supply systems would have greater flexibility to capture the increased winter runoff and help control larger anticipated flood flows. Additional reserve storage would also allow water to be held over for all uses in dry years and droughts.

Potential Costs

Cost estimates for potential surface storage alternatives are not specified in this narrative because they vary extensively by region and specific project design. In most cases, the costs of multipurpose storage projects are shared by many beneficiaries and often include a State or federal cost-share component. The magnitude of individual project benefits and corresponding costs for new water supply, hydropower, flood management, and water quality, as examples, can be expected to vary significantly from project to project such that average cost information is not accurate.

Major Implementation Issues

Climate Change

Climate change projections indicate that California will experience more extreme weather, such as floods and droughts. At the same time, warming temperatures are expected to raise the snowfall elevation, causing more winter precipitation in the Sierra Nevada to occur as rainfall. This will lead to larger and earlier runoff events. As a result of these changes, several maf of natural snowpack storage could be lost annually, reducing available water supply. In addition, the increasing severity of storms and increased runoff could overwhelm existing reservoir flood protection capacity and increase flood risks downstream.

Adaptation

Expansion of surface storage capacity can be an effective climate change adaptation strategy because increasing local and regional surface storage can provide greater flexibility for capturing runoff and managing supplies to meet increasingly variable future conditions. The ability to store water from wet years for use in dry years is critical to addressing increasing climate variability. Additional surface storage allows water to be held over from year to year as a hedge against dry years and droughts. Surface storage facilities south of the Sacramento-San Joaquin Delta

(Delta) allow water to be moved through the Delta when conditions allow it. Even if the water isn't needed immediately, the water can be stored for later use, providing additional protection from Delta supply interruptions and cutbacks. Surface storage provides unique climate change adaptation characteristics that are difficult to achieve with other management strategies: the ability to quickly detain and retain flood flows to protect downstream assets, and the ability to quickly release large quantities of water when demands increase or to meet instream temperature requirements. Reservoirs also allow storage of water that can be released slowly at rates that match groundwater basin percolation rates and facilitate recharge of downstream groundwater basins.

Mitigation

Increases in greenhouse gas (GHG) concentrations in Earth's atmosphere are thought to be the main cause of current climate warming. Human activities, such as the burning of fossil fuels and deforestation, have been identified as the origin of higher GHG concentrations. Construction of surface storage reservoirs typically requires substantial construction and heavy equipment activity, which can emit large quantities of GHGs. In addition, offstream surface storage projects often require water to be pumped into the reservoir for storage, requiring electricity to run pumps (most electricity generation emits GHGs). In this way, development of new or expanded surface storage projects can work against efforts to mitigate the effects of climate change through GHG emission reduction efforts.

Conversely, depending on how individual surface storage projects are operated, they can provide substantial climate change mitigation benefits that in some cases more than offset emissions from construction. Enhancing the surface storage capacity of local water supplies near water users may reduce the need for energy intensive water conveyance and pumping. Surface storage reservoirs with hydroelectric generating capacity provide effective backup power supplies to be operated in tandem with intermittent renewable energy resources, such as wind and solar energy. Excess wind or solar energy can be used to run pumps to move water into offstream reservoirs, and water can be released from surface storage facilities to generate electricity when clouds obscure solar generation or when winds die down and reduce wind generation. Onstream reservoirs can produce substantial quantities of renewable, GHG-free hydroelectric energy.

Funding and Identifying Project Beneficiaries

Construction usually requires a substantial amount of money in a short time — millions to hundreds of millions of dollars. Included in the long-term capital outlay are planning costs, such as administrative, engineering, legal, financing, environmental documentation, permitting, and mitigation costs. Some new-storage options, such as raising existing reservoirs, reoperating them, or constructing small local reservoirs, may require significantly less capital but may require local funding through revenue or general obligation bonds.

There are concerns related to how the beneficiaries will be determined, who will actually pay, and who will control a storage operation. One financing concept assumes that only the direct beneficiaries of a proposed storage project should pay for the construction and operation costs. However, many of the beneficiary groups do not have adequate financial resources to build large projects without outside financial assistance.

Another general financing concept relies on a large percentage of State and federal funding support to assist in the construction of new projects. With this method, the project beneficiaries would have a smaller, more affordable project cost component to fund. However, the process of obtaining funding approval from either federal or State government agencies generally requires substantially more time and justification documents. The challenge is to develop financial and operations agreements that have the best possibility for successful allocation of project costs corresponding directly to the beneficiaries and uses of a given project.

Impacts

New storage can affect environmental and human conditions and can create economic impacts for the surrounding community and flow impacts both upstream and downstream of diversions. New reservoirs may result in the loss of property tax revenue to local governments in the area where they are located, due to inundated developed land or land suitable for development, or may result in an increase of local property values by firming up a water supply. Regulatory and permitting requirements mean that surface storage investigations must consider potential impacts on streamflow regimes, potential adverse effects on designated wild and scenic rivers, potential water quality issues, potential changes in stream geomorphology, loss of fish and wildlife habitat, and risk of failure during seismic or operational events. Existing environmental laws require that these effects be addressed and potentially mitigated. Mitigation of environmental effects is normally accomplished through implementation strategies that avoid, minimize, rectify, reduce over time, or compensate for negative impacts. New surface storage projects are required to address impacts under the application of various laws, regulatory processes, and statutes, such as public trust doctrine, State dam safety standards, area-of-origin statutes, the California Environmental Quality Act, the National Environmental Policy Act, the Clean Water Act, California's Porter-Cologne Act, the federal Migratory Bird Treaty Act, and the California Endangered Species Act and federal Endangered Species Act.

Suitable Sites

Most of the best natural reservoir sites in California have already been developed, and environmental regulations and mitigation requirements impose significant constraints on development of new surface storage in California's mountainous areas. In some areas, the development of new offstream storage is a feasible alternative if the geographic terrain provides suitable locations. Another option that has received consideration in recent years is the rehabilitation and enlargement of existing reservoirs. This has the advantage of using an established reservoir site, but the feasibility and costs for rehabilitation of an older facility must be carefully evaluated.

Project Funding

The range of surface storage development options is generally more limited for smaller local agencies than for the State and federal governments, because limited agency funding and staff resources affect their capability to complete complex feasibility studies, design documents, environmental impact studies, and related project planning needs. These circumstances severely constrain the ability of local governments and agencies to finance and implement the projects necessary to sustain the local economy, preserve or restore riparian habitats, and provide water supplies for regional population growth. Traditionally, small local agencies have been unwilling to fund projects outside their service areas. However, recently, local partnerships through integrated regional water management plans (IRWMPs) have pooled resources and collaborated on local shared storage projects aimed at benefiting all regional participants.

Recommendations

1. Local agencies seeking to implement storage projects should develop a comprehensive methodology for analyzing all project benefits and costs. DWR should provide guidance, technical expertise, and planning process assistance to local agencies if requested.

2. Reservoir operators and stakeholders should continue to adaptively manage operations of existing facilities in response to increased understanding of system complexities and demands, as well as changes in natural and human considerations, such as social values, hydrology, and climate change.

3. DWR and other State, federal, and local resource management agencies should continue studies, research, and dialogue focused on a common set of tools that would help determine the full range of benefits and impacts, as well as the costs and complexities of surface storage projects.

4. Water resources scientists, engineers, and planners, including those at DWR, should recognize the potential long development time required for new surface storage in securing funding needed for continuity of planning, environmental studies, permitting, design, construction, and operation and maintenance.

5. Rehabilitation and possible enlargement of existing older dams and infrastructure should be given full consideration as an alternative to new reservoir storage.

6. As an alternative to new storage, agencies should consider the potential to develop water purchasing agreements to buy water from other agencies that own storage reservoirs with substantial water supplies.

7. Local agencies should investigate integrating existing surface storage with groundwater management or other water supply options (e.g., water use efficiency).

8. Local agencies should team with other regional agencies through the IRWMP process on new regional storage projects.

9. Surface storage can be the centerpiece of a comprehensive IRWMP offering multiple benefits and the flexibility to fully implement many other resource management strategies. Shared local or regional surface storage can enhance water user ability to implement conjunctive groundwater storage, integrate flood management practices, take full advantage of water transfers, assist in ecosystem restoration, and offer recreation benefits — all by augmenting consumptive water use.

10. The California Air Resources Board, California Public Utilities Commission, and California Energy Commission should consider developing policies to support the use of pumped energy storage to increase the development of solar and wind energy in a cost-effective manner.

References

References Cited

California Department of Water Resources. 2009. *California Water Plan Update 2009*. Volume 4, "Reference Guide." Topic: "Infrastructure." Section 2, "California Reservoir Summary." Viewed online at: http://www.waterplan.water.ca.gov/docs/cwpu2009/0310final/v4c13a02_cwp2009.pdf. Accessed: March 27, 2013.

California Department of Water Resources. 2005. *Fish Passage Improvement: An Element of CALFED's Ecosystem Restoration Program.* Bulletin 250.

Additional References

U.S. Department of the Interior, U.S. Department of Agriculture, U.S. Department of Commerce, California Department of Fish and Game, et al. 2013. "Klamath Basin Water Issues." [Web site.] Viewed online at: http://klamathrestoration.gov/. Accessed: March 27, 2013.