REPORT ON
YOSEMITE VALLEY WATER SYSTEM
YOSEMITE NATIONAL PARK, CALIFORNIA

Department of Health, Education and Welfare
Public Health Service
San Francisco, California
December 1955

GPO 970213

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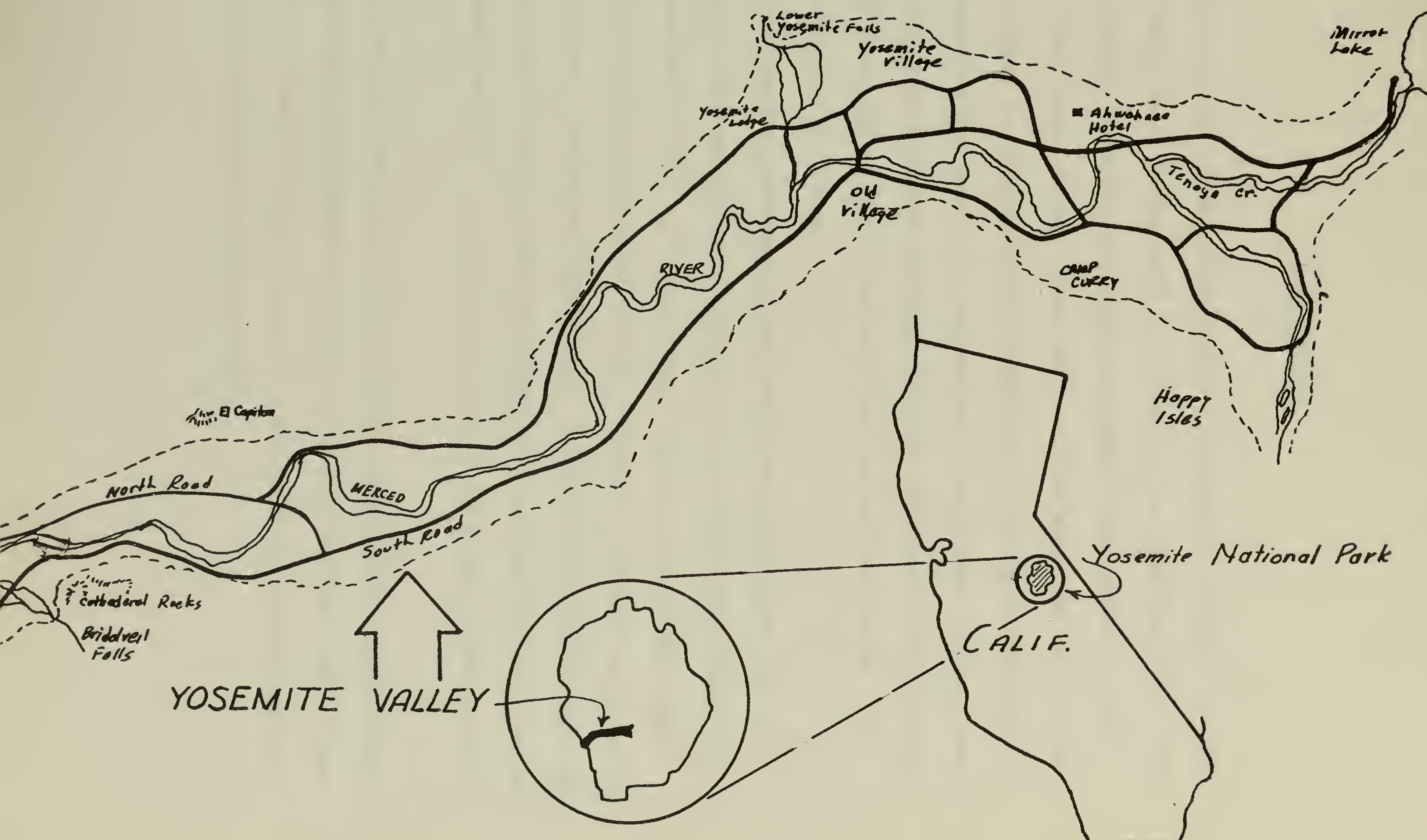

Fig. 1. Location of Yosemite National Park - Yosemite Valley.

GPO 970212

Introduction

For some time National Park Service officials have realized that the Yosemite Valley water system would be in need of some improvement and extension. On several occasions Park Service engineers have started to make studies of the system so that future plans could be made, but due to other pressing matters the studies were not completed. Also the Pacific Fire Rating Bureau has made some field inspections of the system. Several construction projects have been completed in recent years which have improved the Valley water system, but it was felt that the need existed for a complete study of the system.

An interagency agreement of many years standing provides for the furnishing of sanitary engineering services by the Public Health Service of the Department of Health, Education and Welfare to the National Park Service of the Department of the Interior. Early in 1955 the Western Office of the Division of Design and Construction, National Park Service, requested the Public Health Service to make an evaluation of any existing deficiencies and recommend additions to the system to provide for future demands as they may occur.

In June 1955, the Public Health Service assigned Mr. J. Kent Roberts, Sr. Assistant Sanitary Engineer (Reserve) to Yosemite National Park to make the study. At the beginning of his work in the Park, Mr. Roberts submitted the following outline of the proposed study:

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Demand:

1. Obtain domestic water consumption data to determine average, maximum day, and maximum hour demand.
2. Correlate water consumption with population and predict future domestic requirements.
3. Determine possible present and future fire demands.

Source:

1. Analyze present sources of water, both quantitatively and qualitatively.
2. If deemed necessary, study possible new sources of supply.

Distribution System:

1. Make hydraulic analysis of present system to determine its ability to handle present predicted domestic and fire flow demands, including possible extensions to new areas where development is proposed or probable.
2. Determine additions to system necessary to meet any deficiencies and to serve planned new improvements.

Treatment Facilities:

1. Study effectiveness of present water treatment.
2. Determine what may be needed in additional treatment facilities to meet deficiencies and to provide for increased demand.

Conclusions and Recommendations:

1. Summarize above studies and through recommendations present a long range plan for an orderly development of the Yosemite Valley water system.

The outline was submitted to Mr. John Preston, Park Superintendent, and to the Western Office of the Division of Design and Construction for information and comment. Park Service officials concurred with the outline as to content and objectives. Field work was completed in late July 1955.

A preliminary draft of the report was prepared and submitted to the Western Office of the Division of Design and Construction for review and comment. As a result of their review, the WODC requested that a cost estimate covering the proposed improvements to the water supply system be included as a part of the study. Reassignment of Public Health Service personnel prevented preparation of a cost analysis in time to be included in this report. However, cost estimates will be developed in the near future and submitted to the Park Service as a supplement to this report.

Acknowledgements

Grateful acknowledgement is made of the cooperation and assistance of the many National Park Service personnel who gave freely of their time to varied phases of the study and made possible its success.

The Public Health Service is especially indebted to Mr. Luther T. Peterson, Jr., Park Engineer, and Mr. Christof P. Hauck, Park Sanitation Officer. Without the generous help and cooperation of these officials this study would have been much more difficult.

Summary and Recommendations

The valley of Yosemite National Park contains many tourist attractions and developments which draw large numbers of visitors, especially during the summer months. Population estimates divide the population into four clases: daytime visitors; campers; hotel and cabin occupants; and resident personnel. Since each of these classes do not place the same per capita demand on the water system, a use factor has been assigned to each classification of population in order to determine an equivalent population based on water demand.

Over the four-day week-end of July 4, 1955, the population reached 28,400, representing an equivalent population of 16,240. The "long week-end" population is estimated to be 36,500 in 1980, representing an equivalent population of 19,700. Average population in July 1955 was approximately 17,550 (equivalent population 11,300); the water demand averaged about 1.5 million gpd (gallons per day), or 135 gpcd (gallons per capita daily) (equivalent population). Water demand is expected to increase to about 155 gpcd, so the peak domestic water demand can be expected to reach 3.05 million gallons per day by 1980.

The present sources of water are Illilouette Creek and the Merced River with a small spring as an emergency standby. These sources are adequate to meet the domestic demand even during periods of extreme low flow. A settling tank with a capacity of 80,000 gallons provides the only storage, so there is the possibility of not having enough water to meet a major fire demand when the flow in the streams is low.

Stream water is treated by chlorination and plain sedimentation and then flows through the distribution system by gravity. Chlorination is discontinued during winter months. The settling basin is adequate for present flows, except for brief periods following extremely heavy rains upstream, but is not large enough to meet future demands.

Pipes comprising the main network of the system are adequate to handle the necessary fire flow. In several developed areas the fire demand cannot be met due to deficiencies in the pipes which extend from the distribution network to the area. In some areas there is not a sufficient number of fire hydrants.

New Yosemite Lodge buildings are to be constructed in another area just to the southwest of the present structure, and a utility and residential area near Rocky Point is planned.

Recommendations:

To correct deficiencies and to provide adequate service for an anticipated 1980 population the following recommendations are made:

1. Construct a small permanent dam across the Merced River below the water supply intake structure to divert water into the intake during periods of extreme low flow.
2. Provide year-round chlorination.
3. Provide duplicate chlorinators to insure uninterupted sterilization.
4. Provide a master meter on the 18-inch feeder main. Meter preferably to be of the recording type with totalizer.
5. Construct a covered concrete sump for the pumping station at the emergency spring source.

6. Construct, as soon as possible, an addition to the present settling basin about 58 feet square with a water depth of 8 feet.
7. Construct a loop of 6-inch pipe around Camp Curry and connect loop with existing mains. This would require about 2350 feet of asbestos-cement or cement lined pipe. Install 6 fire hydrants in the Camp Curry area.
8. Install approximately 2300 feet of asbestos-cement or cement lined cast iron pipe to and around the Ahwahnee Hotel. Connect existing 6-inch main to new line at the Hotel. Connect existing fire hydrants to new 6-inch loop around Hotel.
9. Construct new 6-inch asbestos-cement or cement lined cast iron pipe to the Stables area and install two new fire hydrants. This would require about 1100 feet of pipe. Interconnect this new line with the present 4-inch pipe.
10. Install two new fire hydrants in the Tecoya area and one in Camp 16.
11. Install about 500 feet of 8-inch asbestos-cement or cement lined cast iron pipe to the new Yosemite Lodge area. Install 3 fire hydrants in the Lodge area.
12. Construct a one million gallon covered storage reservoir on the talus slope just to the west of Indian Creek and interconnect this reservoir with the distribution system by a 12-inch asbestos-cement or cement lined pipe; or

    Construct a one million gallon covered storage reservoir on the talus slope near the beginning of the Four Mile Trail and connect this reservoir to the recommended 12-inch main to the Rocky Point

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development with approximately 2500 feet of 12-inch asbestos-cement or cement lined pipe.

12. Install approximately 10,400 feet of 12-inch asbestos-cement or cement lined cast iron pipe to the Rocky Point development from the end of the existing 12-inch main which is just southeast of the present Yosemite Lodge. About 10 fire hydrants are recommended for the Rocky Point area.

Physical Environment

Yosemite National Park, containing 1,189 square miles, is located in the central part of California's Sierra Nevada range. The canyon of the Merced River, Yosemite Valley, is the most spectacular feature of the Park with its nearly perpendicular walls towering an average of 3,000 feet on either side of the nearly level valley floor and being graced by numerous waterfalls. Yosemite Valley proper is about one mile wide and 5½ miles long.

Yosemite Valley contains a concentration of housing, stores, living facilities, campgrounds, hotels, offices and tourist attractions. These developments and attractions draw a large number of visitors whose number reaches a peak in the summer season. This large number of visitors and the concentration of buildings has placed heavy demands on the roads and utilities of the Valley. The large influx of tourists starts with the week of Memorial Day in May, rises to a peak in July, and ends rather abruptly at the end of the Labor Day week-end. The number of Park visitors reaches extreme peaks when Memorial Day, or July 4, falls on a Friday or Monday, thus creating a three-day week-end.

In the Valley there are seven free (except for Park automobile entrance fee) public campgrounds operated by the Park Service, and two campgrounds for employees. The general concessioner is the Yosemite Park and Curry Company, which operates the Ahwahnee Hotel, Camp Curry, Yosemite Lodge, Stables, and various stores. Both the Park Service and the concessioner have employee residential areas.

Future developments for the Valley now in the planning stage include: concessioner's utility and residential area at Rocky Point; abandonment of Old Village Area and development of similar facilities in the New Village Area; and construction of a new Yosemite Lodge immediately southwest of the present location.

Climate

TABLE 1

CLIMATOLOGICAL SUMMARY FOR YOSEMITE NATIONAL PARK, PARK HEADQUARTERS STATION, MARIPOSA COUNTY, CALIFORNIA

Elevation: 3,983 feet Latitude: 37°45'N. Longitude: 119°35'W

	Temperature - Degrees F					Precipitation - Inches		
Month	Highest	Mean Daily Maximum	Mean Daily	Mean Daily Minimum	Lowest	Greatest Monthly	Mean	Lowest Monthly
Jan.	66	46.1	35.0	23.7	-6	24.62	6.57	0.95
Feb.	81	52.6	39.6	26.4	1	19.53	6.58	0.18
March	90	60.0	44.9	29.8	9	20.98	5.28	0.61
April	96	67.0	50.9	34.8	12	9.73	2.84	Trace
May	99	72.9	56.2	39.8	15	7.90	1.46	0.00
June	103	81.4	63.2	45.0	22	3.13	0.67	0.00
July	104	90.2	70.6	50.9	33	1.36	0.19	0.00
August	110	89.5	69.4	49.1	31	1.36	0.19	0.00
Sept.	103	82.4	62.8	43.2	24	7.09	0.80	0.00
Oct.	96	72.0	53.9	35.7	19	10.71	1.96	0.00
Nov.	85	58.6	43.4	28.2	10	11.96	2.94	0.00
Dec.	72	47.5	36.1	24.8	-1	16.79	5.61	0.23
Annual	-	68.4	52.2	36.0	-	-	35.09	-

Note: Above Table based on approximately 40 years of record.

The climatological summary shown in Table 1 gives an insight to important factors affecting the water supply system. It will be noted that the summer months are hot and dry, with a maximum temperature of 110 degrees and

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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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practically no rainfall. The combination of low rainfall, heat, and the sandy nature of the soil leads to an abundance of lawn and garden irrigation.

Population

Figure 2 shows the history and indicated trend of annual visitors to the Park. An inspection of the record over the period of years discloses that the number of visitors tends to increase, even though there are temporary setbacks during periods of national emergency. In view of the very consistent increase, the straightline extension prediction is considered as reliable as any method of population prediction and shows a 60% increase in the number of annual Park visitors by 1980.

Since the Valley water system only serves the population living and visiting on the Valley floor proper, the number of visitors to the Park does not give the necessary information for analysis. The area of the Valley is definitely limited by the canyon walls and the present policy of the Park Service is to allow no increase in the Valley facilities which would increase the Valley population. In fact there is a trend in Park policy which would actually decrease the number of people who may obtain campground accomodations.

In view of the desire of an obviously increasing number of people who wish to use the Park, it is questionable as to whether the Park Service will be able to maintain this policy of discouraging expansion. Examination of a topographic map and field inspection reveals that there are suitable areas toward the west end of the Valley where additional campgrounds might be constructed and very probably will be built in response to public demand.

However, the Valley population is approaching a saturation level due to the lack of additional space; so it cannot be expected to increase to the extent that is indicated by the total number of Park visitors.

In order to estimate the Valley population 25 years in the future for the purpose of determining future domestic water consumption, the following assumptions are made:

1. Because of Park policy the number of persons obtaining hotel and cabin accomodations with the Yosemite Park and Curry Company will be held to the present 4,000.
2. The number of resident personnel will increase 25 percent from 2,000 to 2,500 to take care of the increased number of Park visitors.
3. The peak camper population will increase approximately 25 percent from 16,000 to 20,000 as additional campground facilities will be opened in response to demand.
4. Daytime visitors will increase 67 percent from the present 6,000 to 10,000, the percentage increase indicated by Figure 2 in regard to total Park visitors.

As shown in Table 3 this will give an estimated total peak Valley population of 36,500 over a "long" 4th of July week-end in 1980.

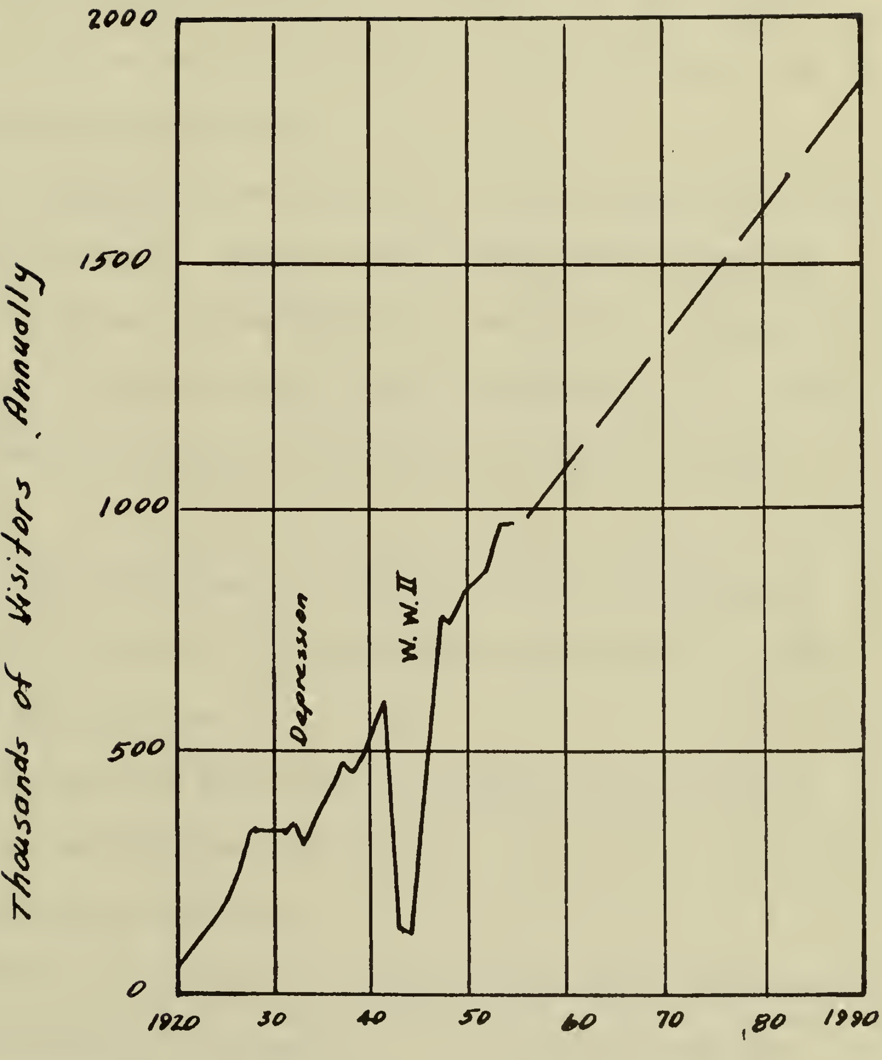

Fig. 2. History and indicated trend in visitors to Yosemite National Park.

Existing Water System

Yosemite Valley receives its water from Illilouette Creek and the Merced River. Two 18-inch cast iron pipes, one from each source, lead from screened concrete intake structures and take the water from the streams near their confluence just southeast of the east end of the Valley floor to an 80,000 gallon concrete settling tank.

Water is drawn exclusively from Illilouette Creek so long as its flow is sufficient to meet the demand. As the summer season advances and the flow drops off in the Illilouette, the intakes on the Merced are opened to make up the deficiency. Illilouette Creek water is preferred as it is from an uninhabited watershed and is thus of better quality from a sanitary standpoint.

Flow of water from the sources is controlled by manually operated valves by the operator who checks on the installation twice daily in the summer and once daily in the winter.

In the event of fire, Park employees are charged with the responsibility of going to the settling basin and opening up the intake valves if necessary to keep the settling tank full.

Water is drawn into the reservoir by gravity in a sufficient volume to insure a constant excess over the demand. All of the intake can be chlorinated and the excess water goes to the river. The settling basin provides for chlorine contact, plain sedimentation, and the only storage on the system. This is a concrete, uncovered surface tank, and obviously

too small for storage requirements. The settling basin can be bypassed and water from either or both sources can be placed directly into the distribution system without treatment of any kind.

From the settling tank the water is drawn by gravity to the vicinity of Happy Isles footbridge in an 18-inch cement lined cast iron feeder main which was placed in service in 1950.

From the end of the 18-inch feeder main water is distributed over the Valley floor by a network of cast iron and asbestos-cement pipes. A map showing the location of the water mains and other features of the Valley is presented in Plate I. Two 8-inch cast iron pipes extend from the Happy Isles Junction to the west end of Camp Curry. The main that is the more southern of the two was laid in 1912, while the northern pipe was laid in 1921. Just west of Camp Curry these two 8-inch mains join together and from this junction one 8-inch pipe, used since 1912, extends west through the Old Village area to Yosemite Lodge; while another, in place since 1922, crosses the creek in the vicinity of Stoneman Bridge and extends through the Tecoya area to the New Village and the Government Center. From this latter 8-inch line, starting near Stoneman Bridge, a 6-inch cast iron pipe goes to the Ahwahnee Hotel.

A 12-inch asbestos-cement pipe extends from the 18-inch feeder at Happy Isles to a point just southwest of the Government Center where it joins the 8-inch main from Camp Curry. This 12-inch asbestos-cement pipe was laid in 1938 and is tapped by a 4-inch connection which leads to the stables. It is also connected with the 6-inch line to the Ahwahnee at their point of crossing, and connected with the 8-inch line from Camp Curry by an 8-inch line in the vicinity of the New Village. A loop of 8-inch pipe and several

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small lines run from the Government Center around through the residential area and rejoin at the end of the 12-inch asbestos-cement pipe. From this junction just southwest of Government Center a 12-inch cement lined cast iron pipe extends to the east side of the Yosemite Lodge area. Just north of the Superintendent's house it is crossed by and connected with the 8-inch cast iron pipe which extends from the Old Village to Yosemite Lodge. From the end of the 12-inch cast iron main an 8-inch cement lined cast iron main continues to a dead-end through the Yosemite Lodge cabin and tent area.

There are numerous short pipes of 2, 4, and 6-inch sizes which serve areas not immediate to the mains.

There are 51 double $2\frac{1}{2}$-inch outlet fire hydrants on the network of mains and shown on Plate I. In addition, there are numerous 2-inch wharf type hydrants which are connected to 2 and 4-inch pipes maintained by the concessioner.

Each of the two swimming pools, one at Camp Curry and the other at Yosemite Lodge, has in place a 4-inch pipe arrangement so that in a necessity fire truck pumps can draw water from this storage.

A spring located to the southwest of Happy Isles is connected by an 8-inch cast iron pipe to one of the 8-inch mains, so that in event of emergency spring water can be used. A check valve on the spring supply line prevents spring water from entering the system so long as the elevation of the hydraulic grade line of the system is above the elevation of the spring. This spring is actually more of an infiltration gallery consisting of buried radial tile pipes which feed water into two covered concrete spring chambers. From these chambers the water can flow by gravity to the Valley distribution system, or to an underground, wood-lined and covered sump.

To provide for higher pressure than would be possible by gravity, two electric motor-driven centrifugal pumps are provided and draw water from the sump and discharge to the system. The capacity of both pumps totals about 250 gallons per minute.

Water Demand

Domestic Requirements

There are intake and overflow weirs with corresponding staff gages on the settling basin so that water demand at any time may be determined. It has been the practice to record these gage readings twice daily. Since the rate of use changes throughout the day these gage readings can be used only as a guide to determine the water demand. Also these gages seem to have slipped, as they do not read zero at no flow.

So that water use records in the future can be obtained, a recording meter should be installed in the 18-inch feeder main between the settling basin and Happy Isles. This meter should contain, in addition to the recording apparatus, a "daily totalizer."

In order to determine the water demand characteristics, recording water-stage indicators were installed on June 24, 1955, and a continuous record of water use was obtained from that date until August 12, 1955, when the recorders were removed. The demand characteristics of a typical summer day are shown in Figure 3. During July 1955, water consumption averaged 1.549 million gallons daily, or approximately 1,000 gallons per minute.

The population of the Valley is constantly changing and is unknown except for estimates made each Sunday by the Park Rangers. These estimates divide the population into four classes: daytime visitors; campers; hotel and cabin occupants; and resident personnel. It is logical that each of these classes will not place the same per capita demand on the water system.

There has been assigned a use factor to each classification of population in order to determine an equivalent population based on water demand. In order to obtain a numerical value for these use factors, the factor for resident personnel was assumed as unity and estimates made of comparitive amounts of water used by the other classifications. These factors were arrived at after consultation with Park Officials. These use factors are shown in Table 2, along with population data for a typical Sunday in summer.

Water consumption on this typical Sunday amounted to 1,512,000 gallons; so using the equivalent population of 11,300 the water demand can be stated at 135 gallons per capita daily (equivalent population).

TABLE 2

EQUIVALENT POPULATION - TYPICAL SUMMER SUNDAY - 1955

Class of Population	Use Factor	Population	Equivalent Population
Daytime Visitors	0.2	2,000	400
Campers	0.6	9,710	5,830
Hotel & Cabin Occupants	0.8	3,840	3,070
Resident Personnel	1.0	2,000	2,000
Totals:	-	17,550	11,300

As mentioned above, the peak domestic consumption can be expected when July 4th falls on a Friday or a Monday, causing a "long week-end" of three days. Observations of water use made during the long 4th of July week-end in July 1955, and later in the summer show another axiom of water demand: that is, the higher the temperature the higher the demand. The weather was

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cool (daily high temperature of 76°F) over the week-end of July 4, 1955, and a high equivalent population of 16,240 was experienced in the Valley. Water consumption amounted to an average of 1.549 million gallons daily; or, stated differently, about 95 gallons per capita daily (equivalent population). Later in the summer when the weather had warmed considerable (daily high temperature in the upper eighties), the water consumption increased to 145 gpcd based on estimates of population. This would indicate that had the temperature been higher during the July 4th week-end the water consumption probably would have been about 50 percent greater.

TABLE 3

EQUIVALENT POPULATION FOR JULY 4TH "LONG WEEK-END"

Class of Population	Use Factor	Estimated 1955		Estimated 1975-1985	
		Pop.	Equiv. Pop.	Pop.	Equiv. Pop.
Daytime Visitors	0.2	6,000	1,200	10,000	2,000
Campers	0.6	16,400	9,840	20,000	12,000
Hotel & Cabin occupants	0.8	4,000	3,200	4,000	3,200
Resident Personnel	1.0	2,000	2,000	2,500	2,500
Totals:	-	28,400	16,240	36,500	19,700

The present average hot weather consumption of approximately 135 gallons per capita daily will in all probability increase as time goes on. Without a doubt a goodly number of the cabins without bath operated by the concessioner will be replaced as they deteriorate beyond repair by cabins with bath, and thus increase somewhat the per capita water demand. The estimated peak water consumption is 155 gallons per capita daily (equivalent population).

By multiplying the 155 gpcd estimate by the 19,700 equivalent population estimate shown in Table 3, the future maximum daily domestic water demand is computed as 3.050 million gallons daily or about 2,110 gallons per minute.

The National Board of Fire Underwriters expects that a water system will meet the domestic water demand at the average rate of the maximum day of the year, plus the fire demand. For the purpose of estimating future domestic requirements in the several areas of development in the Valley, meter readings for the month of July 1954, were obtained and are listed in Table 4. In some areas there are no meters, so the demands listed were estimated by Park Officials. Figure 3 shows the variations in water demand and the average daily rate of consumption during a typical summer day in 1955 and the estimated maximum day in 1980.

Fire Requirements

One of the principle reasons for the existence of a water supply system is the fire protection which it affords. This fire protection adds to the cost of a small distribution system such as the Valley system, because the pipe sizes must be larger to handle the fire flows. In municipally owned water systems this added cost is returned to the taxpayers in the form of reduced fire insurance premiums on their property. In the case of privately owned systems the added cost must be returned to the water company owners by increasing the cost of the water to the consumer.

The Pacific Fire Rating Bureau made an inspection of the water system and the buildings in the Valley in 1950, and a reinspection in 1953. Based

TABLE 4

WATER DEMAND BY DISTRICTS

District	Typical Summer Day 1955		Estimated		
	Demand (gpd)	Average (gpm)	Max. Day Average Rate (gpm)	Fire Demand (gpm)	Duration of Fire (Hours)
Campgrounds:					
No. 4	9,800*	7	10		
No. 6	36,800*	25	36		
No. 7	41,400*	29	42		
No. 9	2,700*	2	3		
No. 11	66,200*	46	66		
No. 12	26,700*	16	23		
No. 14	83,200*	58	84		
No. 15	24,900*	17	25		
No. 16	33,800*	23	28		
Yosemite Village (Government Center)	250,400*	175	250	1,750	1½
Residential Area (Government)	243,200*	170	245	1,000	1½
Maintenance Yard (Concessioner)	15,000	10	14	1,500	2
Hospital	15,000	10	14	1,250	2
Stables	31,700	22	32	1,500	2
Camp Curry	93,000	65	94	3,000	3
Old Village	29,000	20	29	2,000	2
Ahwahnee Hotel	108,700	75	110	1,750	2
Tecoya Group	103,000	72	105	2,250	2
Yosemite Lodge	111,300	78	110	1,750	2
Army Row & Indian Village	116,000*	81	120	750	1½
Rocky Point (Proposed Development)	-	-	15	1,750	2
Miscellaneous Areas and New Camp Facilities	107,200	75	655	-	-
Totals:	1,549,000	1,076	2,110	-	-
(*Estimated)					

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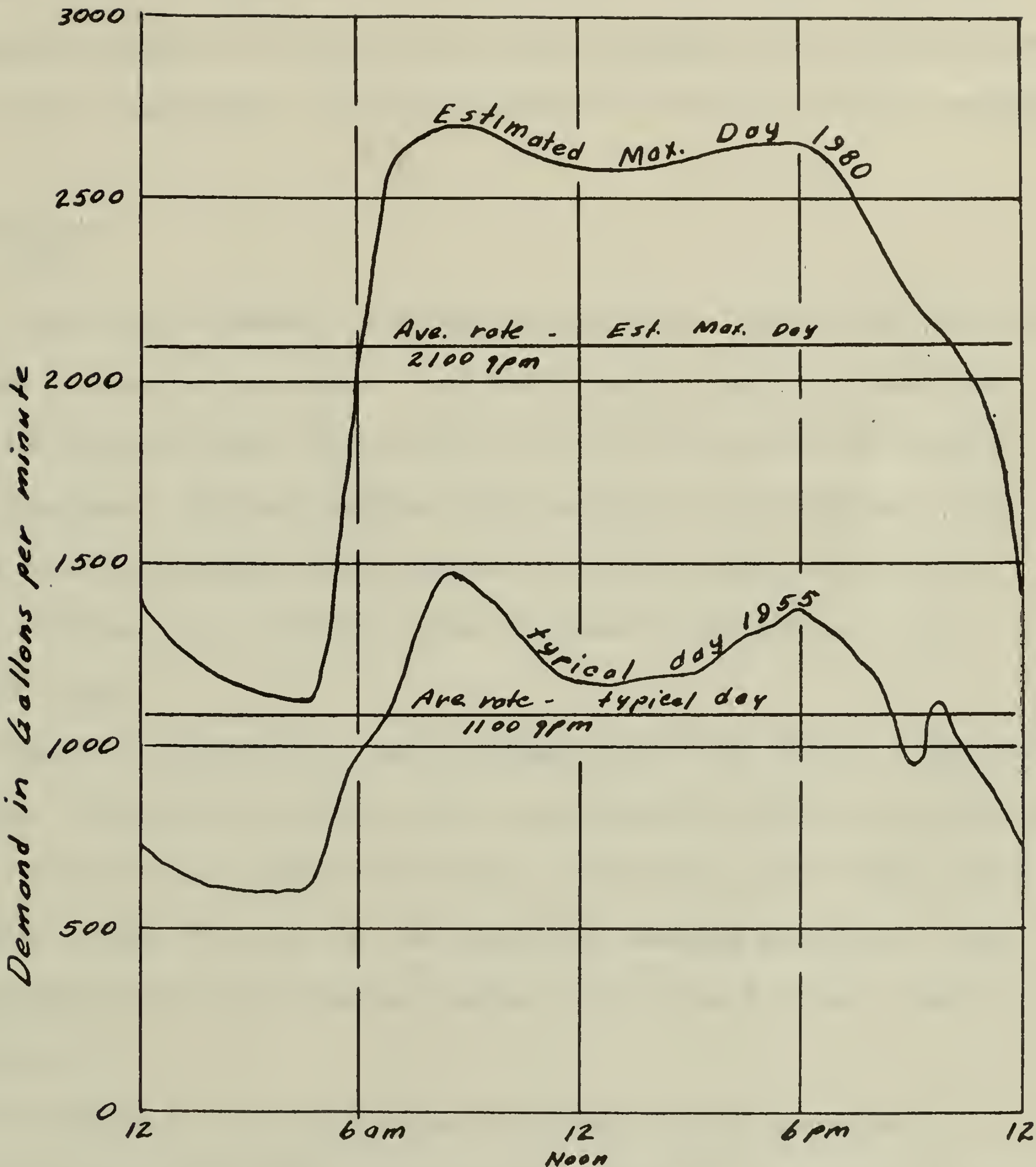

Figure 3. Daily Variations in Demand.

on these inspections the Bureau has recommended provision for fire flows for specific areas as shown in Table 4. These recommendations represent the maximum in fire protection and the flows indicated very likely would never be approached because of limited fire fighting equipment and trained personnel. Flows of about two-thirds of those recommended are the more probable maximums.

Water Wastage

There is no evidence to indicate any unusual or unreasonable losses of water due to leaks in the mains. Such leaks, however, might go unnoticed due to the pervious nature of the soil and the fact that there are several stream crossings. Pressure readings were recorded at the junctions of the various mains periodically during the course of this study, and the subsequent plotting of the hydraulic grade line gave no indication of any excessive leaks.

Water is distributed to the government residential area at a flat rate per house, and metered wholesale to the concessioner's employees residential area. This flat rate coupled with the dry, hot weather in the summer tends to produce a water waste by the lawn and garden watering practices. Some lawn sprinklers have been observed running at full rate for over a week in the same spot.

The museum in Yosemite Village (Government Center) maintains a botanical garden which uses a large amount of water in its artificial spring and irrigation creek, in addition to hoses and sprinklers. This volume has been measured at 250,000 gallons per day or a rate of 175 gallons per minute. A goodly portion of this water is actually waste as it flows through the garden and out; the excess is useful only for esthetic effect. In view

of the purpose of the Park and the museum, it is doubtful that the water used in the garden, even for esthetic effect alone, should be considered as a waste.

Numerous drinking fountains throughout the Valley and urinals in comfort stations run continuously and add to the water wasted.

In view of a plentiful supply of good water, with practically no treatment cost and no pumping cost, the water waste described in the previous paragraphs is not as serious as it might be in other situations, as the only cost of this wasted water is the extra chlorine used.

In case of a water shortage, which has occurred in an extremely dry year and usually in the fall, water conservation measures stopping water wastage are advisable and possible.

Sources of Supply

Surface Supply

Both the Merced River and the Illilouette Creek provide a good supply of water for the Valley. As can be seen from the chemical analysis shown in Table 5, the water is soft and contains no objectionable mineral or chemical constituents.

TABLE 5

CHEMICAL ANALYSIS, YOSEMITE PARK WATER - 1950

Conductivity ($KX10^{-5}ohm^{-1}$)	2.9
pH	7.1
Total Solids (calculated)	22
Silica (SiO_2) (colorimetrics)	4
Sodium (Na)	4
Calcium (Ca)	1.6
Magnesium (Mg)	0.5
Iron, dissolved (Fe)	0.01
Aluminum (Al)	0
Manganese (Mn)	0
Boron (B)	0.1
Fluoride (F)	0
Carbonate (CO_3)	0
Bicarbonate (HCO_3)	8.5
Sulphate (SO_4)	1
Chloride (Cl)	6
Nitrate (NO_3)	0.03
Hardness, Versonate	6
Alkalinity ($CaCO_3$)	8

Notes: (1) Calcium and magnesium values obtained using versonate method. Sulphate and sodium values were calculated.
(2) Chemical analysis made by San Francisco Water Department Laboratory.
(3) Results reported in parts per million.

Bacteriological tests of the raw water made in June and July of 1955 indicate a small amount of contamination. The watersheds of the streams are used by the public and are the home of both large and small game. This contamination is probably of animal as well as human origin. Watershed use by the public makes it obligatory that adequate chlorination be practiced continuously.

The Surface Water Branch of the U. S. Geological Survey has maintained a stream gaging station downstream from the water intake on the Merced River at Happy Isles Bridge near Yosemite since 1915. The records of stream flow have been published annually since that time in the Geological Survey Water Supply Papers in Part II, Pacific Slope Basins in California. These records were examined and it was noted that the minimum flow of record was 1.5 cfs on September 30, 1926. Further examination reveals that in a general way flows are high during the early summer months, dropping gradually to the lowest flows in late September or October.

There is little doubt that the combination of flows from the Illilouette Creek and the Merced River will be adequate to meet both domestic and possible fire flows during the peak demand summer months. In dry years, however, the stream flow in September, October and November have at times become dangerously low. This happened in 1954, and a sand bag dam was necessary to divert enough water to maintain an overflow in the settling basin. This overflow was considered necessary in order to provide for possible fire demand. Fortunately this period of low stream flow occurs at a time when the population of the Valley is rather low, so that the major demand for water is irrigation (which can be restricted) and possible fire flows. Adequate reservoir capacity would eliminate the fire danger during this period of low stream flow.

[illegible]

[illegible]

[illegible]

Spring Supply

The spring which can be used as an auxiliary source of supply has a rather limited volume of flow compared to the demand of the Valley and is not intended to supply more than an emergency domestic need. It is used infrequently. As the head available from this source is low, pumps are used to draw the water from a sump and discharge it to the system. The capacity of the pumps is about 250 gallons per minute and the spring produces just slightly more than that amount. Bacteriological tests made in July 1955, indicate that the water from the spring was free of any contamination at that time.

If the spring is to be left interconnected to the Valley system, it is recommended that the water be protected by providing a concrete covered sump to eliminate possible surface contamination. The spring is already so protected.

Treatment Facilities

Due to the very good quality of the water from the sources, there is need for very little treatment. The water usually contains very little suspended material, has no objectionable chemicals, and has only a slight bacteriological contamination. Since the water contains a very low concentration of bicarbonates, the water is quite soft and exhibits a corrosive tendency.

The only treatment necessary at this time is plain sedimentation and chlorination. The installation of cement lined cast iron or asbestos-cement pipe is recommended for the control of corrosion in the distribution system.

The present chlorination facilities consist of a Wallace and Tiernan manually controlled dry feed chlorinator. The chlorinator and appurtenances are housed in a small shed located at the inlet end of the settling basin. Chlorine is applied by direct feed through a diffuser plate located in the inlet chamber of the settling basin. It is the practice to remove the chlorinator during the winter months so that the water does not receive chlorine for a period of several months. The thought behind this move is that the watershed is not populated, so no danger exists.

It is recommended that a new direct feed chlorinator be provided and that the existing chlorinator be used for standby service. Chlorination should be practiced continuously, even during the winter months. Winter operation will require that the units be housed in an insulated and heated building.

The existing sedimentation basin is adequate for present flow, except for brief periods when the turbidity of the river water rises due to severe thunderstorms at the higher elevations. When these storms produce rains of "cloudburst" intensity the suspended material increases tremendously and is of a lighter nature than the usual turbidity. Under these conditions the settling basin is inadequate and the water is not drinkable or suitable for normal domestic purposes. This extremely high turbidity lasts for only a few hours. While this occurrence is infrequent, happening only once in about four or five years, it is serious at the time, and a simple solution to the problem is available which fits in with other needed improvements in the system.

Increased sedimentation facilities will be needed to handle the expected future demand and more adequate storage structures are necessary for both domestic and fire purposes.

To give more detention time for sedimentation and provide additional storage, an addition to the present settling tank is recommended. This new tank should be square in plan and attached to the southwest side of the existing tank. The size suggested is 58 feet by 58 feet by 8 feet deep, corresponding to the length and depth of the existing tank. The present tank should have a baffle wall constructed in the first chamber to divert the inflowing water to the side, then to the new tank. The holes in the diversion wall between the two present chambers should be closed and holes made in the walls between the present and new basins. A sketch of the proposal is shown in Figure 4.

This proposed addition to the settling basin would provide approximately 200,000 gallons capacity for storage and would provide for a total

detention period of a little over two hours at estimated ultimate peak demand rates. The 280,000 gallon total storage in the settling basins would go a long way toward providing fire protection storage, and the two hour detention period would be more adequate for sedimentation. Should this increased detention period prove inadequate during the extreme conditions of turbidity, additional reservoir capacity (recommended in another place in this report) would allow the intakes to be closed and the demand met for a few hours by using water from storage.

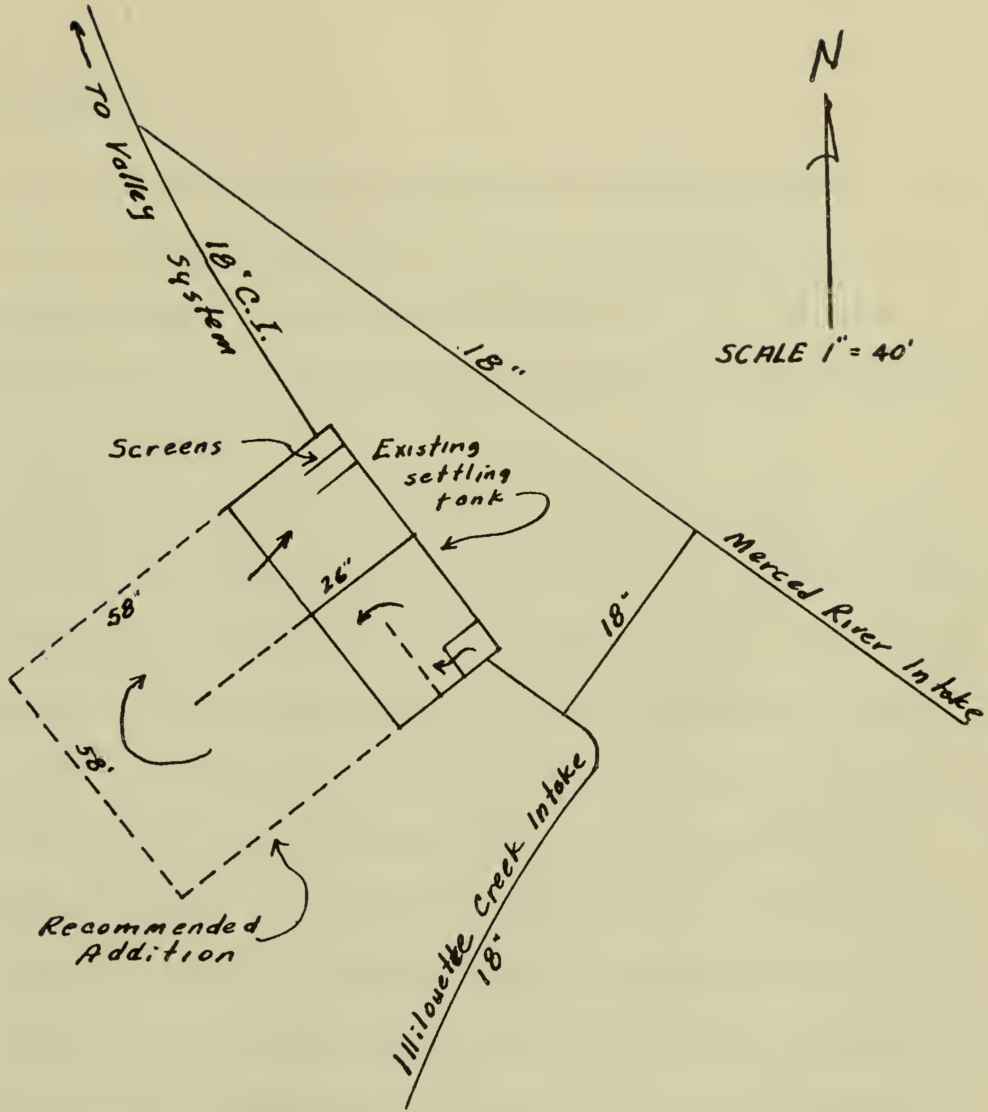

Fig. 4 Plan of Treatment Facilities.

Distribution System

Present Network Analysis

During this study measurements of pressure at various points of the distribution system indicate that the mains are entirely adequate to care for the peak domestic demand. The pressures varied from about 60 to 80 pounds per square inch all over the Valley during periods of heavy domestic flow.

Since it was not considered feasible (or possible in some cases) to actually draw water from the system at the rate necessary to simulate actual fire flows, the hydraulics of the system were studied using the Hardy Cross method of analysis. The purpose of this analysis was to determine operating pressures under a combination of domestic and fire flows. Domestic flows used in the analysis were the average rate of the maximum day as estimated and listed in Table 4. The fire flows used were two-thirds or more of those listed in Table 4. The Camp Curry and Yosemite Lodge areas were the only ones used at the two-thirds level. In all cases the resulting pressures computed by the analysis were in excess of 20 pounds per square inch, which is the minimum acceptable to the Pacific Fire Rating Bureau. From the above hydraulic analysis the conclusion is reached that the principle network of mains is entirely adequate to accomodate the predicted future domestic and fire demands of the Valley.

In order to determine the internal conditions of the pipes in place since 1912 and 1921, so that the coefficient for the Hazen-Williams formula

would be known, a pitot meter was used. Actual velocities in the pipe were measured with the pitot meter and the discharges computed; at the same time pressure readings were taken at the ends of the pipe under study. The Hazen-Williams coefficient was found to be 82 for both ages of pipe. Coefficient for the asbestos-cement and cement lined cast iron pipe was assumed to be 140.

While The principle network has an adequate capacity, the pipes which furnish water from the network to several areas of developments would be seriously overtaxed in the event of a major fire. These deficient areas are Camp Curry, Stables, Ahwahnee Hotel, and Yosemite Lodge, and new service lines of sufficient size to handle fire flows should be constructed to serve them. Also new fire hydrant installations should be made on existing mains in the Tecoya and Camp 16 areas.

Additions Needed to Meet Deficiencies

Camp Curry - It is recommended that a loop of 6-inch asbestos-cement or cement lined cast iron pipe be installed to surround the main buildings. The ends of this loop to be connected to both of the 8-inch mains in front of Camp Curry. Also, connect the southwest corner of the loop with the 6-inch main to the west. Four 6-inch fire hydrants located on the loop at the approximate corners of the main group of buildings, and another 6-inch hydrant about half way between the loop and the existing 6-inch main, are recommended. In addition a 6-inch hydrant should be installed just off the 8-inch mains near the Curry Garage; the mains should be interconnected at this point.

The installation of these recommended additions will provide for flows in this area of 2,200 gallons per minute with pressures remaining slightly above 20 pounds per square inch.

Stables - In order to meet the possible fire demand of 1,500 gallons per minute in the stable area, a 6-inch asbestos-cement or cement lined cast iron pipe from the 12-inch main in Camp 14 is recommended. This new line should be connected to the present 4-inch line near the stables and two 6-inch hydrants should be installed on the new line.

Ahwahnee Hotel - A new 6-inch asbestos-cement or cement lined cast iron pipe is recommended for installation between the 12-inch main in Camp 15 and the Ahwahnee Hotel, which together with the present 6-inch line to the hotel will be adequate for flows up to 1,750 gallons per minute. This new main should be connected with the existing line near the hotel and the present 4-inch pipe loop around the hotel should be replaced with a 6-inch loop.

Yosemite Lodge - Since the existing Lodge is to be replaced by new structures in another location just southwest of the present position, no recommendations are being made to eliminate the deficiencies in this area.

Additions to Serve New Areas

The only new areas of development planned at the present time are the concessioner's utility and residential area in the vicinity of Rocky Point and the New Yosemite Lodge.

Rocky Point - According to the Master Plan Development Outline the Rocky Point area will consist of:

30,000 square feet of warehousing space

60,000 square feet of vehicle storage

30,000 square feet of shop space

5 single dwellings

13 apartment units

1 dormitory for 26 employees

1 garage space for 20 cars

3 duplex sites (for Telephone Company employees)

Additional sites for future expansion

It is estimated that the probable fire demand for this area will be 1,750 gallons per minute for two hours duration.

To provide for the fire and domestic demand the three plans outlined below were considered:

1. Well or infiltration gallery near the Merced River with 200,000 gallon storage reservoir. Pumps to raise water from source to reservoir for gravity distribution.
2. 200,000 gallon storage reservoir supplied by 6-inch pipe from existing Valley network and source.
3. 12-inch asbestos-cement or cement lined cast iron pipe connected to Valley network at the end of the existing 12-inch main near Yosemite Lodge. Use reservoir capacity same as rest of system.

The third of these plans was selected for recommendation, as it presented the best long-run economy and offered more simple and foolproof operation.

Within the proposed development area about 10 fire hydrants and some smaller water pipe will be necessary to provide adequate protection; exact location of these will depend on final layout of the area.

New Yosemite Lodge - The new Lodge facilities will replace the present Lodge and will use approximately the same volume of water.

The area can adequately be supplied by a dead-end 8-inch line from the existing 8-inch main lying just south of the area. Three fire hydrants on this 8-inch line will be needed to meet the fire demand. Although not necessary, connecting this new 8-inch line with the recommended 12-inch feeder to Rocky Point will improve the system.

Reservoir

The most serious shortcoming of the entire present system is the lack of storage.

The recommended addition to the settling basin, by providing an additional 200,000 gallons of storage, will help to solve the storage problem, but is not considered to be sufficient.

It is recommended that a one million gallon capacity covered storage reservoir be constructed on the surface of a talus slope and connected to the distribution network. This reservoir should be built at about the elevation of the settling tank so that at periods of low demand water will flow into storage and flow out to the system when the demand is high. This would allow water to be drawn into the settling basin at a lower rate, which would be of value during periods of extreme low stream flow.

The capacity necessary to allow for this continuous inflow in 1980 is estimated to be 500,000 gallons. Due to the unusual type of developments in the Valley, the usual recommendations (based on populations) of the National Board of Fire Underwriters regarding the necessary storage for fire will not apply. By assuming a maximum fire demand of 2,000 gpm and allowing for a total duration of 5 hours, the necessary fire storage is computed as 600,000 gallons. This would total 1,100,000 gallons of required storage. In addition

to these usual needs for storage, the possibility of the settling tank not being able to remove the extreme turbidities experienced due to thunderstorm rains gives a need for some additional storage. It is improbable that maximum domestic and fire demand will occur during the few hours that it might be necessary to utilize stored water due to turbidity difficulties, and the total recommended storage capacity of 1,280,000 gallons is considered satisfactory and reasonable.

The reservoir could be constructed of either steel or concrete. Post-tensioned or pre-stressed concrete might very well prove the more economical.

Two locations for the reservoir are presented - one just northeast of the Government Center near Indian Creek, and the other toward the west end of the Valley on the talus to the south of the Giant Yellow Pine area. The Indian Creek site is recommended because being closer to the center of demand it meets the hydraulic requirements better. While this portion of the Valley is in direct sight of Glacier Point, it is believed that the reservoir could be partially buried, screened by trees, and camouflaged to such an extent that most viewers from Glacier Point would never see it, and the hydraulic advantages outweigh the esthetic deficiencies.

The alternate site to the west near the beginning of the Four Mile Trail to Glacier Point will be satisfactory. However, its remoteness from the center of demand and the resulting hydraulic head losses make it less desirable than the Indian Creek location.

The Indian Creek reservoir should be connected to the distribution network by a 12-inch asbestos-cement or cement lined cast iron pipe at a point just south of the New Village area.

The Four Mile Trail reservoir would be connected by a 12-inch line to the recommended 12-inch pipe leading to the proposed Rocky Point development.

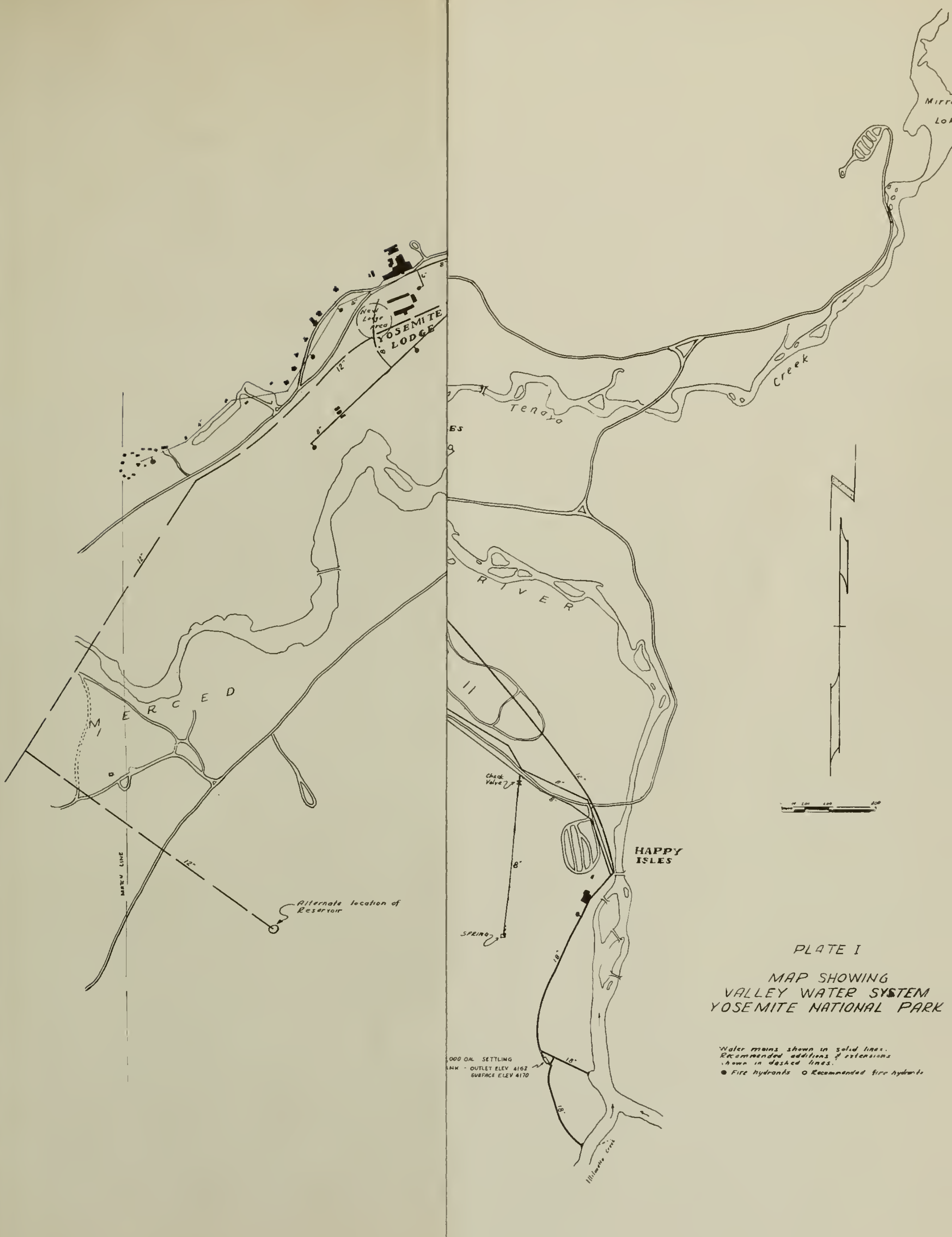

PLATE I

MAP SHOWING
VALLEY WATER SYSTEM
YOSEMITE NATIONAL PARK

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PLATE I
MAP SHOWING
VALLEY WATER SYSTEM
YOSEMITE NATIONAL PARK
GOV'T CENTER
NEW VILLAGE
TECOYA
AHWANEE HOTEL
YOSEMITE LODGE
OLD VILLAGE
CAMP 6
CAMP 7
CAMP 15
CAMP 16
CAMP 12
CAMP 14
CAMP 11
STABLES
CAMP CURRY
HAPPY ISLES
MERCED RIVER
Tenaya Creek
Mirror Lake
ROCKY POINT
DEVELOPMENT PROPOSED BY YOSEMITE PARK & CURRY CO
Recommended location of Reservoir
Alternate location of Reservoir
Alternate location of Reservoir
may be changed to here

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