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A SUMMARY VIEW OF WATER SUPPLY AND DEMAND IN THE SAN FRANCISCO BAY REGION, CALIFORNIA

By

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A SUMMARY VIEW OF WATER SUPPLY AND DEMAND IN THE SAN FRANCISCO BAY REGION, CALIFORNIA

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ABSTRACT

This report presents a summary view of the water-supply situation in the nine counties that comprise the San Francisco Bay region, California, and thereby provides water data, based on 1970 conditions, that are needed for regional planning. For the purpose of this study the nine-county region has been divided into 15 subregions on the basis of hydrologic and economic considerations. Firm water supply is tabulated for each subregion by source--ground water, surface water, and imported water. Water demand in 1970 is tabulated for each subregion by type of use or demand--public supply, rural self-supply, irrigation, self-supplied industrial water, and thermoelectric power generation.

The San Francisco Bay region is dependent to a large degree on imported water. Under 1970 conditions of development, the firm water supply is 2.2 million acre-feet per year; of that quantity, almost 1 million acre-feet per year is imported water. The water demand in 1970 was 1.9 million acre-feet, about half of which was consumed. Under 1970 conditions of water development and use, a series of dry years would probably necessitate some curtailment of irrigation activities in four of the subregions, where the bulk of the demand is for irrigation water. Under those same conditions there is generally ample water for municipal and industrial use throughout the region, except in eastern Marin County, where the firm municipal supply does not exceed the 1970 demand for municipal and industrial water.

Although the firm water supply of the San Francisco Bay region, including imported water, is generally adequate to meet present needs, supplemental supply will be required to meet increased demand in the future. The expansion of existing surface-water facilities and the construction of new surface-water projects, now considered feasible, could provide a combined firm supplemental yield of slightly more than 1 million acre-feet per year, almost three-fourths of which would be available for import by those subregions that might experience a water deficiency in the future. However, any supplemental water that might be developed by such alternative methods as desalination of brackish or salt water, weather modification, and various conservation measures, will correspondingly reduce requirements for supplemental water from the more conventional sources.

The aspect of water quality is not discussed in this paper. Because of the present availability of imported water of good or acceptable quality, water quality, as it affects the supply, is not a serious problem at this time, except perhaps in local areas adjacent to San Francisco Bay and in the Sacramento-San Joaquin Delta. In those areas ground water had been degraded by salinity intrusion. Although the prediction of future trends in population, land use, and water demand is beyond the scope of this report, there is no doubt that vigilance and careful planning will be required to prevent serious future deterioration of the quality of the water supply.

INTRODUCTION

Purpose and Scope

The purpose of this report is to present a summary of the water-supply situation in the nine counties that comprise the San Francisco Bay region (fig. 1), and thereby provide water data, based on 1970 conditions, that are needed for regional planning. It should be recognized that this, or any other, framework for water-resources planning will require continual updating as water and land usage change with time. The quantitative data on water supply were compiled from material in the files of the many water-planning agencies operating in California, including those under Federal, State, county, and local administration. The sources or derivations of quantitative data on water demand are discussed in appropriate places in the text.

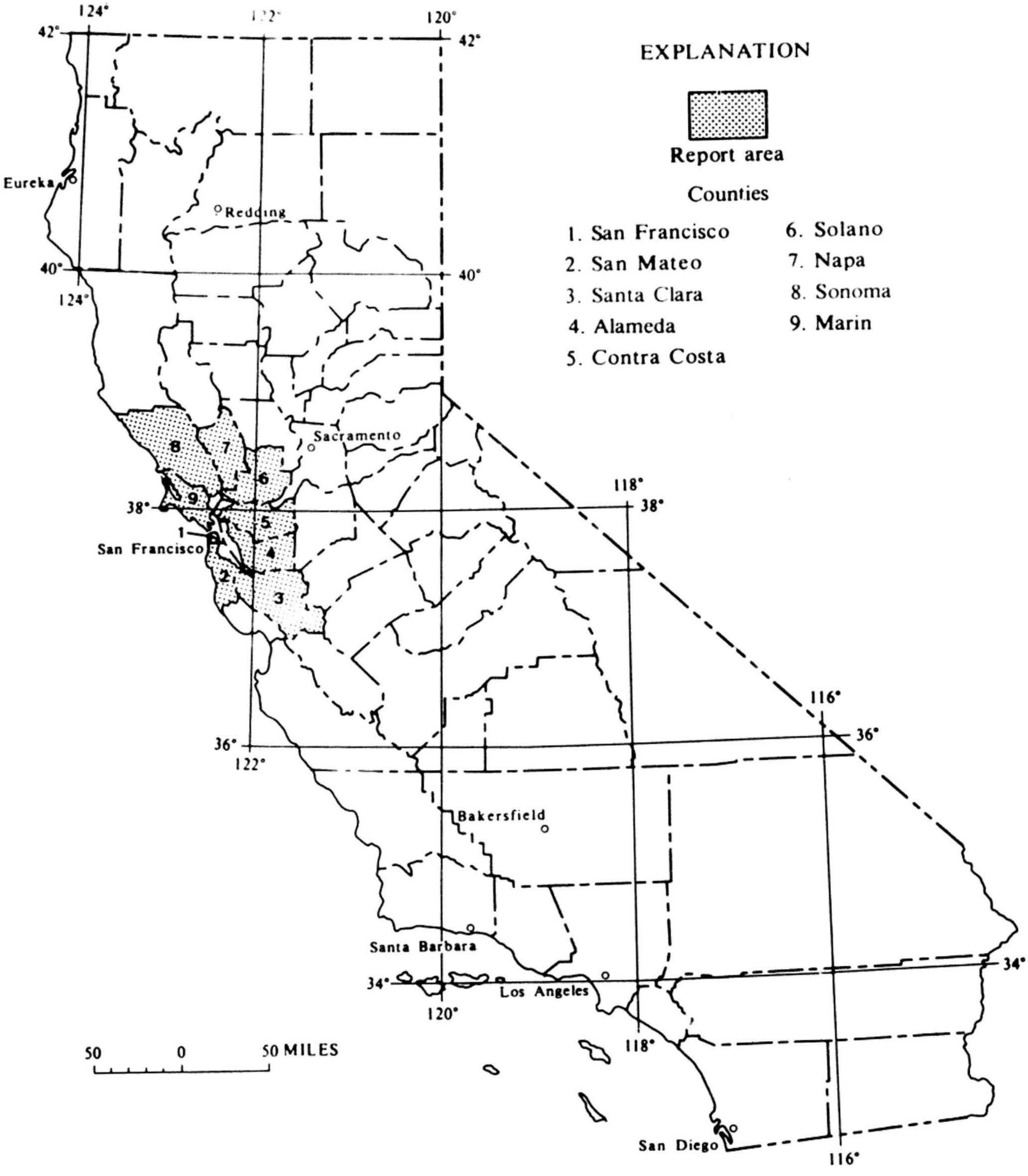


FIGURE 1.--Location of report area.

The region has been divided for study into 15 subregions on the basis of both hydrologic and socioeconomic considerations. The regional subdivision represents a compromise of conflicting factors: political boundaries (county lines) only occasionally coincide with topographic basin boundaries; ground-water divides often do not coincide with surface-water divides, and individual ground-water basins, therefore, often underlie several surface-water basins or extend beyond the areal limits of the San Francisco Bay region; furthermore, the boundaries of service areas for imported water from individual sources often do not coincide with the boundaries of either the surface- or ground-water basins that are served. The 15 subregions used in this report are listed in table 1 along with identifying letter and pertinent statistics with regard to area, population, and principal source of water supply. The subregions are delineated in figures 2 and 3, where they are identified by the letter given in table 1.

Because of the seasonal nature of the precipitation regime, streams in the region are generally dry, or their flow is reduced to little more than a trickle, during the dry summer season when water demand is at a maximum. Consequently, the only dependable sources of appreciable local supply are: (1) underlying ground-water bodies that are naturally recharged, primarily by the seepage of streamflow and to a lesser degree by precipitation, and (2) surface water stored in reservoirs created by damming streams. Because the local water supply is inadequate to meet the demand in most developed areas in the region, water is imported from other areas where the surface-water supply exceeds the local demand. The imported water is either used directly or is stored for later use in terminal reservoirs. In some areas, stored surface water, of either local or imported origin, is released to the stream channel at a rate that ensures optimum seepage into the streambed for artificial recharge of the underlying ground-water body.

Minor sources of local supply include scattered springs and small ground-water bodies. In addition, in some areas of light water demand, the flow of small streams is utilized in those months when flow is available, after which time water is pumped from small local ground-water bodies.

TABLE 1.--*Pertinent statistics fo subregions in the San Francisco Bay region*

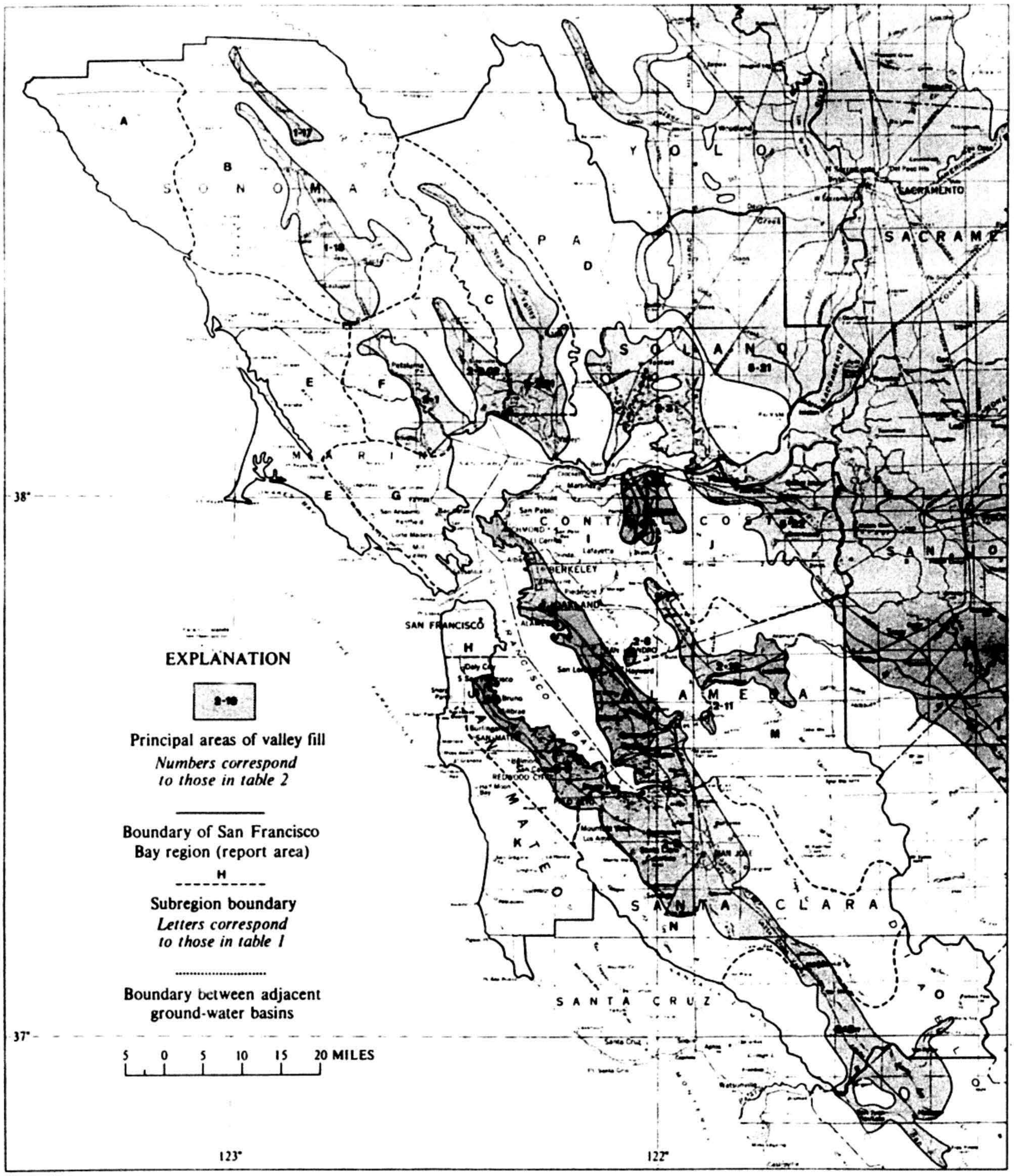
Subregion: Identi-fying letter	Subregion: Name	Land area (sq mi)	Population in 1970	Principal sources of water supply in 1970
A	Northwestern Sonoma County	304	1,000	Wells; Gualala River tributaries
B	Lower Russian River basin	888	134,000	Wells; Russian River and tributaries.
C	Napa Valley	332	78,000	Wells; Napa River and tributaries; import of Putah Creek water via Putah South Canal and North Bay Aqueduct.
D	Solano and eastern Napa Counties	1,278	171,000	Wells; Putah Creek via Putah South Canal, Sacramento River (local pumping and conveyance via Cache Slough Conduit).
E	Southwestern Sonoma and western Marin Counties	383	6,300	Wells and springs.
F	Novato-Petaluma-Sonoma area	355	108,000	Wells; Novato Creek; import of Russian River water via Petaluma and Santa Rosa-Sonoma Aqueducts.
G	Southeastern Marin County	194	161,700	Lagunitas and Nicasio Creeks.
H	San Francisco County	45	715,700	Import via Hetch Hetchy Aqueduct.[1]
I	Western Contra Costa and northwestern Alameda Counties	424	1,213,900	Wells; imports via Mokelumne Aqueduct[2] and Contra Costa Canal.[3]
J	Eastern Contra Costa County	427	81,300	Wells; Sacramento-San Joaquin Rivers system (local pumping and conveyance via Contra Costa Canal).[3]
K	Western San Mateo County	267	13,000	Wells and springs.
L	Eastern San Mateo County	180	543,200	Wells; import via Hetch Hetchy Aqueduct.[1]
M	Alameda Creek basin	841	336,400	Wells; Arroyo Valle, Alameda and San Antonio Creeks; imports via Hetch Hetchy Aqueduct[1] and South Bay Aqueduct.[4]
N	North Santa Clara Valley	695	1,037,700	Wells; streams in the Guadalupe River-Coyote Creek-Stevens Creek system; imports via Hetch Hetchy Aqueduct[1] and South Bay Aqueduct.[4]
O	Southern Santa Clara County	381	27,000	Wells; Uvas, Llagas, and Pacheco Creeks.
Total		6,994	4,628,200	

[1]Hetch Hetchy Aqueduct conveys water diverted from the Tuolumne River (a Sierra Nevada stream) and from Alameda Creek basin (subregion M).

[2]Mokelumne Aqueduct conveys water diverted from the Mokelumne River (a Sierra Nevada stream).

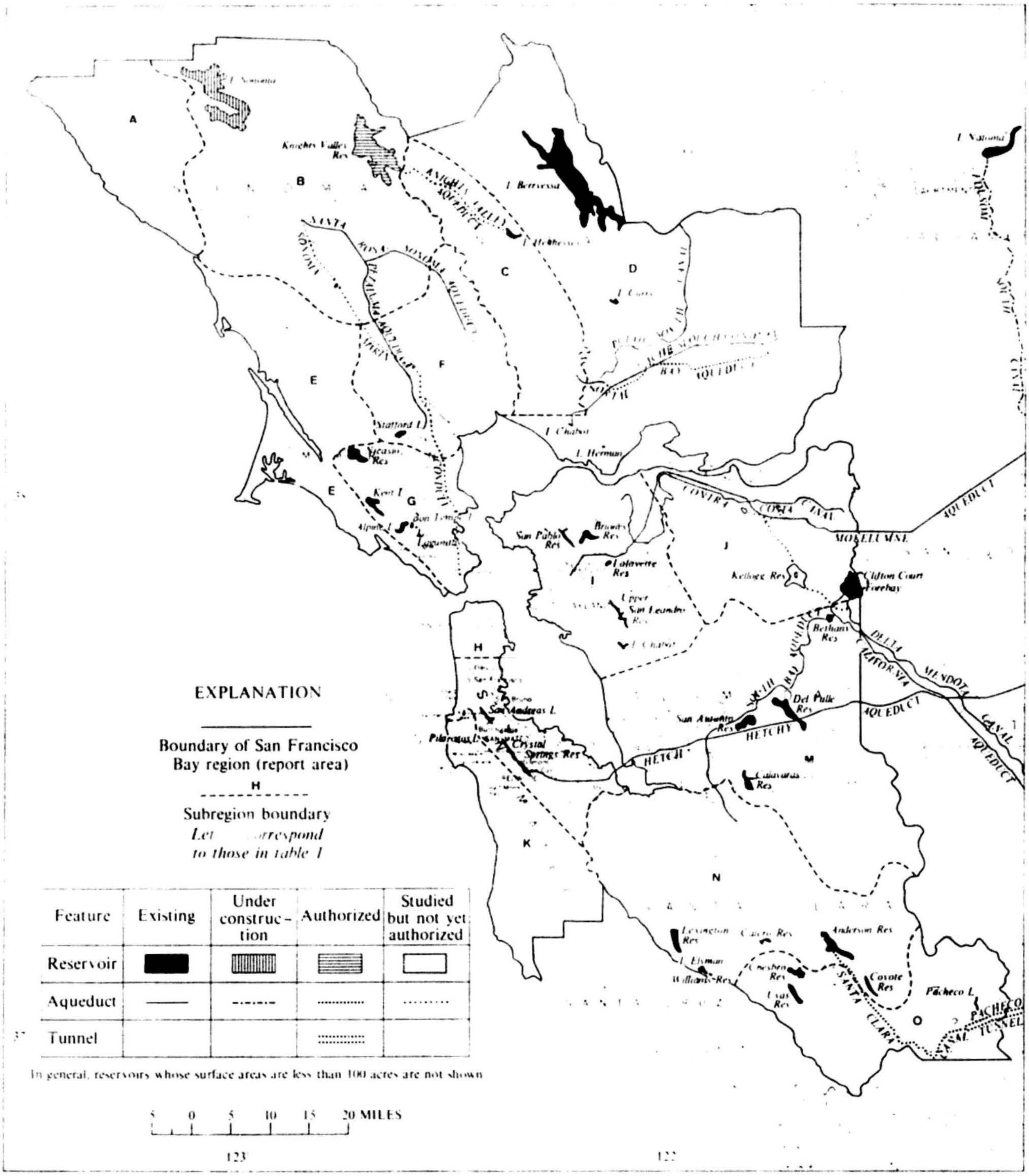
[3]Contra Costa Canal conveys water diverted in the delta area from the Sacramento-San Joaquin Rivers system.

[4]South Bay Aqueduct conveys water diverted in the delta area from the Sacramento-San Joaquin Rivers system.



Base from U.S. Geological Survey STATE OF CALIFORNIA, 1953, 1:500,000

FIGURE 2.--Subregion boundaries and principal areas of valley fill.



Base from U.S. Geological Survey
STATE OF CALIFORNIA, 1953, 1:500,000

FIGURE 3.--Subregion boundaries and surface-water projects

The nature of the water supply, as described above, largely dictates the type of information to be included in this report. The data presented for each of the 15 subregions include the following information for 1970: safe yield of ground-water basins, artificial recharge of ground-water basins, firm yield of existing surface-water projects, firm yield from minor ground- and surface-water sources, and firm exports and imports of water. (Definitions of the terms used in the preceding sentence are given in appropriate sections of the text.) Also given in this paper is the estimated water demand in 1970 by subregion and by type of use or demand. This report also includes a section on the firm yield of surface-water projects under construction as of 1972; those authorized for future construction; and selected projects, as yet unauthorized, but whose feasibility has been established by preliminary study. The projects included in that last category are limited to those that, in the opinion of the author, have a fair likelihood of being authorized in the foreseeable future. An example of a proposed project that has been studied but is omitted from discussion in this report, is Worley Flat Reservoir on Pescadero Creek in southwestern San Mateo County. Firm exports and imports are also tabulated for surface-water projects that either are now under construction, have been authorized, or have been studied but are as yet unauthorized.

The sources of future supply mentioned above are all of conventional nature--additional storage or diversion of streamflow. No quantitative data are available concerning the additional supply that may be provided by the development of less conventional sources--desalination of brackish or salt water and artificially increased precipitation through weather modification (cloud seeding)--or made available by the utilization of such conservation measures as reclamation of wastewater, suppression of reservoir evaporation, conjunctive use of surface and ground water, improved practices in irrigation, and watershed management. Because of the lack of quantitative data those measures are discussed only in general, although the additional water supply made available in 1970 through the limited reclamation of wastewater is reported.

This report is limited to a discussion of the quantitative aspect of the water supply, although it is realized that a comprehensive treatment of the subject also requires inclusion of the quality aspect. However, because of the present availability of imported water of good or acceptable quality, water quality, as it affects the supply, is not a serious problem at this time, except in local areas adjacent to San Francisco Bay and in the Sacramento-San Joaquin Delta. In those areas, salt water has intruded the ground-water aquifers. Although the prediction of future trends in population, land use, and water demand is beyond the scope of this report, it is safe to predict that vigilance and careful planning will be required to prevent serious future deterioration of the quality of the water supply.

It is appropriate to close this introduction with a remark about the section of this report that deals with supplemental water supply for the future. If that section appears to be strongly oriented toward surface-water projects, it is because most water-resources investigations in the past were concerned with such projects, and consequently quantitative project data are available. It is only lately that water planners in the region have been seriously concerned with the development of supplemental water from less conventional sources and by utilization of various conservation measures, and consequently the appropriate quantitative data are lacking. It is the imbalance in availability of quantitative data that gives that section of the report its apparent cast.

Acknowledgments

This report was prepared by the U.S. Geological Survey, in cooperation with the U.S. Department of Housing and Urban Development. The work was done during 1972 under the overall direction of R. D. Brown, Jr., project director of the San Francisco Bay region environment and resources planning study, and under the general supervision of L. R. Peterson, district chief in charge of water-resources investigations in California.

The cooperation of personnel of the California Department of Water Resources, particularly M. D. Roos and D. J. Finlayson, in furnishing a significantly large part of the data used in this study, is gratefully acknowledged. Thanks are also due to the many water-planning agencies in the region--too numerous to list--that graciously gave the author access to data in their files.

WATER SUPPLY IN 1970

As explained earlier, the dependable water supply for a subregion includes the safe yield of ground-water basins within the subregion, the firm yield of existing surface-water projects within the subregion, and firm imports of water from projects outside the subregion. Definitions of those terms follow.

Safe yield of a ground-water basin.--Safe ground-water yield is a somewhat ambiguous concept in that safe yield varies with the quantity of water withdrawn from the ground-water body and with the time and areal pattern of withdrawal. Nevertheless, it is a useful concept for a general appraisal of the ground-water supply. For this study, safe ground-water yield is defined as the annual pumpage, at the 1970 level of development, that can be sustained without permanent change in ground-water storage, or without short-term changes in storage that result either in excessive pumping costs or in excessive degradation of the water quality. Future change in land or water use may cause future change in safe yield.

Firm yield of a surface-water project.--Firm yield of a surface-water project can be defined, in general terms, as the maximum dependable draft that can be made continuously on a surface-water project, such as a reservoir, to meet the water demand predicted for some preselected future date (for example, year 2000) during a period of drought of given recurrence interval or during a period of drought whose severity is equivalent to that of the driest period of record in the region. In California it is customary to use the most critical drought period of record as a criterion. In most regions in the State, including the San Francisco Bay region, that period commonly includes the consecutive years, 1924-34. The term "dependable draft" is variously defined, but all definitions refer to the frequency with which the predicted water demands will be met. The frequency criteria in all definitions require that domestic, municipal, and industrial demands be met every year, but the frequency criteria in the various definitions vary somewhat with regard to the magnitude and number of annual deficits that may occur with respect to the demand for irrigation water. Despite this lack of consistency in definition, the values of firm surface-water project yield used in this study are adequate for general evaluation of the surface-water supply.

Firm import.--If the firm surface-water project yield (maximum dependable draft) in a region exceeds the draft required to meet the predicted local water demand, the difference between the two draft rates is a measure of the firm quantity of water available for export to a water-deficient region. Where such export is made, that quantity of water becomes the firm import of the water-deficient region.

Although we have differentiated between local surface-water and ground-water supplies, it should be remembered that they are actually parts of a single entity--the total local water supply. An increase in surface-water withdrawal, unless made from flow that would otherwise reach the ocean, depletes the natural recharge to ground-water bodies. Conversely, an increase in ground-water withdrawal, unless made from isolated ground-water storage or made in a manner that substitutes beneficial use for evapotranspiration by nonbeneficial vegetation, eventually depletes the ground-water outflow that feeds surface streams. There are instances, too, where it is difficult to label the source of the water withdrawn. For example, pumping from a well field close to a stream, as on the Russian River in subregion B, will usually induce seepage from the stream to the well field. Whether it is ground water or surface water that is being pumped is a matter of semantics, but the pumped water should not be attributed to both ground- and surface-water supply in preparing a water budget. In Santa Clara County (subregions N and O) where onstream reservoirs store water for subsequent release and artificial recharge in the stream channels, it is virtually impossible to quantitatively categorize part of the local firm water supply as firm reservoir yield and part as safe ground-water yield. That is so because the streams, even without regulation, would naturally recharge the underlying ground-water bodies, albeit to a lesser degree, and therefore the entire local firm water supply must be treated as a single entity.

Safe Yield of Ground-Water Basins and of Miscellaneous Minor Sources of Water Supply

Table 2 lists the principal ground-water basins in the San Francisco Bay region, along with the numbers that identify the basins on the map in figure 2. That map, derived from a report by the California Division of Water Resources (1952, pl. 1), actually delineates the area of valley fill in each of the basins, rather than the total extent of the principal aquifers in each basin. However, the boundaries of the areas of valley fill usually closely match the boundaries of the principal basin aquifers. Table 2 also gives the areal extent of the principal basin aquifers, the subregion or subregions in which the ground-water basins lie, the artificial recharge both in 1970 and that which is available on a firm basis from import or local supply, and the estimated safe yield of each basin under 1970 conditions of water use. In keeping with local custom the basic unit of measure used is thousands of acre-feet per year--1,000 acre-feet per year is equivalent to 620 gallons per minute, or 0.893 million gallons per day. All tables pertaining to water demand show values not only in thousands of acre-feet per year, but also in equivalent million gallons per day. Similar conversions are given elsewhere in the text where deemed useful.

The estimates of safe yield given in this report are consensus values obtained by consultation with ground-water hydrologists of the U.S. Geological Survey and the California Department of Water Resources. It is seen in figure 2 that Santa Clara Valley (basin 2-9) occupies parts of four subregions, and it was therefore necessary to arbitrarily estimate the safe yield of each of the four sections of that basin. On the other hand, three of the basins (3-3, 5-21, and 5-22) extend beyond the boundaries of the study area, and it was necessary to arbitrarily estimate safe yield for those parts of the basins that lie within the study area.

Some of the basins in Alameda and Santa Clara Counties until recently had been subject to overdraft--that is, annual pumpage exceeded annual natural recharge--but that imbalance has been halted by artificial recharge and probably no basins in the San Francisco Bay region are now being overdrawn. Table 3 summarizes, by subregion, the data on safe yield given in table 2.

Table 3 also summarizes the estimated firm yield of miscellaneous minor sources of local water supply. These minor sources include scattered springs (ground-water outflow) and small ground-water bodies. Also included are small streams which, in some areas of light water demand, are utilized in those months when flow is available, after which time water is pumped from small local ground-water bodies.

TABLE 2.--*Pertinent statistics for principal ground-water basins in the San Francisco Bay region*

Ground-water basin: Identifying number (fig. 2)	Ground-water basin: Name	Subregion in which basin lies	Areal extent of principal basin aquifers (sq mi)	Artificial recharge (thousands of acre-feet): In 1970	Artificial recharge (thousands of acre-feet): Firm annual value	Estimated safe yield (thousands of acre-feet per year)
1-17	Alexander Valley	B	35	0	0	3
1-18	Santa Rosa-Healdsburg Valleys	B	180	0	0	30
2-1	Petaluma Valley	F	127	0	0	10
2-2.01	Napa Valley	C	230	0	0	12
2-2.02	Sonoma Valley	F	150	0	0	10
2-3	Suisun-Fairfield Valley	D	259	0	0	10
2-5	Clayton Valley	J	30	0	0	5
2-6	Ygnacio Valley	I	32	0	0	5
2-7	San Ramon Valley	I	31	0	0	3
2-8	Castro Valley	I	4	0	0	2
2-9	Santa Clara Valley	I	88 (584 total)	0	0	5
		L	73	0	0	10
		M	133	[1] 15	[2] 32	[3] 25
		N	290	[4] 119	[5] 60	[6] 180
2-10	Livermore Valley	M	170	[2] 3	[2] 7	[7] 18
2-11	Sunol Valley	M	20	0	0	2
3-3	Gilroy-Hollister Valley (Santa Clara County portion)	O	75	[8] 27	[9] 19	[6] 75
5-21	Sacramento Valley (Solano County portion)	D	380	0	0	60
5-22	San Joaquin Valley (Contra Costa County portion)	J	200	0	0	30

[1]Delivered by South Bay Aqueduct and includes local contribution from Del Valle Reservoir.

[2]Delivered by South Bay Aqueduct. All water for recharge is imported; the 6,000 acre-feet of aqueduct water that originates as firm natural inflow to Del Valle Reservoir is considered, in this report, as being used for municipal and industrial purposes in Alameda County.

[3]Does not include the 32,000 acre-feet of recharge water imported via South Bay Aqueduct.

[4]Consists of 38,000 acre-feet imported via the South Bay Aqueduct and 81,000 acre-feet from the local reservoir system.

[5]The figure of 60,000 acre-feet per year represents the firm yield of the local reservoir system. After 1975 all water imported via the South Bay Aqueduct will be treated and used for industrial and municipal purposes; none will be used for artificial recharge in subregion N.

[6]This value represents the combined surface- and ground-water components of the locally derived water supply.

[7]Does not include the 7,000 acre-feet of recharge water imported via South Bay Aqueduct.

[8]Consists of 21,000 acre-feet released from Uvas and Chesbro Reservoirs, and an estimated 6,000 acre-feet released from Pacheco Lake.

[9]The figure of 19,000 acre-feet per year represents the firm yield of the local reservoir systems. Uvas and Chesbro Reservoirs have a combined firm yield of 15,000 acre-feet per year; Pacheco Lake has a firm yield of 4,000 acre-feet per year.

TABLE 3.--*Estimated safe (firm) yield in 1970 from principal ground-water basins and from miscellaneous minor ground- and surface-water sources, by subregion*

Subregion: Identifying letter	Subregion: Name	Estimated safe yield from principal ground-water basins (from table 2)	Estimated miscellaneous firm supply from minor ground- and surface-water sources[1]
		Thousands of acre-feet per year	
A	Northwestern Sonoma County	--	3
B	Lower Russian River basin	33	10
C	Napa Valley	12	2
D	Solano and eastern Napa Counties	70	20
E	Southwestern Sonoma and western Marin Counties	--	5
F	Novato-Petaluma-Sonoma area	20	3
G	Southeastern Marin County	--	4
H	San Francisco County	--	5
I	Western Contra Costa and northwestern Alameda Counties	15	2
J	Eastern Contra Costa County	35	2
K	Western San Mateo County	--	12
L	Eastern San Mateo County	10	2
M	Alameda Creek basin	45	2
N	North Santa Clara Valley	[2] 180	2
O	Southern Santa Clara County	[3] 75	2
Total		495	76

[1]See page 11 for description of miscellaneous minor sources of water supply.
[2]Includes firm yield of 60,000 acre-feet per year from surface-water reservoirs in the north Santa Clara Valley reservoir system.
[3]Includes firm yield of 19,000 acre-feet per year from Uvas and Chesbro Reservoirs and from Pacheco Lake.

It is difficult to generalize concerning the yield of wells in the region because of the areal variability of the transmissivity of the aquifers. Suffice it to say that in the central core of the valley-fill areas shown in figure 2, well yields commonly range from 500 to 1,500 gpm (gallons per minute); in the outer parts of the valley-fill areas the range is commonly from 50 to 500 gpm; in low foothill areas the range is commonly from 5 to 50 gpm; in areas of higher altitude the range is commonly from 0.5 to 5 gpm. The following tabulation translates these ranges of well yield to water utility:

Well Yield	*Water Utility*
0.5 to 5 gpm	Marginally adequate to adequate for stock use or single family domestic use.
5 to 50 gpm	Adequate for stock or single family domestic use.
50 to 500 gpm	Adequate for light industry, but inadequate to marginally adequate for irrigation, heavy industry, or municipal supply.
500 to 1,500 gpm	Marginally adequate to adequate for irrigation, heavy industry, or municipal supply.

Firm Surface-Water Yield

Table 4 lists, by subregion, the principal surface-water projects operative in 1970, and the firm surface-water yields they provide. The projects listed in the table are shown in figure 3, except for Lake Mendocino on East Fork Russian River which is about 25 miles upstream from, or north of, the northern boundary of subregion B. More than half the inflow to Lake Mendocino is water diverted from the Eel River. Lake Mendocino regulates the augmented flow of the Russian River, but because the diversion of Russian River water is made in subregion B, releases from Lake Mendocino are considered part of the local supply of subregion B and not an import to the subregion.

In three of the subregions--B, D, and J--water is surplus to the local need and is exported to subregions that have a water deficiency. The water transported from the Sacramento-San Joaquin Delta area in the Contra Costa Canal is considered part of the local supply of subregion J, because the diversion is made in subregion J and much of the transported water is used in that subregion.

TABLE 4.--*Firm yield of surface-water projects in 1970*

Sub-region	Project	Firm yield, in thousands of acre-feet per year		
		For local use	For export	Total
A	None	--	--	--
B	Lake Mendocino (East Fork Russian River)	43.2	[1] 8.8	[2] 52.0
C	Lake Hennessey (Conn Creek)	11.0 } 19.0	0 } 0	11.0 } 19.0
	Minor reservoirs (Rector, Milliken)	8.0	0	8.0
D	Lake Berryessa (Putah Creek) and Putah South Canal	[3] 183.5 } 324.3	[4] 12.5 } 12.5	[3] 196.0 } 336.8
	Local pumping from Sacramento River	115.0	0	115.0
	Cache Slough Conduit (Vallejo diversion from Sacramento River)	21.5	0	21.5
	Minor reservoirs (Lake Curry, Lake Herman)	[5] 4.3	0	[5] 4.3
E	None	--	--	--
F	Stafford Lake (Novato Creek)	2.0	0	2.0
G	Reservoir system on Lagunitas and Nicasio Creeks (Lake Lagunitas, Bon Tempe Lake, Alpine Lake, Kent Lake, and Nicasio Reservoir)	30.0	0	30.0
H	None	--	--	--
I	Local inflow to terminal reservoirs of Mokelumne Aqueduct (Lake Chabot and Briones, San Pablo and Upper San Leandro Reservoirs)	10.0	0	10.0

See footnotes at end of table.

TABLE 4.--*Firm yield of surface-water projects in 1970*--Continued

Sub-region	Project	Firm yield, in thousands of acre-feet per year					
		For local use		For export		Total	
J	Local pumping from delta (Sacramento-San Joaquin Rivers system)	[6] 120.0	185.0	0	65.0	[6] 120.0	250.0
	Contra Costa Canal (from Sacramento-San Joaquin Rivers system in delta)	[7] 65.0		[8] 65.0		[7] 130.0	
K	None	--		--		--	
L	Local inflow to terminal reservoirs of Hetch Hetchy Aqueduct (Crystal Springs Reservoir, Pilarcitos Lake, and San Andreas Lake)	10.0		0		10.0	
M	Calaveras and San Antonio Reservoirs (Alameda and San Antonio Creeks)	[9] 38.0	44.0	0	0	[9] 38.0	44.0
	Del Valle Reservoir (Arroyo Valle)	[10] 6.0		0		[10] 6.0	
N	Lake Elsman and Williams Reservoir (both on Los Gatos Creek) and diversion from Saratoga Creek	[11] 5.0	[12] 65.0	0	0	[11] 5.0	[12] 65.0
	Santa Clara Valley reservoir system (Lexington, Guadalupe, Almaden, Calero, Coyote, Anderson, and Stevens Creek Reservoirs)	[13] 60.0		0		[13] 60.0	
O	Uvas and Chesbro Reservoirs (Uvas and Llagas Creeks)	15.0	[14] 19.0	0	0	15.0	[14] 19.0
	Pacheco Lake (Pacheco Creek)	4.0		0		4.0	

[1]Export to subregion F as follows: Novato area--3,600 acre-feet per year; Petaluma area--2,600 acre-feet per year; Sonoma area--2,600 acre-feet per year.

[2]Total firm yield is actually 60,000 acre-feet per year, but 8,000 acre-feet per year is allocated to Mendocino County, which is upstream from that part of the Russian River basin that lies in the San Francisco Bay region.

[3]Of this quantity, 7,500 acre-feet per year is allocated for use in the Putah Creek basin in northeastern Napa County; the remainder is allocated to Solano County.

[4]Export to Napa Valley (subregion C) via a short operative section of the North Bay Aqueduct. In 1970, the quantity exported was 3,600 acre-feet. After completion of the North Bay Aqueduct in 1980, diversion to Napa Valley will no longer be made from Putah Creek, but will be made from the Sacramento River.

[5]Of this total, 3,300 acre-feet per year is allocated to Solano County and 1,000 acre-feet per year to Napa County.

[6]Includes water for irrigation pumped by the East Contra Costa Irrigation District, the Byron-Bethany Irrigation District, and private irrigators on the delta islands. Also included is water pumped by the Contra Costa County Water District, which is then treated for municipal and industrial use. Not shown in the table is 2.2 million acre-feet of water, about half of which is brackish, that is pumped annually for cooling purposes and then returned to the delta--see table 12, subregion J.

[7]Although the firm yield is 130,000 acre-feet per year, half of which is for local use, only 90,000 acre-feet was withdrawn in 1970, half of which was used locally and the remaining half exported to subregion I.

[8]Export to subregion I.

[9]This quantity, conveyed in the Hetch Hetchy Aqueduct, is considered to be part of the water delivered for use in Alameda County (subregion M).

[10]This quantity, whether released down the stream channel or conveyed in the South Bay Aqueduct, is considered to be part of the water delivered for use in Alameda County (subregion M).

[11]For use by city of San Jose.

[12]Refer to footnote 13; 60,000 acre-feet of the 65,000 acre-feet shown has been included in the safe yield of the ground-water basin in subregion N (table 3).

[13]The 60,000 acre-feet per year shown for the Santa Clara Valley reservoir system is included in the safe yield of the ground-water basin in subregion N (table 3), and should not be used twice in a hydrologic budget.

[14]The 19,000 acre-feet per year shown for reservoirs in subregion O is included in the safe yield of the ground-water basin in that subregion (table 3), and should not be used twice in a hydrologic budget.

It should be remembered that in most years the actual surface-water yield will exceed the firm surface-water yield--that follows from the definition of firm yield of a surface-water project given on page 10, where it is stated that the value of firm yield is largely based on the availability of water during dry years.

Firm Water Imports

Table 5 lists, by subregion, the firm imports available from projects operative in 1970, and the actual quantities imported in 1970 from those projects. Figure 3 shows the principal storage facilities and aqueducts involved in the transfer of water, except for the reservoirs on the Sierra Nevada streams--Tuolumne and Mokelumne Rivers--from which water is diverted into the Hetch Hetchy and Mokelumne Aqueducts, respectively. Those reservoirs are east of the eastern boundary of figure 3. Actual imports in 1970 were less than the firm import values in all subregions other than F, because the additional water available was not needed.

Wastewater Reclamation

About 3,700 acre-feet (3.3 million gallons per day) of reclaimed (reused) wastewater was used in the region in 1970 (Deaner, 1971). Figure 4 shows the location of water-reclamation sites in the region. The identifying site numbers in figure 4 are those used in the above-cited report by Deaner. The numbers are used again in table 6, which gives the name of each site, the quantity of wastewater reclaimed in 1970, and the use to which the reclaimed water was put.

The quantity of wastewater used in 1970 is only a minute part of that discharged, as shown in a report by the California Department of Water Resources (1971, p. 135-137). That report states "The 59 (reporting) dischargers (in the San Francisco Bay region) released 589,104 acre-feet wastewater and of this total seven dischargers reused 2,611 acre-feet of wastewater." It is a foregone conclusion that the reclamation of wastewater for beneficial use will increase significantly in the future.

TABLE 5.--*Firm water imports from projects operative in 1970*

Sub-region	Canal or aqueduct in which imported water is conveyed	Import (thousands of acre-feet per year)			
		In 1970		Firm import	
A	None	0		0	
B	None	0		0	
C	Putah South Canal and North Bay Aqueduct[1]	3.6		12.5	
D	None	0		0	
E	None	0		0	
F	Petaluma and Santa Rosa-Sonoma Aqueducts[2]	[3]8.8		[3]8.8	
G	None	0		0	
H	Hetch Hetchy Aqueduct[4]	111		130	
I	Contra Costa Canal[5]	45	257	65	429
	Mokelumne Aqueduct[6]	212		364	
J	None	0		0	
K	None	0		0	
L	Hetch Hetchy Aqueduct[4]	[7]76		[7]123	
M	Hetch Hetchy Aqueduct[4]	[8]0	18	[8]10	92
	South Bay Aqueduct[9]	[10,11]18		[10,12]82	
N	Hetch Hetchy Aqueduct[4]	48	136	73	173
	South Bay Aqueduct[9]	[13]88		[14]100	
O	None	0		0	
Total		610.4		968.3	

[1]Diversion to Napa Valley from Lake Berryessa (Putah Creek) which is in subregion D. Delivery is made via Putah South Canal and a short operative section of the North Bay Aqueduct. After completion of the North Bay Aqueduct in 1980, diversion to Napa Valley will no longer be made from Putah Creek, but will be made from the Sacramento River.

[2]Diversion from Russian River in subregion B. The Russian River is regulated upstream from subregion B by Lake Mendocino.

[3]Import by subregion F as follows: Novato area--3,600 acre-feet per year; Petaluma area--2,600 acre-feet per year; Sonoma area--2,600 acre-feet per year.

[4]Hetch Hetchy Aqueduct conveys water diverted from the Tuolumne River (a Sierra Nevada stream) and from Alameda Creek basin (subregion M).

[5]Contra Costa Canal conveys water diverted in the delta area (subregion J) from the Sacramento-San Joaquin Rivers system.

[6]Mokelumne Aqueduct conveys water diverted from the Mokelumne River (a Sierra Nevada stream).

[7]Does not include 10,000 acre-feet per year of local inflow (firm yield) to terminal reservoirs in San Mateo County.

[8]Does not include 38,000 acre-feet per year of local inflow (firm yield) to reservoirs that are part of the Hetch Hetchy system in Alameda County.

[9]South Bay Aqueduct conveys water diverted in the delta area from the Sacramento-San Joaquin Rivers system.

[10]Does not include firm yield of Del Valle Reservoir (6,000 acre-feet per year) in subregion M, the diversion of which is also conveyed in the South Bay Aqueduct for use within subregion M.

[11]Entire 18,000 acre-feet was used for artificial recharge in 1970.

[12]Of the 82,000 acre-feet shown, 39,000 acre-feet will be used for artificial recharge of ground water.

[13]Of the 88,000 acre-feet, 38,000 acre-feet was used for artificial recharge; the remainder was used for municipal and industrial purposes.

[14]None of this water will be used for recharge after 1975; it will all be used for municipal and industrial purposes.

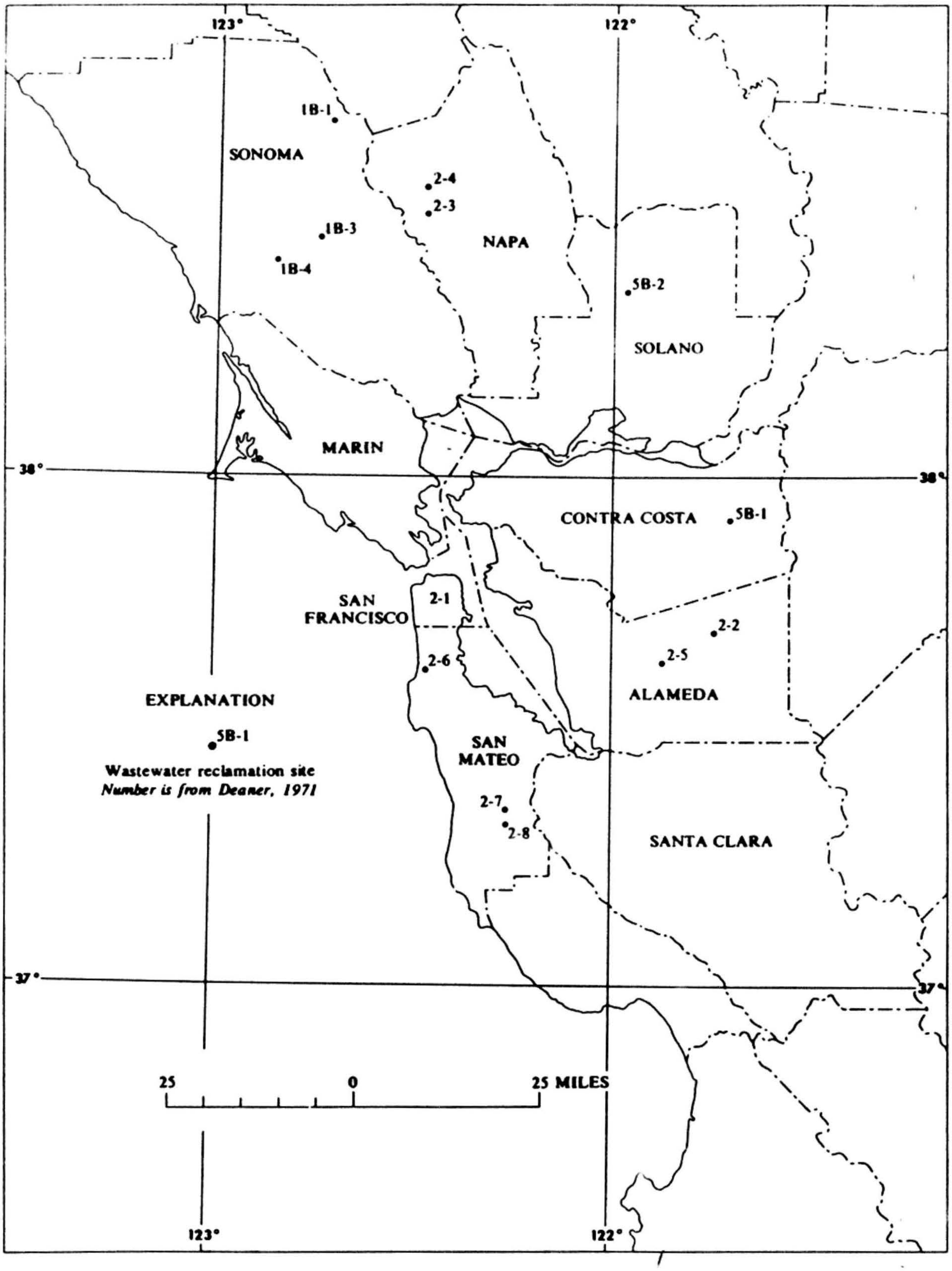


FIGURE 4.--Wastewater reclamation sites.

TABLE 6.--*Reclaimed wastewater in 1970*

Site			Quantity of wastewater reclaimed		Use of reclaimed wastewater
Number (fig.4)	County	City treatment plant or institution	Million gallons per day	Acre-feet	
1B-1	Sonoma	Marine Cooks and Stewards School	0.038	43	Ornamental lake
1B-3	do.	Santa Rosa sewage treatment plant	.178	199	Crop irrigation (pasture and fodder)
1B-4	do.	Sebastopol sewage treatment plant	.137	153	Crop irrigation (pasture)
2-1	San Francisco	Golden Gate Park water reclamation plant	.630	706	Landscape irrigation, scenic lakes
2-2	Alameda	Livermore water reclamation plant	.548	614	Golf course and landscape irrigation
2-3	Napa	Meadowood Community	.014	16	Golf course irrigation
2-4	Napa	Pacific Union College	.132	148	Crop irrigation (fodder)
2-5	Alameda	Pleasanton sewage treatment plant	.959	1,074	Crop irrigation (pasture)
2-6	San Mateo	San Francisco County Jail #2	.137	153	Golf course irrigation
2-7	do.	San Mateo County Boys' Ranch	.003	3	Landscape irrigation
2-8	do.	Log Cabin Ranch School	.008	9	Landscape irrigation
5B-1	Contra Costa	Brentwood sewage treatment plant	.137	153	Crop irrigation (pasture)
5B-2	Solano	California Medical Facility (Vacaville)	.356	399	Crop irrigation (pasture)
Total			3.277	3,670	

Summary of Water Supply in 1970

Table 7 summarizes, by subregion and source of supply, the firm supply of water in the San Francisco Bay region in 1970. The data given are abstracted from tables 3-5; they do not include the small quantity of wastewater reclaimed in 1970, that is shown in table 6. Also excluded is the 1.1 million acre-feet per year of fresh cooling water for thermoelectric generation that is withdrawn from the Delta in subregion J--see table 4, footnote 6. The cooling water is returned to the withdrawal sites virtually unchanged in quantity and quality, except for its raised temperature. The figures in table 7 differ slightly from those in tables 3-5 because of rounding to the nearest integer in table 7.

TABLE 7.--*Firm water supply in 1970*

Subregion		Firm (safe) yield, in thousands of acre-feet per year				
		Locally derived				
Identi-fying letter	Name	Ground water	Surface water	Miscel-laneous[1]	Import	Total
A	Northwestern Sonoma County	--	--	3	0	3
B	Lower Russian River basin	33	[2] 43	10	0	86
C	Napa Valley	12	19	2	[3] 12	45
D	Solano and eastern Napa Counties	70	[4] 324	20	0	414
E	Southwestern Sonoma and western Marin Counties	--	--	5	0	5
F	Novato-Petaluma-Sonoma area	20	2	3	9	34
G	Southeastern Marin County	--	30	4	0	34
H	San Francisco County	--	--	5	[6] 130	135
I	Western Contra Costa and northwestern Alameda Counties	15	10	2	[7] 429	456
J	Eastern Contra Costa County	35	[8] 185	2	0	222
K	Western San Mateo County	--	--	12	0	12
L	Eastern San Mateo County	10	10	2	[6 9] 123	145
M	Alameda Creek basin	45	44	2	[10] 92	183
N	North Santa Clara Valley	[11] 180	[12] 5	2	[13] 173	360
O	Southern Santa Clara County	[14] 75	[15] 0	2	0	77
Total		495	672	76	968	2,211

[1]See page 11 for description of miscellaneous minor sources of water supply.
[2]Excludes 9,000 acre-feet per year for export to subregion F.
[3]Imported from Lake Berryessa, in subregion D, via Putah South Canal and short operative section of North Bay Aqueduct.
[4]Excludes 12,000 acre-feet per year for export to subregion C.
[5]Imported from Russian River in subregion B.
[6]Imported from Tuolumne River (a Sierra Nevada stream) via Hetch Hetchy Aqueduct.
[7]Includes 65,000 acre-feet per year from Sacramento-San Joaquin Rivers system in subregion J, via Contra Costa Canal; and 364,000 acre-feet per year from Mokelumne River (a Sierra Nevada stream) via Mokelumne Aqueduct.
[8]Excludes 65,000 acre-feet per year for export to subregion I.
[9]Does not include 10,000 acre-feet per year of local inflow (firm yield) to terminal reservoirs of Hetch Hetchy system in San Mateo County; that 10,000 acre-feet is shown as surface-water yield for subregion L.
[10]Includes 10,000 acre-feet per year imported via Hetch Hetchy Aqueduct and 82,000 acre-feet per year imported via South Bay Aqueduct. The Hetch Hetchy import shown does not include any of the 38,000 acre-feet per year of firm yield of reservoirs that are part of the Hetch Hetchy system in Alameda County. The 38,000 acre-feet is included in the 44,000 acre-feet shown for surface-water yield. The South Bay Aqueduct import shown does not include 6,000 acre-feet per year of firm yield of Del Valle Reservoir; that 6,000 acre-feet is included in the 44,000 acre-feet shown for surface-water yield.
[11]Includes 60,000 acre-feet per year (firm yield) from the north Santa Clara Valley reservoir system for artificial recharge.
[12]Excludes 60,000 acre-feet per year from the north Santa Clara Valley reservoir system for artificial recharge of the ground-water basin.
[13]Includes 73,000 acre-feet per year imported via Hetch Hetchy Aqueduct, and 100,000 acre-feet per year imported via South Bay Aqueduct.
[14]Includes 19,000 acre-feet per year (firm yield) from Pacheco Lake and Uvas and Chesbro Reservoirs for artificial recharge.
[15]Excludes 19,000 acre-feet per year from Pacheco Lake and Uvas and Chesbro Reservoirs for artificial recharge of the ground-water basin.

WATER DEMAND IN 1970

Water demand in 1970 in the San Francisco Bay region is discussed under the following headings:

1. *Public supply.*--This category includes all water supplied by public or private water-distribution agencies, for domestic, municipal, commercial, and industrial use.
2. *Rural self-supply.*--This category includes all water self-supplied for domestic use, including the irrigation of lawns and small noncommercial truck gardens, and for livestock use.
3. *Irrigation.*--This category includes all water, either purchased or self-supplied, for the irrigation of commercial farms or orchards.
4. *Self-supplied industrial water.*--This category includes all self-supplied water used by industry other than that used in the generation of commercial electric power or in mining.
5. *Thermoelectric power generation.*--This category includes all water used for the generation of commercial electric power. No hydroelectric power is generated in the region.

The above five categories include the principal water uses that deplete or seriously degrade the water supply. (The quantity of water consumed in the generation of thermoelectric power is small, but the quantity withdrawn is large. Detailed figures of such use are given in this paper because of their availability from the Federal Power Commission.) Other water uses commonly considered in an inventory of water demand include those for recreation, fish and wildlife enhancement, and mining. The estimated average quantity of water to meet the combined requirements of recreation and fish and wildlife in the region totals 10,000 acre-feet per year (less than 10 million gallons per day), and such use does not seriously conflict with other demands. Although not considered in this inventory because the use of brackish water is involved, it should be mentioned that 200,000 acre-feet per year of brackish water is required to sustain the natural vegetation in Suisun Marsh needed by waterfowl. Mining, including the removal of sand and gravel from streambeds, requires an estimated 20,000 acre-feet of water per year. From a regional standpoint that total quantity is small, but it should be realized that a mining operation may cause local problems with regard to water quality or deterioration of other aspects of the environment. Such problems are beyond the scope of this report.

Firm contracts for the export of water from a subregion of water surplus to one of water deficiency constitute a demand on the water supply of the subregion of surplus. In this paper, however, imports and exports of water are discussed in the sections on water supply.

Public Supply

Table 8 shows, by subregion, the population served by public and private water-distribution agencies in 1970, the water demand (quantity delivered) and the water consumed. The figures of population served and quantities of water delivered were obtained from a report by Limerinos and Van Dine (1971). That report also included a map showing the service areas of the various purveyors of water in the region. It is estimated that about 90 percent of the water delivered was of surface-water origin, and that about one-fourth of all water delivered was used by commerce and industry.

It is further estimated that about 40 percent of all water delivered was consumed. There is no firm basis for that estimate with regard to water consumed by commerce and industry, other than the judgment of coworkers involved in studies of water use. The rationale on which that estimate is based, with regard to domestic water consumption, is as follows:

1. Little of the domestic water used within the house is consumed.
2. About three-fourths of the domestic water used outside the house--lawn irrigation, for example--is consumed.
3. About half the domestic water delivered is applied outside the house.
4. Multiplying 50 percent (from step 3) by 75 percent (from step 2) gives 37.5 percent; rounding that percentage upward for the small quantity of water consumed within the house (from step 1) gives 40 percent.

TABLE 8.--*Water use in 1970--public supply*

Subregion		Population served (thousands)	Water demand			Water consumed	
Identifying letter	Name		Thousands of acre-feet	Millions of gallons per day	Gallons per capita per day	Thousands of acre-feet	Millions of gallons per day
A	Northwestern Sonoma County	0	0	0	--	0	0
B	Lower Russian River basin	70.0	13.6	12.1	173	5.4	4.9
C	Napa Valley	58.0	14.0	12.5	216	5.6	5.0
D	Solano and eastern Napa Counties	150.0	27.0	24.1	161	10.8	9.6
E	Southwestern Sonoma and western Marin Counties	3.0	.4	.3	100	.2	.1
F	Novato-Petaluma-Sonoma area	83.0	11.2	10.0	120	4.5	4.0
G	Southeastern Marin County	160.0	32.5	29.0	181	13.0	11.6
H	San Francisco County	715.7	110.5	98.7	138	44.2	39.5
I	Western Contra Costa and northwestern Alameda Counties	1,200.0	248.6	222.0	185	99.4	88.8
J	Eastern Contra Costa County	75.0	14.2	12.7	169	5.7	5.1
K	Western San Mateo County	11.0	1.4	1.3	114	.6	.5
L	Eastern San Mateo County	537.0	91.6	81.8	152	36.6	32.7
M	Alameda Creek basin	310.0	50.4	45.0	145	20.2	18.0
N	North Santa Clara Valley	980.0	207.2	185.0	189	82.9	74.0
O	Southern Santa Clara County	18.0	3.9	3.5	195	1.6	1.4
	Total or average	4,370.7	826.5	738.0	169	330.7	295.2

Rural Self-Supply

Table 9 shows, by subregion, the population self-supplied with water for domestic and livestock use in 1970, and the water demand (quantity applied) for those uses. The population figures were obtained by subtracting the population served by public and private water-distribution agencies in each subregion (table 8) from the total population in each subregion as estimated from the official 1970 Census of Population for California (U.S. Bureau of the Census, 1971). Per capita domestic water use was estimated to be 100 gallons per day, about half of which was consumed. It is also estimated that about 95 percent of the water for domestic use was obtained from wells.

TABLE 9.--*Water use in 1970--self-supply, rural*

Subregion		Population self-supplied (thousands	Domestic water demand		Livestock water demand		Total water demand	
Identifying letter	Name		Thousands of acre-feet	Millions of gallons per day	Thousands of acre-feet	Millions of gallons per day	Thousands of acre-feet	Millions of gallons per day
A	Northwestern Sonoma County	1.0	0.1	0.1	0.6	0.5	0.7	0.6
B	Lower Russian River basin	64.0	7.2	6.4	1.2	1.1	8.4	7.5
C	Napa Valley	20.0	2.2	2.0	.4	.4	2.6	2.4
D	Solano and eastern Napa Counties	21.0	2.3	2.1	1.1	1.0	3.4	3.1
E	Southwestern Sonoma and western Marin Counties	3.3	.4	.3	1.2	1.1	1.6	1.4
F	Novato-Petaluma-Sonoma area	25.0	2.8	2.5	.8	.7	3.6	3.2
G	Southeastern Marin County	1.7	.2	.2	.5	.4	.7	.6
H	San Francisco County	0	0	0	0	0	0	0
I	Western Contra Costa and northwestern Alameda Counties	13.9	1.6	1.4	.5	.4	2.1	1.8
J	Eastern Contra Costa County	6.3	.7	.6	.9	.8	1.6	1.4
K	Western San Mateo County	2.0	.2	.2	.2	.2	.4	.4
L	Eastern San Mateo County	6.2	.7	.6	.1	.1	.8	.7
M	Alameda Creek basin	26.4	3.0	2.7	.8	.7	3.8	3.4
N	North Santa Clara Valley	57.7	6.5	5.8	1.0	.9	7.5	6.7
O	Southern Santa Clara County	9.0	1.0	.9	.4	.4	1.4	1.3
Total		257.5	28.9	25.8	9.7	8.7	38.6	34.5

NOTE.--Consumption of domestic and livestock water is estimated to equal 50 percent of the water demand.

The water use by livestock was computed by applying the following estimates of unit use to figures obtained from the 1970 livestock census for California (California Department of Agriculture, 1970).

Type of livestock	*Unit water use, in gallons per animal per day*
Milk cows	25
Beef Cows	15
Horses and mules	15
Hogs	3
Sheep	2
Chickens	.04
Turkeys	.06

It is estimated that about 40 percent of the water for livestock use was obtained from wells. It is further estimated that about half of all water supplied to livestock was consumed.

Irrigation

Table 10 shows, by subregion, the irrigated acreage in 1970, the quantity of water withdrawn for use, the conveyance loss between points of withdrawal and farm headgates, the water applied to crops, and the irrigation water consumed by crops. Acreage figures were obtained from the files of the California Department of Water Resources, and to those were applied the following average unit values, as obtained in a joint preliminary study by the California Department of Water Resources and the U.S. Bureau of Reclamation.

	Subregions D and J	*All other subregions*
Water withdrawn (acre-feet per acre)	3.00	2.75
Conveyance loss (acre-feet per acre)	.55	.55
Water applied (acre-feet per acre)	2.45	2.20
Irrigation water consumed (acre-feet per acre)	1.65	1.50

The quantities of water withdrawn given in table 10 include both self-supplied and agency-supplied water. It is estimated that about 50 percent of the water supply for irrigation was of surface-water origin. That relatively large percentage reflects the predominant use of surface water for irrigation in the agricultural subregions, D and J. Of the water lost in conveyance channels, half was estimated to have been consumed by evapotranspiration and the other half to have percolated to the underlying ground-water body. Irrigation efficiency was estimated at about 68 percent, meaning that about two-thirds of the applied water was consumed by crops and the remaining one-third percolated to the underlying ground-water body.

TABLE 10.--*Water use in 1970--irrigation*

Subregion: Identifying letter	Subregion: Name	Irrigated acreage (thousands)	Water withdrawn	Conveyance loss	Water applied to crops	Water consumed by crops
			Thousands of acre-feet			
A	Northwestern Sonoma County	([1])	([1])	([1])	([1])	([1])
B	Lower Russian River basin	25.0	69	14	55	38
C	Napa Valley	6.4	18	4	14	10
D	Solano and eastern Napa Counties	137.6	413	76	337	227
E	Southwestern Sonoma and western Marin Counties	.8	2	([1])	2	1
F	Novato-Petaluma-Sonoma area	3.6	10	2	8	5
G	Southeastern Marin County	.5	1	([1])	1	1
H	San Francisco County	([1])	([1])	([1])	([1])	([1])
I	Western Contra Costa and northwestern Alameda Counties	7.9	21	4	17	12
J	Eastern Contra Costa County	45.9	138	25	113	76
K	Western San Mateo County	5.5	15	3	12	8
L	Eastern San Mateo County	.2	1	([1])	1	([1])
M	Alameda Creek basin	16.3	45	9	36	24
N	North Santa Clara Valley	40.0	110	22	88	60
O	Southern Santa Clara County	30.0	82	16	66	45
Total		319.7	925	175	750	507

[1]Negligible.
NOTE.--Half the conveyance loss is estimated to have been consumed by evaporation.

Self-Supplied Industrial Water

Table 11 shows, by subregion, the self-supplied fresh water used in 1970 for industrial purposes other than the generation of commercial electric power or mining. In arriving at the figures given in the table, a determination was first made of the self-supplied fresh water withdrawn in each county for industrial use. That determination was based on figures of per capita withdrawal of such water in each of the nine counties in the San Francisco Bay region, as given in a report by the California Department of Water Resources (1968, table 8). The per capita withdrawal figures were multiplied by the appropriate county populations for 1970 to give withdrawal totals for each county. Personal judgment was then used in subdividing the county totals to arrive at the subregion figures shown in table 11. It is estimated that about 90 percent of the fresh water withdrawn (water demand) was ground water, and that about 15 percent of all water withdrawn was consumed.

TABLE 11.--*Water use in 1970--self-supply (fresh water), industrial*

Subregion		Water demand	
Identifying letter	Name	Thousands of acre-feet	Millions of gallons per day
A	Northwestern Sonoma County	0	0
B	Lower Russian River basin	4.5	4.0
C	Napa Valley	.1	.1
D	Solano and eastern Napa Counties	.1	.1
E	Southwestern Sonoma and western Marin Counties	0	0
F	Novato-Petaluma-Sonoma area	3.2	2.8
G	Southeastern Marin County	.2	.2
H	San Francisco County	.8	.7
I	Western Contra Costa and northwestern Alameda Counties	40.0	36.0
J	Eastern Contra Costa County	50.0	45.0
K	Western San Mateo County	0	0
L	Eastern San Mateo County	1.2	1.1
M	Alameda Creek basin	12.7	11.0
N	North Santa Clara Valley	20.0	17.8
O	Southern Santa Clara County	.2	.2
Total		133.0	119.0

NOTE.--It is estimated that about 15 percent of the water withdrawn (water demand) was consumed.

A large quantity of brackish water--water containing dissolved solids in excess of 1,000 parts per million--is also withdrawn by industry. Using per capita figures of brackish water withdrawal, from the above-cited report by the California Department of Water Resources, the total withdrawal of brackish water in the region in 1970 was found to be about 200,000 acre-feet (180 million gallons per day). About three-fourths of the brackish water was withdrawn in Contra Costa County, and almost all the remainder was withdrawn in Alameda, Santa Clara, and San Francisco Counties. Relatively little brackish ground water is used, it being estimated that about 90 percent of the brackish water withdrawn was saline surface water. Probably no more than 5 percent of the brackish water was consumed. The proximity of the ocean and San Francisco Bay, and their long shorelines, assures an almost unlimited supply of saline water for industrial purposes including the cooling water required for thermoelectric power generation.

Thermoelectric Power Generation

Table 12 shows, by subregion, the quantity of water used in the generation of commercial electric power in 1970. With the exception of a geothermal steam plant at The Geysers in Sonoma County, all power generation in the region is fossil fueled; no thermonuclear or hydroelectric power is generated. The great bulk of the water withdrawn is for condenser cooling, and except where cooling towers are used, only a small percentage of the cooling water is consumed by evaporation--the great bulk of the cooling water returns to the water body from which it was originally withdrawn. The fresh water consumed in boiler makeup and other uses is very small, and is usually estimated to equal one-tenth of 1 percent of the condenser water consumed.

TABLE 12.--*Water use in 1970--thermoelectric power generation*

Subregion		Condenser requirement		Condenser water consumed	
		Thousands of acre-feet			
Identifying letter	Name	Fresh water	Saline water	Fresh water	Saline water
A	Northwestern Sonoma County	0	0	0	0
B	Lower Russian River basin	Geothermal steam plant at The Geysers uses a negligible amount of cooling water			
C	Napa Valley	0	0	0	0
D	Solano and eastern Napa Counties	0	0	0	0
E	Southwestern Sonoma and western Marin Counties	0	0	0	0
F	Novato-Petaluma-Sonoma area	0	0	0	0
G	Southeastern Marin County	0	0	0	0
H	San Francisco County	0	815	0	3.4
I	Western Contra Costa and northwestern Alameda Counties	1	65	1.0	.4
J	Eastern Contra Costa County	1,100	1,170	2.6	4.5
K	Western San Mateo County	0	0	0	0
L	Eastern San Mateo County	0	0	0	0
M	Alameda Creek basin	0	0	0	0
N	North Santa Clara Valley	0	0	0	0
O	Southern Santa Clara County	0	0	0	0
Total		1,101	2,050	3.6	8.3

NOTE.--Fresh water consumed in boiler "make-up" and other uses is estimated to total about 12 acre-feet, or one-tenth of 1 percent of the condenser water consumed.

All fossil-fueled powerplants in the region are in the Sacramento-San Joaquin Delta or along San Francisco Bay. These plants generated a total of about 11.5 billion kilowatt-hours of electricity in 1970. In the context of this study, only the fresh-water requirement and consumption is of importance because of the unlimited quantity of saline water for condenser cooling that is available in the ocean and in San Francisco Bay. It is predicted that all thermoelectric powerplants built in the foreseeable future will be located near a source of saline water, and the precise site location will be governed largely by environmental considerations.

Summary of Water Use in 1970

Tables 13 and 14 summarize, by subregion and type of use, the quantities of fresh water withdrawn and the fresh water consumed in the region in 1970. The tables do not include an estimated annual quantity of 30,000 acre-feet (27 million gallons per day) of fresh water to meet requirements for mining, recreation, and fish and wildlife enhancement. Only a small percentage of that water is consumed and its use does not seriously conflict with other water demands. Also omitted from the tables is the 1.1 million acre-feet per year of fresh water withdrawn in the region for thermoelectric power generation. Virtually all that water is withdrawn from the delta for condenser cooling in subregion J and is returned to the withdrawal sites little changed in quantity or quality, except for its raised temperature. Because no shortage of cooling water from the delta is anticipated, the 1.1 million acre-feet withdrawn was also omitted from the tabulation of firm surface-water supply, but mention of it was made in footnote 6 of table 4.

As for brackish water, almost all of which is withdrawn from San Francisco Bay and the lower Sacramento-San Joaquin Delta, 2 million acre-feet (1,800 million gallons per day) was used in the commercial generation of electric power, and an additional 200,000 acre-feet (180 million gallons per day) was used by other industries. Very little of the brackish water is consumed.

TABLE 13.--*Summary of fresh-water demand in 1970*

Subregion		Public supply		Self-supply, rural		Irrigation		Self-supply, industrial		Total	
Identi-fying letter	Name	Thousands of acre-feet	Millions of gallons per day	Thousands of acre-feet	Millions of gallons per day	Thousands of acre-feet	Millions of gallons per day	Thousands of acre-feet	Millions of gallons per day	Thousands of acre-feet	Millions of gallons per day
A	Northwestern Sonoma County	0	0	0.7	0.6	([1])	([1])	0	0	0.7	0.6
B	Lower Russian River basin	13.6	12.1	8.4	7.5	69	61.6	4.5	4.0	95.5	85.2
C	Napa Valley	14.0	12.5	2.6	2.4	18	16.1	.1	.1	34.7	31.1
D	Solano and eastern Napa Counties	27.0	24.1	3.4	3.1	413	369.0	.1	.1	443.5	396.3
E	Southwestern Sonoma and western Marin Counties	.4	.3	1.6	1.4	2	1.8	0	0	4.0	3.5
F	Novato-Petaluma-Sonoma area	11.2	10.0	3.6	3.2	10	8.9	3.2	2.8	28.0	24.9
G	Southeastern Marin County	32.5	29.0	.7	.6	1	.9	.2	.2	34.4	30.7
H	San Francisco County	110.5	98.7	0	0	([1])	([1])	.8	.7	111.3	99.4
I	Western Contra Costa and northwestern Alameda Counties	248.6	222.0	2.1	1.8	21	18.8	40.0	36.0	311.7	278.6
J	Eastern Contra Costa County	14.2	12.7	1.6	1.4	138	123.0	50.0	45.0	203.8	182.1
K	Western San Mateo County	1.4	1.3	.4	.4	15	13.4	0	0	16.8	15.1
L	Eastern San Mateo County	91.6	81.8	.8	.7	1	.9	1.2	1.1	94.6	84.5
M	Alameda Creek basin	50.4	45.0	3.8	3.4	45	40.2	12.7	11.0	111.9	99.6
N	North Santa Clara Valley	207.2	185.0	7.5	6.7	110	98.2	20.0	17.8	344.7	307.7
O	Southern Santa Clara County	3.9	3.5	1.4	1.3	82	73.2	.2	.2	87.5	78.2
Total		826.5	738.0	38.6	34.5	925	826.0	133.0	119.0	1,923.1	1,717.5

[1]Negligible.

TABLE 14.--*Summary of fresh water consumed in 1970*

Subregion		Public supply		Self-supply, rural		Irrigation[1]		Self-supply, industrial		Total	
Identi-fying letter	Name	Thousands of acre-feet	Millions of gallons per day	Thousands of acre-feet	Millions of gallons per day	Thousands of acre-feet	Millions of gallons per day	Thousands of acre-feet	Millions of gallons per day	Thousands of acre-feet	Millions of gallons per day
A	Northwestern Sonoma County	0	0	0.4	0.3	(2)	(2)	0	0	0.4	0.3
B	Lower Russian River basin	5.4	4.9	4.2	3.8	45	40.2	.7	.6	55.3	49.5
C	Napa Valley	5.6	5.0	1.3	1.2	12	10.7	(2)	(2)	18.9	16.9
D	Solano and eastern Napa Counties	10.8	9.6	1.7	1.5	265	236.6	(2)	(2)	277.5	247.7
E	Southwestern Sonoma and western Marin Counties	.2	.1	.8	.7	1	.9	0	0	2.0	1.7
F	Novato-Petaluma-Sonoma area	4.5	4.0	1.8	1.6	6	5.4	.5	.4	12.8	11.4
G	Southeastern Marin County	13.0	11.6	.3	.3	1	.9	(2)	(2)	14.3	12.8
H	San Francisco County	44.2	39.5	0	0	(2)	(2)	.1	.1	44.3	39.6
I	Western Contra Costa and northwestern Alameda Counties	99.4	88.8	1.0	.9	14	12.5	6.0	5.4	120.4	107.6
J	Eastern Contra Costa County	5.7	5.1	.8	.7	88	78.6	7.5	6.8	102.0	91.2
K	Western San Mateo County	.6	.5	.2	.2	10	8.9	0	0	10.8	9.6
L	Eastern San Mateo County	36.6	32.7	.4	.3	(2)	(2)	.2	.2	37.2	33.2
M	Alameda Creek basin	20.2	18.0	1.9	1.7	28	25.0	1.9	1.6	52.0	46.3
N	North Santa Clara Valley	82.9	74.0	3.8	3.3	71	63.4	3.0	2.7	160.7	143.4
O	Southern Santa Clara County	1.6	1.4	.7	.7	53	47.3	(2)	(2)	55.3	49.4
Total		330.7	295.2	19.3	17.2	594	530.4	19.9	17.8	963.9	860.6

[1]Includes 50 percent of conveyance loss in addition to irrigation water consumed by crops.
[2]Negligible.

SUPPLEMENTAL WATER SUPPLY FOR THE FUTURE

It will be shown in a later section of this report that the firm water supply of the San Francisco Bay region, including imported water, is generally adequate to meet present needs. However, supplemental supply will be required to meet increased demand in the future. The quantitative prediction of future demand is highly speculative and even the basic assumptions for such prediction are subject to much controversy. Traditionally it has been assumed that the growth of population and the attendant production of goods follows the trend established in the past--particularly the immediate past--and an increased or supplemental water supply must be planned to meet the needs of the predicted future development. Recently another school of thought has attained popularity; namely, that the population will always expand to the limit set by the available water-supply facilities, and that by limiting the development of the water supply, the growth of a region can be controlled at some desirable level. Some have set that level at "zero population growth," where the birth and death rates are equivalent. However, even if the goal of zero population growth were immediately adopted, it would require years for stability of the population to be attained--the estimate of the Bureau of the Census in 1970 was 65 years for the United States--and during the transition period the population, and therefore the water demand, would increase.

Supplemental Supply from Surface-Water Sources

The prediction of future population and water demand is outside the scope of this report and we leave such prediction to the demographers and regional planners. This section of the report will merely be a quantitative discussion of supplemental supply for the future from surface-water sources. Those sources will be divided into three categories: projects under construction (as of 1972), projects authorized, and projects whose feasibility has been established by study at the reconnaissance level, but which are as yet unauthorized. Only those projects now under construction are a certainty. The authorized projects are not necessarily funded as yet, and those that are federally funded require detailed engineering study before construction can begin. In the detailed study, projected water demands and environmental impacts are reexamined, and the reexamination may show that the authorized project is actually not economically feasible or is so detrimental to the environment that it should not be built. The third category--projects studied but as yet unauthorized--does not include all projects studied and found feasible, but only those that, in the opinion of the author, have a "reasonable" probability of being built.

The surface-water projects for supplemental supply that are discussed in the paragraphs that follow are shown in figure 3. Table 15 gives the firm yield of those projects. The distribution of supplemental water between local use and export, as shown in table 15 for those projects whose source of water is within the San Francisco Bay region, is tentative at best, and was made to round out the table. If no figures for local use and export are given opposite the project name in the table, it means the project lies outside the boundaries of the indicated subregion and is a source of imported water for that subregion. For reasons explained on page 14, Lake Mendocino releases are considered to be part of the local supply of subregion B, and water transported in the Contra Costa Canal is considered to be part of the local supply of subregion J. By similar reasoning, water transported in the North Bay Aqueduct is considered to be part of the local supply of subregion D.

Projects Under Construction (1972)

1. Lake Sonoma, a reservoir on Dry Creek (Russian River tributary) that is now under construction in subregion B, will have a firm yield of 115,000 acre-feet per year, part of which will be available for export to subregions F and G. The quantities of water for export will depend on the water demand in those subregions. Actually the increased allocation to the San Francisco Bay region will be 103,000 acre-feet per year, because Mendocino County, upstream from subregion B, will be allocated an additional 12,000 acre-feet per year of Russian River water.

Projects Authorized

1. Enlargement of Lake Mendocino, an existing reservoir on East Fork Russian River, 25 miles north of the northern boundary of Sonoma County, has been authorized. By increasing the height of the impounding dam, an additional 74,000 acre-feet per year of firm yield would be provided. Actually, the increased allocation to the San Francisco Bay region would be 72,000 acre-feet per year, because Mendocino County, upstream from subregion B, would be allocated an additional 2,000 acre-feet per year of Russian River water.

2. Knights Valley Reservoir on Franz and Maacama Creeks (Russian River tributaries) in subregion B, would have a firm yield of 45,000 acre-feet per year, part of which would be available for export to subregions C, F, and G. The quantities of water for export would depend on the water demand in those subregions. Actually, the increased allocation to the San Francisco Bay region would be 43,000 acre-feet per year, because Mendocino County, upstream from subregion B, would be allocated an additional 2,000 acre-feet per year of Russian River water.

TABLE 15.--*Firm supplemental supply for the future from surface-water projects*

Subregion	Project	Firm supplemental yield, in thousands of acre-feet per year			Firm supplemental import, in thousands of acre-feet per year
		Total	For local use	For export	
A	None	--	--	--	--
B	Lake Sonoma[1]	103	34	69	
	Enlarged Lake Mendocino[2]	72	38	34	
	Knights Valley Reservoir[2]	43	10	33	
C	Knights Valley Reservoir[2] and Knights Valley Aqueduct[3]				25 (from subregion B)
	North Bay Aqueduct[2]				[4] 13 (from subregion D)
D	North Bay Aqueduct[2]	[4] 67	[4] 54	[4] 13	
E	None	--	--	--	--
F	Lake Sonoma[1]				25 (from subregion B)
	Enlarged Lake Mendocino[2]				34 (from subregion B)
	Knights Valley Reservoir[2]				8 (from subregion B)
G	Lake Sonoma[1] and Sonoma-Marin Conduit[3]				44 (from subregion B)
H	Enlarged Hetch Hetchy Aqueduct[2]				[5] 21
I	Contra Costa Canal (new pumps)[2]				10 (from subregion J)
	Kellogg Reservoir[3]				145 (from subregion J)
	American Aqueduct[2]				[5] 150
J	Contra Costa Canal (new pumps)[2]	20	10	10	
	Kellogg Reservoir[3]	290	145	145	
K	None	--	--	--	--
L	Enlarged Hetch Hetchy Aqueduct[2]				[5] 57
M	Enlarged Hetch Hetchy Aqueduct[2]				[5] 12
N	Enlarged Hetch Hetchy Aqueduct[2]				[5] 22
	Pacheco Tunnel and Santa Clara Canal[2]				[5] 167
O	Pacheco Tunnel and Santa Clara Canal[2]				[5] 43
Total		595	291	304	[6] 776

[1]Project under construction (1972).

[2]Project authorized.

[3]Project studied but as yet unauthorized.

[4]The actual allocation of the 67,000 acre-feet per year is 42,000 acre-feet per year for local use in subregion D and 25,000 acre-feet per year for export to subregion C. However, subregion C now has a firm import of 12,500 acre-feet per year of Putah Creek water from subregion D. When the North Bay Aqueduct is built the Putah Creek diversion will cease and that 12,500 acre-feet of exported Putah Creek water will revert to subregion D. Hence, the change produced by construction of the North Bay Aqueduct will be a net increase of 12,500 acre-feet of water imported by subregion C (25,000 acre-feet minus 12,500 acre-feet); subregion D will have its local supply increased by the 12,500 acre-feet of Putah Creek water which it will no longer export, plus the 42,000 acre-feet it will obtain from the North Bay Aqueduct.

[5]Water is imported from a source outside the San Francisco Bay region.

[6]Of this total, 304,000 acre-feet per year is imported from projects within the San Francisco Bay region and 472,000 acre-feet per year is imported from projects outside the region boundaries.

3. The short section of the North Bay Aqueduct tnat is operative (1970) receives water from Lake Berryessa (Putah Creek) via Putah South Canal in subregion D, and transports the water to subregion C. Following the authorized completion of the North Bay Aqueduct--probably in 1980--the diversion of Putah Creek water to subregion C would cease, and the aqueduct would instead carry Sacramento River water diverted in subregion D. The firm yield of the North Bay Aqueduct would be 67,000 acre-feet per year, 42,000 acre-feet of which would be allocated to subregion D, and the remaining 25,000 acre-feet would be allocated for export to subregion C.

4. An additional pipeline along the present route of the Hetch Hetchy Aqueduct between the Oakdale and Tesla Portals--a distance of 47.5 miles--has been authorized. The additional pipeline would increase the capacity of the water system by 112,000 acre-feet per year.

5. New pumps have been authorized for the Contra Costa Canal in subregion J. These pumps would give the canal a firm yield of 150,000 acre-feet per year, an increase of 20,000 acre-feet per year over its present (1972) firm yield. Of the 20,000 acre-feet per year, approximately half would be allocated to subregion J and the remaining half would be allocated for export to subregion I.

6. The diversion of 150,000 acre-feet of water from the American River (a Sierra Nevada stream) by the East Bay Municipal Utility District has been authorized, its purpose being to meet future demands for water for municipal and industrial use in subregion I. The water would be diverted from the Folsom South Canal (under construction) and conveyed to subregion I in a new American Aqueduct. Folsom South Canal is shown along the upper right-hand edge of figure 3; the American Aqueduct is not shown in figure 3 because the route to be followed by the aqueduct has not yet been determined.

7. The authorized Pacheco Tunnel and Santa Clara Canal would convey Central Valley water diverted from existing San Luis Reservoir, which is outside the San Francisco Bay region (east of southeastern Santa Clara County). Firm yield would be 210,000 acre-feet per year, of which 167,000 acre-feet would be allocated to subregion N and 43,000 acre-feet to subregion O.

Projects Studied But As Yet Unauthorized

1. Knights Valley Aqueduct would convey water diverted from authorized Knights Valley Reservoir in subregion B to existing Lake Hennessey in subregion C. The firm yield of the export to Napa Valley (subregion C) is tentatively set at 25,000 acre-feet per year.

2. Sonoma-Marin Conduit would convey water diverted from the Russian River in subregion B to subregion G. The firm yield of the export to eastern Marin County (subregion G) would be 44,000 acre-feet per year.

3. Kellogg Reservoir in subregion J would give the Contra Costa Canal a firm yield of 440,000 acre-feet per year, an increase of 290,000 acre-feet over the firm yield of the canal with the authorized new pumps installed. Of the 290,000 acre-feet per year, approximately half would be allocated to subregion J and the remaining half would be allocated for export to subregion I.

Supplemental Supply From Less Conventional Sources

The preceding section of this paper discussed supplemental supply from surface-water sources. Alternative methods of meeting increased water demand in the future include the development of water from two less conventional sources--desalination of brackish or salt water, and artificially increased precipitation through weather modification (cloud seeding). Desalination is still in the developmental stage; weather modification is still in the experimental stage. For that reason no attempt will be made to predict the quantities of additional water that those techniques may make possible. Each of the methods is briefly discussed below.

Desalination of brackish or salt water.--Desalination is in limited use in California, but not as yet in the San Francisco Bay region. Additional prototype desalting plants are needed to provide additional factual information on operational characteristics and on capital and operating costs.

Weather modification.--Weather modification, as a means of increasing precipitation, has been studied for about 20 years. In the modification process a nucleating agent, usually silver iodide, is introduced into clouds to induce or increase precipitation. The full effectiveness of the process is still uncertain, but because the cost of cloud seeding is small relative to the possible benefits, it is practiced in many areas in California. In the San Francisco Bay region the only agency with a weather-modification program is the Santa Clara County Flood Control and Water District.

Supplemental Supply Through Conservation Measures

Another alternative method of meeting increased water demand in the future is by the use of such conservation measures as reclamation of wastewater, suppression of reservoir evaporation, conjunctive use of surface and ground water, reduction of per capita use of municipal and industrial water, improved practices in irrigation, and watershed management. Because those measures, other than wastewater reclamation, are not fully developed as yet, they can be discussed only in general terms; our knowledge is insufficient for quantitative estimates of the water they might conserve. Several studies of wastewater reclamation at specific sites in the region are in progress or are planned, but no quantitative data are yet available from those studies concerning the additional water supply that may be produced.

Reclamation of wastewater.--Wastewater reclamation is practiced on a limited scale in the region at present (table 6). However, that practice is certain to increase significantly in the future, if only in response to the more stringent controls that are being enforced on the quality of wastewater effluent that is discharged into streams and other water bodies. In 1970, at least 0.6 million acre-feet of wastewater was discharged from the region. That quantity is equivalent to the total import of water in the region in that same year (table 5). If the reclamation of a significant part of the wastewater is feasible, it will correspondingly reduce dependence on supplemental water from more conventional sources.

Suppression of reservoir evaporation.--There has been considerable experimentation in suppressing reservoir evaporation by spreading a monomolecular film on the lake surface. Several monolayer-forming materials have been tested. However, technical problems exist and work continues on improving the techniques for applying, maintaining, and evaluating the effectiveness of the evaporation-retarding film. A major problem is that of maintaining a film on the water surface in the presence of wind and waves, particularly on the larger reservoirs. The many reservoirs in the San Francisco Bay region, most of them small, have a combined surface area of about 40,000 acres; a conservative estimate of the annual evaporation would be 100,000 acre-feet. If an appreciable part of that evaporation loss could be eliminated, the quantity of water salvaged would be significant, particularly in some local areas. Artificial recharge for storage in ground-water reservoirs will also reduce evaporation loss.

Conjunctive use of surface and ground water.--The use of subsurface storage conjunctively with surface storage to make optimum use of storage facilities is a conservation measure that is practiced widely in Santa Clara County and to a somewhat lesser degree in Alameda County. Conjunctive use of storage requires that surface reservoirs impound streamflow that is then transferred at an optimum rate to ground-water storage. Surface reservoirs can usually supply most annual water requirements, and ground-water reservoirs, generally being many times larger, can be used primarily for cyclic storage covering series of years of subnormal precipitation. There is still much to be learned concerning optimum techniques of applying water for storage underground. In some areas, too, there is a likelihood that artificial recharge of a ground-water basin will raise legal questions as to ownership of the water.

Reduction of per capita use of municipal and industrial water.--Per capita use of water has been increasing over the years, except possibly in some areas where the increase in population density has resulted in a decrease in the outside use of domestic water. There are two courses of action that may be taken to stabilize per capita water use at its present level or even to reduce it. One is by means of a consumer education program; the other is by applying economic pressure. Economic measures include metering water that is now provided unmetered for a flat fee, and changing the price structure of metered water. If, contrary to present pricing practice, the unit price for some basic volume of water was low, but was progressively higher for additional volumes of water used there would be a strong incentive to conserve water. We would probably see less domestic water wasted and more industrial water recycled (reused). Because a large part of the domestic supply is used outside the house for irrigating landscape vegetation, a saving of water can be effected by substituting landscape plants having a low water demand for those that require large quantities of water.

Improved practices in irrigation.--Irrigated agriculture accounts for almost half the water demand and for about 60 percent of the water consumed in the San Francisco Bay region (tables 13 and 14). It would appear that even a small increase in the efficiency of irrigation practices might provide water in sufficient quantity to be an alternative to additional development or use of water from conventional sources. However, in the opinion of most agricultural experts, irrigation practices in the region are such that, in general, little additional water could be salvaged by a change in operational procedures. Although not strictly an irrigation practice, the replacing of crops that are heavy users of water with others having an equivalent benefit but a lighter water use, would conserve water.

Watershed management.--The aims of watershed management in the San Francisco Bay region, as they relate to water conservation, would include the conversion of foothill lands from areas of low water production to ones of higher water production. That would involve the substitution of shallower rooted grasses for the deeper rooted brush which consumes more water. Auxiliary benefits from such conversion would include reduction of the fire hazard and the substitution of vegetation having an economic grazing potential for vegetation having no economic potential. Measures should also be taken to reduce erosion and sedimentation, thereby maintaining or improving water quality.

SUMMARY OF THE WATER-SUPPLY SITUATION

Comparison of Water Supply and Demand--1970 Conditions

Table 16 provides a comparison of fresh-water supply and demand in the San Francisco Bay region under 1970 conditions of development and water use. The dependence on imported water is apparent. The firm supply is about 2.2 million acre-feet per year, almost half of which is imported. The water demand in 1970 was about 1.9 million acre-feet, about half of which was consumed. It should be remembered that in most years the actual supply is greater than the firm supply, the value of the latter being based on the availability of water during a series of dry years.

TABLE 16.--*Fresh-water supply and demand under 1970 conditions of development and water use*

Subregion		Water supply			Water demand (quantity withdrawn)	Water consumed
Identi-fying letter	Name	Local origin	Import	Total		
		Thousands of acre-feet per year				
A	Northwestern Sonoma County	3	0	3	1	([1])
B	Lower Russian River basin	86	0	86	95	55
C	Napa Valley	33	12	45	35	19
D	Solano and eastern Napa Counties	414	0	414	443	278
E	Southwestern Sonoma and western Marin Counties	5	0	5	4	2
F	Novato-Petaluma-Sonoma area	25	9	34	28	13
G	Southeastern Marin County	34	0	34	34	14
H	San Francisco County	5	130	135	111	44
I	Western Contra Costa and northwestern Alameda Counties	27	429	456	312	120
J	Eastern Contra Costa County	222	0	222	204	102
K	Western San Mateo County	12	0	12	17	11
L	Eastern San Mateo County	22	123	145	95	37
M	Alameda Creek basin	91	92	183	112	52
N	North Santa Clara Valley	187	173	360	345	161
O	Southern Santa Clara County	77	0	77	87	55
Total		1,243	968	2,211	1,923	963

[1]Negligible.

This study shows that there is generally ample water for municipal and industrial use throughout the region. A notable exception is the situation in subregion G in southeastern Marin County, where the firm supply for municipal areas is slightly less than the 1970 demand for municipal and industrial water. Although table 16 shows that the total demand in 1970 and the total firm supply in subregion G both equaled 34,000 acre-feet per year, the demand for municipal and industrial water in 1970 was 32,500 acre-feet, whereas the firm municipal supply was 30,000 acre-feet per year. Again, it should be remembered that the supply in most years will exceed the figure for firm annual supply. The existing (1972) distribution system for importing Russian River water is such that the cities of Novato and Petaluma in subregion F could be hard-pressed to meet water demands in the very near future, should those demands increase only moderately over present levels. The difficulty lies in the limited capacity of the section of the Petaluma Aqueduct between Santa Rosa and Cotati; that section of aqueduct now operates at almost full capacity during periods of peak demand.

In the four subregions where the total 1970 demand exceeded the total firm supply--subregions B, D, K, and O--the bulk of the total demand is for irrigation water, and some curtailment of irrigation activities would be necessary should a series of dry years occur before new sources of firm supply are developed. The deficiency in available irrigation supply may be somewhat exaggerated by the figures given in this report because some incidental reuse of excess applied irrigation water (return flow) usually occurs. Above all, it should be remembered that the only precise figures of water quantity in this report are those for the public water requirement in 1970; all other figures represent the best estimates that can be made at this time.

Outlook for the Future

As mentioned earlier, it is beyond the scope of this report to project water requirements into the future. Predictions made by planners as recently as 1965, have been revised downward sharply in accordance with a more recent downward trend in the rate of population increase, and considerable uncertainty now exists concerning future water needs. We merely point out in this section of the report that physical conditions are favorable for increasing the water supply in the future.

Table 15 showed that surface-water projects that are now under construction or authorized, or whose feasibility has been favorably reported, have a combined firm supplemental yield of slightly more than 1 million acre-feet per year. That total amounts to about 50 percent of the firm yield from all sources in 1970. The data in table 15 can be summarized as follows:

Supplemental supply for the future from surface-water projects	Firm yield, in thousands of acre-feet per year		
	Total project yield	For use in subregion where project is located	For import by subregions within the San Francisco Bay region
Water developed in projects within the San Francisco Bay	595	291	304
Water developed outside the region for import to the San Francisco Bay region	--	0	472
Total	--	291	776
		1,067	

The dependence on imported water is again apparent. At this point we might refer to the specific problem of potentially imminent shortages in municipal water supply in subregions F and G, as discussed on the preceding page. One way of eliminating that problem would be to construct the proposed Sonoma-Marin Conduit, but some of the alternative methods that are referred to in the following paragraph should also be considered.

Alternative methods of meeting increased water demand in the future were discussed qualitatively on pages 35-37. Those methods include desalination, weather modification, and various conservation measures. Because the practices described are largely in the experimental or developmental stage, no quantitative data are available concerning the additional water supply that they may make possible. However, the water that may be developed from those practices will correspondingly reduce dependence on supplemental water from the more conventional sources.

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