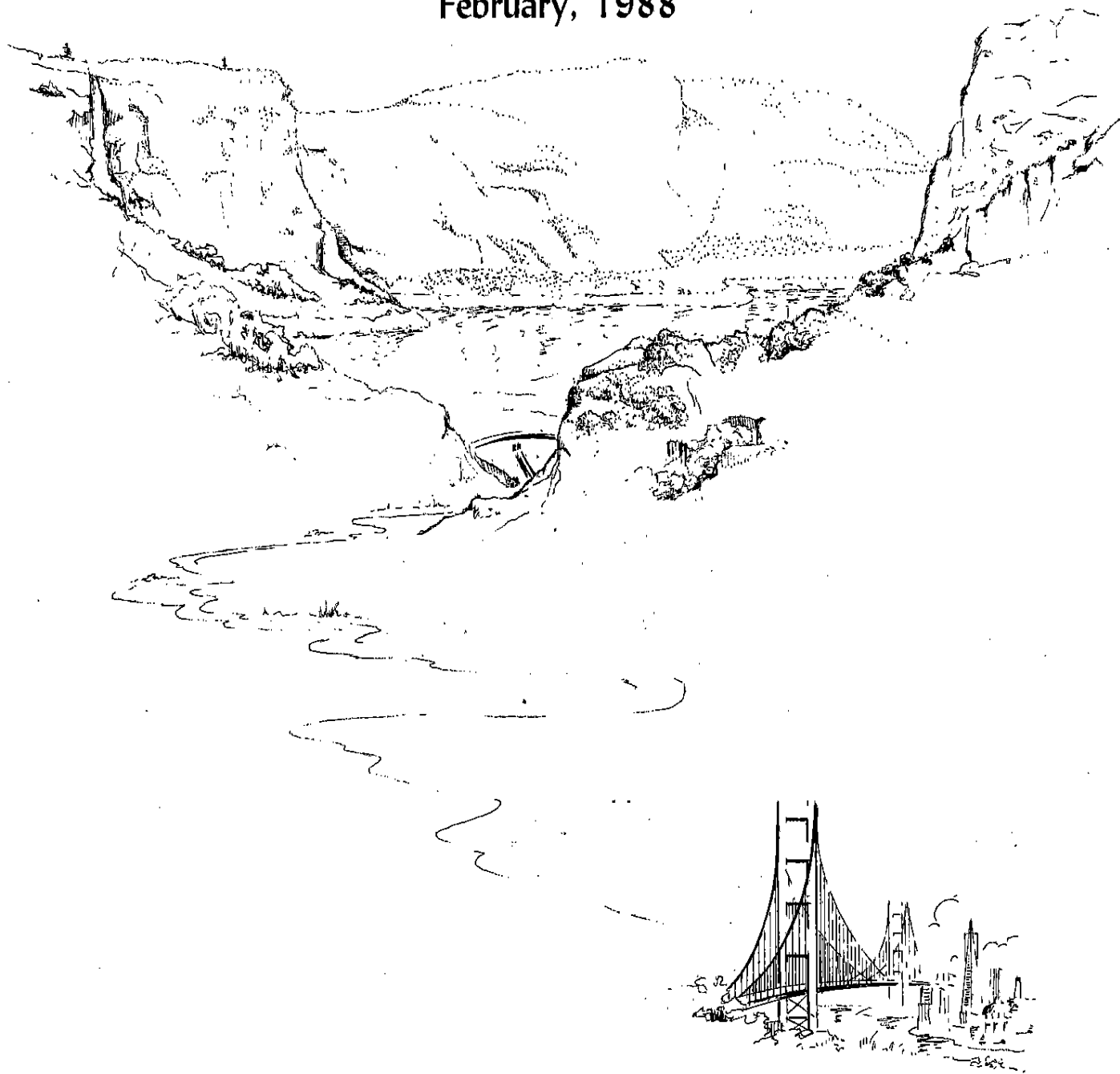


Hetch Hetchy:

Water and Power Replacement Concepts

February, 1988



Bureau of Reclamation

Mid-Pacific Region
2800 Cottage Way
Sacramento, CA 95825

To: All Interested Parties

Hetch Hetchy: Water and Power Replacement Concepts, Final Report

In September 1987, Secretary of the Interior, Don Hodel, asked the Bureau of Reclamation, on behalf of the National Park Service, to evaluate the potential for removing O'Shaughnessy Dam and restoring Hetch Hetchy Valley to a natural environment in Yosemite National Park California.

The Mid-Pacific Region of Reclamation, acting as an engineering and technical consultant to the National Park Service, surveyed several water and power replacement options and prepared a conceptual overview of options that initially appeared promising. During preparation of the report, Reclamation relied heavily on public information prepared by the City and County of San Francisco and on information provided directly by the city. Other assistance came from the Modesto and Turlock Irrigation Districts and the Western Area Power Administration, who provided materials and data.

The report was released to the public on November 15, 1987, for a 30-day review period, which by request of some responding parties, was extended through January. Comments were received from 20 individuals and entities. Respondents and their comments are tabulated on Table A-1 in the Appendix. Texts of the letters are also included in the Appendix.

With minor exceptions to ensure accuracy, comments received during the public comment period were not incorporated into the Water and Power Replacement Concepts Final Report. Rather, they will be used during plan formulation of any feasibility study of replacement concepts that is undertaken. All comments would then be addressed as an essential part of the feasibility study and would serve as an invaluable basis from which to establish a program for public participation in the study.

This report and the appended public responses document Reclamation's appraisal of the conceptual possibilities for alternative sources of water and power for users of the Hetch Hetchy System. Reclamation thanks those individuals, agencies, and organizations responding during the public review period.

HETCH HETCHY:

**A Survey of Water & Power
Replacement Concepts**

**Prepared on behalf of the
National Park Service by the
Bureau of Reclamation
Mid-Pacific Region
Sacramento, California**

February, 1988

PREFACE

*Everybody needs beauty as well as bread,
places to play in and pray in, where
Nature may heal and cheer and give strength
to body and soul alike.*

John Muir, writing in 1912 about Yosemite National Park, eloquently expresses man's need for both "beauty and bread," for utility and aesthetics. It is a balance achieved with difficulty. Indeed, throughout much of his history, man has worked to subdue his environment, and in his search for security and sustenance, has wrought technological marvels and reshaped his world.

In 1872, the United States Congress established Yellowstone as the first national park. The phrase inscribed on the cornerstone of its gate, "for the benefit and enjoyment of the people," embodies the spirit of that commitment.

As steward of the nation's natural resources, the Secretary of the Interior is charged with the commitment that must balance the nation's need to use its resources with its need to enjoy and appreciate the beauty and grandeur of its environmental heritage. In the words of the late Gifford Pinchot, the goal is the foresighted use, preservation, and renewal of resources "for the greatest good of the greatest number for the longest time."

In July 1987, Secretary of the Interior Don Hodel, acting within this tradition, asked the American public to consider a seemingly radi-

cal idea: the restoration of Hetch Hetchy Valley to Yosemite National Park.

Initially startling, this idea, on second consideration, begins to intrigue the mind and free the imagination to consider the creative potential of such a proposal. One begins to see the possibilities inherent in the opportunity to re-evaluate a past decision in the light of not only today's but tomorrow's needs.

On the one hand is the city of San Francisco and nearby areas and their need for the best and least costly water and power supply possible, a supply which the present Hetch Hetchy system has served and continues to serve well. On the other hand is the undeniable stress on the National Park system on the whole, and on Yosemite in particular, and the increasingly critical need to protect this resource if it is to be enjoyed by future generations.

In 1913, in striking the difficult balance between "bread and beauty," the decision was made to flood Hetch Hetchy Valley and provide a much needed water and power supply to a growing city--one of the great cities of the West and of the world. At that time the decision was the best and most beneficial use of that resource.

In 1987, when values have changed, the issue has risen again, this time the result of an overcrowded national park system and the pressing need to maintain the integrity of the Sacramento-San Joaquin Rivers Delta and San Francisco Bay. The problems of modern civilization from which the parks offer an essential respite now threaten the parks themselves. Fortunately, however, some losses are not irretrievable. Man's increasing technological prowess enables him to re-evaluate former commitments of resources in the light of today's knowledge.

Could the City of San Francisco receive a comparable water and power supply from other sources? Could the Hetch Hetchy Valley be restored as part of the living heritage of our National Park system? In a world of diminishing natural resources, what is the highest use of the valley? The questions are worth asking.

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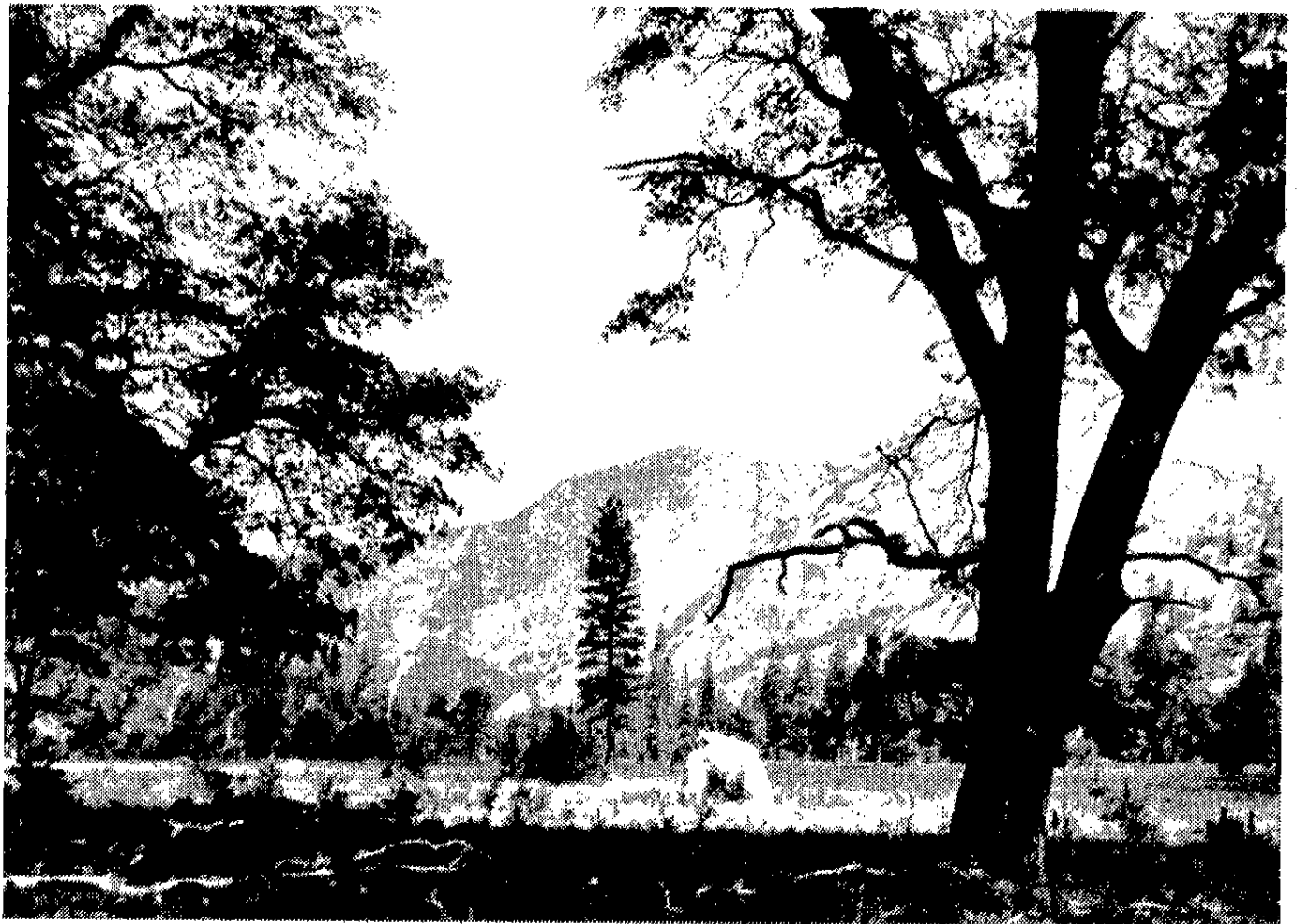
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SUMMARY



Photograph by Joseph Le Conte

The Hetch Hetchy Valley before the O'Shaughnessy Dam was completed in 1923.

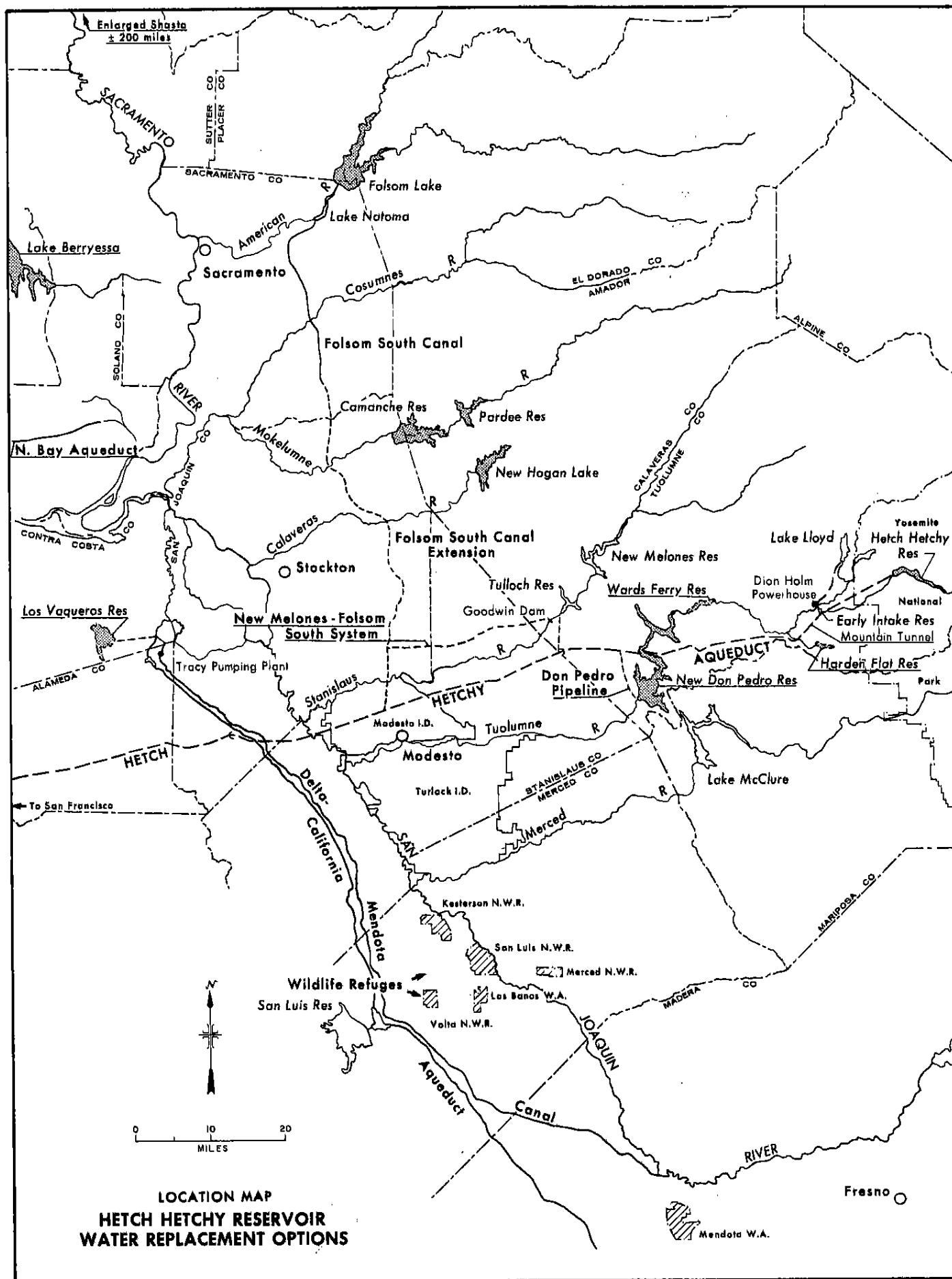


FIGURE 1

SUMMARY

This report presents the results of a preliminary analysis made by the Bureau of Reclamation of the idea of restoring Hetch Hetchy Valley to its natural environment as a unit of Yosemite National Park. The report was prepared on behalf of the National Park Service, with assistance from the City and County of San Francisco, Modesto and Turlock Irrigation Districts, and the Western Area Power Administration, who provided materials and data.

The report also presents the basis for a feasibility study of the restoration of Hetch Hetchy Valley should it be determined that further analyses are warranted. Although concepts for replacing water and power supplies from San Francisco's Hetch Hetchy system were examined cursorily, based on existing information only, several replacement strategies appeared promising for further study. Emphasis in a future study should be on those options and on establishing the specific replacement requirements, which are only generally known at present.

Restoring the 1,970 acres of land presently impounded by Hetch Hetchy Reservoir to National Park uses would generate many long-term environmental benefits, including improving the area's environmental, ecological, and recreational resources. Restoration would, however, eliminate the potential for meeting the water supply provided to San Francisco and nearby cities from the Hetch Hetchy Reservoir; this supply over the past 11 years has averaged about 214,000 acre-feet annually. Restoration would also reduce power benefits from the Hetch Hetchy system.

The Hetch Hetchy system is comprised of three storage reservoirs: Hetch Hetchy (360,360 acre-feet); Lake Eleanor (27,100 acre-feet); and Lake Lloyd (268,800 acre-feet), as well as various hydro-electric power facilities. New Don Pedro Reservoir (2,030,000 acre-feet), located downstream of the Hetch Hetchy system, is owned jointly by the City and the Turlock and Modesto Irrigation Districts. Hetch Hetchy Reservoir is operated to

directly provide water supplies for San Francisco; Lakes Eleanor and Lloyd are operated to generate power, meet instream water requirements, and, in part, to provide inflow into New Don Pedro Reservoir, as part of the City's obligation to the districts.

San Francisco operates its Hetch Hetchy system under authorities provided by the Federal Raker Act of 1913 and water rights granted by the State of California. Agreements with the Turlock and Modesto Irrigation Districts outline water rights and the operation of the City's Cherry Valley Dam, impounding Lake Lloyd, and the New Don Pedro Dam. Agreements with the Department of the Interior on fish releases and with the Corps of Engineers on flood control also govern, in part, operation of the Hetch Hetchy system.

Identifying viable water and power replacement alternatives is critical to the pursuit of any plan to create a "second Yosemite Valley." Although detailed studies of alternatives capable of replacing the Hetch Hetchy water and power supplies have yet to be made, several opportunities appear promising. Among them, and the logical first step toward replacement, is operation of the City's Tuolumne River (Hetch Hetchy) system and the downstream New Don Pedro Reservoir to salvage as much water and power as possible without Hetch Hetchy Reservoir and to keep the Turlock and Modesto Irrigation Districts' water supply intact.

Based on dry-year hydrology, it appears that operation of the Hetch Hetchy system without Hetch Hetchy Reservoir could provide a minimum of 336,000 acre- feet of Tuolumne River water annually to San Francisco through the City's existing system. (At the present time, 336,000 acre-feet per year is the maximum amount that can be conveyed through existing conduits.)¹ Over 100,000 acre-feet of replacement supply could be provided from river level diversion from below O'Shaughnessy damsite and another 250,000 acre-feet from changes in operation in Lakes Eleanor and Lloyd. In total, enough water could be captured to

1 *Capacity of the existing Hetch Hetchy Aqueduct across the San Joaquin Valley is 300 million gallons per day.*

operate the City's existing conveyance system at full capacity and deliver almost 100,000 acre-feet more than is currently being used.

In addition to providing water and power supplies, any reoperation of the Tuolumne River system would consider flood control and instream flow needs, and Sacramento-San Joaquin Delta/San Francisco Bay requirements. Water from the City's facilities without Hetch Hetchy Reservoir could be conveyed through existing City conveyance systems; water, if any, from New Don Pedro Reservoir would require new facilities to introduce and treat replacement supplies into the City's conveyance system.

If needed, additional replacement supplies could be developed through storage of Tuolumne River water in new terminal storage facilities in the City's service area. Previous City studies¹ suggest that the existing San Antonio and Crystal Springs Reservoirs have the potential for increased storage. Long-term reliability of using those sources would be directly related to the seismic potential of the area.

The restoration of Hetch Hetchy Valley would affect the power supplies of the Turlock and Modesto Irrigation Districts and the power supplies and revenues associated with San Francisco's Hetch Hetchy system. Water supplies to the Kirkwood and Moccasin Creek Powerplants would be reduced. These plants presently produce about 1,155 million kilowatt-hours of electricity, or about 60 percent of the Hetch Hetchy system's generation.

Also affected would be the fishery and recreation resources of the Tuolumne River and a reach of the river that is included in the Federal Wild and Scenic River system.

Water supplies for the City not replaced by coordinated or modified operation of present Tuolumne River facilities could be provided from various other sources. These are summarized in the matrix on Table 1. The three most promising options at this

1 *Kennedy/Jenks Engineers. January 1986. Alternative Means of Providing Additional Water to the San Francisco Water Department. "Executive Summary." Report Completed in association with Tudor Eng. Co.*

time appear to be a conjunctive use program for the American, Stanislaus, and Tuolumne River Basins, which drain a portion of the eastern Sierra Nevada foothills; construction of an offstream storage reservoir at the proposed Los Vaqueros damsite in Contra Costa County; and coordination of the Solano Project's Lake Berryessa with the State of California's North Bay Aqueduct.

Conjunctive use of the Tuolumne River Basin could be incorporated into an ongoing Reclamation use study of existing projects, facilities, and river systems between the American and Stanislaus River basins. Replacement water could be delivered through new facilities constructed directly to the City's Hetch Hetchy system. Any water developed, however, would be shared with other users in the area and would not all be available for Hetch Hetchy replacement supplies.

Supplies from either offstream storage or coordinated operation of State- Federal facilities would be delivered to the City from the Delta using either the existing Federal Delta-Mendota Canal or the State Aqueduct to the point where the Hetch Hetchy Aqueduct crosses these facilities.

Capacity in the Federal canal is limited, however, and enlargement would be required. Use of the State Aqueduct would require a wheeling agreement. Quality of water from the Delta would be adequate for municipal uses although it would be less than the quality the City presently enjoys. Use of Delta supplies would also require through-Delta water conveyance improvements as the water that can be moved across the Delta is limited by the capacity of Delta channels.

The role of San Francisco in sharing in the maintenance of Sacramento-San Joaquin Rivers Delta/San Francisco Bay standards may be a consideration in determining future water supplies, but is not considered in this report. Any City responsibility will be a consideration in the present hearings on Bay/Delta water standards now underway by the State Water Resources Control Board.

MATRIX KEY

The following matrix summarizes 11 concepts for replacing water and power supplies now generated by the existing Hetch Hetchy system on the Tuolumne River. Specific details for each of the concepts, or options, described and the amount of water that would need to be replaced will not be known until more detailed studies are made.

The present system can furnish 300,000 million gallons per day (336,000 acre-feet annually) to its service area as limited by conduit capacity. Past studies indicate the potential to produce up to 400 million gallons per day (448,000 acre-feet annually) if these conveyance restrictions are eliminated. Assuming either value for purposes of discussion, however, it appears that no single replacement option would suffice, and that some combination of options would be required to replace supplies.

Reoperation 1/ of Existing Tuolumne Facilities.

Replacement concepts and what is known about them from a brief review of existing data are presented on the matrix. The first three listed are not options in the sense that they can be compared one against the other so that one could be selected and another rejected. Rather they would be considered together as a logical first step to recoup as much water and power as possible from the facilities remaining after Hetch Hetchy Valley was restored. They represent a step that must be taken regardless of the overall replacement plan selected.

Although studies will be required to confirm the amount of supplies that could be generated by reoperating existing facilities on the Tuolumne River without Hetch Hetchy Reservoir, it is believed that the bulk of the replacement of the present water supply could be provided through options 1 through 3. These supplies would be available in many years, particularly if supplemental storage for Tuolumne water could be found (Option 4).

Options to Supplement Reoperation of Tuolumne System.

Water Replacement. The remaining options (4-11) represent actions that might be taken to supplement supplies derived from reoperation of the present Tuolumne system without Hetch Hetchy Reservoir if further replacement is needed. These options are not equal in terms of potential accomplishments, costs, impacts, or ease of implementation, and they must be compared one against the other to determine which one, or combination, should be selected as part of an overall replacement plan.

Power Replacement. Reoperation of the City of San Francisco's Tuolumne facilities will not recoup power losses caused by dewatering Hetch Hetchy although enough power would be produced under reoperation to meet the City's power uses. Some additional generation could occur at New Don Pedro because of increased inflow into the reservoir after Hetch Hetchy storage is removed. The remaining water replacement options will be net power users and, hence, will contribute nothing toward replacement of the power lost. No replacement power project is suggested in the matrix. It is suggested, however, that net losses could be replaced by purchase from existing power supplies. Long-term replacement cost, however, would have to be weighed against the amortized cost of initial capital replacement.

1/ The term "reoperation" refers to the manner in which existing facilities might be operated after Hetch Hetchy Reservoir is removed. Some physical modification of or addition to the existing facilities would be required.

Options	Potential Replacement Capability 1, 2			
	Water			Power
	San Francisco	Turlock and Modesto ID's	Tuolumne Instream Uses	
I. TUOLUMNE RIVER SYSTEM: Logical First Steps Toward Replacement 1. Reoperation of remaining San Francisco facilities on Main Tuolumne River. Assumes only reoperation of diversion capabilities at Mountain Tunnel.	- Partial replacement of present supply. Amount available would depend on how much would be provided for instream uses.	- Unknown until studies are made.	- Potential depletion depending on share allocated to other uses.	- Partial replacement assuming that power would be incidental to water operations.
2. Reoperation of remaining San Francisco facilities including the Lake Lloyd - Lake Eleanor - Holm P.P. with modified facilities to permit routing the water through Mountain tunnel.	- Increased partial replacement of present supply over 1 above. Amount available would depend on how much would be provided for power at Holm and instream uses.	- Unknown until studies are made.	- Potential depletion to above.	- Same as in 1 above. - Could result in reduction with reoperation of Cherry Lake - Lake Eleanor system.
3. Reoperation of New Don Pedro Reservoir and additional conveyance provided to Hetch Hetchy Aqueduct.	- Further increase over 1 and 2 above of partial replacement of present supply. - Amount available dependent on assumptions and redirection upstream for City.	- Unknown until studies are made.	- No change from 1 and 2 above.	- No change from 1 and 2 above. - Some possible additional power at New Don Pedro available from additional inflow to new Don Pedro.

¹ Measured from the condition as it would be without Hetch Hetchy Reservoir and no diversions to San Francisco.

² Options 1, 2, and 3 are measures that will be taken together.

TABLE 1

Matrix of Potential Replacement Concepts

Costs/Issues/Impacts				
New Facilities Required	Relative Cost	Institutional Issues	Water Quality Considerations	Environmental Considerations
- None - Assumes no modifications to existing facilities.	- None since no new or modified facilities	<ul style="list-style-type: none"> - Issues on instream uses in Tuolumne River, i.e., municipal fish hatchery, rafting, wild and scenic river. - Issues on New Don Pedro Reservoir and its water and power supplies 	- Water would be of the same quality as present supplies.	<ul style="list-style-type: none"> - Impacts on flows in Tuolumne River. - Impacts on rafting and wild and scenic river. - Downstream impacts to Tuolumne and San Joaquin River and the Delta.
- Facilities to permit Hoim P.P. discharges to be diverted through Mountain Tunnel.	- Low cost for these facilities yet to be determined from studies.	- Same as in 1 above plus issues related to Cherry and Eleanor Creeks.	- Water would be of the same quality as present supplies.	<ul style="list-style-type: none"> - Increase impacts to 1 above from increased diversion of Tuolumne River flows and impacts to Cherry and Eleanor Creeks. - Impacts of construction of new facilities.
- New pumping plant and conveyance facilities to Hetch Hetchy Aqueduct. Treatment ment may be required.	- Costs yet to be determined from studies.	<ul style="list-style-type: none"> - Same as in 1 and 2 above. - Issues on present agreements including water banking. 	- Water would be slightly lesser quality than upstream source.	<ul style="list-style-type: none"> - No change to 1 and 2 above from New Don Pedro reoperation. - Additional decreased flow in San Joaquin River and into the Delta from the Tuolumne River. - Impacts of construction of new facilities. - Impacts of increased fluctuations in New Don Pedro.

Options	Potential Replacement Capability 1			
	Water			Power
	San Francisco	Turlock and Modesto ID's	Tuolumne Instream Uses	
II. OPTIONS TO PROVIDE BALANCE OF REQUIRED REPLACEMENT A. Tuolumne River System 4. New Reservoir closer to San Francisco (enlarge the city's San Antonio and Crystal Springs Dam.)	- Unknown but probably only minor replacement supplies.	- Would reduce in-flow to New Don Reservoir.	- Partial replacement. Could reduce instream flow depending on share allocated to instream flows.	- Partial replacement.
5. New storage on Tuolumne River. (Wards Ferry and Harden Flat Dams).	- Partial replacement of present supply. Amount available unknown until studies are made.	- Unknown until studies are made.	- Wards Ferry would inundate part of designated wild and scenic river. - Harden Flat could provide some replacement.	- Partial replacement assuming power features would be included.

¹Measured from the condition after implementation of options 1, 2 and 3.

Table 1

Costs/Issues/Impacts				
New Facilities Required	Relative Cost	Institutional Issues	Water Quality Considerations	Environmental Considerations
<ul style="list-style-type: none"> - Enlargement of two dams. - Pumping facilities. 	<ul style="list-style-type: none"> - Enlargement of the dams, approximately \$8 million. 	<ul style="list-style-type: none"> - Possible seismic considerations related to the enlargements. - Additional issues on instream uses in Tuolumne River, i.e., municipal, fish hatchery, rafting, wild & scenic rivers. - Additional issues on New Don Pedro Reservoir and its water and power supplies. 	<ul style="list-style-type: none"> - Same high Tuolumne River quality as the present supply would be blended with local runoff. 	<ul style="list-style-type: none"> - Increased impacts to 1 above and less water available for instream use above and below New Don Pedro. - Unknown impacts associated with reservoir enlargements.
<ul style="list-style-type: none"> - New storage reservoirs - Wards Ferry and Harden Flat. New pumping and conveyance to Hetch Hetchy Aqueduct. Some treatment may be required. 	<ul style="list-style-type: none"> - High. - Conveyance facilities need to be identified and costs determined. 	<ul style="list-style-type: none"> - Wards Ferry would be in designated wild and scenic portion of river. - Issues on other instream uses similar to 1, 2, & 3 above. 	<ul style="list-style-type: none"> - Water at Wards Ferry would be slightly lesser quality upstream source. 	<ul style="list-style-type: none"> - Increased impacts to 1 above with reduced flows available to lower system (i.e., San Joaquin River and Delta and New Don Pedro. - Impacts of new reservoirs to: Recreation Wildlife Habitat Endangered Species Cultural Resources. - Wild and Scenic River System.

Options	Potential Replacement Capability 1			
	Water			Power
	San Francisco	Turlock and Modesto ID's	Tuolumne Instream Uses	
<p>B. <u>Sierra Nevada Supplies</u></p> <p>6. Eastside optimization conjunctive use concepts extended to Tuolumne River.</p>	<ul style="list-style-type: none"> - Might provide balance of replacement required for present supplies. Studies are required. - Might provide supplemental supplies to San Francisco. Studies are required. 	<ul style="list-style-type: none"> - Might provide some water directly to irrigation Districts and thereby reduce new Don Pedro's requirements. 	<ul style="list-style-type: none"> - Might provide fishery flows through exchange below New Don Pedro. 	<ul style="list-style-type: none"> - None. Alternative would consume power with pumping required for ground water and to export from the collection conveyance system into the San Francisco system.
<p>C. <u>Delta Supplies</u></p> <p>7. Los Vaqueros Reservoir.</p>	<ul style="list-style-type: none"> - Could provide balance of replacement required for present supplies. 	<ul style="list-style-type: none"> - None. 	<ul style="list-style-type: none"> - None. 	<ul style="list-style-type: none"> - None. System would be a major net power consumer. Pumping would be from the Delta into the reservoir and from the export canal into the San Francisco system.

¹ Measured from the condition after implementation of options 1, 2, and 3.

Table 1

Costs/Issues/Impacts				
New Facilities Required	Relative Cost	Institutional Issues	Water Quality Considerations	Environmental Considerations
<ul style="list-style-type: none"> - Extend new conveyance from Folsom South Canal and New Melones Reservoir to San Francisco system. - This would require pumping. Some treatment would be required. 	<ul style="list-style-type: none"> - Medium - Cost for conveyance and pumping facilities to be determined from studies - Treatment costs. 	<ul style="list-style-type: none"> - Water developed would have to be shared with users from the American to the Tuolumne which would limit supplies available to replace Hetch Hetchy water. - Agreement with various districts and entities from American River to Turlock and Modesto to make plan workable. - CVP authority required. - Water rights. - American River instream flow issues would have to be resolved. - Agreements with fishery entities on tributary streams from American to Tuolumne Rivers. 	<ul style="list-style-type: none"> - Fairly high quality but less than that of San Francisco's present Tuolumne River supply. 	<ul style="list-style-type: none"> - Impacts on instream flow uses in American River, Stanislaus River, Tuolumne River, and other tributary streams, i.e., Mokelumne and Calaveras Rivers. - Impacts of new facilities to: Recreation, Vegetation and Wildlife, Endangered Species, Cultural Resources.
<ul style="list-style-type: none"> - Los Vaqueros Dam, Reservoir, pumping and power facilities. - Cross Delta Conveyance. - Export capacity through enlarged Delta-Mendota Canal or wheeling agreement for use of State Aqueduct. - Connection from export canal to City's Coast Range Tunnel. - Full treatment would be required. 	<ul style="list-style-type: none"> - Very high. - Los Vaqueros facilities approximately \$825 million would be shared with partners in the project. - Cross Delta facility would be shared with DWR. - Enlarged Delta-Mendota Canal approximately \$25 million would be shared with other users. 	<ul style="list-style-type: none"> - Delta water quality standards. - Competition for Los Vaqueros water with other potential participants in the project. - Agreements with "partners" in Los Vaqueros, export conveyance and cross Delta projects. - Water rights for Los Vaqueros. - Authority (BOR) to participate in Los Vaqueros and other required actions. - Delta and related San Francisco Bay and export issues are extremely complex, involve a wide range of interests, and are not likely to be resolved soon. 	<ul style="list-style-type: none"> - Water quality is suitable for municipal uses after treatment and is so used by Contra Costa County and most of southern California. The quality would not be as high as the City's present Tuolumne River supplies. 	<ul style="list-style-type: none"> - Impacts of additional diversions in the Delta to: <ul style="list-style-type: none"> Fisheries Vegetation Wildlife Recreation Cultural Resources - Impacts of Cross Delta Conveyance. - Impacts of Los Vaqueros Reservoir to endangered species and riparian habitat.

Options	Potential Replacement Capability ¹			
	Water			Power
	San Francisco	Turlock and Modesto ID's	Tuolumne Instream Uses	
8. Enlarged Shasta.	<ul style="list-style-type: none"> - Could provide up to full replacement for present supplies. - Could provide supplemental supplies to San Francisco. 	- None.	- None.	- Unknown. Some partial replacement, theoretically, possible but not a likely source of replacement power.
9. Wildlife refuges in the San Joaquin Valley (used as offstream storage).	- Might provide balance of replacement required for present supplies.	- None.	- None.	- None. Alternative would consume power by pumping from the Delta to the export canal and from the canal into the San Francisco system.

¹ Measured from the condition after implementation of options 1, 2, and 3.

Table 1

Costs/Issues/Impacts				
New Facilities Required	Relative Cost	Institutional Issues	Water Quality Considerations	Environmental Considerations
<ul style="list-style-type: none"> - Enlarged Shasta Dam and related facilities. - Cross Delta Conveyance. - Export capacity through enlarged Delta-Mendota Canal or wheeling agreement to use State Aqueduct. - Connection from export canal to City's Coast Range Tunnel. - Full treatment would be required. 	<ul style="list-style-type: none"> - Extremely high. - Enlarged Shasta facilities would exceed \$3 billion which would be shared with partners. - Cross Delta facility would be shared with State. - Enlarged Delta-Mendota Canal approximately \$25 million would be shared with other users. - Full treatment costs. 	<ul style="list-style-type: none"> - Enlarged Shasta is an extremely large undertaking which involves many interests. The needs related to the replacement of Hetch Hetchy would be only a minor factor. - Delta issues related to Cross Delta conveyance and export conveyance. - Water rights for Enlarged Shasta. - Authority to participate in Enlarged Shasta Cross Delta projects. 	<ul style="list-style-type: none"> - Same as for 7 above. 	<ul style="list-style-type: none"> - Impacts of Enlarged Shasta to: <ul style="list-style-type: none"> Wildlife habitat inundated Endangered species Sacramento River Recreation New roads Cultural Resources - Impacts of additional diversions on the Delta to: <ul style="list-style-type: none"> Fisheries Vegetation Wildlife Recreation Cultural Resources - Impacts of Cross Delta Conveyance.
<ul style="list-style-type: none"> - Cross Delta Conveyance - Export capacity through enlarged Delta-Mendota Canal or wheeling agreement to use State Aqueduct. - Connection from export canal to City's Coast Range Tunnel. - Facilities on refuges to manage and recapture the stored water. - Full treatment would be required. 	<ul style="list-style-type: none"> - High. - Cross Delta facility would be shared with State. - Enlarged Delta Mendota Canal approximately \$25 million would be shared with other users. - Cost of facilities required to recapture the supplies stored on the refuges and to transmit them to the ultimate users. - Full treatment costs. 	<ul style="list-style-type: none"> - Delta issues related to Cross Delta conveyance and export conveyance. - Water rights for the storage of water on the refuges. - Authority (Reclamation) to participate in the storage program and the required actions. - Exchange Agreements with users of Central Valley Project water to accept the water from the refuges to free up the water for San Francisco. 	<ul style="list-style-type: none"> - Water delivered to San Francisco would be from the Delta with quality consideration the same as 7 above. - The quality of the water stored on the refuges is unknown but there is the potential for quality degradation by the process. 	<ul style="list-style-type: none"> - Impacts to: <ul style="list-style-type: none"> Shore bird habitat on refuges. Endangered species. - Impacts of additional diversions on the Delta to: <ul style="list-style-type: none"> Fisheries Vegetation Wildlife Recreation Cultural Resources - Impacts of Cross Delta Conveyance.

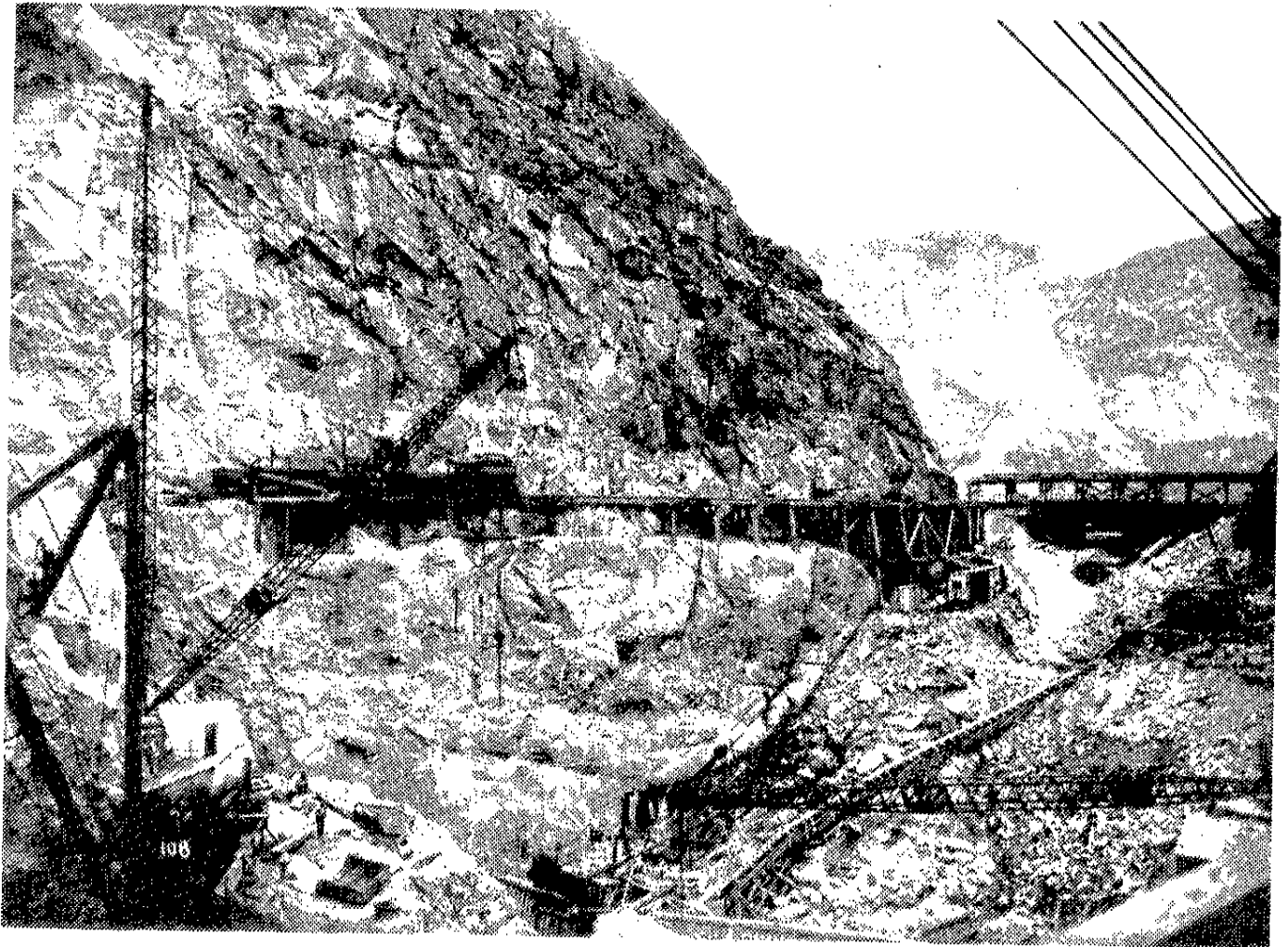
Options	Potential Replacement Capability ¹			
	Water			Power
	San Francisco	Turlock and Modesto ID's	Tuolumne Instream Uses	
10. Coordination of Lake Berryessa with the State's North Bay Aqueduct.	<ul style="list-style-type: none"> - Might provide balance of replacement required for present supplies. - Might provide supplemental supplies to San Francisco. 	- None.	- None.	- None. Pumping would be required to pump from the Delta and into the San Francisco system.
III. PURCHASE REPLACEMENT POWER	- N/A	- N/A	- N/A	- Fully compensate for lost net generation after implementation of water supply options through purchase of power on the market.

¹ Measured From the condition after implementation of options 1, 2 and 3.

Table 1

Costs/Issues/Impacts				
New Facilities Required	Relative Cost	Institutional Issues	Water Quality Considerations	Environmental Considerations
<ul style="list-style-type: none"> - Cross Delta Conveyance - Export capacity through enlarged Delta-Mendota Canal or wheeling agreement for use of State Aqueduct. - Connection from export canal to City's Coast Range Tunnel. - Full treatment would be required. 	<ul style="list-style-type: none"> - High. - Cross Delta facility would be shared with State. - Enlarged Delta-Mendota Canal approximately \$25 million would be shared with other users. - Facilities to develop and convey the new supplies to the Delta. 	<ul style="list-style-type: none"> - Delta water quality standards. - Agreements with the various districts and entities regarding sharing of new supplies and costs. - Central Valley Project authority required. - Water rights. 	<ul style="list-style-type: none"> - Same as for 7 above. 	<ul style="list-style-type: none"> - Additional diversions on the Delta: <ul style="list-style-type: none"> Fisheries Vegetation Wildlife Recreation Cultural Resources - Impacts of Cross Delta Conveyance - Impacts on Lake Berryessa

INTRODUCTION



Photographer Unknown

Construction of the O'Shaughnessy Dam and Hetch Hetchy Reservoir
In Yosemite National Park sometime between 1915-22.

INTRODUCTION

At the request of Secretary of the Interior Don Hodel, the National Park Service is evaluating the potential for removing O'Shaughnessy Dam and restoring Hetch Hetchy Valley to a natural environment as a unit of Yosemite National Park, California. In this effort, the Mid-Pacific Region of the Bureau of Reclamation (Reclamation) is acting in the capacity of an engineering and technical consultant to the National Park Service and has conducted a preliminary and cursory evaluation of the idea of restoration and the options available to replace water and power supplies for San Francisco.

The restoration of Hetch Hetchy Valley to its natural environment would be a stunning acknowledgment of technological man's ability not only to recognize the usefulness of restoration, but also to accomplish such a feat. Preliminary analyses suggest there are numerous options to replace the water. These include modifying operations of the Hetch Hetchy system after removal of O'Shaughnessy Dam, selectively using water from other sources, or combining these two. Depending on the water supply option, there may be power generation or power requirements. Net power requirements could be obtained by purchasing surplus supplies in or available to northern California or by constructing new powerplants.

The range of replacement concepts presented in this report is not inclusive. Any further, more detailed, studies would be undertaken in the spirit of public participation in the plan formulation and decisionmaking process. Based on public comment and information, options could be validated and expanded, deleted, or added.

PURPOSE AND SCOPE

This report presents a general overview of replacement possibilities for Hetch Hetchy's water and power supplies, and identifies elements and issues that would be included in a detailed plan formulation and feasibility study. Locations and the facilities required in the replacement options are shown in Figure 1. Potential adverse or beneficial impacts associated with implementing the options, issues involved, facilities required, as well as relative costs are summarized in the matrix, shown in Table 1. The data presented are preliminary and conceptual in nature and were derived from existing information, which was insufficient to outline detailed options, costs, or impacts.

In order to effectively and thoroughly analyze the concepts presented here, a feasibility study would be required. Such a study would look at the benefits, impacts, and costs of restoring Hetch Hetchy Valley as a natural environment and determine whether restoration would be feasible from an engineering, economic, financial, social, and environmental perspective.

At the present time, the Hetch Hetchy system is a major source of water supply to the City and County of San Francisco and surrounding area. Any study must recognize and balance the positive impacts to the park system of restoring Hetch Hetchy Valley with the water and power needs of San Francisco. In addition to impacts to the City's water and power supply, other impacts to be considered include: the power and water supplies of the Turlock and Modesto Irrigation Districts, which hold both riparian and appropriative water rights on the Tuolumne River downstream of

Hetch Hetchy; the fishery and recreation resources of the Tuolumne River; and a reach of the Tuolumne River that is included in the Federal Wild and Scenic Rivers system.

Reclamation is working with the National Park Service, Western Area Power Administration, Modesto and Turlock Irrigation Districts, the City and County of San Francisco, and various water and environmental interest groups to assure that realistic options are identified with respect to the needs and responsibilities of each agency. The objective is to identify and assess conceptual water and power replacement supply options or to determine their equivalent value to users of the Hetch Hetchy system.

AUTHORITIES

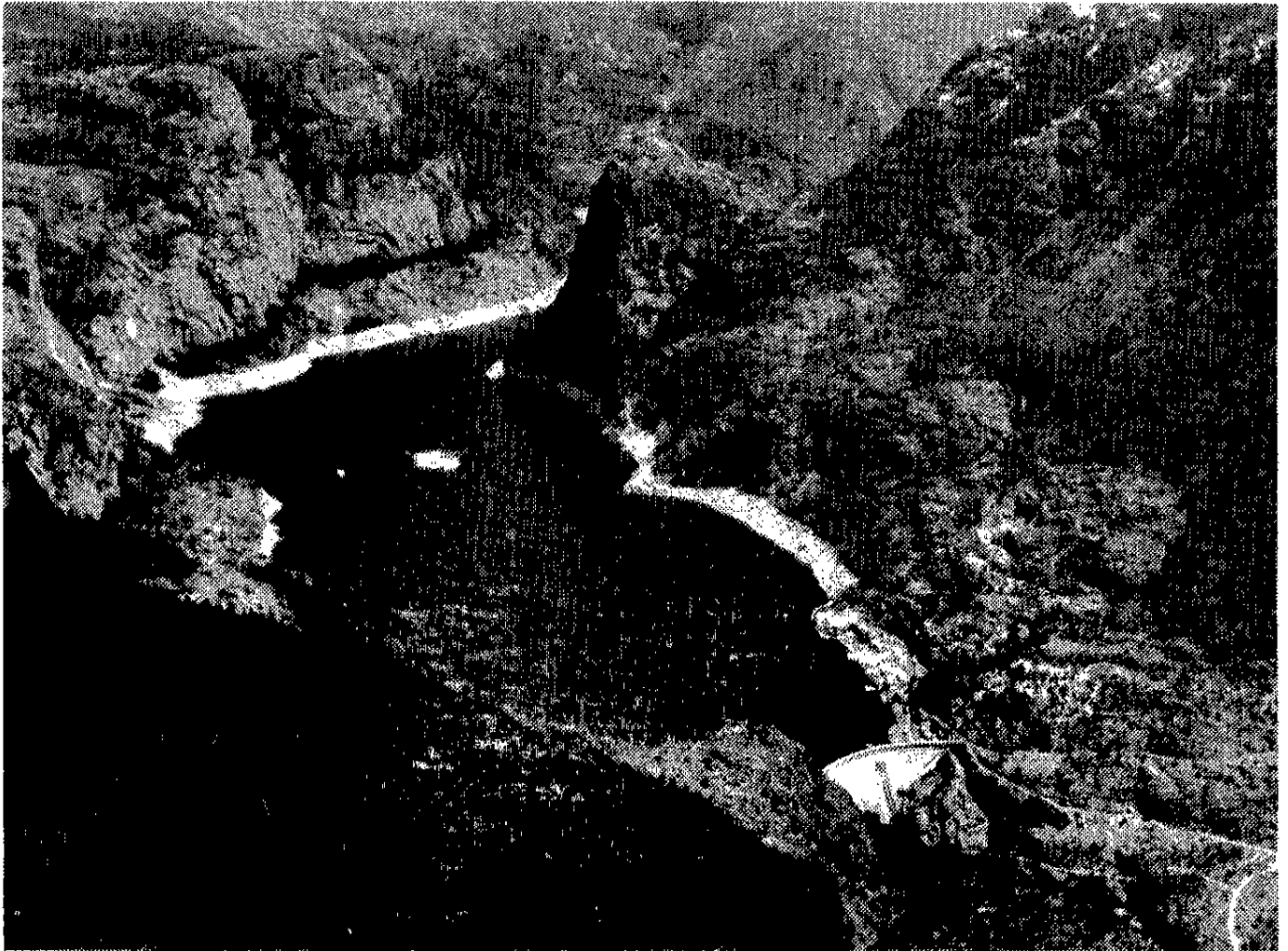
Justification for a program to study restoration of Hetch Hetchy Valley to its natural environment must be based on a comparison of the beneficial social, environmental and aesthetic values

generated by a restored valley against the costs and impacts associated with such a restoration. Authority for a program to study in detail the feasibility of restoring Hetch Hetchy Valley and replacing water and power supplies would likely require legislative authority.

ACKNOWLEDGMENTS

In preparing this report, Reclamation relied heavily on public information prepared by the City and County of San Francisco and on information provided directly by the City. Reclamation also acknowledges information contributed by the Turlock Irrigation District, Modesto Irrigation District, U.S. Fish and Wildlife Service, Western Area Power Administration and the California State Department of Water Resources.

THE HETCH HETCHY SYSTEM



Bureau of Reclamation Photo

Hetch Hetchy Dam and Reservoir (1979) on the Main Stem of the
Tuolumne River in Yosemite National Park.

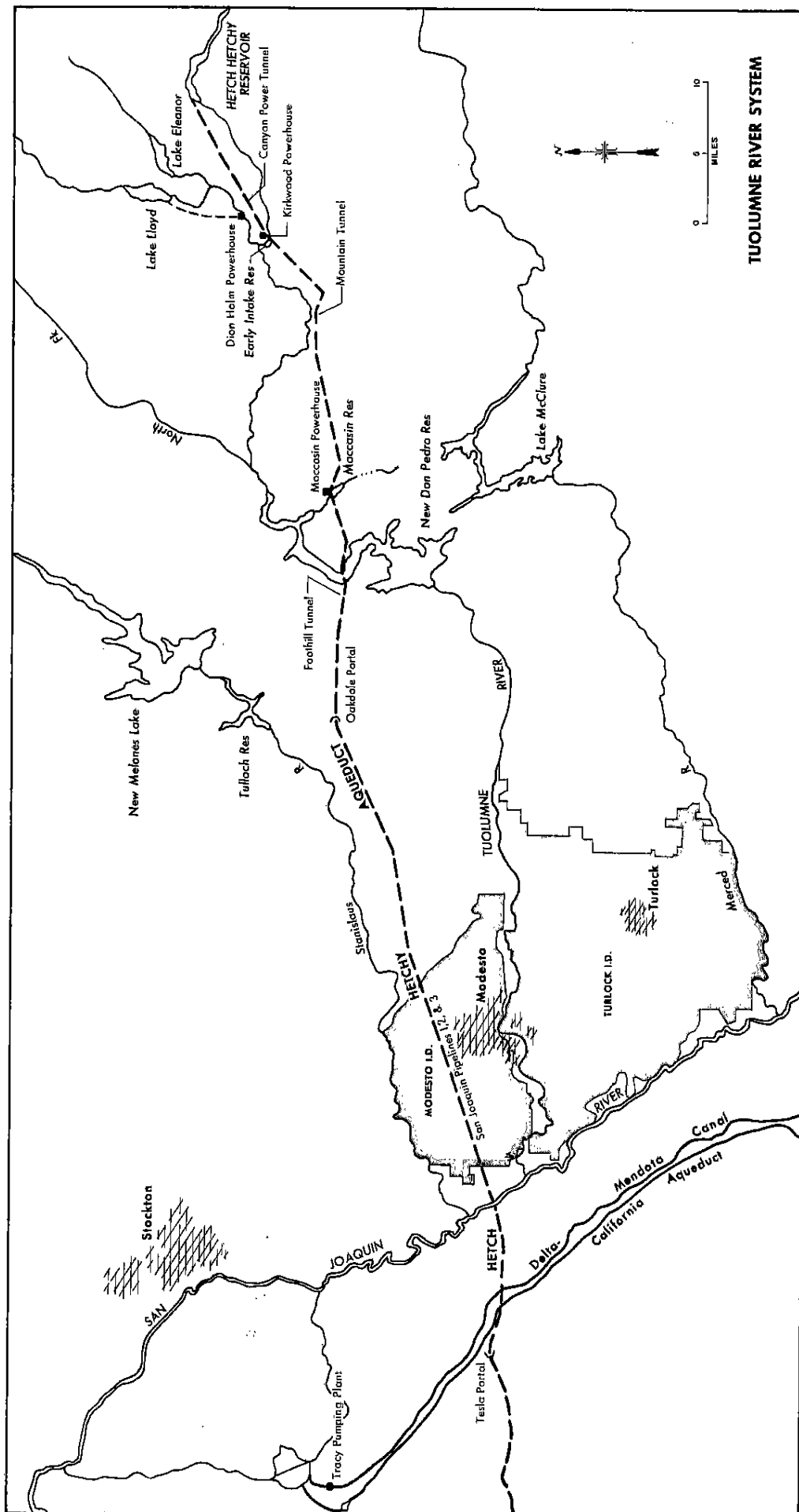


FIGURE 2

THE HETCH HETCHY SYSTEM

The City and County of San Francisco currently obtains 77 percent of its municipal and industrial water supplies from its Hetch Hetchy system, located in the Tuolumne River watershed in the Sierra Nevada. The Tuolumne River Basin and its present development are shown on Figure 2.

In addition to San Francisco, the Hetch Hetchy system, through the San Francisco Water Department, supplies water for major suburban areas in San Mateo, Santa Clara, and Alameda Counties for a total service to about 2 million people. About 2 billion kilowatt-hours (kWh)¹ of hydroelectric energy is also produced annually. The Raker Act established priority for use of Hetch Hetchy power. The first priority is for the municipal needs of San Francisco; the second is for municipal and pumping needs in the irrigation district areas; and the third is for public entities. Generation surplus to these priority uses is sold to industry.

Under present operational criteria, water supplies diverted by the City to its service area from the Hetch Hetchy system vary from year to year. For the 11- year period, July 1976 through June 1986, diversions averaged 214,000 acre- feet annually.² In fiscal year 1986, a total of 257,600 acre- feet was diverted. At present, delivery capability is limited by conveyance capacity in the pipelines crossing the San Joaquin Valley. Maximum capacity is 300 million gallons per day or about 336,000 acre-feet per year.

The existing Hetchy Hetchy system, with some modification to its conveyance facilities, could develop and supply up to 400 million gallons per day (448,000 acre-feet per year) from the Tuolumne River Basin. Previous studies prepared for the City of various means to expand the City's water supplies include Hetch Hetchy Reservoir as a key element in any plan.

BACKGROUND AND AGREEMENTS GOVERNING THE HETCH HETCHY SYSTEM

In 1903, the City of San Francisco was assigned water rights to appropriate water from the Tuolumne River at the mouth of the Hetch Hetchy Valley and at points along two of the Tuolumne's tributaries, Eleanor and Cherry Creeks. The seeds for this action were sown in 1776 when Mission San Francisco and Pueblo Presidio were established as Spanish outposts in the New World. Early water supplies for the City were derived from local streams, wells, and springs and after 1849, and the Gold Rush population explosion, by potable water brought in and sold by the barrel.

- 1 *Average residential electricity use in northern California is about 6,000 kWh per year. (California Energy Commission.)*
- 2 *Average household water use in northern California is about .675 acre-foot per year.*

In 1858, a private corporation, the Spring Valley Water Company, with a water charter obtained from the State of California, began deliveries from local springs, later augmenting this source with supplies imported from the Sunol and Alameda Creek watersheds. These supplies remain a part of the city's present water supply system.

By 1900, however, aware that its expanding population would soon outstrip even this supply, the City began to examine the merits of a municipal public works system to transport supplemental water supplies into the City from other watersheds.

Of the possible water sources evaluated, the Tuolumne River flowing from the western Sierra Nevada with the Hetch Hetchy Valley in Yosemite National Park as a storage reservoir, was deemed the superior choice because of high water quality, appropriate reservoir size and gravity conveyance, and hydroelectric power generation potential.

In 1913, enactment of the Raker Act outlined the provisions under which San Francisco could construct and operate a water supply system on the Tuolumne River. The Act granted the City the authority to construct a water supply and hydropower system in the Hetch Hetchy and Eleanor Valleys in Yosemite National Park, in Cherry Valley in the Stanislaus National Forest, and in the canyon of the Tuolumne River downstream of these valleys. The act also defined the City's obligations to the Turlock and Modesto Irrigation Districts, and limited the City's authority to export and distribute water.

Construction of the system began in 1914. Storage of water in Lake Eleanor began in 1918, and in 1934, the first water from Lake Hetch Hetchy impounded behind O'Shaughnessy Dam, was delivered to San Francisco. The dam was raised 85.5 feet in 1938, giving the reservoir its present capacity of 360,360 acre-feet.

In addition to provisions in its basic water rights and the Raker Act, San Francisco's Hetch Hetchy system is governed by other agreements. At various times, the City has entered into agree-

ments with the Department of the Interior on fishery releases and the maintenance of minimum flows at various points in the Tuolumne River Basin. Agreements with the Turlock and Modesto Irrigation Districts outline water rights and construction and operation of the City's Cherry Valley Dam and the New Don Pedro Dam, owned jointly by the City and the two irrigation districts. In 1984, 25-year, uniform contracts negotiated between San Francisco and 30 cities and other agencies established the method by which capital and operating costs of the Hetch Hetchy Water and Power Department and the San Francisco Water Department facilities were allocated between San Francisco and its wholesale purchasers.

Agreements between the districts, the City, and the Corps of Engineers pertain to the operation of New Don Pedro Dam and certain of the City's facilities for flood control. The California Wilderness Act, enacted by Congress in 1984, placed the Tuolumne River, from its headwaters to New Don Pedro Reservoir, in the National Wild and Scenic Rivers System. Although further development on the river is restricted, the act preserved all of San Francisco's rights under the Raker Act.

WATER RIGHTS

As discussed above, the City of San Francisco claims that the water rights for its Tuolumne River facilities are all derived from pre-1914 appropriations. As such, their rights are not subject to the jurisdiction of the State Water Resources Control Board. Under current State law, any changes in point of diversion that might be required without the Hetch Hetchy Reservoir would be permitted only if no other downstream water user is harmed.

In the preliminary analyses contained in this report, it was assumed that the City's claim of pre-1914 appropriative rights was factual and that any necessary changes in the points of diversion could be made without injury to other downstream users. Any further studies of replacement supplies from the Tuolumne River for the City of San Francisco would have to investigate and verify the validity of these assumptions.

FACILITIES AND OPERATIONS¹

The Hetch Hetchy system, shown on Figure 3, is comprised of three storage reservoirs (Hetch Hetchy, Lake Eleanor and Lake Lloyd), and various hydroelectric power facilities. New Don Pedro Reservoir, owned jointly with the Turlock and Modesto Irrigation Districts, but operated by the districts, is related to the City's system.

HETCH HETCHY, LAKE ELEANOR, AND LAKE LLOYD RESERVOIRS

Hetch Hetchy Reservoir is located on the mainstem of the Tuolumne River in Hetch Hetchy Valley and is formed by water impounded by O'Shaughnessy Dam, a 312-foot-high, gravity arch concrete dam. The reservoir, with its capacity of 360,360 acre-feet, is supplied primarily by snow-melt from a watershed of 459 square miles located entirely within Yosemite National Park.

Lake Eleanor Reservoir, located on Eleanor Creek about 3 miles above the confluence of Eleanor and Cherry Creeks, is impounded by a 60-foot concrete arch dam. The reservoir's 27,100 acre-foot capacity receives water from a 79 square-mile watershed. Lake Lloyd Reservoir, located on Cherry Creek, about 4 miles above its confluence with Eleanor Creek, receives water from a 114 square-mile watershed. The 268,800 acre-foot reservoir is formed by Cherry Valley Dam, a 315-foot-high earth and rockfill structure. Lake Eleanor and Lake Lloyd are linked by a

mile-long tunnel and can be operated as a single storage unit.

Of the three reservoirs, only Hetch Hetchy is normally operated to convey water supplies directly to the San Francisco Bay area. Except in dry years, Lake Eleanor and Lake Lloyd are operated primarily to supply water to Turlock and Modesto Irrigation Districts and facilitate San Francisco's use of Hetch Hetchy as a domestic supply. To the extent that water can be released from Lakes Eleanor and Lloyd for downstream demands, optimum use of water stored in Hetch Hetchy can be made for domestic supplies. All three reservoirs are operated to control floods, maintain instream flows in the Tuolumne river system, and generate hydroelectric power.

During droughts, such as occurred in 1976-77, and other emergencies, the City diverts water from Cherry Valley Dam through a Lower Cherry aqueduct capable of delivering about 100 million gallons per day to Early Intake Reservoir on the mainstem of the Tuolumne River.

NEW DON PEDRO RESERVOIR

New Don Pedro Reservoir was designed to operate as an integral part of the Hetch Hetchy system. In a sense, the City "shares" the Tuolumne River with the Turlock and Modesto Irrigation Districts. The districts' main facilities are New Don Pedro Dam, Reservoir and Powerplant. The City, by agreement with the two districts owns space in New Don Pedro Reservoir, which it uses to enhance operation of its upstream facilities by meeting, in part, its obligation to the Turlock and Modesto Irrigation Districts.

1 *The information on operations and facilities was derived from Report of the City and County of San Francisco to the State Water Resources Control Board, Phase One, Bay Delta Water Quality Hearings. July 16, 1987.*

HETCH HETCHY PROJECT FACILITIES

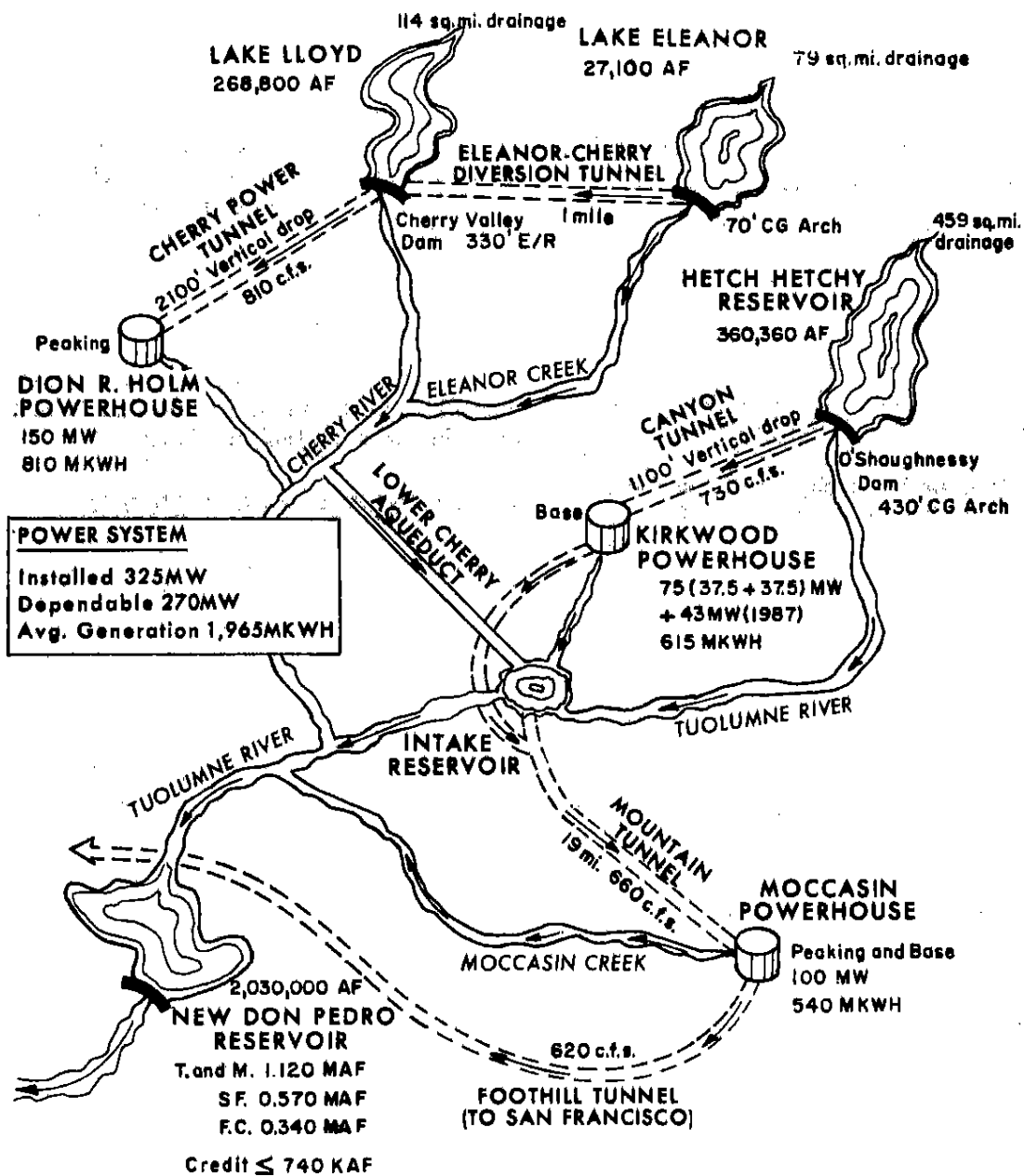


FIGURE 3

The reservoir has a total capacity of 2,030,000 acre-feet with storage allocated as shown in the following tabulation.

	Acre-feet
Turlock and Modesto Irrigation Districts	1,120,000
Flood Control	340,000
City of San Francisco (Water Bank) ¹	570,000
	2,030,000

An agreement specifies that the maximum amount of water that may be credited to San Francisco in the water bank at any one time is 570,000 acre-feet plus one-half of the flood control space (170,000 acre-feet), a total of 740,000 acre-feet.

HYDROPOWER GENERATION

Hydropower is generated at the three powerplants, as shown on Figure 3. Capacities and generation are shown on Table 2.

Holm Powerplant, located on Cherry Creek about 2 miles upstream from its confluence with the Tuolumne River, generates hydropower from water released from Lakes Eleanor and Lloyd at Cherry Valley Dam. Water flows through the 810 cubic foot per second (cfs) Cherry Power Tunnel and drops 2,100 feet through a steel penstock into two 75-MW turbine generators for release into Cherry Creek and the Tuolumne River.

Kirkwood Powerhouse, located at Early Intake on the Tuolumne River, generates power from water released from Hetch Hetchy Reservoir. Water diverted from O'Shaughnessy Dam flows

11 miles through the 730-cfs Canyon Tunnel to Kirkwood Powerhouse, where it drops 1,100 feet into two 37.5-MW turbine generators.

Most of the water released from Kirkwood is conveyed 19 miles via the 660-cfs Mountain Tunnel to Priest Regulating Reservoir on Rattlesnake Creek near the town of Big Oak Flat. The 1,055 acre-foot reservoir, impounded by an earth and rockfill dam, releases water to drop 1,316 feet into two 50-MW turbine generators in Moccasin Powerhouse, located at the foot of Old Priest Grade on State Highway 120 and the last hydroelectric plant in the Hetch Hetchy system. Of the three powerplants, Holm is operated for peaking power, Kirkwood for baseload, and Moccasin for peaking and baseload.

CONVEYANCE

At Moccasin Powerhouse water not needed for the City's domestic use is released into Moccasin Creek, where it flows into New Don Pedro Reservoir. Water supplies for the San Francisco Bay area are diverted into the 620-cfs capacity 16-mile-long Foothill Tunnel for conveyance to the three San Joaquin Valley Pipelines, which carry the water 47 miles to Tesla Portal. With their combined capacity of 465 cfs or 300 million gallons per day, the pipelines represent the existing maximum delivery capacity of the Hetch Hetchy system.

From Tesla Portal, the water is conveyed 29 miles beneath the coastal mountains via the 620-cfs Coast Range Tunnel to Alameda East Portal, located in Fremont. The Alameda East Portal marks the end of the Hetch Hetchy system and the beginning of the San Francisco Water Department's jurisdiction over Hetch Hetchy water.

- ¹ The term "water banking" refers to an agreement between the City and County of San Francisco and the Turlock and Modesto Irrigation Districts, (May 1966) under which the City can release water from its three upstream reservoirs for storage in New Don Pedro during years of high runoff. This water satisfies the districts' senior water rights and increases the storage available in the upstream reservoirs for the City's own uses.

Powerplant	Installed Capacity (MW)	Average Annual Generation (1 million kWh)
Holm	150	810
Kirkwood	75 <u>a/</u>	615
Moccasin	100	540
Total	325 <u>b/</u>	1,965

TABLE 2
Hetch Hetchy Powerplants

a/ Two 37.5 megawatt (MW) turbine generators. A third 43-MW unit is scheduled to go online in late 1987.

b/ Dependable capacity is 270 MW

Entity	Acre-feet Per Year
Alameda County Water District	14,450
Bear Gulch Dist., CA Water Service	11,302
Belmont County Water District	4,462
Brisbane	321
Burlingame	3,722
City and County of San Francisco	104,160
Other San Francisco Suburban Cust.	10,976
Coastside County Water District	1,360
Cordilleros Municipal Water Assn.	7
Daly City	5,081
East Palo Alto Waterworks Dist.	2,285
Estero Municipal Improve. Dist.	6,325
Guadalupe Valley Municipal Improvement District	326
Hayward	18,614
Hillsborough	4,629
Los Trancos County Water Dist.	78
Menlo Park	4,677
Millbrae	3,235
Millipitas	9,505
Mountain View	12,279
North Coast County Water District	3,317
Palo Alto (City)	18,034
Palomar Park Waterworks District	91
Purissima Hills Water District	1,612
Redwood City	11,699
San Carlos District - CA Water Service	5,211
San Mateo District - CA Water Service	14,546
Santa Clara	4,390
Santa Cruz	3,382
Skyline County Water District	136
South San Francisco - CA Water Service	7,375
Stanford	3,016
Sunnyvale	14,427
Westborough County Water Dist.	1,341
Total	306,371

TABLE 3
Deliveries by the City and County of San Francisco To Neighboring Communities in Fiscal Year 1985-86.

Source: Information supplied by San Francisco Bay Area Water Users Association. Totals for City/County of San Francisco supplied by the San Francisco Water Dept.

SALE AND DISTRIBUTION

The San Francisco Water Department sells water to suburban wholesale customers in San Mateo, Santa Clara, and Alameda Counties. The 1987 price to these customers was \$139 per acre-foot. The service involves 17 communities from San Jose to San Francisco on the west side of the Bay and as far north as Hayward on the east. The entities served and the annual supplies provided in fiscal year 1986-86 are shown on Table 3.

The relative use of local water supplies and Hetch Hetchy system water in the City's service area varies from year to year. Total supplies derived from each source for each of the past 11 years over this period are shown on Table 4. Local sources met on the average 23 percent of usage, while 77 percent came from Hetch Hetchy.

REVENUES

As of June 30, 1987, San Francisco's total fixed investment in plant, property, and equipment in the Hetch Hetchy system was approximately

\$414.5 million. Because the City uses an enterprise-based budgeting approach (i.e., depreciation of fixed capital plant assets), the net book value of the Hetch Hetchy system as of the above date was about \$272.8 million. The remaining balance to be repaid on Hetch Hetchy facilities totaled \$3.4 million.

During the fiscal year which ended on June 30, 1987, the Hetch Hetchy system generated water revenues of approximately \$7.8 million and \$89.6 million in power sales. Corresponding operation and maintenance expenses totaled \$70.5 million. Consequently, the Hetch Hetchy system was responsible for generating \$26.9 million in net operation-related revenues. During the 6-year period between fiscal years 1982-1987, average water and power revenues totaled \$87.7 million; average operational expenses totaled \$49.1 million; and average net revenues generated totaled \$38.7 million. Revenue and expenses for this 6-year period are shown in Table 5.

TABLE 4
Amount of Water Supplied by
San Francisco Water Department a/

Fiscal Year	Amount of Water Supplied						Percent of Supply	
	Bay Area Sources		Hetch Hetchy		Total		Bay Area Sources	Hetch Hetchy
	MGD	Acre-feet	MGD	Acre-feet	MGD	Acre-feet		
1975-76	80	89,000	190	213,000	270	302,000	30	70
1976-77	(15)	(16,000) ^{b/}	245	276,000	230	258,000	(7)	107
1977-78	55	62,000	145	162,000	200	224,000	28	73
1978-79	25	28,000	205	230,000	230	258,000	11	89
1979-80	55	61,000	190	213,000	245	276,000	22	78
1980-81	80	90,000	170	190,000	250	280,000	32	68
1981-82	45	51,000	195	218,000	240	269,000	19	81
1982-83	100	112,000	140	157,000	240	269,000	42	58
1983-84	85	95,000	180	202,000	265	297,000	32	68
1984-85	65	73,000	210	235,000	275	308,000	24	76
1985-86	45	50,000	230	258,000	275	308,000	16	84
Average	56	63,182	191	213,818	247	277,000	23	77

a/ From San Francisco Water. July 16, 1987. Report of City and County of San Francisco to the State Water Resources Control Board.

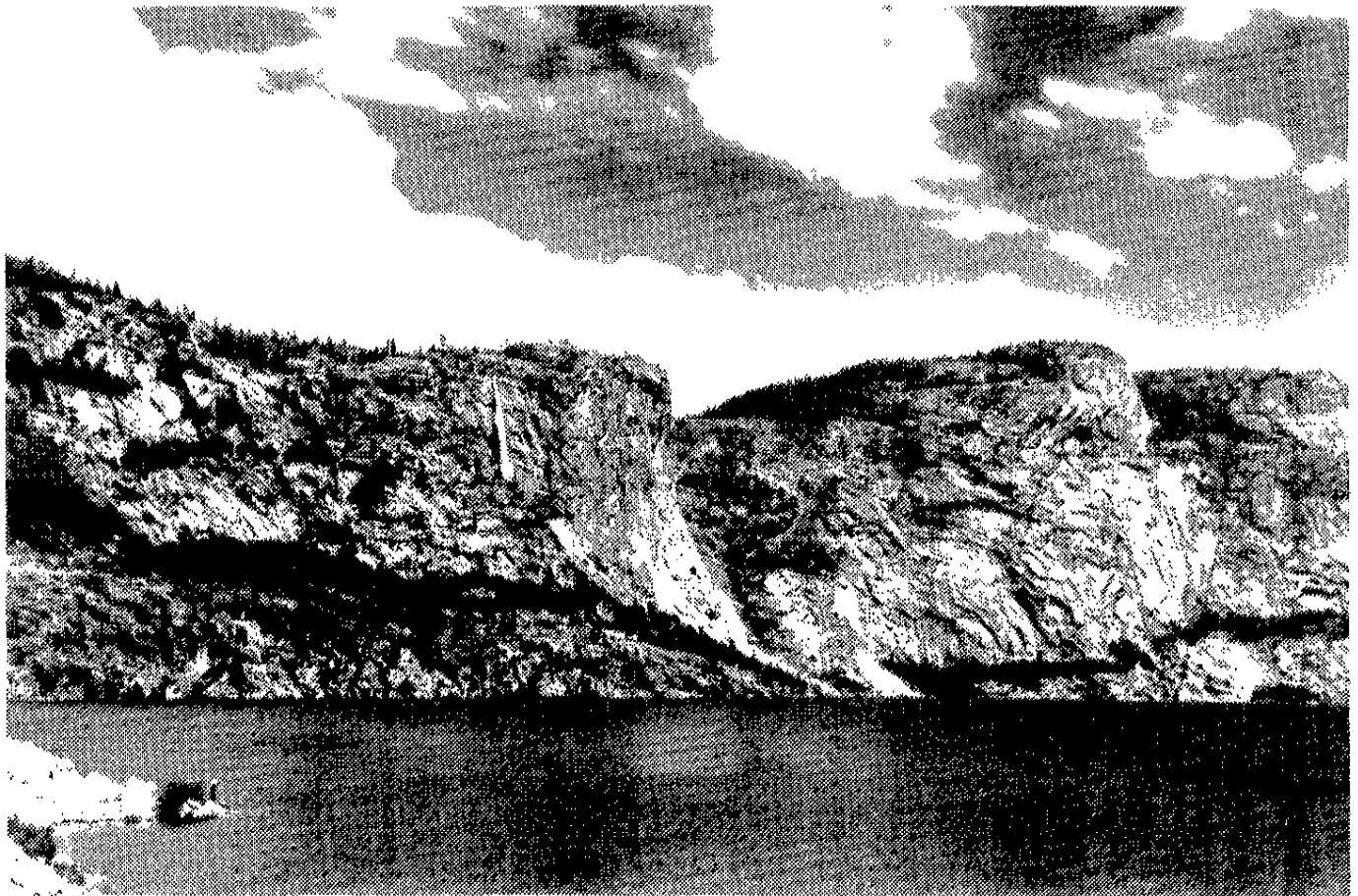
b/ All water losses from Bay area reservoirs (evaporation and seepage) have been deducted.

Note: Water supplies figures rounded to nearest 5 mgd or 1,000 acre-feet. Changes in Bay area reservoir storage neglected. Between 7/1/75 and 6/31/86, storage change was 1,300 acre-feet.

TABLE 5
Revenues and Operating Expenses
Fiscal Years 1982-1987

Operating Revenues	FY 1987	FY 1986	FY 1985	FY 1984	FY 1983	FY 1982
Water	7.8	7.6	7.1	6.8	4.6	6.5
Power	89.6	118.6	60.2	70.3	76.2	71.1
Subtotal	97.4	126.2	67.3	77.1	80.8	77.6
Oper. & Maint. Expenses	70.5	75.9	50.5	33.3	24.8	39.3
Net Revenues	\$26.9	\$50.3	\$16.8	\$43.8	\$56.0	\$38.3

WATER & POWER REPLACEMENT CONCEPTS



National Park Service Photo

Looking north at Hetch Hetchy Reservoir in Yosemite National Park.
Tueeulala Falls to the west (left) and Wapama Falls to the east (right).

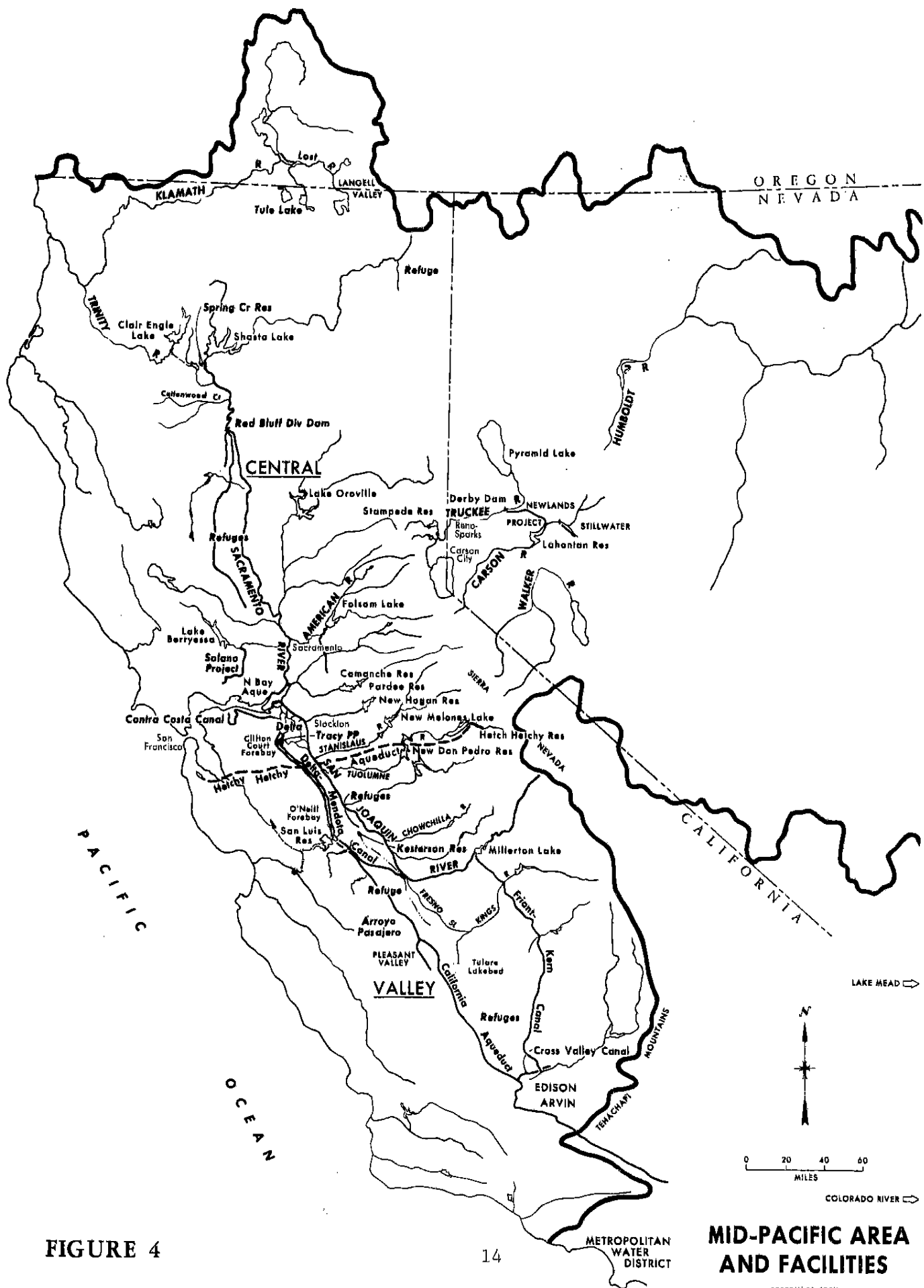


FIGURE 4

MID-PACIFIC AREA AND FACILITIES

SEPTEMBER 1987

WATER AND POWER REPLACEMENT CONCEPTS

The City and County of San Francisco's Tuolumne River water and power system is one of numerous water development and conveyance projects that have evolved over many years in and adjacent to the Central Valley of California.

Positive impacts of no longer using Hetch Hetchy Reservoir for a water supply would evolve around the long-term environmental and public trust benefits associated with restoration of the site to its natural condition as a unit of Yosemite National Park. Such restoration would renew the national commitment to maintaining the integrity of the national park system and keep in perpetual conservation an irreplaceable and unique natural area.

Terrestrial and aquatic benefits would accrue to recreation, aesthetics, and the overall area ecology. To the extent that water that would otherwise be diverted remains in the river system through the San Joaquin River to the Delta and San Francisco Bay, removal of O'Shaughnessy Dam could have potential for positive impacts to the San Joaquin River and estuarine ecosystems.

The obvious negative impact of restoring the valley could be the potential loss of a portion of water supplies to the City of San Francisco and nearby cities. Significant power losses would be experienced, and various uses and interests in or adjacent to the Tuolumne River Basin would be affected. There would also be hydrologic and operational conditions on the Tuolumne River not previously contemplated when New Don Pedro Reservoir was designed and when the various agreements, permits, and legal conditions regulating operations on the Tuolumne River were estab-

lished. The impacts of removal of the dam on this legal and operational framework would need to be identified and adverse impacts mitigated.

Restoring Hetch Hetchy Valley to its natural condition would require replacement of a water supply that over the past 11 years has averaged about 214,000 acre-feet per year from the Tuolumne River.

The entities whose water supplies could be adversely impacted by removal of the reservoir could receive replacement water from three basic sources: (1) Operational changes and/or new development in or related to the Tuolumne River Basin; (2) Optimization-Coordination-Conjunctive uses of surface and ground-water supplies; and (3) New supplies from the Sacramento-San Joaquin Delta conveyed by wheeling through the State Aqueduct or by enlarging the Delta-Mendota Canal to the Hetch Hetchy Aqueduct, which crosses both of these conduits. Existing water development facilities are shown on Figure 4.

The following observations would be pertinent in compensating for specific impacts:

- Conceptually, the replacement of water to San Francisco and its service area could be derived from all three of the basic sources. As a practical matter, however, the Tuolumne River should be used to provide as much water as possible before consideration is given to any other source.
- Turlock and Modesto Irrigation Districts' water supplies should be replaced to the extent possible from Tuolumne River sources with possible supplements from

optimization-coordination-conjunctive use programs.

- Instream uses of water in the Tuolumne River Basin must be maintained to the extent possible from Tuolumne River sources.
- Almost any method of developing new supplies in northern California or "freeing-up" existing supplies could provide replacement supplies for Hetch Hetchy in the Delta. Maintenance of the City's high water quality would present the greatest challenge.
- The outcome of the present State Water Resources Control Board's Bay/Delta hearings could influence the water quality issue. The City's future role or responsibility in maintaining Bay/Delta standards is unknown at this time, but are likely to become a factor in the future.

REPLACEMENT WATER SUPPLIES

Recent studies have been made by the City^{1 2} of means to increase its water and power supplies from the Tuolumne River. All of these studies included Hetch Hetchy Reservoir and the alternatives considered are therefore not directly applicable to this examination of replacement options.

Many of the basic developmental concepts could be considered in replacement scenarios, however, and are described as replacement options in this report. These include creating new storage on the Tuolumne River outside of the National Park; using the Delta as a source of supply, delivering water from various sources, including the

Tuolumne, to the City's system at the Coast Range Tunnel, and constructing new storage reservoirs near the service area.

THE TUOLUMNE RIVER SYSTEM: Logical First Step Toward Replacement

From the perspectives of water quality, proximity to the City's gravity conveyance system, complexity, and cost, the option of using the Tuolumne River to the maximum extent possible appears to be the preferred method. From what is known now, most, if not all of the City's present supplies could be replaced from this source; and these possibilities should be pursued to the extent that they are practical.

Operation of Remaining Facilities on Main Tuolumne River³

Without Hetch Hetchy Reservoir, water could be directly diverted from the Tuolumne River at either the O'Shaughnessy damsite or the Early Intake structure (the headworks of the City's Hetch Hetchy water conveyance system) and conveyed via the Mountain Tunnel.

If substantial winter flows occurred and were diverted, they could be stored in the City's terminal storage reservoirs in the Bay area, if capacity were available. This would be a deviation from present operations, however, in which most of Hetch Hetchy water is delivered directly from the pipeline since the system allows the majority of the supply to be provided without significant pumping costs.

Direct river diversions are limited by conveyance capacity of the San Joaquin Pipeline portion of the Aqueduct, fishery flows, recreational use of the

1 Kennedy/Jenks Engineers. January 1986.

2 Sverdrup & Parcel. June 1981. Hetch Hetchy Water and Power Systemwide Power Study. Completed in association with Bookman-Edmonston Engineers, Inc. and Jordan/Avent and Associates and Woodward-Clyde consultants.

3 Assumes operating only the diversion capabilities at Mountain Tunnel.

river, and the status of the river as part of the National Wild and Scenic Rivers system.

At the present time, the City maintains fishery flows in the Upper Tuolumne River in accordance with agreements with the U.S. Department of the Interior, California Department of Fish and Game, Sierra Club, and others. Minimum flows range from 50 to 100 cfs during the winter and spring and from 100 to 125 cfs during the summer, except in drought years.

Natural flows could not maintain this flow level in all years in summer months. In many years, natural flows in the Tuolumne subside to 50 cfs or less in August and September. The largest portion of the runoff occurs from April through July. Reaches of the river below the confluence of the South and Middle Forks and the 18 miles of river between this point and Wards Ferry in the upper reaches of New Don Pedro Reservoir are extensively used for rafting.

Operation of Remaining Facilities (Including Lakes Lloyd and Eleanor) with Modified Facilities

Under this concept, the Cherry River system (Lakes Eleanor and Lloyd) would be operated for both water and power purposes. With a total gross storage capacity of 296,000 acre-feet, approximately 250,000 acre-feet of usable reservoir storage space would be available at the two reservoirs. At the present time the reservoirs are operated primarily to produce peaking power through the Holm Powerplant. They also maintain instream uses downstream from Holm and help meet the City's obligations for inflow to New Don Pedro Reservoir.

Some structural changes would be required since the Holm Powerplant is at a lower elevation than the intake to the Mountain Tunnel (Early Intake), which eventually feeds the water supply conduit to the City's water service area.

Water from the Cherry River system could be diverted to Early Intake through the existing 150-cfs capacity Lower Cherry Creek Aqueduct, located at an elevation high enough to discharge into the intake. This Aqueduct bypasses the Holm Powerplant and now is used only in emergencies

and critically dry years. Holm Powerplant discharges to Cherry Creek at an elevation that requires pumping of water if it were to be diverted into the Early Intake diversion facility. Other possible modifications could be done either to relocate the Holm Powerplant to a higher elevation or to pump into Early Intake regulating reservoir through a short conveyance facility.

Reoperating New Don Pedro Reservoir

Restoring Hetch Hetchy Valley would increase uncontrolled inflow into New Don Pedro Reservoir, which would have to be reoperated to the extent possible, first to keep the districts' water supply intact and maintain flood control, and second to develop replacement supplies for San Francisco.

A replacement supply for the City from New Don Pedro could be either pumped and conveyed directly to the Hetch Hetchy Aqueduct or released downstream to the Delta, where it could be delivered to the City's Hetch Hetchy Aqueduct via either the State's California Aqueduct or an enlarged Delta-Mendota Canal.

Reoperating New Don Pedro Reservoir must provide the water needed for the Turlock and Modesto Irrigation Districts. It is unlikely the districts would suffer from a water shortage in normal or wet years. In drought years, however, from what is presently known, water supplies to the districts, as well as the supply available to the City without reoperation of New Don Pedro Reservoir could be less than that available under present operations with Hetch Hetchy Reservoir.

OPTIONS WHICH COULD PROVIDE BALANCE OF REPLACEMENT SUPPLIES

Options to provide the balance of the required replacement include creating additional storage on the Tuolumne River, developing supplies from conjunctive use of Sierra Nevada streams, or using existing or newly developed supplies in the Delta.

Tuolumne River

Constructing New Reservoirs Nearer to San Francisco. Raising the height of the City's existing dams impounding Crystal Springs and San An-

tonio Reservoirs could create additional replacement supplies. Additional winter flows from the Tuolumne River could be conveyed through the Hetch Hetchy Aqueduct system to these local storage reservoirs for subsequent release to the City's service area. In dry years, there may not be sufficient supply to fill the enlarged reservoirs, and the degree to which enlargement could provide a firm water supply must be determined. Construction costs for enlargement of both reservoirs are estimated at \$8 million total.¹

New Storage Dams on the Tuolumne River Outside Yosemite National Park Boundary. Investigations have been conducted on several reservoir storage sites on the Upper Tuolumne River between New Don Pedro Reservoir and Yosemite National Park. Two proposals include Wards Ferry Dam and Reservoir, with a potential capacity of about 160,000 acre-feet, on the mainstem Tuolumne River, and the Harden Flat Dam and Reservoir, with a potential capacity of 42,000 acre-feet on the South Fork Tuolumne River. These proposals were for projects that would have power generation as the primary purpose.

These new storage sites could develop a portion of the firm replacement water supplies that could be pumped from the storage facilities to the Hetch Hetchy conveyance system. Previous studies estimate that yields would range from 10,000 to 20,000 acre-feet. (These must be re-evaluated in terms of water supply, pumping cost, and environmental impacts for conditions without Hetch Hetchy Reservoir.) Power capabilities are 100 MW and 1150 million kWh per year at Wards Ferry and 22 MW and 91 million kWh per year at Harden Flat.

Sierra Nevada Supplies

Conjunctive Use of Stanislaus, Lower American, and Tuolumne River Systems. Reclamation's preliminary evaluation of optimization-coordination-conjunctive use options

for surface and ground water between the American and Stanislaus River Basins could be extended to include New Don Pedro Reservoir and the Tuolumne River system. The "new" water gained could be used, at least in part, to replace the reduction in Hetch Hetchy water supply.

Under this approach, additional usable water supplies would become available through "efficiencies" resulting from the common operation of water development and management systems that currently are operated independent of each other. The conjunctive use of surface and ground-water resources is included in the concept, which would further add to the usable supplies.

Work to date on conjunctive use of the Stanislaus and American River Basins indicates a potential for obtaining from 150,000 to 225,000 acre-feet of additional water. Reclamation undertook this evaluation as part of its study of Folsom-South area water needs and flow requirements in the Lower American and Stanislaus Rivers for recreational and fish and wildlife purposes. The evaluations included the modeling of alternative options for reoperating Folsom, Pardee, Comanche, New Hogan, and New Melones Reservoirs with ground-water basins to meet the area's needs.

Any replacement water from this option should be of excellent quality. Costs would be incurred for regulation and conveyance, and there would be complex policy, legislative, and legal issues to resolve. Detailed studies would be required to determine exactly how much replacement water could be derived.

Supplies from the Delta

Water made available at the Delta from existing or newly developed supplies has the potential to replace the reduction in Hetch Hetchy supply with quality adequate for municipal uses. A new supply would be costly, however, as any project would be a large and complex endeavor encompassing

1 Kennedy/Jenks Engineers. January 1986.

all of the issues related to the Delta and export conveyance.

Representative concepts for a Delta supply to replace the reduction from Hetch Hetchy include an offstream storage reservoir at the Los Vaqueros site in Contra Costa County, enlarging Shasta, developing offstream storage on wildlife refuges, and coordinating operations of Lake Berryessa with the State of California's North Bay Aqueduct.

Los Vaqueros Reservoir. Los Vaqueros Reservoir, a proposed offstream storage reservoir to be located on Kellogg Creek just south of the Delta, could be integrated into a system supplying water to San Francisco via the California Aqueduct or Delta-Mendota Canal. The reservoir's intake would be located at either the State's Clifton Court Forebay or the Federal Tracy Pumping Plant on the Delta-Mendota Canal, and releases could be made directly into either the Aqueduct or Canal for pumping into the Hetch Hetchy Aqueduct.

Studies by Reclamation and the Department of Water Resources indicate a potential reservoir capacity of up to 1,065,000 acre-feet, with a firm yield up to 265,000 acre-feet annually at a cost of about \$825 million. Smaller facilities could also be constructed. Operation of Los Vaqueros Reservoir would result in a net use of power. It is expected that the project would be a joint program with Contra Costa Water District and others.

Enlarged Shasta. Enlarging Shasta Dam and Reservoir, located on the upper Sacramento River, could meet the full replacement water needs for the City of San Francisco, and partially compensate for the loss in power generation incurred by restoring Hetch Hetchy Valley. Results of a joint Reclamation- Department of Water Resources study indicated that an increase in height of 200 feet would increase water yield 1.4 million acre-feet and power by 230 million kilowatt-hours, at a cost of about \$3 billion.

Wildlife Refuge Offstream Storage. Replacement supplies could also come from development of offstream storage on several managed wet-

lands, including National Wildlife Refuges in the San Joaquin Valley. Reclamation's Refuge Water Supply Study of water needs and alternative delivery requirements for 15 National Wildlife Refuges, State Wildlife Management Areas, and private wetlands within the Grasslands Resource Conservation District has identified that new yield for the San Joaquin Valley could be created on these refuges either by providing ground-water recharge or by recapturing and recycling the refuge water in the spring.

The supply thus developed could be exchanged for an equivalent project supply conveyed through either the California Aqueduct or Delta-Mendota Canal and pumped into the Hetch Hetchy Aqueduct. The quantities of additional yield that could be developed by refuges are not yet available.

Lake Berryessa/North Bay Aqueduct Coordination Operations. Integration of Reclamation's Lake Berryessa-Putah South Canal Solano system with the State of California's North Bay Aqueduct could result in 100,000 to 150,000 acre-feet of water supply. Under this coordinated operation, portions of southern Solano County--Vacaville, Benica, Fairfield, Vallejo--could be served from the North Bay Aqueduct during most years so that Lake Berryessa water could be used in dry and critical years. Some of the new water supply would have to be shared with other interests, and not all of the supply would be available as a replacement supply to San Francisco.

IMPLEMENTING A REPLACEMENT SUPPLY

Any studies of means to replace a reduction of Hetch Hetchy water must include consideration of, and a positive proposal for, effecting the changeover from Hetch Hetchy Reservoir to the replacement supply source(s). Continuity and reliability of service would be vital components of implementing any replacement supply. Staged implementation should be explored to shorten the time required for changeover, to spread the cost of construction over a longer period, and allow for phasing in of new facilities.

TABLE 6

Inventory of Power Supplies Available
to Northern California Power Users

Source	Means of Replacement	Discussion
<u>Within Northern California area:</u>		
Pacific Gas & Electric Co. (PG&E) (existing supplies)	<ul style="list-style-type: none">• United States purchase of power through a long-term contract.• City purchase of power.	Could occur if United States paid damages to the City and did not find a replacement supply.
Sacramento Municipal Utility District <u>a/</u>	<ul style="list-style-type: none">• United States purchase of replacement power via a long-term contract	
<u>Outside northern California area (imports):</u>		
Pacific Northwest (contingent on transmission access to the Northwest)	<p>Transmission access options:</p> <ul style="list-style-type: none">• PG&E's existing Northwest/Southwest Intertie• Upgrading existing 500 kilovolt (kV) alternating (AC) intertie from existing transfer capacity of 2800 MW to 3200 MW.• Proposed Third AC/California Oregon Transmission Project.• Proposed 345-kV Intertie• Thousand Springs Project - Coal-Fired generation station in northwest Nevada.• Fallon Geothermal - Known resource area in U.S. Naval Weapons Station, Fallon, Nevada. Nevada.	Would require contract with PG&E and members of California Pool Companies
Trans-Sierra Imports <u>b/</u>		Contingent on safety tests which look favorable Agreement with PG&E would be needed.
Southwest Imports		Capability could either be part of settlement or used to import.
		Fully subscribed at this time.
		Under consideration by Sierra Pacific Resources (parent company to Sierra Pacific Power Co.
		Drawbacks to development are lack of need for power in northern Nevada and export transmission availability
		Contingent on transmission, e.g., completion of Mead-Adelanto line.

a/ SMUD will have surplus power available when the PG&E contract expires in 1989 and the Rancho Seco Nuclear Plant is back on line.

b/ SMUD and the Sierra Pacific Power Co. are studying the feasibility of constructing a 345-kV alternating current

Opportunities to connect the City's system to the adjacent systems of the East Bay Municipal Utility District and the Santa Clara Valley Water District should be evaluated. Such a connection could increase system reliability during the changeover to the replacement supply and might be mutually advantageous over the long-term to participating parties.

REPLACEMENT POWER SUPPLIES

Removal of O'Shaughnessy Dam would reduce the power accomplishments of the Hetch Hetchy system as follows:

- Possible complete elimination of generation at the Kirkwood Plant. Because the inlet to the Canyon Tunnel is at or near the streambed at the dam, some diversion of the unregulated riverflow would be possible. However, there would be no dependable capacity because instream requirements for fish would probably require all the flow in most of the summer months of dry years.
- Significant reduction in generation at the Moccasin Plant. Hetch Hetchy staff estimated that generation would be half of average. In addition, dependable capacity would be zero for the same reason as Kirkwood.
- Possible reduction of generation and dependable capacity at Holm. Modification of the Cherry River system (Lakes Lloyd and Eleanor) for water supply, as discussed earlier, would reduce generation and dependable capacity at the Holm Plant. Otherwise removal of O'Shaughnessy Dam would not affect generation at the Holm Plant.

Total reduction in power accomplishment of existing Hetch Hetchy system with Kirkwood out and no change to the Cherry Creek system would approach 150 MW of dependable capacity and 900 million kWh of average annual generation. Estimated reductions represent about 60 percent

of dependable capacity and 50 percent of annual generation.

The exact amount of the reduction in power generation would depend on what power generation capability would remain after O'Shaughnessy Dam was removed and the remainder of the Hetch Hetchy system was optimized for water, power, fishery, and recreation. To obtain the total net effect on power, any additional amount of power, either generated or required to make the project whole in water supply, would have to be accounted for.

Of the total power generated from the Hetch Hetchy system, about 25 percent goes to the City of San Francisco, 65 percent to the Modesto and Turlock Irrigation Districts, and 10 percent to industries in the San Francisco bay area. San Francisco was first priority under the Raker Act. The amount going to Modesto and Turlock includes both the second and third priorities under the Raker Act.

All things being equal, whatever reduction in generation would be applied in the order of priority. However, the total power from the Hetch Hetchy system is made up of the Kirkwood Powerplant as baseload generation, Moccasin as both baseload and peaking, and Holm as peaking. The system is operated first for water supply. With operational constraints for water supply, power is optimized. Individual user requirements vary in the amounts of baseload and peaking power. A major reduction in baseload and/or peaking power could therefore affect more than just the lower priority users.

POWER REPLACEMENT SUPPLIES

Ultimately, replacing the power lost by removing O'Shaughnessy Dam would result in the construction of new power facilities. For the next 10 to 20 years, however, there is enough power in or available to northern California, either developed or in the planning, design, or construction stages, to replace the amount reduced. An inventory of power replacement options, both within and outside of northern California, prepared by the Western Area Power Administration, is

presented on Table 6. These represent only a "shopping list" and need further investigation to determine both the viability and feasibility of each. Other options should also be identified and evaluated.

Estimated costs, based on Pacific Gas and Electric Company's marginal costs are shown on Table 7. Cost of replacement power would depend on the timing of the purchase. Future costs include both general inflation and fuel escalation.

Over how many years the replacement cost would occur is dependent on the expected economic life of those facilities of the existing system that would be removed or reduced in output capability. An exact number of years would be the result from an appraisal of the specific power facilities. An alternative could be a lump sum amount that could be paid to the City.

As a check on the cost of surplus power, a comparison should be made with the cost of a new power project, including several that have been proposed in the Tuolumne River Basin between

Early Intake and New Don Pedro. Wards Ferry and Harden Flat are two recently evaluated projects, which could be examined for comparison purposes.

TABLE 7
Cost of Replacement Power

Year	Energy (cent/kWh)	Capacity (\$/kW/month)	Replacement Cost (\$/year)
1987	2.23	17.07	51,000,000
1990	3.52	17.69	64,000,000
2000	8.47	18.31	109,000,000

FEASIBILITY STUDY DESIGN



Photographer Unknown

The Hetch Hetchy Valley.

FEASIBILITY STUDY DESIGN

This report, prepared on behalf of the National Park Service, presents the results of a preliminary analysis of the "idea" of restoring Hetch Hetchy Valley to its natural environment. Opportunities to replace water and power supplies were studied only as concepts. Data were insufficient to outline detailed options, costs, or impacts. Despite the cursory nature of this analysis, however, several concepts appeared very promising and meritorious for further study.

This part delineates the foundation for a feasibility study to look at the benefits, impacts, and costs of restoring Hetch Hetchy Valley as a natural environment in Yosemite National Park, should a determination be made that such a study is warranted. Despite an overall National Park orientation, any program to restore Hetch Hetchy Valley to a natural environment would be heavily involved in water resources development and management. Accordingly, plan formulation studies are needed to determine the manner of water and power replacement. These studies would:

- Define the replacement requirements, i.e., the water, power, and revenues that would be reduced with the restoration of Hetch Hetchy Valley;
- Develop costs, accomplishments, impacts, and acceptability for potential replacement options;
- Select a preferred replacement plan;
- Develop detailed alternative methods for physically removing O'Shaughnessy Dam.
- Prepare and process a Planning Report/Environmental Statement, including recommendations, which describe the study and are suitable as the basis for appropriate action by Congress.

Public participation would occur throughout the course of the study; the public would help in identifying significant issues related to the study, and in selecting the preferred replacement plan. Representative water and power replacement options for water and power presented in this report could be expanded or deleted and other options included as a result of public involvement.

Replacement studies should include all relevant matters related to the various options, including the quantity and quality of water and power supplies, physical or operational alternatives within the various options, costs, accomplishments, environmental and social impacts, and legal and institutional issues. No plan would be included for development and use of the valley, as these subjects would be addressed by the National Park Service in separate but coordinated studies.

Socioeconomic justifications that weigh the value of restoration to park use benefits against the costs of the restoration and replacement would be included. Non-park use benefits included in a particular replacement option but incidental to replacement would be analyzed. The study would develop a financial plan for implementing the replacement program. A preliminary plan formulation study work schedule is presented in Figure 5.

PLAN FORMULATION STUDIES

The following material identifies topics that would comprise part of the plan formulation studies on water replacement options. The options are discussed in terms of their physical and operational aspects and the legal, institutional and

environmental issues that would be involved. Although these topics are believed to represent the content of the study, they were derived from the present imperfect information base and are therefore not all inclusive. It is expected that as the study progressed and the public actively participated in the decisionmaking process, more topics would arise and be included.

REOPERATION OF TUOLUMNE RIVER SYSTEM

Operation of a modified Tuolumne River system with and without Hetch Hetchy Reservoir and developing Tuolumne River storage in new terminal storage facilities near the City's service area (Options 1 through 4 on Table 1) would merit primary consideration.

Physical and Operational Aspects

- Determining the amount of water that could be directly diverted from the Tuolumne River at Early Intake Reservoir (the headworks of the City's Hetch Hetchy water conveyance system) and the effect of reduced regulated flows on power generation. Alternately, the diversions might be made to Canyon Tunnel at O'Shaughnessy damsite.
- Determining the degree to which a direct diversion supply could be supplemented through coordination with a modified and reoperated Cherry River system (Lakes Eleanor and Lloyd).
- Examining the reoperation of Cherry Creek system for both water and power purposes.
- Evaluating the structural changes that would be required to achieve the reoperation of the Cherry Creek system. These include: (1) Relocating Holm Powerplant to a higher location and conveying the water through a new tunnel conveyance to Early Intake; (2) Pumping from below Holm Powerplant and constructing conveyance to transport water to Early Intake; and (3) Increasing capacity in existing Lower Cherry Creek Aqueduct.
- Evaluating the potential of New Don Pedro Reservoir with Hetch Hetchy

Reservoir removed to develop replacement supplies while maintaining present Turlock and Modesto Irrigation Districts supplies, flood control, and downstream fishery releases.

- Determining the best means of conveying any replacement supply developed from reoperation of New Don Pedro Reservoir to the City. These include: (1) Pumping and conveying water from New Don Pedro through new facilities to Hetch Hetchy Aqueduct; and (2) Releasing water downstream to Delta for delivery to the Hetch Hetchy Aqueduct via the California Aqueduct or an enlarged Delta-Mendota Canal.
- Evaluating the potential for raising the height of the existing City dams that impound Crystal Springs and San Antonio Reservoirs to create storage for additional winter flows diverted from the Tuolumne River. Consideration would include: (1) Seismic potential of area; (2) Quantity and occurrence of additional winter flows from the Tuolumne River Basin; (3) Conveyance of flows; (4) Dry-year supplies available; and (5) Degree to which enlargement could increase firm water supply.

Institutional and Legal Issues

Legal and institutional issues of reoperation of the Tuolumne River system include:

- Possible water rights modifications required for the City's use of water diverted from New Don Pedro Reservoir.
- Impacts on Turlock and Modesto Irrigation Districts' water and power supplies obtained from the Tuolumne River or the City's Hetch Hetchy system.
- Impact of the Raker Act on any proposed modifications in the Tuolumne River watershed to provide the replacement water supply.
- Impacts on water supply for the City of Groveland and the Moccasin Fish Hatchery.

- Impacts on present agreements between the City and the Turlock and Modesto Irrigation Districts including water banking in New Don Pedro Reservoir.
- Possible seismic and other local area considerations related to evaluation of storage enlargements for existing City reservoirs in the Bay area.
- Replacement of or compensation for the lost net power generation.

Environmental Considerations

Removal of O'Shaughnessy Dam would reintroduce the natural flow regime to the Tuolumne River. In this regime, higher flows occur from April through July. In many years, particularly dry ones, natural flows can subside to 50 cfs or less during August and September. Resources or uses which would be impacted by restoration of natural flows include:

- Agreements on fishery flows (present agreements include those with the the U.S. Department of the Interior, California Department of Fish and Game, and Sierra Club.) Minimum flows now range from 50 to 100 cfs during the winter and spring and from 100 to 125 cfs during the summer, except in drought years. Natural flows could not maintain his flow level in all years in summer months.
- Rafting use of river reaches below the confluence of the South and Middle Forks and the 18 miles of the river between this point and Wards Ferry in the upper reaches of New Don Pedro Reservoir. Normal year low flows in summer and fall could negatively impact rafting.
- Status of river above New Don Pedro Reservoir as part of the National Wild and Scenic Rivers system.
- Recreation at New Don Pedro Reservoir.
- Impact on salmon fishery and the South Delta area as a result of increasing flows downstream of New Don Pedro at certain times of the year.
- Impacts on fish and wildlife habitat, endangered species, and cultural resources resulting from proposed new facilities: modification in the upper Tuolumne-

Hetch Hetchy system, conveyance facilities from New Don Pedro, and increased storage at the City's existing storage reservoirs.

BALANCE OF REPLACEMENT SUPPLIES

Sierra Nevada Supplies

Conjunctive Use of Stanislaus, Lower American, and Tuolumne River Systems. This optimization-coordination-conjunctive use option would be evaluated as a supplemental supply that could replace that portion of the City's water if it is found that sufficient water could not be provided from reoperating the Tuolumne River system. This option would involve integrating and adding the Tuolumne River and New Don Pedro Reservoir to the existing Reclamation model for reoperating Folsom, Pardee, Comanche, New Hogan, and New Melones Reservoirs in conjunction with the ground-water basins.

Physical and Operational Aspects

- Determining the facilities needed for conveyance of the replacement supply from the Folsom-South Service Area and New Melones Reservoir to the Hetch Hetchy Aqueduct and/or to the Turlock and Modesto Irrigation Districts.
- Determining amount of water available as a replacement supply to the City.

Institutional and Legal Issues

- Contracts and agreements for sharing newly developed water and the costs of developing and delivering it among the users of river basins involved.
- Agreements with various districts and entities from the American River to Turlock and Modesto required to implement the plan.
- Central Valley Project authorizing authority.
- Addition of City of San Francisco as place of use to Central Valley Project water rights permits.

- Agreements with fishery entities on tributary streams from the American to the Tuolumne Rivers.
- American River instream flow issues and other related water supply problems for serving Sacramento, San Joaquin, and Stanislaus Counties.

Environmental Considerations

- Evaluation of potential impacts to fishery, riparian, and recreational resources of any changes in flow regimes of American, Stanislaus, and Tuolumne Rivers and other tributary streams (i.e., Mokelumne, Calaveras Rivers).
- Identification of new facilities and their impacts on vegetation, fish and wildlife, recreation, endangered species, and cultural resources.

Supplies From the Delta

Construction of an offstream storage reservoir at the Los Vaqueros damsite and coordination of Lake Berryessa with the State's North Bay Aqueduct were considered as the most likely Delta water supply replacement options to be studied for possible implementation should additional replacement supplies be needed.

Physical and Operational Aspects

At the present time, use of any Delta supply is limited by the conveyance capacity available both through and south of the Delta. Channel capacity in the Delta itself limits the amount of water that can be moved to either the State Delta or Federal Tracy Pumping Plants. Conveyance capacity south is also limited. The Delta-Mendota Canal has no available capacity to carry more Delta supplies. Additional capacity could be obtained through:

- Negotiating a wheeling agreement for use of the State's California Aqueduct and using some capacity of the pumps to be installed at the Banks Pumping Plant;
- Enlarging the Delta-Mendota Canal by 500 cfs for about 20 miles to its intersection with the Hetch Hetchy Aqueduct;

- Constructing a new canal from the Delta to the Hetch Hetchy Aqueduct.

Institutional and Legal Issues

- Definition and maintenance of Delta water quality standards.
- Competition for water and agreements among entities participating in implementation of any Los Vaqueros or North Bay Aqueduct/Lake Berryessa Project.
- Agreements among the "partners" in the export conveyance and cross-Delta projects required to convey water through and south of the Delta.
- Central Valley Project authorizing authority.
- Amending Central Valley Project water rights permits to include additional point of diversion and to add the City of San Francisco in the project's place of use.

Environmental Considerations

Providing replacement supplies from the Delta would be evaluated in terms of impacts to Delta resources. Increased pumping and improvement of through-Delta conveyance facilities could produce a wide range of impacts. To the extent that Delta supplies replace supplies from the Tuolumne River, however, increased flows into the Delta from the Tuolumne river would have positive impacts in the Tuolumne and San Joaquin Rivers, to the South Delta Water Agency, and in the Delta itself. Considerations include:

- Impacts of increased pumping and subsequent reverse flows on the fishery.
- Water Quality.
- Impingement and entrainment of young fish.
- Delta outflows.
- Channel velocities.
- Effect on Kellogg Creek watershed of construction of Los Vaqueros Reservoir. (Preliminary environmental evaluations have been completed in connection with Reclamation's Offstream Storage Study and by the Department of Water Resources. Concerns are: (1) Loss of riparian

habitat (2) Potential impacts to threatened and endangered species.

- Impacts to Lake Berryessa uses, including fishery and recreation.

specific plans for restoring the valley or for its development and uses. About \$500,000 would be required in the first year of the study. Funding requirements by fiscal year are as follows:

SCHEDULE AND BUDGET

Figure 5 shows a work schedule that includes the various aspects and elements described in previous sections. This study would require about \$3 to \$5 million to accomplish, exclusive of any planning that the Park Service would require to adopt

Fiscal Year	Funding (\$1,000)
1	500
2	1,000 - 1.5
3	700 - 1.2
4	500 - 1.1
5	200 - .5
3	100 - .2

Hetch Hetchy

Plan Formulation Study

Work Schedule

October 1987

	FY 1	FY 2	FY 3	FY 4	FY 5	FY 6	FY 7
Initiate Study	A						
Develop List of Replacement Options							
Preliminary Screening of Replacement Options							
Appraisal Evaluations of Replacement Options							
Selection of Preferred Option							
Feasibility Evaluation of Preferred Option							
Preparation of PR/DEIS							
Review and Processing of PR/DEIS							
Public Involvement							
Study Coordination							
FWS Evaluations							
NPS Evaluations							
Negotiate Contracts or Agreements With S. F.							
Authorization							

FIGURE 5

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