State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
Southern District

San Bernardino-San Gorgonio
WATER RESOURCES MANAGEMENT INVESTIGATION

December 1986

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
Southern District

San Bernardino-San Gorgonio WATER RESOURCES MANAGEMENT INVESTIGATION

Copies of this report at $4 each may be ordered from:

State of California
DEPARTMENT OF WATER RESOURCES
P. O. Box 6598
Los Angeles, CA 90055

Make checks payable to DEPARTMENT OF WATER RESOURCES. California residents add sales tax.

December 1986

FOREWORD

In its continuing effort to find environmentally and economically acceptable ways to augment the yield of the State Water Project, the Department of Water Resources is looking into the possibility of using local ground water basins in conjunction with the State Water Project. The Bunker Hill Basin in San Bernardino County is among the basins under consideration.

An earlier reconnaissance-level study had indicated that such a program in this basin held promise. Accordingly, the Department, San Bernardino Valley Municipal Water District, and San Gorgonio Pass Water Agency, in 1982, entered into a contract for an investigation to determine if the program were feasible.

It soon became apparent, however, that the persistence of high ground water, which had first appeared in the basin in 1980, could delay implementation of the program. Therefore, the investigators shifted their emphasis to the development of conceptual programs that the local agencies could use in devising and evaluating alternative plans for managing the basin--including both controlling the high ground water and making conjunctive use of the basin with the State Water Project.

This report presents a four-step program that would begin with agreement among the concerned agencies on a plan to solve the high ground water problem, including development of a conjunctive use management plan for optimizing local supplies from the basin, and could eventually lead to enlargement of that local conjunctive use program to provide additional yield for the State Water Project.

Robert G. Potter

Robert G. Potter
Acting Deputy Director
Department of Water Resources

TABLE OF CONTENTS

FIGURES

TABLES

PLATES
(Bound at back of report)

State of California
GEORGE DEUKMEJIAN, Governor

The Resources Agency
GORDON K. VAN VLECK, Secretary for Resources

Department of Water Resources
DAVID N. KENNEDY, Director

JOHN P. CAFFREY, Deputy Director

ROBERT G. POTTER, Acting Deputy Director

ROBERT E. WHITING Deputy Director

SALLE S. JANTZ, Assistant Director

ROBERT W. JAMES, Chief Counsel

SOUTHERN DISTRICT

Carlos Madrid* . . . . Acting Chief, Southern District

This report was prepared under
the direction of

Robert Y. D. Chun** . . . . Principal Engineer

by

Charles R. White . . . . Chief, Operations Branch

Assisted by

Michael Taweel**. . . . . Associate Engineering Geologist
William Hom . . . . Associate Engineer
Diane Sanchez . . . . Water Resources Engineering Associate
Phyllis J. Yates . . . . Research Writer
Nancy A. Paisley . . . . Word Processing Technician
Yolanda F. Alvarez . . . . Secretary
Dean Wilson** . . . . Senior Delineator
Mila Dery . . . . Management Services Technician
Susan Kashev . . . . Technical Trainee
David Liu** . . . . Engineering Student Assistant
Wayne MacRostie . . . . Consulting Engineer

Statewide assistance was provided by Division of Planning

John McClurg . . . . Supervising Engineer
John Fielden . . . . Associate Planner
Joyce Peters . . . . Supervising Engineer

*Robert G. Potter was Chief until October 1986.
**No longer with Department of Water Resources.

SAN BERNARDINO VALLEY MUNICIPAL WATER DISTRICT

Board of Directors

Henry H. Van Mouwerik, President

George Aguliar

C. Patrick Milligan

William Katona

Margaret Wright

Staff

G. Louis Fletcher, General Manager and Chief Engineer

Robert L. Reiter, Assistant Chief Engineer

Randall J. Van Gelder, Manager of Administrative Services

SAN GORGONIO PASS WATER AGENCY

Board of Directors

George Jorritsma, President

A. C. Dysart, Vice-President and Treasurer

Anthony L. Augustyn

Fred A. Hicks

Lewis W. Haskell

Philip J. Lamm

Paul F. Lewis

Staff

Donald B. Houston, Manager-Secretary

Jack Beaver, Consultant

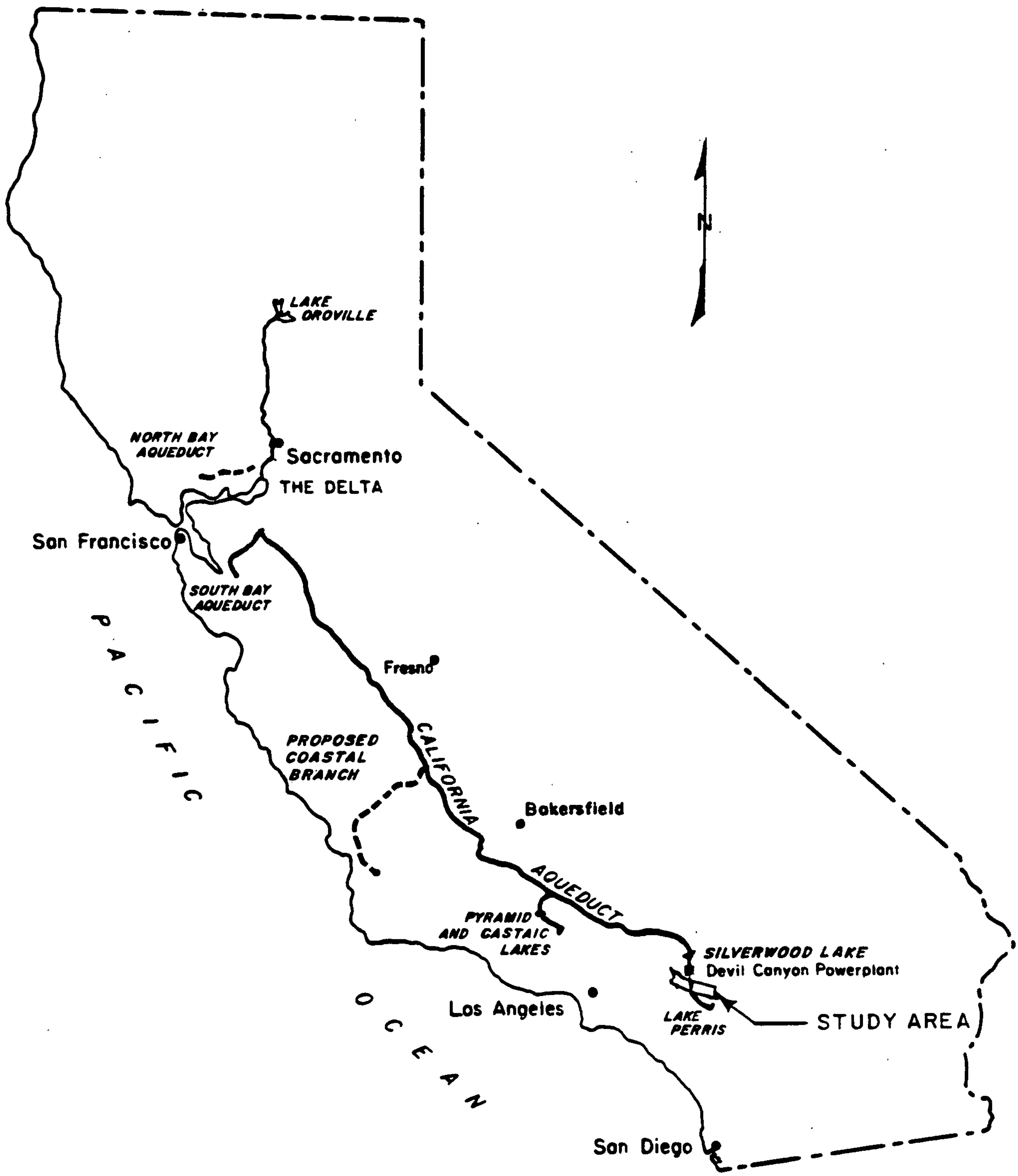


FIGURE 1 - CALIFORNIA STATE WATER PROJECT

I. INTRODUCTION

Recognizing that the dependable water supply of the State Water Project (SWP) (Figure 1) is sufficient to deliver only about half of the 4,230,000 acre-feet of full entitlement to all contractors, the Department of Water Resources (DWR) has established an ongoing program to study measures for augmenting the future yield of the SWP. Among the measures being explored is the conjunctive use concept. This concept involves the coordinated use of local ground water resources (aquifer conveyance, ground water storage capability, and ground water in storage) in conjunction with either local surface water or water from the SWP system.

Beginning in 1979, DWR conducted a series of reconnaissance studies to identify ground water basins in the San Joaquin Valley and Southern California with the potential for conjunctive use with SWP water and facilities. Among those so identified were the Chino Basin in Los Angeles and San Bernardino Counties and Bunker Hill Basin in San Bernardino County.

In 1980, DWR and The Metropolitan Water District of Southern California (MWD) jointly funded a feasibility study of the Chino Basin. This study indicated that, by using water imported through the California Aqueduct in wet years, more than 100,000 acre-feet of additional yield could be developed for use in dry years.

Accordingly, MWD is proceeding with additional studies to develop the necessary legal and institutional arrangements, complete an environmental impact report, and conduct preliminary engineering work so that the Chino Basin can be used for regional ground water basin storage within its service area.

The Bunker Hill Basin study is the second to be given additional consideration. It was conducted in cooperation with the two SWP contractors in the area--San Bernardino Valley Municipal Water District (SBVMWD) and San Gorgonio Pass Water Agency (SGPWA)--and is based on a three-party contract among DWR, SBVMWD, and SGPWA. The study has been expanded to include the entire area served by the two local agencies.

Objective of Investigation

The study objective, as stated in the contract signed by DWR, SBVMWD, and SGPWA in October 1982, was to develop a program that would use the ground water basin resources in conjunction with SWP facilities to help meet the annual entitlement of the SWP. Specifically, the contract called for the program to:

1. Define a cost-effective plan for use of ground water basin storage space for storing SWP water during wet periods and using this water to meet SWP critical dry period contractual commitments;

2. Integrate SWP project development and operation with the activities of other agencies to best meet Statewide, regional, and local goals and objectives;

3. Identify the impacts on local agencies of the proposed ground water basin storage program;

4. Identify legal and institutional constraints and establish a

framework for subsequent contract negotiations; and

5. Identify a plan that is feasible and can be implemented.

The investigators found, however, that this objective could not be reached at this time. The reasons are:

1. Problems related to high ground water levels in the pressure area of the Bunker Hill Basin, which had begun in 1980, have persisted. These water levels will make it impractical, for sometime to come, to implement a comprehensive conjunctive use program with the Bunker Hill Basin.

2. The mathematical model of the basin that existed during the study was inadequate for determining the impact of a storage program. No provision was made in the contract for construction of a model because the U. S. Geological Survey was at that time developing a model. However, it lacks updated hydrologic, water supply, and water use information needed to examine scenarios for possible future conditions.

Therefore, when the investigators developed the data that would be useful for examining the scenarios, they shifted the emphasis to work on a conceptual program that could be used in devising and evaluating alternative plans for managing the basin (including solving the high ground water condition) and for making conjunctive use of the basin and the SWP.

Because of the limitations on the mathematical model, SBVMWD has hired a consultant to provide an updated model that will be able to determine responses for future scenarios.

Area of Investigation

The study area, shown on Plate 1, is located in portions of San Bernardino and Riverside Counties, approximately 50 miles from the Pacific Ocean. The study area contains a total of 357,000 acres, of which 128,000 acres is habitable land.

Elevations range from 11,500 feet above sea level at the peak of Mount San Gorgonio, which is the highest point in Southern California, to 840 feet near the San Bernardino-Riverside County line and Riverside Avenue near the Santa Ana River.

The study area has a semiarid Mediterranean climate characterized by warm, dry summers and intermittent rain during the mild winters. Approximately 75 percent of the annual precipitation occurs from December through March, with less than 5 percent in June through September.

On the valley lands, precipitation comes in the form of rainfall. During the winter, the higher peaks of the San Gabriel, San Bernardino, and San Jacinto Mountains have snow. Average annual depths of rainfall on the valley floor range from 12 inches in the vicinity of the Badlands and at the eastern boundary of the SGPWA to 25 inches at the base of the mountains on the extreme eastern and northwestern portions of the valley floor. Historic fluctuations in precipitation and accumulated departures from the mean (in percent) for the Redlands portion of the study area are shown on Figure 2. Isohyets for the study area are depicted on Figure 3.

The Santa Ana River begins in the San Bernardino Mountains and, after entering the valley, flows westward across the study area. It crosses the San Jacinto fault at Colton Narrows, which is just south of the City of San Bernardino. The river then flows southwestward across the southern half of the Chino-Riverside area and passes Prado Dam on its way toward the coastal plain of Orange County and ultimately

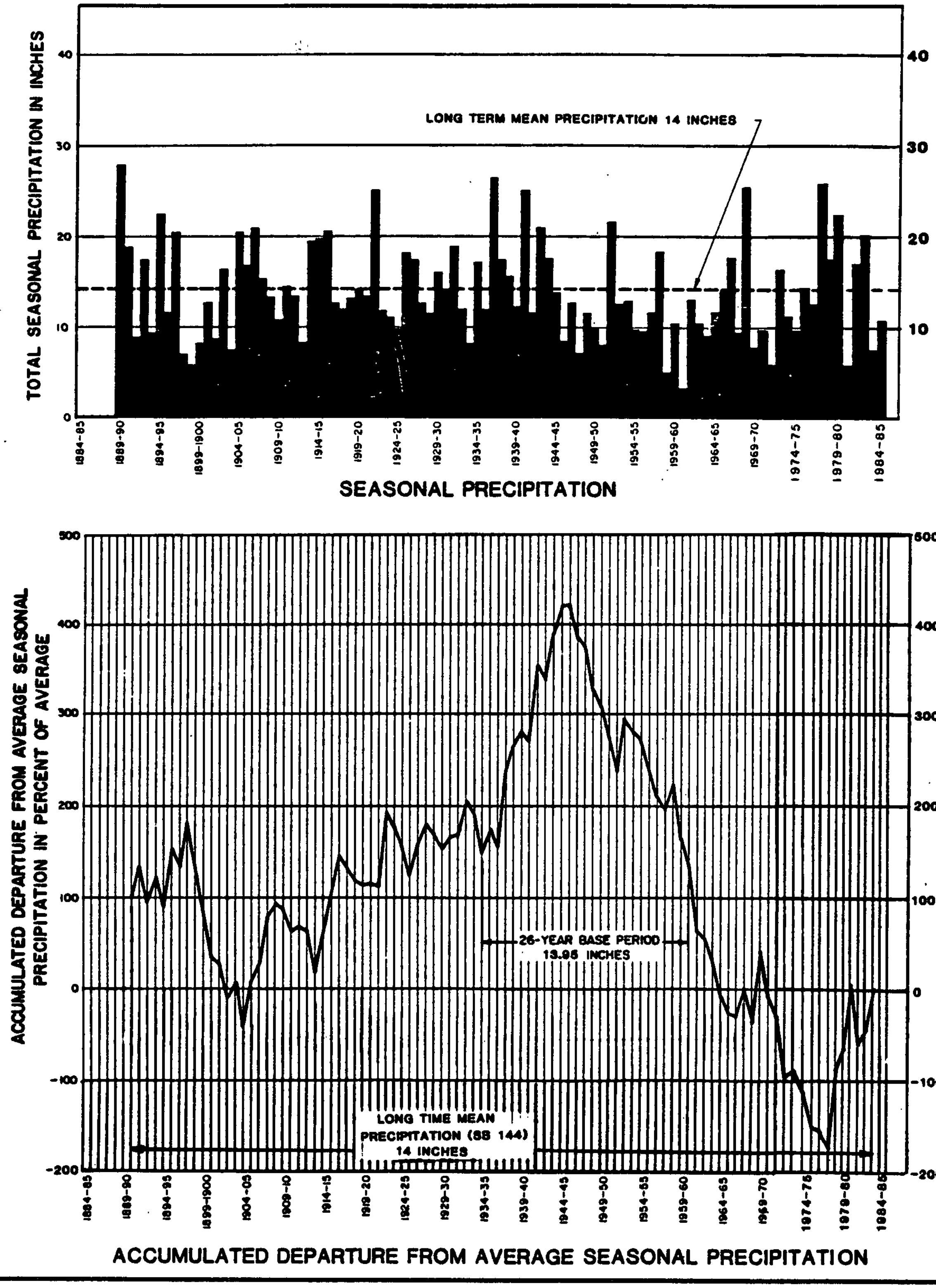


FIGURE 2. PRECIPITATION CHARACTERISTICS AT REDLANDS

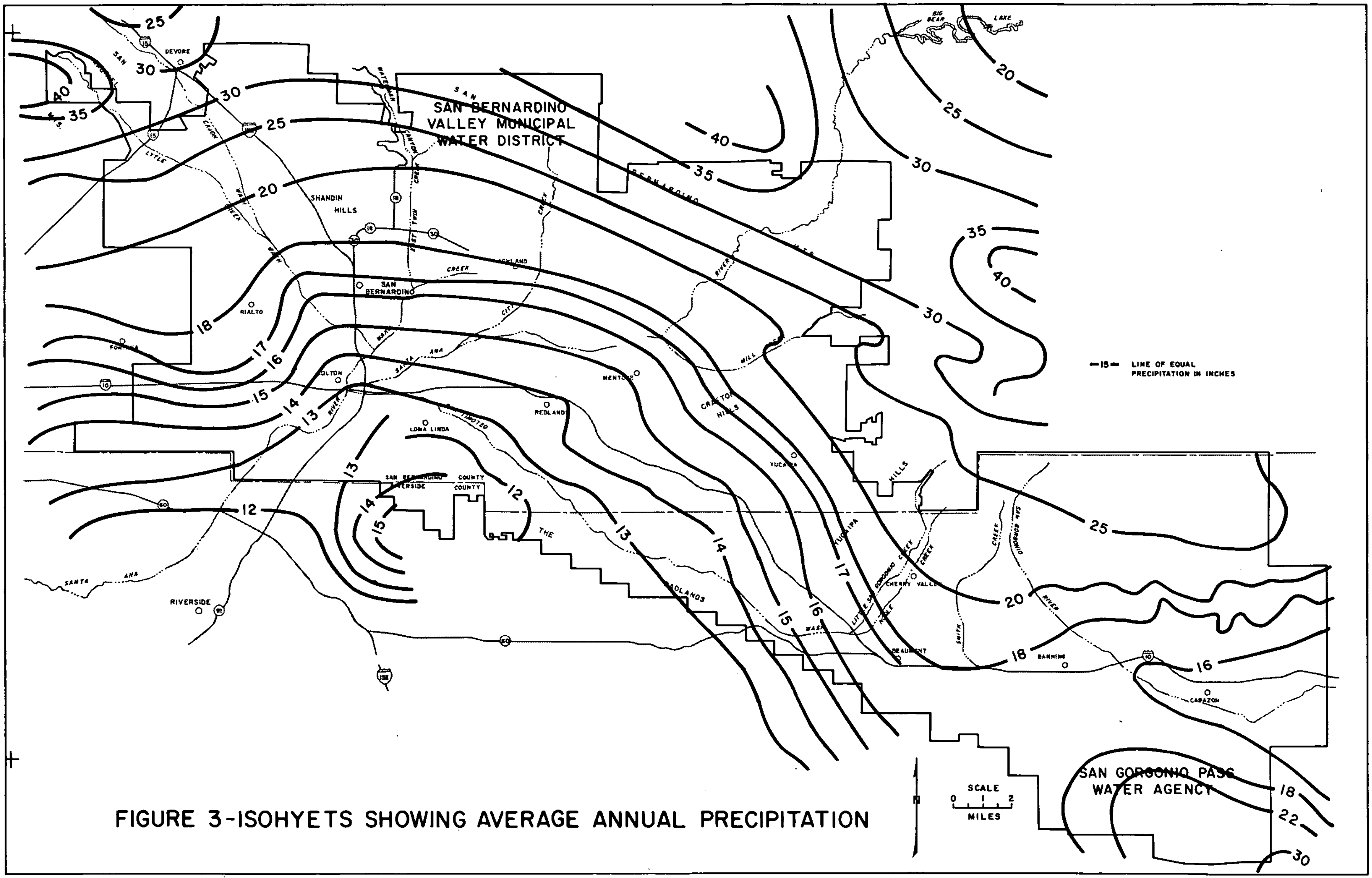


FIGURE 3-ISOHYETS SHOWING AVERAGE ANNUAL PRECIPITATION

discharges into the Pacific Ocean near Huntington Beach.

The major water-bearing portion of the study area is the alluvium-filled structural depression between the San Jacinto fault on the west and the San Bernardino Mountains on the north and northeast. To the southeast are water-bearing areas near the Cities of Redlands, Yucaipa, and Beaumont.

Also included in the study area is the Colton-Rialto area, which is southwest of the San Jacinto fault; it includes portions of the Chino and Riverside Basins. In addition, the Banning-Cabazon and San Jacinto areas on the east and southeast also have alluvial and ground water basin areas.

In addition to the San Jacinto fault, the San Andreas fault also crosses the study area.

The East Branch of the California Aqueduct crosses the study area beginning at Devil Canyon. From there, SWP water goes into the Santa Ana Valley Pipeline, which is a closed conduit under pressure, and eventually enters Lake Perris (Plate 1). The Santa Ana Valley Pipeline has a hydraulic pressure head of about 900 feet where it crosses the San Jacinto fault.

The two water districts in the study area that contract for SWP water are SBVMWD, with a maximum annual entitlement of 102,600 acre-feet, and SGPWA, with 17,300 acre-feet.

The area served by each was divided into subareas (Plate 1) for the study. In SBVMWD are Colton-Rialto, Bunker Hill, Bunker Hill Pressure, and Yucapia Subareas. In SGPWA are San Timoteo and Banning-Cabazon Subareas.

The high ground water in the Bunker Hill Pressure Subarea is critical because of the associated problems. These are:

1. A potential for soil liquefaction under buildings in the Bunker Hill Basin pressure zone in the event of an earthquake, according to Dr. Bolton Seed, Professor at the University of California, Berkeley, a seismic engineer and authority on soil liquefaction.

2. Loss of natural water to the ocean because there is no more storage space in the basin into which water can percolate.

3. Ground water pollution from pollutants introduced near the ground surface (such as fuel storage tanks, waste disposal sites, and fertilization).

4. Ground water infiltration into sewer pipelines, basements, and construction excavations.

5. Creation of breeding areas for mosquitoes in standing water at ground surface.

6. Damage to underground conduits, drains, roads (including Interstate Highways 10 and 215), bridges, and other infrastructure.

7. Loss of water to evapotranspiration by plants growing in areas of high ground water and rising water.

8. Reduction in the percolation capability of the Santa Ana River (additional natural treatment takes place in the soil as the secondary treated waste water effluent discharged in or near the river channel percolates*).

*Because the high ground water in the river channel is interfering with this percolation, the California Regional Water Quality Control Board, Santa Ana Region, is considering requiring the treatment plants in the area involved to go to tertiary treatment.

9. Increase in the cost of construction for foundations because of saturated soil conditions. Structures that were designed to function under dry conditions may not perform adequately when soils around them are saturated.

Conduct of Study

For the study, all available data, information, and reports that were pertinent to this investigation were reviewed.

Key information was obtained from DWR Bulletins 104-3, "Meeting Water Demands in the Chino-Riverside Area" (May 1971), and 104-5, "Meeting Water Demands in the Bunker Hill-San Timoteo Area" (December 1970). The subareas for SBVMWD are based on percolation criteria, subsurface flows, and other geologic and hydrologc basic data reported in Bulletin 104-5. The Colton-Rialto Subarea is the same as that used in Bulletin 104-3. The Banning-Cabazon Subarea, however, was not included in either of the bulletins.

Also, valuable information was obtained from the following:

- California Regional Water Quality Control Board, Santa Ana Region, "Water Quality Control Plan Report, Santa Ana River Basin (8)", 1984;
- Hardt, W. F., and C. B. Hutchinson, "Development and Use of a Mathematical Model of the San Bernardino Valley Ground-Water Basin, California", U. S. Geological Survey Open-File Report 80-576, 1980.
- DWR, Southern District Report, "Report on the Feasibility of Extending the California Aqueduct into Upper Coachella Valley", April 1979;
- DWR Bulletin 186, "A Ground Water Storage Program for the State Water Project: San Fernando Basin Theoretical Model", May 1979;
- DWR Bulletin 71-64, "Upper Santa Ana River Drainage Area Land and Water Use Survey, 1964", July 1966;
- DWR Bulletin 132-85, "Management of the California State Water Project", September 1985;
- DWR, Southern District Memorandum Report, "Meeting Water Demands in the Chino-Riverside Area", Appendix B: "Operation-Economics", May 1971;
- DWR, Southern District Report, "Upper Santa Ana River Drainage Area Land Use Survey, 1984", June 1985;
- SBVMWD, "Annual Report on the Water Supply, 1980", May 1981;
- "Annual Report of the Western San Bernardino Watermaster", 1981, Vol. 1-7, Riverside County Superior Court Case 78426, August 1, 1983;
- Land use surveys conducted by DWR in 1975 for Upper Santa Ana River drainage area, in 1978 for Coachella and Imperial Valleys, and in 1984 for SBVMWD and San Timoteo areas;
- The two cooperators, SBVMWD and SGPWA;
- Local agencies--City of Banning, Fontana Union Water Company, San Bernardino County Flood Control District, and Riverside County Flood Control and Water Conservation District;
- U. S. Bureau of the Census, Riverside County Planning Department, and California Department of Finance (for past and current population);
- Southern California Association of Governments, "Draft SCAG--82 Growth Forecast Policy", January 1982, and supplement, September 1982 (for

future conditions);

- o Settlement documents in Orange County Superior Court Case 117628, Orange County Water District, et al. v. City of Chino, et al., which is referred to in this report as the Orange County case;

- o Settlement document in Riverside County Superior Court Case 78426, Western Municipal Water District of Riverside County, et al. v. East San Bernardino County Water District, et al., referred to in this report as the Western case. In addition, the stipulated judgment in The Irvine Company, a corporation v. Water Conservation Association, a corporation, et al., Case Y-36-M in San Bernardino County Superior Court, was studied for this investigation.

The review of the above reports concentrated on elements that related to surface and ground water management in the area.*

The future period covered by the study is 1990-2040.

*A list of reports used in conducting this study and preparing this report is published at the back of the report.

II. GEOHYDROLOGY

Only geologic and hydrologic information related to ground water management is presented in this report. It was obtained from other reports and basic data used for those reports. The primary geologic information was obtained from DWR Bulletins 104-3 and 104-5. In addition, technical information records (TIRs) compiled for Bulletin 104-5 were used. For additional details on geohydrology, the bulletins and their basic data may be reviewed.

Because geologic information for subsurface flow was based on the TIRs that were developed for the two bulletins, the flows represent the average conditions that were experienced during the investigation for those two reports. If conditions change in the future, the values for subsurface flow would be different.

When the mathematical model now under development by SBVMWD is completed, future subsurface flows will be determined.

Storage Capacity

Information on the elevation of the effective base of fresh ground water in the study area is depicted on Figure 4. The maximum depth is 1,200 feet.

April 1984 produced, for most of the area, one of the highest ground water levels in history. Consequently, it was used in this report as a historic extreme in calculating wet and dry storage and costs for pumping. The total storage capacity, dry storage available in April 1984, and historic low wet storage for each subarea are shown in Table 1.* The table shows that the total storage capacity in the study area is more than 11 million acre-feet.

To prevent waterlogging and other adverse effects of high ground water that were mentioned in Chapter I, to minimize waste to the ocean and rising water, and to allow space to store natural recharge in wet years, a portion of the storage in the study area should be kept unsaturated.

In 1984, about 20 percent of the total storage in the study area was unsaturated. The actual amount of unsaturated storage in the future will depend on how the basin is managed.

Figure 5 depicts the April 1984 depth to ground water in the study area.

Figure 6 is a contour map showing the historic recorded low ground water levels (greatest depths to ground water). These low ground water levels occurred during 1965 in most of the study area.

Figure 7 depicts the cumulative annual change in ground water storage from 1934 through 1980 for the Bunker Hill

---

*For a description of how computations were made, see the TIR "Estimated Dry Storage Capacities and Weighted Average Depths in the San Bernardino Valley Municipal Water District-San Gorgonio Pass Water Agency Study Area". This TIR and others cited were prepared as part of this study and may be seen in the offices of DWR Southern District in Los Angeles, SBVMWD in San Bernardino, or SGPWA in Beaumont. A list of all TIRs prepared in this study is given at the back of the report.

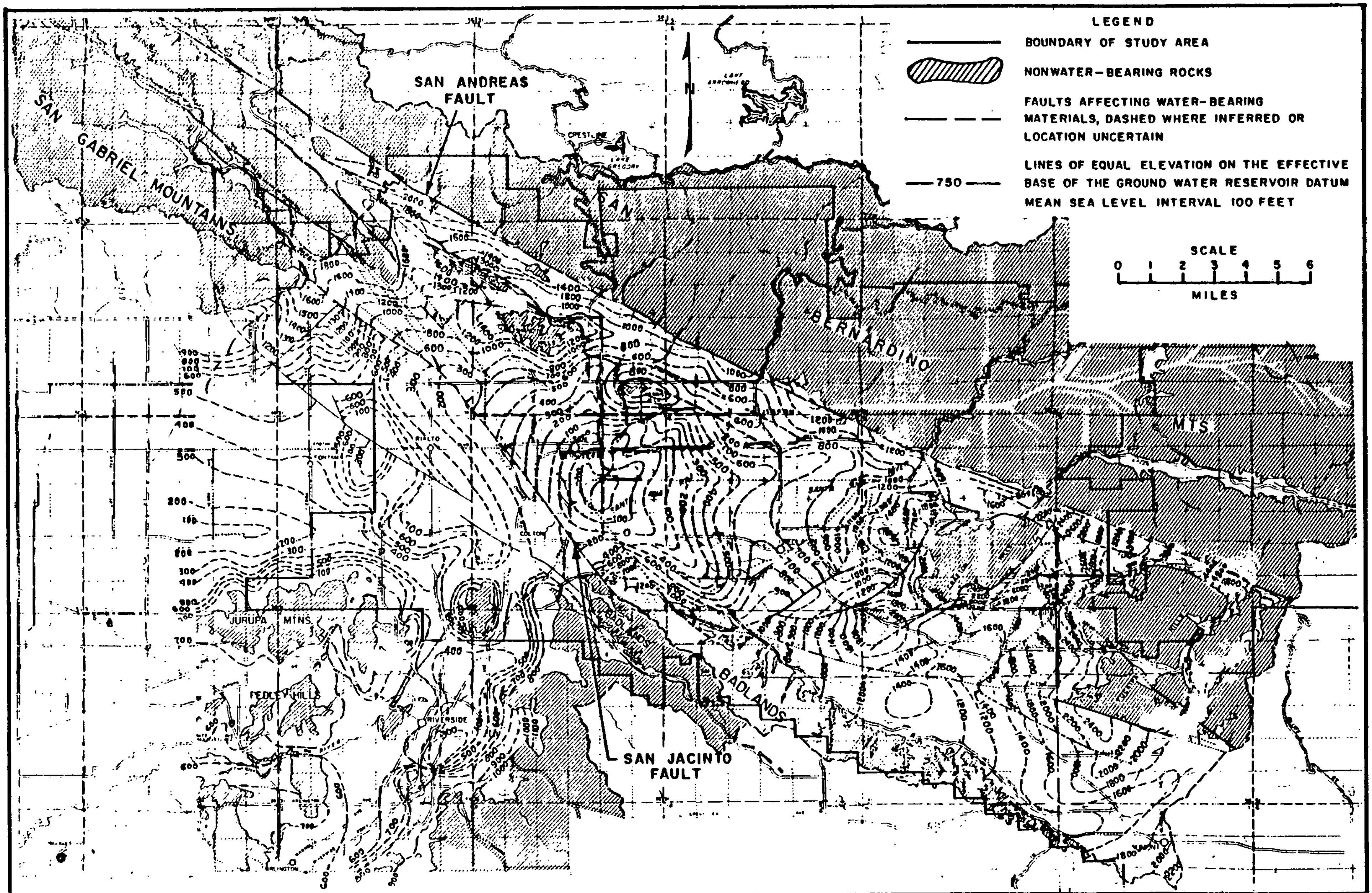


FIGURE 4 - LINES OF EQUAL ELEVATION OF EFFECTIVE BASE OF GROUND WATER

TABLE 1

TOTAL STORAGE CAPACITY AND DRY STORAGE CAPACITY,
SAN BERNARDINO VALLEY-SAN GORGONIO PASS AREA

Subarea	Total storage capacity, in acre-feet	April 1984		Historic low	
		Dry storage capacity, in acre-feet	Weighted average depth, in feet	Dry storage capacity, in acre-feet	Weighted average depth, in feet
Colton-Rialto	2,517,000	996,000	240	1,272,000	300
Bunker Hill	4,296,000	818,000	100	2,052,000	260
Bunker Hill Pressure	1,680,000	75,000	40	297,000	160
Yucaipa	783,000	244,000	150	560,000	350
San Timoteo	2,006,000	377,000	140	1,031,000	380
Banning-Cabazon*	---	---	---	---	
Total	11,282,000	2,510,000		5,212,000	

*No estimates were made because of insufficient data in the subarea.

Basin (San Bernardino) only, as calculated by SBVMWD. As shown on this figure, the cumulative change in storage since 1959 is about 800,000 acre-feet. (Before 1979-80, the last year in which rising water appeared was 1959.)

It should be noted that no data are available on the base of fresh water or the amount of ground water in storage in the Banning-Cabazon Subarea. Consequently, no storage values are shown for this subarea in Table 1.

Major Faults

The two major faults in the area are the San Andreas and San Jacinto, also known as the Bunker Hill Dike (Plate 1). Both have been active in recent geologic time, and earth scientists have predicted they will become active again within the next 50 years. The San Andreas fault zone appears to impede movement of ground water emanating from weathered and fractured rocks upgradient from the fault. The San Jacinto fault, which separates the Colton-Rialto Subarea from the Bunker Hill Pressure Subarea, impedes ground water movement, forcing water to rise to the surface in the area known as Colton Narrows.

Figure 8 depicts a cross section that traverses the Santa Ana River from the San Andreas fault to the San Jacinto fault. It shows the base of fresh water, ground surface elevation, April 1984 ground water levels, and confining members in the Bunker Hill Pressure Subarea.

High Water in Pressure Subarea

The high ground water in the Bunker Hill Pressure Subarea has been caused by many factors, some more significant than others. These factors include:

1. Above average rainfall, runoff, and percolation in 1978, 1980, 1982, and 1983.

2. Significant increase in the amount of artificial recharge of local water by San Bernardino Valley

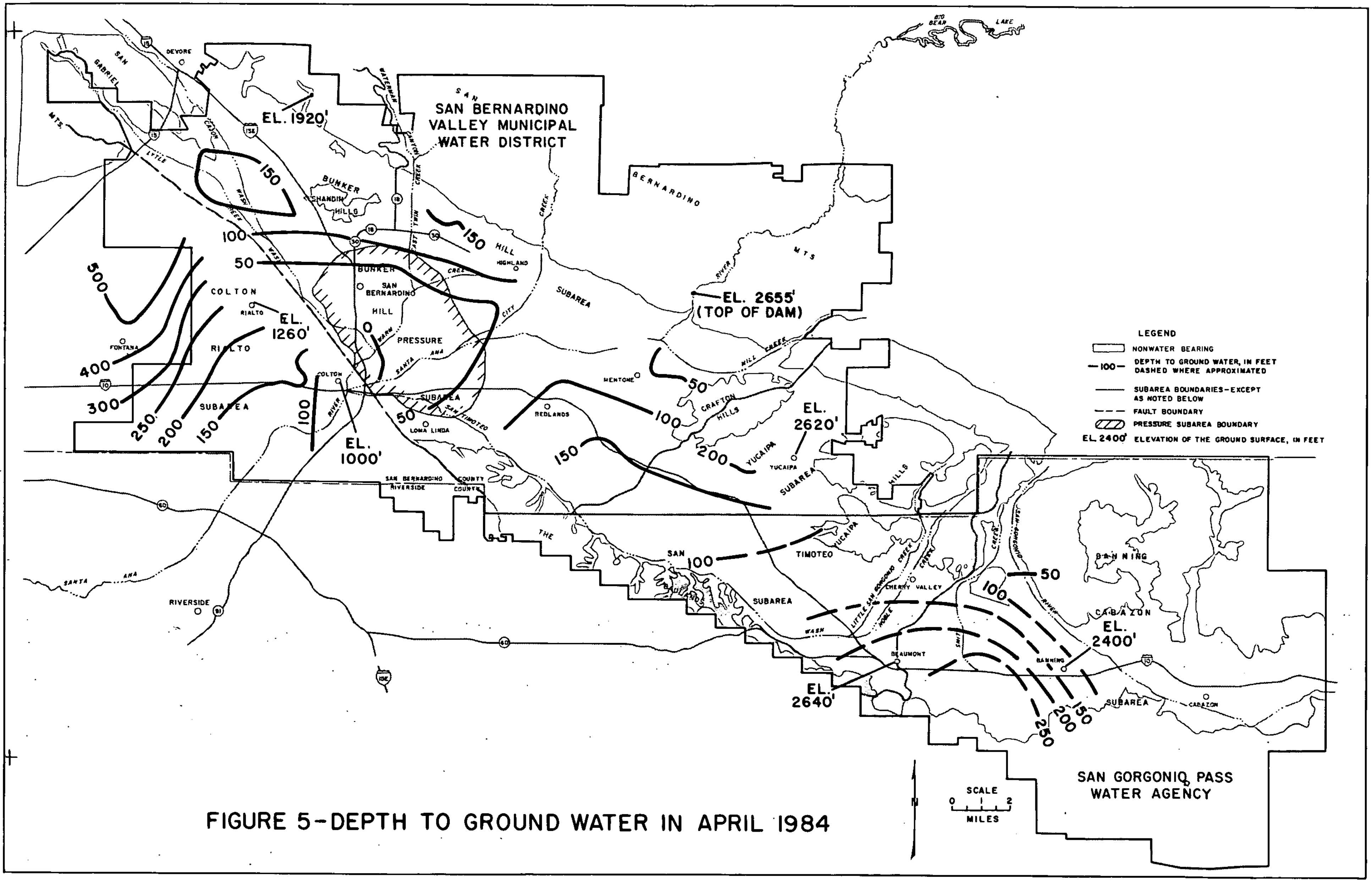


FIGURE 5–DEPTH TO GROUND WATER IN APRIL 1984

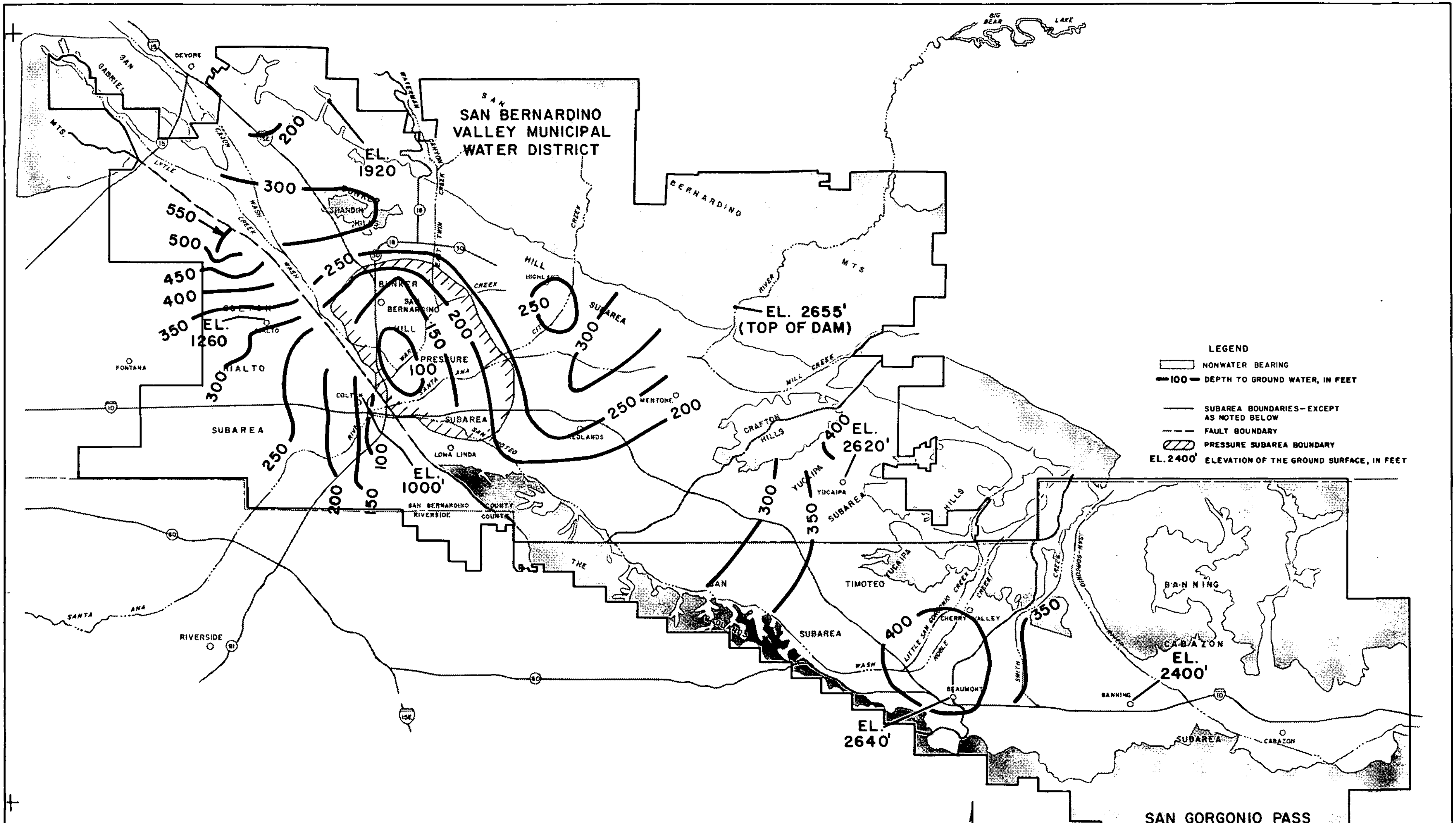


FIGURE 6-HISTORICAL LOW GROUND WATER LEVELS

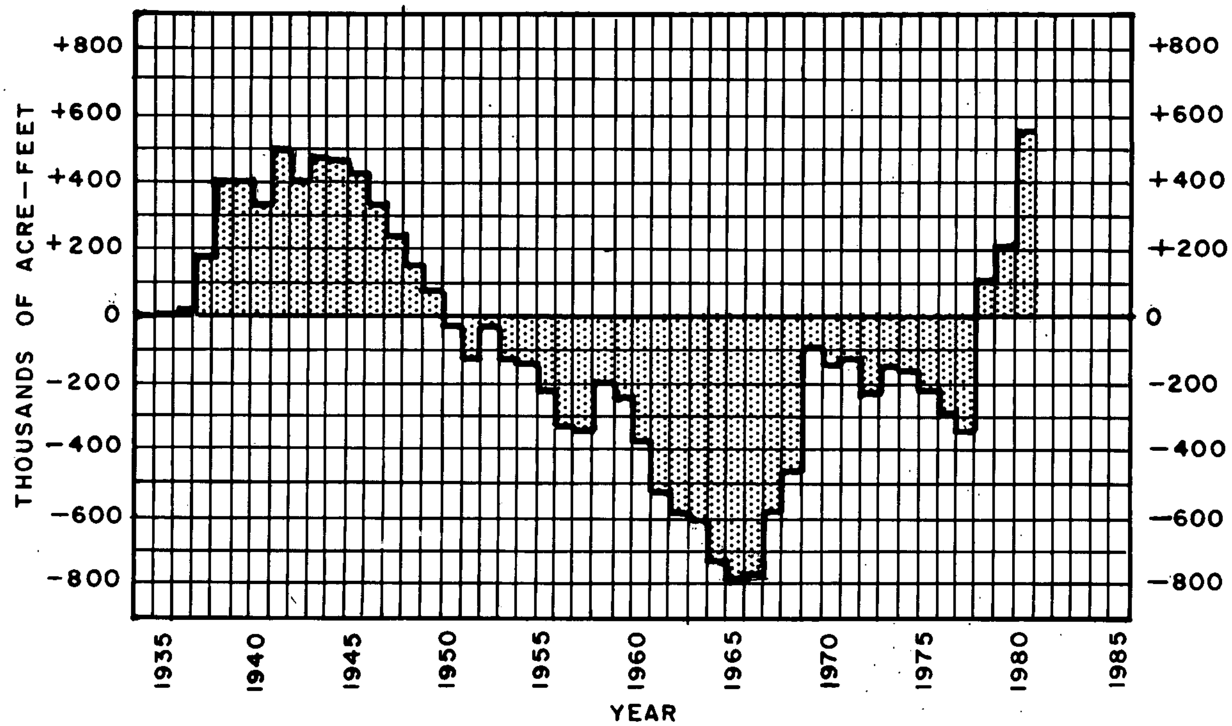


FIGURE 7-CUMULATIVE ANNUAL CHANGE IN GROUND WATER STORAGE, BUNKER HILL BASIN, CALCULATED BY SBVMWD

Water Conservation District, beginning in 1969.

3. Reduction of water requirements in the Bunker Hill Subarea since 1965, primarily caused by change from agricultural land use to urban. In 1965, water requirements were estimated to be 191,000 acre-feet in the study area (excluding the Banning-Cabazon Subarea), according to Bulletins 104-3 and 104-5. By 1990, the requirement for the same area is estimated to be 161,000 acre-feet.

4. Importation and recharge of SWP water by SBVMWD beginning in 1972 (Figure 9).

Based on storage calculations made for the Bunker Hill Subarea by SBVMWD, the total volume of excess ground water is about 800,000 acre-feet.

Recharge in Subareas*

The geologic and hydrologic characteristics of the Bunker Hill Subarea (forebay area) and Pressure Subarea are not the same.

The Bunker Hill Subarea, which is relatively unconfined, consists mostly of alluvium, sand, and gravel. This area has very high capability to percolate water, as evidenced in wet years such as 1980 and 1983, when percolation of local water in streambeds, spreading grounds, and other pervious areas was more than twice that which occurred during normal rainfall years.

In the Pressure Subarea are numerous

*A list of recharge facilities in the study area is contained in the TIR "Recharge Facilities in the San Bernardino Valley Municipal Water District-San Gorgonio Pass Water Agency Study Area".

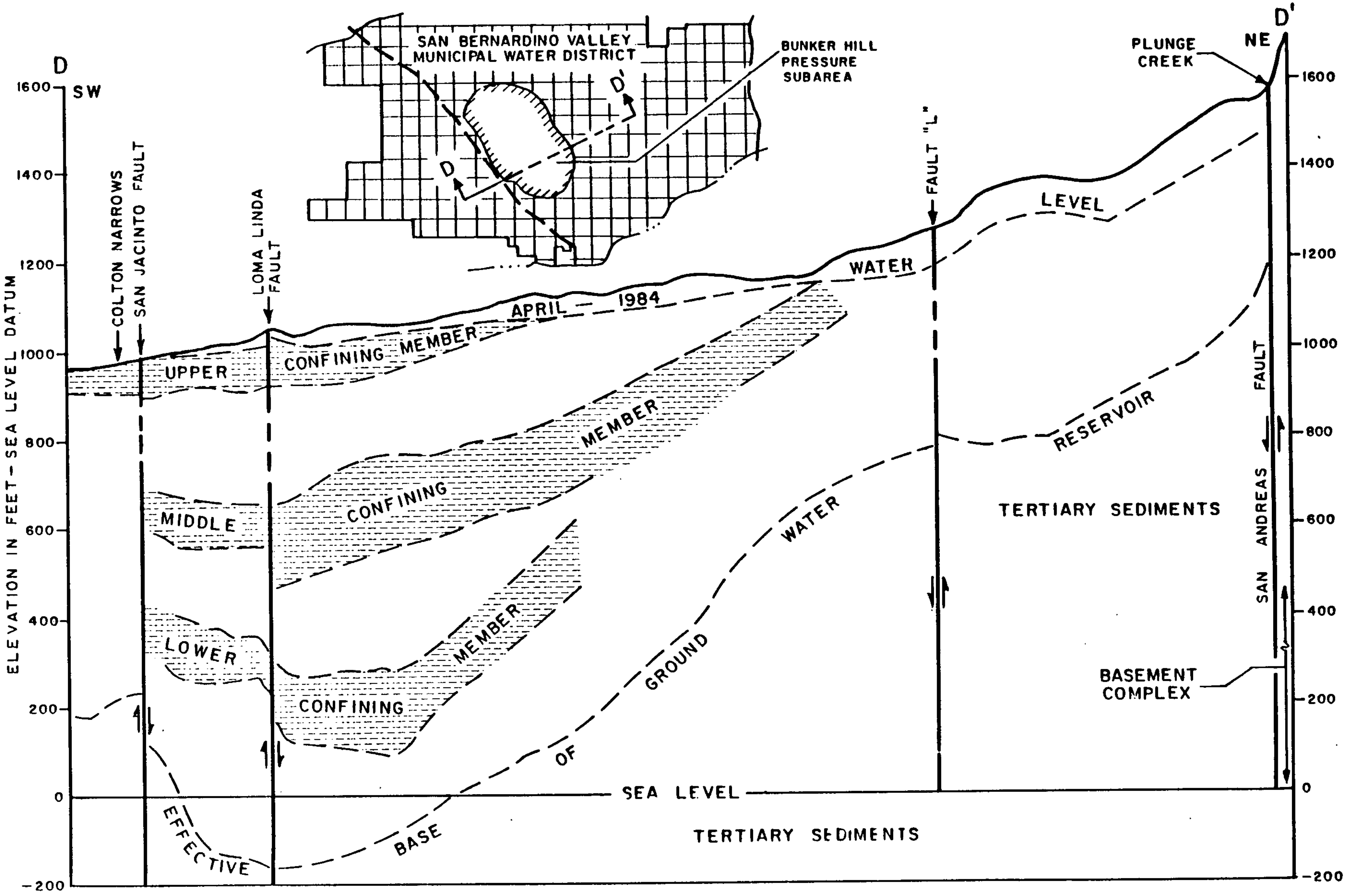


FIGURE 8 - GEOLOGY CROSS SECTION ALONG SANTA ANA RIVER

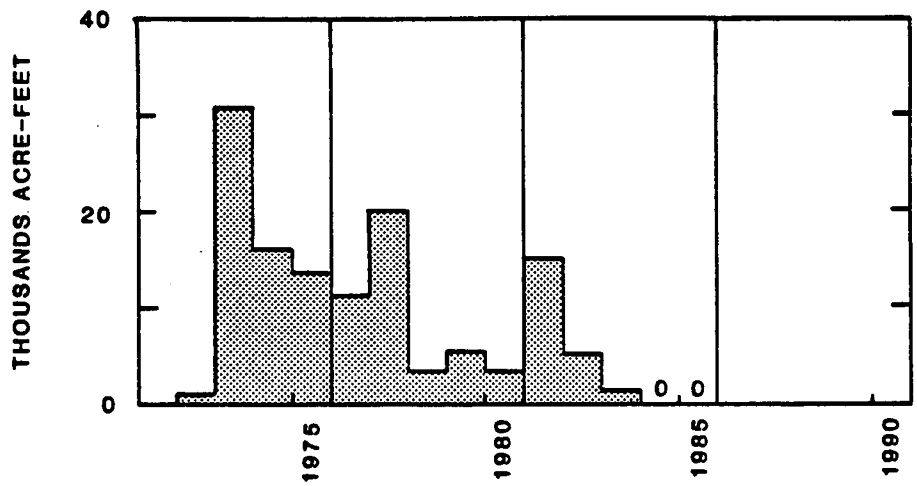


FIGURE 9. ARTIFICIAL RECHARGE OF IMPORTED WATER IN BUNKER HILL BASIN

clay layers that contain perched water. A swamp existed in the 1920s near the intersection of Warm Creek and the Santa Ana River. It should be noted that the water levels in Bunker Hill Pressure Subarea are a function of recharge and extractions in the forebay area. Even though there may be available (dry) ground water storage capacity in the forebay area, the usable dry storage capacity in the forebay is limited by the ground water levels in the Pressure Subarea. In other words, the two systems must be considered as a single hydraulic system.

The geologic characteristics of the Colton-Rialto Subarea, most of which lies in the Chino Ground Water Basin, are also different from those of the Bunker Hill Subarea. The Bunker Hill Subarea has numerous recharge sites (Plate 2), whereas the Colton-Rialto Subarea has very few. In addition, the depth to ground water in the northern portion of the Colton-Rialto Subarea is more than 350 feet, whereas, even in the time of the historic low ground water levels, it was never that much in the Bunker Hill Subarea. The Colton-Rialto Subarea, however, does have high ground water levels in its eastern portion along the Santa Ana River.

The Yucaipa Subarea has, as listed in Table 1, 783,000 acre-feet of total ground water storage space. The subarea has a limited number of artificial recharge sites and has a much higher ground surface elevation. Because costly pumping would be required, artificial recharge of SWP water would be limited.

In the San Gorgonio Pass Area, the San Timoteo Subarea has, as depicted on Plate 2, a limited number of artificial recharge sites, and the Banning-Cabazon Subarea has three relatively small sites at this time. Several studies by the U. S. Geological Survey have indicated that new artificial recharge sites could be developed in these subareas; however, not enough geohydrologic and economic data were available for this investigation to determine if it would be economically feasible for SGPWA to pursue the development of these potential recharge sites. A cooperative study, now under way, by SGPWA, its consultant, Boyle Engineering, and DWR is seeking to develop the geohydrologic and economic data needed.

III. WATER REQUIREMENTS

Present and future requirements for water in the study area were estimated (for municipal and industrial--M and I--purposes) on the basis of past and present population, land use, and per capita water use and (for agricultural purposes) on the basis of average unit use.

Land Use

This study relies on the latest land use surveys made by DWR that were available at the time of the study. Therefore, the land was grouped into two major divisions, habitable and nonhabitable. The habitable land is further subdivided into: urban, irrigated and nonirrigated agriculture, and vacant. Urban includes residential; commercial; industrial; suburban; and parks, golf courses, and cemeteries. Irrigated agriculture encompasses small grains, alfalfa, pasture, truck crops, field crops, and others; nonirrigated agriculture takes in all varieties of dry farm crops. The vacant category includes vacant lots, bare ground, and raw land. The nonhabitable consists of hills, mountains, streambeds, and other land not suitable for human development.

Table 2 shows land use in SBVMWD and SGPWA for 1975 and 1978. A land use survey was completed in 1984 for SBVMWD and for a portion of SGPWA. Comparison of results from this survey shows that the land use projection, based on the 1975 survey, is close to the actual land use in 1984. Based upon these land use surveys and the population estimates for the same years, the 1975 and 1978 urban land use information was updated, assuming that there was a direct relationship between the population increase to 1980 and the increase in urban land use. Corresponding to the increase in urban lands for this period was a decrease in the agricultural and vacant land.

To estimate future land use, these assumptions were made:

- For SBVMWD, agricultural and vacant land will continue to diminish until it is nonexistent in all subareas.

- For SGPWA, agricultural and vacant land will continue to decrease at a rate equal to the projected increase in urban land.

Table 3 shows the 1980 and projected future amounts of urban, agricultural, and vacant land for each of the six subareas in the study area. (The TIR "Land Use in the San Bernardino Valley Municipal Water District-San Gorgonio Pass Water Agency Study Area" describes the methods used to derive these values.)

M and I Applied Water Use

For M and I water requirements, the past population was examined for each of the six subareas, and future projections of population were made. Then future urban per capita water use values were estimated based on past trends in per capita use. The amounts of M and I applied water required were obtained by multiplying the forecast population by the per capita use.

Population

Table 4 shows the U. S. Census Bureau population for 1960, 1970, and 1980 for each of the six subareas and for SBVMWD

TABLE 2

LAND USE IN SAN BERNARDINO VALLEY MUNICIPAL WATER DISTRICT AND SAN GORGONIO PASS WATER AGENCY*

In acres

	San Bernardino Valley Municipal Water District						San Gorgonio Pass Water Agency		
	Colton-Rialto Subarea	Bunker Hill Subarea	Bunker Hill Pressure Subarea	Yucaipa Subarea	1975 Total	1984** Total	San Timoteo Subarea	Banning-Cabazon Subarea	Total
Habitable area									
Urban	12,150	20,510	9,720	5,520	47,900	76,400	2,850	5,180	8,030
Agriculture									
Irrigated	4,230	11,760	1,340	420	17,750	14,300	1,320	690	2,010
Nonirrigated	1,490	1,380	430	530	3,830	3,200	7,500	8,020	15,520
Vacant	8,150	5,110	2,780	970	17,010	8,500	980	14,820***	15,800
Subtotal	26,020	38,760	14,270	7,440	86,490	102,400	12,650	28,710	41,360
Nonhabitable area	16,380	103,600	700	11,760	132,440	110,600	24,500	72,170	96,670
Total	42,400	142,360	14,970	19,200	218,930	213,000	37,150	100,880	138,030

*DWR's 1975 land use studies of Upper Santa Ana River Drainage Area used for land use pattern in SBVMWD and SGPWA. Coachella and Imperial Valleys Agricultural Land Use Study, 1978, also used for SGPWA.

**1984 land use listed for comparison only, it was not available until this investigation was nearly completed. (See DWR Southern District Report "Upper Santa Ana River Drainage Area Land Use Survey, 1984".)

***About 11,440 acres of the 14,820 acres of vacant habitable lands belong to the Morongo Indian Reservation.

TABLE 3

1980 AND PROJECTED URBAN, AGRICULTURAL, AND VACANT LAND
In 1,000 acres

Subarea	1980	1990	2000	2010	2020	2030	2040
San Bernardino Valley Municipal Water District							
Colton-Rialto							
Urban	13.2	17.5	21.0	26.0	26.0	26.0	26.0
Irrigated agriculture	4.0	2.5	1.2	0	0	0	0
Nonirrigated agriculture	1.3	0.8	0.4	0	0	0	0
Vacant	7.5	5.2	3.4	0	0	0	0
Subtotal	26.0	26.0	26.0	26.0	26.0	26.0	26.0
Bunker Hill							
Urban	21.4	29.0	35.1	38.8	38.8	38.8	38.8
Irrigated agriculture	11.4	6.7	2.3	0	0	0	0
Nonirrigated agriculture	1.2	0.7	0.2	0	0	0	0
Vacant	4.8	2.4	1.2	0	0	0	0
Subtotal	38.8	38.8	38.8	38.8	38.8	38.8	38.8
Bunker Hill Pressure							
Urban	9.7	9.7	9.7	9.7	10.8	12.6	14.3
Irrigated agriculture	1.7	1.7	1.7	1.7	1.4	0.3	0
Nonirrigated agriculture	0.1	0.1	0.1	0.1	0.1	0.1	0
Vacant	2.8	2.8	2.8	2.8	2.0	1.3	0
Subtotal	14.3	14.3	14.3	14.3	14.3	14.3	14.3
Yucaipa							
Urban	6.2	7.4	7.4	7.4	7.4	7.4	7.4
Irrigated agriculture	0.3	0	0	0	0	0	0
Nonirrigated agriculture	0.4	0	0	0	0	0	0
Vacant	0.5	0	0	0	0	0	0
Subtotal	7.4	7.4	7.4	7.4	7.4	7.4	7.4
San Bernardino Valley MWD							
Urban	50.5	63.6	73.2	81.9	83.0	84.8	86.5
Irrigated agriculture	17.4	10.9	5.2	1.7	1.4	0.3	0
Nonirrigated agriculture	3.0	1.6	0.7	0.1	0.1	0.1	0
Vacant	15.6	10.4	7.4	2.8	2.0	1.3	0
Total	86.5	86.5	86.5	86.5	86.5	86.5	86.5
San Gorgonio Pass Water Agency**							
San Timoteo Subarea							
Urban	3.4	4.5	5.5	6.1	6.7	7.4	8.1
Irrigated agriculture	1.2	1.1	1.0	0.9	0.8	0.7	0.6
Nonirrigated agriculture	7.2	6.3	5.5	5.1	4.7	4.2	3.7
Vacant	0.8	0.7	0.6	0.5	0.4	0.3	0.2
Subtotal	12.6	12.6	12.6	12.6	12.6	12.6	12.6
Banning-Cabazon Subarea							
Urban	5.3	6.1	6.8	7.4	8.2	9.0	9.9
Irrigated agriculture	0.7	0.6	0.5	0.4	0.3	0.2	0.1
Nonirrigated agriculture	8.0	7.5	7.1	6.8	6.4	6.0	5.5
Vacant*	3.3	3.1	2.9	2.7	2.4	2.1	1.8
Subtotal	17.3	17.3	17.3	17.3	17.3	17.3	17.3
San Gorgonio Pass Water Agency							
Urban	8.7	10.6	12.3	13.5	14.9	16.4	18.0
Irrigated agriculture	1.9	1.7	1.5	1.3	1.1	0.9	0.7
Nonirrigated agriculture	15.2	13.8	12.6	11.9	11.1	10.2	9.2
Vacant*	4.1	3.8	3.5	3.2	2.8	2.4	2.0
Total	29.9	29.9	29.9	29.9	29.9	29.9	29.9

*Does not include about 11,400 acres of vacant land on the Morongo Indian Reservation.

**Since DWR's last land use surveys in the study area, nonirrigated agriculture acreage in SGPWA has declined significantly. A reconnaissance-level survey conducted in November 1986 showed total acreage was 5,700.

TABLE 4

HISTORIC POPULATION WITHIN
SAN BERNARDINO VALLEY MUNICIPAL WATER DISTRICT
AND SAN GORGONIO PASS WATER AGENCY*

Subarea	1960	1970	Percent change by decade 1960-1970	1980	Percent change by decade 1970-1980
San Bernardino Valley Municipal Water District					
Colton-Rialto	59,100	81,900	39	96,500	18
Bunker Hill	110,300	147,700	34	163,000	10
Bunker Hill Pressure	62,300	63,600	2	62,500	-2
Yucaipa	12,400	21,500	73	27,900	30
Subtotal	244,100	314,700	29	349,900	11
San Gorgonio Pass Water Agency					
San Timoteo	6,800	9,900	46	13,900	40
Banning-Cabazon	14,000	16,900	21	20,800	23
Subtotal	20,800	26,800	29	34,700	29
Total study area	264,900	341,500	29	384,600	13

*Data from U. S. Census Bureau

and for SGPWA. The method utilized to calculate these values is described in the TIR "Historic Population in the San Bernardino Valley Municipal Water District-San Gorgonio Pass Water Agency Study Area". As depicted on the table, the population has been increasing in the area since 1960.

For projected population to the year 2000, the Southern California Association of Governments (SCAG) 1982 report "Growth Forecast Policy" was utilized. For the years 2000 to 2040, population growth rates were based on past population growth rates in the study area and in the surrounding Southern California region.

SCAG-82 projections for rates of growth in RSA 29 (East San Bernardino Valley) for the next two decades are substantially above the growth rate (11 percent) for the decade 1970 to 1980. Some of the factors that are expected to contribute to higher rates of growth are: extension of State Highway Route 30, expansion of Ontario International Airport and development of more light industries in the surrounding area, availability of less expensive land and housing than in Los Angeles and Orange Counties, overflow of population from these two counties, and increased migration from other states and from other areas in California.

SCAG-82 projections for growth in RSA 50 (San Gorgonio Pass) assume introduction of some new industries and jobs; overflow of population from Los Angeles, Orange, and San Bernardino Counties; and migration from other parts of California and other states.

Table 5 shows the 1980 and projected

population for SBVMWD and SGPWA and for each of the six subareas. (See the TIR "Projected Population in the San Bernardino Valley Municipal Water District-San Gorgonio Pass Water Agency Study Area" for details on estimating the future population.)

Figures 10-12 show the past and projected population for SBVMWD, SGPWA, and the total study area.

Per Capita Water Use

The per capita applied water use is the amount of M and I water used per person, in gallons per capita per day or in acre-feet per capita per year. Data on per capita water use for major producers in SBVMWD and SGPWA were obtained from data files for Bulletin 166-3, "Urban Water Use in California" (October 1983); from the water agencies; and from other reports. (See the TIR "1980 and Projected Water Use in the San Bernardino Valley Municipal Water District-San Gorgonio Pass Water Agency Study Area" for further details on estimating per capita water use.)

The 1980 M and I applied water use for each subarea was calculated by multiplying the per capita use value for the subarea by the 1980 population of the subarea.

In projecting the M and I applied water use for 1990 through 2040, it was assumed that there would be no significant change in per capita water use. Therefore, the values determined for per capita water use in the subareas in 1980 were also used for each decade from 1990 through 2040.

TABLE 5

1980 AND PROJECTED POPULATION WITHIN
SAN BERNARDINO VALLEY MUNICIPAL WATER DISTRICT
AND SAN GORGONIO PASS WATER AGENCY*

In 1,000s

Subarea	1980	1990**	2000	2010	2020	2030	2040
San Bernardino Valley Municipal Water District							
Colton-Rialto	96.5	127.9	153.0	190.0	204.0	217.0	232.0
Bunker Hill	163.0	220.2	267.0	295.0	316.0	338.0	363.0
Bunker Hill Pressure	62.5	62.5	62.5	62.5	70.0	82.0	95.0
Yucaipa	27.9	35.5	39.5	43.5	48.0	52.0	55.0
Subtotal	349.9	446.1	522.0	591.0	638.0	689.0	745.0
San Gorgonio Pass Water Agency							
San Timoteo	13.9	18.3	22.5	25.0	27.5	30.2	33.2
Banning-Cabazon	20.8	23.7	26.5	29.0	31.9	35.1	38.6
Subtotal	34.7	42.0	49.0	54.0	59.4	65.3	71.8
Total study area	384.6	488.1	571.0	645.0	697.4	754.3	816.8

*To year 2000, based on SCAG "Growth Forecast Policy".
**January 1984 population was estimated to be 379,000 for SBVMWD and 38,000 for SGPWA. Based on SCAG's estimates contained in its latest growth forecast report (total study area population is 417,000).

The assumption that there would be no significant change in per capita water use was based on: (1) the fact that, although there are various factors that tend to increase per capita water use, there are other factors that tend to decrease per capita use; and (2) the assumption that these factors will tend to offset each other.

Total M and I applied water use for 1990 through 2040 was calculated for each subarea by multiplying the per capita use value for the subarea by the projected population of the subarea in each decade, 1990 through 2040.

Table 6 shows per capita water use and total M and I applied water use for each subarea for 1980 and projected for 1990 through 2040.

Agricultural Applied Water Use

The irrigated acreage for each crop category (taken from the most recent land use survey) was multiplied by the unit applied water use value for that crop category.

Then the total applied water use for all irrigated crops within each agency was divided by the total acreage of irrigated crops in the agency. This gave the weighted average crop unit applied water use value for irrigated agriculture within the agency and the subareas within it.

The 1980 agricultural applied water use was determined for each subarea by multiplying the crop unit applied water use value for the subarea by an estimated 1980 irrigated acreage in the subarea.

The amount of agricultural applied water use for the subareas for 1990 through 2040 was determined by multiplying the projected irrigated

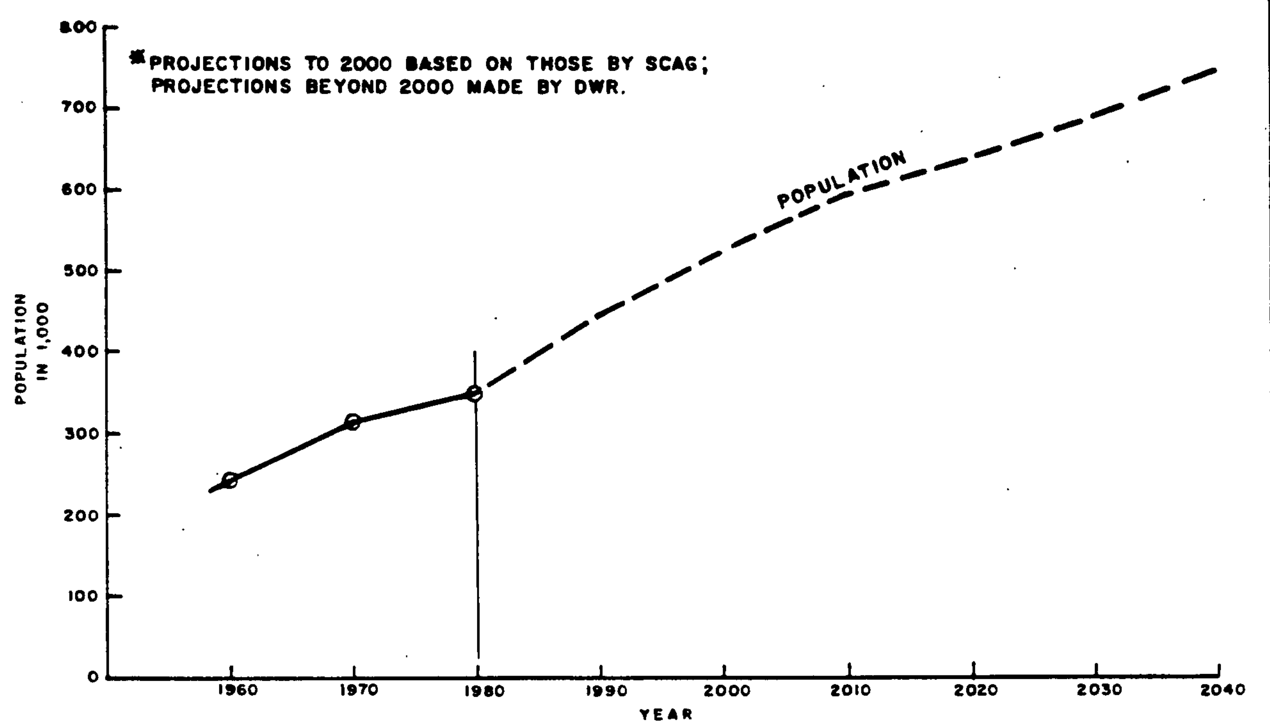


FIGURE 10 - HISTORICAL AND PROJECTED* POPULATION, SAN BERNARDINO VALLEY MUNICIPAL WATER DISTRICT

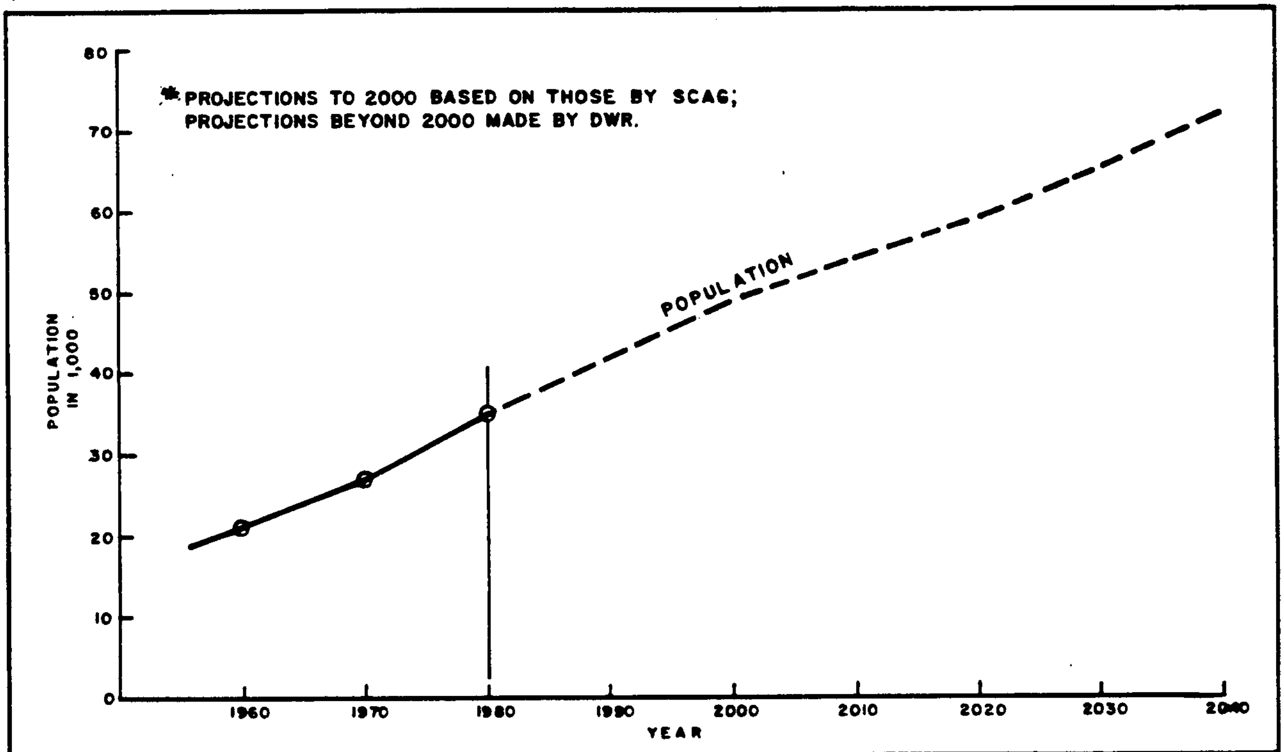


FIGURE 11 - HISTORICAL AND PROJECTED* POPULATION, SAN GORGONIO PASS WATER AGENCY

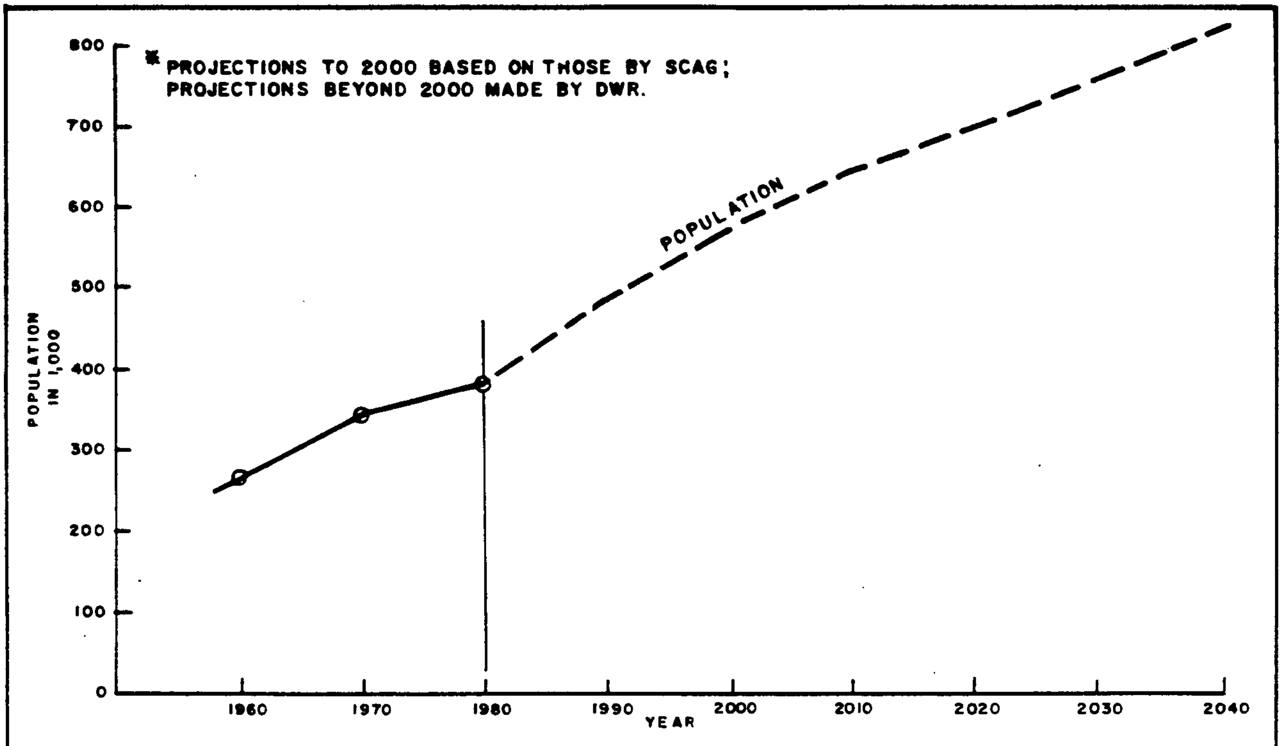


FIGURE 12 - HISTORICAL AND PROJECTED* POPULATION, TOTAL STUDY AREA

TABLE 6

PER CAPITA WATER USE AND 1980 AND
PROJECTED MUNICIPAL AND INDUSTRIAL APPLIED WATER USE

In 1,000 acre-feet

Subarea	Per capita water use AFPY*	1980	1990	2000	2010	2020	2030	2040
San Bernardino Valley Municipal Water District								
Colton-Rialto	.2715	26.2	34.7	41.5	51.6	55.4	58.9	63.0
Bunker Hill	.2747	44.8	60.5	73.3	81.0	86.8	92.8	99.7
Bunker Hill Pressure**	.2542	15.9	15.9	15.9	15.9	17.8	20.8	24.1
Yucaipa	.2632	7.3	9.3	10.4	11.4	12.6	13.7	14.5
Total**		94.2	120.4	141.1	159.9	172.6	186.2	201.3
San Gorgonio Pass Water Agency								
San Timoteo	.2677	3.7	4.9	6.0	6.7	7.4	8.1	8.9
Banning-Cabazon	.3077	6.4	7.3	8.2	8.9	9.8	10.8	11.9
Total		10.1	12.2	14.2	15.6	17.2	18.9	20.8

*AFPY = acre-feet per person per year. The overall value for SBVMWD is .2692 AFPY and for SGPWA is .2911 AFPY.

**In addition to the amounts shown, 1,800 acre-feet of water was used by Southern California Edison Company for cooling in 1980. It is estimated that for 1990 through 2040, about 2,000 acre-feet of water will be required annually for this use.

acreage in each subarea by the crop unit applied water use value for the subarea. It was assumed that in the future the crop mix would remain the same as it is at present. Table 7 shows the agricultural applied water use for each subarea for 2040.

Total Applied Water Requirements

The total applied water use is the sum of the M and I applied water use and the agricultural applied water use.

Table 8 and Figures 13 and 14 show the projected applied water use in SBVMWD and SGPWA for 1990 through 2040.

Figure 15 compares the M and I, agricultural, and total applied water use for SBVMWD and SGPWA in 1990 with that projected for 2040.

TABLE 7

1980 AND PROJECTED AGRICULTURAL APPLIED WATER USE

In 1,000 acre-feet

Subarea	1980	1990	2000	2010	2020	2030	2040
San Bernardino Valley Municipal Water District*							
Colton-Rialto	11.2	7.0	3.4	0	0	0	0
Bunker Hill	31.9	18.8	6.4	0	0	0	0
Bunker Hill Pressure	4.8	4.8	4.8	4.8	3.9	0.8	0
Yucaipa	0.8	0	0	0	0	0	0
Total	48.7	30.6	14.6	4.8	3.9	0.8	0
San Gorgonio Pass Water Agency**							
San Timoteo	5.0	4.6	4.2	3.8	3.4	2.9	2.5
Banning-Cabazon	2.9	2.5	2.1	1.7	1.3	0.8	0.4
Total	7.9	7.1	6.3	5.5	4.7	3.7	2.9

*Assuming weighted average crop unit water use of 2.8 acre-feet per acre.
**Assuming weighted average crop unit water use of 4.2 acre-feet per acre.

TABLE 8

PROJECTED TOTAL APPLIED WATER USE

In 1,000 acre-feet

Subarea	1990	2000	2010	2020	2030	2040
San Bernardino Valley Municipal Water District						
Colton-Rialto	41.7	44.9	51.6	55.4	58.9	63.0
Bunker Hill	79.3	79.7	81.0	86.8	92.8	99.7
Bunker Hill Pressure*	20.7	20.7	20.7	21.7	21.6	24.1
Yucaipa	9.3	10.4	11.4	12.6	13.7	14.5
Total water demand*	151.0	155.7	164.7	176.5	187.0	201.3
San Gorgonio Pass Water Agency						
San Timoteo	9.5	10.2	10.5	10.8	11.0	11.4
Banning-Cabazon	9.8	10.3	10.6	11.1	11.6	12.3
Total water demand	19.3	20.5	21.1	21.9	22.6	23.7

*It is estimated that, for 1990 through 2040, about 2,000 acre-feet of water will be required annually for cooling water by Southern California Edison Company. Not included in table.

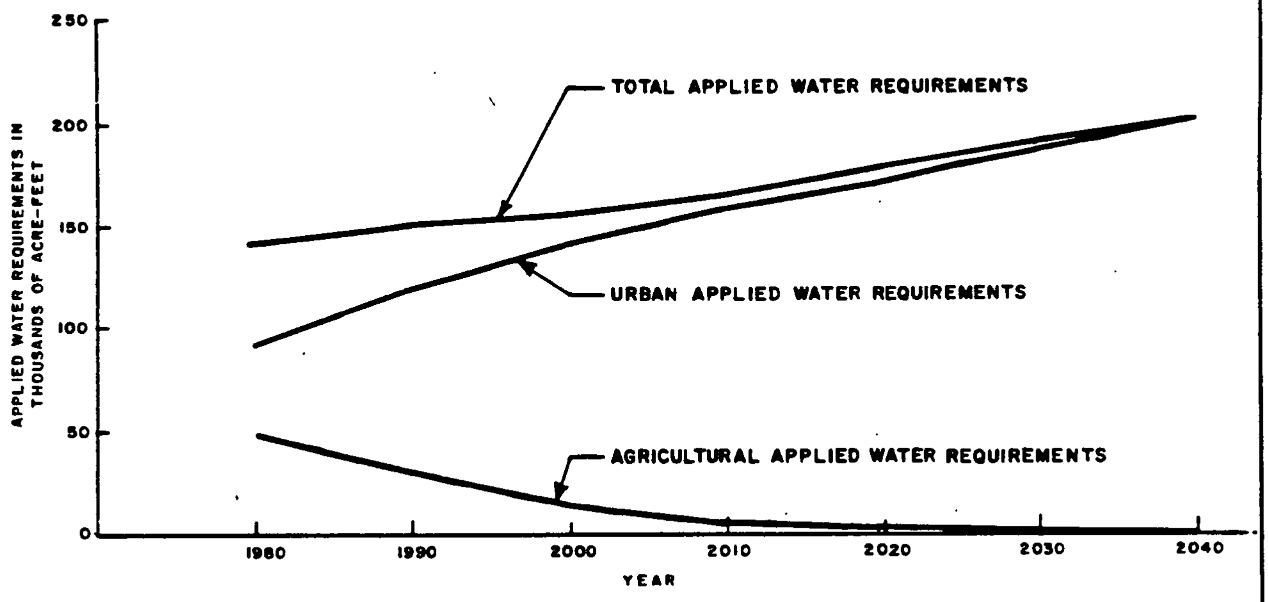


FIGURE 13 - 1980 AND PROJECTED APPLIED WATER REQUIREMENTS, SAN BERNARDINO VALLEY MUNICIPAL WATER DISTRICT

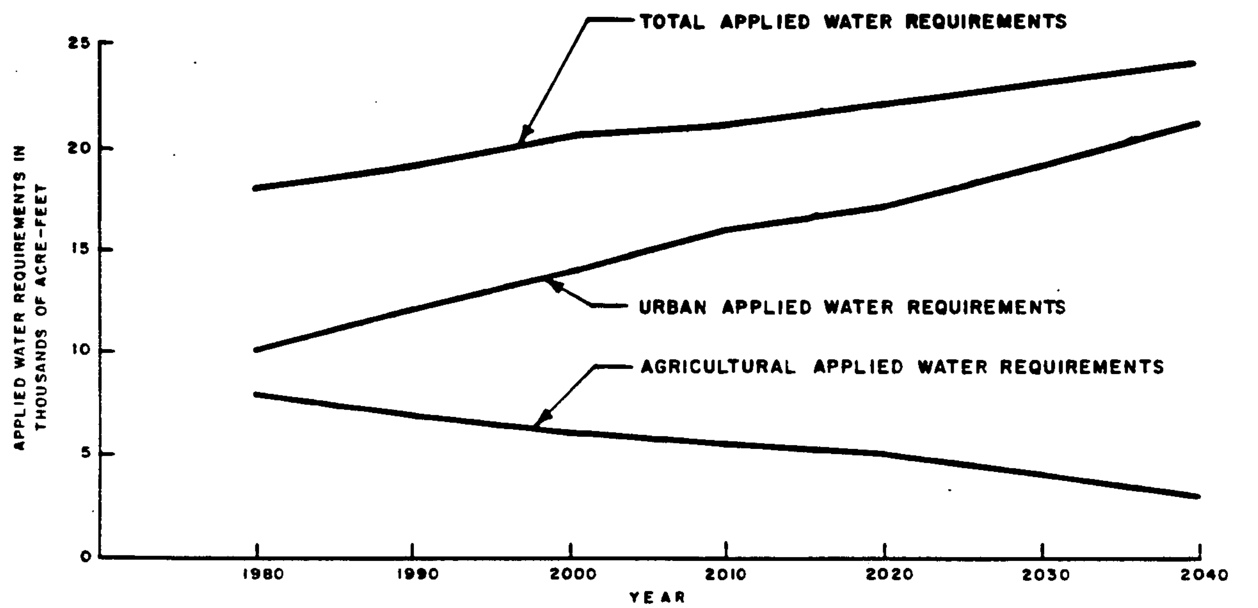


FIGURE 14 - 1980 AND PROJECTED APPLIED WATER REQUIREMENTS, SAN GORGONIO PASS WATER AGENCY

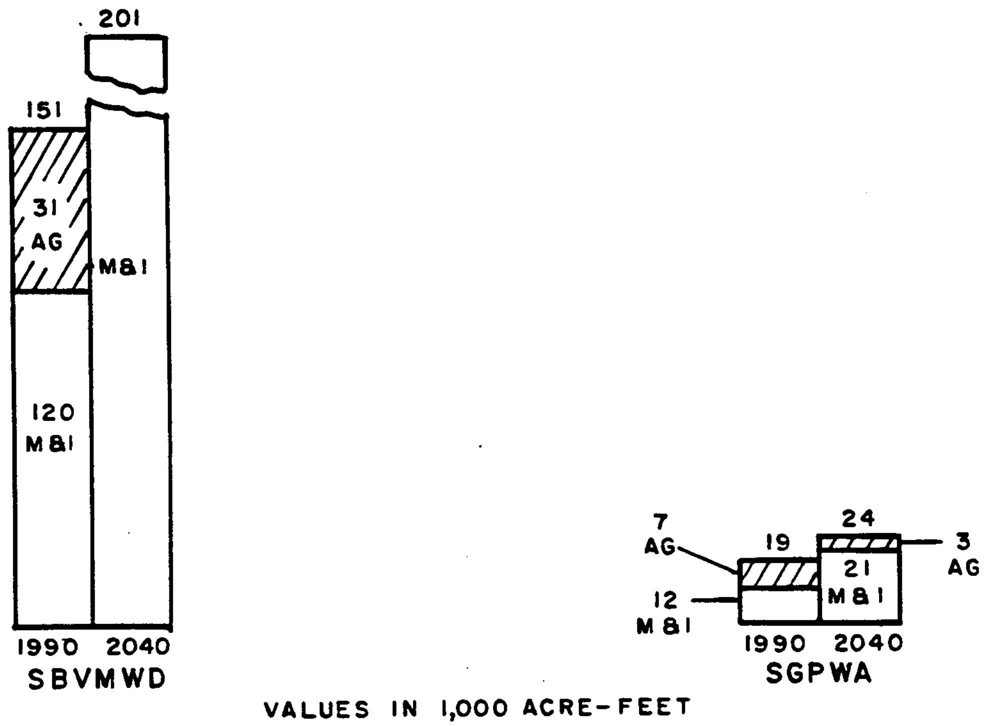


FIGURE 15– 1990 AND 2040 APPLIED WATER USE IN STUDY AREA

IV. WATER SUPPLY

The current water supply for the study area consists of imported water, diverted streamflow, and ground water. At present, almost all imported water is used for recharge of the ground water basin. Figure 16 shows the sources of water used for agricultural and M and I purposes in 1980.

Imported Water

The East Branch of the California Aqueduct delivers SWP water to the study area. Water from Silverwood Lake, located about 15 miles north of San Bernardino, flows through the San Bernardino Tunnel and then drops into the Devil Canyon Powerplant. From the Devil Canyon Powerplant Afterbay, the water travels 28 miles underground through the Santa Ana Valley Pipeline to Lake Perris, which is the terminus of the East Branch, in Riverside County. Plate 2 depicts the SWP facilities in the study area.

SWP water quality is excellent, as shown by the 1984 values given in Table 9.

Three major regional pipelines begin at Devil Canyon Afterbay--MWD's Foothill Feeder, San Gabriel Valley Municipal Water District's Lytle Creek Pipeline, and SBVMWD's Foothill Pipeline. The

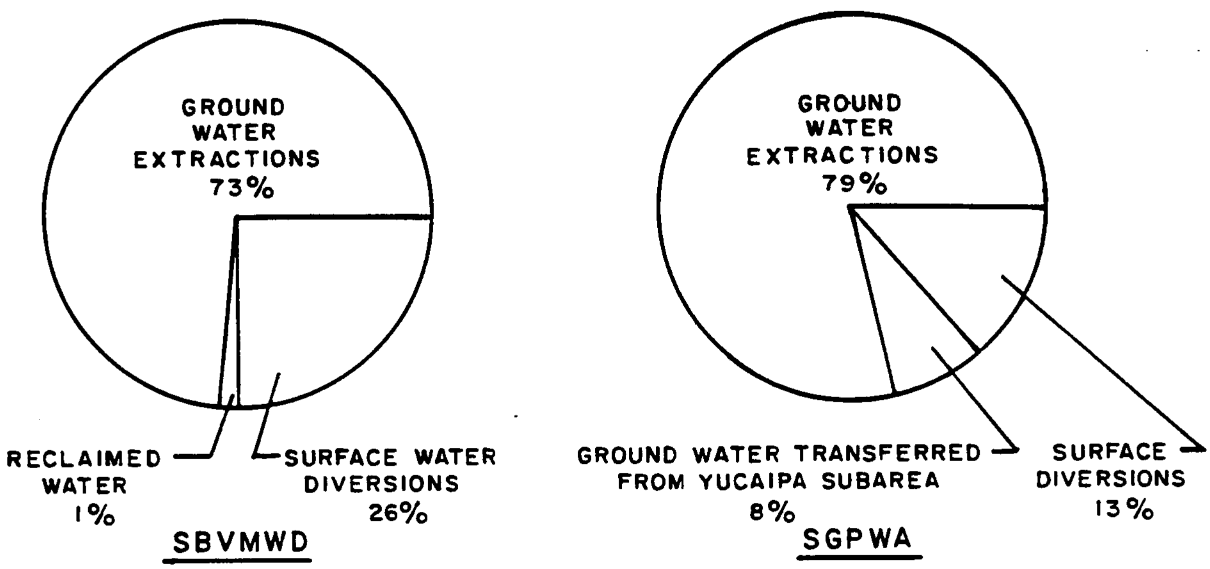


FIGURE 16-WATER SUPPLY FOR 1980 IN STUDY AREA

TABLE 9

SWP WATER QUALITY IN THE STUDY AREA IN 1984
In parts per million unless otherwise noted

	Silverwood Lake, outlet to San Bernardino Tunnel			Lake Perris, outlet from Santa Ana Valley Pipeline			Monthly average quality objectives
	Min.	Avg.	Max.	Min.	Avg.	Max.	
Total dissolved solids	85	156	214	159	179	204	440
Total hardness	45	69	82	76	79	82	180
Chlorides	9	27	37	35	37	39	110
Sulfates	12	28	44	27	31	34	110
Sodium* in percent	38	43	47	44	46	47	50
Boron	0.1	0.2	0.2	0.2	0.2	0.2	0.6

*Amounts of sodium as a percentage of the total sodium, calcium, magnesium, and potassium in solution.

water surface elevation at Devil Canyon Powerplant is 1,925 feet above mean sea level.

SBVMWD, which has a maximum annual entitlement of 102,600 acre-feet of SWP water, transports its deliveries through the Foothill Pipeline and the Lytle Creek Pipeline, in which it has obtained capacity rights from San Gabriel Valley Municipal Water District (Figure 17). The Foothill Pipeline, which has a diameter of 75 to 78 inches, has a maximum capacity of 290 cubic feet per second. When requested by SBVMWD, SWP water flows by gravity in this pipeline to the nine turnouts along its route. There is also the physical capability for local water to flow by gravity from the Santa Ana River to Devil Canyon Powerplant in this pipeline. The flow capacity in the reverse direction, which is currently limited by the diversion works, is estimated to be 60 cubic feet per second. To use this pipeline in the reverse direction would require agreement among parties who have rights to the diversions.

SGPWA, which has a maximum annual entitlement of 17,300 acre-feet, has no facilities to deliver SWP water to its service area; however, SGPWA has purchased capacity rights in SBVMWD's Foothill Pipeline. A study by SGPWA, its consultant, and DWR will determine how best to transport this water to the SGPWA service area to meet its future water needs. The study includes the exchange of a portion of SGPWA's entitlement to SWP water for water diverted from Mill Creek in the Yucaipa Subarea.

SBVMWD began importing SWP water into its service area in 1972. Table 10 lists the annual amounts of SWP imports into the study area, and Figure 18 depicts these amounts graphically. Almost all the SWP water used has been for recharge of the ground water basin in the Bunker Hill and Colton-Rialto Subareas, with most of it in the Bunker Hill Subarea. At present, water from the SWP can be delivered to the Bunker Hill Subarea via the Foothill Pipeline and to the Colton-Rialto Subarea via the Lytle Creek Pipeline.

The future amounts of SWP water needed in the study area for artificial recharge will depend on amounts of ground water extractions, amounts of rainfall, and ground water storage space available.

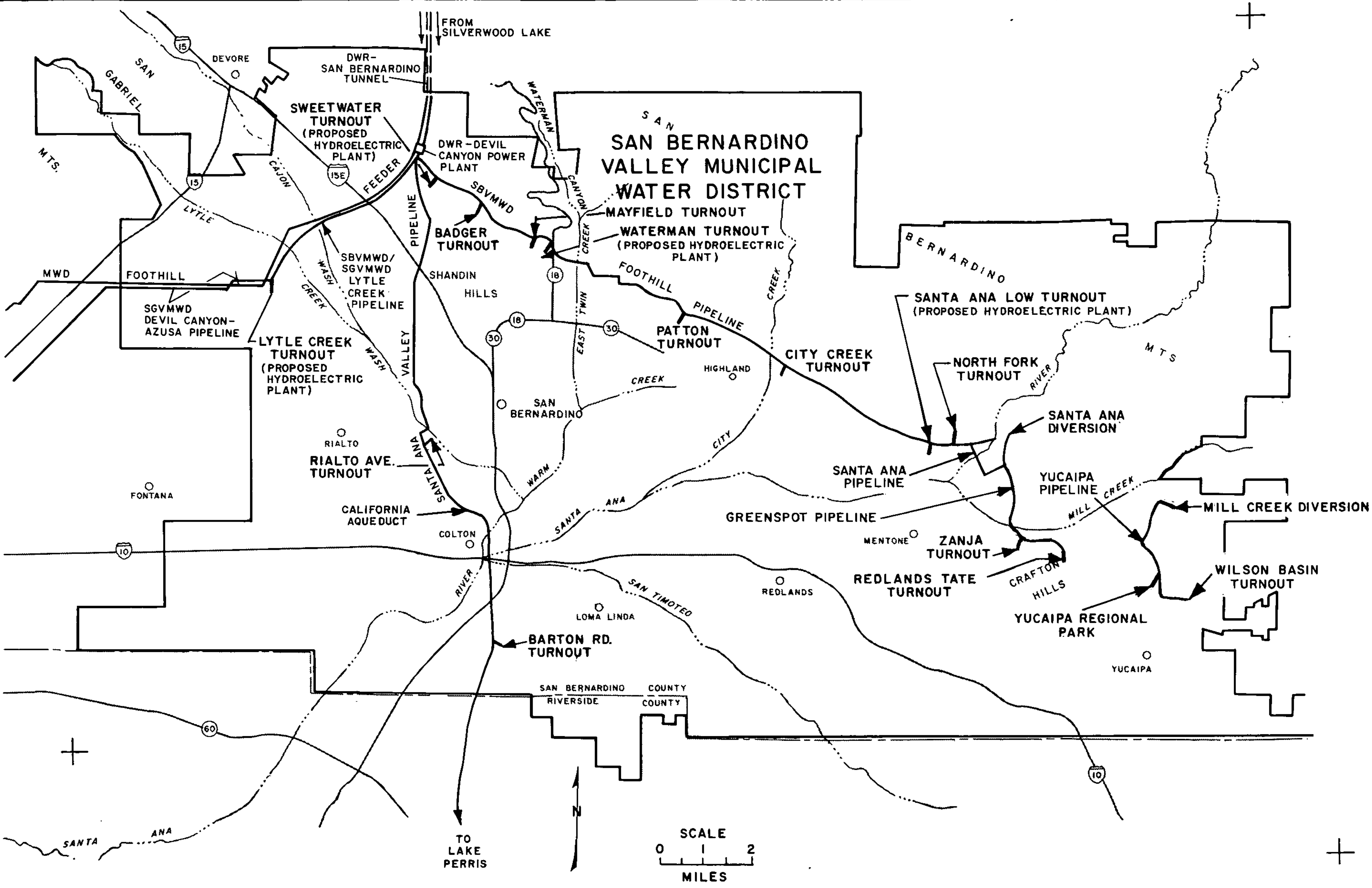


FIGURE 17 - SAN BERNARDINO VALLEY MUNICIPAL WATER DISTRICT TRANSMISSION SYSTEM

TABLE 10

IMPORT OF STATE WATER PROJECT WATER
TO STUDY AREA BY SBVMWD*
In acre-feet

Calendar year	Import
1972	1,275
1973	32,426
1974	16,605
1975	13,865
1976	12,273
1977	24,833
1978	4,055
1979	18
1980	0
1981	16,021
1982	8,409
1983	5,994
1984	5,461
1985	7,390

*Data from DWR Bulletin 132-86, "Management of the California State Water Project", September 1986.

One pipeline under consideration for future delivery of SWP water is the Pass Route Pipeline, which was studied by DWR in 1979 and discussed in its "Report on the Feasibility of Extending the California Aqueduct into Upper Coachella Valley" (published as a Southern District Report). This proposed pipeline is shown as a dashed line on Plate 2. According to SBVMWD, this pipeline could also serve SGPWA, Desert Water Agency, and Coachella Valley Water District, and if all four agencies participated, they would share its cost. This proposal is now under study by Metcalf and Eddy, SBVMWD's consultant. Preliminary costs, final routing, and location of pumping plants and other appurtenant structures have not been developed to the point where they could be included in this report.

As shown on Plate 2, MWD's Colorado River Aqueduct enters the study area east of Cabazon and exits south of Banning. MWD's Upper Feeder also

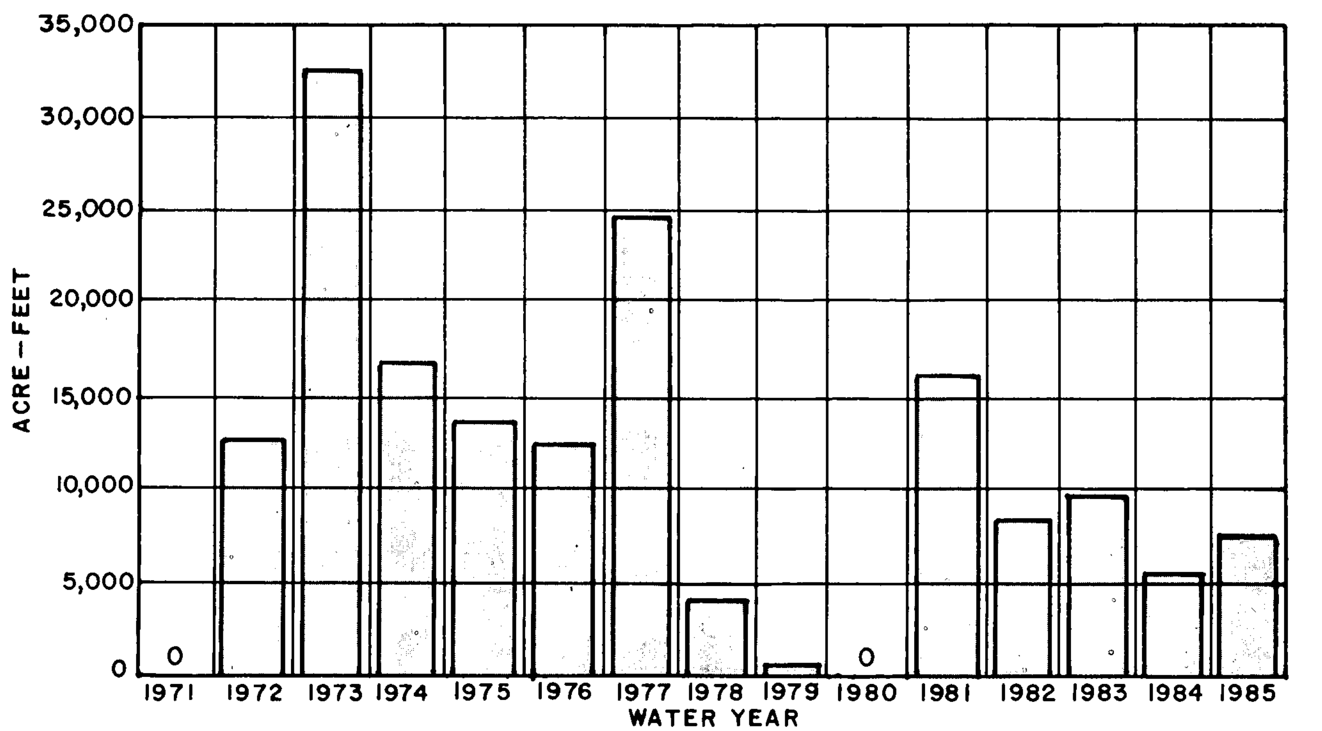


FIGURE 18 - SBVMWD STATE WATER PROJECT IMPORTATIONS

crosses the study area near its western boundary, in the Colton-Rialto Subarea.

Local Surface Water Diversions

An important source of supply has been local surface water that has been diverted from the streams. It is diverted mostly along the foothills of the San Bernardino and San Gabriel Mountains in the Bunker Hill Subarea and along the foothills of the San Jacinto and San Bernardino Mountains in the Banning-Cabazon Subarea. The study area has an extensive network of surface water diversion facilities, including those on Mill Creek, Lytle Creek, Santa Ana River, and San Gorgonio River.

Estimates of diversions are listed in the TIR "Reported 1980 and Future Surface Water Diversion in the San Bernardino Valley Municipal Water District-San Gorgonio Pass Water Agency Study Area". Diversions used within the study area amounted to 52,200 acre-feet in 1980, of which 49,700 acre-feet were diverted in the Bunker Hill Subarea and 2,500 acre-feet were diverted in the Banning-Cabazon Subarea (Table 11). These amounts do not include the streamflow that was diverted for artificial recharge. Figure 19 shows the major diverters in 1980 (diversions of more than 1,000 acre-feet), their points of diversion, and their areas of use. These reported diversions were used for agriculture and M and I.

This water has been of excellent to good mineral quality.

Based on information obtained from the City of San Bernardino, City of Redlands, and East Valley Water District, the use of diverted streamflow for M and I uses will increase in the future and that for agricultural purposes will have a corresponding decline. From discussions with the affected local agencies, the amounts of future diversion in Bunker Hill Subarea shown on Table 12 were developed.

Estimates of future diversions were based on the mean annual rainfall. If the rainfall is less than the mean, there will be a resulting decline in the amount of water available for diversion. If, in the future, the rainfall exceeds the mean, no additional water could be treated because capacity of the plants is limited. (Figure 20 shows locations of the filtration plants.)

Ground Water

The ground water extraction system includes wells that supply the study area's needs as well as the needs for a major portion of the City of Riverside, which is located outside the study area.

For 1980, a detailed study of the extraction system was made; from this, Table 13 was developed. Plate 3 depicts the locations of extractions throughout the study area for 1980 and includes water that was pumped in the study area and exported outside the study area, primarily to the City of Riverside.

For 1990 through 2040, it was assumed that: (1) surface diversions, when available, would be used first to meet water requirements within the study area; (2) the remaining water requirements (water requirements less surface diversions) would be met with ground water extractions; and (3) the exports, primarily to the City of Riverside, would be met in accordance with the amounts shown on Table 14, which were based on discussions with the City of Riverside and in consideration of the court-approved amounts (Western case) that the City of Riverside is allowed to extract.

Quality

Based on ground water sampled in the

TABLE 11

1980
SURFACE WATER DIVERSIONS
FOR MUNICIPAL, INDUSTRIAL, AND
AGRICULTURAL USES WITHIN STUDY AREA*

Diverter	Amount diverted, in acre-feet	Point of diversion	Name of stream
Diversion in Bunker Hill Subarea			
Bear Valley Mutual Water Co.	20,480**	1S/2W-4N	Santa Ana River
Blue Banner Co.	80	1S/2W-9L	Santa Ana River
Cook Canyon	10	1N/3W-27R	City Creek
Crafton Water Co.	3,740	1S/2W-13	Mill Creek
East Highlands Ranch	1,900	1N/3W-36	Plunge Creek
East Highlands Ranch	70	1N/3W-25Q	Plunge Creek
East Highlands Ranch	730	1S/2W-4N	Santa Ana River
Greenspot Mutual Water Co.	600	1S/2W-22	Mill Creek
Guerth	250	1N/3W-27M	City Creek
Hodgdon	300	1N/4W-14C	East Twin Creek
Mount Vernon Water Co.	720	1N/5W-22M	Lytle Creek
North Fork Water Co.	4,800	1S/2W-4N	Santa Ana River
Redlands, City of	9,830	1S/2W-14N	Mill Creek
Redlands Water Co.	900	1S/2W-8	Santa Ana River
Regina Grape Product	30	1N/5W-5B	Lytle Creek
Rialto, City of	700	1N/5W-22M	Lytle Creek
San Bernardino, City of	2,860	1N/4W-6	Cajon Creek
San Bernardino, City of	1,450	1N/5W-6	Lytle Creek
West San Bernardino County Water District	220	1N/5W-22M	Lytle Creek
Subtotal	49,670		
Diversion in Banning-Cabazon Subarea			
Banning Heights Mutual Water Co.	1,570	2S/1E-8A	South Fork of Whitewater River
Cabazon County Water District	320	2S/2E-32	Millard Canyon
Cabazon County Water District	190	2S/2E-32L	Millard Canyon
Private water user	160	2S/2E-36	Stubbe Canyon
Private water user	20	2S/2E-36	San Gorgonio River
Riverside, County of	100	3S/2E-32	San Gorgonio River
Southern Pacific Transportation Co.	120	2S/2E-32	Millard Canyon
Subtotal	2,480		
Total	52,150		

*Diversion information for Bunker Hill Subarea obtained from "Annual Report of Watermaster", August 1, 1983, Volumes 1 through 7; diversion information for Banning-Cabazon Subarea from local water agencies, flood control districts, mutual water companies, or Division of Water Rights, State Water Resources Control Board.

**Some water may be used for spreading.

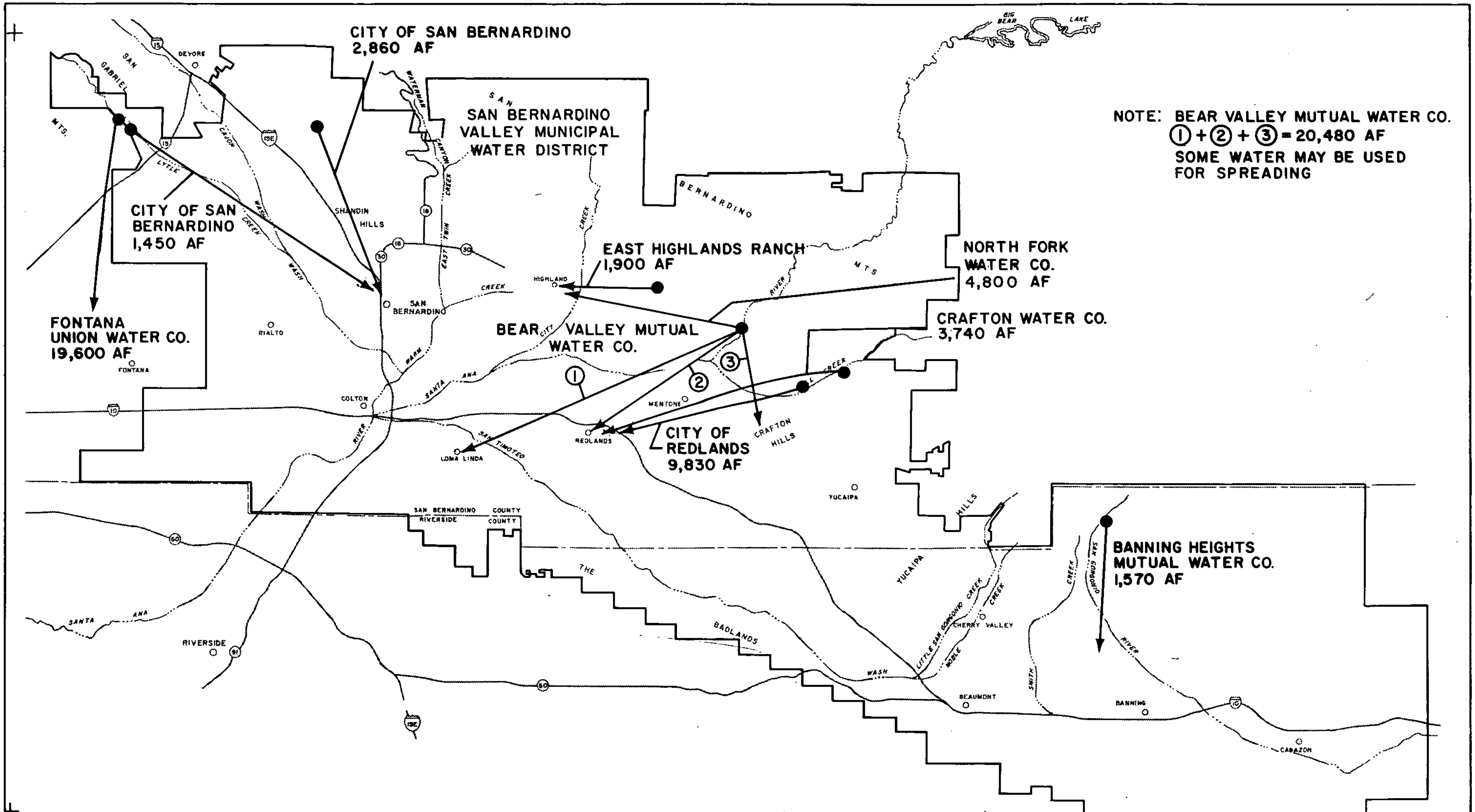


FIGURE 19-MAJOR DIVERSIONS FOR MUNICIPAL, INDUSTRIAL, AND AGRICULTURAL WATER IN 1980

TABLE 12

PROJECTED ALLOCATION OF SURFACE WATER DIVERSIONS
FROM STREAMS IN BUNKER HILL SUBAREA, 1990-2040
FOR MEAN RAINFALL

In 1,000 acre-feet

	1990	2000	2010	2020	2030	2040
Gross diversions	62.4	66.7	68.0	69.5	70.8	72.0
Export to Chino Basin						
Fontana Union Water Company*	-10.2	-10.2	-10.2	-10.2	-10.2	-10.2
Subtotal**	52.2	56.5	57.8	59.3	60.6	61.8
Transfers to:						
Colton-Rialto Subarea***						
City of Rialto	- 3.1	- 3.1	- 3.1	- 3.1	- 3.1	- 3.1
West San Bernardino County Water District	- 0.3	- 0.3	- 0.3	- 0.3	- 0.3	- 0.3
Subtotal	- 3.4	- 3.4	- 3.4	- 3.4	- 3.4	- 3.4
Yucaipa Subarea						
Yucaipa Valley County Water District#	- 3.7	- 7.3	- 8.3	- 9.5	-10.6	-11.4
San Timoteo Subarea##						
SGPWA	- 1.1	- 1.8	- 2.1	- 2.4	- 2.6	- 3.0
Total transfers	- 8.2	-12.5	-13.8	-15.3	-16.6	-17.8
Remaining local surface water diversion to be used in Bunker Hill Subarea by:***						
East Valley Water District	20.0	20.0	20.0	20.0	20.0	20.0
City of Redlands	19.6	19.6	19.6	19.6	19.6	19.6
City of San Bernardino	4.4	4.4	4.4	4.4	4.4	4.4
Total	44.0	44.0	44.0	44.0	44.0	44.0

*"Report of Watermaster", Volume 7, 1981, Table A (p. 1), shows 10,200 acre-feet (rounded to the nearest 100) as the amount of verified extractions that the company may produce from the San Bernardino Basin area (Bunker Hill and Bunker Hill Pressure Subareas) and may deliver for use on lands not within Western Municipal Water District of Riverside County or tributary to Riverside Narrows.

**Under mean annual precipitation conditions in study area, about 77,000 acre-feet has been available for municipal, industrial, and agricultural uses and for ground water recharge. (See "Reported 1980 and Future Surface Water Diversion in the San Bernardino Valley Municipal Water District--San Gorgonio Pass Water Agency Study Area", TIR Study Code No. 1610-7552-7).

***Amounts planned for 1990 by water purveyors.

#Yucaipa Valley County Water District and staff of SBVMWD indicated these are the amounts expected to be used when ground water extractions decrease and demands increase. Water is to be made available under the Santa Ana River-Mill Creek Cooperative Water Project Agreement: water from Mill Creek and/or Santa Ana River for water imported from SWP.

##It is assumed that, after 1980, water will be obtained from SBVMWD to recharge the ground water basin, based on discussions with staff members of SGPWA and SBVMWD. Water will be obtained from Mill Creek and/or the Santa Ana River, if available; otherwise, water will be provided from SWP.

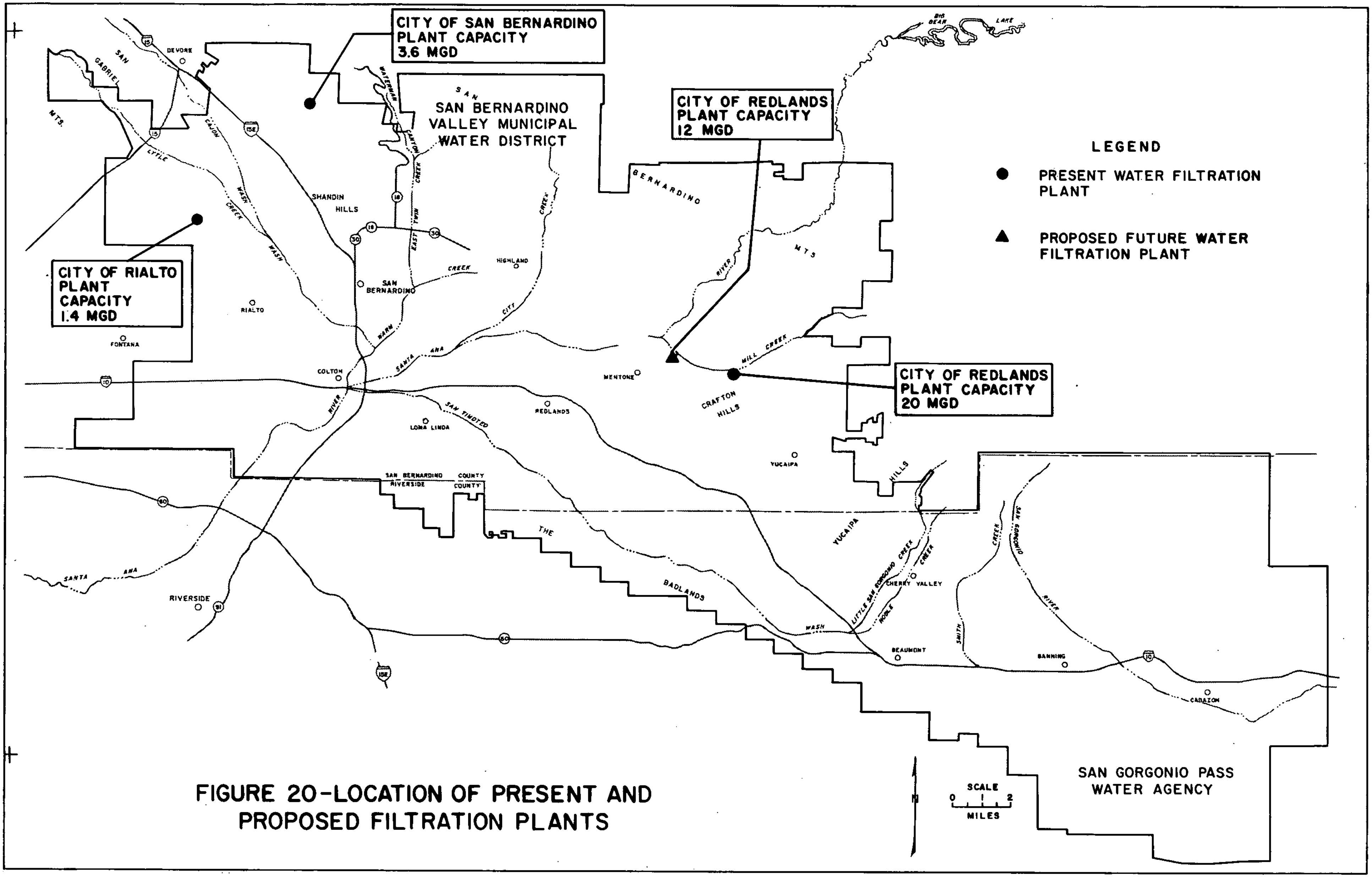


FIGURE 20-LOCATION OF PRESENT AND PROPOSED FILTRATION PLANTS

TABLE 13

GROUND WATER EXTRACTION
BY SUBAREA IN 1980

Subarea	In acre-feet	In percent
Colton-Rialto	28,272	14
Bunker Hill	81,870	41
Bunker Hill Pressure	71,925	35
Yucaipa	4,485	2
San Timoteo	7,248	4
Banning-Cabazon	7,720	4
Total extracted	201,520	100
Amount exported	65,810	33
Amount used in study area	135,710	67

study area, the mineral quality is, with few exceptions, good to excellent. Values for filterable residue (total dissolved solids--TDS) range from 150 milligrams per litre (mg/L) to 550 mg/L (Plate 4). Most wells sampled are in the 200 to 350 mg/L range. The higher values are generally located in the Yucaipa Subarea and portions of the Colton-Rialto, San Timoteo, and Banning-Cabazon Subareas.

Information on contamination of ground water supplies in the study area was obtained from the California Regional Water Quality Control Board (CRWQCB), Santa Ana Region.

Several wells near Redlands in the Bunker Hill Subarea have high nitrate values, but the nitrate problem appears to be limited to a very small area and to a few wells. It is believed to be the result of fertilizer that had been applied in the past.

Also near Redlands, some wells have been found to be contaminated from dibromochloropropane (DBCP), which had been used to protect citrus trees from nemotodes.

In addition, several wells in the Bunker Hill Subarea have been found to be contaminated with trichloroethylene (TCE) and tetrachloroethylene (PCE). Wells owned by the City of San Bernardino and by the Southern California Water Company had to be shut down by the CRWQCB, Santa Ana Region. The well fields of these two agencies are adjoining, but it is not known if the contamination is from the same source. The Southern California Water Company has ceased pumping its wells. The City of San Bernardino has initiated a cleanup program to remove the contaminants from the water so that its wells can be returned to service.

TCE and PCE contamination of the ground water was first noted in 1980 when ground water samples from 11 wells in the Bunker Hill Basin were found to contain one or the other of the contaminants.

The City of San Bernardino, State Department of Health Services, and CRWQCB, Santa Ana Region, conducted further sampling and performed a preliminary investigation to determine if any obvious source of the pollutants could be identified. TCE and PCE were found at concentrations that were above drinking water action levels (5 and 4 parts per billion--ppb) of the State Department of Health Services. The TCE concentrations were as high as 25 ppb

TABLE 14

PROJECTED GROUND WATER EXPORTS TO AREAS IN RIVERSIDE COUNTY OUTSIDE THE STUDY AREA, 1990-2040*

In acre-feet

Agency		Exports	Total
From Colton-Rialto Subarea**			
Inter County Water Company		100	
Jurupa Water Company		800	
La Sierra Water Company		2,100	
Meeks & Daley Water Company		800	
City of Riverside***		13,300	
Riverside Highland Water Company		2,800	
Temescal Water Company		1,300	
American Cement Company (Riverside Cement Company)		1,000	
West Riverside 350" Water Company		2,400	
	Total		24,600
From Bunker Hill Subarea#			
Riverside Highland Water Company		400	
	Total		400
From Bunker Hill Pressure Subarea#			
City of Riverside		49,600	
Riverside Highland Water Company		1,400	
Meeks & Daley Water Company and Agua Mansa Water Company		7,500	
University of California		500	
	Total		59,000
	Total Exports		84,000

*Values rounded to nearest 100.

**Values from verified average annual exports by agencies during 1959-1963, reported in "Annual Report of Watermaster", Volume 2, 1981, Table 4 (p. 17), and Volume 3, 1981, Table 4 (p. 33). Based on discussions with Donald L. Harriger, Western-San Bernardino Watermaster, and with water purveyors, the assumption was made that the water purveyors will take the amounts shown.
Because of rounding, the total for the subarea (24,600 acre-feet) exceeds the sum of the amount for Colton Basin (3,400) plus that for Riverside Basin in San Bernardino County (21,100 acre-feet). This minor difference is considered insignificant, and the pumpers who export are allowed to overextract up to 30 percent in a given year as long as, over a 5-year period, no more than 5 times the 5-year average annual amount is exported or replenishment is provided.

***Amounts reported for City of Riverside include those for Gage Canal and those produced from Colton and Riverside Basins in San Bernardino County. Ken Anderson of the City of Riverside has said the City may export its total from the Colton Basin because of quality problems in water from the City's wells in Riverside Basin.
Discussions with Watermaster Harriger indicate that Riverside County entities may take more water from Colton or Riverside Basins than is stipulated in the annual reports of watermaster, if combined total export for the two basins does not exceed that allowed or replenishment is provided.

#Values for Bunker Hill and Bunker Hill Pressure Subareas from the unnumbered table "Adjusted Rights for Extractions by Plaintiffs from the San Bernardino Basin Area Based on Natural Safe Yield of 232,100 acre-feet per Annum Classified According to Service Area", on p. 19, of "Annual Report of the Western-San Bernardino Watermaster for Calendar Year 1981". The table gives a total amount for delivery to areas outside the study area. Except for Riverside Highland Water Company, the sources are all in the Bunker Hill Pressure Subarea. On the basis of past and recent practices (most of the water exported by Riverside Highland Water Company has been produced in Bunker Hill Pressure Subarea) and discussions with staff of the company, it is assumed that the company will export 400 acre-feet from Bunker Hill Subarea and 1,400 acre-feet from Bunker Hill Pressure Subarea.

and PCE concentrations were as high as 51 ppb. Generally, PCE concentrations were higher than those of TCE. Wells producing from the deeper zones generally yielded higher levels of contaminants than the shallower wells.

Sampling of selected wells in February 1985 showed TCE as high as 20 ppb and PCE as high as 145 ppb (Plate 4). Eleven wells remain shut down pending remedial action.

The preliminary investigation did not find any signs of a potential source that is operating now. However, several abandoned public facilities in the area were determined to be potential sources. These were a former city airport site, a U. S. Army equipment depot, and a former military prisoner of war compound. In particular, the old San Bernardino Airport site was identified as warranting further investigation.

The CRWQCB, Santa Ana Region, contracted with a consultant to determine the sources of the TCE and PCE contamination and then to use the results of that study to clean up and abate this problem.*

Deep Percolation

In this investigation, the percolation of future water supplies was based on criteria developed for Bulletins 104-3 and 104-5. The percolation was separated into delivered water, streamflow, offstream percolation of rainfall, and artificial recharge of natural water in spreading grounds. The delivered water component can be subdivided into three parts: agricultural return water, return water from urban lawns, and waste water return.

For each subarea and the entire study area, percolation for the above components was estimated for 1980 and for future years (Tables 15-21). The 1980 values were based on actual rainfall for that year, which was a very wet year. The future values were based on the assumption that a mean annual rainfall would occur during 1990 to 2040.

The percolation values for 1980 were also based on the assumption that ground water storage space was available to store all the amounts developed using the criteria curves from the Bulletin 104 series. The future values for percolation also assume that there is space available in the ground water basin for percolation.

By checking hydrographs of several key wells for the depth to ground water in Bunker Hill Subarea, where most of the percolation occurs, it was found that there was enough space to accommodate the large volume of streamflow percolation. For the Banning-Cabazon Subarea, no estimate could be made for stream percolation because no data were available.

As shown in Tables 15-21, the greatest increase in percolation in the future will be the delivered water component, which increases from 93,000 acre-feet in 1990 to 126,800 in 2040. This increase is largely the result of urbanization and the subsequent reduction in agricultural use. Approximately 50 to 60 percent of the water supplied to meet M and I water requirements is waste water. In this study area, the waste water effluent returns to the stream system or to cesspools and percolates to the ground water basin if space is available.

The waste water treatment plants in the SBVMWD portions of the study area discharge their effluent into the Santa

*"Investigation of Sources of TCE and PCE Contamination in the Bunker Hill Ground Water Basin", by URS Corporation in association with ERM-West, submitted to CRWQCB, Santa Ana Region, August 1986.

TABLE 15

ESTIMATED DEEP PERCOLATION FOR
SAN BERNARDINO VALLEY-SAN GORGONIO PASS
STUDY AREA, 1980-2040*

In acre-feet

Year	Local spreading**	Stream-flow***	Delivered water	Precipi-tation	Total
1980	72,800	158,600	84,100	114,100	429,600
1990	21,400	90,000	93,000	24,400	228,800
2000	17,800	92,500	99,000	23,500	232,800
2010	16,800	93,000	106,300	22,900	239,000
2020	15,600	93,500	112,800	22,800	244,700
2030	14,500	94,000	118,900	22,700	250,100
2040	13,700	94,500	126,800	22,600	257,600

*Actual 1980 precipitation values were used for deep percolation of local spreading, streamflow, and precipitation. For 1990-2040, mean rainfall of each subarea was assumed.
**Local spreading occurs only in the Bunker Hill Subarea.
***The streamflow data do not include the Banning-Cabazon Subarea because no data are available.

TABLE 16

ESTIMATED DEEP PERCOLATION FOR
COLTON-RIALTO SUBAREA
1980-2040*

In acre-feet

Year	Local spreading	Stream-flow	Delivered water	Precipi-tation	Total
1980	0	11,500	19,500	29,200	60,200
1990	0	20,000	22,700	9,200	51,900
2000	0	20,000	25,200	8,600	53,800
2010	0	20,000	29,600	8,000	57,600
2020	0	20,000	31,300	8,000	59,300
2030	0	20,000	32,900	8,000	60,900
2040	0	20,000	34,800	8,000	62,800

*Actual 1980 precipitation value (30.74 inches) was used for deep percolation of local spreading, streamflow, and precipitation. For 1990-2040, mean rainfall (16.30 inches) was assumed (26-year average).

TABLE 17

ESTIMATED DEEP PERCOLATION FOR
BUNKER HILL SUBAREA
1980-2040*

In acre-feet

Year	Local spreading	Stream-flow	Delivered water	Precipi-tation	Total
1980	72,800	116,000	38,000	36,500	263,300
1990	21,400	55,200	41,600	7,500	125,700
2000	17,800	57,200	43,800	6,800	125,600
2010	16,800	57,600	45,600	7,000	127,000
2020	15,600	58,000	48,200	7,000	128,800
2030	14,500	58,400	50,900	7,000	130,800
2040	13,700	58,800	54,000	7,000	133,500

*Actual 1980 precipitation value (35.10 inches) was used for deep percolation of local spreading, streamflow, and precipitation. For 1990-2040, mean rainfall (18.00 inches) was assumed (26-year average).

TABLE 18

ESTIMATED DEEP PERCOLATION FOR
BUNKER HILL PRESSURE SUBAREA
1980-2040*

In acre-feet

Year	Local spreading	Stream-flow	Delivered water	Precipi-tation	Total
1980	0	17,800	11,900	5,900	35,600
1990	0	8,500	11,900	900	21,300
2000	0	8,800	11,900	900	21,600
2010	0	8,800	11,900	900	21,600
2020	0	8,900	12,800	900	22,600
2030	0	9,000	13,400	900	23,300
2040	0	9,000	15,100	900	25,000

*Actual 1980 precipitation value (29.00 inches) was used for deep percolation of local spreading, streamflow, and precipitation. For 1990-2040, mean rainfall (15.05 inches) was assumed (26-year average).

TABLE 19

ESTIMATED DEEP PERCOLATION FOR
YUCAIPA SUBAREA
1980-2040*

In acre-feet

Year	Local spreading	Stream-flow	Delivered water	Precipi-tation	Total
1980	0	10,600	5,200	4,500	20,300
1990	0	5,000	6,200	900	12,100
2000	0	5,200	6,600	900	12,700
2010	0	5,300	7,100	900	13,300
2020	0	5,300	7,700	900	13,900
2030	0	5,300	8,200	900	14,400
2040	0	5,400	8,600	900	14,900

*Actual 1980 precipitation value (30.00 inches) was used for deep percolation of local spreading, streamflow, and precipitation. For 1990-2040, mean rainfall (16.51 inches) was assumed (26-year average).

TABLE 20

ESTIMATED DEEP PERCOLATION FOR
SAN TIMOTEO SUBAREA*
1980-2040

In acre-feet

Year	Local spreading	Stream-flow	Delivered water	Precipi-tation	Total
1980	0	2,700	4,500	18,000	25,200
1990	0	1,300	5,200	2,600	9,100
2000	0	1,300	5,800	2,800	9,900
2010	0	1,300	6,100	2,700	10,100
2020	0	1,300	6,400	2,700	10,400
2030	0	1,300	6,700	2,600	10,600
2040	0	1,300	7,000	2,600	10,900

*Actual 1980 precipitation value (31.60 inches) was used for deep percolation of local spreading, streamflow, and precipitation. For 1990-2040, mean rainfall (16.32 inches) was assumed (26-year average).

TABLE 21

ESTIMATED DEEP PERCOLATION FOR
BANNING-CABAZON SUBAREA
1980-2040*

In acre-feet

Year	Local spreading	Stream-flow	Delivered water	Precipi-tation	Total
1980	0	—	5,000	20,000	25,000
1990	0	—	5,400	3,300	8,700
2000	0	—	5,700	3,500	9,200
2010	0	—	6,000	3,400	9,400
2020	0	—	6,400	3,300	9,700
2030	0	—	6,800	3,300	10,100
2040	0	—	7,300	3,200	10,500

*Actual 1980 precipitation value (34.00 inches) was used for deep percolation of local spreading, streamflow, and precipitation. For 1990–2040, mean rainfall (17.20 inches) was assumed (26-year average).

Ana River. Most of the plants (Figure 21) are located in the vicinity of the Bunker Hill Pressure Subarea.

In the past, the amounts of local streamflow available for artificial recharge and percolation to the ground water basin within the study area depended on the amount of rainfall and subsequent runoff, amount of streamflow diverted for beneficial use to meet agricultural and M and I requirements, and, prior to 1969, legal limitations on the amount of water that could be recharged. Although this last restriction has been lifted, the Mayor of San Bernardino in 1982 requested that water agencies artificially recharging the Bunker Hill Basin agree to a moratorium on spreading water for a period of 30 days. During that time, a task force was formed to study possible measures that could be taken to mitigate the problem of high ground water. Although there has been no formal agreement between the agencies, both SBVMWD and San Bernardino Valley Water Conservation District have reduced the amounts of water recharged artificially into the Bunker Hill forebay. Since 1980, most of SBVMWD's replenishment of SWP water has gone to the Colton-Rialto Subarea.

The TIR "Deep Percolation in the San Bernardino Valley Municipal Water District-San Gorgonio Pass Water Agency" describes the method used to estimate the future amounts of artificial recharge to the ground water basin. Figure 22 depicts the relation between the amount of rainfall and the total amount of water available for either artificial recharge or M and I and agricultural requirements. For a mean rainfall, the total amount of water available for either purpose is 77,000 acre-feet. The availability of water varies directly with the amount of rain.

Because of future urbanization within the study area, smaller quantities of water will be diverted for agriculture. In accordance with desires of the affected local agencies, more water will be utilized to meet M and I requirements. According to these agencies, they will build additional water treatment plants to treat the

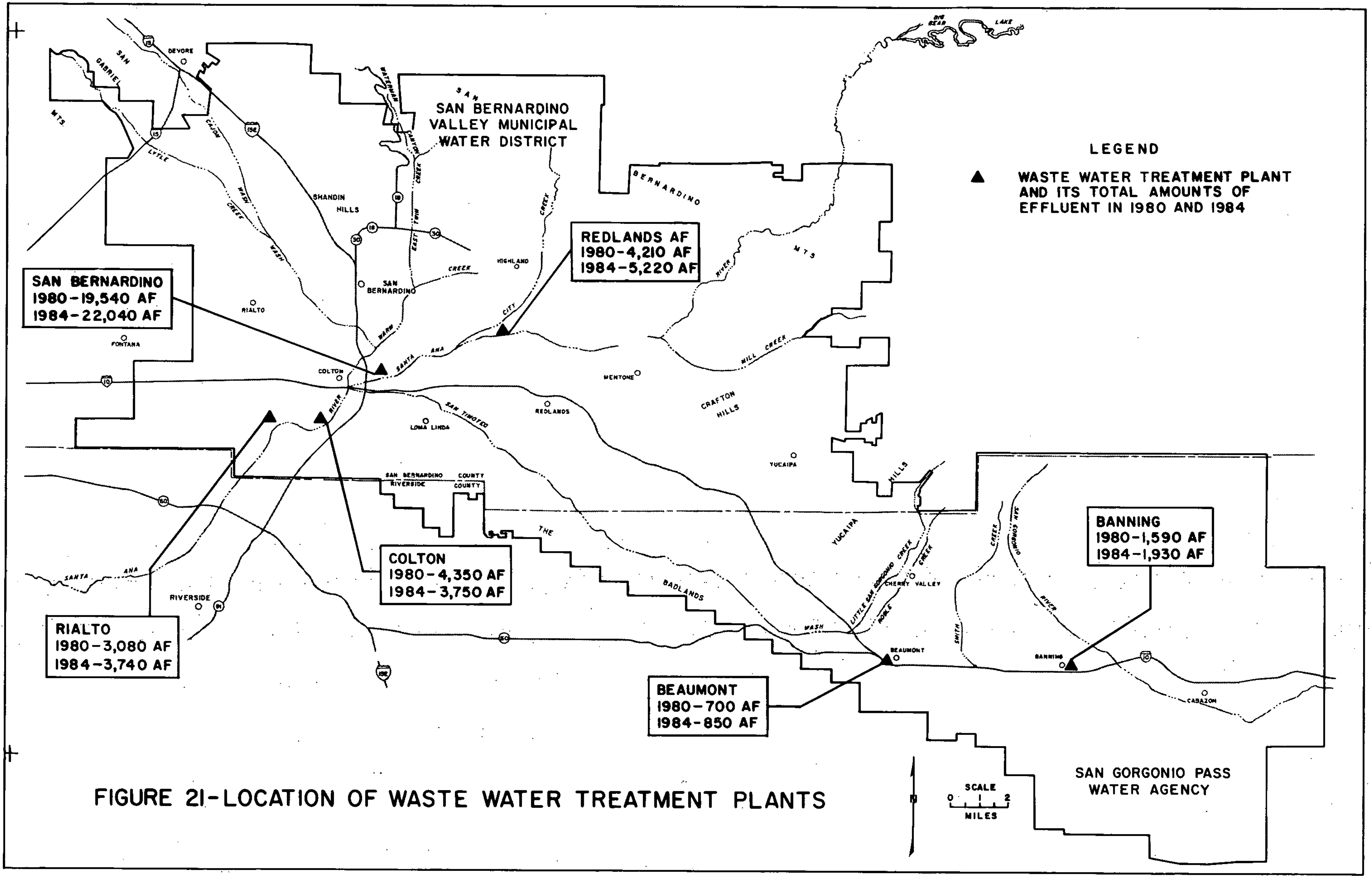
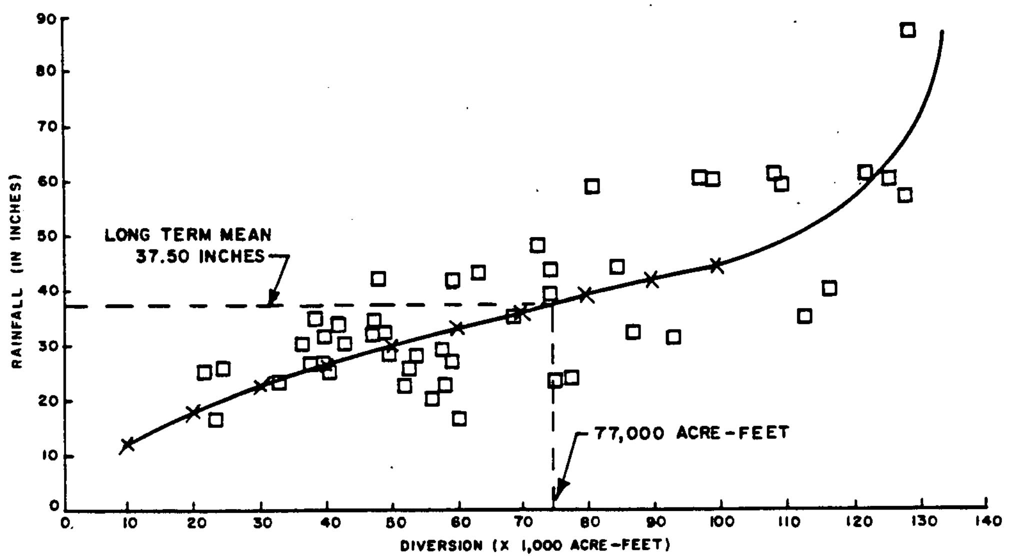


FIGURE 21-LOCATION OF WASTE WATER TREATMENT PLANTS



Note: 1. Historical rainfall records shown are at Big Bear Lake Dam, Raingage Station No. 32. Data were obtained from San Bernardino County Flood Control District.

2. Diversion data included water used for M&I, agricultural, and artificial recharge purposes. Diverted water for export was not included. Data were obtained from Meeting Water Demands in Bunker Hill-San Timoteo Area: Geology, Hydrology, and Operation-Economic Studies, DWR Memorandum Report, February 1971; Updated Hydrologic Conditions in the Bunker Hill-San Timoteo Area, DWR Letter Report, November 1978; and Draft 1984 Annual Report on Water Supply by SBVMWD.

FIGURE 22-HISTORICAL PRECIPITATION VS. HISTORICAL SURFACE WATER DIVERSION IN THE BUNKER HILL SUBAREA, WATER YEARS 1934-35 THROUGH 1980-81

local stream diversions.

Values that were presented in Table 12 reflect the assumptions for future stream diversions and also reflect a mean rainfall. Because the capacity of the current water treatment plants and those that are scheduled to be built in the future are fixed, higher values for rainfall would not increase the quantities of water that would be diverted and utilized to meet M and I requirements.

Subsurface Flow

Subsurface inflow comes from the San Bernardino Mountain front itself, as well as from the canyons and streams. These subsurface flow values were estimated from a comparison of similar conditions in the Chino-Riverside and San Gabriel Valley investigations.

In making this evaluation, special consideration was given to the San Andreas fault zone, which apparently acts as an impediment to subsurface inflow. The magnitude of the effect of this barrier is not precisely known because of a lack of data, but water level maps indicate an approximate difference of 200 feet in water elevation.

The approximate length of the San Bernardino Mountain front is 24 miles, excluding the width of the major stream canyons. An underflow estimate of about 400 acre-feet per mile per year was used. This value is consistent with the values used in similar investigations in Chino, Riverside, and San Gabriel areas. The total inflow, using 400 acre-feet per mile, comes to about 9,600 acre-feet per year.

Subsurface inflow also occurs underneath the Lytle Creek channel and Cajon Creek. The average amount of flow, according to Bulletin 104-5, was 3,300 acre-feet for Lytle Creek and 2,800 acre-feet for Cajon Creek. Other inflows occur underneath the following creeks and streams along the boundary: Santa Ana River, 2,500 acre-feet; Mill Creek, 1,100 acre-feet; Plunge Creek, 500 acre-feet; East Twin Creek, 700 acre-feet; Waterman Canyon, 500 acre-feet; City Creek, 800 acre-feet; and Devil Canyon, 700 acre-feet, for a total of 6,800 acre-feet (Figure 23).

The average annual subsurface flow that occurred in the past was assumed to be the same for the future study period, 1990 to 2040. However, differences in water levels would result in different subsurface flows, and high ground water levels, as they are at present, would also influence the amounts of subsurface flows.

For this study, the subsurface outflow along the Bunker Hill Dike is not really a boundary condition because this is not along the study area boundary. However, in looking at the Bunker Hill Basin, this subsurface flow is significant. Historically, the flow has ranged from 26,700 acre-feet in 1936 to 10,500 in 1960. These were the values assumed as outflow during the study for Bulletin 104-5.

In any plan for managing the ground water basin in the Bunker Hill area, consideration must be given to the actual subsurface flow that may occur along the Bunker Hill Dike.

Other Factors Affecting Future Supply

Figure 24 shows annual amounts of the extractions that will be transferred between subareas in 1990-2040, as well as the amounts of water that are exported outside the study area, if current practice continues. In the case of the Bunker Hill, Bunker Hill Pressure, and Colton-Rialto Subareas, the amounts shown on Figure 24 are based upon amounts stipulated by the court as indicated in the Western case judgment. Also shown are the amounts of extraction that will be necessary to meet 1990 water requirements, assuming that there is going to be a mean rainfall and a streamflow diversion of approximately 58,000 acre-feet. Tables 22-27 list the supplies that will be used in 1990-2040 if current practice is continued.

The U. S. Army Corps of Engineers, as an alternative to the Mentone Dam that was originally proposed as part of the All-River Plan in the Santa Ana River Flood Control Project, has looked into the possibility of constructing a multi-purpose dam, the proposed Seven Oaks Dam, on the Santa Ana River, as shown on Plate 2. This dam would be primarily for flood control purposes, but if local or State agencies would agree to pay for it, a portion of the reservoir would be allocated exclusively for water storage.

According to the latest Corps estimates, this reservoir would have a 40,000-acre-foot capacity. Other capacities that were investigated were 20,000 and 70,000 acre-feet. According to the Corps, the 40,000-acre-foot reservoir would be able to capture an additional 7,000 acre-feet of local water that would have gone to the ocean. In addition, the reservoir would be available to store excess SWP water from Northern California.

The Corps places a value of $300 per acre-foot on the local water salvaged. Approximately $100 of this would be for energy saved by not having to deliver the water over the Tehachapi Mountains. The other $200 is the conservation savings.

However, the Corps has discontinued the study because of an administrative decision in Washington that the water supply portion of the flood control project must be a local responsibility.

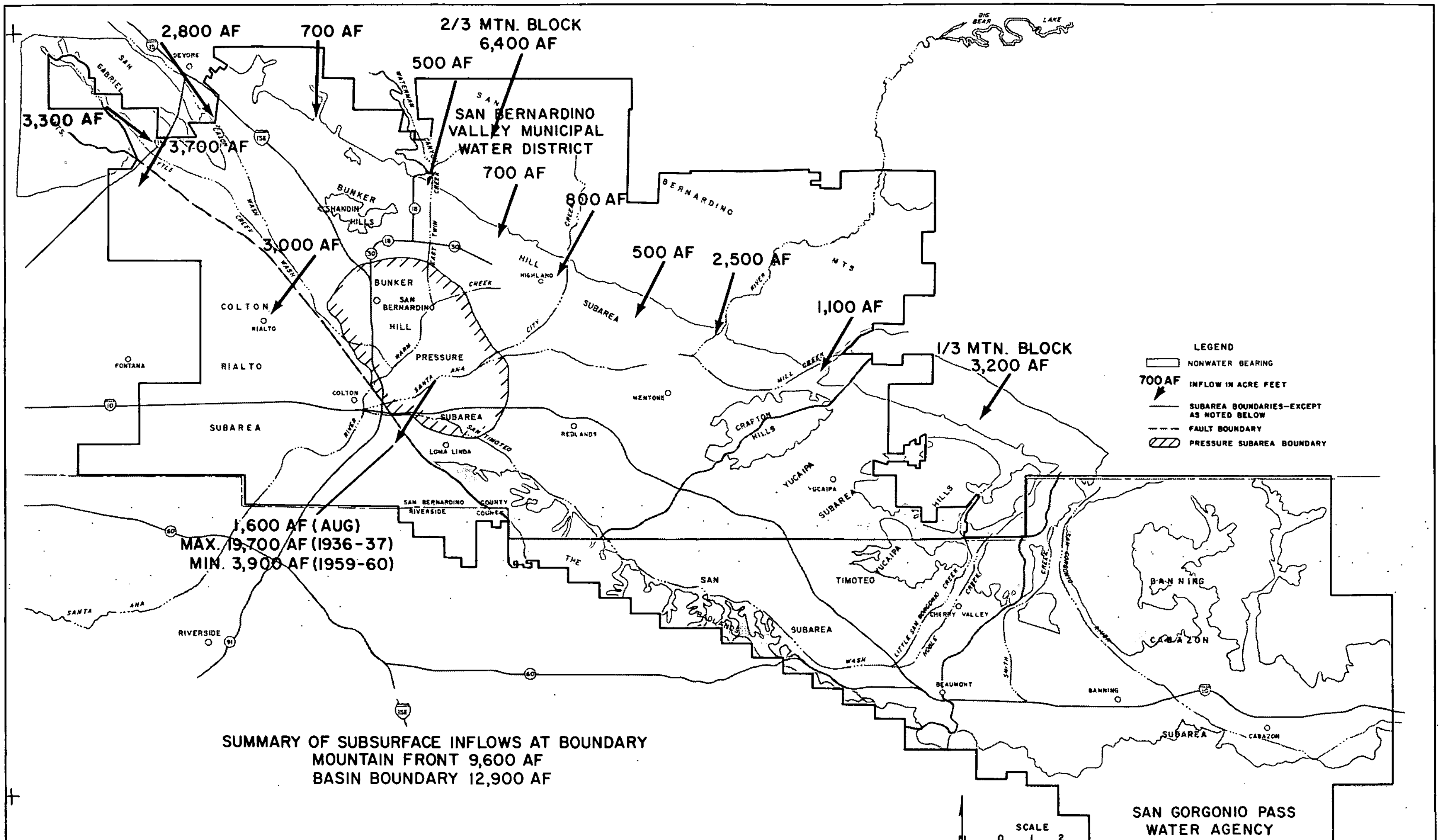


FIGURE 23-AREAS OF UNDERFLOW

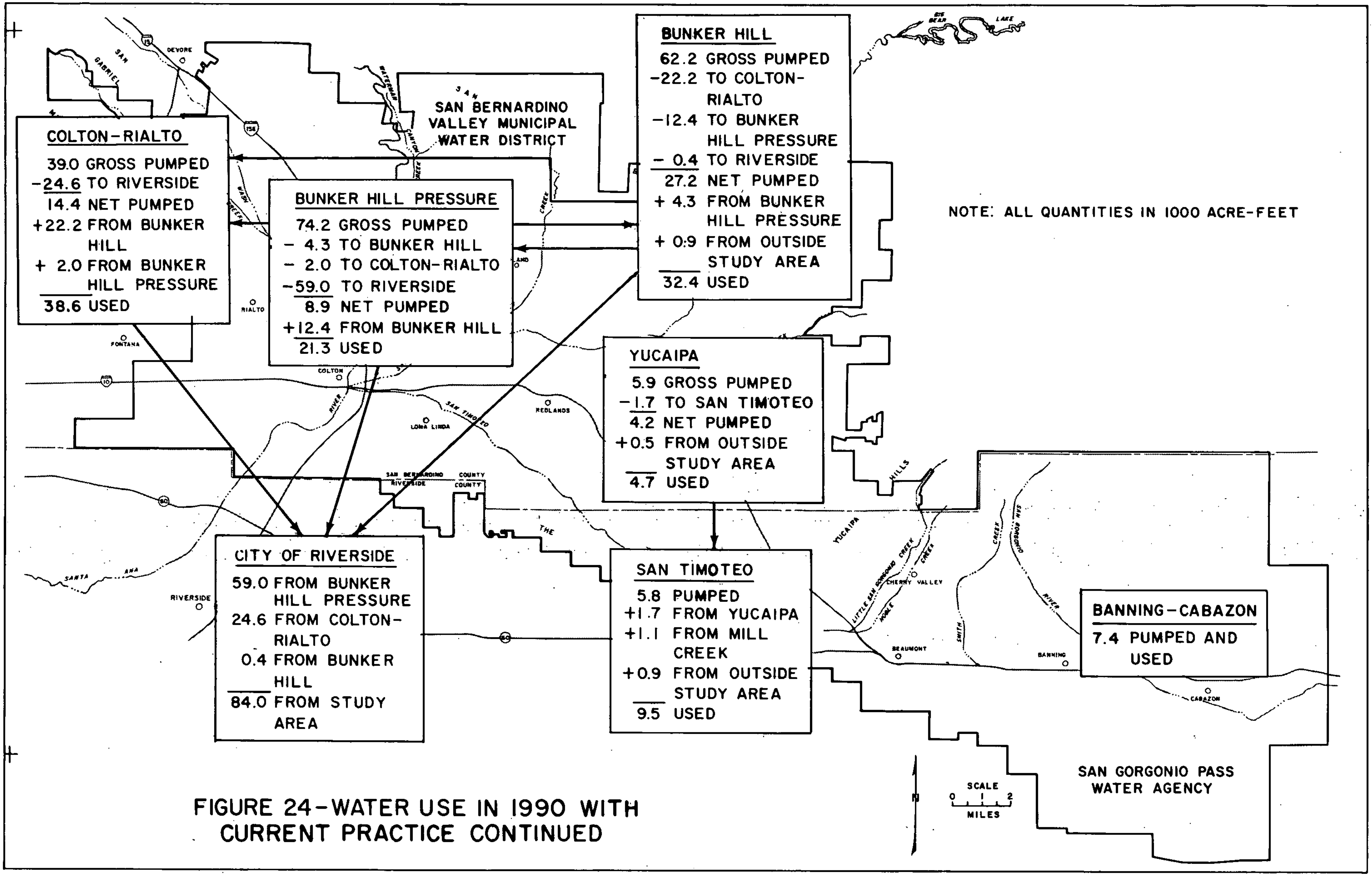


FIGURE 24-WATER USE IN 1990 WITH CURRENT PRACTICE CONTINUED

TABLE 22

WITH CURRENT PRACTICE CONTINUED, WATER USED IN 1990

In 1,000 acre-feet

Subarea	(1) Exported out of study area	(2) Transferred: Into sub-area	(3) Transferred: Out of sub-area	(4) Net pumped & used in subarea	(5) =1+3+4 Gross pumped	(6) Imported from outside study area	(7) =2+4+6 Total used in subarea	(8) Surface diversions in subarea	(9) Re-claimed water used in subarea	(10) =7+8+9 Total water used in subarea
Colton-Rialto	24.6	24.2	0	14.4	39.0	0	38.6	3.4	0	42.0
Bunker Hill	0.4	4.3	34.6	27.2	62.2	0.9	32.4	47.6	0	80.0
Bunker Hill Pressure	59.0	12.4	6.3	8.9	74.2	0	21.3	0	1.7	23.0
Yucaipa	0	0	1.7	4.2	5.9	0.5	4.7	4.6	0	9.3
San Bernardino Valley MWD	84.0	40.9	42.6	54.7	181.3	1.4	97.0	55.6	1.7	154.3
San Timoteo	0	1.7* 1.1**	0	5.8	5.8	0.9	9.5	0	0	9.5
Banning-Cabazon	0	0	0	7.4	7.4	0	7.4	2.4	0	9.8
San Gorgonio Pass Water Agency	0	2.8	0	13.2	13.2	0.9	16.9	2.4	0	19.3
Total	84.0	43.7	42.6	67.9	194.5	2.3	113.9	58.0	1.7	173.6

*From Yucaipa
**From Mill Creek

TABLE 23

WITH CURRENT PRACTICE CONTINUED, WATER USED IN 2000

In 1,000 acre-feet

Subarea	(1) Exported out of study area	(2) Transferred	(3)	(4) Net pumped & used in subarea	(5) =1+3+4 Gross pumped	(6) Imported from outside study area	(7) =2+4+6 Total used in subarea	(8) Surface diversions in subarea	(9) Re-claimed water used in subarea	(10) =7+8+9 Total water used in subarea
		Into sub-area	Out of sub-area							
Colton-Rialto	24.6	24.2	0	17.4	42.0	0	41.6	3.4	0	45.0
Bunker Hill	0.4	4.3	34.6	27.2	62.2	0.9	32.4	47.6	0	80.0
Bunker Hill Pressure	59.0	12.4	6.3	8.9	74.2	0	21.3	0	1.7	23.0
Yucaipa	0	0	1.7	1.7	3.4	0.5	2.2	8.2	0	10.4
San Bernardino Valley MWD	84.0	40.9	42.6	55.2	181.8	1.4	97.5	59.2	1.7	158.4
San Timoteo	0	1.7* 1.8**	0	5.8	5.8	0.9	10.2	0	0	10.2
Banning-Cabazon	0	0	0	7.9	7.9	0	7.9	2.4	0	10.3
San Gorgonio Pass Water Agency	0	3.5	0	13.7	13.7	0.9	18.1	2.4	0	20.5
Total	84.0	44.4	42.6	68.9	195.5	2.3	115.6	61.6	1.7	178.9

*From Yucaipa
**From Mill Creek

TABLE 24

WITH CURRENT PRACTICE CONTINUED, WATER USED IN 2010

In 1,000 acre-feet

Subarea	(1) Exported out of study area	(2) Transferred Into sub-area	(3) Transferred Out of sub-area	(4) Net pumped & used in subarea	(5) =1+3+4 Gross pumped	(6) Imported from outside study area	(7) =2+4+6 Total used in subarea	(8) Surface diversions in subarea	(9) Re-claimed water used in subarea	(10) =7+8+9 Total water used in subarea
Colton-Rialto	24.6	24.2	0	24.4	49.0	0	48.6	3.4	0	52.0
Bunker Hill	0.4	4.3	34.6	28.2	63.2	0.9	33.4	47.6	0	81.0
Bunker Hill Pressure	59.0	12.4	6.3	8.9	74.2	0	21.3	0	1.7	23.0
Yucaipa	0	0	1.7	1.7	3.4	0.5	2.2	9.2	0	11.4
San Bernardino Valley MWD	84.0	40.9	42.6	63.2	189.8	1.4	105.5	60.2	1.7	167.4
San Timoteo	0	1.7* 2.1**	0	5.8	5.8	0.9	10.5	0	0	10.5
Banning-Cabazon	0	0	0	8.2	8.2	0	8.2	2.4	0	10.6
San Gorgonio Pass Water Agency	0	3.8	0	14.0	14.0	0.9	18.7	2.4	0	21.1
Total	84.0	44.7	42.6	77.2	203.8	2.3	124.2	62.6	1.7	188.5

*From Yucaipa
**From Mill Creek

0202016 33

TABLE 25

WITH CURRENT PRACTICE CONTINUED, WATER USED IN 2020

In 1,000 acre-feet

Subarea	(1) Exported out of study area	(2) Transferred: Into sub-area	(3) Transferred: Out of sub-area	(4) Net pumped & used in subarea	(5) =1+3+4 Gross pumped	(6) Imported from outside study area	(7) =2+4+6 Total used in subarea	(8) Surface diversions in subarea	(9) Re-claimed water used in subarea	(10) =7+8+9 Total water used in subarea
Colton-Rialto	24.6	24.2	0	28.4	53.0	0	52.6	3.4	0	56.0
Bunker Hill	0.4	4.3	34.6	34.2	69.2	0.9	39.4	47.6	0	87.0
Bunker Hill Pressure	59.0	12.4	6.3	9.9	75.2	0	22.3	0	1.7	24.0
Yucaipa	0	0	1.7	1.7	3.4	0.5	2.2	10.4	0	12.6
San Bernardino Valley MWD	84.0	40.9	42.6	74.2	200.8	1.4	116.5	61.4	1.7	179.6
San Timoteo	0	1.7* 2.1**	0	5.8	5.8	0.9	10.8	0	0	10.8
Banning-Cabazon	0	0	0	8.7	8.7	0	8.7	2.4	0	11.1
San Gorgonio Pass Water Agency	0	4.1	0	14.5	14.5	0.9	19.5	2.4	0	21.9
Total	84.0	45.0	42.6	88.7	215.3	2.3	136.0	63.8	1.7	201.5

*From Yucaipa
**From Mill Creek

TABLE 26

WITH CURRENT PRACTICE CONTINUED, WATER USED IN 2030

In 1,000 acre-feet

Subarea	(1) Exported out of study area	(2) Transferred: Into sub-area	(3) Transferred: Out of sub-area	(4) Net pumped & used in subarea	(5) =1+3+4 Gross pumped	(6) Imported from outside study area	(7) =2+4+6 Total used in subarea	(8) Surface diversions in subarea	(9) Re-claimed water used in subarea	(10) =7+8+9 Total water used in subarea
Colton-Rialto	24.6	24.2	0	31.4	56.0	0	55.6	3.4	0	59.0
Bunker Hill	0.4	4.3	34.6	40.2	75.2	0.9	39.4	47.6	0	87.0
Bunker Hill Pressure	59.0	12.4	6.3	9.9	75.2	0	22.3	0	1.7	24.0
Yucaipa	0	0	1.7	1.7	3.4	0.5	2.2	11.5	0	13.7
San Bernardino Valley MWD	84.0	40.9	42.6	83.2	209.8	1.4	125.5	62.5	1.7	189.7
San Timoteo	0	1.7* 2.6**	0	5.8	5.8	0.9	11.0	0	0	11.0
Banning-Cabazon	0	0	0	9.2	9.2	0	9.2	2.4	0	11.6
San Gorgonio Pass Water Agency	0	4.3	0	15.0	15.0	0.9	20.2	2.4	0	22.6
Total	84.0	45.2	42.6	98.2	224.8	2.3	145.7	64.9	1.7	212.3

*From Yucaipa
**From Mill Creek

TABLE 27

WITH CURRENT PRACTICE CONTINUED, WATER USED IN 2040

In 1,000 acre-feet

Subarea	(1) Exported out of study area	(2) Transferred Into sub-area	(3) Transferred Out of sub-area	(4) Net pumped & used in subarea	(5) =1+3+4 Gross pumped	(6) Imported from outside study area	(7) =2+4+6 Total used in subarea	(8) Surface diversions in subarea	(9) Re-claimed water used in subarea	(10) =7+8+9 Total water used in subarea
Colton-Rialto	24.6	24.2	0	35.4	60.0	0	59.6	3.4	0	63.0
Bunker Hill	0.4	4.3	34.6	47.2	82.2	0.9	52.4	47.6	0	100.0
Bunker Hill Pressure	59.0	12.4	6.3	11.9	77.2	0	24.3	0	1.7	26.0
Yucaipa	0	0	1.7	1.7	3.4	0.5	2.2	12.3	0	14.5
San Bernardino Valley MWD	84.0	40.9	42.6	96.2	222.8	1.4	138.5	63.3	1.7	203.5
San Timoteo	0	1.7* 3.0**	0	5.8	5.8	0.9	11.4	0	0	11.4
Banning-Cabazon	0	0	0	9.9	9.9	0	9.9	2.4	0	12.3
San Gorgonio Pass Water Agency	0	4.7	0	15.7	15.7	0.9	21.3	2.4	0	23.7
Total	84.0	45.6	42.6	111.9	238.5	2.3	159.8	65.7	1.7	227.2

*From Yucaipa
**From Mill Creek

V. LEGAL AND INSTITUTIONAL ASPECTS

Legal and institutional factors that must be considered in arriving at a solution to the high ground water problem, as well as in developing a management plan that includes possible conjunctive use of SWP water, are contained in decisions in several court cases and authorizing legislation for the major water agencies. Also to be taken into account are provisions of pending legislation, agreements among agencies, and current legal activity.

Court Cases

Several court cases have affected the amounts and locations of future water obligations for SBVMWD.

The first case was the Orange County case in which Orange County Water District, as plaintiff, sued the City of Chino, et al. This court case, No. 117628 filed in Orange County Superior Court, was settled in 1969 by a stipulated judgment. The essential feature of that judgment specified that SBVMWD will be responsible for delivery of an average annual supply of 15,250 acre-feet of so-called base flow and, in addition, "SBVMWD each year shall be responsible at Riverside Narrows for not less than 13,420 acre-feet of Base Flow plus one-third of any cumulative debit . . . ." Base flow is defined as surface flow less storm flow.

Also, the judgment specifies that the "amount of Base Flow at Riverside Narrows received during any year shall be subject to adjustment based on the weighted average annual TDS in such Base Flow . . . ." Table 28 gives the adjustment to the base flow for quality.

SBVMWD has an agreement with the City of San Bernardino that, from its sewerage plants, the city will continue to discharge across the Bunker Hill Dike at least 16,000 acre-feet of treated effluent each year in the manner now being done for the use and benefit of SBVMWD and for meeting its obligations in its agreement with downstream interests. Such effluent shall not be of lesser quality than will meet the present requirement of the CRWQCB, Santa Ana Region.

SBVMWD's credit for base flow at Riverside Narrows has grown continuously since the stipulated judgment went into effect in 1970, primarily because of the increases in the amount of treated waste water effluent discharged by the Cities of San Bernardino, Colton, and Rialto along the Santa Ana River. Table 29 summarizes SBVMWD's credit for base flow.

The other court case that has affected SBVMWD is that of <u>Western Municipal Water District of Riverside County</u> v. <u>East San Bernardino County Water District, et al</u>. This case, the Western case, was filed in 1963 in the Superior Court in Riverside County as No. 78426. It was settled in 1969.

Under terms of this judgment (see Paragraph VI of the judgment), which was entered into in 1969, SBVMWD is obligated to provide imported water for replenishment of the San Bernardino Basin area at least equal to the amount by which extractions for use in San Bernardino County exceed those during the five-year period 1959-63, "adjusted as may be required by the natural safe yield of the San Bernardino Basin Area..." Table 30 summarizes the status of SBVMWD's obligation for 1976 through 1980 for replenishment water in the San

TABLE 28

ADJUSTMENT FOR QUALITY
OF BASE FLOW
AT RIVERSIDE NARROWS

If the weighted average TDS in base flow at Riverside Narrows is:	Then the adjusted base flow shall be determined by the formula:
Greater than 700 ppm*	$Q - \frac{11}{15,250} Q\,(TDS-700)$
600 ppm - 700 ppm	Q
Less than 600 ppm	$Q + \frac{11}{15,250} Q\,(600-TDS)$

Where: Q = Base flow actually received.

*ppm = parts per million

TABLE 29

SUMMARY OF BASE FLOW OBLIGATION AT RIVERSIDE NARROWS*

In acre-feet by water year

	1977	1978	1979	1980	1981	1982**
Annual adjusted base flow	18,286	21,941	26,456	25,549	19,550	32,778
Cumulative:						
Adjusted base flow	116,700	138,641	165,097	190,646	210,196	242,974
Entitlement of Chino Basin and Western Municipal Water District	106,750	122,000	137,250	152,500	167,750	183,000
Credit	9,950	16,641	27,847	38,146	42,446	59,974
One-third of cumulative debt	0	0	0	0	0	0
Minimum base flow required in following year	13,420	13,420	12,420	12,420	12,420	12,420

*From annual report of Santa Ana River Watermaster, as reported in SBVMWD annual report.
**Not verified by Watermaster.

TABLE 30

SUMMARY OF REPLENISHMENT CREDITS AND OBLIGATIONS FOR THE SAN BERNARDINO BASIN AREA AS DETERMINED BY THE WESTERN-SAN BERNARDINO WATERMASTER*

In acre-feet by calendar year

	1976	1977	1978	1979	1980
Replenishment credits					
Extraction credit**	22,921	22,427	30,198	12,431	8,143
Actual replenishment***	12,555	24,562	13,230	4,012	166
Total credits for year	35,476	46,989	43,428	16,443	8,309
Total accumulated credits	139,020	186,009	229,437	245,880	254,189
Replenishment obligations					
Total obligations	5,268	4,019	6,690	10,935	12,824
Accumulated obligations	32,604	36,623	43,313	54,248	67,072
Net credits (obligations)	106,416	149,386	186,124	191,632	187,117

*From annual report of Western-San Bernardino Watermaster, August 1982, as reported in SBVMWD annual report.
**Amount that may be extracted without replenishment obligations, which, in fact, have not been extracted.
***Total imported SWP water requested by SBVMWD less direct deliveries.

Bernardino Basin area.

It should be noted that the five-year period 1959-63 was a very dry period when agriculture was still a major industry. During this period, requirements for agricultural water were higher than those for M and I. Currently, M and I water constitutes about 75 percent of the total water demand in the study area. Because the unit water use for low density urban development that has occurred in the study area is lower than that for agriculture, there was a general decline in water requirements during the 1960s and into the early 1970s. In 1965, water requirements were estimated to be 191,000 acre-feet in the study area, excluding the Banning-Cabazon Subarea, based on Bulletins 104-3 and 104-5. The 1990 requirement for the same area is estimated to be 161,000 acre-feet.

In addition to the obligation for replenishment water in the San Bernardino Basin area, SBVMWD becomes responsible for the maintenance of water levels in the Colton Basin area as follows: "Extractions from the Colton Basin Area and that portion of the Riverside Basin Area within San Bernardino County, for use within San Bernardino Valley, shall not be limited. However, except for any required replenishment by Western, San Bernardino Valley shall provide the water to maintain the static water levels in the area, as determined by wells numbered 1S/4W-21Q3, 1S/4W-29H1, and 1S/4W-29Q1 at an average level no lower than that which existed in the Fall season of 1963. Such 1963 average water level is hereby determined to be 822.04 feet above sea level. In future years, the level shall be computed by averaging the lowest static water levels in each of the three wells occurring at or about the same time of the year, provided that no measurements will be used which reflect the undue influence of pumping in nearby wells, or in the three wells, or pumping from the Riverside Basin in Riverside County in excess of that determined pursuant to Paragraph IX (a)" of the judgment in the Western case.

Figure 25 gives the average static water level in the three key wells for the Colton Subarea.

The assessment of SBVMWD's obligation for replenishment water in the Bunker Hill Basin ("San Bernardino Basin area" in the Western case judgment) and base flow requirements at Riverside Narrows is prepared by the Western-San Bernardino and Santa Ana River Watermasters, respectively. The watermasters are appointed by the courts and are responsible for the implementation and reporting of their respective judgments.

Legal precedent supporting the amount of conjunctive use or use of excess SWP water in the San Bernardino-San Gorgonio Pass area comes from two major appellate court rulings. They are the 1975 court case The City of Los Angeles v. City of San Fernando and Niles Sand and Gravel Company, Inc. v. Alameda County Water District. In these cases, the California Supreme Court (in the first case) and the First Appellate District Court (in the second case) ruled in favor of giving public agencies certain rights in ground water basins and the authority necessary to implement a ground water storage program.

The decision in the San Fernando case resolved a suit filed by the City of Los Angeles to quiet its title and obtain a declaration of its prior rights to the water in the San Fernando Basin. The City claimed rights to ground water derived from water it had imported into the basin. The California Supreme Court upheld this claim.

In the Alameda County Water District case, the water district raised the water table in the vicinity of the Niles Sand and Gravel Company's excavations and caused some flooding. The gravel company was pumping the water that flooded its excavated areas and was discharging that water into San Francisco Bay. However, the gravel pit had historically held local water supplies, and the ground water level created by the Alameda County Water District's replenishment program was below the historic level. The court held that the water district has a right to store water in natural underground storage space and to prevent the gravel company from taking the stored water, even though the water district was not contemplating capturing the stored water. This confirmed that overlying cities have the right to recapture waters imported from any source that they place in a ground water basin.

The opinions in these two cases confirm and clarify public agencies' rights to use ground water storage capacity for storage of imported water.

In addition, Senate Bill 187, Chapter 268 (Senator Ruben Ayala), which was signed by the Governor in July 1985, permits the State to contract with local agencies to store water in underground basins south of the Sacramento-San Joaquin Delta.

Powers and Authority of Local Agencies

The four major water agencies in the study area are San Bernardino Valley Water Conservation District, San Bernardino County Flood Control District, SBVMWD, and SGPWA. In addition, the City of Riverside obtains

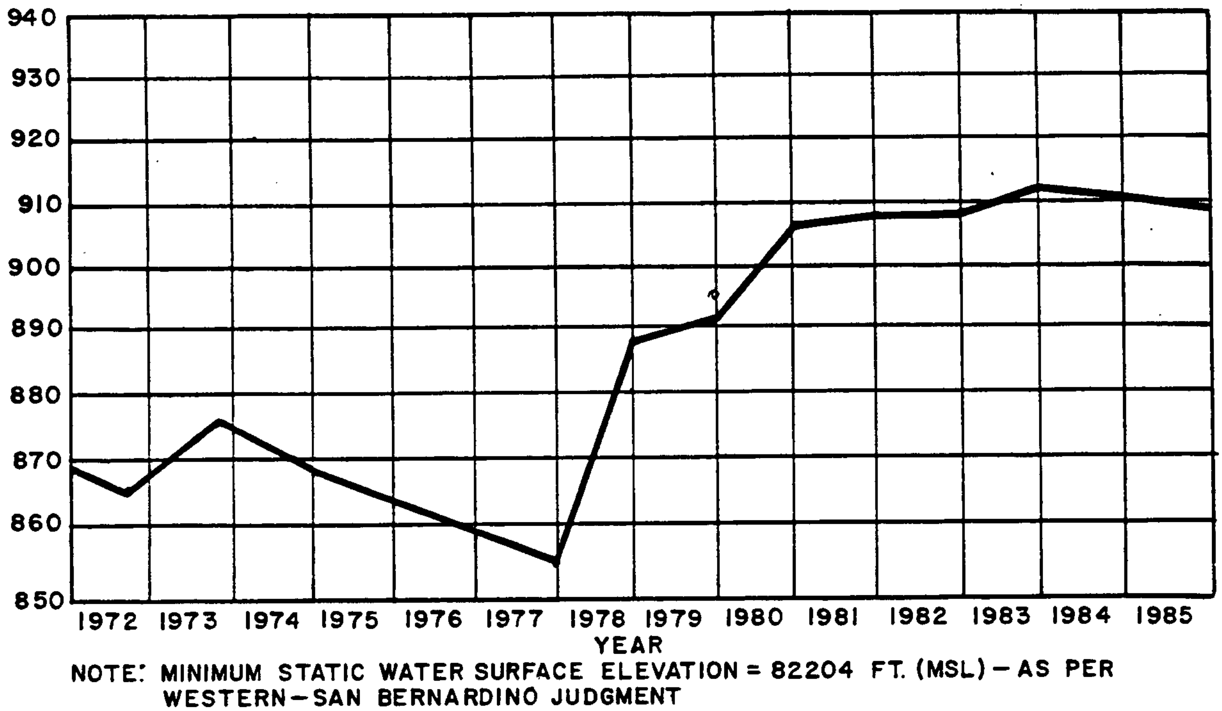


FIGURE 25 - AVERAGE ANNUAL STATIC WATER LEVEL IN WELLS

most of its water requirements from ground water pumped from the Bunker Hill Basin. The importance and major responsibilities of the agencies are discussed below.

San Bernardino Valley Water Conservation District

The San Bernardino Valley Water Conservation District, which began recharging water in 1911, derives its authority from the Conservation Act of 1927, which states that a district may be organized to conserve and store the waters of any stream or unnavigable river by spreading or sinking. The water conservation district recharges native water on both the Santa Ana River and Mill Creek by diverting water into spreading ponds at the upper end of the basin. Prior to 1970, total diversions onto the spreading ground of the Santa Ana River in any single water year were restricted to less than 9,000 acre-feet under a stipulated judgment in Case Y-36-M, The Irvine Company, a corporation v. Water Conservation Association, a corporation, et al., filed in the Superior Court of San Bernardino County. However, in the Orange County case, which was settled in 1969, the Orange County Water District was restrained from enforcing the Irvine suit. Since that time, the conservation district has increased its spreading operation considerably. Between 1978 and 1983, it conserved and spread an average of 47,600 acre-feet of water per year. This is approximately five times the average amount spread over the previous 43 years.

Under contract with SBVMWD, the conservation district has also spread an additional 69,500 acre-feet of imported SWP water. It does not pump.

San Bernardino County Flood Control District

San Bernardino County Flood Control

District was established in 1939. Its primary purposes are to provide for control of flood and storm waters of the district and of streams that flow into the district; to conserve such waters for beneficial and useful purposes by spreading, storing, retaining, and causing to percolate into the soil; to save and conserve such waters in any manner and protect from such waters the watercourses, watersheds, public highways, life, and property in the district; to prevent waste, diminution of supply, and exportation of water from the district; and to obtain, retain, and reclaim drainage, storm, flood, and other water for beneficial use in the district. It may also apply for a supplemental water supply from the SWP and other sources.

The district has used its facilities to recharge both natural flood water and imported SWP water under contract with SBVMWD. It does not pump water.

SBVMWD

SBVMWD, which was established in 1954 as a municipal water district, has the following authority based on the general Municipal Water District Laws of 1935 as amended: To acquire, control, distribute, store, spread, sink, treat, purify, reclaim, recapture, and salvage any water, including sewage and storm waters, for beneficial uses of the district, its inhabitants, or owners of rights to water in the district; to sell water to cities, public agencies, and persons, in the district only, unless there is a surplus; to construct and operate recreational facilities appurtenant to district reservoirs (need not be appurtenant in Big Bear Municipal Water District); to collect, treat, and dispose of sewage, waste, and storm water; to provide fire protection, first aid, ambulance, and paramedic service; to collect and dispose of garbage, waste, and trash; to produce and sell hydroelectric power; and to acquire, construct, or extend water systems for supplying district and inhabitants with water for domestic, agricultural, industrial, or other purposes which the city is authorized to acquire, construct, or extend. As of this writing, SBVMWD does not pump any ground water for use in the study area.

SGPWA

The law creating SGPWA was enacted in 1961; it gives SGPWA the authority to acquire and operate a waterworks plant or system for the benefit of the agency and recreational facilities appurtenant to any reservoir operated by the agency; to sell water to cities, public agencies, and persons within (and, if there is a surplus, outside) the agency; to supply water to publicly owned golf courses or recreational facilities and to public schools; to acquire, control, salvage, and distribute any water, including sewage and storm water, but not including waters of the Whitewater River system except such as may be lawfully acquired; to distribute water in exchange for reduction in ground water extraction and to provide for ground water replenishment; to develop and sell at wholesale hydroelectric energy to aid in financing water projects; and to sell the right to use of falling water. Further, it may join with the State, U. S., and others for carrying out any of its powers and may contract for financing the acquisition, construction, and operation of works; may contract with the State for delivery of water under the SWP; may contract with the U. S. under federal reclamation laws, but must have approval by 2/3 vote at an election if liability in any year would exceed income and revenue.

As of this writing, SGPWA has no pumping capability in the study area.

City of Riverside

The City of Riverside, a municipal

corporation, has obtained a major portion of its water requirements for the city from ground water pumped and exported from the Bunker Hill Pressure Subarea. It also pumps and exports ground water from the Colton-Rialto Subarea. It was a plaintiff in the Western case (1969). According to Appendix B, Table B-1, of the judgment, it can extract (5-year average) 53,448 acre-feet annually from the Bunker Hill Area (San Bernardino Basin).

The city also obtains water from the Western Municipal Water District of Riverside County, which in turn is a member of MWD--the largest SWP contractor.

Table C-1, Appendix C, of the judgment in the Western case limits extractions (5-year average) by Western Municipal Water District for use by the City of Riverside on lands not tributary to Riverside Narrows to 30,657 acre-feet annually.

Current and Proposed Action

Legislation

In January 1985, State Senator Ruben Ayala introduced legislation to address the issue of the high ground water table in the Bunker Hill Basin. SB 148, co-authored by Assemblyman Gerald R. Eaves, was subsequently withdrawn by Senator Ayala.

Agreements

Because of the high ground water problems in the Bunker Hill Pressure Subarea, it was recognized that additional amounts of water may have to be extracted from the subarea and the amount of natural and imported water artificially recharged in the Bunker Hill Subarea may have to be limited.

Pumping additional water requires a modification of the judgment in the Western case; therefore, in October 1983, SBVMWD and Western Municipal Water District of Riverside County signed an agreement for temporary additional extractions from the San Bernardino (Bunker Hill) Basin.* This agreement allows for the pumping of a maximum of 240,000 acre-feet of additional water from the Pressure Subarea, with an annual maximum of 40,000 acre-feet.

The basis for the agreement for temporary additional extractions is Paragraph VI (b) 6 of the judgment, which allows SBVMWD and Western Municipal Water District to enter into such agreements. In addition, the provisions of the Western case judgment give the court continuing jurisdiction to provide changes in the allowed amounts of extraction by any party because of emergency requirements. Also, the court may exercise continuing authority over "other matters not herein specifically set forth which might occur in the future . . . ."

To limit the amount of local recharge in the Bunker Hill Subarea during periods of high ground water in the Pressure Subarea, an agreement among SBVMWD, San Bernardino Valley Water Conservation District, and San Bernardino County Flood Control District would be required.

Agreement and cooperation among all affected parties in the Santa Ana River watershed will also be needed for developing and carrying out a management plan. This will require a forum in which each affected agency can have a voice and participate in management decisions.

*"Agreement for Temporary Additional Extractions from the San Bernardino Basin Area" executed on October 19, 1983, by SBVMWD and Western Municipal Water District of Riverside County.

Legal Action

To pump water from the Pressure Subarea, SBVMWD has proposed the drilling of two high capacity wells ("super wells"). It describes this as an emergency measure designed to mitigate possible liquefaction, which could increase the damages from an earthquake. If the drilling of the wells is determined to be an emergency measure, it would be exempt from review of potential environmental effects.

The City of Riverside, Western Municipal Water District of Riverside County, and East Valley Water District have asked for a halt to the super well project until an environmental impact report (EIR) is prepared.

A temporary restraining order halting the project was issued in January 1986 by San Bernardino County Superior Court Judge Bob Krug, and a hearing on the temporary order was held in March. Following the hearing, Judge Krug ruled that SBVMWD was within its rights to declare the high ground water an emergency condition that would permit it to dispense with the environmental assessment. Since then, the Fourth District Court of Appeal has ordered the Superior Court to vacate its order or show why it should not be vacated. A hearing on this was held October 9, 1986, with a ruling expected within 90 days after that.

VI. CONSIDERATIONS FOR MANAGING BASIN

For ground water management strategies for the San Bernardino-San Gorgonio Pass area to be effective, the different situations in the various subareas must be considered. In particular, management strategies for the Bunker Hill Subarea and the Bunker Hill Pressure Subarea should address the high ground water problems, long-term local conjunctive use operations, and potential conjunctive use operations with additional imported supplies from the SWP.

The most pressing need is to implement measures to eliminate the high ground water problems in the Bunker Hill Pressure Subarea. Therefore, alternative ways of handling these problems will be discussed first. Then, long-term management strategies are discussed. Cost estimates have not been made for any of the short-term or long-term alternatives presented; the local agencies would have to make such estimates and conduct feasibility studies before they could select or implement either a short-term or a long-term plan.

It should be recognized that planning for management of any ground water basin is an iterative process. As management strategies are developed and tested, plans will need to be periodically revised to reflect changes in needs, conditions, or objectives. However, until agreement has been reached on how to handle the high ground water levels in the Bunker Hill Pressure Subarea, agreement cannot be reached on a conjunctive use plan.

Actions to Mitigate High Ground Water

Four kinds of actions are considered to be desirable for mitigating the high ground water situation. They are:

1. Reduce the amounts of natural and artificial recharge by native and imported water in areas impacting water levels in the Bunker Hill Pressure Subarea until acceptable levels have been reached;

2. Do more pumping in the Pressure Subarea at higher than present rates to lower ground water levels and convey the pumpage out of that subarea;

3. Monitor the levels of ground water to ensure that safe levels are reached and maintained;

4. Monitor ground water quality, including that in contaminated areas, to ensure that safe standards are maintained in water pumped for domestic use.

To lower the amount of recharge by native water, the spreading of such water for artificial recharge should be reduced substantially below the quantities spread in recent wet years. To supplement that action, if necessary, part of the flow of the Santa Ana River that would normally percolate in the Bunker Hill forebay could be taken via the Foothill Pipeline (in the reverse direction) to Devil Canyon Powerplant Afterbay of the SWP system and to the Lytle Creek Pipeline and then to the Colton-Rialto Subarea or via district exchange facilities to Yucaipa Subarea. Intercepting the water and taking it to one of these locations would prevent it from percolating and help reduce the high ground water level in the Pressure Subarea. These actions would require agreements with the affected parties including the holders of water rights and spreading agencies.

The second kind of action would be the use of existing wells and conveyance facilities or the provision of additional extraction capability to reduce the current ground water levels in the Bunker Hill Pressure Subarea and to maintain safe levels thereafter. This too would require agreements and possibly judicial concurrence. To the extent that the extracted water was discharged into facilities of the SWP or MWD, agreements would also be required with DWR and/or MWD.

The following paragraphs describe alternative actions that might be taken in lowering the Pressure Subarea ground water levels.

Ground Water Extractions

Because no reliable model is available and because future hydrologic conditions are beyond human control, it is not possible to predict with certainty what amount of pumping would be required to dewater the Bunker Hill Pressure Subarea to an acceptable level. As shown in Table 1, the weighted average depth to ground water in the subarea was 40 feet in 1984. It is estimated that to alleviate the high ground water problem, the water level will have to be lowered an additional 35 feet. Based on available knowledge, to achieve this would require the removal of about 40,000 acre-feet more per year (if rainfall is normal). It must be remembered this is an additional amount above existing pumping.

Described under "Initial Measures" below are proposals that have been made by local agencies to produce and to dispose of approximately 40,000 acre-feet of additional annual extraction. This is the approximate equivalent of a pumping capacity of 60 cubic feet per second continuously for one year. That is the amount the 1985 Papadopulos report* concludes would be sufficient over the long term to keep Pressure Subarea ground water levels within acceptable limits, with various alternative strategies of artificial ground water recharge.

"Acceptable" ground water levels within the pressure zone have been defined in the temporary additional extraction agreement** (October 1983) between SBVMWD and Western Municipal Water District of Riverside County. Such levels have been set at an elevation in the range of 960 to 980 feet in five specified wells located within the Bunker Hill Pressure Subarea.

While this extraction is being carried out, existing SBVMWD mathematical ground water models should be improved or new models prepared. These models would be used to more accurately define the amounts of pumping and ground water recharge required to maintain desired ground water levels throughout the Bunker Hill Subarea. The models and physical observations would be used to assess the impacts of removing 40,000 acre-feet per year. Pumping rates could be modified as necessary and the natural and/or artificial ground water recharge increased or decreased, both according to operating rules that will achieve desired objective ground water levels.

Annual extractions of 40,000 acre-feet or more water may require the

*"Draft Report on a Preliminary Evaluation for the Control of Ground Water Levels, Bunker Hill Ground-Water Basin", prepared for SBVMWD by S. S. Papadopulos and Associates, Inc., October 20, 1985.

**"Agreement for Temporary Additional Extractions from the San Bernardino Basin Area" executed on October 19, 1983, by SBVMWD and Western Municipal Water District of Riverside County.

installation of additional new facilities such as wells, booster pumps, and/or conveyance facilities to develop and transport the water.

Agreements Required

The temporary additional extraction agreement, approved by the Court in 1983, allows that, for a six-year period commencing in 1983, the parties may pump additional amounts up to 40,000 acre-feet per year. The amounts of additional water available each year are to be determined jointly by the two parties. Thus to fully implement this, they would have to agree the 40,000 acre-feet is available.

Upon the expiration of this agreement in 1989, it would have to be renewed to permit continuation of this level of extraction. At that time, the results of the additional mathematical model studies and observations of the effects of the extraction on ground water levels, as described above, should be available. The new agreement could thus account for these factors.

In addition to the temporary agreement and its extensions, a permanent agreement or agreements should be developed among SBVMWD, San Bernardino Valley Water Conservation District, San Bernardino County Flood Control District, and the holders of rights to divert surface flows to limit the amounts of native and imported water artificially recharged in the Bunker Hill Subarea, particularly during periods of high ground water in the Bunker Hill Pressure Subarea. In these agreements, consideration should be given to restricting recharges impacting the Bunker Hill Pressure Subarea until a safe margin of dry storage space is available in the Bunker Hill forebay.

As previously stated, if SWP or MWD facilities are to be involved in receiving the extracted water, agreements with DWR and MWD would be required. These could cover such items as responsibility and procedures for constructing necessary facilities, operational arrangements, compensation for water purchased, provisions governing return of "banked" water, and other matters to the extent they may apply. DWR and MWD have indicated their willingness to discuss the use of their facilities to assist in solving the high ground water problems in conjunction with any plan that has basinwide acceptance.

Initial Measures

There have been five proposals by local agencies for disposal of the additional water that would be pumped out of the Pressure Subarea, if the quality of the water is acceptable. These are:

1. Pump into the Santa Ana River, from which Orange County Water District would use the water for recharging its ground water basin.

2. Pump directly into the Santa Ana Valley Pipeline of the SWP.

3. Pump into the City of San Bernardino system and thence into the Foothill Pipeline for spreading in the Colton-Rialto Subarea and/or Yucaipa Subarea.

4. Deliver to MWD Upper Feeder, utilizing the facilities of the City of Riverside.

5. Use some combination of the alternatives as listed above.

The following paragraphs discuss each of these proposals.

1. Pump into Santa Ana River. This may involve use of existing wells and SBVMWD has proposed the removal of additional water pumped by the two new wells it proposes

to drill in the Bunker Hill Pressure Subarea. The wells would each have a capacity of 4,000 gallons per minute (gpm) and be capable of pumping approximately 13,000 acre-feet per year with continuous operation at cost-effective production efficiency levels.

This water would be conveyed from the wells by an existing storm drain and discharged into a concrete-lined flood control channel, which would convey it to the Santa Ana River near the western boundary of the Bunker Hill Subarea. Although this would probably be the least costly of the disposal methods, it could result in losses to the ocean when Orange County Water District is unable to spread the water.

2. Pump into SWP's Santa Ana Valley Pipeline. This proposal would dispose of water SBVMWD pumps from the two new wells. An existing storm drain would convey the water to the Warm Creek Flood Control Channel, from which the flow would be diverted at a point downstream to a forebay for the relift pumps discharging to the Santa Ana Valley Pipeline. This lift would be 850 or 900 feet, resulting in a large energy cost.

3. Pump to Colton-Rialto Subarea and/or Yucaipa Subarea. The City of San Bernardino has proposed to rehabilitate or replace one or more of its wells in the lower portion of the Bunker Hill Pressure Subarea. If this is done, additional water pumped from them could be delivered in that area to substitute for water served from wells at higher elevations and by exchange made available at Electric Reservoir in the northern part of the city. A pump connection from the reservoir to SBVMWD's Foothill Pipeline, with a capacity of 10,000 to 15,000 gpm has been proposed. At the higher rate, which could be supplied from the city system only during offpeak months, the annual pumping could approach 15,000 acre-feet.

   However, on a continuous basis, if additional booster capacity can be installed within the system, only about 5,000 gpm could be transferred from the Pressure Subarea wells to Electric Reservoir, which would equal an annual amount of about 8,000 acre-feet.

4. Deliver to MWD via Riverside Facilities. The Western Municipal Water District of Riverside County, in a June 1985 report*, made a proposal to utilize seasonal surplus capacity in the City of Riverside's pipeline and well pumping system to extract an additional 20,000 acre-feet of ground water from the Bunker Hill Pressure Subarea and pump it into MWD's Upper Feeder near California Street in the city. To accomplish this, a booster pumping facility with a maximum pump lift of 250 feet would be required. It should be noted that such water would be delivered to MWD at a hydrostatic level some 600 feet lower than would water which would be delivered to the SWP line in proposal 2 above.

   Recent additional pumping by the City of Riverside has been discharged into the Santa Ana River below Riverside Narrows. A portion of this pumping could continue after this disposal method has been implemented.

5. Use a Combination of Alternatives. The sum of the annual pumping potentials of

*"Short Term Emergency Pumping Plan for Solving the High Ground Water Problem in San Bernardino Basin Pressure Area", Western Municipal Water District of Riverside County, June 1985.

proposals 2 through 4, using the lower value of proposal 3, is 41,000 acre-feet, or approximately the same as the initial objective. Here again, it would be important that the resulting levels be observed to determine if the composite pumping rate is adequate.

Program for Long-term Basin Management

Once a plan for reducing high ground water levels in the Bunker Hill Pressure Subarea has been accepted, local agencies can develop alternative plans for managing the basin on a long-term basis so that their water resources can be used most effectively and the possibility of future high ground water can be minimized. It is conceivable that the ground water storage capability of the basin can be used in conjunction with SWP facilities to help meet future annual entitlements of the SWP water supply contractors. This should be determined only after a feasible plan for regulating local water resources and SBVMWD's imported supplies has been developed.

As was stated before, the agencies in the study area will probably continue to use ground water and surface water diversions as primary sources to meet their requirements. Therefore, the amount of rainfall and the resulting amount of surface water in the streams will influence the amount of ground water that will be extracted.

In the past, the study area was chiefly agricultural and most of the surface diversions were used for agricultural purposes. Those not so used were diverted and spread for artificial recharge. Several agencies have acquired rights and have made plans to capture the diverted surface flows, when they are available in the future, and to utilize them to meet M and I water requirements.

The SWP water supply contracts of SBVMWD and SGPWA offer the opportunity to augment local supplies to support continued growth.

Ground Water Level Extremes

In developing comprehensive ground water management plans for the future, historical ground water levels can be used to determine a reasonable range of operational ground water levels. Upper and lower limits of ground water level elevations can be judged on the basis of the levels depicted in Figures 5 and 6. The historic low levels, shown in Figure 6, generally occurred during 1965. Any greater depths to ground water would result in an additional cost of pumping because of the need to deepen wells and lower pump bowls. The April 1984 level shown in Figure 5 is considered one of the highest levels in recent times.

All plans for ground water management in the area should consider these two extremes, and the cyclic fluctuations of water levels should fall above the historic low and below the levels of April 1984 insofar as possible. An investigation now going on will more clearly define maximum desirable operating levels. In the future, an extremely wet or dry series of years will undoubtedly occur. Therefore, enough space must be allocated to accommodate the percolation that would take place in one or more wet years. Conversely, management plans must allow for the possible occurrence of a dry year or a series of dry years, which would tend to drop the levels below the historic low water elevations.

Therefore, for any plan that is selected, extreme cycles of rainfall in the Santa Ana River watershed--both wet and dry--must be considered in determining its feasibility. Further, if later in the planning process, use of ground water storage space for enhancing the yield of the SWP is considered, it will be necessary to account for Northern California wet and dry cycles to determine when surplus SWP water would be available for ground water storage and when the SWP would need the accumulated storage.

Need for Mathematical Ground Water Model

The scope of this cooperative investigation did not include development or use of a ground water mathematical model. In the future, more comprehensive studies to evaluate the possible alternative ground water and surface water management plans will require that a good mathematical model be prepared.

In general, the mathematical model should reflect time and space variations of geohydrologic conditions and events. These should include reactions from: (1) short-term measures to solve high ground water problems in the Pressure Subarea and (2) long-term plans to optimize benefits to affected water extractors and users and to minimize problems from excessively high or low levels.

Specifically, the model should provide ground water reactions (ground water levels and flows, including those across boundaries) to: (1) alternative management scenarios of recharge (natural and artificial) and extractions; (2) percolation resulting from a sequence of wet (winter) and dry (summer) months and from a series of wet and dry years beginning at different times; (3) pumping in the Pressure Subarea, including lowering of ground water levels and draining of the upper aquifer; (4) waste water treatment options in the vicinity of the high ground water; and (5) ground water quality changes with respect to time based on physical factors such as ground water flow and diffusion. As the model is developed and refined, it should prove useful in evaluating water quality problems.

Results from the mathematical model should be accurate enough so that engineering, economic, environmental, and institutional findings and decisions can be made. In this connection, it is understood that both the U. S. Geological Survey (USGS) model used for its 1980 report* and the model developed by Timothy J. Durbin for the 1985 Papadopulos report were designed to answer questions primarily about the high ground water problems in the basin. The Durbin model has a rather coarse nodal grid, and USGS personnel state that the 1980 report model was not designed for use in a comprehensive ground water management study. Therefore, early in the development of a program for long-term management of the Bunker Hill Basin, priority should be given to the revision of existing models or the preparation of a new model capable of making the required analyses to a sufficient degree of accuracy.

With the use of hydrologic data now available and such a mathematical model of the ground water basin, a redetermination could be made by the Western-San Bernardino Watermaster of the safe yield of the basin and of the allocation among the appropriate parties of any new yield. If necessary, concurrence of the court in the Western case judgment would be sought for this redetermination and for approval of a new safe yield value.

The mathematical model should be used to evaluate the alternative management plans for engineering feasibility, cost, water quality, environmental impacts, and effects on local agencies.

*William F. Hardt and C. B. Hutchinson, "Development and Use of a Mathematical Model of the San Bernardino Valley Ground-Water Basin, California", U.S. Geological Survey, Open File Report 80-576, September 1980.

VII. SUMMARY OF KEY FINDINGS, CONCLUSIONS, AND RECOMMENDATION

Summary of Key Findings

1. Total storage capacity of all the ground water basins in the study area is more than 11 million acre-feet. However, because of physical limitations, including high ground water, and practical considerations, not all this capacity can be considered to be usable. Included in the study area are the Bunker Hill Basin in the Bunker Hill Pressure Subarea and Bunker Hill Subarea (forebay), portions of the Chino and Riverside Basins in the Colton-Rialto Subarea, and alluvial and ground water basins in the Banning-Cabazon and San Timoteo Subareas.

2. In April 1984, when the study area recorded one of its highest ground water levels, it had about 2.5 million acre-feet of dry storage capacity. In 1965, when the ground water was at its lowest level, the total dry storage capacity was about 5 million acre-feet.

3. Studies by SBVMWD indicate that rising water conditions last occurred in 1959. Since that time, the amount of ground water in storage in the Bunker Hill Basin has increased by about 800,000 acre-feet.

4. The Bunker Hill Subarea has the largest storage capacity of any of the subareas in the study area (4-1/4 million acre-feet), but in April 1984, only 800,000 acre-feet was dry. This amount of dry space should not be considered as usable for a storage program because (a) space must be maintained to prevent waterlogging and other adverse effects of high ground water, such as soil liquefaction in the event of an earthquake, ground water contamination from pollutants introduced near the ground surface, and damage to surface and underground facilities, and (b) the ground water system in the Bunker Hill Subarea is considered to be a part of the same system as that in the Bunker Hill Pressure Subarea.

5. The Colton-Rialto Subarea had the largest amount of dry storage capacity (about 990,000 acre-feet) in April 1984 of any of the subareas in the study area. Most of this subarea lies in the Chino Ground Water Basin and its geologic, hydrologic, and soil infiltration characteristics are different from those in the Bunker Hill Basin. The Colton-Rialto Subarea has very few recharge sites at present and, in addition, has high ground water levels in its eastern portion along the Santa Ana River.

6. Until agreement is reached on how to manage the high ground water levels in the Bunker Hill Pressure Subarea, agreement cannot be reached on a comprehensive conjunctive use program for supplemental SWP yield.

7. The high ground water in the Bunker Hill Pressure Subarea is caused by many factors, some more significant than others. These include:

   a. Above average rainfall and percolation in 1978, 1980, 1982, and 1983;

   b. Significant increases in the

amount of local water artificially recharged by San Bernardino Valley Water Conservation District, beginning in 1969;

c. Reduction in water pumped and used in the Bunker Hill Subarea since 1965, as a result of the switch from agricultural land use to urban;*

d. Importation and recharge of SWP water requested by SBVMWD beginning in 1972.

8. Current mathematical models developed for the Bunker Hill Basin do not have updated hydrologic information built into them. In addition, consideration should be given to refining the grid. SBVMWD has hired a consultant to improve a mathematical model of the Bunker Hill Basin so it can provide reliable estimates of responses to extractions and replenishment.

9. The study area, including the Bunker Hill Basin, has experienced wide fluctuations in the amounts of deep percolation of streamflow as a result of wide variations in runoff from rainfall. In wet years such as 1980, the amounts have been in the order of 1-1/2 to 2 times the mean seasonal percolation.

10. The 1980 population in the study area was 385,000 and is forecast to be 817,000 in year 2040. The trend of increase in urbanization is expected to continue and agriculture will probably have disappeared from SBVMWD in the next 20 or 30 years. Some agriculture is expected to remain in SGPWA in year 2040.

11. The projected applied water requirement for year 2040 for the study area is 227,000 acre-feet. This includes 224,000 acre-feet of M and I demand and 3,000 acre-feet of agricultural demand. The 1980 demand for applied water was 106,000 acre-feet for M and I and 57,000 acre-feet for agriculture, making a total of 163,000 acre-feet.

12. Water supplies in the study area for agricultural and M and I purposes come from ground water extractions (73 percent of supply in SBVMWD and 79 percent in SGPWA in 1980), surface water diversions (26 percent in SBVMWD and 13 percent in SGPWA), reclaimed water (1 percent in SBVMWD), and ground water from outside the service area (8 percent--from Yucaipa Subarea--in SGPWA). Almost all the SWP water delivered to the study area since 1972 was recharged to the ground water basins. As agriculture declines in SBVMWD, so too will the amount of surface diversions used for that purpose; instead, the diverted water will go for M and I uses.

13. SGPWA has adequate water supplies to meet its expected future water demand, based on current forecasts of population growth. The supplies used to meet this demand will come from ground water, stream diversions, and imports from the Yucaipa Subarea. A portion of SGPWA's SWP entitlements would be exchanged for surface water imported from Yucaipa Subarea.

14. SBVMWD gets SWP water from the Devil Canyon Powerplant Afterbay via its Foothill Pipeline and San Gabriel Valley Municipal Water District's Lytle Creek Pipeline, in which it has capacity rights. The

*In 1965, estimated water requirements in the study area (excluding the Banning-Cabazon Subarea) were 191,000 acre-feet. By 1990, they are projected to have declined to 161,000 acre-feet.

Foothill Pipeline conveys water to the Bunker Hill Subarea; it can also take water from the Santa Ana River to Devil Canyon Powerplant Afterbay. The Lytle Creek Pipeline delivers SWP water to the Colton-Rialto Subarea. SGPWA has purchased capacity rights in the Foothill Pipeline, but does not have facilities to deliver SWP water to its service area.

15. Other State and regional water transportation facilities in the study area are the California Aqueduct's Santa Ana Valley Pipeline and MWD's Foothill Feeder (from Devil Canyon Powerplant Afterbay), Colorado River Aqueduct (crosses from east of Cabazon to south of Banning), and Upper Feeder (crosses near western boundary of study area, in Colton-Rialto Subarea).

16. Mineral quality of the diverted surface water is rated good to excellent, and mineral quality of the local ground water is, with a few exceptions, also rated as good to excellent. Quality of the SWP water brought into the study area is excellent.

17. Dibromochloropropane (DBCP), trichloroethylene (TCE), tetrachloroethylene (PCE), and high nitrates have given cause for concern about ground water quality in the Bunker Hill Subarea. The nitrate contamination is believed to come from past applications of fertilizer and the DBCP from a pesticide that was used to kill pests invading citrus crops. The CRWQCB, Santa Ana Region, contracted with a consultant to determine the sources of TCE and PCE contamination and to use the results of the study to clean up and abate this problem.

18. Two court cases that have affected SBVMWD's water requirements are the Orange County case and the Western case, both settled in 1969.

    a. Under terms of the stipulated judgment in the Orange County case, SBVMWD's responsibilities include delivering an average annual adjusted base flow of 15,250 acre-feet in the Santa Ana River at Riverside Narrows. To help meet this obligation, SBVMWD has an agreement with the City of San Bernardino that the city will discharge into the river at least 16,000 acre-feet of treated effluent from its sewerage plants each year.

    b. The judgment in the Western case, among other requirements, calls for SBVMWD to provide imported replenishment water in an amount at least equal to the amount by which extractions from the Bunker Hill Basin for use in SBVMWD (San Bernardino County portion) exceed the average extractions during the five-year period 1959-63. The judgment further states that the amount of replenishment may be "adjusted as may be required by the natural safe yield of the San Bernardino Basin Area . . ."

19. The ground water extraction and surface water diversion data used in the Western case judgment were based on the 1959-63 period. Since then, the use of Bunker Hill area water has declined. This has occurred because the existing urban low density development uses less water per acre than did the agricultural land it has replaced. Also the period 1959-63 was a very dry hydrologic period; whereas recent years 1978, 1980, 1982, and 1983 have been very wet.

20. Excess ground water exported from the Bunker Hill Pressure Subarea could be pumped, provided that

water quality is acceptable, (a) into the Santa Ana River, from which Orange County Water District could use it for artificial recharge, (b) into the MWD Upper Feeder via the City of Riverside facilities, (c) into the City of San Bernardino system and thence into the Foothill Pipeline for spreading in the Colton-Rialto Subarea and/or Yucaipa Subarea, (d) into the SWP through the Santa Ana Valley Pipeline, or (e) a combination of these. DWR and MWD have indicated that they are willing to discuss the use of their facilities to assist in solving the high ground water problems in conjunction with any plan that has basinwide acceptance.

21. To remove excess ground water from the Bunker Hill Pressure Subarea, SBVMWD and Western Municipal Water District of Riverside County have agreed on and the court has approved the temporary additional extraction of a maximum of 40,000 acre-feet of water each year for 6 years.

Conclusions

1. High ground water problems in the Bunker Hill Pressure Subarea have an adverse impact upon facilities in the area. Building basements are subject to the threat of flooding. Foundations of buildings and other major structures such as bridges, which were designed to function under dry conditions, may not perform adequately when soils surrounding them are saturated; thus the stability of the affected structure may be adversely impacted. In the event of a large earthquake, soil liquefaction in areas of high ground water could add to the structural damage suffered.

2. High ground water also reduces the effectiveness of the ground water basin in producing yield and can have an adverse impact on water quality.

3. One element of a solution of the high ground water problems will require extraction of at least 40,000 acre-feet of ground water per year from the Bunker Hill Pressure Subarea over a period of several years. If the rainfall is less than normal, the amount extracted could be less.

4. Any program for removal of the excess ground water should recognize water quality problems and include appropriate provisions for dealing with them. For example, monitoring and management of DBCP, TCE, PCE, and other contaminants may be necessary.

5. Removal of 40,000 acre-feet per year, as provided for under the agreement between SBVMWD and Western Municipal Water District of Riverside County, may not resolve the high ground water problems. The resulting ground water levels should be observed and the pumping rate increased or decreased until the ground water has been lowered to an acceptable level. If possible, ground water extractions discharged into the Santa Ana River should be in amounts that Orange County Water District is able to percolate and thus prevent loss to the ocean.

6. Although the City of Riverside and other plaintiffs in the Western case are not physically located within the Bunker Hill Basin, their interests must be considered in any negotiated solution to the high ground water because, as a group, they pump significant amounts of ground water from the Bunker Hill Basin. The interests of downstream entities as expressed in the Orange County case must also be

considered. Conversely, the downstream users should recognize the adverse impact that high ground water has on the San Bernardino area.

7. Mathematical models of the Bunker Hill Ground Water Basin need to be improved and developed using recent hydrologic information so that alternative scenarios of water resources management can be examined. With an updated model and hydrologic information now available, a redetermination of the safe yield of the Bunker Hill Basin could be made.

8. Water supplies for the study area are sufficient to meet projected water demands. A portion of SGPWA's entitlement to SWP water will be exchanged for surface water from the Yucaipa Subarea.

9. After a plan has been accepted for correcting the high ground water problems, opportunities for conjunctive use of the local water resources with the SWP supplies by modifying the selected long-term water management plan should be examined. Such conjunctive use should be done without significant detriment to the water rights, economic, and other interests of parties in the Santa Ana River watershed.

10. Implementation of an effective long-term management plan will require the cooperation of all affected parties in the Santa Ana River watershed.

11. All affected parties in the watershed need a forum where they can have a voice and participate in management decisions.

Recommendation

Because the high ground water problems in the Bunker Hill Pressure Subarea are of immediate concern and because attempts at solving those problems have not yet resulted in an accepted management plan, a staged approach is recommended: First, work out agreement on a plan for solving the high ground water problems, then develop a conjunctive use management plan for the entire Bunker Hill Basin, and finally develop and consider a conjunctive use plan designed to provide additional yield to the SWP. Also needed are realistic estimates of the costs of each alternative, its environmental impact, possible mitigation measures, and other information developed in a full feasibility study.

The following recommendation forms a four-step approach to improved ground water management in the Bunker Hill Basin. Central to each step in this approach are the Western and Orange County case judgments, which allocate the water rights in the Santa Ana River system. Therefore, implementation of each step will require agreement by the affected local, regional, and State agencies and, in some instances, approval by the courts. To obtain agreement, the affected agencies will need to determine the institutional arrangement that will reflect the concerns of the affected parties and will provide a forum where all parties have a voice in management decisions.

Step 1

SBVMWD continue participation in discussions with the other affected parties involved in the Western and Orange County case judgments and other producers to establish institutional arrangements which would select and implement short-term measures to solve the high ground water problems. These short-term measures should include monitoring of water quality. In developing such a program, due consideration must be given to all water rights, water quality, environmental, and economic factors. Consideration should be given to the use of existing facilities of others as a means of benefically using ground water extracted as part of the high ground water removal program. The possible purchase or exchange of water on a short-term basis by MWD or the SWP from the parties having water rights in the basin should be explored.

Step 2

SBVMWD, with its consultant and/or the USGS, update and complete the mathematical model of the Bunker Hill Basin with a sufficiently fine grid of analytical elements, or nodes, to permit it to analyze both the forebay and pressure areas of the basin to the required degree of accuracy for the support of management plans and decisions. Alternative plans for solving the high ground water problems should be applied to the model and the results evaluated from the standpoints of hydrology, engineering, economics, and environmental impacts. The actions under step 1 may need to be modified based on results from the model and/or subsequent evaluations of operational results.

Step 3

Using the information and tools developed in steps 1 and 2, examine alternative management plans and select a long-term plan that optimizes benefits to the affected water users (including pumpers and producers) by controlling ground water levels in the pressure area and providing the most effective utilization of natural water in the basin and in the entire Santa Ana River system. This would require maintaining enough empty space in the ground water storage reservoir so that rising water conditions and discharge of water to the ocean would be minimized.

To help in evaluating alternative management plans, the safe yield study of the basin may need to be reexamined. If reexamination suggests that additional yield is available and court approval is obtained, if necessary, the Western-San Bernardino Watermaster could recommend reallocation, using the updated model and available hydrologic data. Included in the long-term plan should be provisions to ensure that SGPWA will be able to obtain SWP water when it is needed.

Step 4

Once a long-term management plan to meet local needs has been agreed to by the affected parties, the opportunities should be investigated for incorporating storage of SWP water in the ground water basin during wet periods in Northern California and extraction of the water for use by the SWP during dry periods. Prevention of high ground water conditions and protection of water rights and water quality must be ensured in any management plan that is implemented.

REFERENCES

Among the reports and other documents used in the study reported here are:

"Annual Report of the Western-San Bernardino Watermaster for Calendar Year 1981", Vol. 1-7, August 1, 1982. Also, August 1, 1983, and August 1, 1985.

California Department of Water Resources. "Feasibility of Serving the San Gorgonio Pass Water Agency from the State Water Project." Bulletin 119-2. February 1963.

____. "Coachella Valley Investigation." Bulletin 108. July 1964.

____. "Upper Santa Ana River Drainage Area Land and Water Use Survey, 1964." Bulletin 71-64. July 1966.

____. "Meeting Water Demands in the Bunker Hill-San Timoteo Area." Bulletin 104-5. December 1970.

____. "Meeting Water Demands in the Chino-Riverside Area." Appendix B: "Operation-Economics." Southern District Memorandum Report. May 1971.

____. "Meeting Water Demands in the Chino-Riverside Area." Bulletin 104-3. May 1971.

____. "Upper Santa Ana River Drainage Area Land Use Studies, 1975." Southern District Report. February 1978.

____. "General Comparison of Water District Acts." Bulletin 155-77. May 1978.

____. "Updated Hydrologic Conditions in the Bunker Hill-San Timoteo Area." Letter Report. November 1978.

____. "Report on the Feasibility of Extending the California Aqueduct into Upper Coachella Valley." Southern District Report. April 1979.

____. "A Ground Water Storage Program for the State Water Project: San Fernando Basin Theoretical Model." Bulletin 186. May 1979.

____. "Ground Water Basins in California." Bulletin 118-80. January 1980.

____. "Coachella and Imperial Valleys Agricultural Land Use Study." Southern District Report. July 1980.

____. "Urban Water Use in California." Bulletin 166-3. October 1983.

____. "Alternative Plans for Offstream Storage South of the Delta." Progress Report. Division of Planning. May 1984.

____. "California Aqueduct Use Study." Division of Planning Report. February 1985.

____. "Santa Barbara County State Water Project Alternatives." Southern District Report. April 1985.

____. "Upper Santa Ana River Drainage Area Land Use Survey, 1984." Southern District Report. June 1985.

____. "Management of the California State Water Project." Bulletin 132-85. September 1985.

California Regional Water Quality Control Board, Santa Ana Region. "Water Quality Control Plan, Santa Ana River Basin (8)." 1984.

Caouette, Norm. "Artificial Recharge in the Bunker Hill-San Timoteo Area, 1959-1977." San Bernardino Valley Municipal Water District. November 1978.

CM Engineering Associates. "Water Report for City of Banning, California." 1979.

Hardt, William F., and C. B. Hutchinson. "Development and Use of a Mathematical Model of the San Bernardino Valley Ground-Water Basin, California." U. S. Geological Survey Open-File Report 80-576. Prepared in cooperation with San Bernardino Valley Municipal Water District. September 1980.

<u>The Irvine Company, a corporation</u> v. <u>Water Conservation Association, a corporation, et al</u>. Settlement Documents. Riverside County Superior Court Case Y-36-M. 1969.

Martin, Robert. "Bunker Hill Artesian Zone Study." San Bernardino Valley Municipal Water District. October 1979.

<u>Orange County Water District</u> v. <u>City of Chino, et al</u>. Settlement Documents. Orange County Superior Court Case 117628. 1969.

San Bernardino Valley Municipal Water District. "Annual Report on Water Supply--1980."

____. "Recommended Comprehensive Program to Mitigate the High Ground Water Problem in the Artesian Zone of the San Bernardino Basin Area in Order to Protect the Public Health, Safety, and Welfare." April 22, 1985.

Southern California Association of Governments. "Draft SCAG--82 Growth Forecast Policy." January 1982. Supplement, September 1982.

S. S. Papadopulos and Associates, Inc. "Draft Report on a Preliminary Evaluation for the Control of Ground-Water Levels, Bunker Hill Ground-Water Basin." Prepared for San Bernardino Valley Municipal Water District. October 20, 1985.

Stetson Engineers Inc. "San Bernardino Valley Municipal Water District Rising Groundwater in Downtown San Bernardino". July 1, 1983.

Stockton, Stephan P. "An Energy-Efficient Water Delivery System." Paper given at ASCE Conference, Atlanta, Georgia. May 1984.

"Thirteenth Annual Report of the Santa Ana River Watermaster 1982-83." April 5, 1984.

U. S. Army Corps of Engineers. "Upper Santa Ana River Flood Storage Alternatives Study Information Paper Economic and Technical Evaluation of Flood Storage Alternatives." April 1985.

U. S. Geological Survey. "Evaluating Earthquake Hazards in the Los Angeles Region--An Earth-Science Perspective." J. I. Ziony, Editor. Professional Paper 1360. 1985.

URS Corporation in association with ERM-West. "Investigation of Sources of TCE and PCE Contamination in the Bunker Hill Ground Water Basin." Submitted to California Regional Water Quality Control Board, Santa Ana Region. August 1986.

Western Municipal Water District of Riverside County v. East San Bernardino County Water District, et al. Settlement Documents. Riverside County Superior Court Case 78426. April 1969.

Western Municipal Water District of Riverside County. "Short Term Emergency Pumping Plan for Solving the High Ground Water Problem in San Bernardino Basin Pressure Area." June 1985.

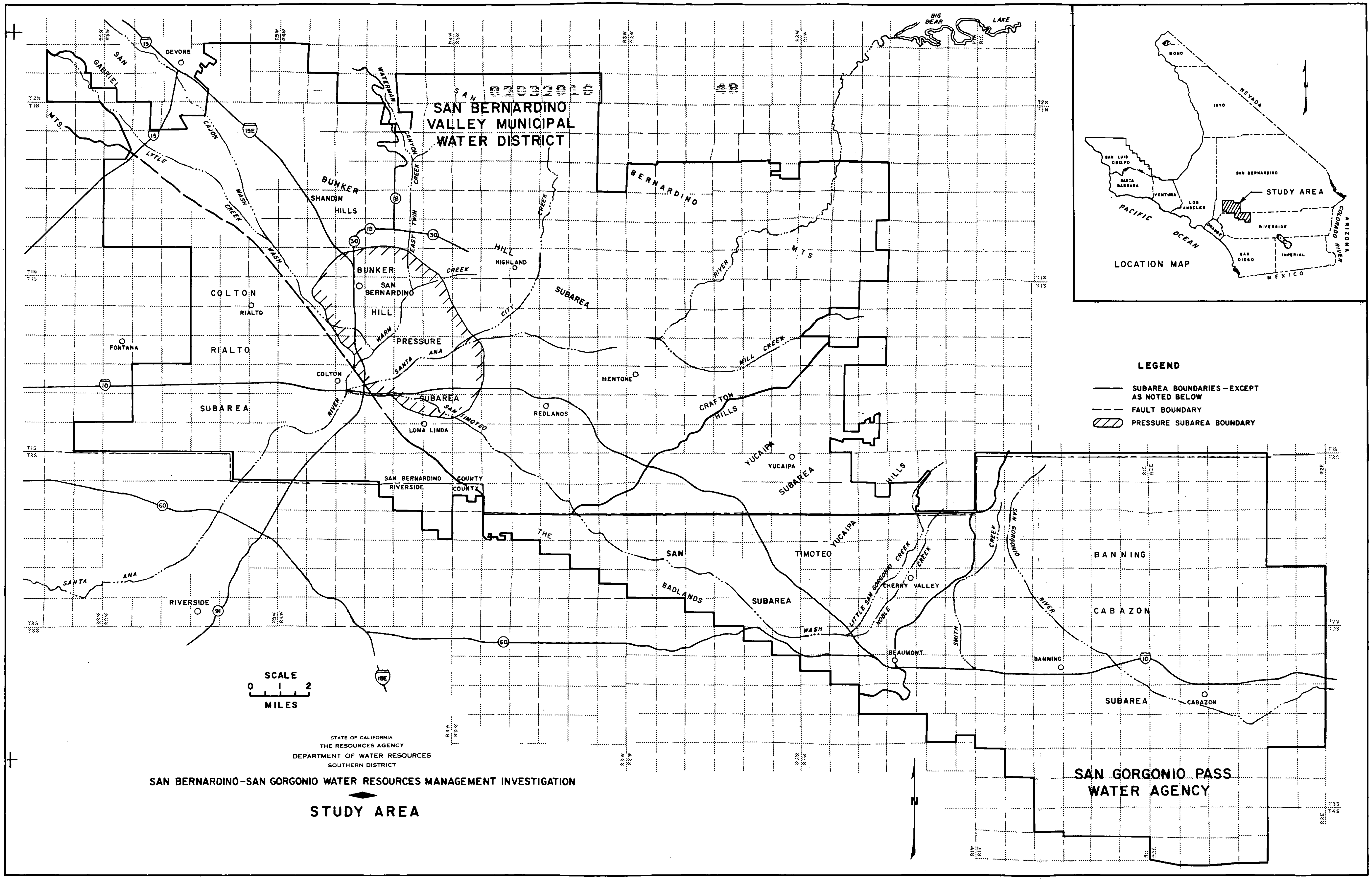
Williamson and Schmid. "Selected Impacts of Dewatering San Bernardino Valley Ground-Water Basin." April 1985.

Information and data developed during the study were recorded in a series of technical information records (TIRs). Copies may be seen in the Southern District office of the California Department of Water Resources, Los Angeles, and in the offices of the San Bernardino Valley Municipal Water District, San Bernardino, and San Gorgonio Pass Water Agency, Beaumont.

- TIR 1610-7552-1, "Historic Population in the San Bernardino Valley Municipal Water District-San Gorgonio Pass Water Agency Study Area," by Diane K. Sanchez, 1983.
- TIR 1610-7552-2, "Land Use in the San Bernardino Valley Municipal Water District-San Gorgonio Pass Water Agency Study Area," by William K. Hom, 1983.
- TIR 1610-7552-3, "Recharge Facilities in the San Bernardino Valley Municipal Water District-San Gorgonio Pass Water Agency Study Area," by Michael E. Taweel, 1983.
- TIR 1610-7552-4, "Projected Population in the San Bernardino Valley Municipal Water District-San Gorgonio Pass Water Agency Study Area," by Diane K. Sanchez, 1984.
- TIR 1610-7552-5, "Ground Water Extraction in the San Bernardino Valley Municipal Water District-San Gorgonio Pass Water Agency Study Area," by William K. Hom, 1984.
- TIR 1610-7552-6, "1980 and Projected Water Supply in the San Bernardino Valley Municipal Water District-San Gorgonio Pass Water Agency Study Area," by Diane K. Sanchez, 1984.
- TIR 1610-7552-7, "Reported 1980 and Future Surface Water Diversion in the San Bernardino Valley Municipal Water District-San Gorgonio Pass Water Agency Study Area," by William K. Hom, 1984.
- TIR 1610-7552-8, "1980 and Projected Applied Water Use in the San Bernardino Municipal Water District-San Gorgonio Pass Water Agency Study Area," by Diane K. Sanchez, 1985.
- TIR 1610-7552-9, "Estimated Dry Storage Capacities and Weighted Average Depths in the San Bernardino Valley Municipal Water District-San Gorgonio Pass Water Agency Study Area," by William K. Hom, 1985.

CONVERSION FACTORS

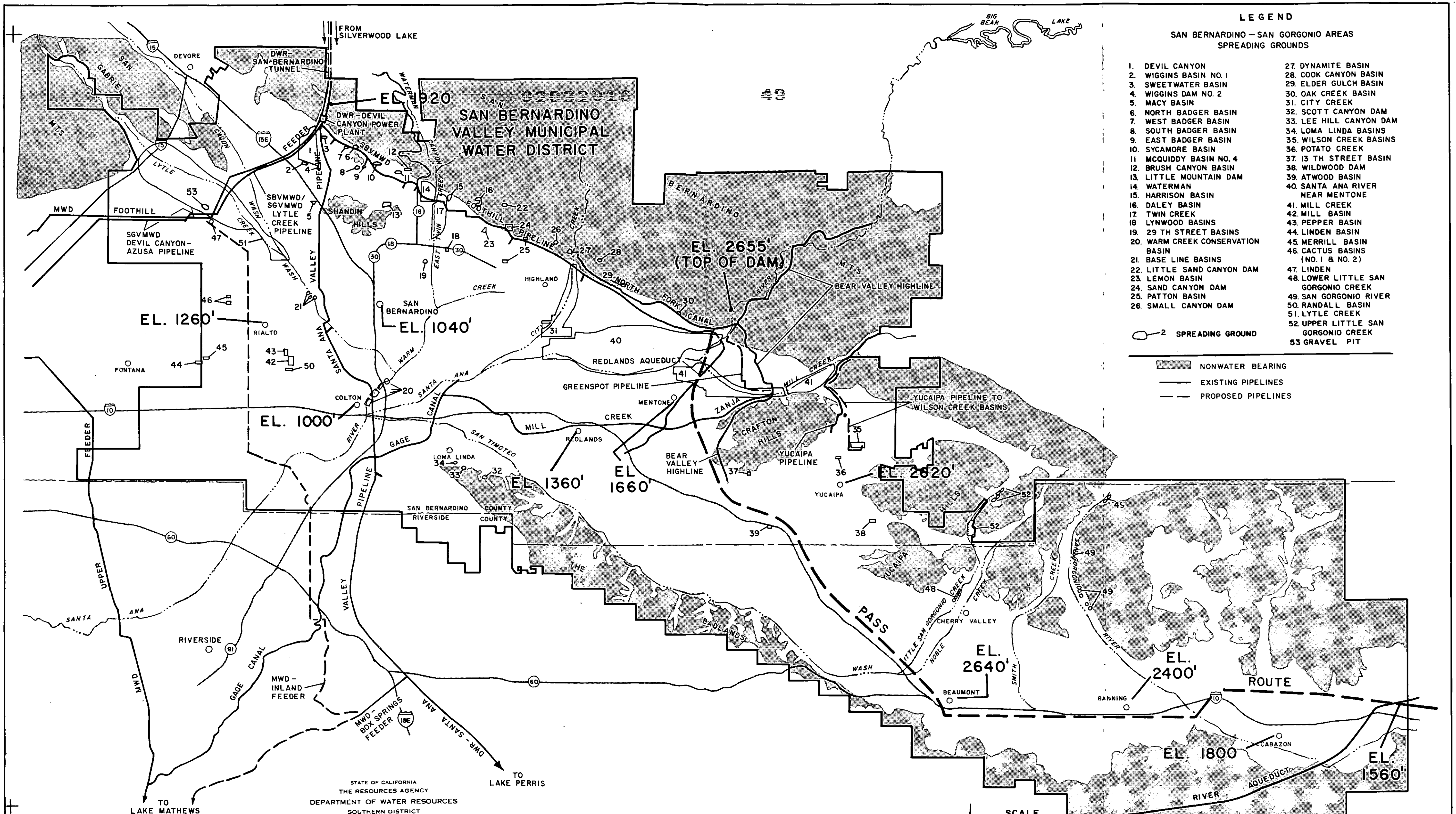
Quantity	To Convert from Metric Unit	To Customary Unit	Multiply Metric Unit By	To Convert to Metric Unit Multiply Customary Unit By
Length	millimetres (mm)	inches (in)	0.03937	25.4
	centimetres (cm) for snow depth	inches (in)	0.3937	2.54
	metres (m)	feet (ft)	3.2808	0.3048
	kilometres (km)	miles (mi)	0.62139	1.6093
Area	square millimetres (mm^2)	square inches (in^2)	0.00155	645.16
	square metres (m^2)	square feet (ft^2)	10.764	0.092903
	hectares (ha)	acres (ac)	2.4710	0.40469
	square kilometres (km^2)	square miles (mi^2)	0.3861	2.590
Volume	litres (L)	gallons (gal)	0.26417	3.7854
	megalitres	million gallons (10^6 gal)	0.26417	3.7854
	cubic metres (m^3)	cubic feet (ft^3)	35.315	0.028317
	cubic metres (m^3)	cubic yards (yd^3)	1.308	0.76455
	cubic dekametres (dam^3)	acre-feet (ac-ft)	0.8107	1.2335
Flow	cubic metres per second (m^3/s)	cubic feet per second (ft^3/s)	35.315	0.028317
	litres per minute (L/min)	gallons per minute (gal/min)	0.26417	3.7854
	litres per day (L/day)	gallons per day (gal/day)	0.26417	3.7854
	megalitres per day (ML/day)	million gallons per day (mgd)	0.26417	3.7854
	cubic dekametres per day (dam^3/day)	acre-feet per day (ac-ft/day)	0.8107	1.2335
Mass	kilograms (kg)	pounds (lb)	2.2046	0.45359
	megagrams (Mg)	tons (short, 2,000 lb)	1.1023	0.90718
Velocity	metres per second (m/s)	feet per second (ft/s)	3.2808	0.3048
Power	kilowatts (kW)	horsepower (hp)	1.3405	0.746
Pressure	kilopascals (kPa)	pounds per square inch (psi)	0 14505	6.8948
	kilopascals (kPa)	feet head of water	0.33456	2.989
Specific Capacity	litres per minute per metre drawdown	gallons per minute per foot drawdown	0.08052	12.419
Concentration	milligrams per litre (mg/L)	parts per million (ppm)	1.0	1.0
Electrical Conductivity	microsiemens per centimetre (uS/cm)	micromhos per centimetre	1.0	1.0
Temperature	degrees Celsius (°C)	degrees Fahrenheit (°F)	(1.8 × °C)+32	(°F−32)/1.8



STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

SAN BERNARDINO-SAN GORGONIO WATER RESOURCES MANAGEMENT INVESTIGATION

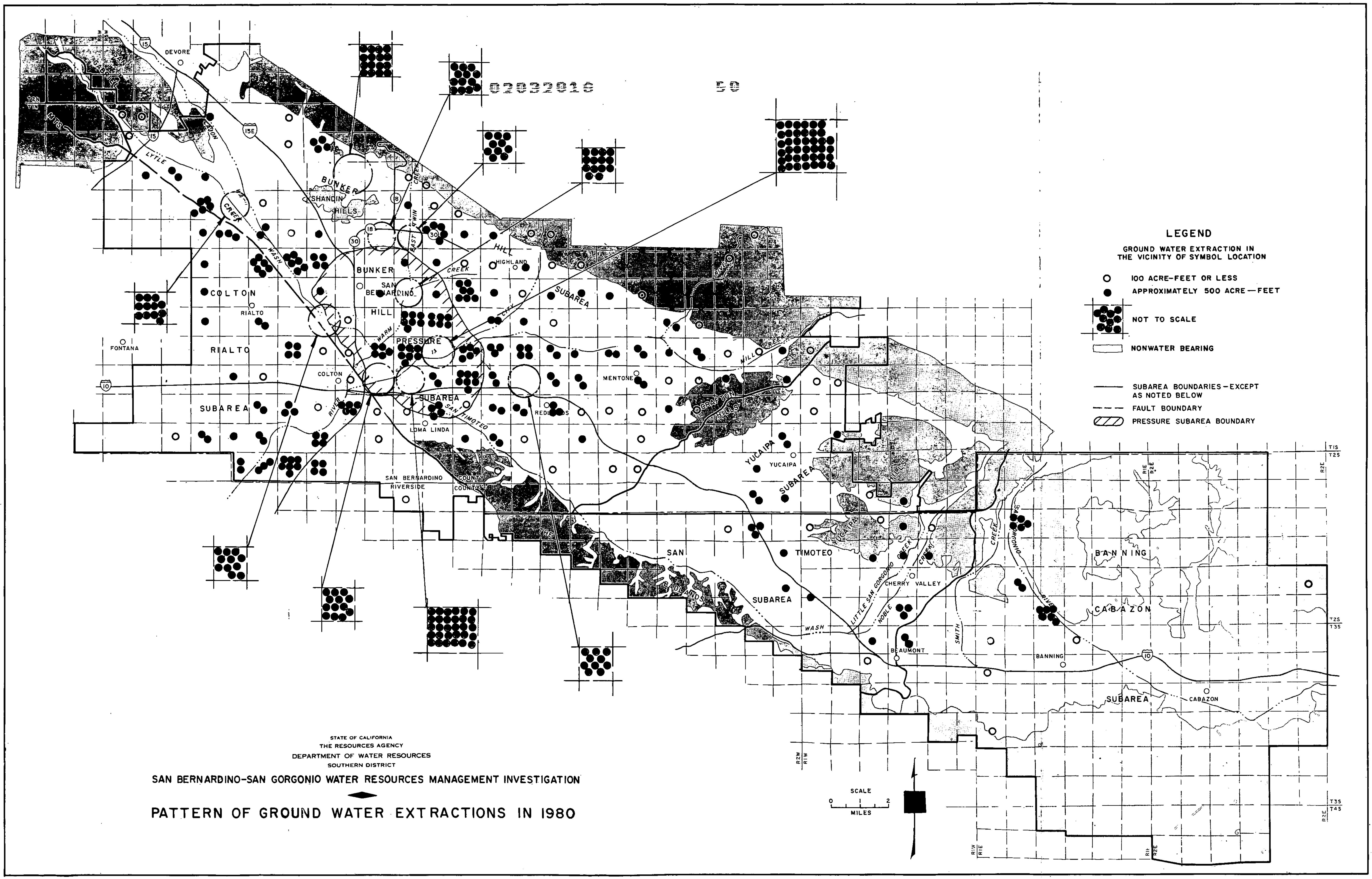
STUDY AREA



SAN BERNARDINO-SAN GORGONIO WATER RESOURCES MANAGEMENT INVESTIGATION

SPREADING GROUNDS AND EXISTING AND PROPOSED PIPELINES

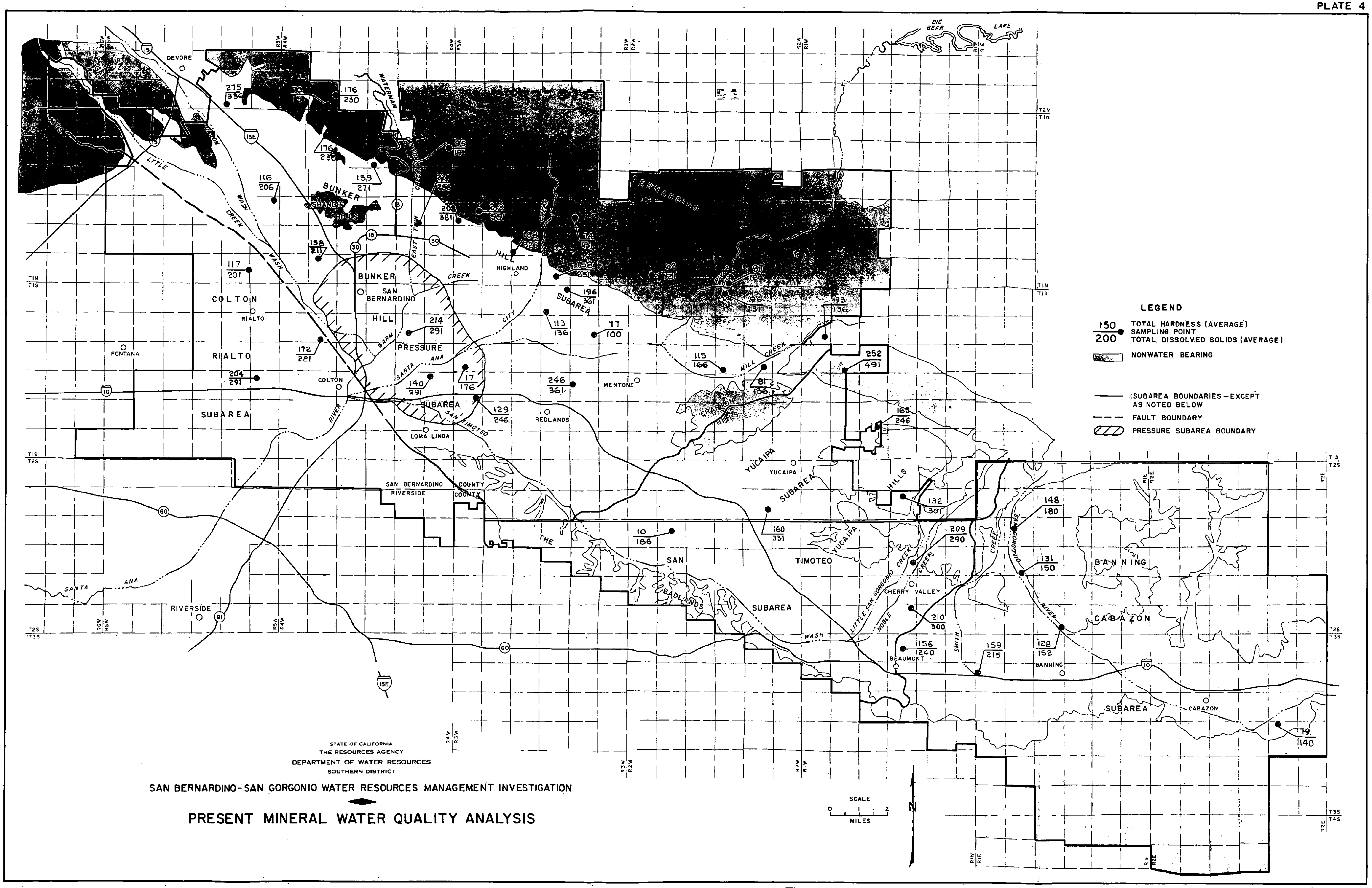
PLATE 3



STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

SAN BERNARDINO-SAN GORGONIO WATER RESOURCES MANAGEMENT INVESTIGATION

PATTERN OF GROUND WATER EXTRACTIONS IN 1980



STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

SAN BERNARDINO-SAN GORGONIO WATER RESOURCES MANAGEMENT INVESTIGATION

PRESENT MINERAL WATER QUALITY ANALYSIS