Hetch Hetchy
Restoration Study

STATE OF CALIFORNIA THE RESOURCES AGENCY Department of Water Resources • Department of Parks and Recreation


Falls
Dome
6165
5200
Tueeulala
Falls
Footbridges
4800
BM 4050
HETCH
Kolana Rock
SPILLWAY 3796
Water
Quarry
5200
4000
HETCHY
7093
6400
5878
6800
Smith Peak
VABM 7751
6800
5600
6300
Smith
Mdw
Cottonwood Creek
6400
6800
Creek
6000
6800

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2006

CONTENTS

FOREWORD

The restoration of Hetch Hetchy Valley on the upper Tuolumne River has once again captured the public's imagination. In order to provide for an informed dialogue about this issue, the Resources Agency has objectively evaluated the many Hetch Hetchy Valley restoration studies produced during the past two decades. In so doing, the state also recognized the great value and benefit of providing a central clearinghouse of all Hetch Hetchy restoration work.

Moreover, in conducting the study, the state provided a neutral, public forum to discuss issues related to Hetch Hetchy restoration, such as water supply and water quality, flood management, cultural resources, environmental impacts, energy generation, and recreation. In all, several hundred people participated in a July 2005 workshop in Sacramento and at other stakeholder meetings throughout the state. In addition, many interested Californians provided written comments for our consideration.

This final report is a comprehensive analysis of Hetch Hetchy Valley restoration studies. But even as a comprehensive analysis, we find, first and foremost, that much study remains to be done because there are major gaps in vital information. For example, objectives for replacing the water supply for the Bay Area, dam removal methods and impacts, and considerations of the public use and benefit of a restored Valley remain largely undefined. Another critical, missing element is a formal public involvement process to engage agencies, Native American tribes, stakeholders and other interested parties in this issue.

While we offer no formal recommendation about next steps, it is clear that further investigations into Hetch Hetchy Valley restoration cannot be led by the State of California alone. Federal participation will be important to help shape future studies and to work with the San Francisco Public Utilities Commission, tribes, and the public on any next steps in this process. Moving forward, the Resources Agency's role in studies and planning for Hetch Hetchy will be consistent with the state's approach to other significant natural resources such as the Sacramento-San Joaquin Delta or the Salton Sea — to protect the public trust by ensuring that these natural places are protected and utilized for the benefit of all Californians.

OVERVIEW OF REPORT

In November 2004, in response to a legislative request, Secretary for Resources Mike Chrisman directed the Department of Water Resources (DWR) and the Department of Parks and Recreation (DPR) to review the many studies prepared during the last 20 years on the restoration of Hetch Hetchy Valley. These studies include work performed by the state and federal governments in response to the 1987 proposal of then-Secretary of the Interior Donald Hodel to study restoring Hetch Hetchy, and more recent analyses by Environmental Defense and the University of California, Davis.

In addition to a review of previous Hetch Hetchy studies, DWR and DPR considered local, state and federal resource plans to help evaluate water supply, drought preparedness, water quality, operational flexibility, flood impacts, environmental and energy issues.

The project also included an evaluation of the likely costs of replacing water and energy supplies, removal of O'Shaughnessy Dam, increased water treatment, and ecosystem restoration activities for Hetch Hetchy Valley.

The state found that most of the previous studies addressed specific or narrow aspects of restoring Hetch Hetchy Valley, sometimes targeting only a single purpose or objective. No single study tackled the entire array of issues involved in restoring Hetch Hetchy Valley. Further, even when these studies are taken collectively, major information

Hetch Hetchy Valley Reports and Major Issues

Major Issues	Report/Organization	1988 **Hetch Hetchy: A Survey of Water and Power Replacement Concepts** US Bureau of Reclamation	1988 **Hetch Hetchy: Striking a Balance** US Department of Energy	1988 **Restoring Hetch Hetchy** State Assembly Office of Research
Valley "Futures"	Restoration			✔
	Public Use			✔
	Dam Removal			
Water Replacement	Upper Tuolumne River	✔	✔	
	Don Pedro	✔	✔	
	Groundwater/conjunctive use	✔	✔	
	SFPUC system	✔	✔	
	Bay-Delta	✔	✔	
Water Quality	Domestic water quality			
	Environmental water quality			
Power Replacement		✔	✔	
Benefits				✔
Costs	Dam removal			
	Valley restoration			
	Water replacement	✔	✔	✔
	Water quality			
	Power replacement	✔	✔	✔
Institutional				

gaps still emerge. For example, very little information is currently available regarding dam removal, public use in a restored valley, or the economic benefits of restoration. Past studies have also largely ignored the environmental impacts of removing O'Shaughnessy Dam and replacing its water and power benefits. Even for water and power replacement options, researchers have not fully evaluated statewide water management impacts or established performance criteria to measure success. Perhaps most noteworthy, a major element missing from most existing studies is a public involvement process. Such a process would engage the public, agencies, and stakeholders in determining the purpose and need of the project, establishing objectives, and grappling with potentially adverse regional and third-party impacts that might result from options involving water and power changes.

The state concludes that the existing body of work—including its own—is insufficient to support sound public policy decision-making at this time; in fact, most of the work to date is not even at the "concept level". However, the state found no fatal flaws in the restoration concept that would preclude additional study. Future studies of Hetch Hetchy restoration should be completed with well-defined objectives, supported by a robust stakeholder process. Moreover, studies should be carried out to a consistent level across all issues, beginning with benefits, public use in a restored Hetch Hetchy Valley, and dam removal.

1988	1990	2003	2004	2004	2005	2005
Alternatives for Restoration of Hetch Hetchy Valley Following Removal of the Dam and the Reservoir National Park Service	**AB 645 Report** Department of Water Resources	**Reassembling Hetch Hetchy: Water Supply Implications of Removing O'Shaughnessy Dam** University of California, Davis	**The Potential Economic Benefits of Restoring Hetch Hetchy Valley** University of California, Berkeley	**Paradise Regained: Solutions for Restoring Yosemite's Hetch Hetchy Valley** Environmental Defense	**Finding the Way Back to Hetch Hetchy Valley** Restore Hetch Hetchy	Rebuttal to **Paradise Regained** San Francisco Public Utilities Commission
✔					✔	
					✔	
					✔	
				✔	✔	
		✔		✔	✔	
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			✔		✔	
					✔	
					✔	
		✔		✔	✔	
		✔		✔		
		✔		✔	✔	
				✔	✔	✔

COST ESTIMATES

The cost estimates in past studies of Hetch Hetchy Valley restoration, even when reviewed collectively, do not cover all aspects and implications of valley restoration. To better understand the potential costs of restoring the valley, the state developed an overall cost estimate that covers valley restoration, public use, and dam removal, as well as water and power replacement.

The cost estimate range of nearly $3 billion to $10 billion is patterned on existing work by making broad assumptions on a mix of facilities that may be required for water and power replacement. Given the uncertainty involved in these assumptions, the state estimate includes a range of costs to reflect the potential variation in facility mix and sizing, as well as the potential for additional environmental protection and water management risk mitigation. The estimate also assumes varying levels of restoration, dam removal and public use, but, in the end, is inherently limited due to the level of information available and the lack of formal project objectives.

The following table provides a summary of Hetch Hetchy Valley restoration cost estimates completed by the San Francisco Public Utilities Commission (SFPUC), Restore Hetch Hetchy (RHH), Environmental Defense (ED), and the state. The table does not include the cost of conducting all of the planning studies required to proceed with further consideration of the program. If a decision is made to continue investigations, the cost would be approximately $65 million.

Hetch Hetchy Valley Restoration Cost Estimate (millions of dollars)

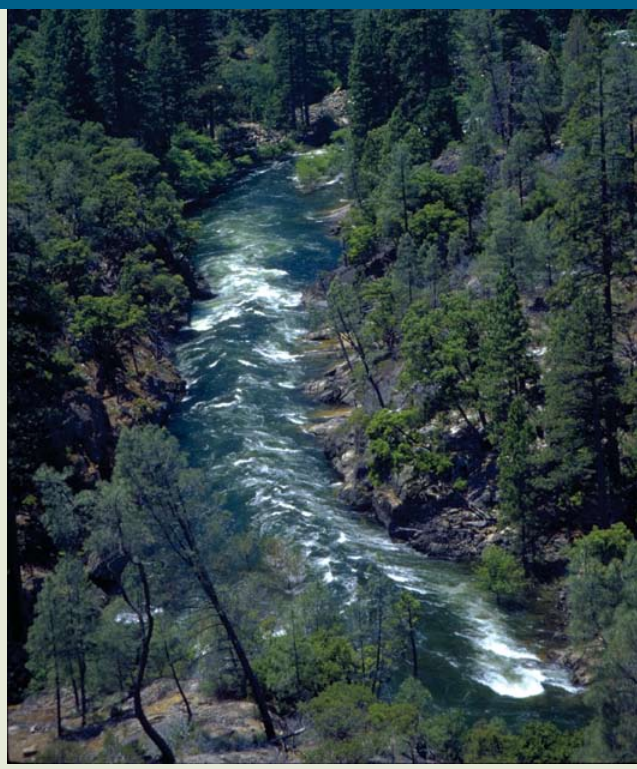
Category	RHH	ED	STATE
Implement Water Replacement Components	626	174 to 652	1,144 to 4,305
Implement Power Replacement Components	217	340 to 693	560 to 820
Dam Modification or Removal	108	Not Included	250 to 915
Restore Valley	23	Not Included	32 to 53
Implement Public Use Plan for Valley	Not Included	Not Included	10 to 91
Subtotal	**974**	**514 to 1,345**	**1,996 to 6,184**
Contingencies	57	-11 to 228	Included in above values
Site-Specific Environmental Documentation, Permitting & Mitigation	Not Included	Included in above values	390 to 1,790
Engineering, Legal and Administration	65	6 to 76	610 to 1,850
GRAND TOTAL	**$1,096**	**$510 TO 1,649**	**$2,996 TO 9,824**

Note: Via memo to DWR dated July 20, 2005, SFPUC provided an estimate of $9 billion in total costs to restore Hetch Hetchy Valley. The SFPUC did not respond to DWR requests to review documentation of this cost estimate; therefore, DWR was unable to examine SFPUC's claim in this report.

NEXT STEPS

The existing studies provide initial conceptual information on Hetch Hetchy Valley restoration, but do not contain enough collective detail to reach conclusions about the feasibility or acceptability of Hetch Hetchy Valley restoration. Future studies could further refine and assess technical, cost, and environmental factors in greater detail. If there is support to move forward with plans for Hetch Hetchy Valley restoration, the following issues need to be examined in more detail:

- Dam owner and beneficiary rights
- Legal contracts and the application of fair principles for determining whether and how to make parties whole
- Potential beneficial and adverse effects of restoring Hetch Hetchy Valley
- Replacement water and power deliveries from new facilities, including potential water quality and water supply reliability benefits and the institutional and operational agreements among potential participants
- Potential costs and financing for Hetch Hetchy Valley restoration and water and power replacement, including allocation of costs among purposes
- A method for determining the value of potential benefits to assist decision-makers in allocating costs
- Increased dialogue among elected officials, federal, state and local agencies, Native American tribes, environmental interest groups and the public, including a formal process engaging the city and county of San Francisco and the Department of Interior regarding objectives for water and power replacement



The Tuolumne River is a federally designated wild and scenic river.

An estimated $7 million is needed for a comprehensive Hetch Hetchy Restoration study at the conceptual level of detail and another $13 million at the appraisal or reconnaissance level. Because Hetch Hetchy Valley is located in a national park, the U.S. Department of Interior must be involved in any further study of valley restoration.

Further investigations into Hetch Hetchy Valley restoration cannot be led by the State of California alone. Federal participation will be important to help shape future studies and to work with the San Francisco Public Utilities Commission, Native American tribes, and the public on any next steps in this process. Federal authorization may be needed to initiate this federal role. A public/private partnership might be one mechanism to proceed with further evaluations. The Resources Agency will participate in any future studies under it mission to manage California's natural resources with the goal of ensuring that future studies or plans adhere to principles of integrated regional water management, that they maximize public benefit, and that they protect the environment, as well as the public trust.

1 INTRODUCTION

Hetch Hetchy is a glacially carved valley located within Yosemite National Park in the Sierra Nevada of California. With its sheer granite walls and waterfalls, it is often compared to Yosemite Valley, about 17 miles to the south. In December 1913, amid much controversy, the federal government granted the city and county of San Francisco the rights to dam Hetch Hetchy Valley to impound the Tuolumne River for water supply and power generation. The reservoir behind O'Shaughnessy Dam can inundate the valley with up to 360,000 acre-feet of water. Hetch Hetchy is the flagship of a system of 10 storage reservoirs relied upon by the San Francisco Public Utilities Commission (SFPUC). It currently supplies an average of 220 million gallons per day of exceptionally high quality water to more than 2.4 million people in the San Francisco Bay Area. The Hetch Hetchy system provides about 85 percent of San Francisco's total water demand and, together with SFPUC's Cherry and Eleanor system, generates an average of 1.7 billion kilowatt-hours of hydroelectric energy annually.

PURPOSE OF REVIEW

In September 2004, in response to a study conducted at the University of California at Davis, Assembly Members Lois Wolk and Joe Canciamilla asked Governor Schwarzenegger to examine the feasibility of restoring Hetch Hetchy Valley and to outline the necessary actions the state should take to achieve this restoration. In response, Secretary for Resources Mike Chrisman directed the Department of Water Resources (DWR) and the Department of Parks and Recreation (DPR) to review and summarize the growing body of information that has been prepared over the last 20 years on potential removal of O'Shaughnessy Dam and restoration of Hetch Hetchy Valley.

The purpose of this report is to provide an objective review of prior work on pertinent water supply, water quality, flood management, public use, environmental, economic, and power issues surrounding proposals to restore Hetch Hetchy Valley. The affected geographic areas covered by this report include Hetch Hetchy Valley, Yosemite National Park, the local Tuolumne River region, the service area of the SFPUC, the service areas of the Modesto and Turlock Irrigation Districts (MID and TID), and the lower San Joaquin River region. The report also addresses Native American and statewide considerations.

STATE INVOLVEMENT

Resources Agency staff undertook this review and analysis, with existing personnel and budget, under its mission to manage California's natural resources. Although Hetch Hetchy is not owned or operated by the state, changes to the Hetch Hetchy system would impact California's natural resource management activities and responsibilities. By reviewing the range of information accumulated over nearly 20 years of studies and evaluating the possible costs of the project, the state can facilitate informed public policy discussions regarding the future of Hetch Hetchy Valley.

SCOPE OF REVIEW

The work by DWR and DPR was limited to a review of prior studies. The goal was to determine if, collectively, there was enough information to show the feasibility of restoring Hetch Hetchy Valley. Due to incomplete cost estimates from previous studies, DWR found it necessary to prepare its own rudimentary estimates of restoration costs. In addition, DWR and DPR conducted a limited analysis of key resource management issues, primarily to compare information from the prior studies.

The review was not intended to answer all the questions surrounding the restoration of Hetch Hetchy Valley. However, DWR and DPR conducted the review with an eye to the following questions:

- Are the assumptions and technical evaluations performed in previous studies complete and reasonable?
- What are the cost considerations of replacing the water and power benefits from O'Shaughnessy Dam?
- What information is available regarding dam removal and its cost?
- What are the Hetch Hetchy Valley restoration and public use opportunities?
- How do the costs of the proposal relate to other resource management needs facing California?
- Who should direct any additional studies necessary to enable a future decision on valley restoration?

DWR and DPR reviewed existing Hetch Hetchy restoration reports and met with stakeholders and agencies, focusing on two primary objectives:

1. Learn enough about the issues to appreciate the scope and complexity of the subjects.
2. Conduct the review from a neutral, objective perspective.

Public Workshop

On July 14, 2005, the Resources Agency held a public workshop and issued a progress report on the study framework and its initial observations. More information is available at http://www.hetchhetchy.water.ca.gov

During the course of this review, DWR and DPR met with the SFPUC and its retailers, MID and TID, Native American tribes, the National Park Service, affected stakeholders downstream of Hetch Hetchy, and environmental interest groups. These meetings provided insight into stakeholder and agency concerns. The general public also had an opportunity to provide comments, via mail, a dedicated web site, and a workshop. Public comments can be found in Appendix J.

DWR and DPR found that considerably more work needs to be done before the financial feasibility of restoring Hetch Hetchy Valley can be determined. While this report cannot make specific recommendations on potential restoration, it does provide:

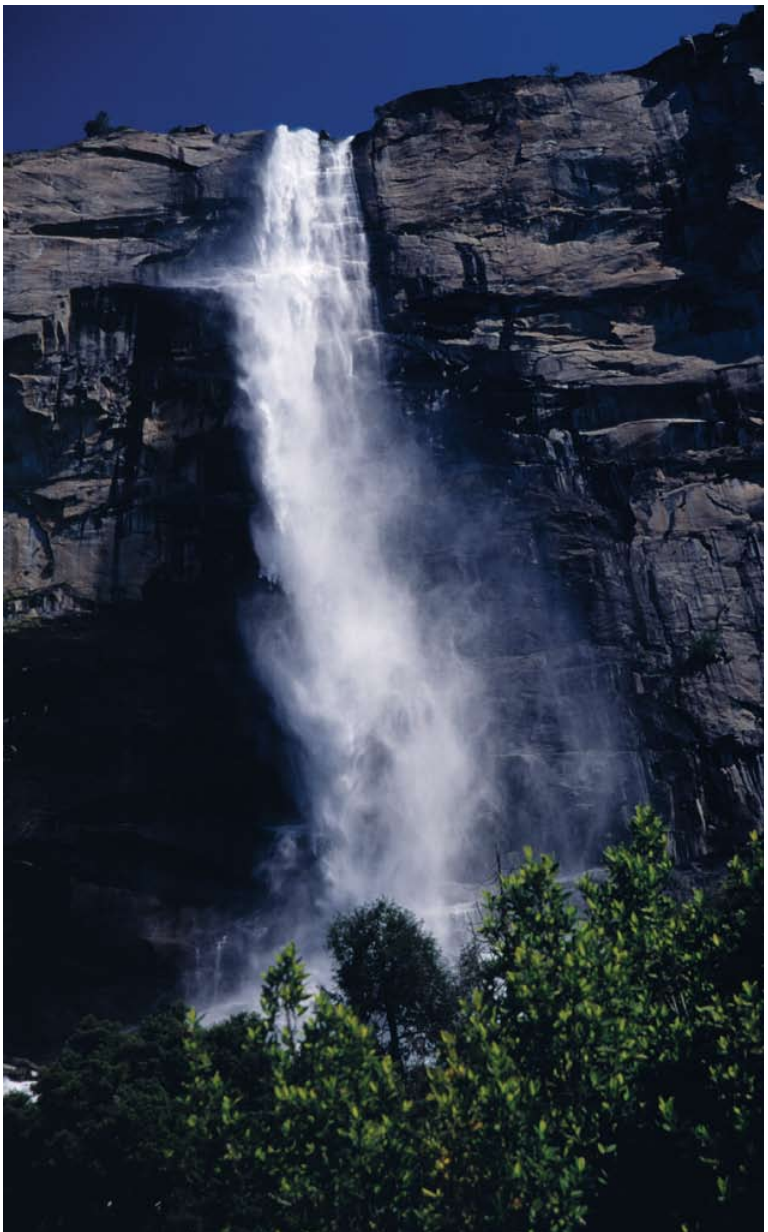
- A compilation of relevant information regarding Hetch Hetchy Valley restoration and water and power replacement.
- Evaluation of previous studies and reports for completeness when compared with common practices.
- Display of existing information on key topics that influence cost and uncertainties.
- Identification of additional information needed for more comprehensive appraisal or feasibility level studies.

DWR and DPR staff engaged a broad array of stakeholders to gather input and perspectives on Hetch Hetchy:

San Francisco Public Utilities Commission
National Park Service
Department of Interior
Tuolumne Band of Me-Wuk Indians
Modesto Irrigation District
Turlock Irrigation District
U.S. Bureau of Reclamation
Bay Area Water Supply and Conservation Agency
Groveland Community
Environmental Defense
Restore Hetch Hetchy
UC Davis
Tuolumne River Trust
Bay Area Council
Silicon Valley Leadership Group
Sierra Club
American Fisheries Society
California Research Bureau
American Water Works Association

- A description of different Hetch Hetchy Valley restoration and public use opportunities that may be possible (with and without the existing reservoir).
- A discussion of statewide and tribal considerations when replacing the current water and power benefits provided by Hetch Hetchy.
- Estimates of costs from existing work including Hetch Hetchy Valley restoration and recreation, removing O'Shaughnessy Dam, and replacing the lost water and power.
- Management options for additional studies necessary to enable a future decision on the restoration of Hetch Hetchy Valley.

SFPUC wholesales water to more than 30 entities in the San Francisco Bay Area, serving 1.7 million people outside the city and county of San Francisco. Most of these entities are members of the Bay Area Water Supply and Conservation Agency.



Tueeulala Falls
is a scenic feature of
Hetch Hetchy Valley.

2 BACKGROUND

HETCH HETCHY SYSTEM

The San Francisco Public Utilities Commission manages and operates the Hetch Hetchy Water System, which begins with facilities in Hetch Hetchy Valley in Yosemite National Park. The water originates as snowmelt and rain runoff in the upper Tuolumne River watershed. From Hetch Hetchy, Tuolumne River water flows by gravity through approximately 160 miles of pipelines and tunnels to the San Francisco Bay Area.

O'Shaughnessy Dam

O'Shaughnessy Dam is the most prominent feature of the Hetch Hetchy water system. The original construction of the dam began in 1914 and finished in 1923. Construction in 1938 raised the dam another 85 feet to its present height of 312 feet. The city and county of San Francisco own the concrete gravity dam.

The dam's spillway consists of three gated, 65-foot wide concrete bays at the left (looking downstream) dam abutment. Drum gates on each weir bay are typically raised annually in the late spring to provide additional storage. Gates are down in the winter to pass storm flows. The discharge capacity of the spillway is 48,600 cubic feet per second (cfs) with the gates down. There are 14 outlets that pass through the dam or its foundation, 11 of which are used to discharge directly to the river. Modifications in 2004 diverted the flow of three outlets into the Canyon Power Tunnel leading to Kirkwood Powerhouse. Two outlets release water directly to the Tuolumne River for instream fishery requirements.

O'Shaughnessy Dam is located in the central portion of the Sierra Nevada geomorphic province. The Sierra Nevada is comprised of Mesozoic age granitic rocks that have intruded into Paleozoic- and Mesozoic-age meta-sedimentary and metavolcanic rocks. No regional faults are mapped in the area of the dam and reservoir.

The state of California began regulating dam safety in 1929. According to DWR's Division of Safety of Dams, the dam has performed well since its construction.

Water Conveyance Facilities

Two additional reservoirs, Lake Lloyd (Cherry Lake) and Lake Eleanor, also collect water that is used for downstream flow obligations to the MID/TID and power generation at Holm Powerhouse.

Upon completion in 1923, O'Shaughnessy Dam impounded the Tuolumne River in Hetch Hetchy Valley.

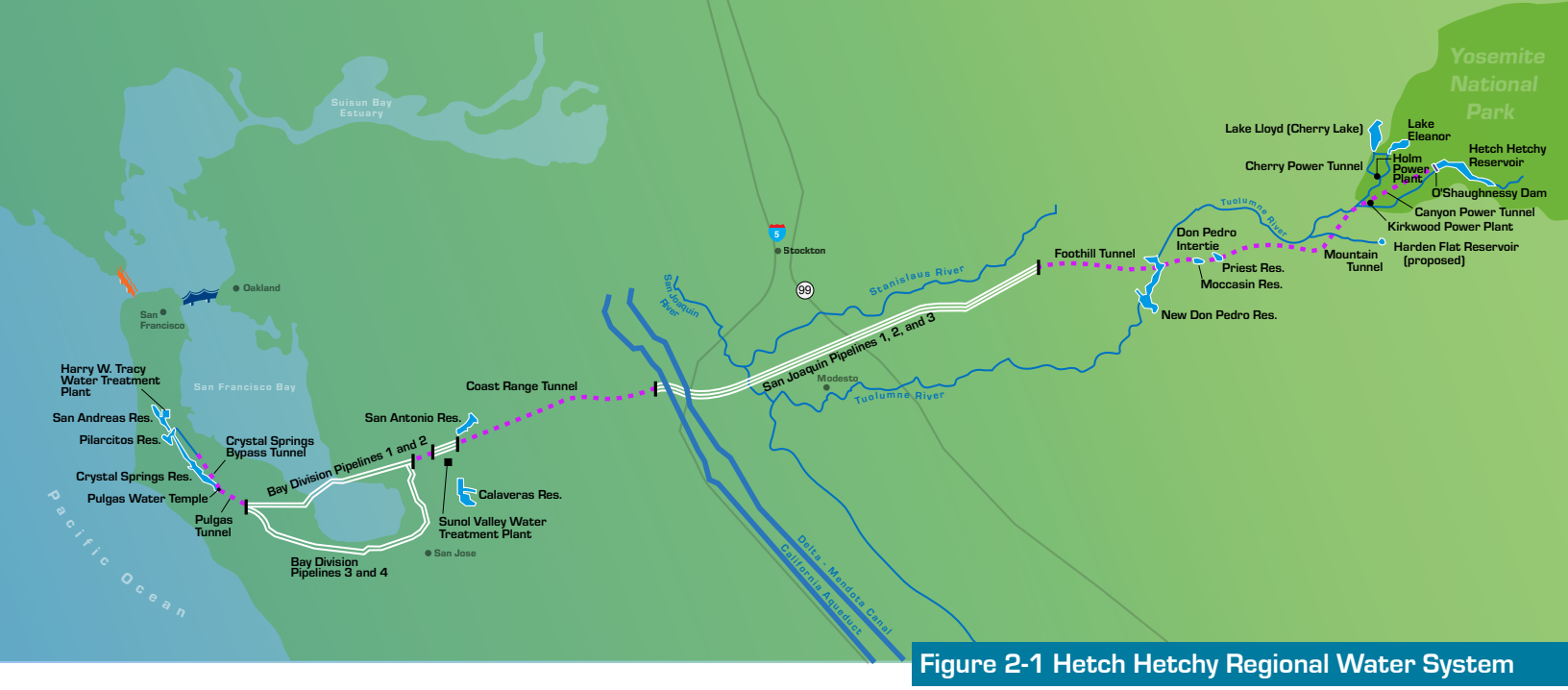


Figure 2-1 Hetch Hetchy Regional Water System

The Department of Health Services has permitted these two lakes, which are hydraulically connected, as standby sources for the SFPUC. Water from the two reservoirs can be diverted to the Early Intake Diversion Structure via the Lower Cherry Aqueduct, where it would enter the Mountain Tunnel to provide additional water supply.[1]

Water from Hetch Hetchy Reservoir is conveyed through a series of tunnels and pipelines, two power houses, and other facilities in its journey to the Bay Area. Figure 2-1 shows the general path that water takes by gravity from Hetch Hetchy Valley.

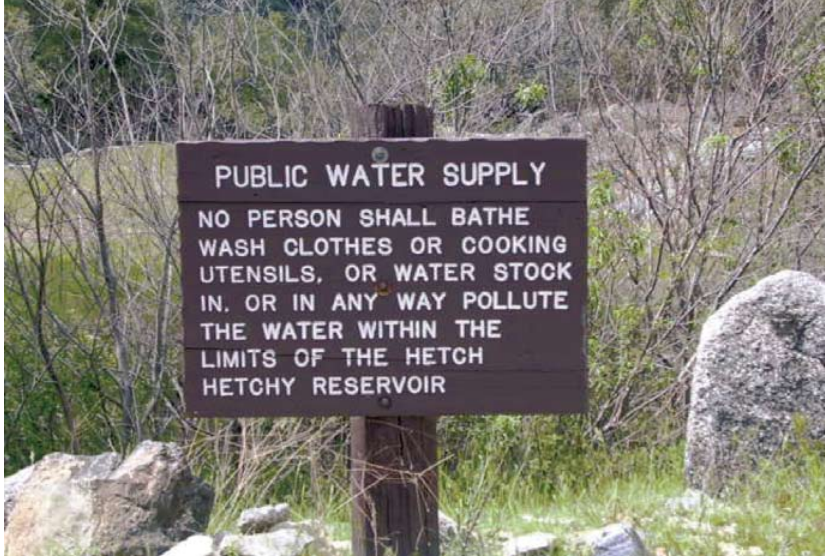
Drinking Water Quality

The Tuolumne River is impounded behind O'Shaughnessy Dam in Hetch Hetchy Valley and currently serves as an exceptionally high quality drinking water source. Its 459 square-mile watershed lies completely within Yosemite National Park, and with the exception of just a handful of locations (such as Tuolumne Meadows), it is undeveloped, federally designated wilderness and is difficult for the public to access.[2] Long-term monitoring of this source consistently shows that the water contains low levels of alkalinity, hardness, dissolved solids, turbidity, organic matter, nutrients, and pathogens; contaminants of concern are usually not even detected in the Hetch Hetchy water supply. The lack of alkalinity, though, results in a poorly buffered water that is unstable in pH, aggressive to pipelines, and a challenge to treat.

The Hetch Hetchy water supply is one of the few surface water sources in the U.S. that is legally delivered unfiltered to customers, with only disinfection required for potability. In 1993, SFPUC applied for, and the U.S. Environmental Protection Agency (USEPA) granted, "filtration avoidance" status for Hetch Hetchy, that is, the water supply meets

[1] Before domestic use, water from Lakes Eleanor and Lloyd would require full conventional treatment at the Sunol Valley Filter Plant. The use of such supplies would impact the community of Groveland, which normally uses Hetch Hetchy water.

[2] Tuolumne Meadows is a recreational area in the High Sierra, 24 miles upstream of Hetch Hetchy, which is open to vehicle traffic only during the summer.



When the Raker Act of 1913 authorized construction of the Hetch Hetchy system, it also mandated protection of water quality in Hetch Hetchy.

USEPA criteria for avoiding filtration. Unlike an exemption or variance, SFPUC must meet these filtration avoidance criteria on a continuous basis, and one of these criteria addresses watershed protection, including an annual watershed sanitary survey.

Only four other major urban areas in the U.S. (Portland, Seattle, Boston, and New York City) have also earned this status for one of their water sources. In 2000, the SFPUC formally reaffirmed its policy of maintaining filtration avoidance status for Hetch Hetchy. In the near future, it is expected that Hetch Hetchy water will require advanced disinfection, as well as potentially some modification to current disinfection practices, to provide for further inactivation of *Cryptosporidium* to comply with USEPA's Long-Term 2 Enhanced Surface Water Treatment Rule.

Even with this special status for Hetch Hetchy, SFPUC actually filters much of this supply. For example, during times when the Hetch Hetchy supply arriving in the Bay Area exceeds system demand, Tuolumne River water is spilled to Upper Crystal Springs Reservoir on the San Francisco Peninsula, where it is subsequently filtered and disinfected at the Harry Tracy Water Treatment Plant. In response to seasonal water quality problems, SFPUC also has the capability of filtering Hetch Hetchy at its Sunol Valley Water Treatment Plant, either directly or after storage in San Antonio Reservoir. Normally, though, Hetch Hetchy is only treated with lime for corrosion control, hypochlorination for primary disinfection, chloramination for secondary disinfection, and fluoridation for the prevention of dental cavities.

Ambient Water Quality

Water diversions in the upper Tuolumne River watershed have impacts to water quality downstream and in the Delta because of lower diluting flows of high quality water from upstream. Some of these impacts can include less water for maintaining habitat and higher concentrations of contaminants. For instance, the lower reach of the Tuolumne River provides habitat for the biggest wild salmon run in the San Joaquin River system, so dissolved oxygen and temperature levels are of concern. As for pollution sources, the lower Tuolumne, like many rivers in the Central Valley, receives urban and agricultural runoff and, during the winter, the City of Modesto discharges its wastewater effluent immediately above the Tuolumne-San Joaquin River confluence. Mine tailings line portions of the lower reach of the Tuolumne as well. In 2002, USEPA formally listed 60 miles of the lower Tuolumne River (from Don Pedro Reservoir to the San Joaquin River) as a water quality limited segment under Section 303(d) of the Clean Water Act, specifically for contamination by diazinon, pesticides, and unknown toxicity. Don Pedro itself was listed at the same time for mercury contamination.

In addition, Hetch Hetchy water is usually blended with a small percentage of SFPUC's local supplies—which are always filtered—in the East Bay (primarily from Calaveras Reservoir) or on the San Francisco Peninsula (from Crystal Springs, San Andreas, Pilarcitos, and Stone Dam Reservoirs.) Some of SFPUC's retailers utilize other water supplies (e.g., State Water Project water, local surface water, and groundwater), with which the Hetch Hetchy supply may be further blended by the time a customer receives "Hetch Hetchy" water. Hetch Hetchy water is also specifically blended in southern Alameda County to dilute hard and saline groundwater, and on the Peninsula to dilute nitrate concentrations in local groundwater and support conjunctive use programs.

LEGAL BACKGROUND

Yosemite Enabling Legislation

In 1864, President Abraham Lincoln signed legislation that granted Yosemite Valley and the Mariposa Big Tree Grove to the State of California, to "be held for public use, resort, and recreation" to be "inalienable for all time ."[3] In 1890, President Benjamin Harrison signed legislation establishing Yosemite National Park as a "forest reservation" to preserve and protect "from injury all timber, mineral deposits, natural curiosities, or wonders" within the park area and to retain them in their "natural condition." The act excluded Yosemite Valley and the Mariposa Big Tree Grove, leaving them under the jurisdiction of the State of California as provided for in the 1864 act. A joint resolution of Congress on June 11, 1906, accepted the transfer of Yosemite Valley and the Mariposa Big Tree Grove from the State of California to the federal government as part of Yosemite National Park.

Raker Act

In 1913, Congress passed, and President Woodrow Wilson signed, the Hetch Hetchy Act, popularly known as the Raker Act after Manteca Congressman Edward Raker. This law authorized the city and county of San Francisco to build dams in the Hetch Hetchy Valley, the Lake Eleanor Basin, and Cherry Valley to provide for a regional water supply for the entire San Francisco Bay Area. The act also protects water quality in Hetch Hetchy by prohibiting certain activities, including "bathing" in the reservoir or in streams within one mile of the reservoir. In addition, the act limits the width of aqueduct right-of-ways crossing the San Joaquin Valley to 250 feet. Since 1934, the Raker Act has required the city to pay an annual rental fee of $30,000 to the U.S. Department of the Interior.

[3] California State Parks measures its beginning from this act, a fact commemorated on the California State Parks logo with the reference, "Since 1864."

Water Rights and Interagency Agreements

San Francisco holds pre-1914 water rights under the Civil Code to appropriate water from the Tuolumne River. MID and TID also hold pre-1914 appropriative rights on the Tuolumne, which are senior to San Francisco's water rights. There are also other appropriative and riparian water users on the system. Because Hetch Hetchy Valley is in a national park, the doctrine of federal reserved water rights also applies.

In addition, San Francisco, MID, and TID have entered into four agreements over the past 72 years that concern water rights to the Tuolumne, operation of Hetch Hetchy, flood control, cost-sharing for Don Pedro Reservoir, a water banking and credit-exchange agreement for Don Pedro, and sharing of Federal Energy Regulatory Commission (FERC) operational requirements at Don Pedro. The rights and duties under these agreements would have to be resolved by the parties in the event that Hetch Hetchy Reservoir no longer exists.

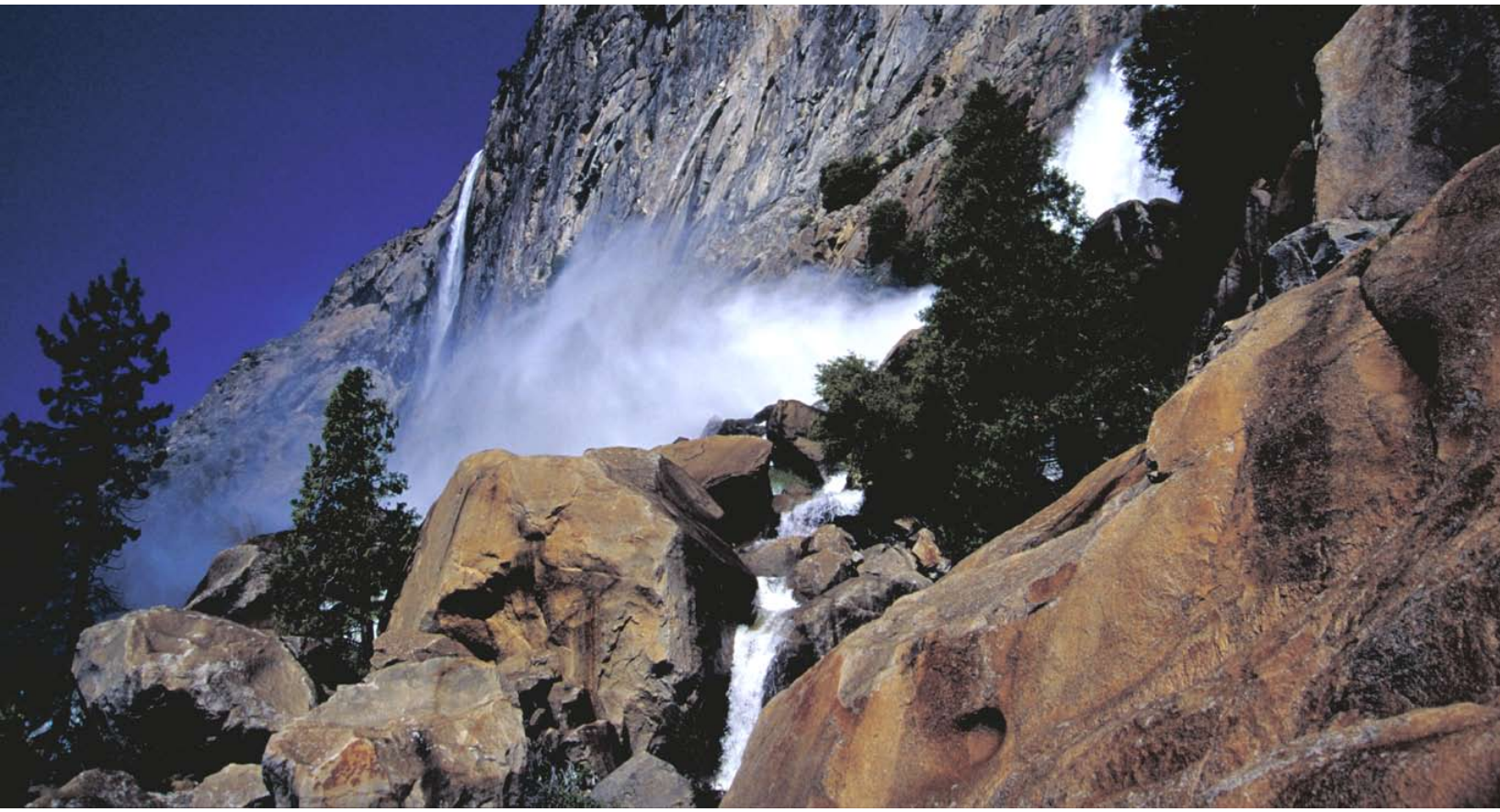
Organic Act

In 1916, Congress passed the Organic Act, establishing the National Park Service and its purpose:

> Promote and regulate the use of the federal areas known as national parks, monuments and reservations by such means and measures as conform to the fundamental purpose of the said parks, monuments and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.

Wilderness Act

In 1964, President Lyndon Johnson signed the Wilderness Act. This act defines and designates wilderness areas as those "where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain." The California Wilderness Act of 1984 resulted in the designation of about 95 percent of Yosemite National Park as the Yosemite Wilderness, including the entire watershed above the high water mark of Hetch Hetchy Reservoir.



Spray from Wapama Falls in foreground.

Wild and Scenic Rivers Act

Passed by Congress in 1968, the National Wild and Scenic Rivers Act requires that designated rivers "be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations." Yosemite National Park manages two Wild and Scenic Rivers and their watersheds, the Merced and the Tuolumne. In the 1984 California Wilderness Act, Congress designated 83 miles of the Tuolumne River as wild and scenic, 54 of which are located within Yosemite National Park. Hetch Hetchy Reservoir is excluded from the Wild and Scenic Rivers Act.

3 PRIOR STUDIES

Prior studies for potential restoration of Hetch Hetchy Valley are clustered in two distinct groupings.

1) A series of studies from 1988 to 1990 were spurred by a restoration study proposal by former Secretary of the Interior Donald Hodel.

2) More recent analyses, conducted between 2002 and 2005, have renewed interest in potential restoration of the valley.

The state has reviewed each of these studies in the context of existing and relevant resource management plans produced by federal, state, and local agencies. These resource management plans, such as the California Water Plan Update 2005 and the California Outdoor Recreation Plan, provide important guidance in evaluating the collection of existing work on Hetch Hetchy.

THE HODEL PROPOSAL

In July 1987, Secretary of the Interior Hodel proposed to study the removal of O'Shaughnessy Dam and restoration of Hetch Hetchy Valley. In response, the federal and state governments issued a total of five related reports between early 1988 and early 1990. Three reports focused on potential alternatives for replacing lost water and power supplies and their costs, while two focused mostly on different options for the restored valley. Only one of the five reports discussed the potential environmental impacts of removing O'Shaughnessy Dam and replacing lost water and power supplies. None of the reports focused on the potential benefits of restoration of, or public use in, Hetch Hetchy Valley, nor attempted to quantify those benefits economically.

The basic conclusion from these five reports was that Hetch Hetchy Valley was more valuable as a water source than as a restored valley. One report suggested that the feasibility of restoring the valley may be more attractive as O'Shaughnessy Dam nears the end of its useful life.

RECENTLY PUBLISHED WORKS

The release of four recent works—major reports from Environmental Defense and Restore Hetch Hetchy and two related master's theses—have rekindled public interest in the restoration of Hetch Hetchy Valley. They generally support the concept of removing the dam and restoring the valley. Also, SFPUC issued four reports as a rebuttal to the report by Environmental Defense.

CONTEXT OF PRIOR STUDIES

Most of the reports resulting from the Hodel proposal, as well as recently published works, were targeted toward a single purpose or objective. Some studies focused mainly on water and power replacement. Some studies focused mainly on restoration of the valley. None of the studies presented a complete view of information necessary to make a decision on the feasibility of the restoration concept. Therefore, the body of prior work must be viewed collectively to judge what further information is needed. The matrix on pages 2 and 3 provides a snapshot of prior studies and the issues covered by each.

In general, the studies did not define an array of broad objectives to guide valley restoration, visitor use, dam removal, and water and power replacement. Environmental Defense conducted computer modeling and cost estimates for various water replacement alternatives, but they did not estimate the cost of dam removal or restoration. Restore Hetch Hetchy did not conduct any modeling of water replacement alternatives, but did estimate the cost of dam removal and restoration under certain assumptions. The method for deconstructing the dam does not include alternative dam removal options such as full removal, partial removal by breach, or draining the reservoir and leaving the dam in place.

Work on water and power replacement included identifying various options for replacing water supplies and lost power, although some options were very conceptual in nature. In addition, modeling to replace water and power supplies lost from the removal of O'Shaughnessy Dam did not evaluate the effects on statewide water management. These evaluations focused on meeting the water and power replacement needs within the Hetch Hetchy system, but did not incorporate geographical or institutional constraints that would need to be addressed as part of any solution.

A major element missing from all of the prior studies is a public involvement process that also engages agencies, tribes, and other stakeholders to determine the goals of the project and to establish objectives. Other elements missing from existing studies include linking restoration and public use alternatives with water and power replacement strategies and evaluating adverse regional and third-party impacts that might result from options involving water and power changes. Also, performance criteria were not established to predict how well alternative strategies would perform in accomplishing the specified objectives.

LEVEL OF DETAIL OF PRIOR STUDIES

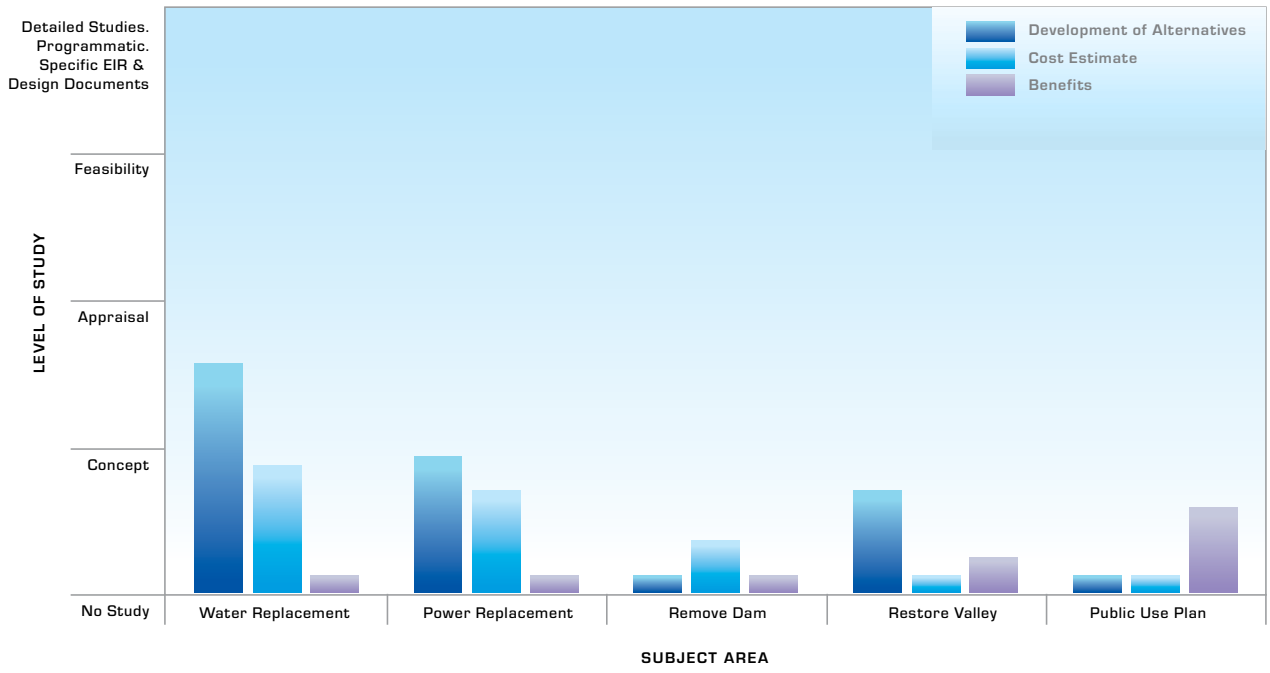
Figure 3-1 shows DWR's and DPR's estimates of the relative levels of alternative development, cost estimates, and benefit information presented by others for key subject areas concerning the restoration of Hetch Hetchy Valley. These characterizations do not address the accuracy or adequacy of the existing work; instead, they simply give perspective to the level of work completed to date.

As the figure shows, some level of work has been completed in each of the subject areas. Our study did not include any new analyses related to development of alternatives or benefits, but did estimate the costs of restoring Hetch Hetchy Valley and replacing the lost water and power.

While different organizations may use different terms and definitions for various study levels, DWR and DPR relied upon their own terminology for this study, which is summarized in the accompanying sidebar on page 20. Thus, using our study definitions, most of the prior work is, at best, at the "concept level" of study. That is, the body of work to date, including the state's work on the potential costs for the potential project, is not sufficient to support sound public policy. However, the state found no fatal flaws in the restoration concept that would preclude additional study.

Completing all aspects of existing studies to a common level (concept or appraisal) would be a key milestone in the decision-making process, by providing a basis for recommendation to either terminate the study or proceed with feasibility investigations.

Figure 3-1 Characterization of Study Level by Key Subject Areas



RELATED RESOURCE MANAGEMENT PLANS

Federal, state, and local resource management plans provide additional guidance and context for the restoration of Hetch Hetchy Valley. The concept of a restored Hetch Hetchy Valley is not currently incorporated into any of these plans.[4]

- California Water Plan
- Integrated Energy Policy Report
- California Outdoor Recreation Plan
- Water 2025 (U.S. Department of the Interior)
- Yosemite National Park General Management Plan 1980
- Tuolumne Wild and Scenic River Comprehensive Management Plan
- Yosemite National Park Resources Management Plan
- Tuolumne County General Plan
- SFPUC Water Supply Master Plan
- SFPUC Water System Improvement Plan

[4] More detail on these plans can be found in Appendix A.

Summary of Levels of Study

Concept-Level studies present preliminary information for review to promote discussion of a proposed project. They generally focus on a single project concept and do not include alternatives analysis or reach any conclusions about the ultimate feasibility or acceptability of a project. The purpose of concept-level studies is to inform participating agencies, stakeholders, and the public about the nature of potential benefits, types of facilities required, and issues that should be addressed in more detailed studies. *All existing Hetch Hetchy studies are at this level, at best.*

Appraisal-Level studies build on the conceptual-level studies and include a preliminary assessment of alternatives, and identification of sensitive environmental resources and legal and institutional constraints. The analyses conducted in appraisal studies are generally based upon the minimum information needed to determine if there are workable solutions or fatal flaws.

Feasibility-Level studies include additional data collection and analyses required to develop a full and reasonable range of alternatives. Feasibility studies provide enough information for decisionmakers to understand what potential risks are involved, and who are potential beneficiaries. The feasibility study process includes items such as: identification of present and future conditions; identification of problems and needs; evaluation of resource capabilities; formulation of alternative plans; analysis and comparison of alternatives and costs; and plan selection. An iterative process is used to arrive at a preferred plan that reasonably maximizes net benefits with acceptable environmental impacts. Feasibility studies are usually integrated with compliance under California Environmental Quality Act (CEQA), National Environmental Policy Act (NEPA), and other related environmental and cultural resources laws. Environmental documentation may be conducted at a programmatic-level or site-specific level.

Site-Specific studies are conducted to quantify resources at a defined geographical location. These studies typically consist of field investigations to identify features such as geological and hydrological conditions and cultural, archeological, or biological resources. Many of the site-specific studies are conducted during the feasibility study phase or as part of the NEPA/CEQA/environmental documentation and permit acquisition processes. Often, study protocols are established to assure that investigations are conducted to meet the requirements of a regulatory agency.

Design-Level studies or documents build on feasibility-level designs based on new or revised plans and information such as updated design practices and cost trends. Design-level studies also include more detailed cost estimates and detailed field investigations, such as subsurface soil explorations and topographic surveys.

Plans and Specifications are the detailed instructions to contractors on how to build the project.

Wildflowers bloom in a meadow along the trail around the Hetch Hetchy Reservoir.

4 MAJOR RESTORATION COMPONENTS

A restoration project for the Hetch Hetchy Valley would require major construction within and beyond the valley. For purposes of discussion, this chapter divides these activities into two major components: 1) activities for valley restoration, and 2) activities to replace the water and power that would be lost. It should be recognized that any construction can create new environmental impacts that must be mitigated.

VALLEY RESTORATION

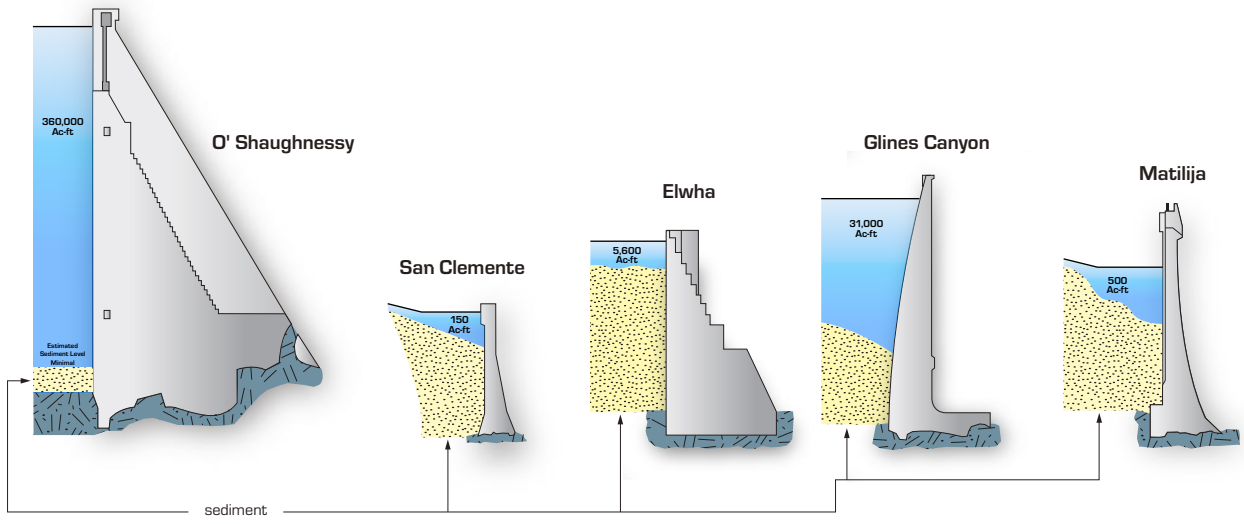
Dam Removal

Before the valley can be restored to resemble its original condition, O'Shaughnessy Dam must be removed, or at least the reservoir must be drained. The prior studies have almost no information on how to remove the dam. The Restore Hetch Hetchy report included some information on dam removal; additional information on costs of dam removal was provided to the state by RHH separately.

Possible methods of demolition include controlled blasting, diamond-saw cutting, or hydraulic ramming. While controlled blasting may be the most efficient, it creates more noise. Depending on the technique, the concrete could end up block

Figure 4-1 Dam Removal and Cost Cosiderations

Dam Name	O'Shaughnessey	San Clemente	Elwha	Glines Canyon	Matilija
Dam Height	312 feet	85 feet	108 feet	190 feet	163 feet
Concrete Volume	662,605 c.y.	7,070 c.y.	26,000 c.y.	15,000 c.y.	47,825 c.y.
Sediment Volume	Unkown (minimal)	2,000 af	2,480 af	8,678 af	3,660 af
Total Project Cost	Unknown	Unknown	$ 182.5 Million in 2004		$110 Million
Dam and/or Sediment Removal Time	Unknown	3 Years (Dam removal & mechanical sediment transportation)	2 Years (Dam removal only Natural river transport for sediment removal)	3 Years (Dam removal only Natural river transport for sediment removal)	2 Years (Dam removal & slurry of fine sediments) Alt. 4B



size or rubble size. Block size would have to be broken down further prior to transportation out of the valley by truck, railroad, or conveyor belt. New roadways will be necessary for construction equipment access. Cofferdams will be needed upstream and downstream of the dam to control water diversion and to keep water out of the site. In the winter, the project could be shut down due to high flows. Concrete above the original streambed elevation would be removed plus some portion of the concrete below ground level to allow fish passage and groundwater flow. The concrete in the higher abutments could remain to avoid leaving a deep trench in the steeper rock slopes. To reduce costs, all or a portion of the dam could remain as an historic structure. Removal is expected to be a multi-year project. Some aesthetic improvement of the site after dam removal will be required.

There have been numerous meadow restorations, but on a very small scale compared to the size of the Hetch Hetchy Valley Reservoir.

More than 400 small dams have been removed in the United States, but none approach the size of O'Shaughnessy Dam. Even proposals to remove larger dams, such as Elwha and Glines Canyon dams on the Elwha River in Olympia National Park in Washington State and Matilija Dam on the Ventura River in Southern California, are small compared with the O'Shaughnessy Dam project. Another proposal involves the concrete arch San Clemente Dam on the Carmel River in California, where removal is only one of the alternatives under study. These dams also differ from O'Shaughnessy because their reservoirs have filled with sediments, diminishing their original water storage capacities.

Ecosystem Restoration

The goal of restoration is to recreate biotic communities that are representative of those that would have occurred naturally in Hetch Hetchy Valley. Some of the restoration will be by natural means with wind and water spreading seeds, but the restoration process could be accelerated by human management. Monitoring and evaluation must be part of any restoration to ensure its effectiveness and progress. There is also a vast range of public use opportunities that could be developed to different degrees that could affect restoration. The primary variable is how passive or active the restoration activities and public use opportunities should be.

The most comprehensive discussions of restoration opportunities are found in the 1988 National Park Service (NPS) document. The NPS outlines three scenarios for how restoration might be accomplished:

- recovery without direct management, in which the reservoir is drawn down in one year;
- recovery with moderate management, with the reservoir drawn down over five years, and with the five years preceding drawdown dedicated to collecting native plants seeds and propagules; and
- recovery with intensive management, also with a five-year drawdown.

Cultural Resources

The draining of the reservoir and the restoration of Hetch Hetchy Valley will trigger compliance with various cultural resources laws and regulations regardless of the level of restoration. Because much of the valley is federally owned property, the most significant law that will apply is the National Historic Preservation Act (NHPA).

Some data are currently available about archaeological sites present in the valley. Seven prehistoric archaeological sites were recorded around the edge of the reservoir by University of California, Berkeley, in 1951 (Montague and Mundy 1995:5). An additional 10 archaeological sites were recorded by National Park Service archaeologists in 1991 when the reservoir level fell to its lowest elevation since its original inundation (Montague and Mundy 1995). All of the sites contain prehistoric components, while three of the sites also include historic elements and one site reflects occupation by Native Americans during the historic era. Eleven isolated artifacts or features were also recorded during the National Park Service study; four were prehistoric isolates and seven were from the historic era.

Cultural resources, other than archaeological sites, also need recording and evaluation, including traditional cultural properties (TCP) and the dam and hydroelectric facilities. It is likely that the entire valley would be considered a TCP given the importance of the area to descendents of the Native Americans inhabiting the valley at the time of Euro-American contact. Furthermore, O'Shaughnessy Dam and the Hetch Hetchy system may be eligible for listing in the National Register.

January 2001 amendments to the NHPA implementing regulations require consultation with tribes during all phases of an undertaking from the identification and evaluation of cultural resources through decisions on mitigation efforts for National Register-eligible properties. Numerous federally recognized tribes and tribes without federal recognition have traditional ties to Hetch Hetchy Valley. These tribes reside on both sides of the Sierra Nevada and include the Tuolumne Band of Me-Wuk, the Southern Sierra Miwuk Nation (American Indian Council of Mariposa County), the North Fork Band of Mono Indians, the Bridgeport Paiute Indian Colony, and the Mono Lake Kutzadika Paiute Indian Community.

continued

Cultural Resources (continued)

To better understand Native American issues related to restoring Hetch Hetchy Valley, state officials met with approximately 20 Native American representatives on March 29, 2005, in Tuolumne, California. A wide variety of opinions were expressed by meeting participants. Should the reservoir be drained, participants were adamant about the need for the tribes to be thoroughly involved in the decision to drain and manage the land. Opinions ranged from returning full ownership of the land to the native tribes to maintaining the valley as a national wilderness area open to the public.

While the appropriate use of the valley would be determined by an intensive planning process involving all stakeholders, the tribes specifically considered several issues to be particularly important: 1) development in the valley should be very limited to avoid duplicating the level of development found in Yosemite Valley, 2) recreation should be restricted to low impact activities, 3) restoration of native plants, wildlife, and springs should be a priority, and 4) the tribes should be provided access to ceremonial grounds.

The tribes want to participate fully in the management of any recreational development, including providing law enforcement and protection of resources. Tribal participants called for a full inventory of cultural resources in the valley if Hetch Hetchy is drained, and for a full survey of cultural resources in any other areas to be inundated to compensate for the loss of Hetch Hetchy water.

In its study assumptions, the NPS also concluded that sediment removal would be unnecessary, the Tuolumne River would return to its original channel on its own, growth of nonnative vegetation would be tolerated to some extent, and widespread herbicide usage would not be employed. The report also mentions the need for "mechanical obliteration of the scars left by dam construction," including excavated material from the damsite deposited in the lower meadow, a gravel pit near Wapama Falls, and a sand pit near the confluence of Rancheria Creek with the Tuolumne. For each alternative, NPS illustrates the potential vegetation and wildlife responses at two or five, 10, 50, 100 and 150 years. While the NPS offered no preference for any of the three restoration scenarios, it did predict that for the latter two alternatives, after 150 years, the "entire valley would appear much as it did before construction" of O'Shaughnessy Dam.

If in the future it is decided that the valley should be restored, new data on alternatives would need to be collected and analyzed. These alternatives could range from draining the reservoir all at once and allowing the valley to recover with no human management, to draining the reservoir gradually and providing a high degree of assistance to the

Hikers cross footbridge
at Wapama Falls
(Photo courtesy of *The Sacramento Bee*)

natural processes. Variables would include fire management, invasive species management, human-assisted revegetation, animal management, duration of drainage, and extent of monitoring. The amount of human management involved in restoration will understandably have an effect on the result. In general, the expectation is that with a higher degree of appropriate active management, ecosystem recovery time would be minimized.

Public Use

Very few of the reports regarding the restoration of Hetch Hetchy Valley address future public use. If the valley was indeed restored, an extensive, public planning process would need to determine the most appropriate uses of a restored Hetch Hetchy, considering the perspectives of all stakeholders as well as the best available scientific information.[5] For this report, the California Department of Parks and Recreation (DPR) considered two alternatives for public use.

Status Quo

Recreation is not allowed on the reservoir in accordance with the Raker Act and to maintain filtration avoidance for Hetch Hetchy water. According to NPS, visitation to the valley during the peak April through June period currently averages approximately 100 cars per day. Nearly all existing recreation in the Hetch Hetchy Valley is of a passive nature. Primary recreational activities in the valley include fishing (from the shore), hiking, backpacking, horseback riding, rock-climbing, and wildlife viewing. Currently, body contact and boating activities are prohibited.

Draining the Reservoir

A range of public use opportunities could be studied, along with desired resource conditions, as part of a plan to manage the restored valley. Additionally, because San Francisco would continue to divert water from the Tuolumne River even without the reservoir, measures would have to be taken to maintain water quality. Also, draining the reservoir would expose artifacts and possibly human remains from the native peoples who once inhabited the valley. Consequently, an assessment would be needed of the cultural resources in the valley, and these resources would need to be protected from theft, vandalism, or exploitation. The public use possibilities in a post-reservoir Hetch Hetchy Valley range from a wilderness reserve with very limited development to a developed public use area.

[5] Appendix C contains more information on public use in the valley. It is understood that involvement of the Native American community in these lands is integral and that the needs and issues involving Native Americans will be considered independent of those of the general public.

Without a wilderness designation, there are many possible public use options that could be explored for Hetch Hetchy Valley, ranging from minimal to full development. Such development could include additional campsites (developed, primitive, stock, and RV/trailer), hardened surface or paved bike and walking paths, and additional opportunities to participate in preexisting public use activities in the valley, such as hiking, rock-climbing, horseback riding, and wildlife viewing.

If the wilderness designation is extended below the high water mark by Congress, minimal development would occur in the valley. Nonetheless, additional trails could be created to provide increased visitor access to the backcountry. Activities such as hiking, backpacking, horseback riding, and climbing would likely be supported; though fully developed facilities and some activities would be incompatible with wilderness values and policy.

Figure 4-2 Hetch Hetchy Outdoor Visitor Uses

Activities with High Latent Demand [6]	Full Reservoir Current Use	Drained Reservoir - Rehabilitated Valley Floor with Wilderness Designation	Drained Reservoir - Rehabilitated Valley Floor without Wilderness Designation
Camping at developed sites			✔
Trail hiking	✔	✔	✔
Walking	✔	✔	✔
Wildlife viewing	✔	✔	✔
Bicycling – paved surfaces			✔
Picnicking	✔	✔	✔
Visiting outdoor interpretive displays	✔	✔	✔
Visiting a historic or cultural site	✔	✔	✔
Fishing	✔	✔	✔
Camping at a primitive site	✔	✔	✔
Horseback riding	✔	✔	✔
Driving for pleasure – scenic			✔
Backpack camping	✔	✔	✔
Swimming – in a lake			
Bicycling – unpaved (Mountain Biking)			✔
Paddle sports – kayaking, canoeing		✔	✔
Jogging	✔	✔	✔
Rock climbing	✔	✔	✔
Motor boating			
Sail boating/windsurfing			
Orienteering/geo-caching	✔	✔	✔

[6] From **Public Opinions and Attitudes on Outdoor Recreation in California: 2002**, a publication of the California Department of Parks and Recreation; activities ranked in descending order based upon a combined index of latent demand and public support.

Figure 4-2 compares the possible visitor use opportunities with each alternative. Increasing the recreation opportunities available in the valley would likely also have a positive economic impact on the communities in the area and strengthen Yosemite National Park's role as a primary economic engine for the communities in the central Sierra Nevada region of the state.

WATER AND POWER REPLACEMENT

Removing O'Shaughnessy Dam or changing its operation will impact the contribution of the Hetch Hetchy system to San Francisco's water and power supplies. Water supply, drought preparedness, drinking water quality, operational flexibility, flood management, environmental impacts, and power production all demand consideration.

Power supply replacement requirements are highly dependent upon the selection of water supply replacement components. Modifications to structural facilities and new infrastructure have already been suggested by various parties. Alternatives for water and power replacement may use different combinations of facilities. The following sections show possible infrastructure changes by geographical area, based on information available from previous Hetch Hetchy studies. Figure 4-3 shows a general map of the potential facilities.

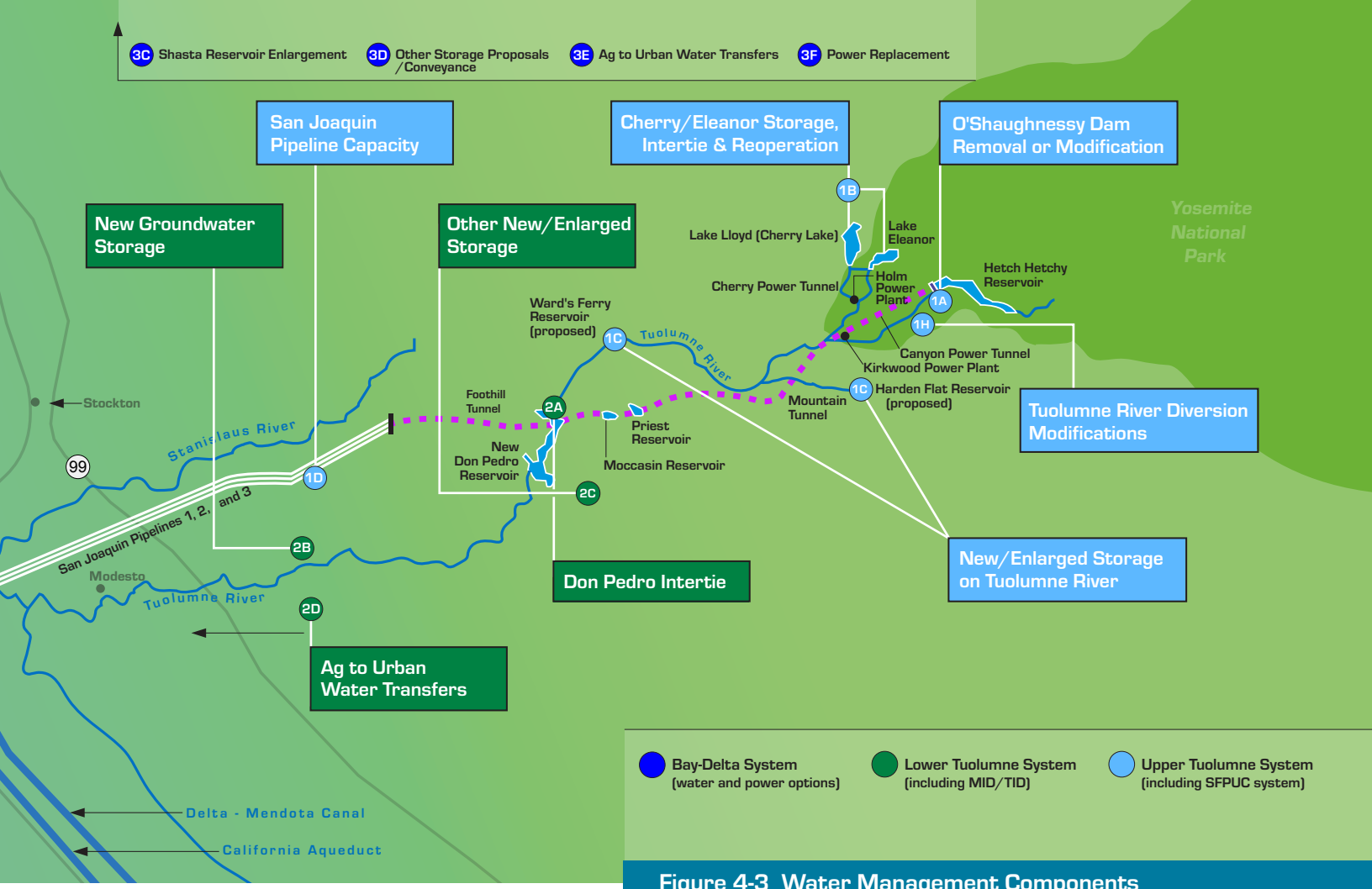


Figure 4-3 Water Management Components

Water Management Components

Potential water management replacement components can be organized into three broad categories based on their geographic and institutional relationships:

1. Modifications to the Hetch Hetchy/Upper Tuolumne River system.
A number of components fall into the category of direct modifications of the SFPUC system.

2. Modifications to the TID/MID/Lower Tuolumne River system.
This category includes components that modify facilities or operation of Don Pedro Dam and Reservoir, as well as conjunctive use programs.

3. Statewide Water and Power Options.
This category includes components that have statewide implications due to interaction with the Bay-Delta system, to which Hetch Hetchy and the Tuolumne River belong. Generally, this category includes recapture of Tuolumne River water and storage and diversions of water on other river systems in California that would ultimately pass through and be exported from the Delta to reach SFPUC customers.

Modifications to the Upper Tuolumne River System/SFPUC System

1A – *O'Shaughnessy Dam Removal or Modification:* Removing O'Shaughnessy Dam and restoring the ecological and biological integrity of the site. Removal of the dam could also help restore downstream ecological functions along the nationally designated wild and scenic Tuolumne River.

1B – *Cherry/Eleanor Storage and Reoperation:* This includes pumping from Holm Powerhouse to Mountain Power Tunnel. A pumping station downstream from Holm could pump up to 730 cfs of Cherry/Eleanor Lakes water into Mountain Power Tunnel. Additional water supply to Mountain Power Tunnel would result in power generation at Moccasin Powerhouse and diversion into the Foothill Tunnel for domestic use in the Bay Area, with any excess spilling to Don Pedro Reservoir.

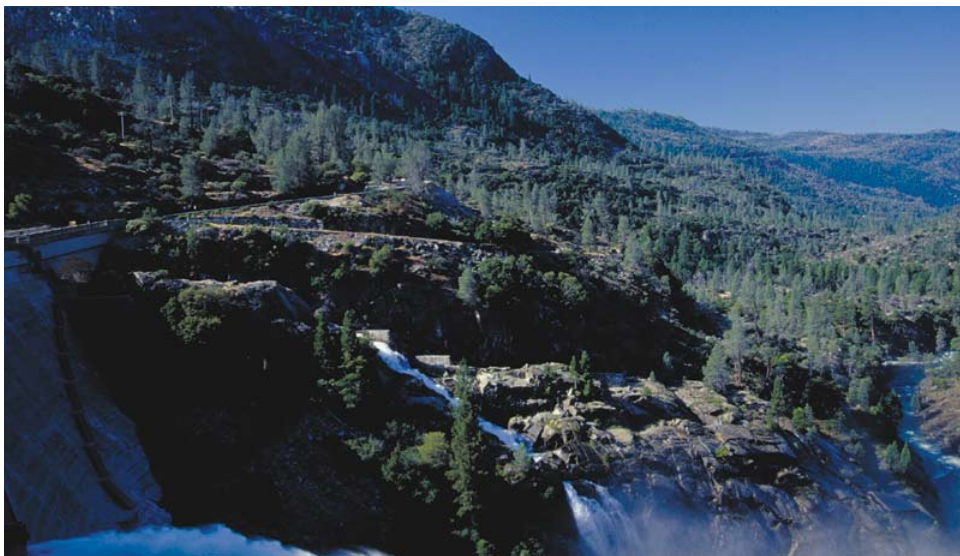
1C – *New/Enlarged Storage on Tuolumne River:* Expanded storage at Don Pedro Reservoir or new storage at Wards Ferry and Harden Flat Reservoirs in the upper Tuolumne Basin could partially replace SFPUC storage for supply and power. Wards Ferry would inundate part of designated wild and scenic river. There is also some potential of increasing storage at Cherry/Eleanor Lakes.

1D – *San Joaquin Pipeline:* A fourth barrel could be added to provide additional conveyance capacity and increase flexibility of operations. The new pipeline could be 48 miles long with a design capacity of 250 cfs, and would run alongside the three existing San Joaquin Pipelines, thus increasing the total conveyance capacity to 542 cfs.

1E – *Calaveras Reservoir Expansion:* An expanded reservoir capacity of 420 taf could store water pumped from the Hetch Hetchy Aqueduct. The existing pipeline capacity from the aqueduct is 74 cfs. A pumping plant is required to increase its capacity to 282 cfs. The reservoir can also impound flows from Upper Alameda Creek, to which it is connected via a diversion dam and tunnel.

1F – *Other Enlarged Local Storage:* SFPUC owns five major reservoirs in the Bay Area. Storage in Crystal Springs and San Antonio reservoirs could be expanded to provide additional capacity for water supply reliability and operational flexibility. Upstream diversions from Tuolumne River would supply water for storage in these reservoirs.

1G – *Conservation and Efficiency Measures:* Further implementation of additional water use efficiency programs, including water recycling, in the SFPUC service area could reduce demand and make better use of the existing water supplies.



The Tuolumne River flows through Poopenaut Valley downstream of Hetch Hetchy.

1H – *Tuolumne River Diversion Modifications:* Diverting and pumping water from Tuolumne River into Canyon Tunnel would help replace water lost due to the removal of O'Shaughnessy Dam.

1H(1) – *Tuolumne River Diversion into Canyon Power Tunnel:* A pumping station and a diversion structure on Tuolumne River just downstream of the O'Shaughnessy damsite could pump 1,500 cfs into the Canyon Power Tunnel.

1H(2) – *Diversion Tunnel from O'Shaughnessy Dam Site to Canyon Power Tunnel:* A 6-mile-long tunnel would divert water at the dam site and would require leaving 20 feet of the dam in the river. This option would cost much more than diverting from the river downstream.

Don Pedro is the largest reservoir on the Tuolumne River.

Modifications to the Lower Tuolumne River System/TID/MID

2A – *Don Pedro Intertie/Reoperation:* Water pumped directly from Don Pedro Reservoir into the Foothill Tunnel could replace lost supply from Hetch Hetchy. The Foothill Tunnel runs directly beneath the reservoir. Capacity of this new intertie could be around 400 cfs. Alternatively, water could be released through the Don Pedro Powerhouse and diverted further downstream via a new pipeline or canal to the Hetch Hetchy Aqueduct which would also require pumping.

2B – *New Groundwater Storage (TID/MID):* Physical potential exists for developing 400,000 acre-feet of groundwater storage in the Lower Tuolumne River basin. During wet years, TID/MID diversions from Don Pedro Reservoir would recharge groundwater which could be used by TID/MID for irrigation supplies. In dry years, surface water diversions from Don Pedro would decrease and groundwater pumping would increase. Water thus saved in the TID/MID Don Pedro system could be used by SFPUC.

2C – *Enlarged Don Pedro Reservoir:* Don Pedro Reservoir storage capacity could be increased by 360,000 acre-feet by raising the dam height by 21 feet. Such a raise, though, would also require a saddle dam between Don Pedro and Exchequer Reservoirs. This would replace the lost Hetch Hetchy Reservoir storage capacity and allow transfer of water from Don Pedro into the Foothill Tunnel through a Don Pedro intertie. Also, raising Don Pedro would provide additional head for power generation.

2D – *Agricultural to Urban Water Transfers:* Water sale agreements with TID and MID, similar to the agreement MID has currently with the city of Modesto, could be arranged for SFPUC users. However, downstream flow requirements in the Tuolumne River below the La Grange Dam, including possible additional flows for steelhead and salmon, would have to be met.

Statewide Water and Power Options

3A – *California Aqueduct Intertie to SFPUC System:* With connection to the State Water Project (SWP) and federal Central Valley Project (CVP) systems, SFPUC could supply water to the local storage reservoirs. San Antonio Reservoir is already physically linked to the Delta via the SWP's South Bay Aqueduct. Delta supplies may be available during periods when the Delta is in surplus. However, in critical years, the intertie would allow SFPUC to purchase supplies from other water users.

3B – *Los Vaqueros Reservoir Enlargement:* Proposed additional storage on Los Vaqueros Reservoir could be used to supplement supplies to the SFPUC system through the expanded South Bay Aqueduct. Presently, the reservoir planning considers the Environmental Water Account as the main beneficiary.

3C – *Shasta Reservoir Enlargement:* New water supplies from enlarging Shasta Reservoir could be used for the Bay Area, conveyed through the SWP or CVP. Raising the dam by 6.5 feet would enlarge Shasta Reservoir by 290,000 acre-feet and improve the average annual water supply by 60,000 acre-feet during the dry periods. Also, this will increase the CVP power production by 10 gigawatt hours per year.

3D – *Other Storage/Conveyance Proposals:* Several new water supplies or additional storage were discussed in the 1988 U.S. Bureau of Reclamation (USBR) report including 1) wildlife refuges in the San Joaquin Valley (used as offstream storage), 2) coordination of Lake Berryessa with the state's North Bay Aqueduct, 3) extend new conveyance from Folsom South Canal and New Melones Reservoir to San Francisco System, and 4) enlarged Delta-Mendota Canal as discussed by USBR.

3E – *Agricultural to Urban Water Transfers:* There is potential for water transfers from agricultural districts to SFPUC during dry years. With an additional intertie to the SWP, the SFPUC could purchase water from a wide variety of sellers statewide. It should be noted, though, that agricultural districts have historically endured water shortages during critically dry years, which would increase competition for scarce water supplies.

3F – *Power Replacement:* In addition to hydropower replacements, other solutions dealing with conservation and energy efficiency programs, photovoltaic cells and new gas turbines have been proposed.

The Tuolumne River generates hydropower at Moccasin Powerhouse.

Climate Change

As a result of global warming, California's future hydrologic conditions will likely be different from patterns observed over the last century. Predictions include increased temperatures, reductions in the Sierra snowpack, earlier snowmelt, and a rise in sea level, although the extent and timing of the changes remain uncertain.

Computer modeling of climate change scenarios predicts large reductions in the Sierra snowpack as a result of warming. Historically the snowpack has contributed around 14 million acre-feet (maf) on average to the state's water supply during the April through July snowmelt period. Much of this is carryover of winter precipitation in our "frozen reservoirs." Loss of a portion of the snowpack will accentuate the state's current lack of storage to maintain supply in dry periods. The amounts have yet to be quantified by system operation studies for potential climate change scenarios, but the direction is clear: a reduction in natural water storage. In the future, then, the value of stored water in reservoirs will increase with climate change.

Modeled Water Management Alternatives

Of all the recently published works on restoring Hetch Hetchy Valley, only two included modeling as a basis for their Hetch Hetchy water and power replacement evaluations: U.C. Davis (Null 2003) and Environmental Defense (2004). Figure 4-4 includes a summary of water management alternatives and related assumptions as modeled by U.C. Davis and Environmental Defense. Options 1C, 1F, 1H, 2C, 3B, 3C, 3D and 3F were not modeled in previous studies. Modeled alternatives for replacing water include

Figure 4-4

Assumed Parameters for Water Supply and Power Management Scenarios Modeled in Past Studies

Study Organization	Upper Tuolumne System (including local SFPUC system)							
	O'Shaughnessy Dam (TAF)	Cherry/Eleanor Storage and Reoperation (TAF)	New/Enlarged Storage on Tuolumne River (TAF)	San Joaquin Pipeline Capacity (CFS)	Calaveras Reservoir Volume (TAF)	Other Enlarged Storage (TAF)	Conservation and Efficiency Measures	Tuolumne River Diversion Modifications
	1A	1B	1C	1D	1E	1F	1G	1H
Environmental Defense								
Water Supply Replacement Alternatives								
Existing Demand Scenarios								
Existing Conditions Base	360	300		465	97		yes	
Surface Storage Replacement	0	300		542	420		yes	
Groundwater Exchange Replacement	0	300		542	97		yes	
Transfer Replacement	0	300		542	97		yes	
Delta Source Transfer Replacement	0	300		542	97		yes	
Future Demand Scenarios								
Potential Future Conditions Base, CIP	360	300		542	420			
Transfer Replacement	0	300		542	420			
Delta Source Transfer Replacement	0	300		542	420			
Groundwater Exchange Replacement	0	300		542	420			
Groundwater Exchange & Transfer Replacements	0	300		542	420			
Don Pedro Intertie & Hetch Hetchy Run-of-River Diversions	0	300		542	97			
Constituents of concern (data)	0	300		542	97			
Bay-Delta System Alternatives								
Existing Demand Scenarios								
Existing Conditions Base	360	300		465	97		yes	
CA Aqueduct Intertie	0	300		465	97		yes	
Future Demand Scenarios								
Potential Future Conditions Base, CIP	360	300		542	97			
CA Aqueduct Intertie, Intermediate Calaveras Expansion	0	300		542	260			
CA Aqueduct Intertie, Full Calaveras Expansion	0	300		542	260			
CA Aqueduct Intertie	0	300		542	97			
UC Davis								
Base	360			465	91			
2020 Level Demand Scenarios								
O'Shaughnessey, with filtration avoidance	360			465	91			
O'Shaughnessey, without filtration avoidance	360			465	91			
New Don Pedro Intertie, no O'Shaughnessey, w/o filtration avoidance	0			465	91			
2100 Level Demand Scenarios								
O'Shaughnessey w/o filtration avoidance	360			465	91			
New Don Pedro Intertie, no O'Shaughnessey, w/o filtration avoidance	0			465	91			
Climate Change (O'Shaughnessey, w/o filtration avoidance)								
Climate Change (no O'Shaughnessey, w/o filtration avoidance)								

Patterned water management components used in state estimate, selection based on most diverse tools available to meet broad objectives for water & power replacement, environmental protection and risk mitigation for California water management.

Note: Values in this table are modeling assumptions used by ED and UCD.
Modeling assumptions were not reviewed for accuracy or acceptability by stakeholders, agencies and the public.

yes = included in the options, but not quantifiable

components modifying, expanding, or reoperating existing reservoirs and conveyance facilities; constructing new facilities; developing new surface storage; developing a groundwater storage and retrieval system; and implementing conjunctive use programs. More information on the water management modeling can be found in Appendix F.

The U.C. Davis modeling focused on an intertie to Don Pedro Reservoir supplemented by dry-year purchases from the agricultural sector and simulations were run using projected urban and agricultural demands for 2020 and 2100.

Water Management Components

Lower Tuolumne System (including local MID/TID)				Outside/Bay-Delta System (Water and Power Options)						Other Modeling Assumptions				
Don Pedro Intertie/ Re-operation Volume (CFS)	Groundwater Storage Volume (TID/MID) (TAF)	Enlarged Don Pedro Reservoir	Local Ag - to - Urban Water Transfers	Calif. Aqueduct Intertie to SFPUC System	Los Vaqueros Reservoir Enlargement	Shasta Reservoir Enlargement	Other Storage Projects	Regional Ag - to - Urban Water Transfers	Power Replacement	Demand (TAF)	Calaveras Reservoir Pump Volume (CFS)	Calaveras Reservoir Output Capacity (CFS)	Sunol Valley Water Treatment Plant Capacity (MGD)	Groundwater Peak Recharge/ Extraction Rates (MID/TID) (CFS)
2A	2B	2C	2D	3A	3B	3C	3D	3E	3F	1	1	1	1	2
0	0									290	0	143	160	0
407	0									290	200	600	400	0
407	400									290	0	143	400	200
407	0		yes							290	0	143	400	0
407	0							yes		290	0	143	400	0
0	0									339	200	600	240	0
407	0		yes							339	200	600	400	0
407	0							yes		339	200	600	400	0
407	400									339	200	600	400	200
407	400		yes							339	200	600	400	200
407	0									339	0	143	400	0
0	0									339	0	143	400	0
										290	0	143	400	
				yes						290	0	143	400	
										339	0	143	400	
				yes						339	200	200	400	
				yes						339	200	200	400	
				yes						339	0	143	400	
										238				
										238				
										238				
yes										238				
										259				
yes										259				
yes														

While the state did not conduct any modeling analyses or work related to the development of alternatives, it did estimate the potential costs of restoring Hetch Hetchy Valley patterned on the most comprehensive water supply and power replacement alternative modeled by ED as follows.

- The Environmental Defense modeled alternative chosen as a basis for the state cost estimate includes:
  - Expanded Calaveras Reservoir to 420 taf (an additional 323 taf)
  - 200 cfs peak groundwater extraction capacity (400 taf storage volume)
  - 407 cfs Don Pedro Intertie
  - 56 taf maximum annual dry year water transfers
  - Future annual demand of 339 taf (up from existing 290 taf)

- Water management components assumed in the state cost estimate include:
  - 250 – 450 taf new surface storage
  - 200 – 300 cfs peak groundwater extraction capacity (400 taf storage volume)
  - 407 cfs Don Pedro or SWP intertie
  - 22 – 86 taf maximum annual dry year water transfers
  - 5 – 20 taf increased water use efficiency

ED conducted two sets of modeling studies to analyze the operations of SFPUC, MID, and TID, using both current and projected 2030 demand levels. One set of modeling studies includes several Water Supply Replacement Alternatives that evaluate replacement of the water supply lost by removing O'Shaughnessy Dam. Another set of modeling studies includes several Bay-Delta System Alternatives that simulate the delivery of Tuolumne River water to the SFPUC service area via the California Aqueduct. These modeling studies are shown in Figure 4-4.

Environmental Defense's most comprehensive water supply replacement alternative modeled under future conditions includes the expansion of Calaveras Reservoir to 420,000 acre-feet, an intertie between Don Pedro Reservoir and the Hetch Hetchy water system, groundwater exchange (both in the San Francisco Bay Area, as well as along the lower Tuolumne and San Joaquin Rivers), and water transfers during dry years. These components primarily provide water supply replacement benefits with some power replacement as well.

The state chose this mix of facilities to pattern its cost estimate on because they provide a diverse mix of potential benefits. None of the existing studies attempted to define the actual or potential benefits of O'Shaughnessy Dam and Hetch Hetchy Reservoir.

While the state estimate makes broad assumptions on a mix of facilities that may be required, it includes the same types of water supply replacement components as proposed by ED, along with increased water use efficiency and additional power replacement components. This combination of water supply and power replacement components was chosen because it has the potential to meet the broad objectives likely to be required in a thoroughly developed study on the restoration of Hetch Hetchy Valley. These broad objectives may include environmental mitigation and enhancement, improved recreation, and replacement of power supply, in addition to water supply replacement. The state's cost estimate also includes costs for dam removal, valley restoration, and public use. Given the uncertainty involved, a cost estimate range was used because the exact location, facility size, and operational parameters are unknown at this time. The facility mix selected and the cost range presented also accounts for additional environmental protection and risk mitigation for water management that may be required to implement these projects.

Tuolumne River flows over the top of O'Shaughnessy Dam spillway.

5 BENEFITS OF RESTORATION

At this conceptual level of detail, benefits may be among the most difficult part of the project to define, or at least quantify. Those who originally fought to prevent the flooding of Hetch Hetchy Valley did not need detailed economic studies to decide that the valley was worth more as a natural wonder than as a reservoir. Others believed the value of developing water and power resources was worth more than preserving the valley. While future detailed benefit studies are unlikely to ever provide conclusive evidence for all parties, such studies could help people put the benefits of a restored valley in perspective with the existing benefits of the Hetch Hetchy water system.

AESTHETICS

While beauty is a subjective concept, perhaps the most aesthetically striking characteristics of a restored Hetch Hetchy Valley would be the monolithic size of the valley's sheer granite cliffs, the expansiveness of the open space from one side of the valley to the other, and the valley's waterfalls that cascade down from impressive heights.

Hetch Hetchy Valley is often compared to Yosemite Valley. To place the size of Hetch Hetchy Valley into perspective, Yosemite Valley and Hetch Hetchy Valley are roughly the same length at approximately seven miles long. According to NPS staff, the primary difference is width. The average width of Yosemite Valley is approximately one mile, while the average width of Hetch Hetchy Valley is just over a half-mile.

According to previous publications on the restoration of Hetch Hetchy Valley, the primary justification for removing the dam and restoring the valley is to reclaim a beautiful landscape that is owned by the American people.

Photographer unknown

Ansel Adams

Hetch Hetchy Valley (left) is often compared to Yosemite Valley (right).

ECONOMIC BENEFITS OF RESTORATION

Very little information is available from previous studies on the potential economic benefits of restoring Hetch Hetchy Valley. One form of benefits would accrue from people visiting or using the valley, called "use benefits." Another type of benefits would result for people that may never visit the valley, but would nonetheless place value on knowing that the valley exists. These benefits, called "non-use benefits," are similar to people valuing, for example, that Mono Lake is protected, though they may never visit it.

Use Benefits

Increased public use opportunity is one of the most obvious benefits of restoring the valley. California's population is increasing and the demand for additional recreational opportunities is growing as well. Restoring Hetch Hetchy Valley is one potential option to increase recreational opportunities.

The 2004 Rider report used a benefits transfer methodology to estimate use benefits as society's willingness to pay for those recreational opportunities. Rider's report uses development scenarios similar to those generated by the 1988 Assembly Office of Research (AOR) study, but provides more detail on the extent of facilities that could be placed in the valley. The estimates of total annual use benefits in excess of what the users pay are:

- Low Development: $14.68 million based on 400,000 visitor days per year
- Medium Development: $15.67 million based on 600,000 visitor days per year
- High Development: $26.12 million based on 1,000,000 visitor days per year

It should be noted that benefits transfer is not necessarily a straightforward exercise. For example, attention must be paid to the extent to which the resources being valued are similar; the scale, magnitude, and nature of the environmental changes valued are comparable; the group surveyed in the original study is comparable to the groups that the policy change under consideration would impact; and the extent to which the original studies were conducted using appropriate methodologies.

Fog descends upon Hetch Hetchy Reservoir.

Non-Use Benefits

There are many examples of studies that have estimated non-use values for a variety of resources. Two such examples are presented below for informational purposes only. We note that the values arising from these studies may not necessarily be representative of values that might arise from a focused study of the non-use values associated with restoring the Hetch Hetchy Valley.

U.S. Fish and Wildlife Service (USFWS 1998) reports a case study to estimate the benefits of dam removal on the Elwha River in Washington State to illustrate how the Contingent Valuation method can be used in benefits estimation. John Loomis of Colorado State University developed a contingent value study to measure the total economic value, both use and non-use, associated with removal of the dams. The analysis elicited estimated willingness to pay information from households in Washington and the rest of the U.S. Annual willingness to pay for dam removal and restoration ranged from $94 to $138 million from residents of Washington and from $3.376 to $6.137 billion from the rest of the U.S.

Loomis also conducted a contingent valuation study (1988) for benefits arising from Mono Lake. He found that the average value was $35.21 for a respondent who never expected to visit Mono Lake. Extrapolating this to 30 million inhabitants of California yields a value of $1.056 billion. The lake is a great distance from population centers and is largely inaccessible from Northern California during the winter months. It is likely that the non-use benefits from Hetch Hetchy would even be higher than the non-use benefits from Mono Lake.

Combined Use and Non-Use Benefits

If the Elwha study (USFWS 1998) is taken as representative of an upper bound of potential non-use benefits for Hetch Hetchy, the annual benefits of restoring Hetch Hetchy Valley range from $26 million (use benefit) to $6 billion (non-use benefit). The extreme range in the estimates of economic benefits that might result from restoring Hetch Hetchy Valley, in and of itself, casts doubt on their ability to provide useful information. Further detailed study is necessary to more accurately estimate both the use and non-use benefits that might accrue if the Hetch Hetchy Valley is restored.

An important point to consider is that estimation of the potential benefits from a project is only part of a benefit cost analysis. Other important considerations include a determination that no other project provides greater net benefits (benefits minus costs) and a determination that there are no other less costly means to obtain the same objective. A benefit cost analysis only determines whether a project is economically justifiable, not whether a project is financially feasible.

STATEWIDE IMPLICATIONS

There are only four glacially-carved valleys in California with features like Hetch Hetchy Valley: Yosemite, Hetch Hetchy, Kings Canyon, and Tehipite. Some of the features that make Hetch Hetchy Valley unique include the following:

- Accessible all year both by car and on foot.
- A flat valley floor with expanses of meadows and forest that provide easy walking.
- Tall waterfalls that vary from misty to thundering.
- Meandering river.
- Waterfalls and rivers are approachable.
- Vertical granite walls with heights in excess of 1,000 feet.

Restoring Hetch Hetchy Valley would return this unique valley to the use and enjoyment of the public.[7] In addition, Hetch Hetchy is at the transition from foothill to montane habitats and therefore provides habitat to a larger number of plant and wildlife species than does Yosemite Valley.

Restoring Hetch Hetchy Valley could also have significant statewide implication from lost water and power and from environmental impacts of replacing the water and power with other infrastructure.

[7] Appendix C provides more detail on public use in the valley.

6 COSTS OF RESTORATION

Without any defined project objectives, any cost estimate is conceptual at best. Different concepts of what the project should be lead to different estimates of cost. For example, an objective of draining the reservoir and leaving the dam in place would provide for a much lower cost than an objective to completely remove the dam. Therefore, the cost estimates provided in previous studies are not directly comparable due to the lack of defined and consistent objectives.

The state found that all previous estimates were incomplete since the studies focused on specific items and were not presented as complete projects. Figure 6-1 shows the cost information available from the previous studies, along with the estimates made by the state for this report.

Figure 6-1 Hetch Hetchy Valley Restoration Cost Estimate (millions of dollars)

Category	Restore Hetch Hetchy	Environmental Defense	STATE
Implement Water Replacement Components	626	174 to 652	1,144 to 4,305
Implement Power Replacement Components	217	340 to 693	560 to 820
Dam Modification or Removal	108	Not Included	250 to 915
Restore Valley	23	Not Included	32 to 53
Implement Public Use Plan for Valley	Not Included	Not Included	10 to 91
Subtotal	**974**	**514 to 1,345**	**1,996 to 6,184**
Contingencies	57	-11 to 228	Included in above values
Site-Specific Environmental Documentation, Permitting & Mitigation	Not Included	Included in above values	390 to 1,790
Engineering, Legal and Administration	65	6 to 76	610 to 1,850
GRAND TOTAL	**$1,096**	**$510 TO 1,649**	**$2,996 TO 9,824**

Note: Via memo to DWR dated July 20, 2005, SFPUC provided an estimate of $9 billion in total costs to restore Hetch Hetchy Valley. SFPUC did not respond to DWR requests to review documentation of this cost estimate; therefore, DWR was unable to examine SFPUC's claim in this report.

STATE COST ESTIMATING METHODOLOGY

Due to the incomplete nature of the cost estimates from the previous studies, the state found it necessary to make its own cost estimate based upon its extensive experience in planning, design, and construction of water projects. This provides one complete estimate that is based on consistent methodology throughout.

The cost estimate is patterned on the prior work by making broad assumptions on a mix of facilities (as proposed by others) that may be required for the restoration project. The facility mix used here is patterned on integrated resource management principles and is similar to the Environmental Defense and Restore Hetch Hetchy work. However, a range was created to cover the lack of fundamental objectives and anticipated environmental mitigation requirements. Since fundamental objectives have not been articulated at this time, there is huge variability in quantities and unit costs.

Total capital costs include water and power replacement components, complete dam removal, Hetch Hetchy Valley restoration, development of a visitor use plan for the valley, environmental protection, mitigation, and land acquisition costs.

Incidental Flood Control from Hetch Hetchy

While there is no requirement to maintain flood control space in Hetch Hetchy Reservoir, the reservoir provides some indirect flood control benefits on the Tuolumne and lower San Joaquin rivers. Reservoir operators normally keep some space during winter months for operational flexibility and to avoid losing power production if there is a winter storm that could force spills beyond the Kirkwood Powerhouse hydraulic capacity (about 1,400 cfs).

During a big snowpack year, the U.S. Army Corps of Engineers allows up to 50,000 af of snowmelt reservation at Don Pedro Reservoir to be transferred to Hetch Hetchy Reservoir if there is enough empty space in Hetch Hetchy and Lake Lloyd.

A 2005 report by MBK Engineers shows how Hetch Hetchy Reservoir has helped control past floods on the Tuolumne River. The report concluded that the maximum Don Pedro Dam release during 1997 would have been about 100,000 cfs without O'Shaughnessy compared to the actual 59,000 cfs recorded in the flood. The 41,000 cfs increase would probably raise the peak stage at La Grange nearly eight feet higher than actually occurred in 1997.

The incidental flood storage in Hetch Hetchy reservoir in a large flood is likely to be in the 60 to 70 thousand acre-feet (taf) range. There is about an equal amount in Lake Lloyd and Lake Eleanor. Combined with storage in Don Pedro Reservoir, the incidental storage help provide flood protection to about 1 in 50 year level. Removing Hetch Hetchy would lower flood protection on the Tuolumne River to about 1 in 40 year level.

Contingencies

The total direct cost for the facility component includes a 30 percent markup for contingencies to cover inaccuracies in quantity estimation, an allowance for unlisted items, and other unknowns at the time of this conceptual-level estimate. This is consistent with DWR's standard estimating practices at this phase of a conceptual project study. To account for site-specific environmental documentation, permitting, and mitigation expenses, the estimate includes an additional markup of 20 to 30 percent applied to the total direct costs. Further, the estimate includes another 30 percent markup to account for engineering, legal, and administration costs.

Some Issues that Could Significantly Change the Cost Estimate

Following are some critical issues that need to be resolved to narrow the cost range.

- How will assumed measures such as water transfers, conservation, recycling and desalination affect total customer water demand and will this demand stabilize or increase in the future?
- Will there be sufficient power replacement within the SFPUC system or will outside power sources be necessary to make up for the loss?
- Will hydrology and/or institutional constraints limit Bay-Delta supplies?
- What should be the level of water treatment?
- What is an acceptable level of environmental protection and mitigation?
- What is an acceptable level of water management risk?
- How and where would material be disposed of from removal of O'Shaughnessy Dam?
- Should O'Shaughnessy Dam be completely removed or left in place with an empty reservoir?

Priest Reservoir regulates flow into Moccasin Powerhouse.

Plan Formulation

If the decision is made to continue with planning, additional funding will be required for appraisal level and feasibility studies, site-specific engineering, environmental documentation, permitting, mitigation, and preparation of plans and specifications for project construction. The planning effort could take up to 10 years of normal planning, feasibility, and environmental studies, including programmatic documents. If there is continued interest in proceeding with all levels of study, the state estimates $65 million would be needed to complete these studies, exclusive of preparation of design plans and specifications.

CONCEPT-LEVEL COST ESTIMATE

Cost estimates at the concept level are often "back-of-envelope" in nature, made without having material quantity estimates. They are generally based on conceptual sketches, at best, and rely on extrapolation of cost information from other existing facilities. Construction cost escalation would generally only be considered at this level of study if there were reason to believe that a substantial disparity in the relative value of various inputs, such as labor, material and power costs, is expected at the time of construction. Without this foresight and without an idea of when the project(s) would be constructed, the state has not included escalation in this cost estimate.

A summary of the state cost estimate is given in Figure 6-2 and information on the specific basis for costs is presented in Appendix G.

Following are some highlights of the state's cost estimate:

- An average cost per unit of surface storage was developed from five surface storage programs currently under joint studies by DWR and U.S. Bureau of Reclamation as part of the CALFED Surface Storage Investigations Program.
- Groundwater storage and extraction costs are based on Proposition 13 projects funded by DWR over the last four years.
- Conveyance costs, such as interties to the SFPUC system, used typical costs developed by DWR's Division of Engineering for the SWP South Bay Aqueduct expansion.
- Intertie structures, such as reservoir intake towers, are based on the SWP's San Bernardino Intake Structure experience.
- Annual operations and maintenance (O&M) costs are assessed at two percent of total project costs based on economic analyses of the Coastal Branch Project, plus energy costs. Present worth of O&M costs are assessed at 6% discount rate over 30 years.
- Power replacement facility costs (including pumps, pipelines, tunnels, motors, valves and other mechanical work) were predicted using actual SWP cost experience with the Coastal Aqueduct, East Branch Extension pump stations, and Mojave Siphon Power Plant.
- Power transmission line costs are based on a quotation from Sacramento Municipal Utility District.
- Dam removal methods and costs were compared to other dam removal projects in the U.S.: Elwha and Glines Canyon Dams on the Elwha River in Olympia National Park, Washington; Matilija Dam on the Ventura River in

From the tailrace of Moccasin Powerhouse, Tuolumne River water is transported via tunnels and pipelines to the San Francisco Bay Area.

California; and San Clemente Dam on the Carmel River in California.

- Valley Restoration and Recreation Plan Development costs are provided by the National Park Service and the California Department of Parks and Recreation.
- In the last two years, DWR has experienced significant increases in construction costs. Based on its recent experience, DWR added 30% for engineering design, construction, and administration costs in its estimate.

Cost Perspective for California Resource Management Challenges

- **$10 billion to $16 billion for flood management**
- **$3 billion to $6 billion for Salton Sea**
- **$3 billion to $10 billion for CALFED**
- **$1 billion to $2 billion for Owens Valley**
- **$3 billion to $10 billion for Hetch Hetchy**

Figure 6-2 A Cost Estimate for Hetch Hetchy Restoration (millions of 2005 dollars) [1]

PLANNING COSTS		
Plan Formulation (site-specific engineering, environmental documentation, permitting, and mitigation are not included in this planning level work, see F and G below)		
Level 1 -	Complete concept level studies	7
Level 2 -	Appraisal-level studies	13
Level 3 -	Feasibility-level studies	32
Level 4 -	Detailed studies and programmatic documents (but not including final design, permits and other site-specific work in Items F and G below)	13
GRAND TOTAL OF PLANNING COSTS		**$65+**
IMPLEMENTATION COSTS		
A	**Implement Water Replacement Components** [2]	**$1,144 – $4,305**
1	Construct new water supply facilities	
a	250,000 to 450,000 af new surface storage [3]	163 - 1,460
b	200 to 300 cfs groundwater banking program [3]	150 - 230
c	Intertie (Don Pedro or SWP)	53 - 234
2	Acquire dry-year supply transfer water	22 - 86
3	Expand water treatment facilities	310 - 515
4	Increase water use efficiency (5,000 to 20,000 af) [3]	46 - 210
5	Present worth of increased annual O&M costs	400 – 1,570
B	**Implement Power Replacement Components** [2]	**$560 - $820**
1	Construct new facilities	
a	new 1,500 cfs Canyon Tunnel intake	70
b	modifications to Kirkwood for reduced "head"	30
c	730 cfs pumped connection from Holm to Mountain Tunnel	40
2	Purchase replacement capacity and energy	420 - 680
C	**Modify or Remove Dam**	**$250 - $915**
1	Mobilization and set-up (crusher, conveyor, roads, etc.)	39 - 65
2	Deconstruct dam	178 - 810
3	Demobilization and clean-up	33 - 40
D	**Restore Valley**	**$32 - $53**
1	Refill quarry excavations and recontour ground surface	1
2	Native species revegetation and stream restoration	30 - 50
3	Maintenance and monitoring (adaptive management)	1 - 2
E	**Implement Public Use Plan for Valley**	**$10 - $91**
Subtotal of Direct Costs		**$1,996 - $6,184**
F	**Site-Specific Environmental Docs, Permits, & Mitigation (20-30%)**	**$390 - $1,790**
G	**Engineering, Legal, and Administration (30%)**	**$610 - $1,850**
GRAND TOTAL OF IMPLEMENTATION COSTS		**$2,996 - $9,824**
TOTAL PROJECT COST		**$3,061 to $9,889**

Hetch Hetchy Reservoir

NOTES FOR FIGURE 6-2

[1] Estimates are based on similar project experience and include a 30% markup for uncertainty in estimating costs (see Appendix G for more detail).

[2] To develop cost estimates, the state used a resource mix based on the ED-modeled alternative — which includes an additional 323 taf storage in Calaveras Reservoir, a 200 cfs groundwater extraction program, a 407 cfs Don Pedro Intertie, 56 taf maximum annual dry year water transfers — to meet increased future demands.

Power replacement facilities were based on other existing Hetch Hetchy water and power replacement studies.

This combination of water supply and power replacement components was chosen for its potential to meet the broad objectives likely to be required for the restoration of Hetch Hetchy Valley. The range of costs was developed using the high and low cost estimates from water management components 1, 2, and 3, as discussed in Chapter 4.

[3] Given the uncertainty involved, a range was used in this cost estimate because the exact location, facility size, and operational parameters are unknown at this time. The facility mix selected and the cost range presented also account for possible additional environmental protection and risk mitigation for California water management that may be required to implement these projects.

7 NEXT STEPS – FUTURE WORK

This study presents initial conceptual information for review and to promote discussion. It does appear technically feasible to restore the Hetch Hetchy Valley. However, it is premature to evaluate its financial feasibility. Based upon the low level of detail of information compiled during this state review, this chapter provides some guidance for others that may have continued interest in the restoration of Hetch Hetchy Valley.

The information from prior reports is not nearly detailed enough to make a decision on the financial feasibility of valley restoration. If a decision is ever to be made, policy makers and the public will need significantly more detailed quantitative information about costs, benefits, and tradeoffs associated with a specific proposal.

ROLE OF THE STATE

Further investigations into Hetch Hetchy Valley restoration cannot be led by the State of California alone. Federal participation, specifically the active and direct participation of the U.S. Department of Interior, will be important to help shape future studies and to work with the San Francisco Public Utilities Commission, Native American tribes, and the public on any next steps in this process. Federal authorization may be needed to initiate this federal role. A public/private partnership might be one mechanism to proceed with further evaluations. The Resources Agency will participate in any future studies under its mission to manage California's natural resources with the goal of ensuring that future studies or plans adhere to principles of integrated regional water management, that they maximize public benefit, and that they protect the environment, as well as the public trust.

If more detailed information becomes available, the state will review it in light of potential impacts on California's natural resource management activities and responsibilities — including water, energy, environmental, and recreation — and how overall public benefits can be maximized. If the federal government continues the investigation of restoring Hetch Hetchy, the state will consider participating as an active member of a cooperative study.

MORE DIALOGUE IS NEEDED

More dialogue must occur among elected officials; federal, state, and local agencies; Native American tribes; environmental interest groups; and the public before a decision is made to continue with restoration studies. Together, these interests will need to grapple with questions such as:

- What specific processes and studies are needed to determine the feasibility of restoring Hetch Hetchy Valley and replacing its current water and power benefits?
- Are water and power replacement options acceptable to the public?
- Can an adequate package of actions and mechanisms assure that a restoration and replacement program will be implemented and operated as intended?
- Who is willing to pay for a comprehensive Hetch Hetchy solution?

Prior to making a decision on whether or not to proceed with investigating the financial feasibility of restoring the Hetch Hetchy Valley, future studies need to be committed to well-defined objectives and supported by a sound stakeholder process. Future studies should also be carried out to a consistent level of study.

MANAGEMENT STRUCTURE

The California Research Bureau (2005) discussed a number of major environmental restoration projects in California and around the country. The report identifies that these projects often utilize various management structures during different stages of their development. Described below are three general structures from the report:

- *Government-Run Study*. This approach relies on government expertise to direct and conduct the analysis. For a large, complex issue, this could be a multi-agency study like what is occurring in the Florida Everglades. These processes usually rely on public and stakeholder advisory bodies to provide advice and feedback.
- *Government-Appointed Task Force*. Projects around the country do not use the term "task force" in a consistent way. In some cases, it means a stakeholder group that will negotiate a result similarly satisfactory (or unsatisfactory) to all parties. In other cases it means a panel of experts or a distinguished leader that brings a neutral, unbiased approach to the problem. For the purposes of this report, the term is used in the spirit of a panel of experts or distinguished leaders. An example is the California's Marine Life Protection Act (MLPA) Blue Ribbon Task Force. Parties expect such a task force to conduct a transparent and unbiased study of the issues; listen to stakeholders, the public, and the experts; and then make recommendations to government. The credibility of the task force with stakeholders, government officials, and the public is key to its success.

- *Collaborative Stakeholder Process*. In the two models described above, stakeholders may be consulted or have a formal advisory role. In the third model, which we call a collaborative stakeholder process, they are directly involved in setting up and overseeing the investigation. Terms commonly used to describe this process are "collaborative analysis" and "joint fact-finding." The Sacramento Area Water Forum is such a process.

It should also be noted that the management structure may not be the same throughout the study period, which could last up to 10 years.

LEVEL OF STUDY DETAIL

The level of detail in the previous Hetch Hetchy restoration studies is generally at the conceptual level or less. A next step in the studies could be elevating all the information to the same level of conceptual detail. Four specific areas could use more study to bring all information to the conceptual level of detail:

- Public use
- Valley restoration
- Dam removal
- Benefits

It is not essential for all the studies to occur at the same time. In fact, an analysis on public use and restoration early in the process would fill in important gaps and enhance efforts to quantify benefits, study dam removal, or define water and power replacement objectives.

Visitors walk across O'Shaughnessy Dam to reach the hiking trail around Hetch Hetchy Reservoir.

Future studies of any subject areas related to Hetch Hetchy Valley restoration will likely examine the issues identified to date through the following activities either under conceptual or appraisal level of study:

- Development and analysis of alternatives
- Public outreach
- Alternatives assessment

More detailed feasibility studies should only be conducted if the proposal looks promising after these less detailed studies.

FORMAL STAKEHOLDER PROCESS

A formal stakeholder process engaging the city and county of San Francisco and the Department of Interior regarding objectives for water and power replacement is critical. As information becomes available, policy makers and the public will have the opportunity to continue, adjust, postpone, or stop the evaluation process.

PURPOSE AND NEED

None of the prior studies articulated project objectives for restoration, public use, and water and power replacement. The next step of study should be based on a well-defined purpose and need statement, accompanied by specific project objectives. This process should also establish performance measures for restoration, public use in Hetch Hetchy Valley, and water and power replacement.

DEVELOP AND EVALUATE ALTERNATIVES

Some of the studies looked at multiple concepts for their area of interest, but generally none evaluated alternatives for the entire project. The next step of studies needs to develop and evaluate a reasonable range of alternatives based on the purpose and needs and established objectives. The evaluation should identify benefits and costs for a range of public use and restoration alternatives, as well as the cost of replacing current water and power benefits.

IMPORTANT ISSUES TO BE ADDRESSED

Through the public workshop and agency contacts to date, the study team has heard the issues and potential impacts identified by the stakeholders that should be addressed in future phases of study. Some of these issues are briefly summarized below. In addition to the following issues, a preliminary list of potential project impacts can be found in Appendix D and public comments can be found in Appendix J.

Project Planning and Objectives

The acceptability of restoring Hetch Hetchy Valley to interested parties around Yosemite National Park and to regional and statewide stakeholders needs to be considered. The planning and implementation issues include:

- Project purpose and need
- Objectives
- Identification and development of a range of alternatives
- Identification of potential project partners and financing
- Required permits and agency consultation
- Interrelationships with other projects and studies
- Institutional arrangements
- Agency and public education and participation

Restoration and Public Use

The potential beneficial and adverse effects of restoring Hetch Hetchy Valley need evaluation. The alternatives evaluation should include analysis of the following factors:

- Ambient water quality
- Number, location, size, design, and impacts of new visitor use facilities
- Impacts of removal or modification of O'Shaughnessy Dam
- Disposal of material from dam demolition
- Disturbance of valley floor by original construction
- Restoration of valley walls
- Sensitive terrestrial species and habitat
- Natural recolonization by plants and animals
- Cultural and other historic resources, including Native American issues
- Third party and environmental justice impacts
- National Park policies

System Operations, Conveyance Pipelines, and Facilities

Replacement water and power supplies from new facilities must be considered, including potential water quality and water supply reliability benefits and the institutional and operational agreements among potential participants. A key issue will be quantifying potential benefits of new facilities and identifying other water users who might be interested in obtaining those benefits. The conveyance, operation, and delivery issues include the following:

- Delivered water quality
- Delivered water amounts, timing, and reliability
- Growth issues
- Operational and institutional agreements among project participants
- Location, size, and impacts of conveyance facilities
- Risk management, including dam safety
- Impacts to downstream users
- Environmental impacts
- Sensitive species and habitat
- Reservoir and water supply security
- Flood control
- Operations during construction and coordination of operations with other projects
- Statewide water management

Legal Issues

The legal issues raised by restoring Hetch Hetchy Valley must necessarily be considered in a general way. They can only be fully and accurately described once a specific proposal is made on how the restoration is to be accomplished, and will obviously turn in great part on what facilities and by what institutional arrangements are proposed. Virtually all the alternatives for water and power supply replacement involve the use of potentially controversial water transfers in the Tuolumne River watershed (including Don Pedro Reservoir), the lower San Joaquin River, and the Sacramento-San Joaquin Delta. The legal issues involved in restoration include:

- Reasonable use and public trust
- Water quality and instream impacts
- Environmental review, documentation, and mitigation
- Safety
- Flood control
- Public use
- Water transfers
- Water rights
- Organizational and contractual obligations
- Wilderness Act
- Wild and Scenic Rivers Act
- Raker Act, including dam removal authority

Cost, Financing, and Institutional Arrangements

The potential costs and financing for Hetch Hetchy Valley restoration and water and power replacement, including allocation of costs among purposes and beneficiaries, must be determined. A method for determining the value of potential benefits is necessary to assist decision makers in allocating costs. The cost and financing areas of investigation include:

- Methods for determining costs and benefits
- Allocation of costs among project purposes
- Funding and financing alternatives and associated institutional requirements
- Institutional and operational arrangements among partner agencies
- Operation and control of facilities
- Mechanism for assuring commitments

Reports on dam removal by the Aspen Institute and the H. John Heinz III Center for Science, Economics, and the Environment stressed several issues important to dam removal:

- Address the rights of dam owners and beneficiaries at the outset
- If new studies are necessary, take key steps up front
- Revise permitting requirements to accommodate dam removal
- Coordinate the applicable regulatory programs.
- Make dam removal activities eligible for funding from existing programs and seek private funds
- Consider creative regulatory approaches

The Pulgas Water Temple marks the terminus of the Hetch Hetchy Aqueduct near Woodside.

REFERENCES

Alameda County Water District. 2004. *Water Quality Report.*

Assembly Office of Research (AOR). 1988. *Restoring Hetch Hetchy*. California State Legislature, State Capitol: Sacramento, California 95814.

California Department of Health Services. 2004. *Domestic Water Supply Permit, San Francisco Regional Water System.*

California Department of Health Services. 2005. *Annual Inspection of the San Francisco PUC Regional Water System.*

California Research Bureau. 2005. Requested Examination of Project Management Options. Memorandum.

Camp Dresser & McKee. 1991. *Hetch Hetchy Water Treatment Plant Siting Study.* (prepared for the San Francisco Public Utilities Commission).

Camp Dresser & McKee. 1995. *Water Quality Planning Study, Tasks 9 and 16.* (prepared for the San Francisco Water Department).

City and County of San Francisco: Public Utilities Commission. 1934. *Hetch Hetchy Water Supply: Summary of Stress Analyses for the Enlarged O'Shaughnessy Dam.*

City of Modesto. 2005. *Consumer Confidence Report.*

Denise Duffy and Associates. 1998. *Draft EIR for the Seismic Retrofit of the San Clemente Dam.*

Denise Duffy and Associates. 2000. Recirculated: *Draft EIR for the Seismic Retrofit of the San Clemente Dam.*

Environmental Defense. 2004. *Paradise Regained: Solutions for Restoring Yosemite's Hetch Hetchy Valley.* Oakland, CA. 116 p. plus appendices.

Freeman, John R. 1912. *On the Proposed Use of a Portion of the Hetch Hetchy, Eleanor and Cherry Valleys within and near to the Boundaries of the Stanislaus U.S. National Forest Reserve and the Yosemite National Park as Reservoirs for Impounding Tuolumne River Flood Waters and Appurtenant Works for the Water Supply of San Francisco, California, and Neighboring Cities: A Report to James Rolph, Jr., Mayor of San Francisco, and Percy V. Long, City Attorney.,* San Francisco. July 15, 1912.

Groveland Community Services District. *2003 Consumer Confidence Report.*

Jones & Stokes Associates. 1993. *Mono Basin Draft Environmental Impact Report, Appendix X: Economics, 1993.* For the Mono Basin Water Rights Hearings before the California State Water Resources Control Board. Available for download at http://www.monobasinresearch.org/onlinereports/deirap.htm

H.H.W.S. 1948. Department of Public Works: Division of Water Resources. *Specifications for Furnishing and Delivering Three Drum Gates: O'Shaughnessy Dam.*

Houk, Ivan E. 1935. U.S. Department of the Interior: Bureau of Reclamation. *Technical Memorandum No. 417: Gravity and Trial Load Analyses of Stresses in Enlarged Hetch Hetchy Dam.*

Kleinfelder, Inc. 2002. *Sediment Characterization Study, San Clemente Reservoir, Monterey County, California.*

Krutilla, John. 1967. "Conservation Reconsidered". *American Economic Review*. Vol. 57, 1967, p. 777-786.

Loomis, John. 1988. "Broadening the Concept and Measurement of Existence Value". *Agricultural and Resource Economics Review.* Vol. 17, No. 1. p. 23-29.

Marliave, Chester. 1934. Department of Public Works: Division of Water Resources. *Geological Report on O'Shaughnessy Dam.*

Marliave, Chester. 1939. Department of Public Works: Division of Water Resources. *Geological Report on O'Shaughnessy Dam.*

MBK Engineers. 2005. *Assessment of the Flood Control Impacts of the Removal of Hetch Hetchy Dam and Reservoir, Tuolumne River, California.* Prepared for the San Francisco Public Utilities Commission.

McAfee, L.T. 1934. City and County of San Francisco: Public Utilities Commission. *Hetch Hetchy Water Supply: Contract No. 149: For the Enlargement of O'Shaughnessy Dam.*

Montague, S. and W. J. Mundy. 1995. *The 1991 Hetch Hetchy Reservoir Archeological Survey*. *Yosemite Research Center Technical Report, No. 1.* National Park Service, Yosemite National Park, California.

National Park Service. 1988. (sometimes cited as Riegelhuth, R., Botti, S., Keay, J., 1988.) *Alternatives for Restoration of Hetch Hetchy Valley Following Removal of the Dam and Reservoir.*

National Park Service, Olympic National Park, Washington State. 1996. *Final Elwha River Ecosystem Restoration Implementation (FEIS).*

National Park Service, Olympic National Park, Washington State. 2004. *Draft Supplemental to the Final Environmental Impact Statement, Elwha River Ecosystem Restoration Implementation (SEIS).*

Null, Sarah E. 2003. *Re-assembling Hetch Hetchy, Water Supply Implications of Removing O'Shaughnessy Dam.* Thesis for the Master of Arts in Geography, University of California, Davis.

Ogilive, T. W. 1950. Department of Public Works: Division of Water Resources. *Enlarged O'Shaughnessy Dam: Photographs of Spillway and Dam.*

Olson, A. O. 1949. City and County of San Francisco: Public Utilities Commission. *Hetch Hetchy Water Supply: Installation of Spillway Gates at O'Shaughnessy Dam.*

Restore Hetch Hetchy. 2005. *Restore Hetch Hetchy: Finding the Way Back to Hetch Hetchy Valley. Sonora, CA. 86 p.*

REFERENCES

Rider, Jessica. 2004. *The Potential Economics Benefits of Restoring Hetch Hetchy Valley.* Study prepared for Environmental Defense.

R. L. A. 1934. Department of Public Works: Division of Water Resources. *Program for Grouting Joints: Enlargement of O'Shaughnessy Dam.*

San Francisco Public Utilities Commission. *2003 Annual Report and Update on Watershed Control Program and Sanitary Survey for the Hetch Hetchy Water Supply.*

San Francisco Public Utilities Commission. *2004 Water Quality Report.*

State Water Resources Control Board. 2003. *Final 2002 Clean Water Act Section 303(d) List of Water Quality Limited Segments.*

The H. John Heinz III Center for Science, Economics and the Environment. 2002. *Dam Removal: Science and Decision Making.*

The H. John Heinz III Center for Science, Economics and the Environment. 2003. *Dam Removal Research: Status and Prospects.*

U.S. Army Corps of Engineers. 2004. *Matilija Dam Ecosystem Restoration Feasibility Study: Environmental Impact Statement/Environmental Impact Report.*

U.S. Army Corps of Engineers. 2004. *Matilija Dam Ecosystem Restoration Feasibility Study: Main Report.*

U.S. Army Corps of Engineers. 2004. *Matilija Dam Ecosystem Restoration Feasibility Study: Appendix D: Hydrologic, Hydraulic and Sediment Studies.*

U.S. Army Corps of Engineers, U.S. Department of the Interior: Bureau of Reclamation. 2003. *Matilija Dam Ecosystem Restoration Feasibility Study: Appendix D: Hydrology, Hydraulics, and Sediment Studies.*

U.S. Army Corps of Engineers. 2003. *Matilija Dam Ecosystem Restoration Feasibility Study: Alternatives Analysis Draft Report (F4) Milestone: Draft Main Report and EIS/EIR.*

U.S. Army Corps of Engineers. 2003. *Matilija Dam Ecosystem Restoration Feasibility Study: Alternatives Analysis Draft Report (F4) Milestone: Technical Appendices.*

U.S. Bureau of Reclamation (USBR). 1988. *Hetch Hetchy: A Survey of Water and Power Replacement Concepts.* Prepared on behalf of the National Park Service by the Bureau of Reclamation Mid-Pacific Region. Sacramento, CA. 32 p. plus appendices.

U.S. Department of Energy (USDOE). 1988. *Hetch Hetchy: Striking a Balance. A Review of the Department of the Interior's Survey of Water & Power Replacement Concepts for Hetch Hetchy.*

U.S. Fish and Wildlife Service (USFWS). 1998. *Economic Analysis for Hydropower Project Relicensing: Guidance and Alternative Methods.* Available for download at http://www.fws.gov/policy/hydroindex.htm

OTHER RESOURCES

California Department of Health Services. Drinking Water Source Assessment Program.

PERSONAL COMMUNICATIONS

Alameda Creek Alliance. 2002. Letter to Paula Kehoe, SFPUC, Regarding: SFPUC Capital Improvement Program—Calaveras Dam. April 18, 2002. 3 p.

Bruce, Margaret, Silicon Valley Leadership Group. 2005. Personal communication.

DeGraca, Andrew, San Francisco Public Utilities Commission. 2005. Correspondence and personal communication.

Fujitani, Paul, U.S. Bureau of Reclamation. 2005. Personal communication.

Graham, Betty, California Department of Health Services. 2005. Correspondence and personal communication.

Grober, Les, Central Valley Regional Water Quality Control Board. 2005. Personal communication.

Olsen, Jenna, Tuolumne River Trust. 2005. Personal communication.

Spano, Joseph, California Department of Health Services. 2005. Correspondence and personal communication.

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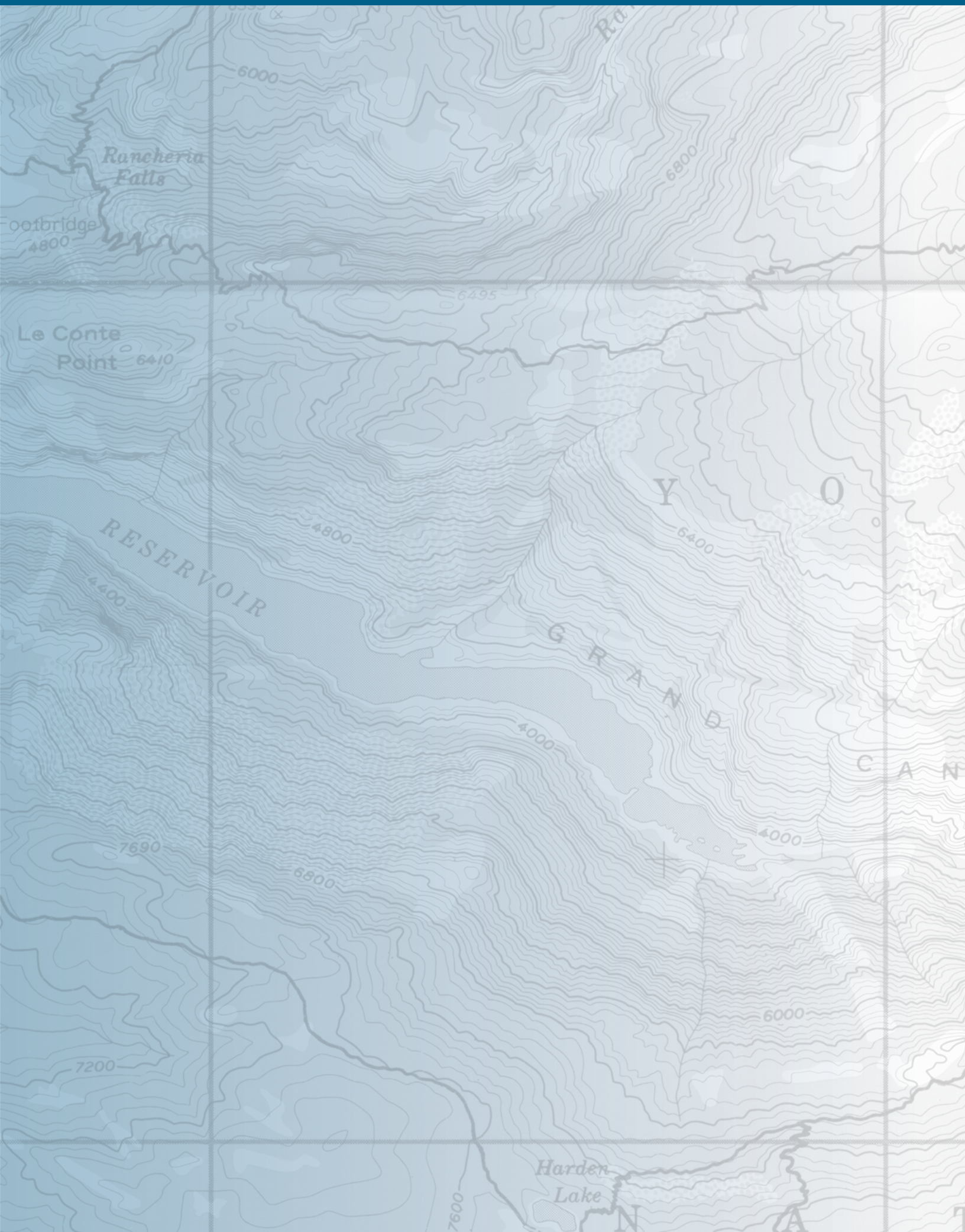
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