

STATE OF CALIFORNIA

The Resources Agency

Department of Water Resources

in cooperation with
Santa Clara Valley Water District

BULLETIN No. 118-1

EVALUATION OF GROUND WATER RESOURCES:
SOUTH SAN FRANCISCO BAY

Volume III:
NORTHERN SANTA CLARA COUNTY AREA

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FOREWORD

The South San Francisco Bay Ground Water Basin, which includes portions of Alameda, San Mateo, and Santa Clara Counties, underlies the southern portion of San Francisco Bay and its gently sloping bayshore plains. The ground water basin has been divided into three subbasins: the Fremont study area, encompassing the Alameda Creek-Niles Cone area and reported on in Volumes I and II of Bulletin No. 118-1, published in 1968 and 1973, respectively; the San Mateo study area, which includes the western shore of the bay; and the North Santa Clara County area, which is the subject of this volume of Bulletin No. 118-1.

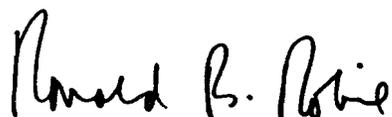
Ground water has played an important part in the development of the Santa Clara Valley area since the first settlers arrived in 1777. As water needs exceeded supplies, most of the surface water runoff was controlled by reservoirs and released for ground water recharge. By the year 1950, almost all of the valley's water needs were met by water pumped from the underlying ground water basin, which was operated in conjunction with surface water storage. This development sent water levels to an all-time low of over 150 feet (46 meters) below the ground surface.

Imported water supplies have been available to the area since 1950 from the City of San Francisco's Hetch Hetchy Aqueduct and since 1965 from the State Water Project's South Bay Aqueduct. During the period 1965-1970, the amount of ground water in storage has increased about 60,000 acre-feet (74 cubic hectometers) a year. The local agency is now reaching the upper limit of its imported water entitlement. Increasing use of water will reduce additions to ground water in storage, and by the 1980's will bring about increasing depletion of ground water in storage unless corrective measures are taken.

This report contains an evaluation of the geologic and hydrologic characteristics of the ground water reservoir and describes the mathematical model developed to simulate the ground water system.

Recommendations are made with regard to a new monitoring well network which will accurately define water levels with respect to the aquifer system. This, in turn, will allow a more accurate determination of changes in the amount of ground water in storage and increase the accuracy of the model.

The study was conducted in cooperation with the Santa Clara Valley Water District. Results of the study will be used by the cooperating agencies to evaluate alternative management plans using surface, ground, and waste waters and for evaluation of artificial recharge sites and pumping pattern changes.



Ronald B. Robie, Director
Department of Water Resources
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TABLE OF CONTENTS

	<u>Page</u>
FOREWORD	iii
ORGANIZATION	x
ORGANIZATION, CALIFORNIA WATER COMMISSION	xi
ORGANIZATION, SANTA CLARA VALLEY WATER DISTRICT	xi
 CHAPTER I. INTRODUCTION	 1
Area of Investigation	2
Previous Investigations	2
History of Water Use	4
Current Investigation	6
 CHAPTER II. CONCLUSIONS AND RECOMMENDATIONS	 7
Conclusions of Geologic Evaluation	7
Conclusions of Hydrologic Evaluation	8
Recommendations	8
 CHAPTER III. GEOLOGIC FEATURES	 11
Nonwater-Bearing Series	11
Water-Bearing Units	11
Santa Clara Formation	12
Valley Alluvium	12
Base of Water-Bearing Deposits	13
Subsurface Deposition	13
Computer Assisted Subsurface Geological Evaluation	13
Faults	16

	<u>Page</u>
Storage Capacity and Transmissivity	17
CHAPTER IV. EVALUATION OF HISTORIC WATER SUPPLY AND DISPOSAL	57
Ground Water Model	59
Study Period	62
Precipitation	63
Tributary Runoff	63
Imported Water	64
Operation of Recharge Facilities	71
Alamitos Percolation Ponds	74
Budd Avenue Percolation Ponds	75
Camden Percolation Ponds	75
Coyote Percolation Pond	75
Ford Road Percolation Ponds	76
Guadalupe Percolation Ponds	76
Kooser Percolation Ponds	76
Los Capitancillos Percolation Ponds	76
McGlincey Percolation Ponds	77
Oka Lane Percolation Ponds	77
Page Percolation Ponds	78
Penitencia Percolation Ponds	78
Sunnyoaks Percolation Ponds	78
Agricultural Water Use	79
Land Use	79
Ground Water Pumpage	83
Water Quality	83

	<u>Page</u>
Quality of Surface Water	83
Calero Reservoir	88
Lexington Reservoir	88
Anderson Reservoir	88
Quality of Imported Water	88
Quality of Ground Water	89
Minor Elements	89
Consumptive Use and Recharge of Rain and Delivered Water .	90
Evaporation	91
Evapotranspiration	92
Soil Moisture and Effective Root Depth	94
Direct Recharge from Rain and Applied Water	94
Stream and Pond Recharge	96
Water from Compaction	100
Ground Water Basin Inventory	100
Change in Storage	100
Use of the Ground Water Model	100
 CHAPTER V. GROUND WATER BASIN SURVEILLANCE SYSTEM . . .	 113
Water Level Measurements	114
Well Qualification	115
Proposed Network	126
Implementation of Network	126
 APPENDIX A. GEOLOGY (Published separately, August 1967)	
 APPENDIX B. BIBLIOGRAPHY	 131
 APPENDIX C. ENGLISH-METRIC EQUIVALENTS	 133

TABLES

<u>No.</u>		<u>Page</u>
1	Specific Yield Values for Drillers Calls	19
2	Gross Ground Water Storage Capacity	20
3	Permeability	20
4	Annual Precipitation and Index of Wetness at San Jose	66
5	Tributary Runoff	68
6	Imported Water	70
7	Percolation Facilities in Santa Clara County	74
8	Unit Values of Applied Irrigation Water: Net Acreage	80
9	Unit Values of Applied Irrigation Water: Gross Acreage	81
10	Land Use	82
11	Ground Water Pumpage	86
12	Average Daily Evaporation Rates	92
13	Agricultural Water Use Factors; Available Water- Holding Capacity of Soils; Effective Rooting Depth	93
14	Ground Water Basin Inventory	96
15	Accumulated Net Recharge and Change in Storage	102
16	Final Branch Transmissivity Used in Ground Water Model	105
17	North Santa Clara Well Qualification Listing	116
18	Proposed Ground Water Surveillance Network	127

FIGURES

<u>No.</u>		<u>Page</u>
1	Area of Investigation	Facing Page 1
2	Elevation Contours on Upper Surface of Nonwater-Bearing Rock	21
3	Geologic Sections: Santa Clara Valley	22
4	Fault Traces in Santa Clara Valley	34
5	Subsurface Deposition: Santa Clara Valley	36
6	Hydrologic System (Schematic)	58
7	Mathematical Model Nodal Network	60
8	Long-Term Precipitation at San Jose	65
9	Mean Annual Precipitation	67
10	Tributary Drainage Areas	69
11	Santa Clara County Artificial Recharge System	72
12	Land Use 1970: Santa Clara Valley	84
13	Depth of Recharge from Rain and Applied Water	95
14	Drainage System: Santa Clara Valley	98
15	Land Subsidence in the Santa Clara Valley	101
16	Accumulated Net Recharge and Change in Storage	103
17	Initial Transmissivity Values	106
18	Mathematical Model Branch Numbers	108
19	Final Computer Output	110
20	Proposed Monitoring Well Network	126

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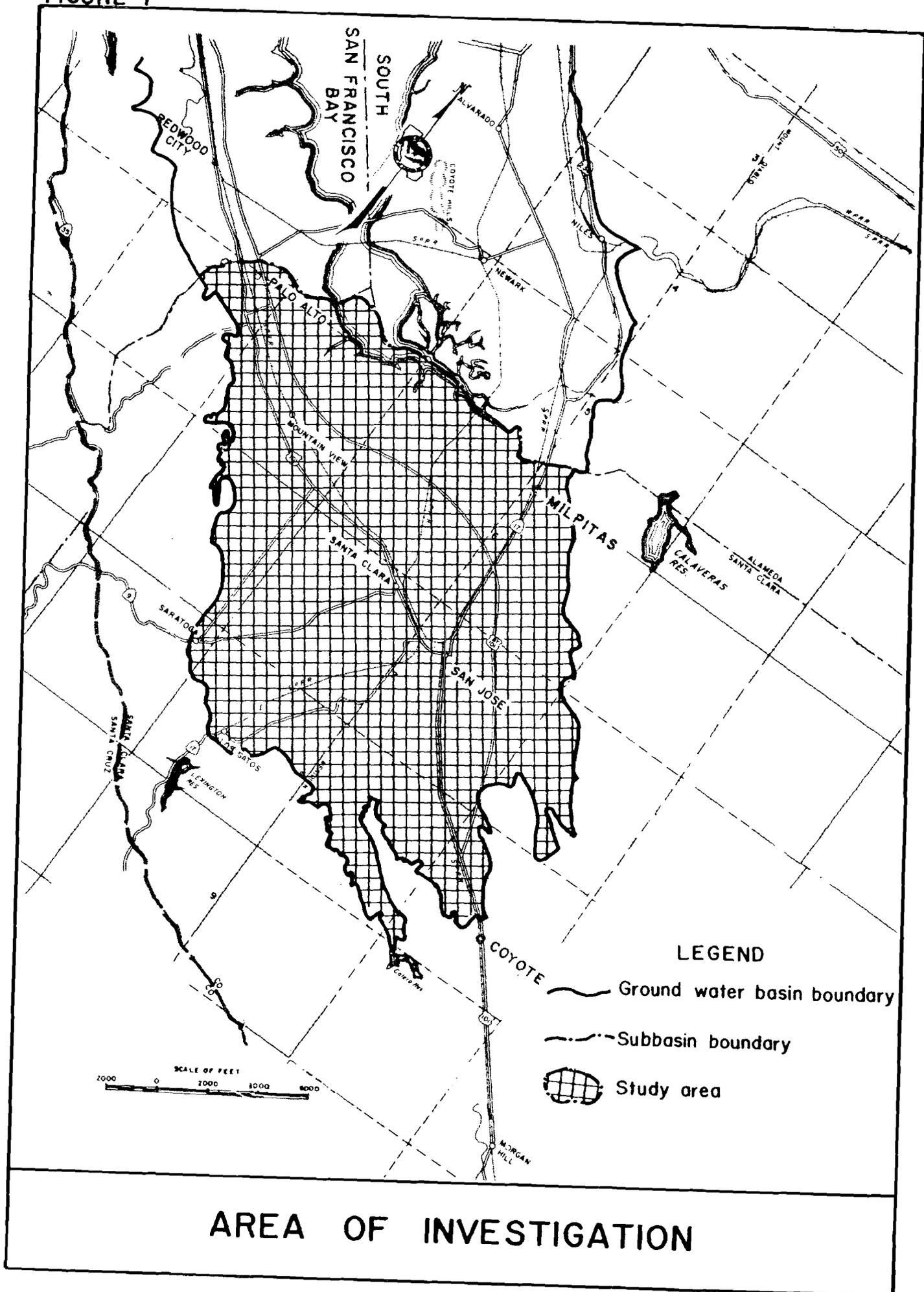
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FIGURE 1



AREA OF INVESTIGATION

CHAPTER I. INTRODUCTION

Since the settlement of Santa Clara County nearly 200 years ago, water has played an important role in the development and economy of the area. The development of an economy based on agriculture, particularly orcharding, and the start of urban development in the early part of this century was based almost exclusively on water pumped from the ground water body. In the years since 1950, local conservation projects and imported water supplies have been utilized in a race to keep up with continually increasing demands for water, and it is expected that even more water supplies will be required by 1980.

During periods when water demands exceeded supplies, the difference was met by overpumping of the ground water basin. When this adverse situation existed for more than just a few years, water levels fell to a point that permitted land subsidence to occur in the area surrounding South San Francisco Bay. Lands thus lowered by subsidence subsequently became subject to flooding from flood runoff and high tides and had to be protected by an extensive levee system.

Santa Clara County is a major water-consuming area, and it uses water supplies from both conservation reservoirs and ground water reservoirs. The effective use of water resources in the county is the concern of both state and local agencies because a part of the county's water supply is imported through the State Water Project and the Hetch Hetchy system of the City of San Francisco.

To obtain adequate information for the preparation of a series of water resource development plans, the State Department of Water Resources entered into an agreement with the Santa Clara Valley Water District to study the water resources of Santa Clara County. This bulletin presents in detail the geohydrologic conditions which affect the occurrence and movement of ground water in the northern part of Santa Clara County. The cooperative agreement is based on a 50-50 sharing of the costs of the study and has included full participation of the staffs of both agencies. A similar study is in progress covering the southern portion of the county. Additional studies of a wide range of management plans for both the north and south parts of the county will be made following the conclusion of the geohydrologic studies. Parallel studies by both agencies on possible use of waste water reclamation to extend the utility of present water supplies have been coordinated over the past two years and are continuing. Furthermore, a water quality management study is being conducted by the two agencies on a cooperative basis to provide information on cause-effect relationships and to form a basis for alternative water quality management plans.

The results of studies by the Department and the District are published so that information is available to local government representatives for consideration in adopting objectives, policies, and plans relative not only to water resource management, but also to other water-related resources.

Area of Investigation

The area of investigation comprises the southern part of the South Bay ground water basin, as shown on Figure 1. The basin is bounded on the west by the Santa Cruz Mountains and on the east by the Diablo Range; these two ranges converge at Coyote Narrows to form the southern limit of the basin. The south part of the basin, the subject of this bulletin, includes northern Santa Clara County and adjacent portions of Alameda and San Mateo Counties.

The northern boundary of the immediate study area, just north of the Santa Clara County line as shown on Figure 1, was chosen for two reasons: (1) it represents the boundary of a manageable ground water unit, and (2) it delimits the depositional area of influence of Coyote Creek, Guadalupe River, and others which drain northerly into San Francisco Bay.

The southern boundary of North Santa Clara Valley, as used in this bulletin, differs from that used in State Water Resources Bulletin No. 7, "Santa Clara Valley Investigation". That bulletin identified the ground water divide near Morgan Hill as the southern boundary of the basin. In this bulletin, the constriction of the water-bearing materials at Coyote Narrows, one mile north of the community of Coyote, is used as the southern boundary of the ground water basin.

Previous Investigations

Ground water has been and continues to be a major source of water for domestic, irrigation, and municipal uses in Santa Clara County. Interest in this subsurface source of water has resulted in the publication, since 1915, of seven significant reports covering all or parts of the present study area. These seven reports, and other geologic reports pertaining to the area, are listed in Appendix B, "Bibliography".

The drastic lowering of ground water levels prior to the 1920's, which resulted from heavy pumping draft, prompted Tibbetts and Kieffer (1921) to prepare the publication, "Report to Santa Clara Valley Water Conservation Committee on Santa Clara Valley Water Conservation Project". This report recommended the establishment of a water conservation district, the construction of dams and surface water conveyance facilities, and the extensive use of artificial recharge of ground water. The recommendations subsequently were adopted, and the facilities which were constructed allowed ground water levels to recover.

The Tibbetts and Kieffer report was followed by Clark (1924), who reported in some detail on the ground water conditions in Santa Clara Valley in U. S. Geological Survey Water-Supply Paper 519, "Ground Water in Santa Clara Valley, California". In this study, Clark included all of the present study area together with that portion of Santa Clara Valley south of Coyote Narrows.

In 1933, the California Division of Water Resources (predecessor to the Department of Water Resources), in response to a request by the newly established Santa Clara Valley Water Conservation District, published Bulletin 42, "Santa Clara Investigation". This bulletin described the historic decline of ground water levels, the amount of ground water depletion, and the quantity of replenishment from surface streams in the area.

The Division of Water Resources again studied that portion of Santa Clara Valley Ground Water Basin underlying Santa Clara County during the period from 1948 to 1954. In this latter investigation, considerable knowledge of the geologic conditions governing the movement of ground water was obtained in both North and South Santa Clara Valley, and the results were published in June 1955 as State Water Resources Board Bulletin 7, "Santa Clara Valley Investigation".

The history of land subsidence in the Santa Clara Valley was summarized by Poland and Green (1962) in U. S. Geological Survey Water-Supply Paper 1619-C, "Subsidence in the Santa Clara Valley - A Progress Report". This brief paper relates subsidence to geology and pumpage of ground water. Material presented in this paper was updated by Poland in 1971 with the publication of U. S. Geological Survey, San Francisco Bay Regional Environment and Resources Planning Study, Technical Report 2, "Land Subsidence in the Santa Clara Valley, Alameda, San Mateo, and Santa Clara Counties, California".

From 1962 to 1965, the Department conducted a geologic investigation of the South San Francisco Bay area and published its findings in August 1967 as Bulletin 118-1, "Evaluation of Ground Water Resources, South Bay, Appendix A: Geology".

The appendix describes in some detail the geology of the water-bearing sediments in the southern part of the San Francisco Bay area, which includes portions of Alameda, Santa Clara, and San Mateo Counties. Information presented is intended to support subsequent studies in the hydrology, water quality, and operational characteristics of the ground water basin. Included in the appendix is a brief discussion of the geologic history which relates the succession of significant geologic events in the area of investigation. Also included is a chapter on the geologic formations and their water-bearing characteristics. In this chapter are described the geologic materials that make up the basin, as well as the aquifers and confining beds that have been identified within them. The

lithology of the more permeable Holocene and Pleistocene sediments is discussed. The older, underlying rocks, which generally are nonwater-bearing, also are briefly discussed. Structural features, such as faults, are discussed along with their relation to ground water movement.

The various exploratory phases of the investigation are described in the appendix, and there are brief sections on the collection and analysis of geologic and geophysical data, the drilling of test holes, and the installation of piezometers.

Finally, the physical and water-bearing characteristics of the various ground water areas, with their respective subareas, are discussed in detail. The discussion includes the location of boundaries and description of extent, thickness, lithology, and water-bearing character of aquifers and confining beds within each subarea.

History of Water Use

Water has played a large and important role in the development of the valley portions of Santa Clara County since the first settlers arrived nearly 200 years ago. With the founding of Mission Santa Clara de Asis along the Guadalupe River by Franciscan padres in 1777, the valley was given its name. Later that same year, Pueblo de San Jose was founded nearby, making it the first civil settlement in California.

The valley has had four distinct periods of economic development and land use: cattle raising, grain farming, fruit production, and the present period of industry and urbanization. In the early part of the last century, cattle ranching was the principal activity in the valley. Following the gold rush, cattle ranching gave way to grain farming. In 1856, Pierre Pellier discovered that the climate and soil of Santa Clara Valley were ideal for raising prunes. By 1870, the prune became nationally popular, and valley farmers began intensive production of this and other deciduous fruits. Subsequently, the Santa Clara Valley became known as the dried fruit and the canning fruit center of the world. The acreages of fruit and nut trees increased tremendously, from 20,000 acres (8,100 hectares)* in the late 1880's to 110,000 acres (44,000 ha) in 1930. The water required to irrigate the orchards had a dramatic impact on local water supplies, and the draft upon the underground water resources of the valley was unprecedented. In 1934, water levels fell to 140 feet (43 meters) below the ground surface, in a valley which once had over 2,000 flowing artesian wells.

*Metric unit equivalents are shown thus (). See Appendix C for equivalents.

The present municipal and industrial period began with the large influx of families and industry into the valley following World War II. The population surged to 291,000 in 1950 and by 1965 had more than tripled to over 900,000. This growth alone made water demands climb, but in addition, the per capita consumption increased 40 percent between 1950 and 1970, creating water needs that were phenomenal. By 1970, the water requirements of the north valley alone were nearly 250,000 acre-feet (308 cubic hectometers)*.

In 1950, most all of the valley's water requirements were met by water pumped from the underlying ground water basin. This stress on the basin sent water levels to an all-time low of over 150 feet (46 m) below the ground surface. To replenish the depleted ground water supply, the Santa Clara Valley Water District constructed eight conservation reservoirs with a combined capacity of over 150,000 acre-feet (185 hm³). The reservoirs capture the runoff from winter rains and store the water until it can be released into streams and percolation ponds for recharge of the ground water basin.

The initial stages of the Hetch Hetchy Aqueduct were constructed by the City of San Francisco in 1934-35. However, it was not until 1952 that an 80 MGD (303,000 m³/d) extension of the Hetch Hetchy System was completed across the northern Santa Clara Valley, where it now supplies water to Sunnyvale, Palo Alto, Mountain View and Milpitas. Hetch Hetchy imports have increased steadily, and were nearly 50,000 acre-feet (62 hm³) in 1973.

When it became evident that the combination of Hetch Hetchy and local water supplies could not meet the water demands, plans were made to acquire additional water from sources outside the valley. The Santa Clara Valley Water District contracted with the State in 1961 to receive 88,000 acre-feet (109 hm³) of water annually through the South Bay Aqueduct of the California Water Project through 1988. By 1994, the District is scheduled to receive a maximum of 100,000 acre-feet (123 hm³) per year. Deliveries to the north valley began in July 1965 and have totaled 100,000 acre-feet (123 hm³) a year. This quantity is composed of 88,000 acre-feet (109 hm³) of contracted water and an additional 12,000 acre-feet (15 hm³) of surplus water when available. Approximately half of this state water is treated for surface distribution. The remainder is used for artificial recharge of the ground water basin. Ground water levels have been recovering since the initiation of water importation through the South Bay Aqueduct.

Most of the increase in water demands are now supplied by treated imported water, and ground water production has remained relatively constant at approximately 150,000 acre-feet (185 hm³) per year. Ground water supplied more than 96 percent of the water needs

* Cubic hectometer (hm³) = 1 million cubic meters.

of Santa Clara County in 1950. In the south county area, all of the water needs are still met from ground water, while in the north county area, ground water now supplies only 60 percent of the total water demand.

The Penitencia Water Treatment Facility was completed in 1974 by the Santa Clara Valley Water District. This 20 MGD (76,000 m³/d) plant treats South Bay Aqueduct water and, with the Rinconada Water Treatment Plant, completed in 1967, eventually will be treating nearly 70 percent of the total South Bay Aqueduct import.

Recent water demand projections indicate that demand will again equal or exceed supplies in the north part of Santa Clara County beginning in about 1978. The Santa Clara Valley Water District is presently considering alternative water supply sources to satisfy this additional need for 145,000 acre-feet (179 hm³) of water. Emphasis is on efforts to secure this water from the San Felipe Division of the Federal Water Project, although the District is continuing to study local projects, waste water reclamation, and water-saving devices and practices.

Current Investigation

The desired result of the geohydrologic phase of the study is a verified mathematical model of the ground water basin. Early in the study the need for further geologic work became apparent with regard to additional detail on aquifer systems previously identified as heterogeneous mixtures of aquifers and confining beds. The need for a refined geologic analysis was met by the development of a statistical approach to the examination of the large quantity of subsurface data available. The major additions to geologic knowledge made by this study are listed in Chapter III and include the results of a detailed analysis of the well drillers' logs to obtain a three-dimensional concept of the subsurface. The results are presented as (1) a contour map of the base of the water-bearing deposits, (2) locations of buried stream channel deposits, and (3) geologic cross sections of the ground water basin.

Chapter IV contains the hydrology in the form of an inventory, or accounting, of the amounts of recharge to and withdrawals from the ground water basin on an annual basis and explains the methods used to obtain numeric values. The simulation of the ground water system by a mathematical model, comparison of the inventory with change of ground water in storage, adjustment of the inventory and verification of the model are also reported. An analysis of historic data needs, as well as data requirements for present and future water resource management, is discussed in Chapter V, along with general criteria for development of water resource surveillance networks.

CHAPTER II. CONCLUSIONS AND RECOMMENDATIONS

The conclusions of the geologic and hydrologic evaluations of the ground water system in north Santa Clara County are set forth below. Recommendations for the further refinement of these conclusions are shown at the end of this chapter.

Conclusions of the Geologic Evaluation

The detailed study of the aquifer system in the north part of Santa Clara County identified and delineated a number of geologic features hitherto unknown. A discussion of these features appears in Chapter III of this bulletin; geologic conclusions, based on these features, are enumerated below:

1. Most streams draining the highland areas surrounding Santa Clara Valley have flowed across the valley floor at roughly their present locations for the past several million years.
2. Only a few streams have had major shifts in their channel locations, and these shifts have been due primarily to the geologic phenomenon called stream capture.
3. Former courses of streams occur today as buried channels composed of sand and gravel enclosed in finer-grained silt and clay.
4. Buried stream channels, which act as water-bearing conduits, are not continuous, but they have been separated into discrete segments due to post-depositional erosion and fault movement.
5. The periodic rise and fall of sea level has had a marked effect on the location and extent of the now-buried stream channels. During periods when the sea stood at a high level, beds of marine clay were deposited over older stream channel deposits. These now act as widespread confining beds to ground water contained in the underlying stream channel deposits.
6. The Santa Clara Valley apparently has been slowly subsiding during the past five to eight million years. This is suggested from the identification of stream channel deposits at a depth of 550 feet (168 meters) below present sea level.
7. There are a great many faults crossing the floor area of Santa Clara Valley; a number of these had not been previously identified. Although the direction and amount of displacement could not be determined, several of the faults appear to have displaced sediments within 50 feet (15 meters) of the present ground surface.

Conclusions of the Hydrologic Evaluation

During the study period 1962-63 through 1969-70, the total increase in the amount of ground water in storage was about 330,000 acre-feet (407 hm³), and the precipitation as measured at San Jose was eight percent above the long-time average. Also, during the study period, the total amount of water imported from the City of San Francisco Hetch Hetchy system and the State Water Project South Bay Aqueduct was about 540,000 acre-feet (666 hm³). Without imported water supplies, the ground water basin would have suffered a net loss of ground water in storage of in excess of 210,000 acre-feet (259 hm³). The basin also would be experiencing severe effects of continued land subsidence, and, in all probability, certain areas would have experienced water quality degradation from the upward movement of connate waters and the inland movement of salt water from the bay.

The levying of a ground water pump tax in 1965 has substantially reduced the amount of water being applied to acreage used for irrigated agriculture and orcharding.

Average recharge to the ground water basin during the 8-year study period was about 190,000 acre-feet (235 hm³) per year. About 60 percent of the total replenishment to the ground water body is through the percolation of conserved and imported water in improved streambeds and percolation ponds.

In spite of its limitations, the mathematical model was found to be very useful as a tool to test the effectiveness of the various concealed faults on the movement of ground water. It is concluded that these concealed faults are not effective barriers in areas where major streams have existed throughout geologic time.

Recommendations

It is recommended that the Santa Clara Valley Water District:

1. Complete verification of the ground water model developed in this study by:
 - a. Redesigning its data collection system on the basis of the geologic and hydrologic information in this bulletin. A suggested water level measurement network is presented in Chapter V. The design of a compatible water quality surveillance network is proceeding under a separate cooperative program.

- b. Testing the accuracy of the ground water model with the data collected during the first three to five years of operation of the redesign data collection system.
2. Use the model without waiting for verification to test the general response of the ground water system to a variety of alternative conjunctive operation plans.
3. Continue to cooperate with other local water agencies in conjunctive operations of the water resources of the area.
4. Take measures to assure that damaging overdraft does not recur by securing new sources of water as needed and obtaining necessary legal authority to prohibit damaging overdraft.



CHAPTER III. GEOLOGIC FEATURES

The various geologic formations of the northern part of Santa Clara County may be divided into two basic groups for the purpose of ground water studies. Consolidated rocks, which range in age from Jurassic to late-Tertiary and in composition from marine sediments to volcanic rocks and serpentine, comprise the nonwater-bearing series. These rocks produce relatively small quantities of water from fractures and seams; the water may be of unpotable quality. By far the most important geologic materials in the Santa Clara Valley area are those of the water-bearing series. These range from Pleistocene to Holocene in age and consist of a thick sequence of valley-fill material ranging in composition from sand and gravel to silt and clay. Nearly all of the water wells in Santa Clara Valley derive their supply from the water-bearing series. All of the nonwater-bearing and water-bearing materials are briefly described below. A detailed description of these materials, as well as a geologic map depicting their surficial extent, appeared in Appendix A to this bulletin, which was published separately in August 1967.

Nonwater-Bearing Series

Rocks of the nonwater-bearing series are exposed in the Santa Cruz and Diablo Mountains and also in the hills that rise above the alluvial plain of Santa Clara Valley. These rock types underlie all of the valley-fill materials at depths ranging from less than 100 feet (30 meters) to over 1,500 feet (460 meters). They mark the lower limit of ground water production in Santa Clara Valley and also define the bottom of the ground water basin. The geologic formations which comprise the nonwater-bearing rocks are composed of marine sediments and a variety of associated intrusive rocks; they range in age from Jurassic to late-Tertiary. The nonwater-bearing rocks all are consolidated and of low permeability. Ground water contained in them exists largely in fractures, joints, shear zones, and faults. These openings provide only minimal space for ground water storage and movement. Hence, these rocks usually provide only small quantities of water to wells. The quality of ground water in the nonwater-bearing rocks often is poor because most of the rocks are of marine origin and consequently may contain saline connate water.

Water-Bearing Units

The sediments comprising the water-bearing formations are present as beds of unconsolidated to semiconsolidated clay, silt, sand, and gravel. The water-bearing materials fall into two principal groups: the older Santa Clara Formation and the younger valley alluvium.

Santa Clara Formation

The Santa Clara Formation, which is of Plio-Pleistocene age, rests unconformably on the older rocks of the nonwater-bearing series. The formation was formed as a continental deposit that has been modified by subsequent folding and faulting; it now is exposed only along the west and east sides of Santa Clara Valley. The top of the Santa Clara Formation is encountered in the central portion of the valley at from depths of a few feet to over 200 feet (61 meters). Along the eastern side of the valley, the formation consists of obscurely bedded pebbly sandstone, siltstone, and clay. On the west side of the valley, exposures of the Santa Clara Formation show it to be composed of poorly sorted, irregularly bedded material ranging in grain size from silt to boulders.

Along the west side of the valley, the Santa Clara Formation dips eastward at from 10 to 65 degrees. Across the valley it appears to dip toward the west. Well data suggest that the permeability of the Santa Clara sediments increases from west to east, and the highest yielding wells tapping the Santa Clara Formation are on the eastern side of the valley. Beneath the central part of the valley, logs of deep wells show that the Santa Clara sediments decrease in grain size and in permeability with depth.

Valley Alluvium

The valley alluvium is of Pleistocene to Holocene age and is the most important water-bearing unit in Santa Clara Valley. The permeability of the valley alluvium generally is high; all large production water wells draw their supplies from the valley alluvium. The alluvium is composed of gravel, sand, silt, and clay, all of which are generally unconsolidated. The sand and gravel deposits have the highest transmissivities and are the major water-producing units; conversely, the layers of silt and clay have low transmissivities and act as confining beds.

The valley alluvium has been deposited principally as a series of coalescing alluvial fans by the numerous streams which drain the adjacent highlands. The alluvium in the gently sloping central portion of the valley is composed of materials which were deposited by the many streams that meandered across the plain on their way to San Francisco Bay. The deposits which underlie the plain become progressively finer-grained toward the central part of the valley. Here, there is a series of blue clay layers that become increasingly thicker toward San Francisco Bay. The blue clay is believed to be of marine origin and was deposited as bay mud during interglacial periods when sea level stood at a higher elevation than at present.

Base of Water-Bearing Deposits

Previous geologic work, published in Appendix A, identified the approximate base of the water-bearing deposits. Because the data presented in Appendix A had a contour interval of 500 feet (150 meters) (see Appendix A, Plate 4), a better definition of the base of the water-bearing deposits was required for the preparation of the mathematical model of the basin. Figure 2 in this bulletin presents a reevaluation of the data used in Appendix A, as well as an augmentation of additional data. The contour interval on Figure 2 is 100 feet (30 meters), which is of adequate detail to be used in the mathematical model. The base of the water-bearing materials could not be defined for the central and northern parts of the valley due to a lack of adequate well data. All wells used which penetrated nonwater-bearing rock are indicated on the figure.

Subsurface Deposition

The geologic information summarized in Appendix A was found to be of insufficient detail to define the aquifer system in Santa Clara Valley to the level required for the mathematical model. To attain this level it was necessary to identify and plot the courses of the now-buried ancient stream channels in the valley. These channels act as conduits for the transmission of ground water from areas of recharge to areas of discharge. In a sense, the channels are an intricate network of pipes underlying the valley floor.

In order to identify these channels, it was first necessary to catalog all of the water wells in the north valley area for which data are available. The data were placed in a computer file and listings obtained, tabulated numerically by well location and alphabetically by well owner, which showed the well location number, owner, well depth, year drilled, well driller, and types of data on file. In all, 3,273 wells were tabulated. Most wells were found to be not over 800 feet (244 meters) in depth; the deepest well in the valley is San Jose Water Works Well No. 2 at the 17th Street Station. This well (No. 7S/1E-9D12) was drilled to a depth of 1,535 feet (468 meters) in 1910.

Computer Assisted Subsurface Geologic Evaluation

One of the principal tasks in the Santa Clara Valley area was the identification of the buried channel network within the ground water basin. This was accomplished through the application of a computer-assisted program, called the GEOLLOG program, which presented subsurface data from well logs in a three-dimensional display. What is found in the subsurface is the product of a series of events that include deposition, folding, faulting, and erosion. This

has resulted in the valley alluvium being composed of a sequence of meandering permeable stream channel deposits separated by less permeable silts and clays. Hence, instead of widespread aquifers separated by confining beds, there were found to be numerous tabular bodies composed of sand and gravel enclosed by silt and clay.

The main data input to the GEOLLOG program were the logs of the deepest wells in each quarter-quarter section. Using this well spacing allowed for a theoretical maximum number of 4,256 data points throughout the valley. In analyzing the selected logs, it was found that the "calls" that various drillers used differed for the same material. It also was found that drillers' "calls" can be grouped, and thus a statistical analysis could be made based on these "calls". This same approach was used by Davis and others (1959), who grouped the drillers' "calls" by specific yield values in their study of the San Joaquin Valley. This grouping of "calls", modified for the Santa Clara Valley area, is presented on Table 1.

Using the groupings of drillers' "calls" shown on Table 1, the Equivalent Specific Yield value is assigned to each interval for each selected well log. Equivalent Specific Yield, or ESY, is defined as being a property of the geologic materials numerically equal to the Specific Yield but without the connotation of either the quantity of ground water contained therein or the degree of confinement. Data are then fed into the computer for all selected wells in the ground water basin. The computer, utilizing the GEOLLOG program, averages the ESY values for each depth increment and prints maps of the basin for the various depth increments. The basic type of output are maps showing numeric values at each well location. These values are that of the average ESY for the particular depth increment.

A more useful printout is the symbolic type, the symbols for which are shown below:

<u>Group</u>	<u>ESY Value</u>	<u>GEOLLOG Symbol</u>
Rock	0	*
Clay	3 to 7	.
Clay-Sand	8 to 12	-
Sand-Clay	13 to 17	+
Gravel-Sand	18 to 25	0

From this it can be seen that most clays, hardpans, and the like will appear as a dot, and the coarse-grained aquifer material will appear as a zero. Division of the materials into these basic symbols simplifies the statistical analysis as well as equalizes differences in drillers' "calls" caused by differing drillers identifying the same material by different names.

For development of geologic cross-sections, the data for each well log is processed by computer to obtain a symbolic representation of the well log based on a series of layers of uniform depth. For example, if the information is based on layers of a ten-foot (3-meter) thickness, the result is a symbolic log having a scale of one inch (2.5 cm) equals 100 feet (30 meters). The output from the computer includes the well number, ground elevation, and the elevation of the top of the log. The geologic cross-section is the combination of a ground-surface profile and symbolic logs. The cross-section is used in developing correlations of coarse-grained materials between symbolic logs.

To assist in analysis of the fine materials, another related computer program was developed. In the Reduced Clay Program, the color of the clayey materials shown on the well logs is coded in the same manner as the ESY values. In this case, reduced clays, which are those reported on the logs as being blue, gray, or green, were coded with a 99. Oxidized clays, those reported as yellow, tan, brown, or red, were coded with a zero. The computer then provided a weighted average for these two values over each ten-foot (3-meter) interval. From this, areas of marine clays (that is, reduced clays) could be differentiated from the areas of terrestrial clays (the oxidized clays).

The final cross sections, shown on Figure 3 (at end of chapter), included interpretations of both the symbolic well logs and the reduced clay logs. Shown are zones of coarse-grained aquifer materials (the stippled pattern), zones of oxidized clay (blank areas), and zones of reduced marine clays (line pattern). Individual wells are not identified due to restrictions in the California Water Code prohibiting the publication of confidential well data.

The second, and perhaps more important, use of the GEOLOG Program is the preparation of maps of the subsurface at differing elevations. In this application, the computer output is an areal map of each township for each ten-foot (3-meter) depth interval. For geologic interpretation, all townships for a given elevation are spliced together and reproduced on transparent media. The transparencies then are stacked for viewing. In Santa Clara Valley, maps were prepared for ten-foot (3-meter) intervals from a top level of +290 feet (+88 meters) to a bottom level of -550 feet (-168 meters). Preparation of maps below this latter elevation was not possible because the number of data points drops off markedly. However, it can be assumed that zones of channel material exist to an elevation of at least -1,440 feet (-439 meters) based on the log of the deepest well in the valley.

Because of the natural slope of the stream channel deposits, each channel theoretically will describe an ellipse as it passes through each horizontal level. Thus, when a sequence of levels is viewed from above, a stream channel can be seen meandering downward through the various levels. This was found to be the case for the various

buried channels of Coyote Creek, Guadalupe River, Stevens Creek, and other major streams. In viewing these levels, it was found that some stream channel deposits appeared to end abruptly. Some of these discontinuities could be attributed to erosional features. However, it was noted that a number of these discontinuities appeared to fall in line. Furthermore, several alignments appeared to be extensions of mapped fault zones. Thus, a technique was developed where fault lines could be inferred. Figure 4 shows a number of fault traces which were identified through the use of the GEOLOG program. Figure 5 shows maps of the buried stream channel deposits which also were identified by the GEOLOG program. These maps include a number of elevation intervals from +100 to +50 feet (+30 to +15 meters) to -500 to -550 feet (-152 to -168 meters).

Utilization of a computer-assisted geologic analysis has greatly increased the ability to adequately analyze the aquifer system in a ground water basin. Heretofore it was necessary to employ geologic expertise in the construction of endless cross sections.

Even then, a horizontal display of the meandering stream channels was lacking. Now, through the use of these new techniques, it has become possible to undertake the detailed analysis of a ground water system at almost any level of detail, the only constraint being the level of adequate well log data.

Other ramifications of the GEOLOG method include the utilization of the numeric data for the estimation of ground water storage capacity, the assignment of transmissivity values, and a number of other geohydrologic parameters necessary for the efficient operation of a mathematical model of a ground water basin.

Faults

Geologic interpretation, using the GEOLOG program, identified many fault traces crossing Santa Clara Valley which hitherto had not been known. The faults appeared as discontinuities on the various computer printout maps of stream channels. Proof of the existence of a number of these faults was borne out in several ways. Some lines of discontinuities appeared as extensions of fault zones previously mapped in upland areas; this was the case of the Cascade Fault (see Figure 4) which had been mapped previously in the Santa Teresa Hills and is shown as the unidentified fault separating Jurassic from Cretaceous rocks on Plate 3 of Appendix A to this bulletin. The Santa Clara Fault, which also has been called the Stanford Fault, is shown as an unidentified fault on Plate 3 of Appendix A. This fault, which was inferred from geophysical data and extends from Redwood City southward to Los Altos on Plate 3, Appendix A, has been further extended on Figure 4 of this bulletin until it now is considered a major structural feature of Santa Clara Valley.

On the east side of Santa Clara Valley, the Hayward Fault previously was mapped only as far south as about Penitencia Creek. Work on the subsurface geology for this bulletin suggests that the fault does not terminate there, but rather it divides into several branches. The existence of one of these branches was further suggested by geophysical studies performed by private consultants for a foundation study for a pipeline.

Of importance to ground water movement and the construction and operation of the mathematical model was the identification of the uppermost level at which the various faults disrupt the water-bearing materials. Although this could not be precisely determined, many of the faults appear to offset buried stream channels as close as 50 feet (15 meters) below ground surface. Thus, much of the Santa Clara Valley area appears to be compartmentized with respect to ground water movement.

Storage Capacity and Transmissivity

The gross storage capacity of Santa Clara Valley ground water basin has been calculated as the theoretical volume of water that is capable of being contained between the base of the water-bearing materials and ten feet (3 meters) below ground surface; it is based on specific yield values shown in Table 1.

The portion of the gross storage capacity shown on Table 2 that can be considered as usable storage capacity has not been determined, but is limited by operational controls to prevent land subsidence and avoid excessive pumping lifts and adverse water quality effects.

Transmissivity values were estimated using a relationship between specific yield and permeability. This relationship was derived for the mathematical model of Livermore Valley and is described in detail in Department of Water Resources Bulletin No. 118-2, "Livermore and Sunol Valleys: Evaluation of Ground Water Resources", March 1974. The values for permeability which were used in the current study are presented on Table 3.

The values describe a curve, and equations describing this curve were derived for input to the computer. That part of the curve for specific yield values from 3 to 10 is described by the following equation:

$$\Delta T = \Delta D \cdot 10 \frac{3.5319 \quad 7.16288}{|sy|^{-0.84}}$$

and that part for specific yield values greater than 10 is described by the equation:

$$\Delta T = \Delta D (100|sy| - 500),$$

where ΔT = incremental transmissivity in gallons per day per foot^{1/},
 ΔD = incremental depth, in feet, and
 $|sy|$ = absolute value of specific yield for given interval

^{1/} Gpd/ft = 0.0124 m²/d.

In addition to the above, a computer program also was written to accept specific yield data which had been coded for the GEOLOG program. Output of this latter program was the summation of the transmissivity values for each node, from bottom to top. These were directional values of transmissivity for flows along the previously identified depositional channels. For use in the mathematical model, the values were modified to apply to each nodal branch.

TABLE 1

SPECIFIC YIELD VALUES FOR DRILLERS CALLS

Type of Material and Specific Yield	Drillers Calls		
Crystalline Bedrock Specific Yield = 00 Percent	Granite Lava	Hard Rock Rock	
Clay and Shale Specific Yield = 01 Percent	Adobe Boulders in Clay Cemented Clay Clay Clayey Loam Decomposed Shale	Granite Clay Hard Clay Hard Pan Hard Sandy Shale Hard Shell Muck Mud	Shale Shaley Clay Shell Rock Silty Clay Loam Soapstone Smearay Clay Sticky Clay
Clayey Sand and Silt Specific Yield = 05 Percent	Chalk Rock Clay and Gravel Clayey Sand Clayey Silt Conglomerate Decomposed Granite Gravelly Clay Lava Clay Loam	Peat Peat and Sand Pumice Stone Rotten Conglomerate Rotten Granite Sand and Clay Sand and Silt Sand Rock Sandstone	Sandy Clay Sandy Silt Sediment Shaley Gravel Silt Silty Clay Silty Loam Silty Sand Soil
Cemented or Tight Sand or Gravel Specific Yield = 10 Percent	Black Sand Blue Sand Caliche Cemented Boulders Cemented Gravel Cemented Sand	Cemented Sand and Gravel Dead Gravel Dead Sand Dirty Pack Sand Hard Gravel	Hard Sand Heavy Rocks Lava Sand Soft Sandstone Tight Boulders Tight Coarse Gravel Tight Sand
Gravel and Boulders Specific Yield = 15 Percent	Cobbles and Gravel Coarse Gravel Boulders Broken Rocks	Gravel and Boulders Heaving Gravel Heavy Gravel Large Gravel Muddy Sand	Rocks Sand & Gravel, Silty Tight Fine Gravel Tight Medium Gravel
Fine Sand Specific Yield = 15 Percent	Fine Sand	Quicksand	Sand, Gravel, and Boulders
Sand and Gravel Specific Yield = 20 Percent	Dry Gravel Loose Gravel	Gravelly Gravelly Sand Medium Gravel	Sand and Gravel Sand Water Gravel
Coarse Sand and Fine Gravel Specific Yield = 25 Percent	Coarse Sand	Fine Gravel	Medium Sand Sand and Pea Gravel

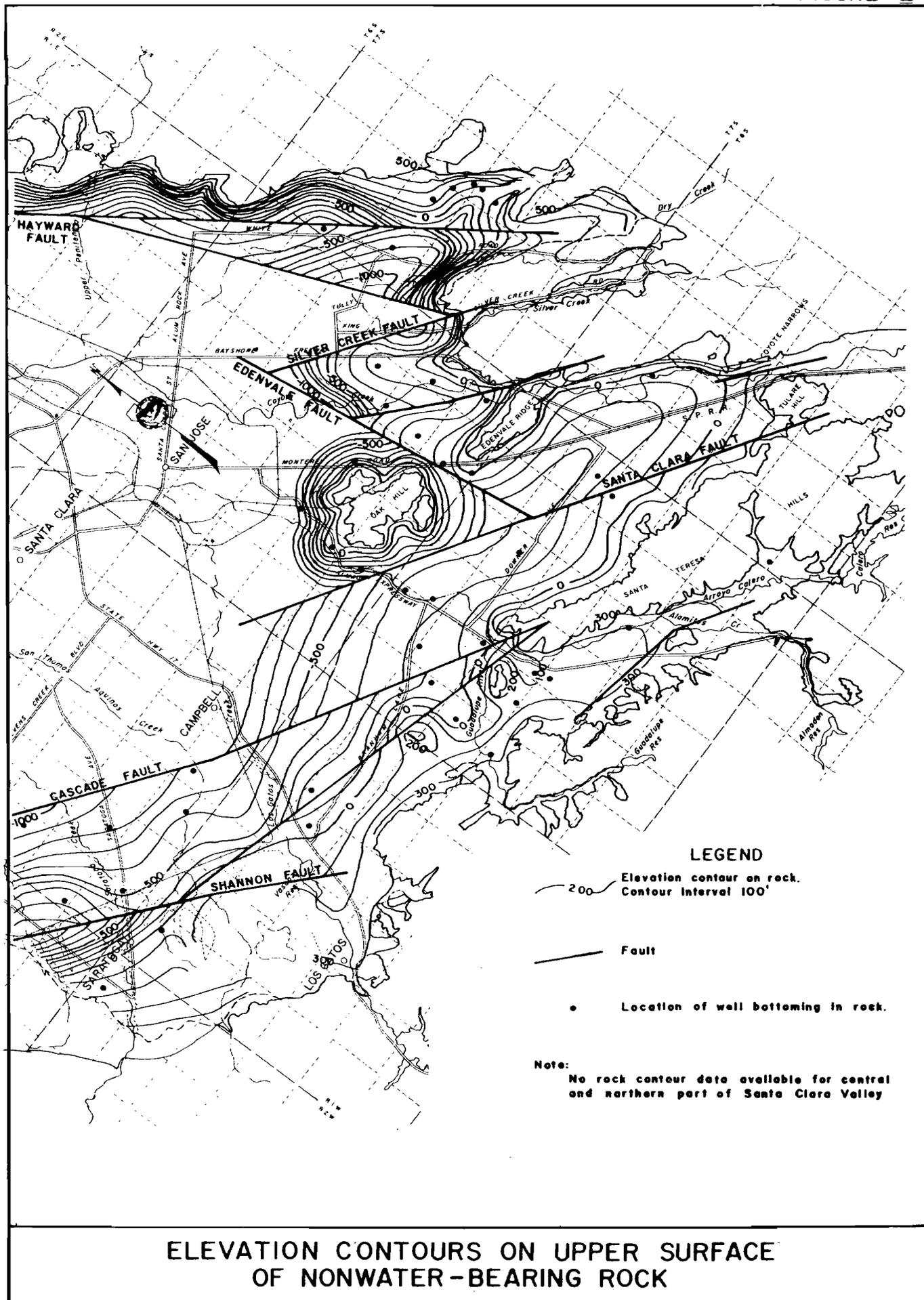
Modified after Davis, and others (1959).

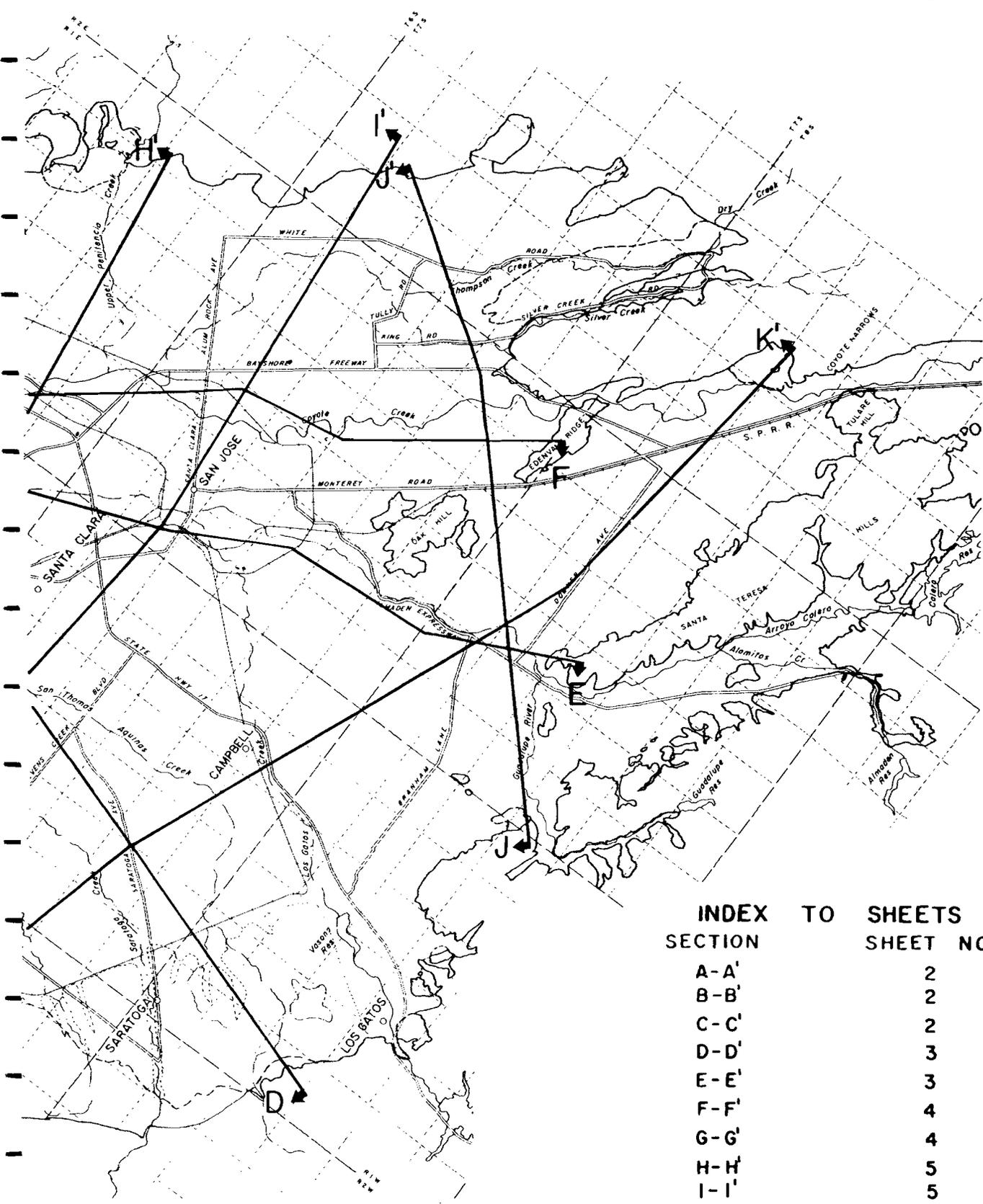
TABLE 2
GROSS GROUND WATER STORAGE CAPACITY

Depth below Ground Surface (feet)		Gross Storage Capacity (acre-feet)	Depth below Ground Surface (meters)		Gross Storage Capacity (cubic hectometers)
From	To		From	To	
10	110	1,220,000	3	34	1,504
10	210	2,267,000	3	64	2,795
10	310	3,255,000	3	94	4,013
10	410	4,195,000	3	125	5,172
10	510	5,020,000	3	155	6,190
10	610	5,695,000	3	186	7,022
10	710	6,331,000	3	216	7,806
10	810	6,825,000	3	247	8,415
10	910	7,088,000	3	277	8,740
10	1,010	7,257,000	3	308	8,948

TABLE 3
PERMEABILITY

Specific Yield (percent)	Permeability	
	(gal/day/ft ²)	(darcys)
3	1	0.055
5	30	1.65
10	400	22.0
15	800	44.0
20	1,200	66.0
25	1,500	82.5

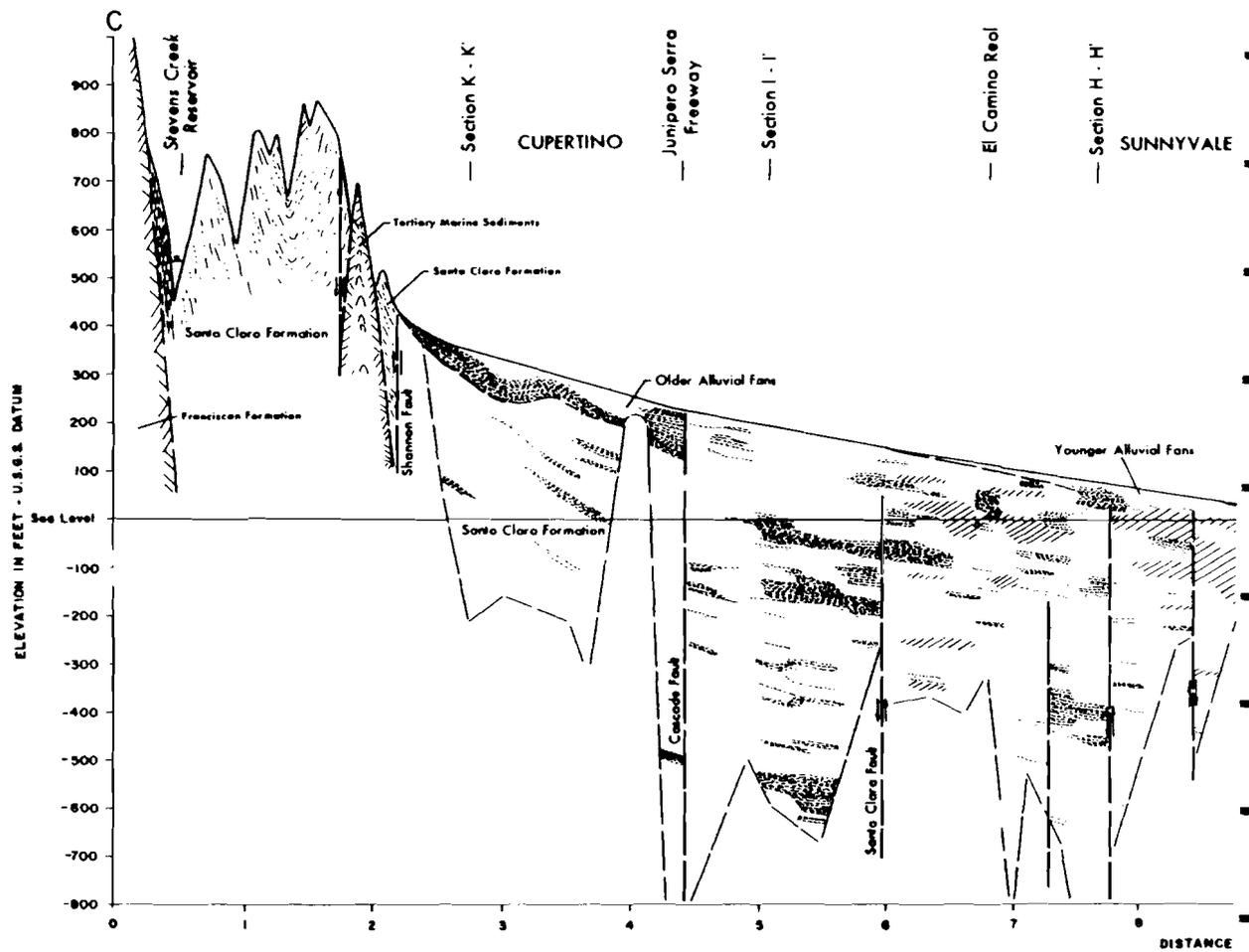
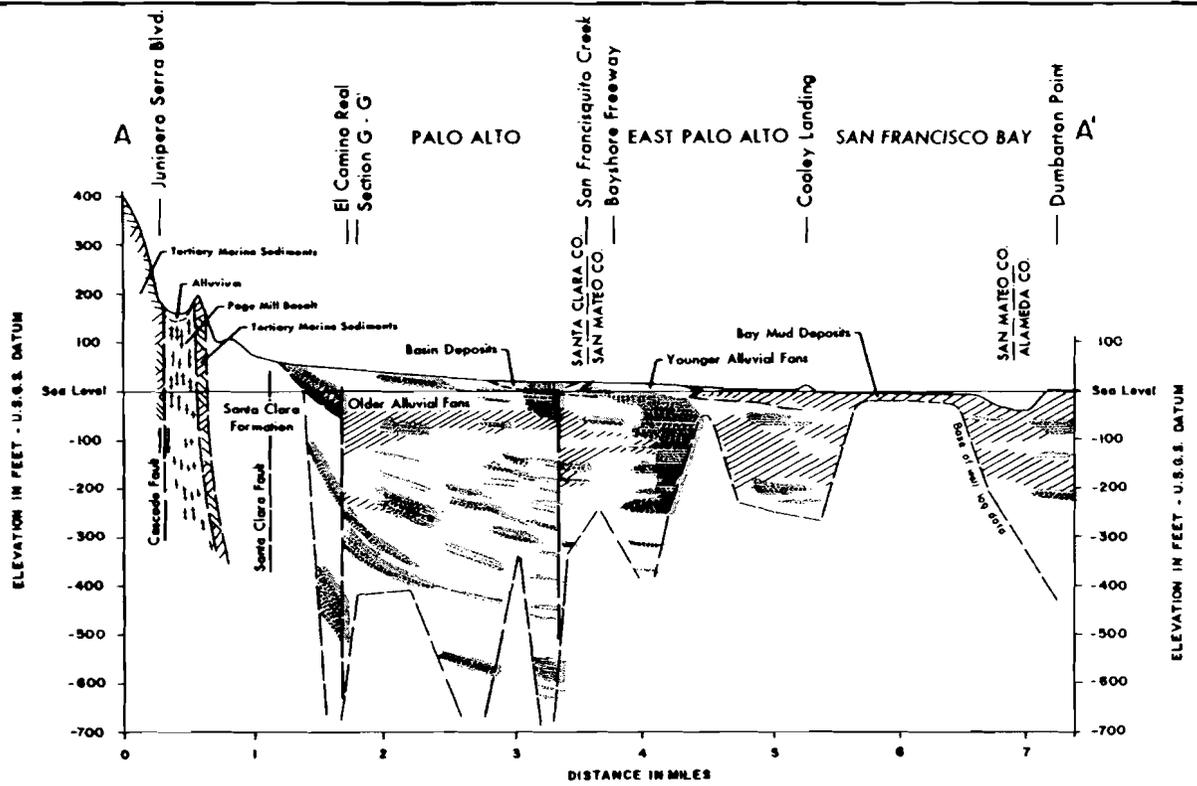




INDEX SECTION	TO SHEETS SHEET NO.
A-A'	2
B-B'	2
C-C'	2
D-D'	3
E-E'	3
F-F'	4
G-G'	4
H-H'	5
I-I'	5
J-J'	6
K-K'	6

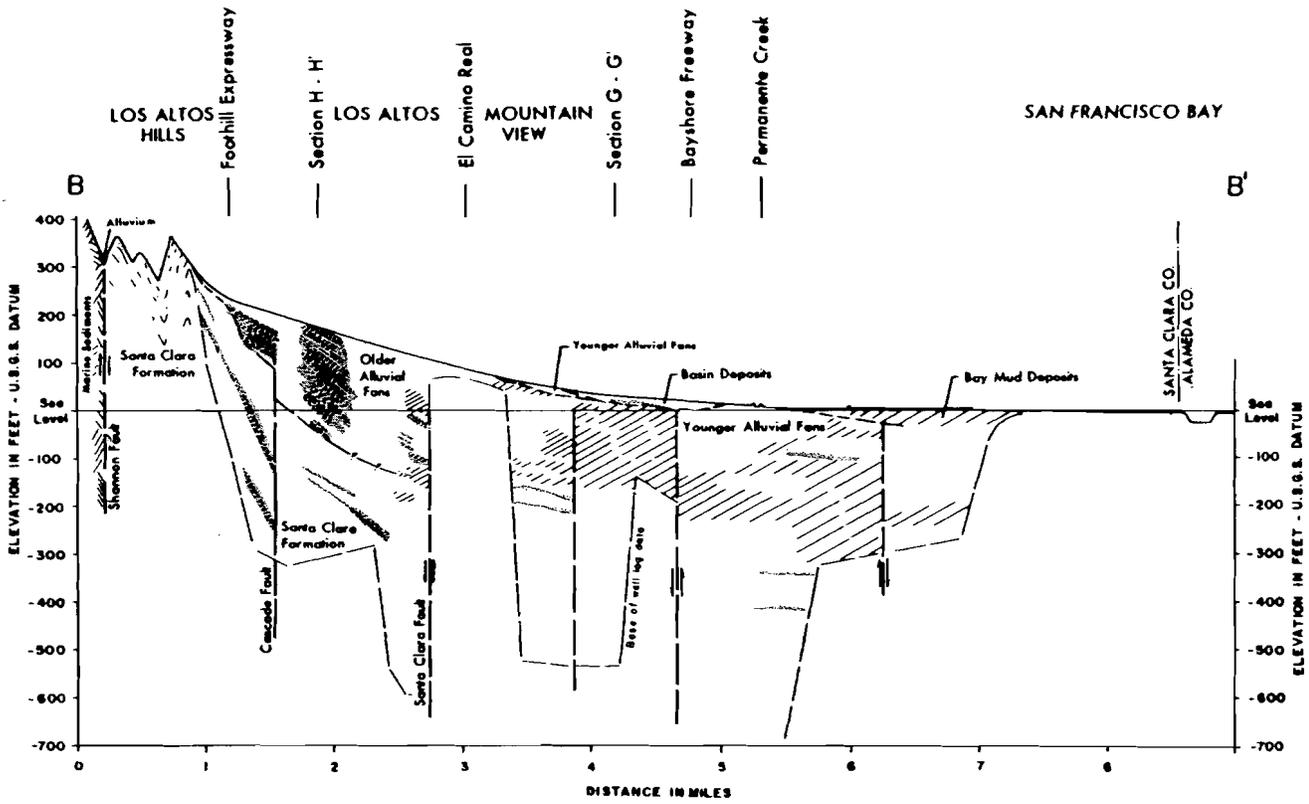
SHEET

SANTA CLARA VALLEY



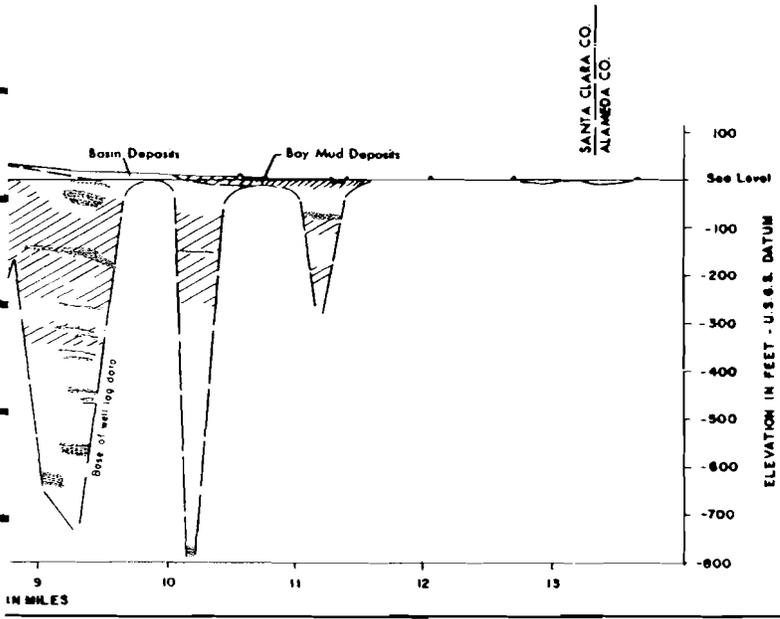
GEOLOGIC SECTIONS

See Sheet I for location of section



Bayshore Freeway
Section G - G
Guadalupe River
Alvito Creek
Coyote Creek

Section C-C'

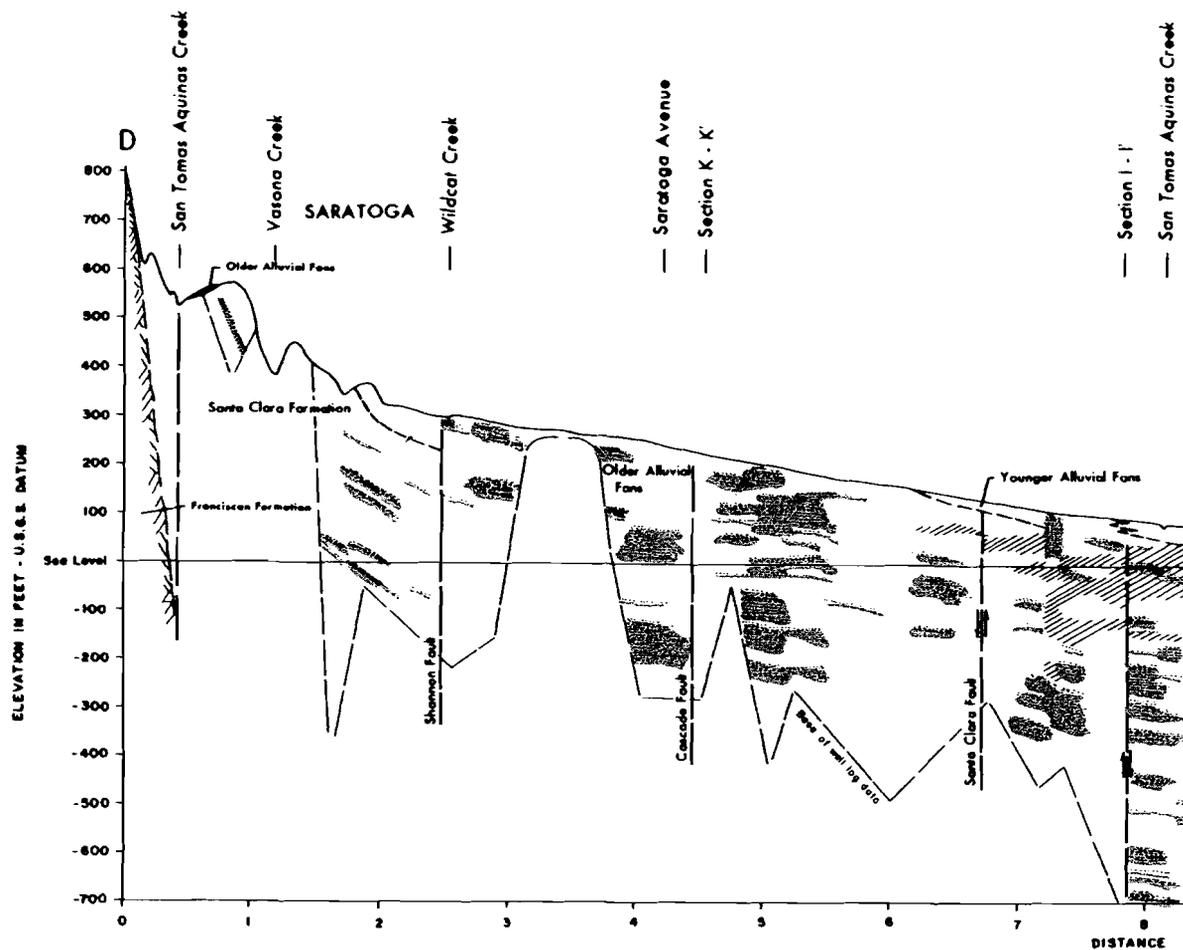


LEGEND

- CHANNEL DEPOSITS Sand and gravel deposited by meandering streams, act as aquifers.
- OXIDIZED CLAY Yellow and brown clay formed during periods of continental deposition
- REDUCED CLAY Blue, gray, and green clay formed during periods of aqueous deposition. Includes marine clays (old bay muds)

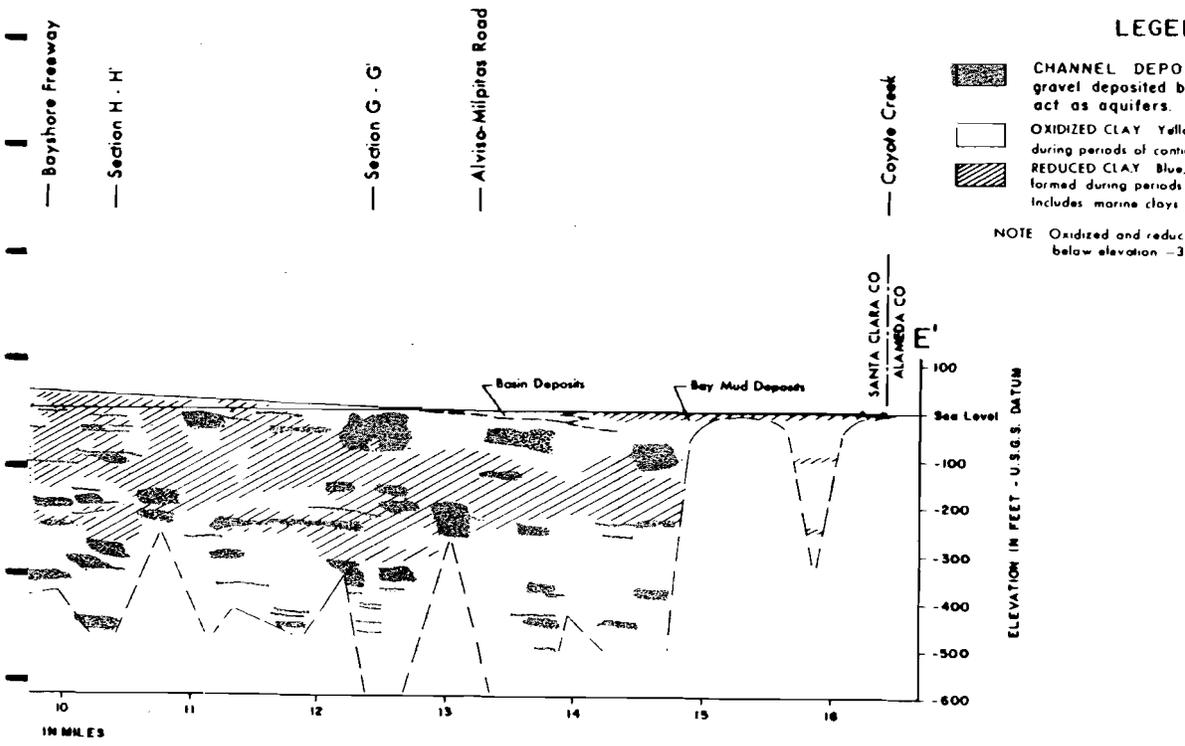
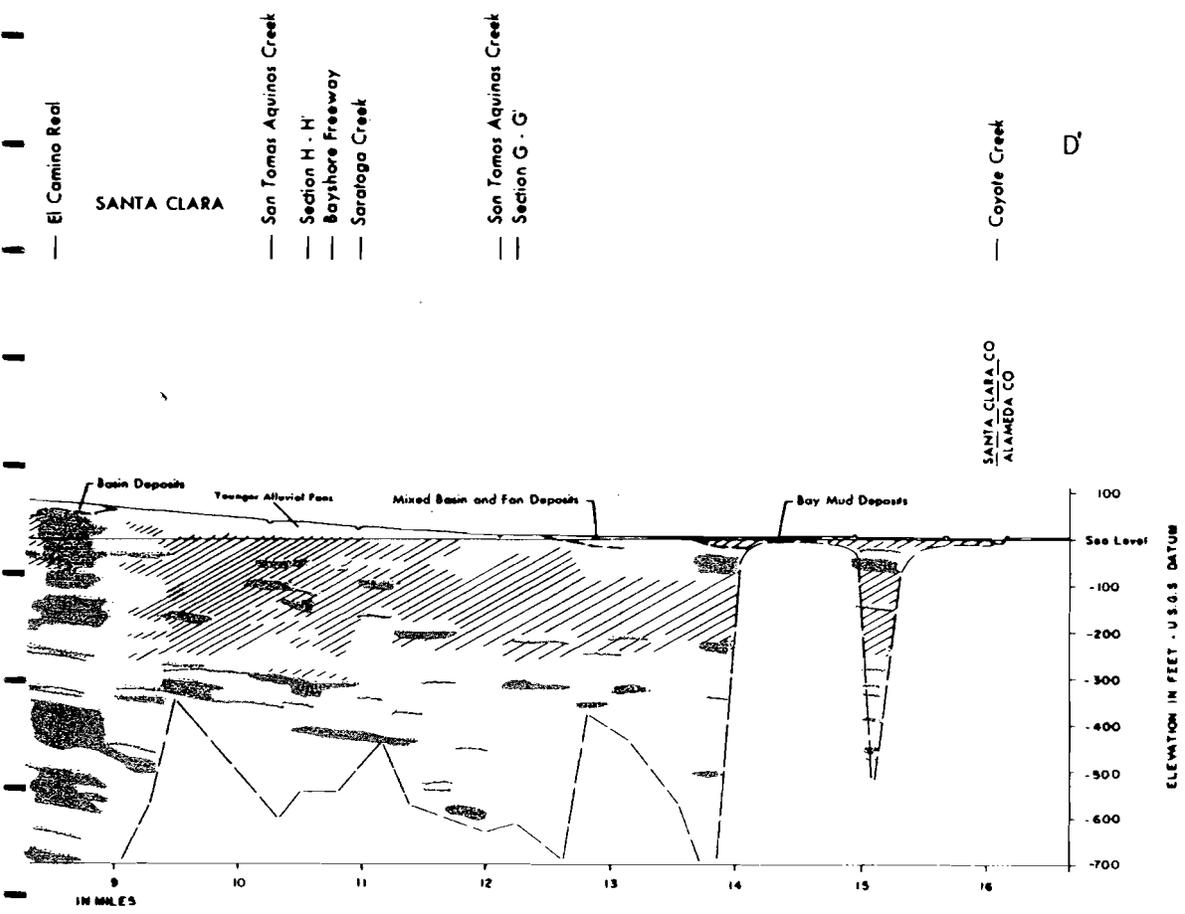
NOTE Oxidized and reduced clays not differentiated below elevation -300 feet

SANTA CLARA VALLEY



GEOLOGIC SECTIONS

See Sheet 1 for location of section

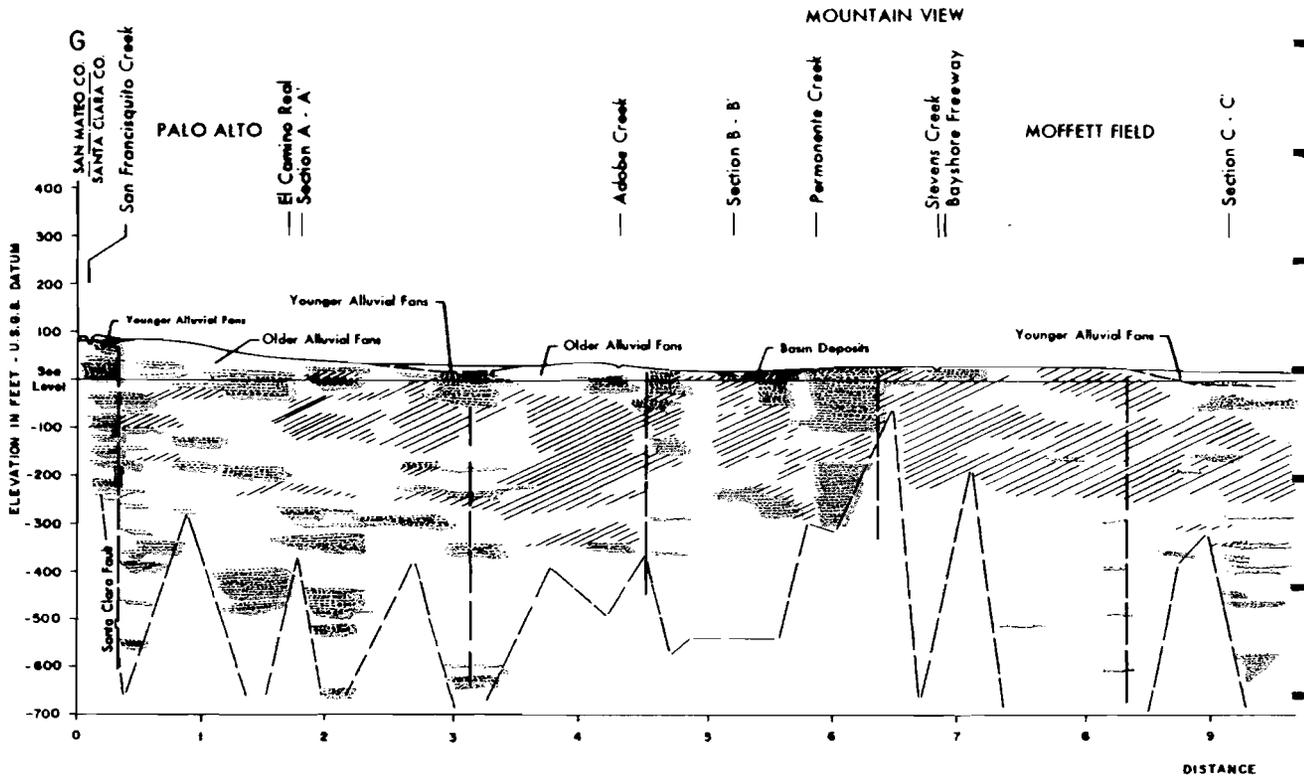
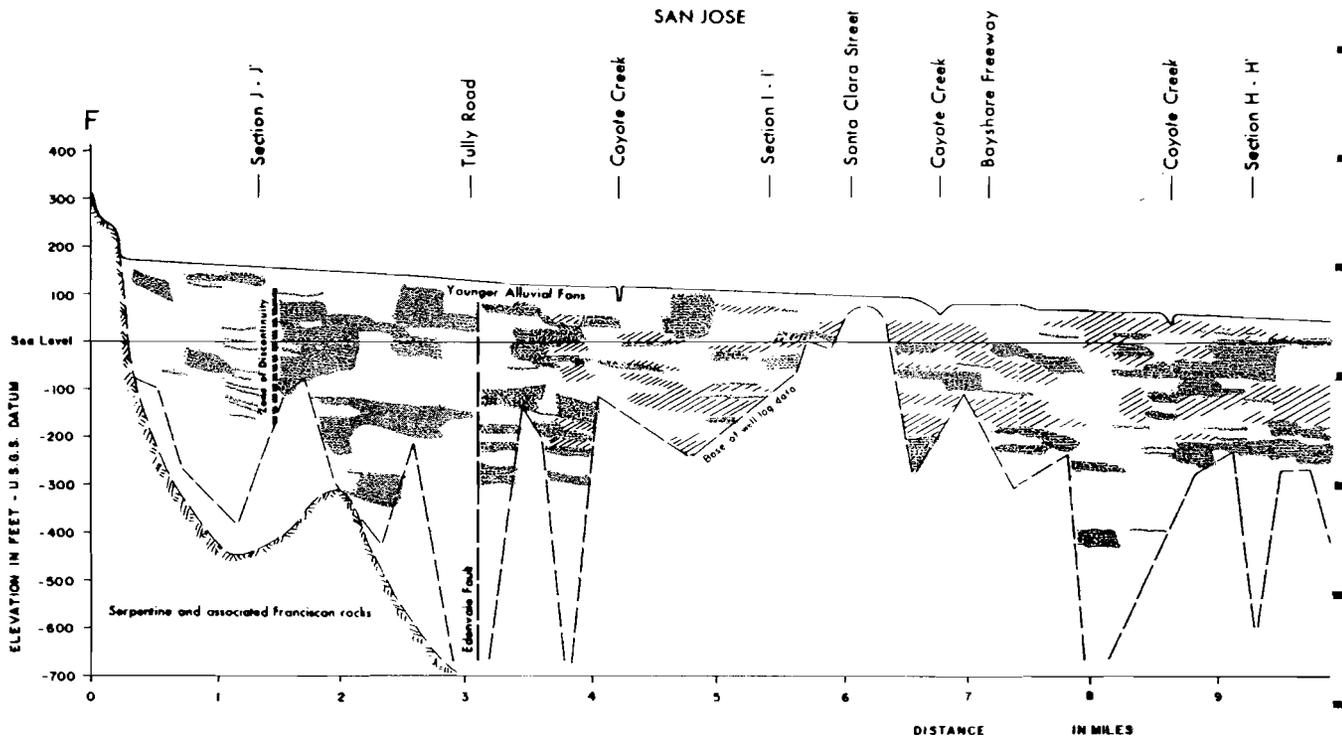


LEGEND

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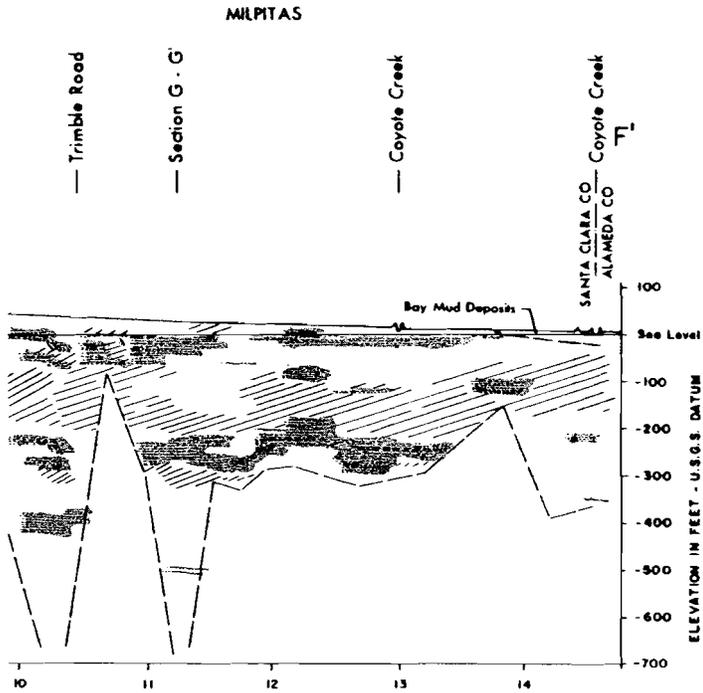
NOTE Oxidized and reduced clays not differentiated below elevation -300 feet

SANTA CLARA VALLEY

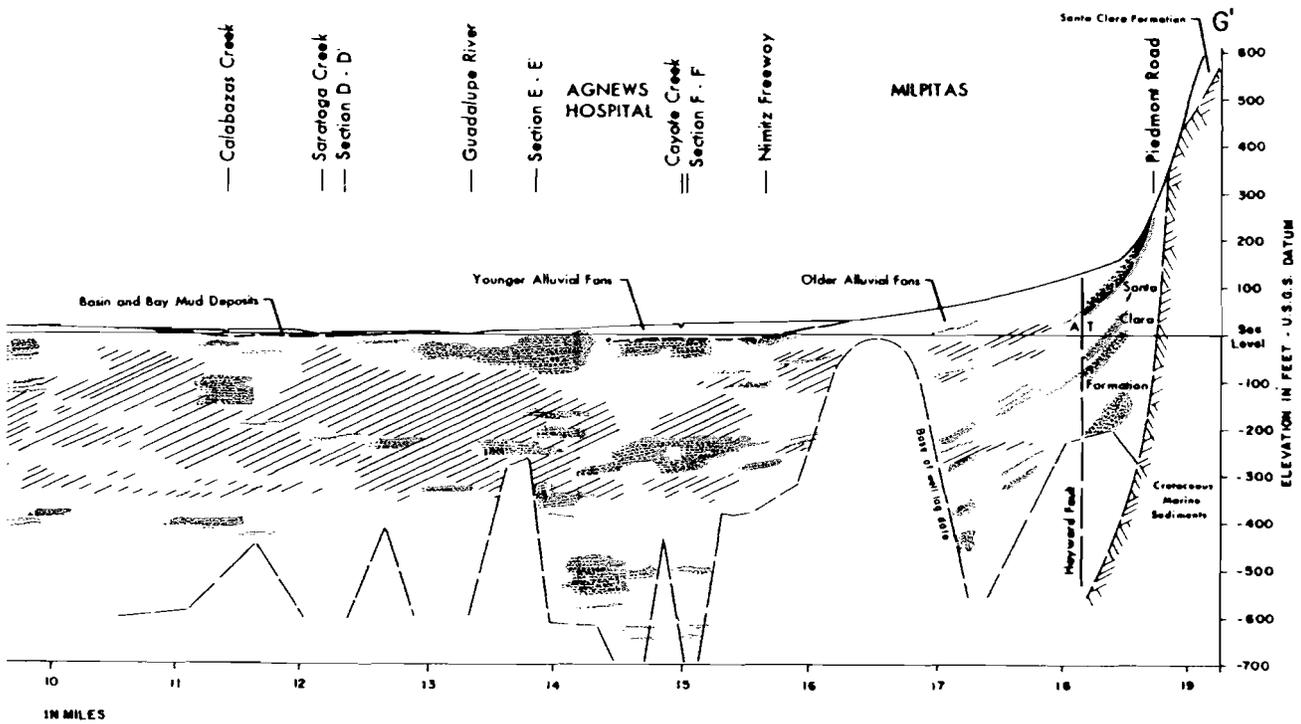


GEOLOGIC SECTIONS

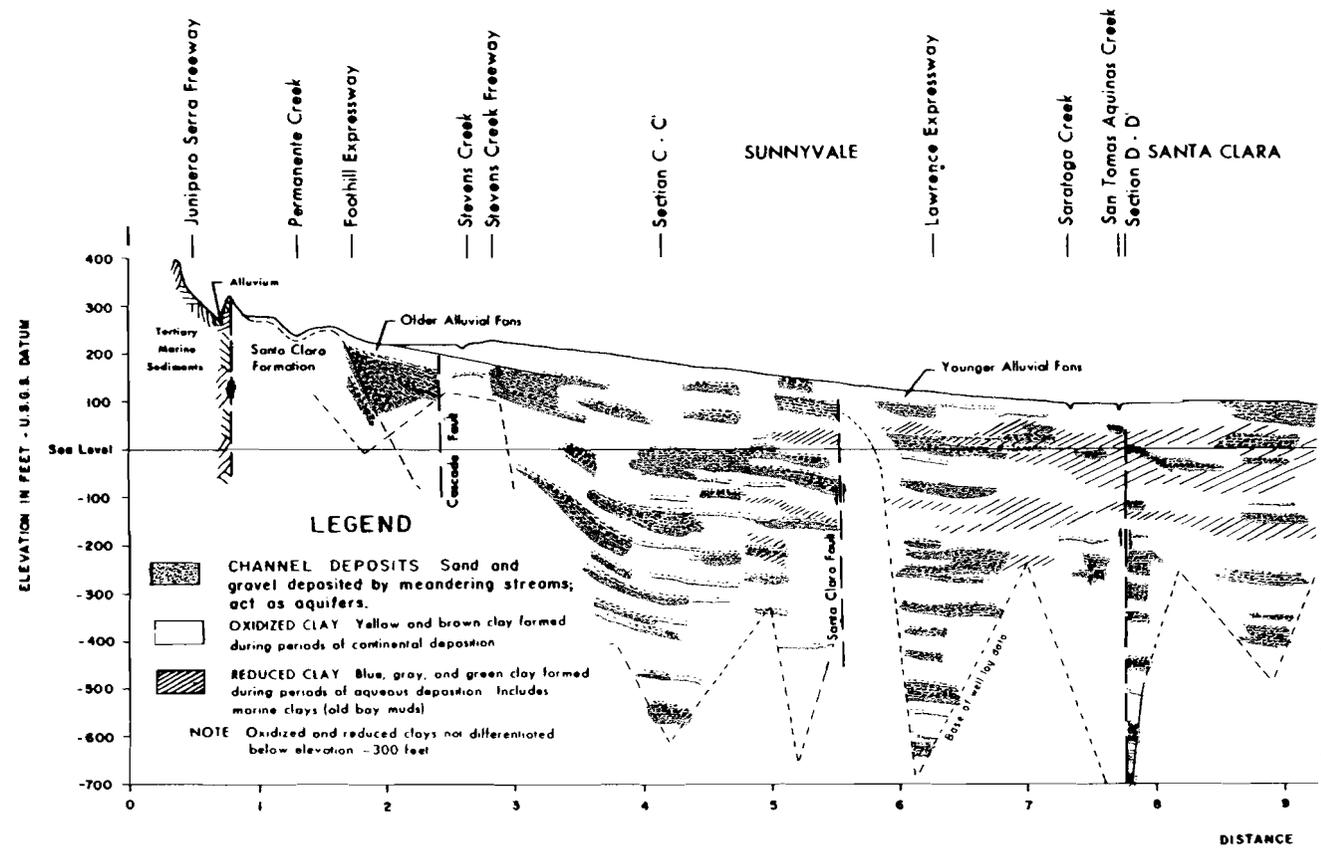
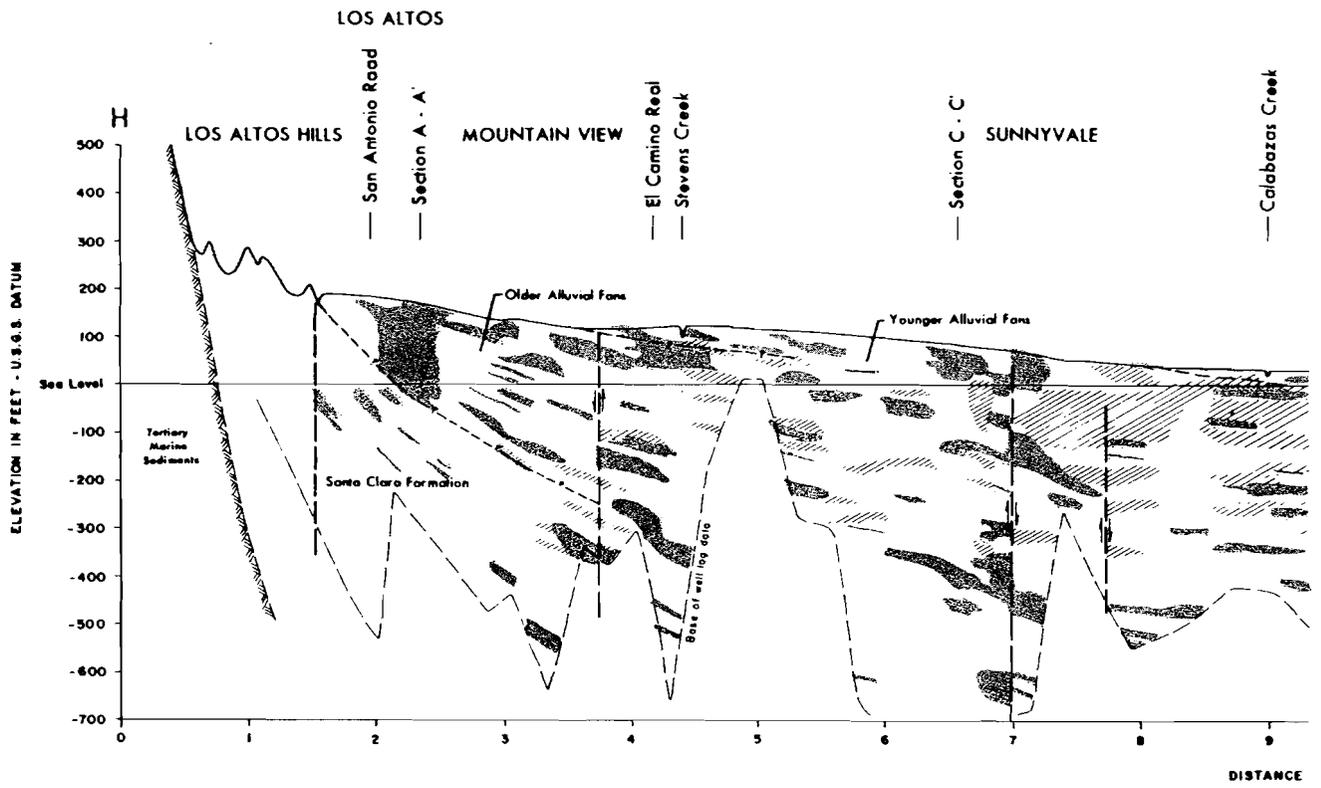
See Sheet I for location of section



- LEGEND**
- CHANNEL DEPOSITS Sand and gravel deposited by meandering streams; act as aquifers.
 - OXIDIZED CLAY Yellow and brown clay formed during periods of continental deposition
 - REDUCED CLAY Blue, gray, and green clay formed during periods of aqueous deposition Includes marine clays (old bay muds)
- NOTE Oxidized and reduced clays not differentiated below elevation -300 feet



SANTA CLARA VALLEY



LEGEND

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- REDUCED CLAY Blue, gray, and green clay formed during periods of aqueous deposition. Includes marine clays (old bay muds)

NOTE Oxidized and reduced clays not differentiated below elevation -300 feet

GEOLOGIC SECTIONS

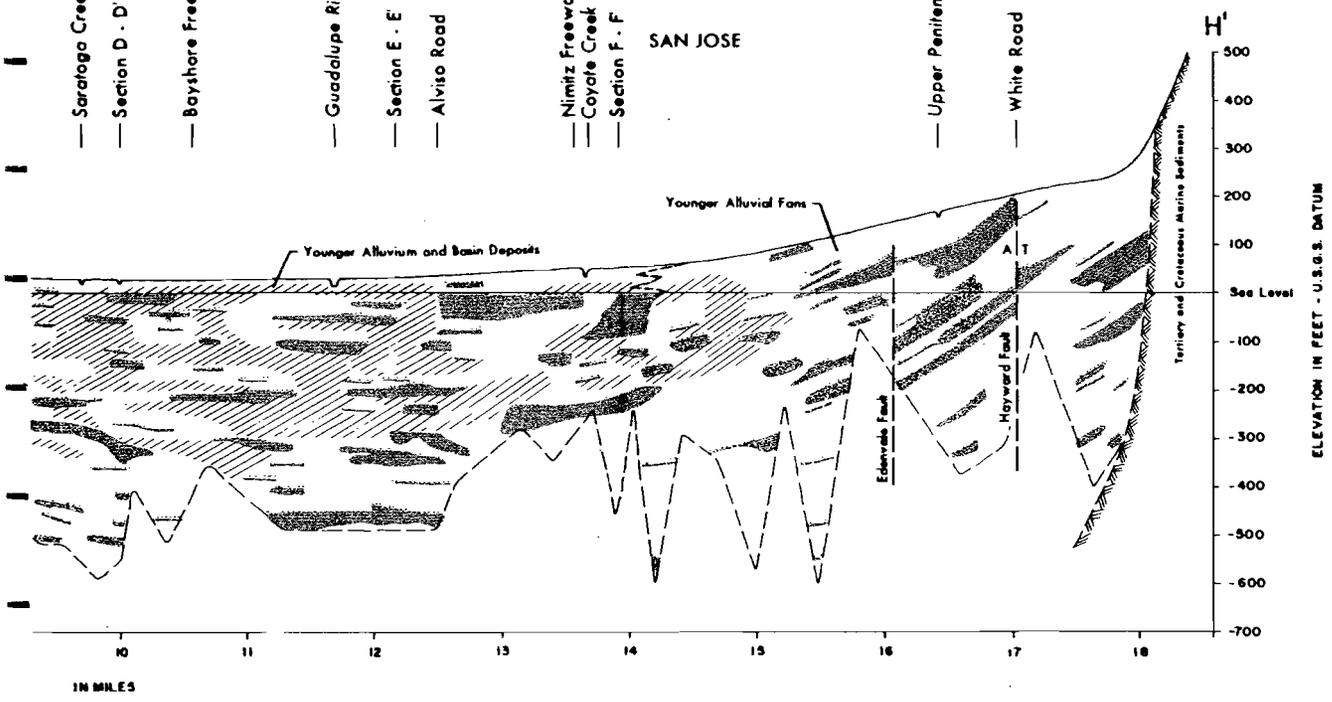
See Sheet I for location of section

SANTA CLARA

- Saratoga Creek
- Section D - D'
- Bayshore Freeway
- Guadalupe River
- Section E - E'
- Alviso Road
- Nimitz Freeway
- Coyote Creek
- Section F - F'

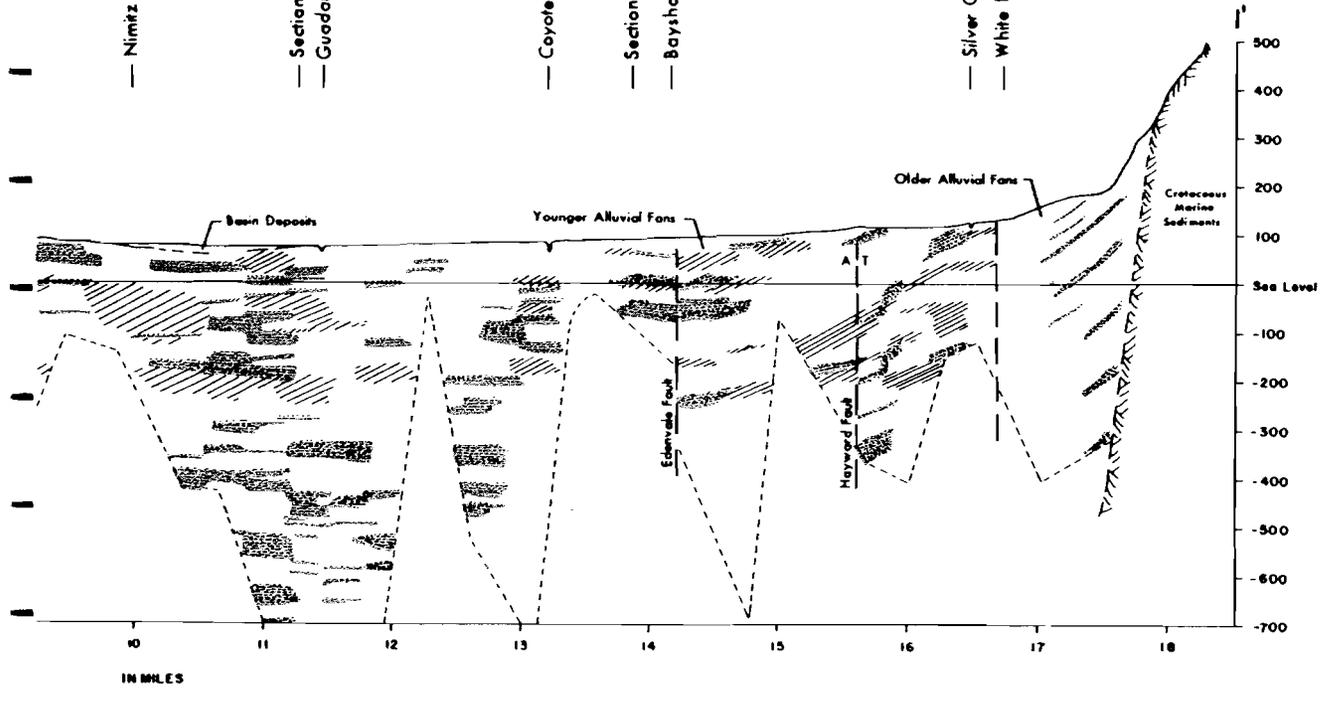
SAN JOSE

- Upper Penitencia Creek
- White Road

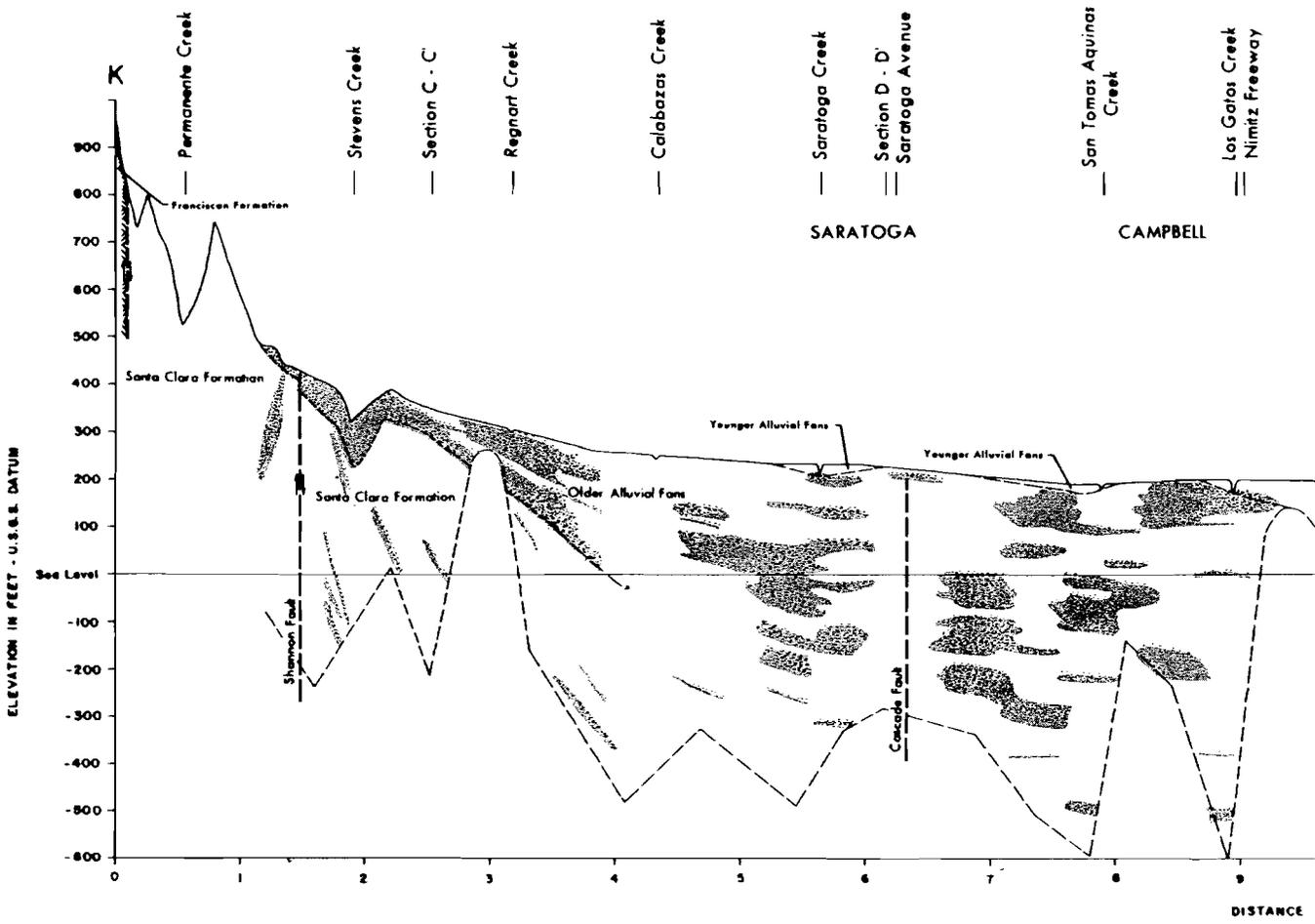
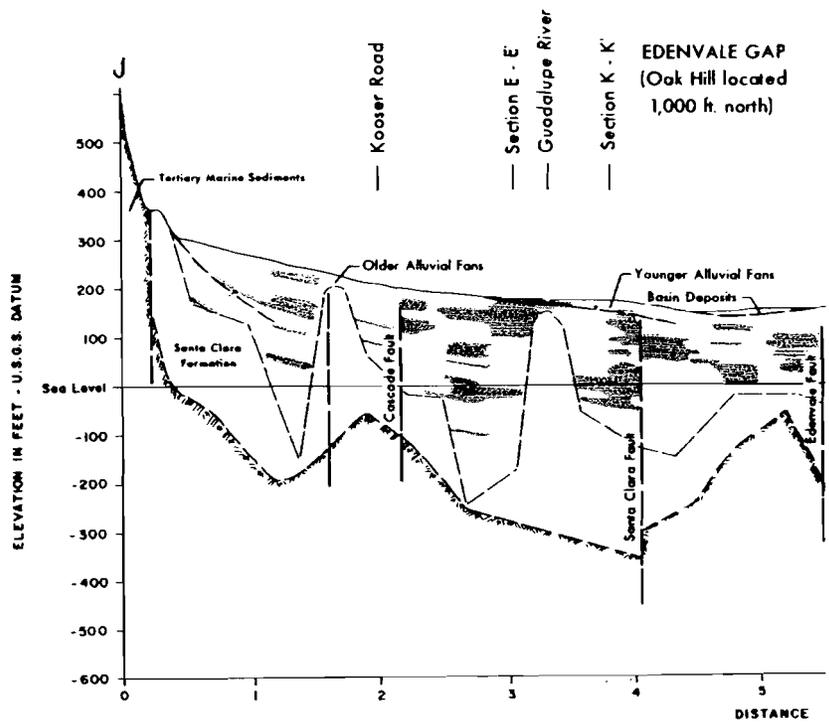


SAN JOSE

- Nimitz Freeway
- Section E - E'
- Guadalupe River
- Coyote Creek
- Section F - F'
- Bayshore Freeway
- Silver Creek
- White Road

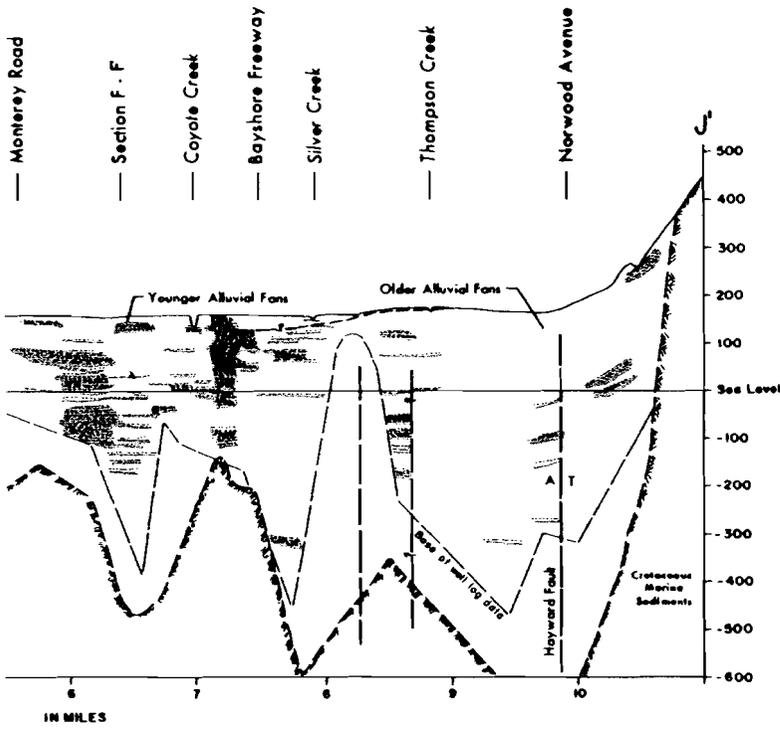


SANTA CLARA VALLEY



GEOLOGIC SECTIONS

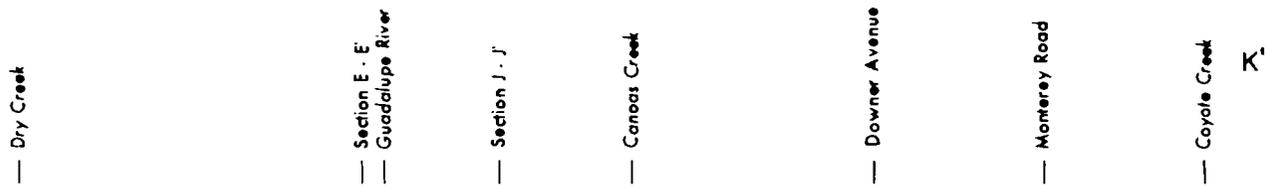
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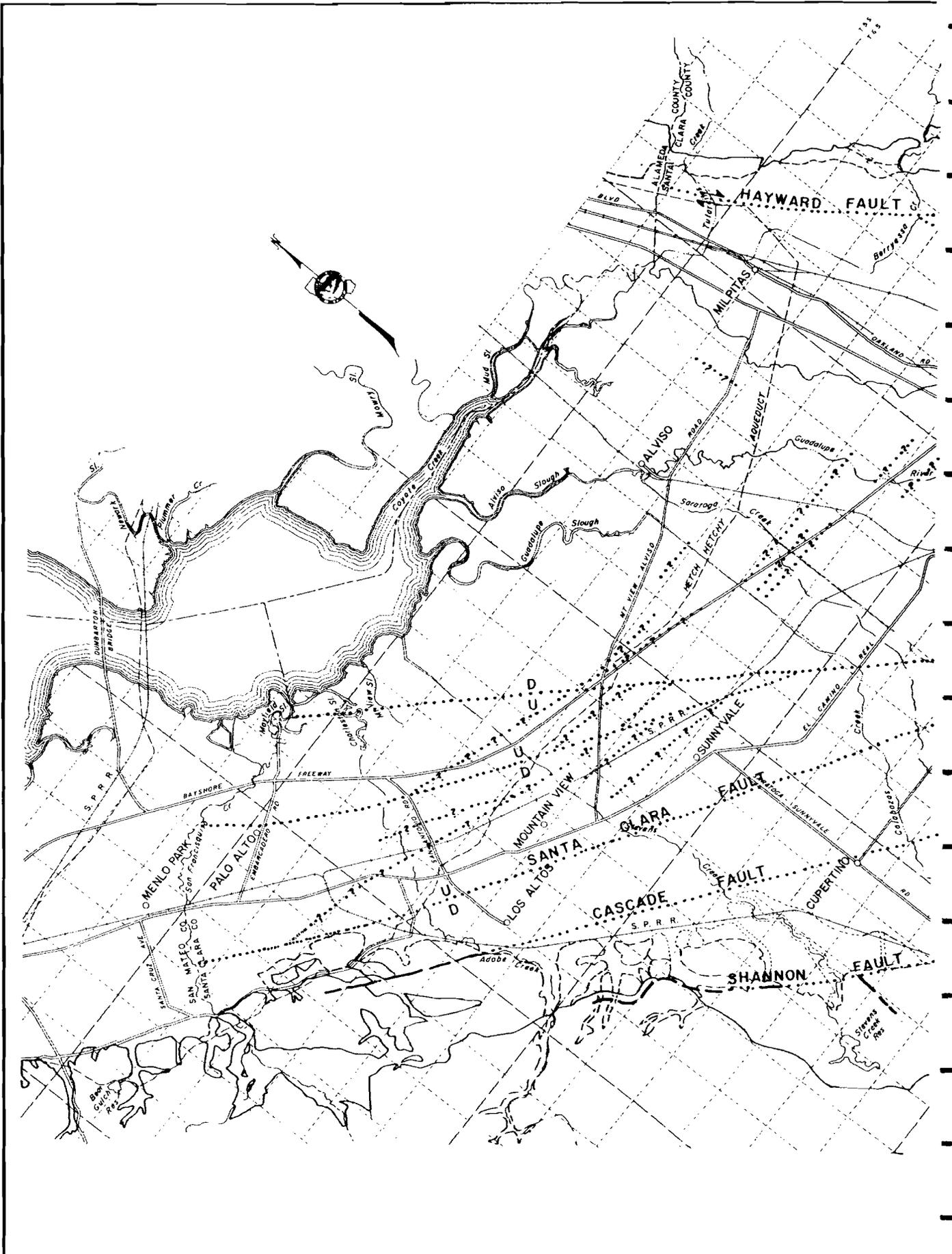
LEGEND

CHANNEL DEPOSITS Sand and gravel deposited by meandering streams; act as aquifers.

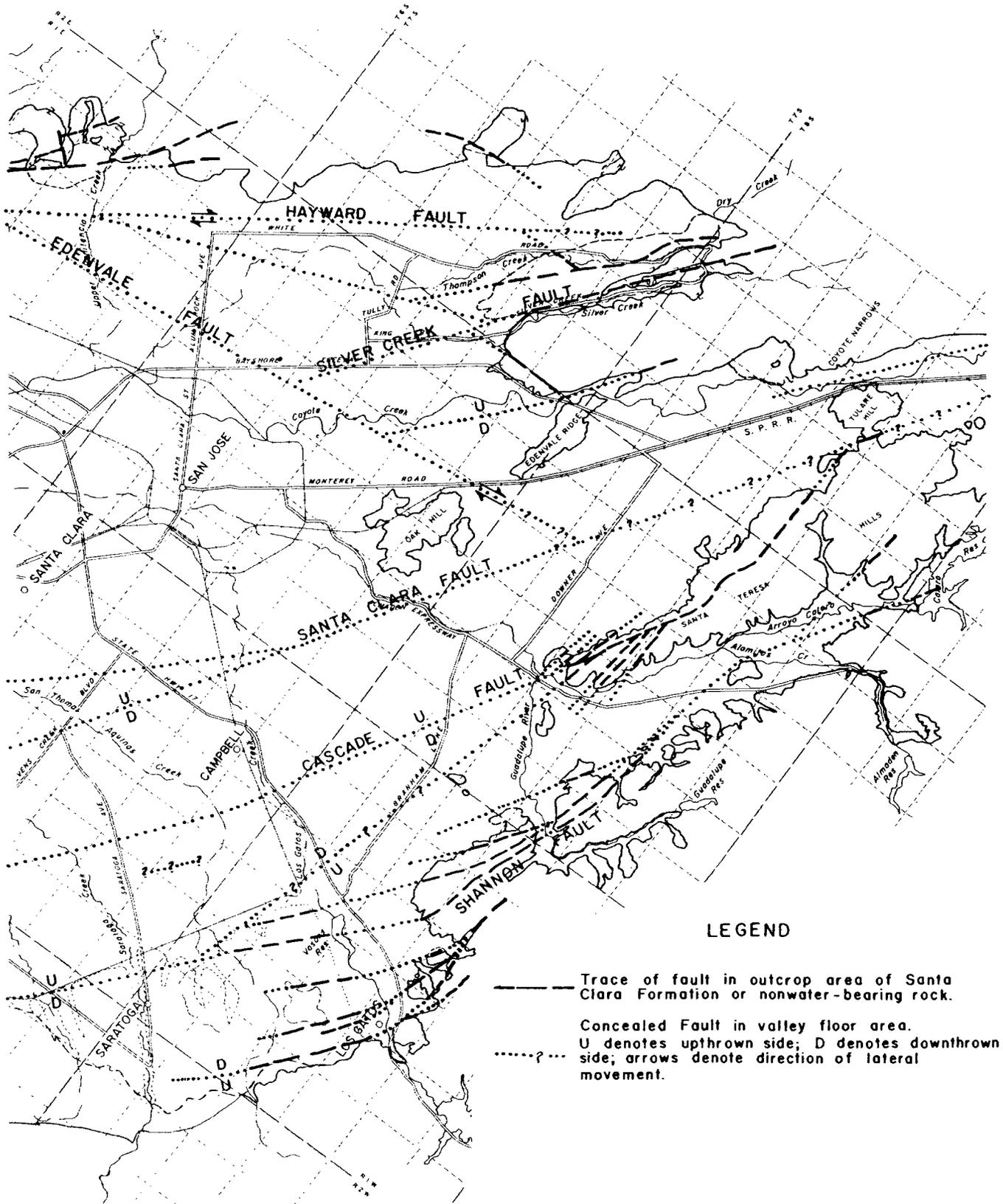
OXIDIZED CLAY Yellow and brown clay formed during periods of continental deposition



SANTA CLARA VALLEY



FAULT TRACES IN



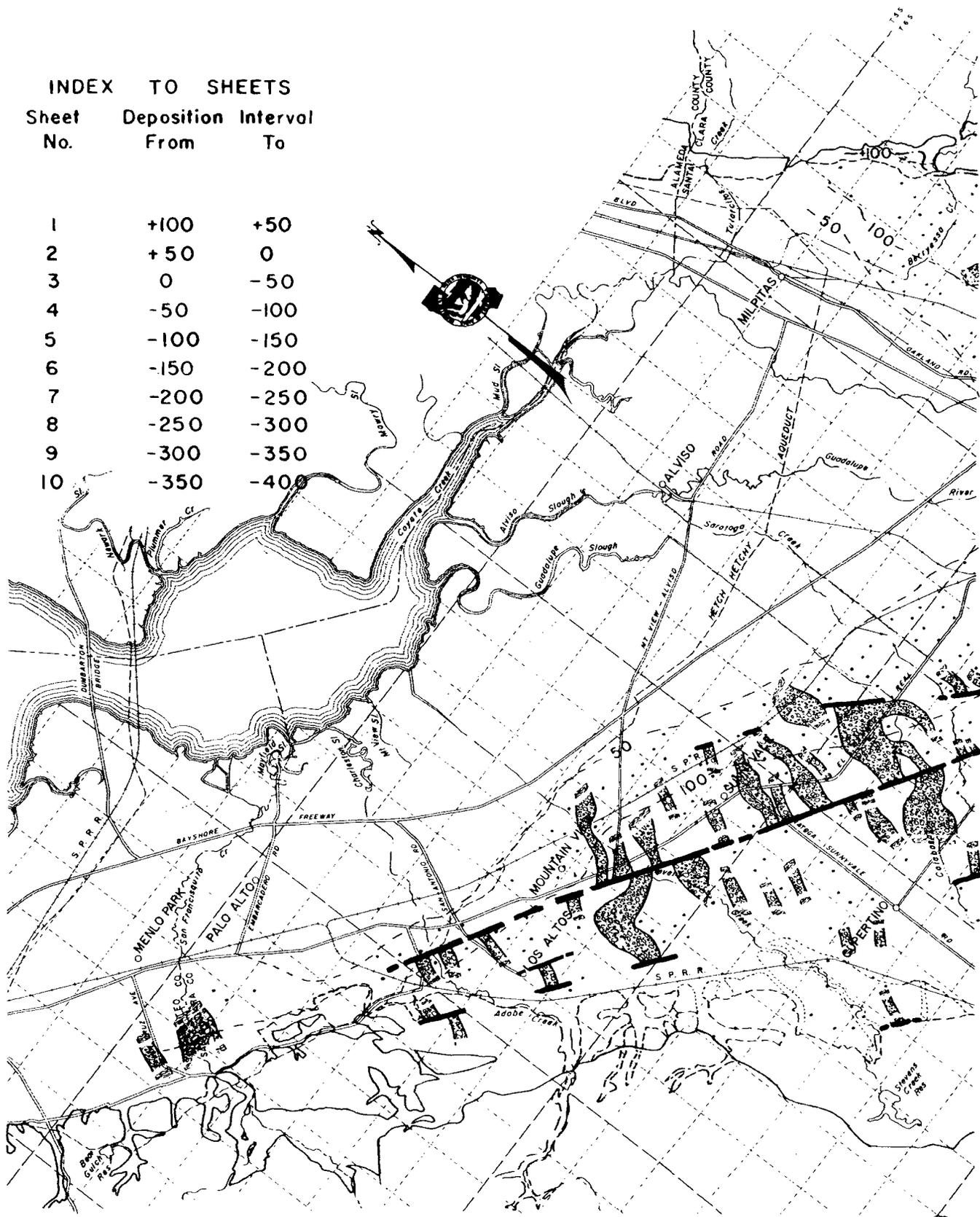
LEGEND

- Trace of fault in outcrop area of Santa Clara Formation or nonwater-bearing rock.
- Concealed Fault in valley floor area.
- U denotes upthrown side; D denotes downthrown side; arrows denote direction of lateral movement.

SANTA CLARA VALLEY

INDEX TO SHEETS
 Sheet No. Deposition Interval
 From To

1	+100	+50
2	+50	0
3	0	-50
4	-50	-100
5	-100	-150
6	-150	-200
7	-200	-250
8	-250	-300
9	-300	-350
10	-350	-400



ELEVATION + 100

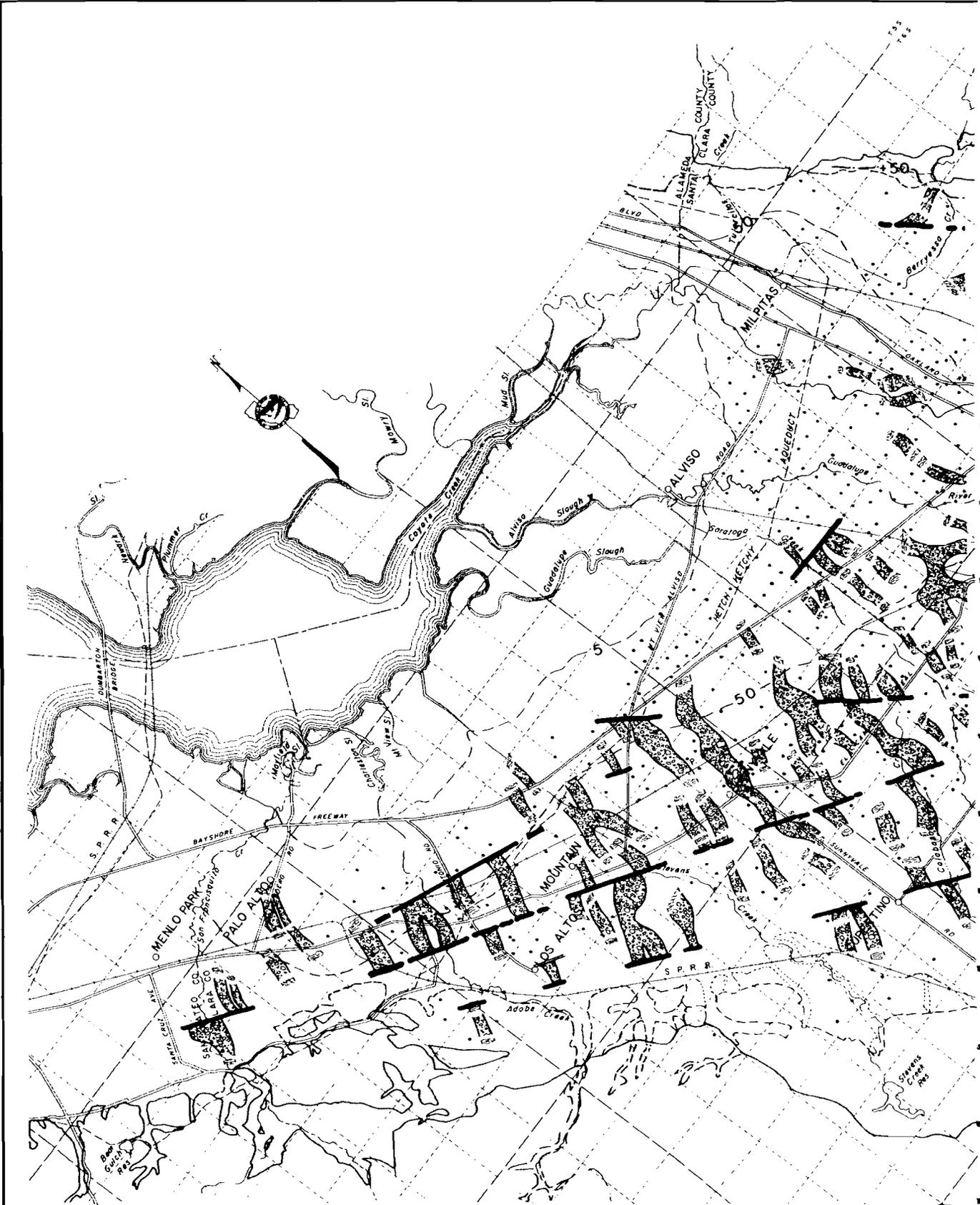
SUBSURFACE DEPOSITION



- LEGEND**
-  Stream channel materials
 -  Well intercepting predominantly clayey materials for given elevation interval.
 -  Trace of fault
 -  -200- Bedrock contour showing elevation. Indicates edge of ground water basin for elevation indicated
 -  -100- Ground surface elevation contour

TO +50 FEET

SANTA CLARA VALLEY



ELEVATION +50

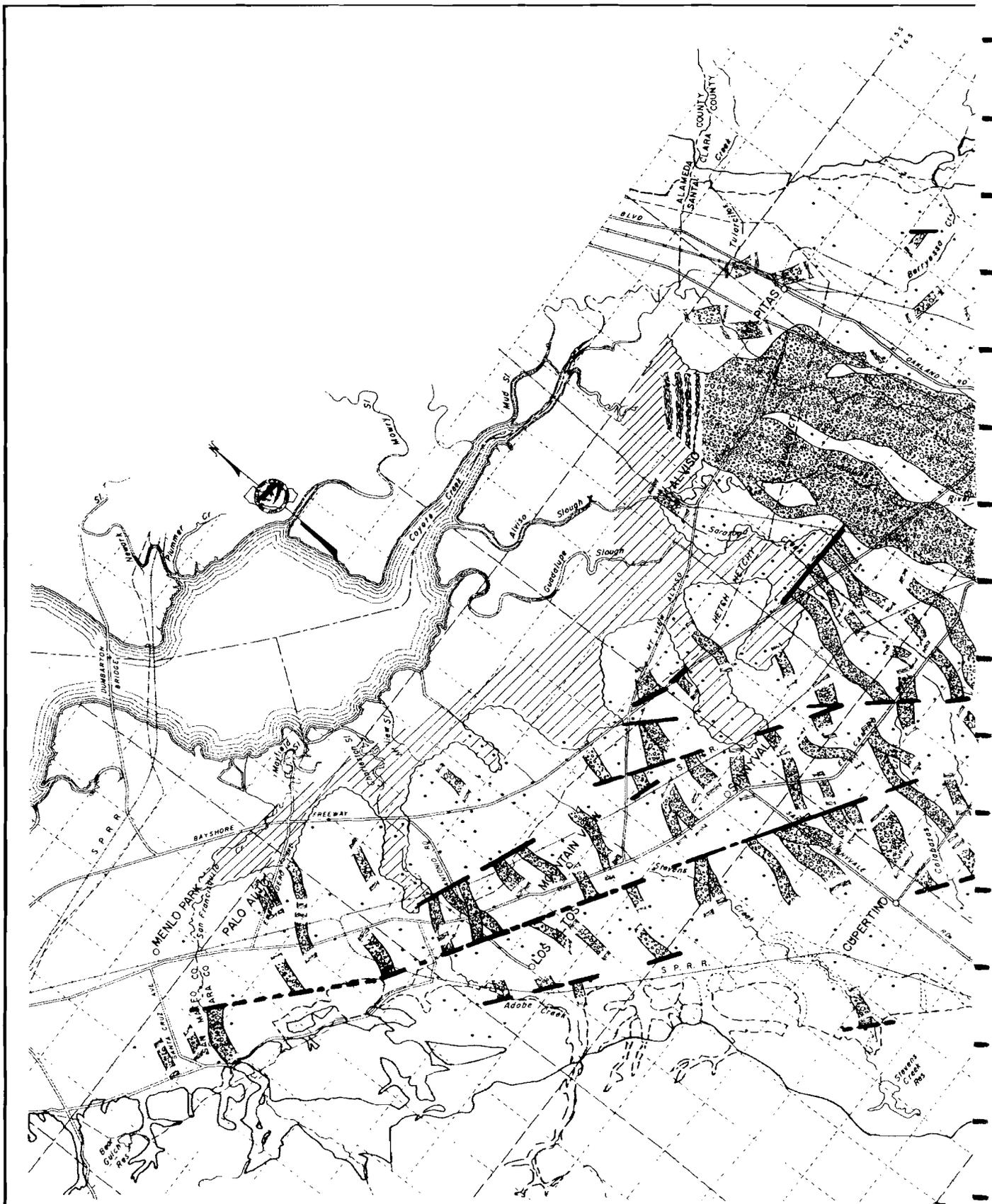
SUBSURFACE DEPOSITION



- LEGEND**
-  Stream channel materials
 -  Well intercepting predominantly clayey materials for given elevation interval.
 -  Trace of fault
 -  200 Bedrock contour showing elevation. Indicates edge of ground water basin for elevation indicated
 -  100 Ground surface elevation contour

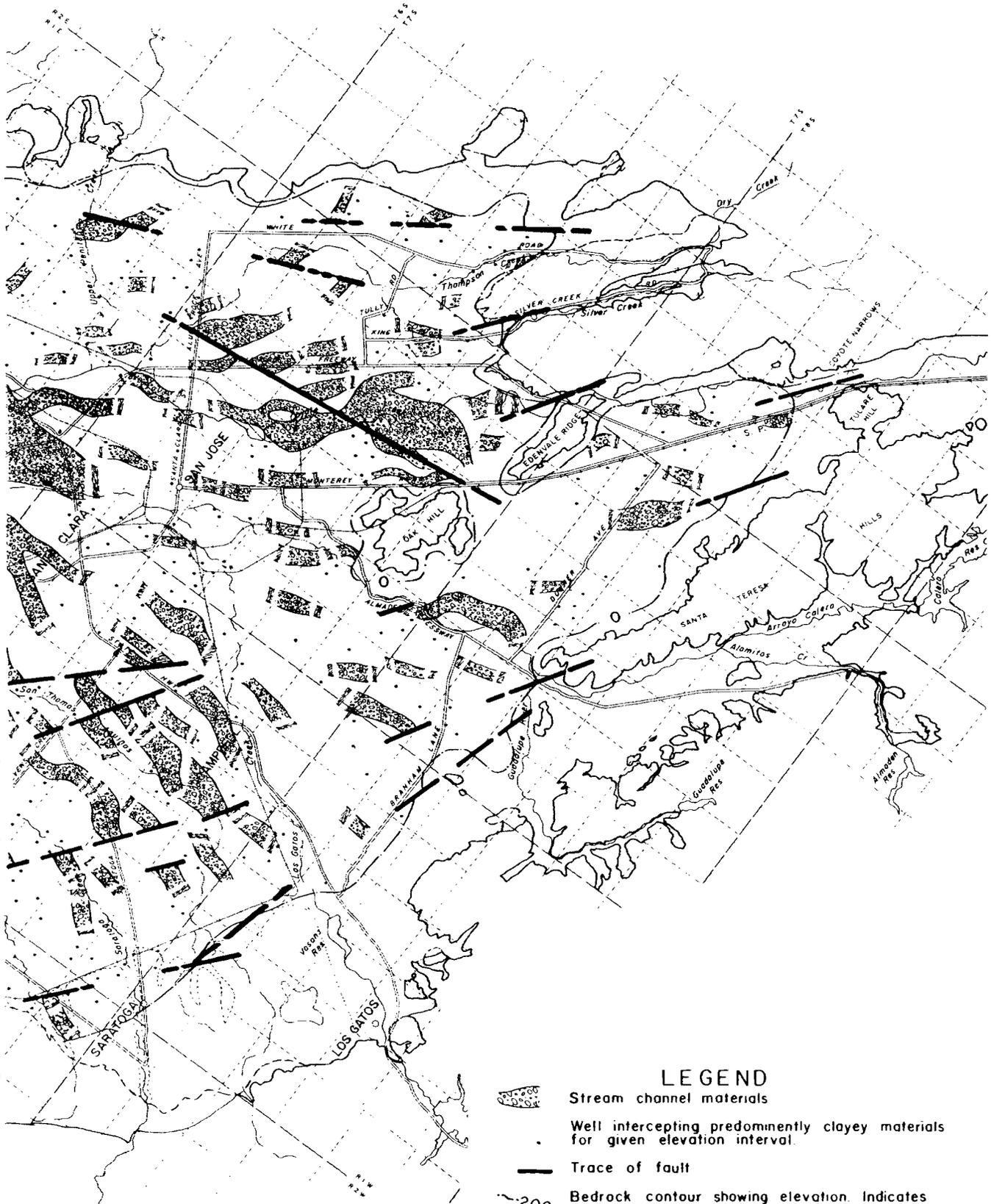
TO 0 FEET

SANTA CLARA VALLEY



ELEVATION 0

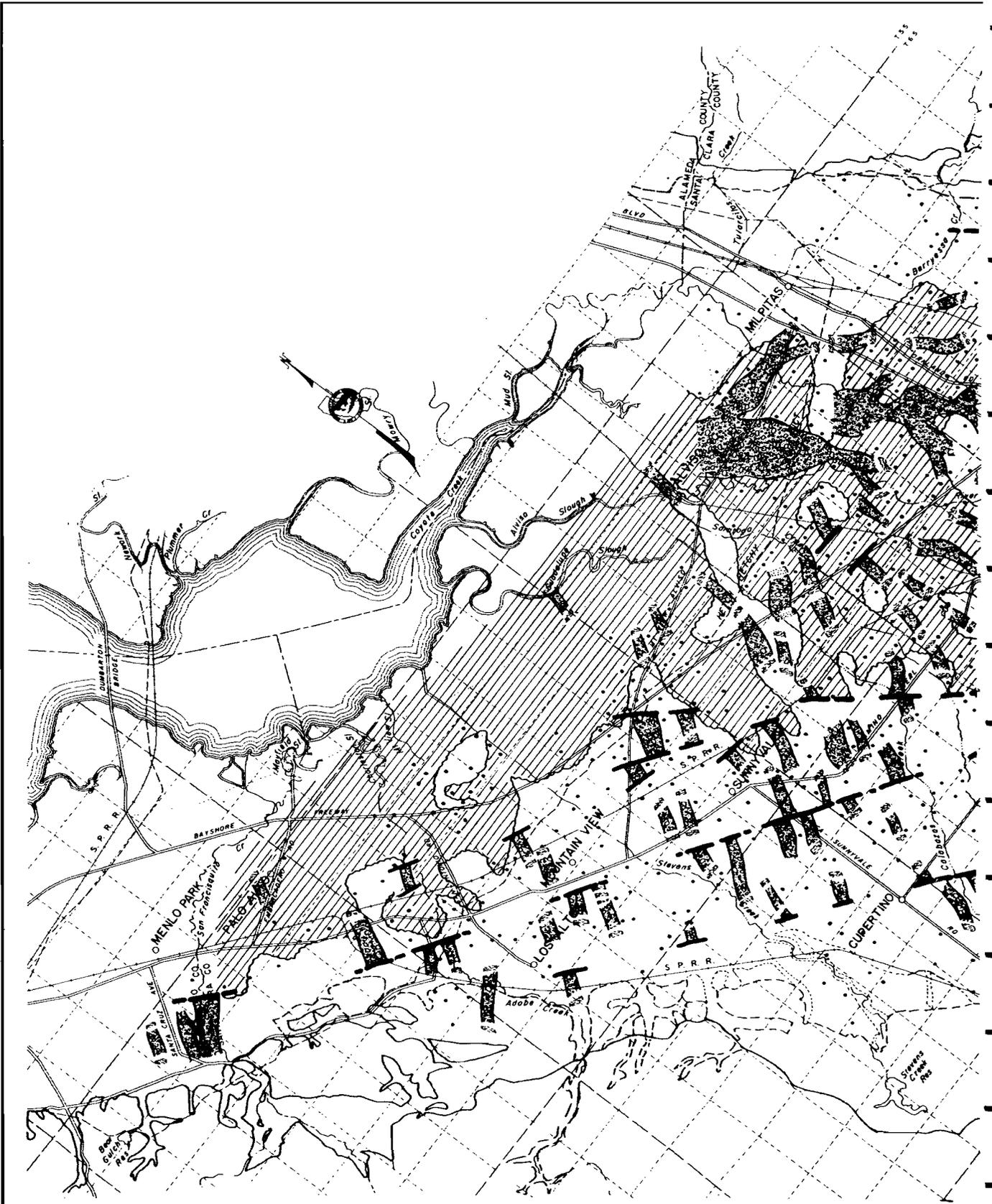
SUBSURFACE DEPOSITION



- LEGEND**
-  Stream channel materials
 -  Well intercepting predominantly clayey materials for given elevation interval
 -  Trace of fault
 -  Bedrock contour showing elevation. Indicates edge of ground water basin for elevation indicated
 -  Reduced (marine) clay. Non-shaded area is oxidized (terrestrial) clay.

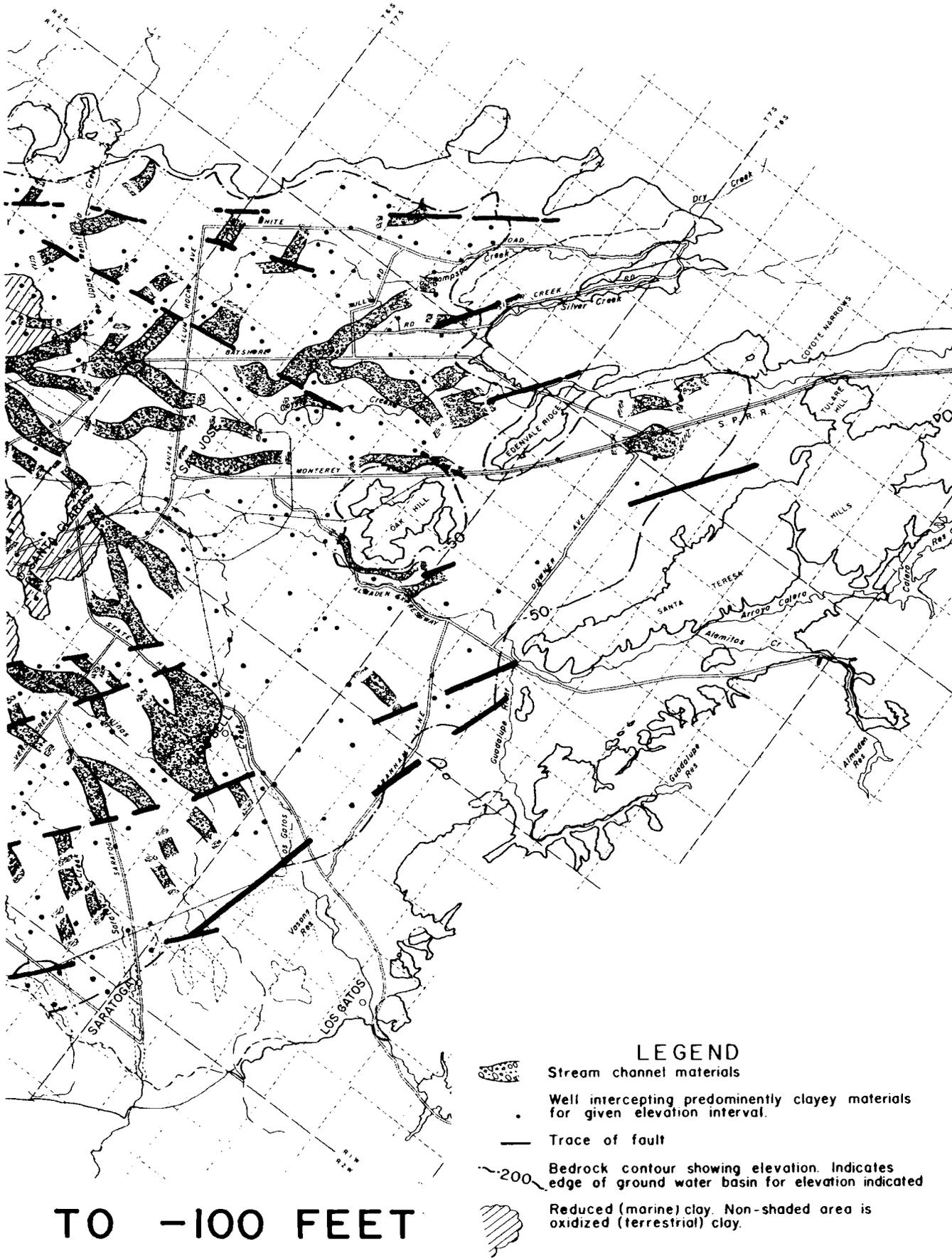
TO -50 FEET

SANTA CLARA VALLEY



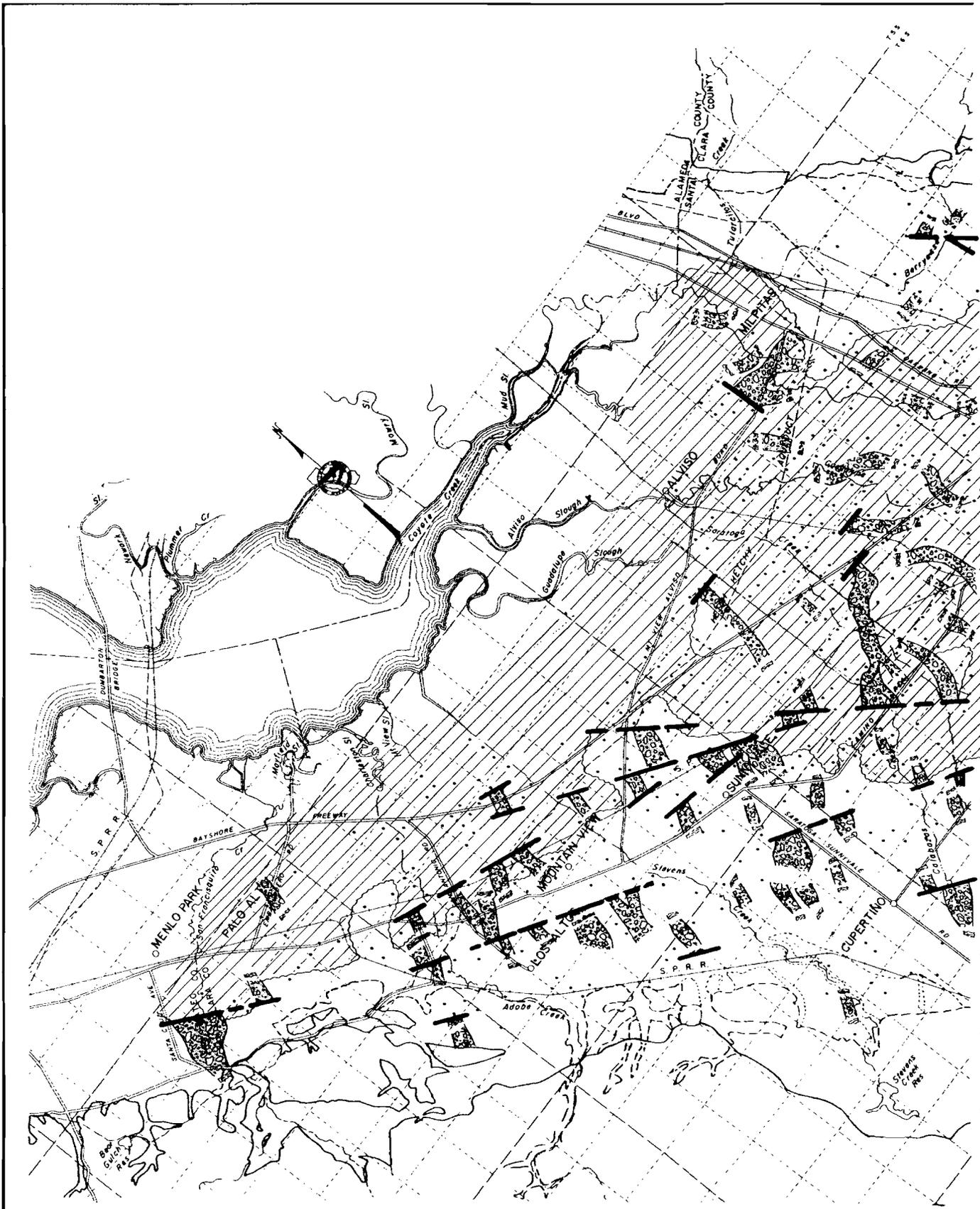
ELEVATION -50

SUBSURFACE DEPOSITION



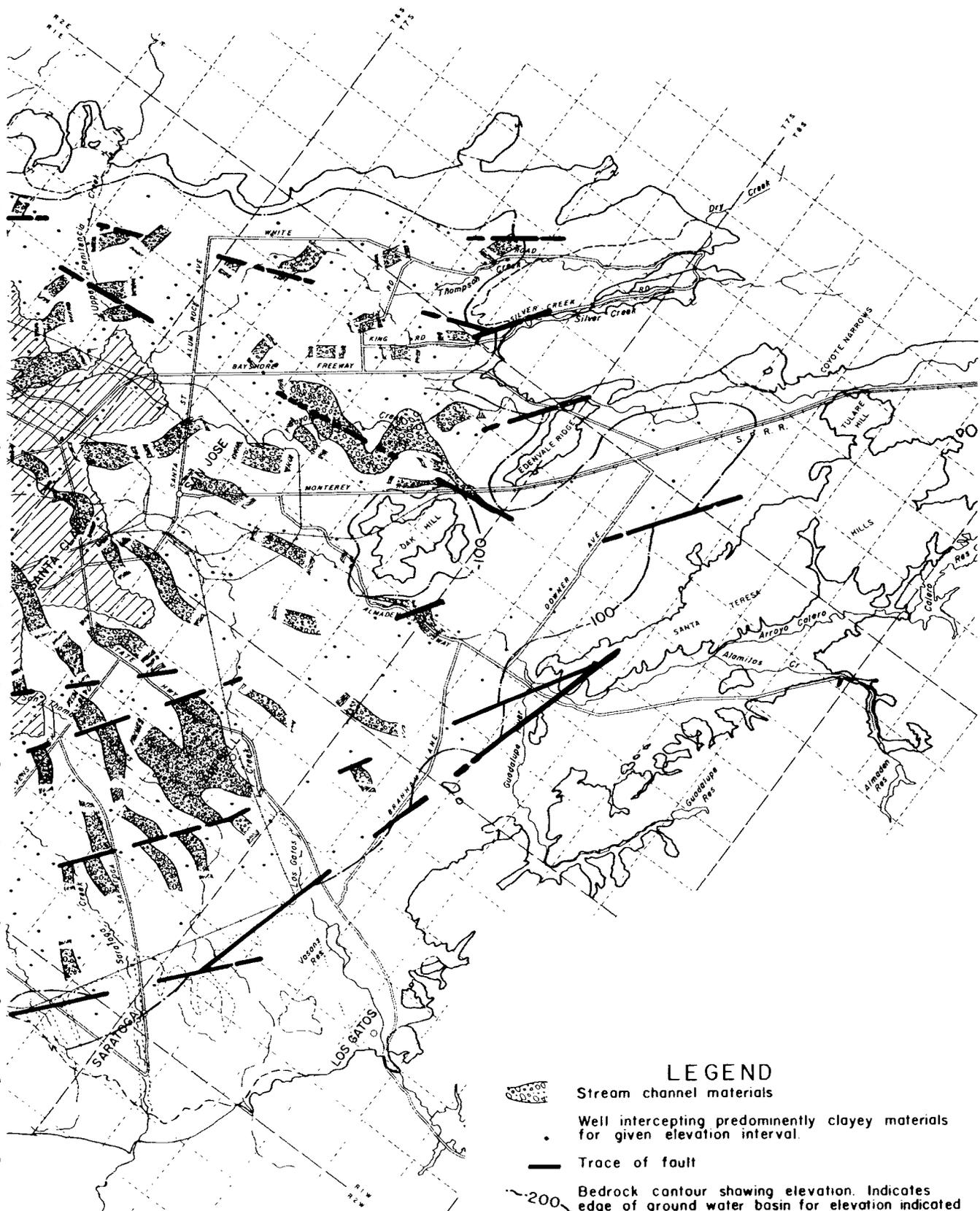
TO -100 FEET

SANTA CLARA VALLEY



ELEVATION -100

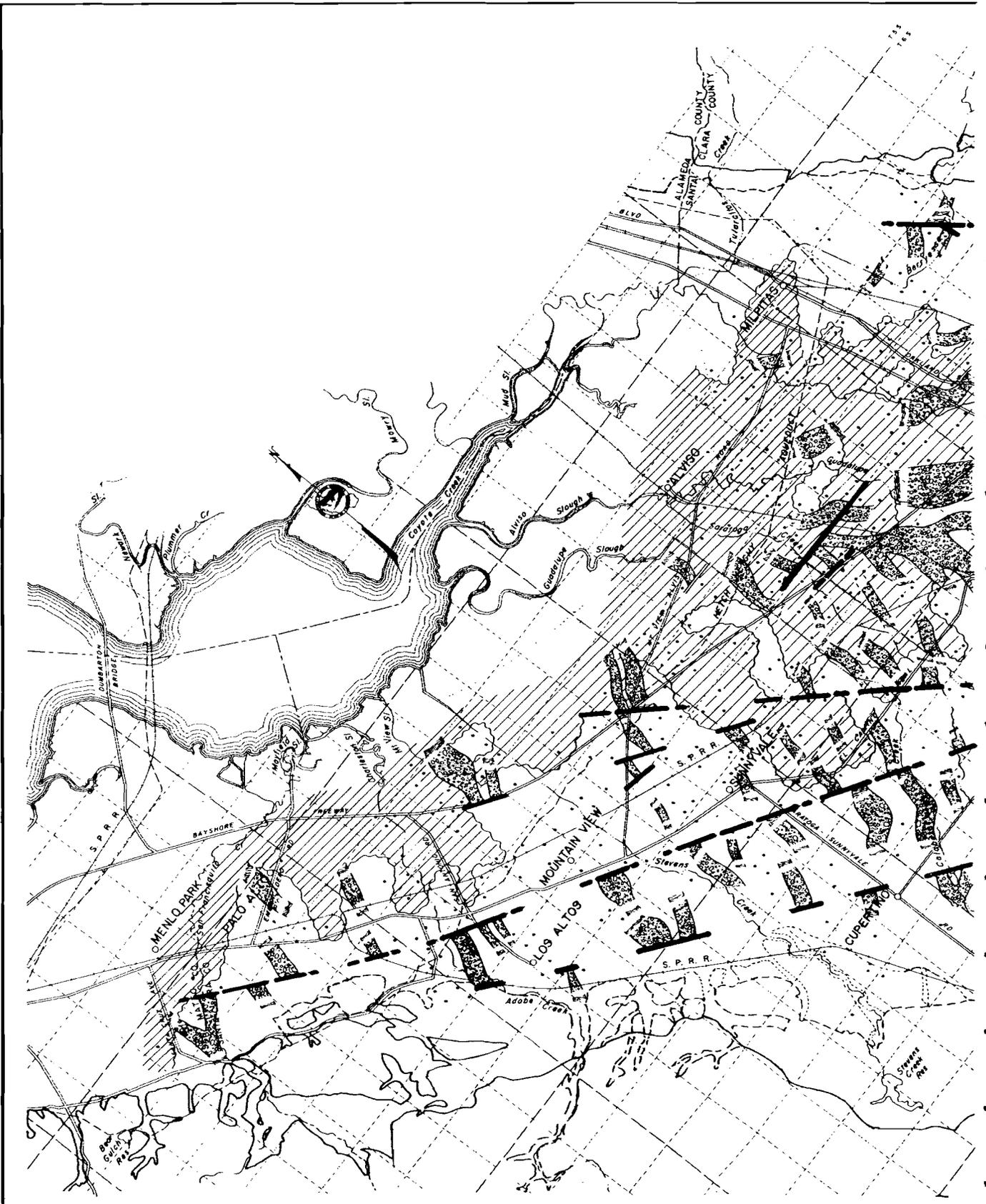
SUBSURFACE DEPOSITION



- LEGEND**
-  Stream channel materials
 -  Well intercepting predominantly clayey materials for given elevation interval.
 -  Trace of fault
 -  Bedrock contour showing elevation. Indicates edge of ground water basin for elevation indicated
 -  Reduced (marine) clay. Non-shaded area is oxidized (terrestrial) clay.

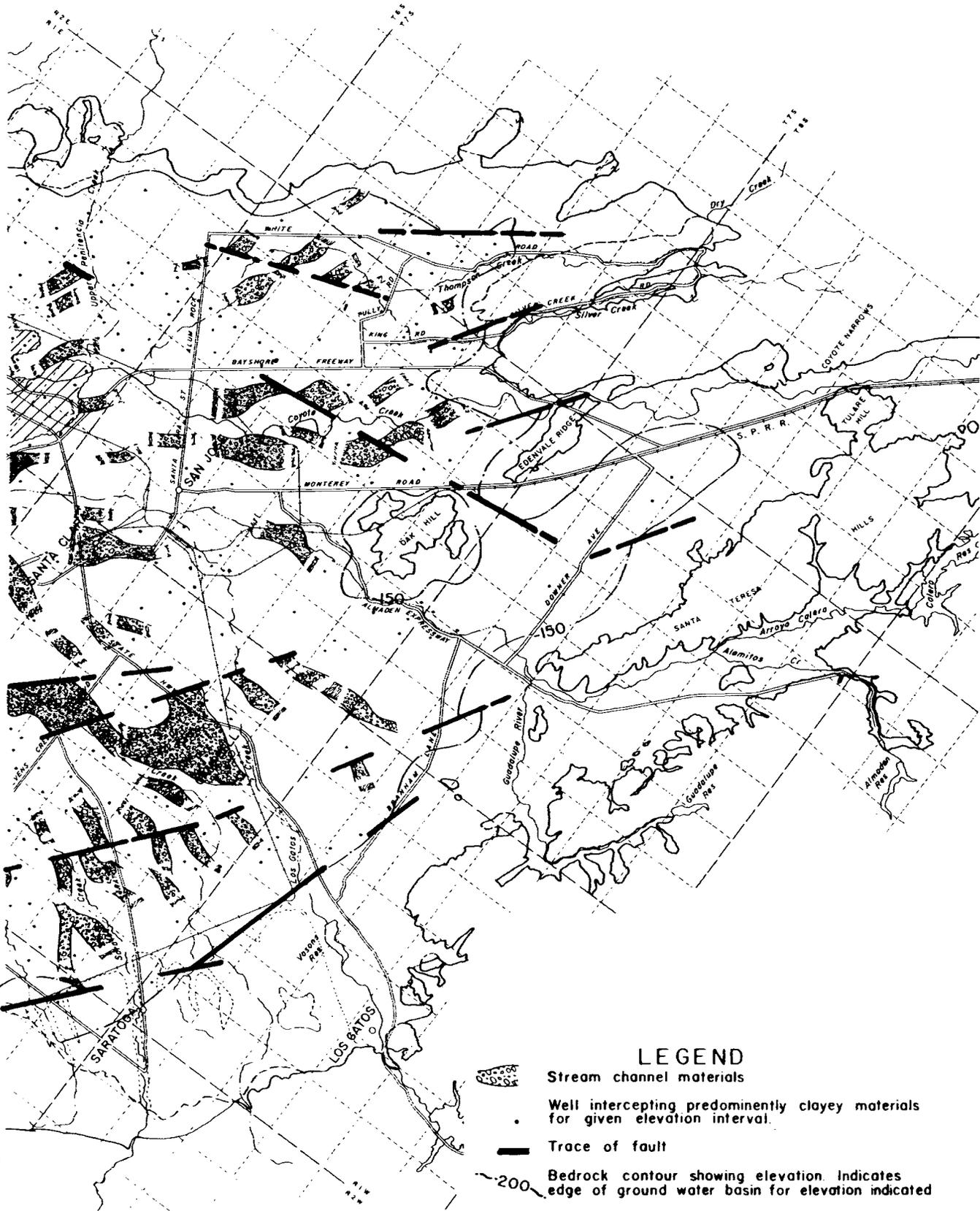
TO -150 FEET

SANTA CLARA VALLEY



ELEVATION -150

SUBSURFACE DEPOSITION

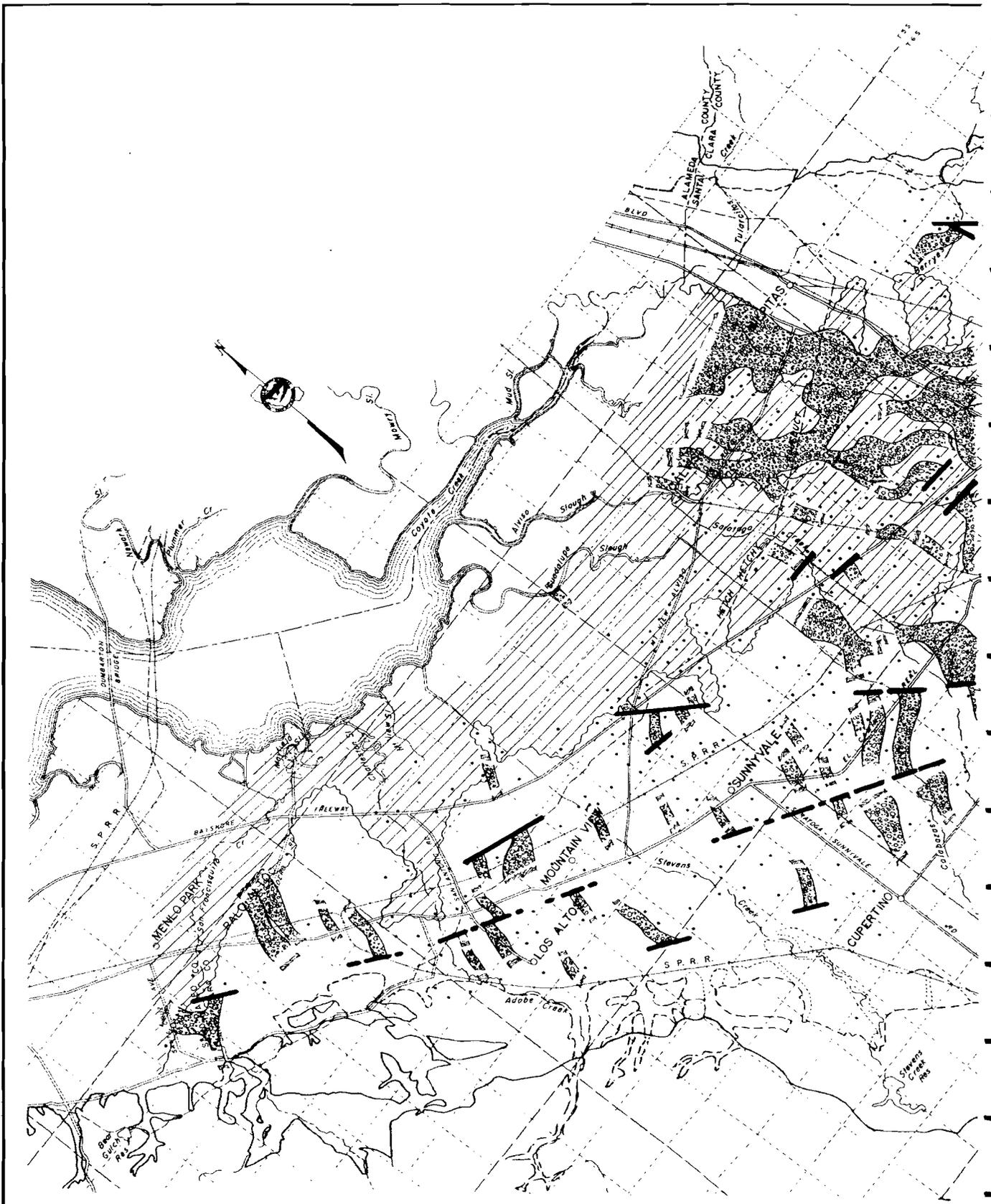


LEGEND

-  Stream channel materials
-  Well intercepting predominantly clayey materials for given elevation interval.
-  Trace of fault
-  Bedrock contour showing elevation. Indicates edge of ground water basin for elevation indicated
-  Reduced (marine) clay. Non-shaded area is oxidized (terrestrial) clay.

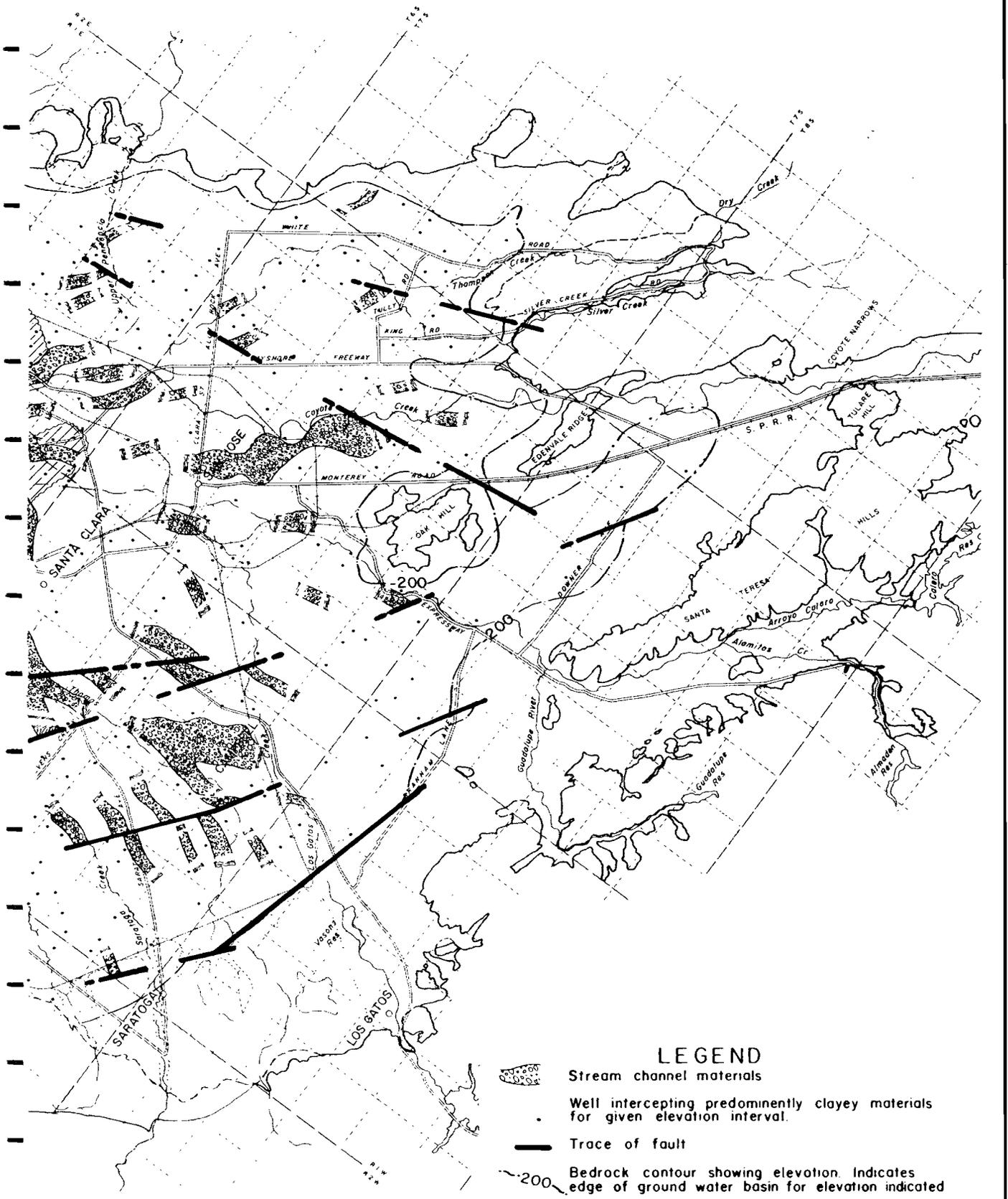
TO -200 FEET

SANTA CLARA VALLEY



ELEVATION -200

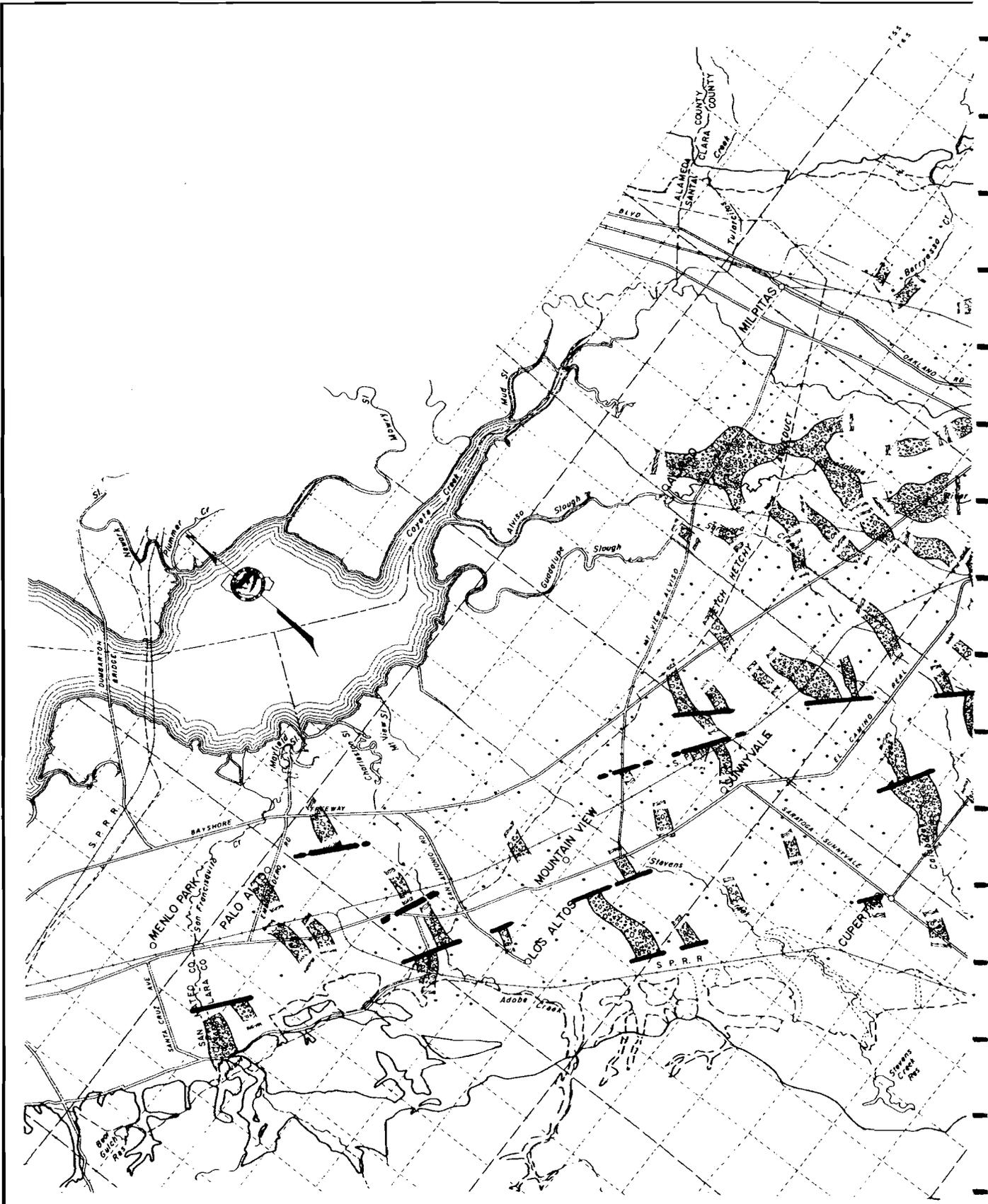
SUBSURFACE DEPOSITION



- LEGEND**
-  Stream channel materials
 -  Well intercepting predominantly clayey materials for given elevation interval.
 -  Trace of fault
 -  Bedrock contour showing elevation. Indicates edge of ground water basin for elevation indicated
 -  Reduced (marine) clay. Non-shaded area is oxidized (terrestrial) clay.

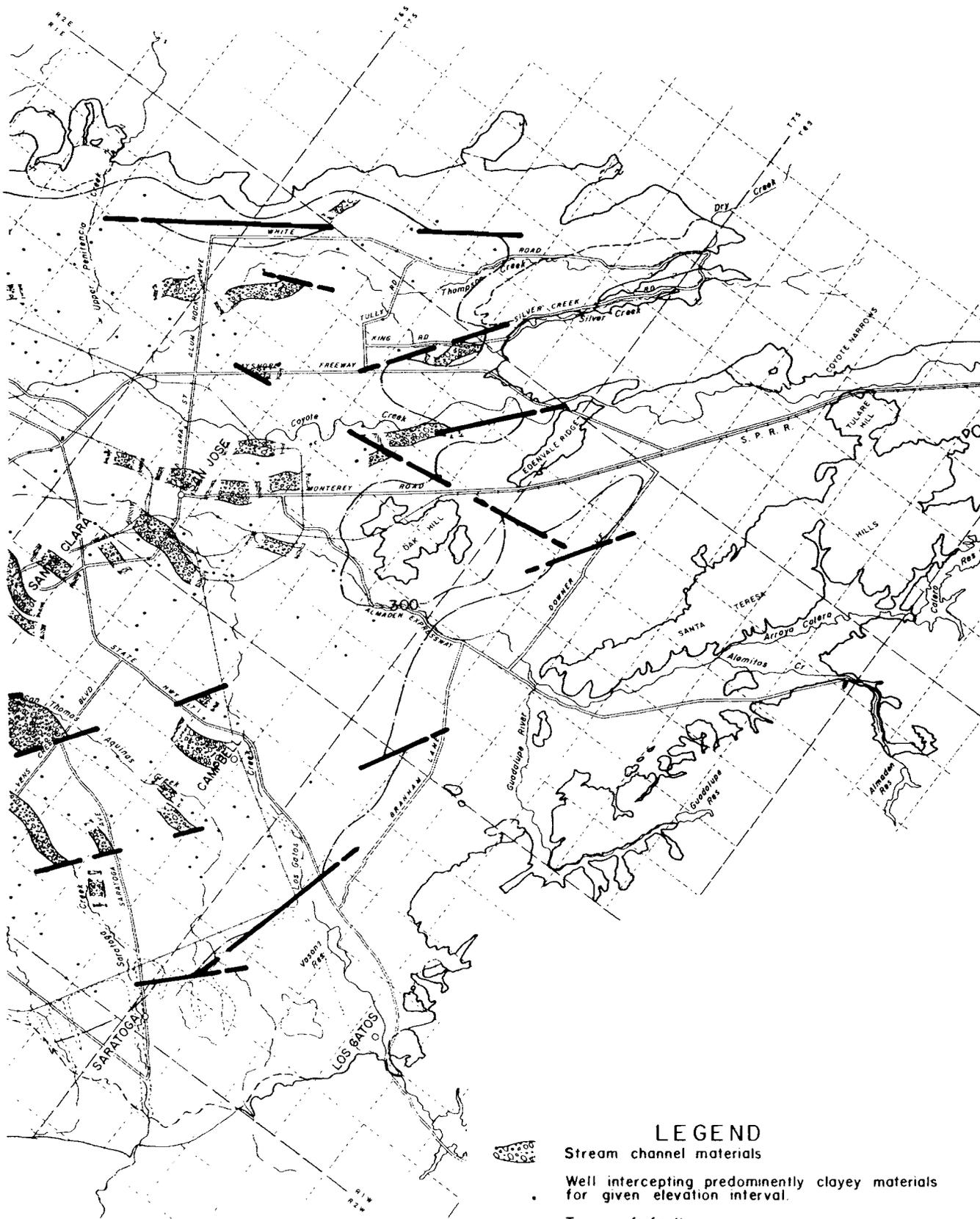
TO -250 FEET

SANTA CLARA VALLEY



ELEVATION -300

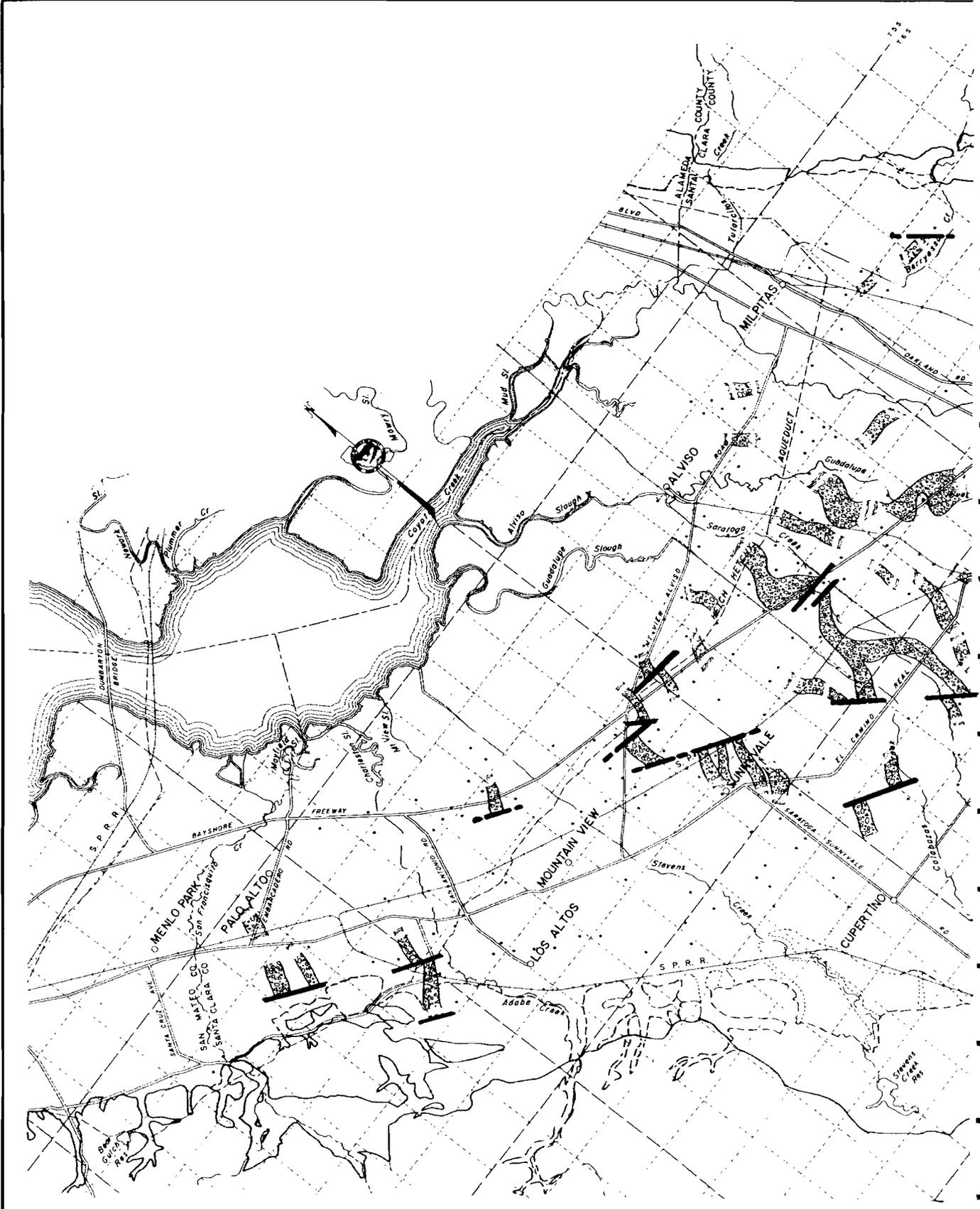
SUBSURFACE DEPOSITION



TO -350 FEET

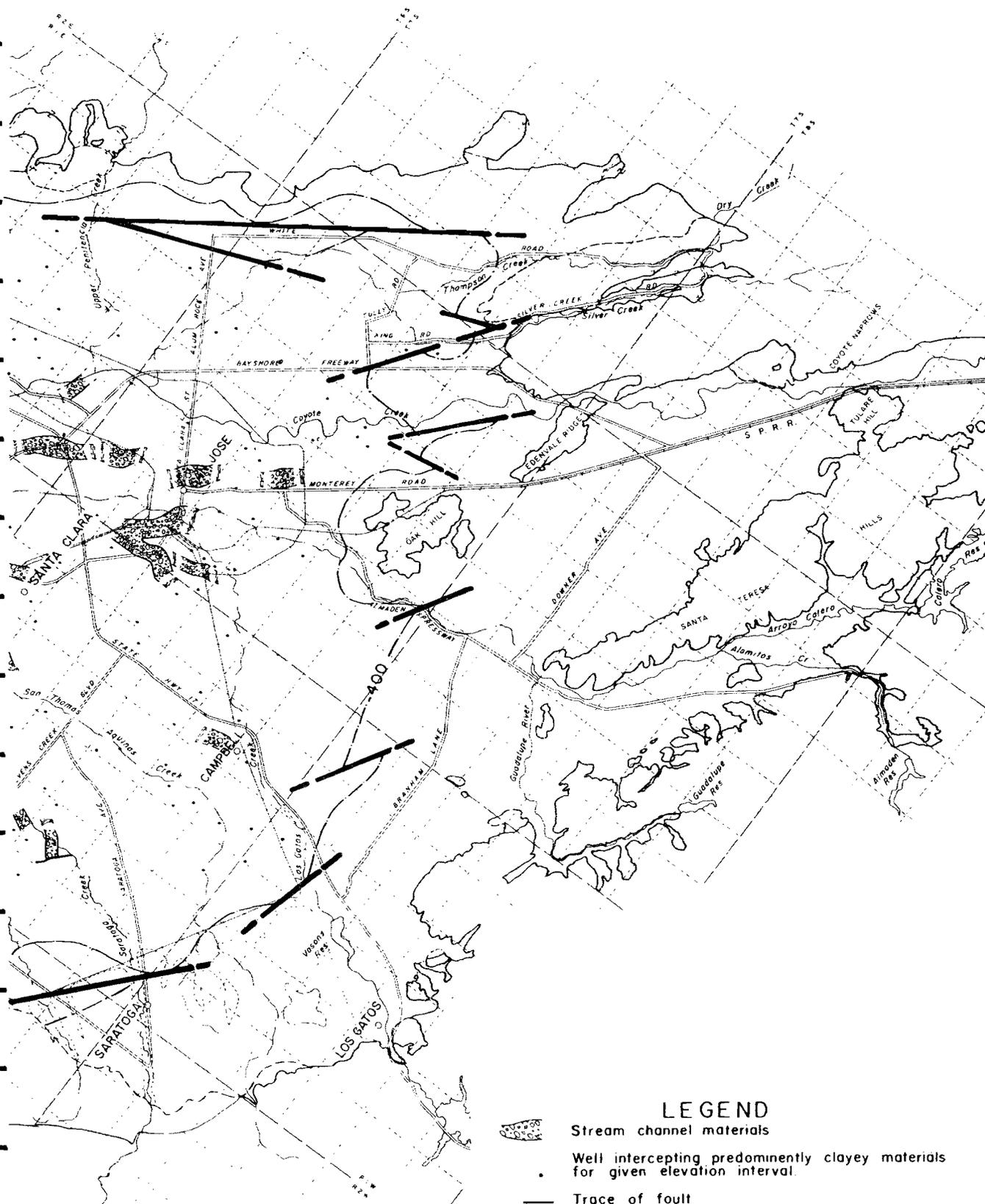
- LEGEND**
-  Stream channel materials
 -  Well intercepting predominantly clayey materials for given elevation interval.
 -  Trace of fault
 -  Bedrock contour showing elevation. Indicates edge of ground water basin for elevation indicated

SANTA CLARA VALLEY



ELEVATION -400

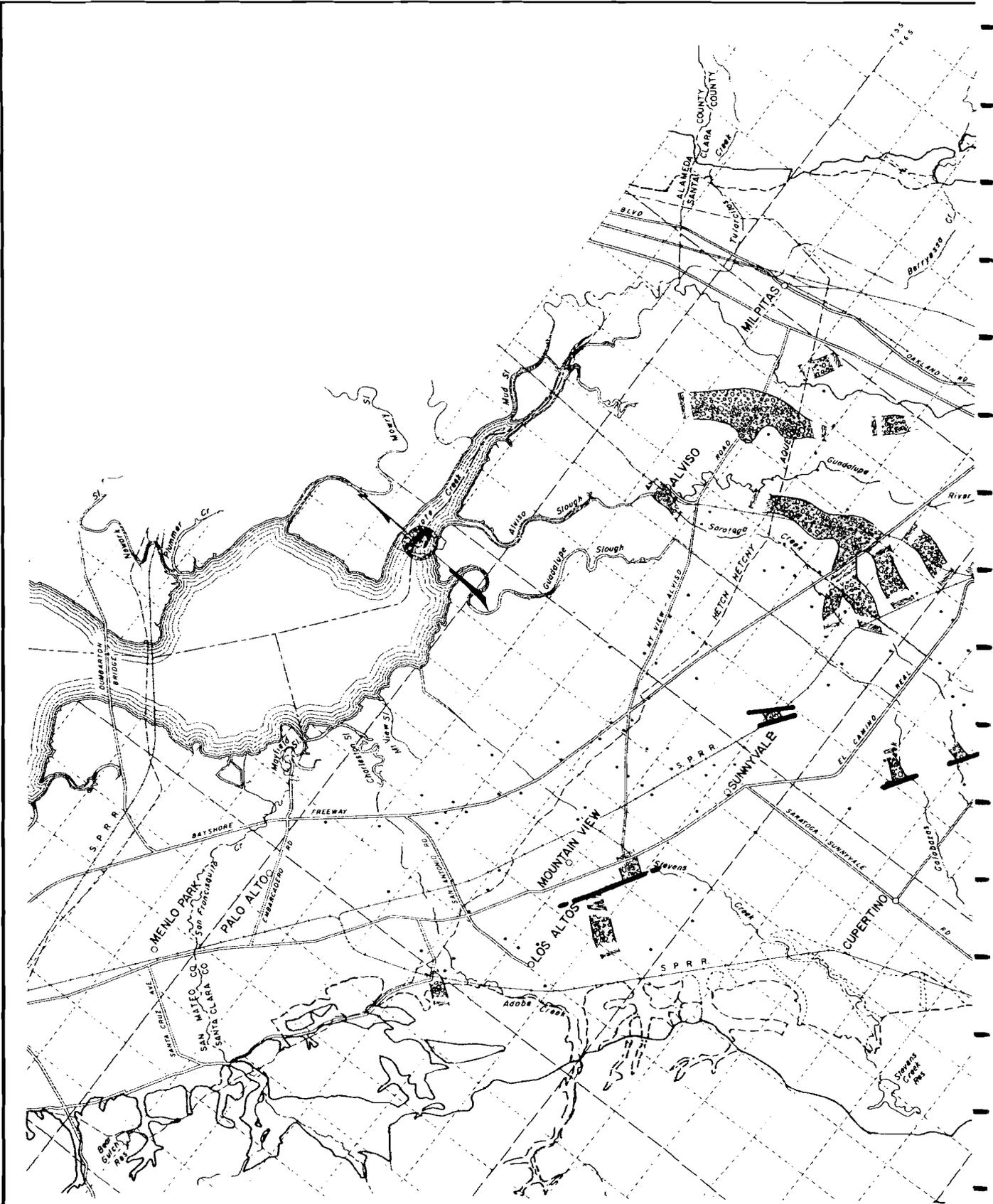
SUBSURFACE DEPOSITION



- LEGEND**
-  Stream channel materials
 -  Well intercepting predominantly clayey materials for given elevation interval.
 -  Trace of fault
 -  Bedrock contour showing elevation. Indicates edge of ground water basin for elevation indicated

TO -450 FEET

SANTA CLARA VALLEY



ELEVATION -500'

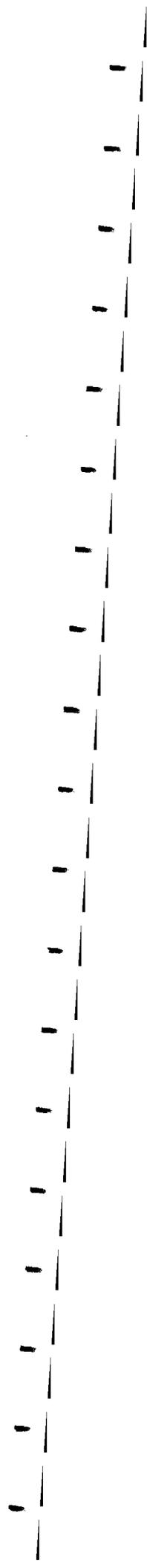
SUBSURFACE DEPOSITION



- LEGEND**
-  Stream channel materials
 -  Well intercepting predominantly clayey materials for given elevation interval.
 -  Trace of fault
 -  Bedrock contour showing elevation. Indicates edge of ground water basin for elevation indicated

TO -550 FEET

SANTA CLARA VALLEY



CHAPTER IV. EVALUATION OF HISTORIC WATER SUPPLY AND DISPOSAL

The evaluation of the ground water system with regard to the acceptance, storage, and transmission of water is obtained by the development of an inventory of supply to and disposal from the ground water body. The ability of the system to store and transmit water under changing conditions can be evaluated by superimposing the works of man on natural hydrologic events such as precipitation, recharge, and consumptive use and then determining the reaction of the ground water system using the previously developed geologic information.

A ground water system can be described as many zones of gravel and sand separated from each other by zones of clay and having some degree of interconnection. This ground water system is only a portion or subsystem of the entire hydrologic system; the interrelationships of each part of the hydrologic system is shown schematically in Figure 6.

An analysis of the ground water system is made by using a specific historic period. The reference, or base, used in the ground water analysis is the amount of ground water in storage. This is derived by making an inventory on an annual basis using the assumption that water which percolates below the root zone will reach the ground water body during the same water year. The analysis is stated by the equation:

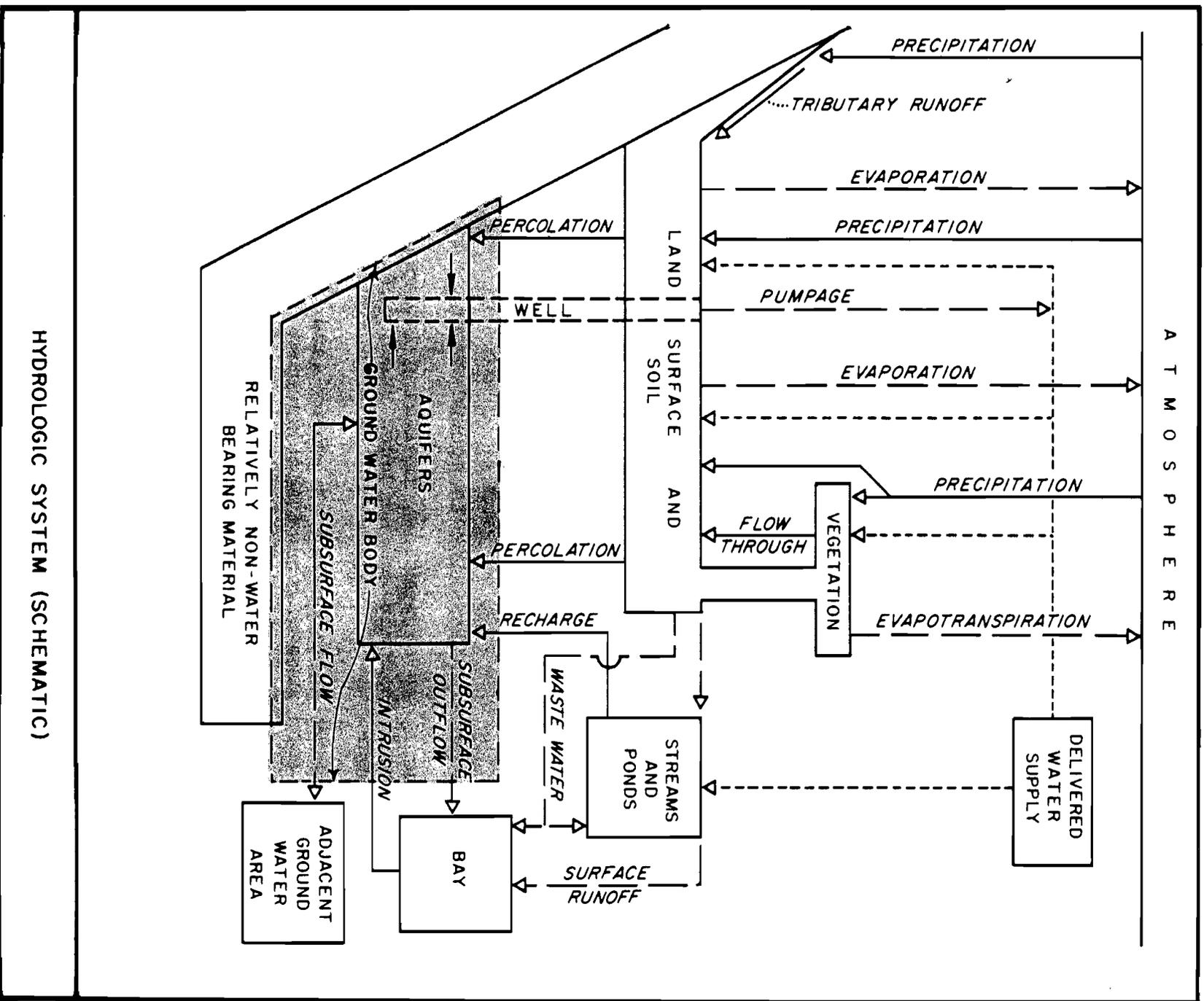
$$\text{Supply} - \text{Withdrawal} = \text{Change in storage}$$

The items of supply, or recharge, to the ground water body are derived mainly from the following:

1. Precipitation infiltrating to ground water.
2. Storm runoff, or streamflow, including imported water released into natural channels and adjacent ponds infiltrating to ground water.
3. Applied water infiltrating to ground water. Applied water includes both pumped ground systems and imported water put directly into water distribution systems.
4. Subsurface inflow from adjacent areas.
5. Water released by compaction of clay beds.

Withdrawals from the ground water body consist of ground water pumpage and subsurface outflow from the basin. From the values for each of the above items, the change in storage is computed as the annual volume of ground water gained or lost from storage. A negative value indicates a depletion of ground water in storage.

FIGURE 6



HYDROLOGIC SYSTEM (SCHEMATIC)

Some of the items in the ground water inventory are directly measurable, some must be calculated, and some were measured for only a part of the study period and calculated for the remainder thereof. Of items that were calculated, most were on a water year basis (October 1 through September 30). The principal exception is ground water pumpage, which was calculated on a calendar year basis. Because each calendar year and water year contain the same summer period, and this period is when the variation in pumpage will occur, use of differing type of years has a minor effect.

The result of the ground water inventory is a theoretical change in the amount of water in storage. The accuracy of the analysis can be gaged by how close the calculated change in storage based on historic water levels compares with the net difference between recharge to and withdrawals from the ground water system.

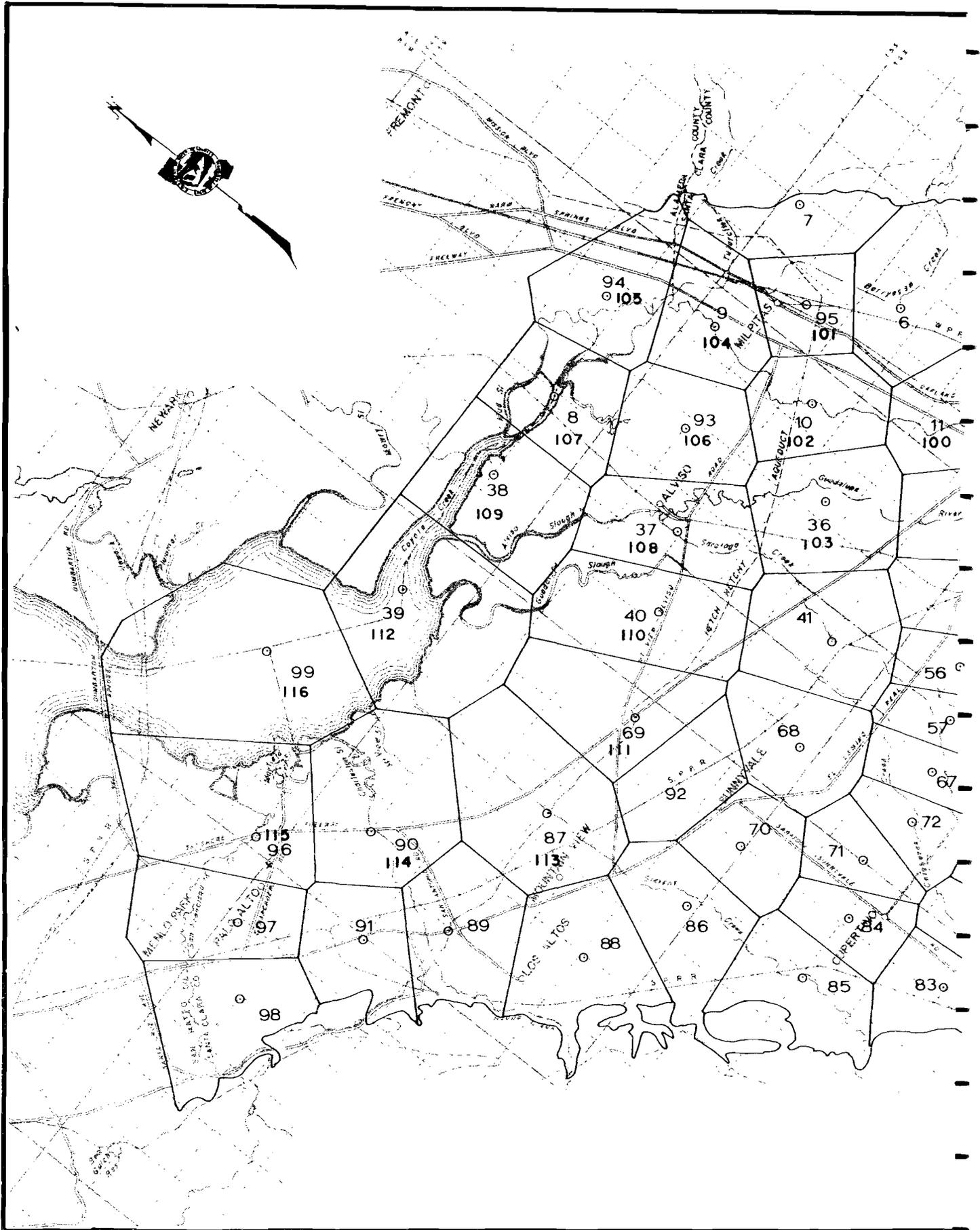
The inventory is done on two bases: the first treats for the basin as a whole; and second subdivides the ground water area into many small units and uses. These units in a mathematical model were prepared to simulate the hydrologic system of the study area and to provide a means for testing the reaction of the ground water system to alternative plans. The model was programmed on computers to permit economic solution of repetitious computations.

Ground Water Model

The ground water area shown on Figure 1 has been approximated by the mathematical model shown in Figure 7. In the model configuration, the orientation of the individual nodal areas is based on detailed geologic and hydrologic interpretations. The northern end of the study area is an area of overlap of deposition from Alameda Creek and the various Santa Clara County streams. This condition of overlap has been simulated by using Nodes 8, 38, 39, 94, and 99 of the Santa Clara model in the mathematical model of the adjacent Fremont ground water area. This latter model is discussed in detail in Bulletin 118-1: "Evaluation of Ground Water Resources: South San Francisco Bay: Volume II: Additional Fremont Area Study".

Confinement in the lower portion of the present study area has been simulated by using three layers, two aquifers separated by a confining bed. The areas of lower confinement are shown on Figure 7 by double node numbers; the lower aquifer portions of the nodes are numbered 100 through 116.

The amounts of recharge, withdrawal, and change in storage have been determined for each nodal area in the model. In this bulletin, many of the results have been summarized and reported only for the total ground water area, but detailed nodal information is available in the department files.



MATHEMATICAL MODEL

In northern Santa Clara County, the ground water system consists of many related tabular aquifers. Water wells in the study area usually have been constructed to tap most of the aquifers penetrated. This makes it nearly impossible to determine the amounts of water extracted from particular aquifers and hence makes it necessary to evaluate the series of aquifers as if it were only a single aquifer. The only exception to this is in the area adjacent to the Bay, where the existence of a thick, extensive clay layer permits the series of aquifers to be divided into two distinct zones.

Analysis of water levels for individual wells in the study area indicates that composite water levels for different combinations of aquifers tend to be nearly parallel to each other. This permits the use of most of the available water level data to determine annual changes in water levels for the total aquifer system. It does not, however, permit the identification of those water levels which represent the potentiometric surface of the free (unconfined) ground water. Measurements representing this free ground water surface are not available for the study period in most of the ground water area. Because complete validation of the mathematical model is dependent on matching model-developed water levels against historic free ground water levels, the validity of the present model could not be established at the level of reliability desired for detailed evaluation of alternative plans.

The inability to obtain complete validation of the model is not a serious problem because the validity of the hydrology has been established by the verification of the hydrologic balance for the entire basin. The model can be used as a general planning tool but should be used with care in the evaluation of alternative plans. The historic ground water measurements and proposed changes in the monitoring network are discussed in Chapter V.

Study Period

In selection of a segment of time to use as a study period, it is desirable to specify certain criteria. The hydrologic conditions during the study period should represent the long-time hydrologic conditions. Furthermore, the selected time segment should begin at the end of a dry period and should end at the conclusion of another dry period in order to minimize any difference between the amount of water in transit prior to both the beginning and the end of the study period. The change in water levels from the beginning to the end of the study period should also be minimal in order to avoid the effects of perched water and water in transit. Finally, the time segment should be within the period of available records and should include recent changes in land utilization to aid in the determination of the effect of these changes on the recharge of ground water.

This report uses an eight-year study period, 1962-63 through 1969-70. The year 1962-63 was selected as the initial year because it is preceded by a year of subnormal precipitation, represents conditions prior to importation of additional water supplies, and is the start of a period of generally above-average rainfall. This latter condition permitted easier conversion of results to normal or average rainfall conditions. The chosen study period is not entirely ideal, however, because the initial year is preceded by several consecutive dry years, while the ending year is preceded by only one such year. In addition, a large recovery of water levels has taken place during the study period. It should be noted that the artificial recharge of ground water is the major source of ground water replenishment, making variations of precipitation less important. The relationship of precipitation during the long-term and the study period is shown on Figure 8.

Precipitation

The yearly amounts of rainfall at San Jose and their variations from the average are shown in Table 4. Variations in average precipitation over the study area are shown on Figure 9.

Tributary Runoff

Only a small portion of the drainage area tributary to Santa Clara Valley is gaged. Runoff from the remaining area was determined by developing runoff-precipitation relationships for the gaged areas and applying the relationships to the ungaged areas. Table 5 lists the tributary watersheds and the annual amounts of estimated runoff. The locations of tributary drainage areas are shown on Figure 10.

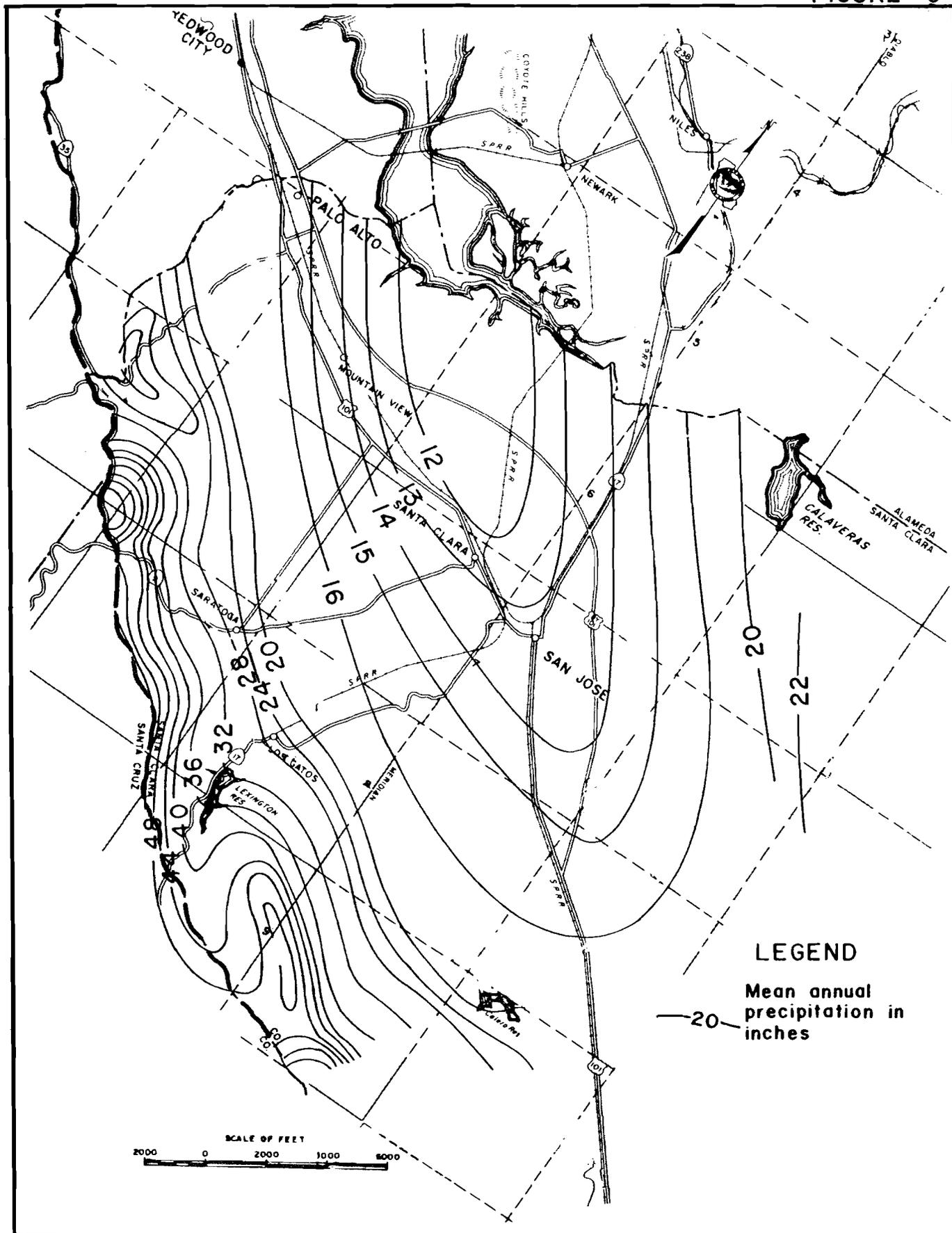
Estimates of tributary stream runoff from the west and the east hilly areas (most of which are ungaged) into the valley floor were made on the rainfall -- runoff correlations at representative (usually nearby) gaged basins. For developing correlation curves, seasonal stream runoff (in inches) was plotted against the seasonal basin precipitation (in inches). A straight line correlation of the data points fitted very well within the range of the data studied. The straight line has an intercept (b) on the abscissa, which is the amount of precipitation that would be consumed prior to the initiation of runoff.

Seasonal runoff from an ungaged area can be computed from the following formula when runoff data from a nearby gaged area and precipitation data for the two areas are available:

TABLE 4
ANNUAL PRECIPITATION AND INDEX OF WETNESS
AT SAN JOSE
1874-1971

Water Year	Precipitation		Index of Wetness	Water Year	Precipitation		Index of Wetness
	Inches	Centi-meters			Inches	Centi-meters	
1874-75	7.80	19.81	55.2				
1875-76	19.59	49.76	138.6	1925-26	14.44	36.68	102.2
76-77	4.72	11.98	33.4	26-27	13.90	35.31	98.4
77-78	19.76	50.19	139.8	27-28	10.09	25.63	71.4
78-79	15.92	40.44	112.7	28-29	10.14	25.76	71.8
79-80	13.80	35.05	97.7	29-30	10.89	27.66	77.1
1880-81	12.47	31.67	88.3	1930-31	8.30	21.08	58.7
81-82	11.77	29.89	82.3	31-32	13.40	34.04	94.8
82-83	11.44	29.06	81.0	32-33	8.90	22.61	63.0
83-84	20.07	50.98	142.0	33-34	8.97	22.78	63.5
84-85	11.19	28.42	79.2	34-35	16.49	41.88	116.7
1885-86	20.66	52.48	146.2	1935-36	11.90	30.23	84.2
86-87	11.96	30.38	84.6	36-37	16.90	42.43	119.6
87-88	12.14	30.84	85.9	37-38	18.75	47.63	132.7
88-89	15.11	38.38	106.9	38-39	10.77	27.36	76.2
89-90	30.35	77.09	214.8	39-40	16.35	41.53	115.7
1890-91	13.20	33.53	93.4	1940-41	21.25	53.98	150.4
91-92	16.14	40.99	114.2	41-42	16.56	42.06	117.2
92-93	25.17	63.93	178.1	42-43	13.13	33.35	92.9
93-94	14.00	35.56	99.1	43-44	11.47	29.13	81.2
94-95	22.29	56.62	157.7	44-45	12.44	31.60	88.0
1895-96	14.71	37.36	104.1	1945-46	11.26	28.60	79.7
96-97	15.70	39.88	111.1	46-47	9.00	22.86	63.7
97-98	7.79	19.79	55.1	47-48	9.89	25.12	70.0
98-99	8.79	22.33	62.2	48-49	11.59	29.44	82.0
99-00	14.06	35.71	99.5	49-50	8.31	21.11	58.8
1900-01	20.13	51.13	142.5	1950-51	14.12	35.86	99.9
01-02	12.54	31.85	88.7	51-52	19.57	49.71	138.5
02-03	13.89	35.28	98.3	52-53	9.67	24.56	68.4
03-04	12.66	32.16	89.6	53-54	9.99	25.37	70.7
04-05	15.77	40.06	111.6	54-55	11.85	30.10	83.9
1905-06	15.22	38.66	107.7	1955-56	18.54	47.09	131.2
06-07	22.64	57.51	160.2	56-57	9.86	25.04	69.8
07-08	11.99	30.45	84.9	57-58	21.71	55.14	153.6
08-09	18.97	48.18	134.3	58-59	11.75	29.85	83.2
09-10	13.90	35.31	98.4	59-60	8.39	21.31	59.4
1910-11	22.56	57.30	159.7	1960-61	10.05	25.53	71.1
11-12	11.30	28.70	80.0	61-62	12.44	31.60	88.0
12-13	5.81	14.76	41.1	62-63	20.49	52.04	145.0
13-14	19.28	48.97	136.5	63-64	10.29	26.14	72.8
14-15	22.75	57.79	161.0	64-65	15.09	38.33	106.8
1915-16	17.06	43.33	120.7	1965-66	10.81	27.46	76.5
16-17	11.86	30.12	83.9	66-67	19.62	49.83	138.9
17-18	15.68	39.83	111.0	67-68	15.08	38.30	106.7
18-19	12.79	32.49	90.5	68-69	19.30	49.02	136.6
19-20	8.57	21.77	60.7	69-70	11.18	28.40	79.1
1920-21	15.21	38.63	107.6	1970-71	14.92	37.90	105.6
21-22	14.56	36.98	103.0				
22-23	14.48	36.78	102.5				
23-24	5.92	15.04	42.0				
24-25	14.27	36.25	101.0				

97 Year Average (1874-1971) = 14.13 inches (35.89 centimeters)



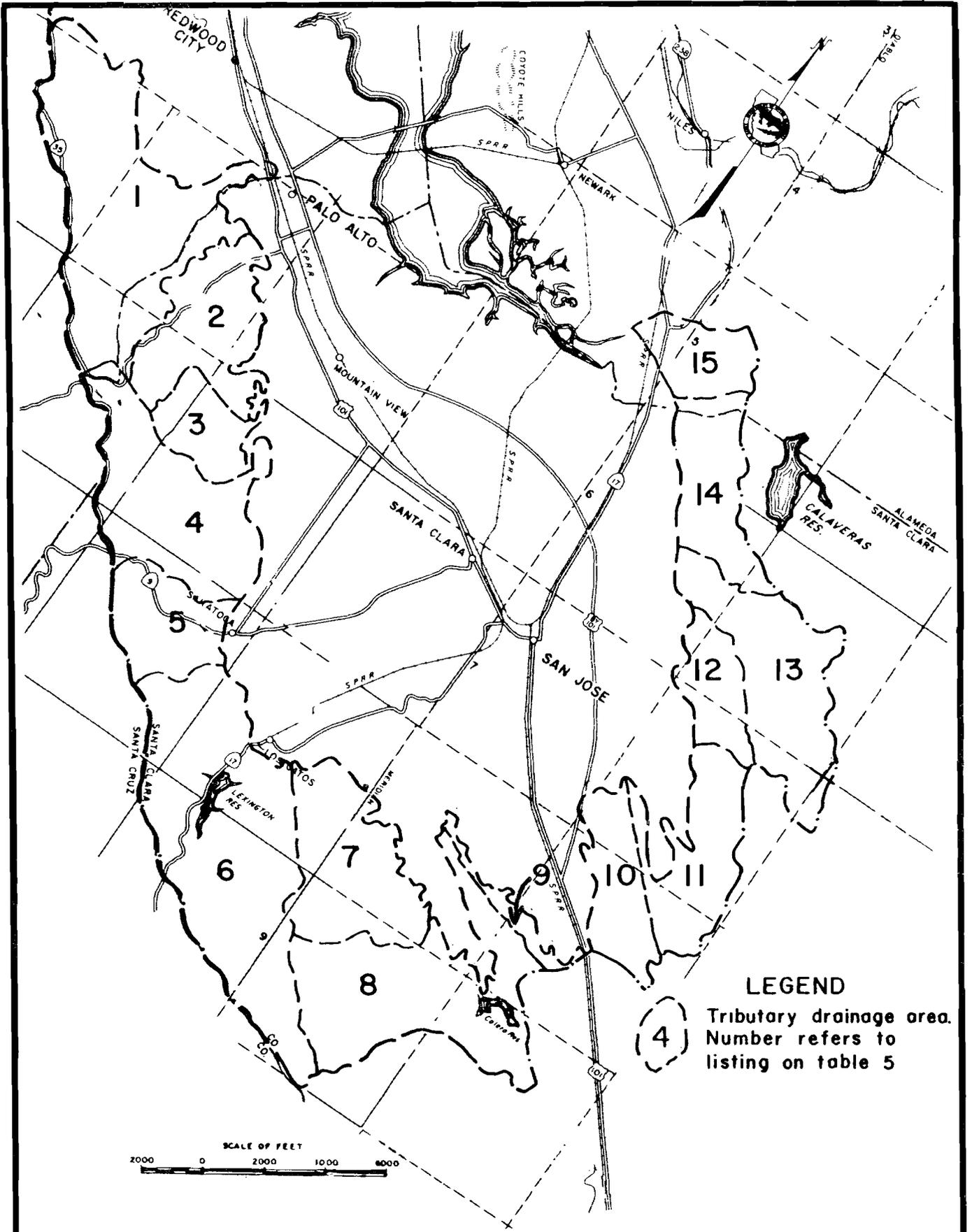
MEAN ANNUAL PRECIPITATION

TABLE 5
 TRIBUTARY RUNOFF

Tributary Drainage Area*	Area (square miles)	Runoff (thousand acre-feet)							
		1962 -63	1963 -64	1964 -65	1965 -66	1966 -67	1967 -68	1968 -69	1969 -70
1	39.1	16.80	1.93	16.12	4.55	29.40	4.28	31.96	17.18
2	17.2	4.02	1.24	3.58	2.70	8.64	3.27	12.62	6.22
3	7.6	3.32	0.45	2.59	1.13	3.81	0.73	4.70	1.91
4	24.5	18.67	5.10	19.35	4.46	19.54	5.23	22.70	9.77
5	10.9	12.76	1.13	10.68	2.17	13.93	2.74	19.23	7.04
6	43.6	74.13	14.90	34.31	9.32	55.88	17.38	66.32	29.95
7	20.5	23.30	4.46	12.20	4.09	26.35	7.99	25.12	8.82
8	27.9	23.92	8.57	11.83	8.68	22.31	11.55	27.41	12.91
9	3.2	0.67	0.00	0.53	0.00	0.97	0.05	1.26	0.15
10	11.0	1.00	0.06	1.29	0.00	2.64	0.18	2.35	0.00
11	13.8	1.42	0.24	2.43	0.26	4.04	0.40	3.67	0.35
12	8.6	0.76	0.03	1.02	0.00	2.06	0.12	1.81	0.00
13	23.1	2.84	0.79	5.93	1.04	8.58	1.11	8.01	1.97
14	13.2	1.27	0.07	2.25	0.14	3.66	0.21	3.17	0.42
15	8.5	0.82	0.05	1.45	0.09	2.36	0.14	2.04	0.27

Tributary Drainage Area*	Area (square kilometers)	Runoff (cubic hectometers)							
		1962 -63	1963 -64	1964 -65	1965 -66	1966 -67	1967 -68	1968 -69	1969 -70
1	101.3	20.66	2.37	19.83	5.60	36.16	5.26	39.31	21.13
2	44.5	4.94	1.53	4.40	3.32	10.63	4.02	15.52	7.65
3	19.7	4.08	0.55	3.19	1.39	4.69	0.90	5.78	2.35
4	63.5	22.96	6.27	23.80	5.49	24.03	6.43	27.92	12.02
5	28.2	15.64	1.39	13.14	2.67	17.13	3.37	23.65	8.66
6	112.9	91.18	18.33	42.20	11.46	68.73	21.38	81.57	36.84
7	53.1	28.66	5.49	15.01	5.03	32.41	9.83	30.90	10.85
8	72.3	29.42	10.54	14.55	10.68	27.44	14.21	33.71	15.88
9	8.3	0.82	0.00	0.65	0.00	1.19	0.06	1.55	0.18
10	28.5	1.23	0.07	1.59	0.00	3.25	0.22	2.89	0.00
11	35.7	1.75	0.29	2.99	0.32	4.97	0.49	4.51	0.43
12	22.3	0.93	0.04	1.25	0.00	2.53	0.15	2.23	0.00
13	59.8	3.49	0.97	7.29	1.28	10.55	1.37	9.85	2.42
14	34.2	1.56	0.09	2.77	0.17	4.50	0.26	3.90	0.52
15	22.0	1.01	0.06	2.78	0.11	2.90	0.17	2.51	0.33

*For location, see Figure 10.



LEGEND
 (4) Tributary drainage area.
 Number refers to listing on table 5

TRIBUTARY DRAINAGE AREAS

Table 6
IMPORTED WATER

Fiscal Year	Hetch Hetchy	State Water Project ^{1/}			Total
		Ground Water Recharge	Rinconada Water Treatment Plant ^{2/}	Local Irrigation	
<u>Acre-Feet</u>					
1962	15,490				-0-
1963	23,140				-0-
1964	27,090				-0-
1965	29,590	500	-0-	-0-	500
1966	33,580	29,350	-0-	-0-	29,350
1967	36,040	31,460	310	-0-	31,770
1968	40,160	54,580	8,150	270	63,000
1969	42,180	45,640	11,450	570	57,660
1970	48,350	37,590	39,170	470	77,230
1971	45,210	43,790	43,990	710	88,490
1972	49,880	42,530	48,820	800	92,150
1973	48,890	46,990	44,990	600	92,580
<u>Cubic Hectometers^{3/}</u>					
1962	19.1				-0-
1963	28.5				-0-
1964	33.4				-0-
1965	36.5	0.6	-0-	-0-	0.6
1966	41.4	36.2	-0-	-0-	36.2
1967	44.4	38.8	0.4	-0-	39.2
1968	49.5	67.3	10.1	0.3	77.7
1969	52.0	56.3	14.1	0.7	71.1
1970	59.6	46.4	48.3	0.6	95.2
1971	55.8	54.0	54.2	0.9	109.1
1972	61.5	52.4	60.2	1.0	113.6
1973	60.3	57.9	55.5	0.8	114.2

1/ SBA deliveries began in June 1965.

2/ Rinconada Water Treatment Plant began operation in June 1967.

3/ Million cubic meters.

When it became evident that both locally developed water and Hetch Hetchy water would not keep pace with the growth, the Santa Clara Valley Water District contracted with the State to receive water from the State Water Project through the South Bay Aqueduct. Deliveries to the north valley began in July 1965 and presently total about 100,000 acre-feet (123 hm³) a year. Deliveries include 88,000 acre-feet (109 hm³) of contracted water and an additional 12,000 acre-feet (15 hm³) of surplus water when available. Annual deliveries are listed in Table 6.

Approximately half of this imported water now is being treated for surface distribution at the Santa Clara Valley Water District Rinconada Water Treatment Plant, which was completed in 1967, and the Penitencia Water Treatment Facility, completed in 1974. The remainder is used for recharge of the ground water basin. The Penitencia Plant has capacity to treat 20 MGD (76,000 m³/d) of South Bay Aqueduct water. The Rinconada and Penitencia Water Treatment Plants will eventually be treating nearly 70 percent of the total South Bay Aqueduct import. This will result in the reduction of imported water available for ground water recharge. Ground water levels have been recovering steadily since the initiation of water importation.

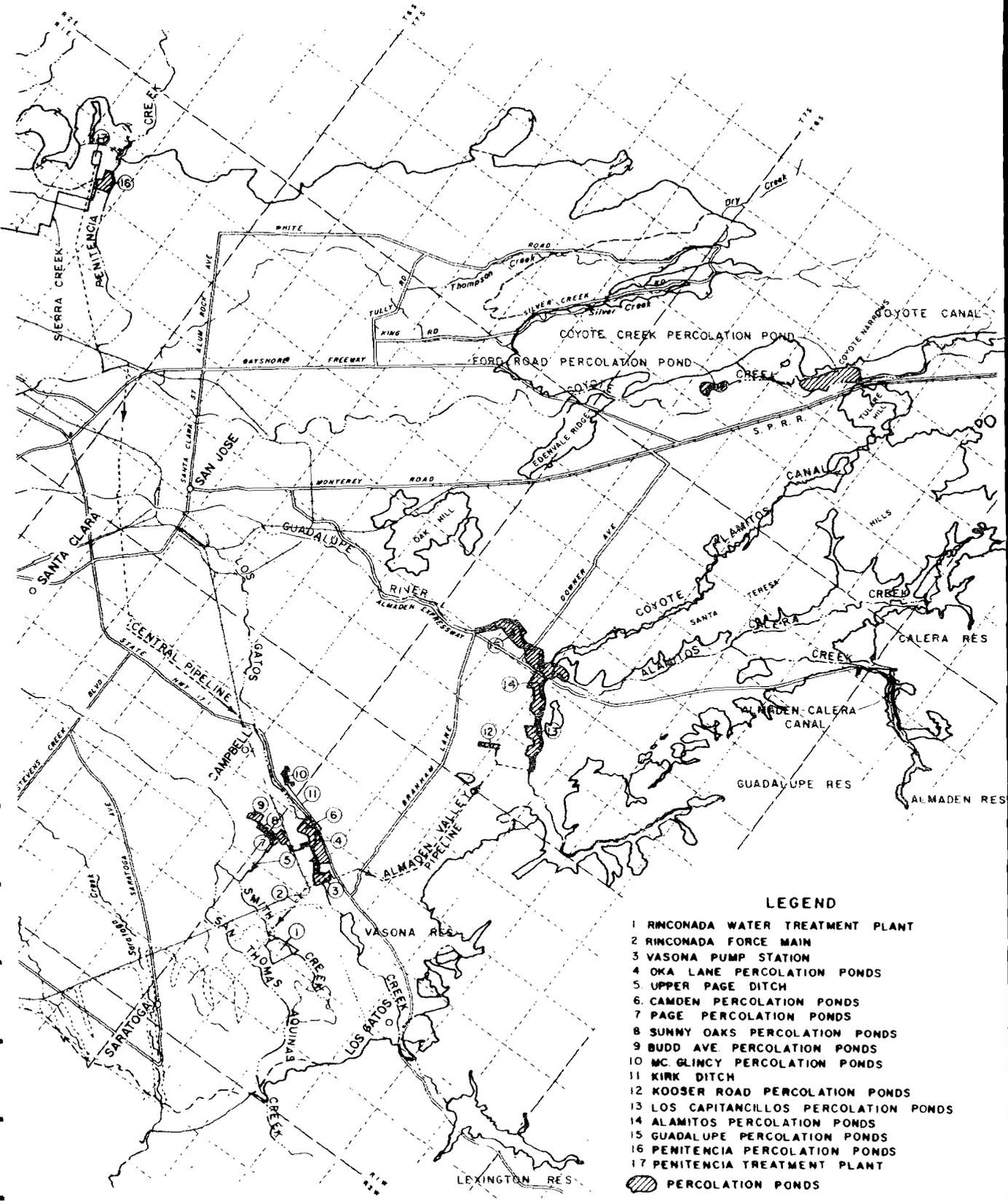
Increases in water demands have been supplied by treated imported water, so that ground water production has remained relatively constant at approximately 150,000 acre-feet (185 hm³) per year.

Operation of Recharge Facilities

The primary purpose of the water retained in the various District reservoirs is to replenish the ground water basin. Water is released from the reservoirs to allow for its maximum use during the summer operation period. Annual analyses are made to determine the amounts of water available for recharge from the various reservoirs and the amounts of water available from imported water sources. The imported water available for recharge is that water not delivered to the Rinconada Water Treatment Plant or served directly for irrigation. An operational schedule is developed based on the amount of water available and on constraints such as maintenance and construction projects in natural channels and maintenance of recharge facilities. Recreational needs are met whenever possible. Those recharge facilities that are part of a park complex or leased to other agencies for recreation are operated whenever possible. Long-term recreational pools during the summer months are maintained if possible.

Reservoir releases are made to meet the downstream demands with the intention to maximize the total amount of water recharged. The areas of ground water deficiency would be first on a priority for recharge.

Data on percolation facilities are summarized in Table 7; Figure 11 shows the locations of the recharge facilities. Descriptive material on each facility is given below:



ARTIFICIAL RECHARGE SYSTEM

TABLE 7
PERCOLATION FACILITIES IN SANTA CLARA COUNTY

Name	Location	Number of Ponds	Total Surface Area		Maximum Recharge Rate		Source of Water
			(acres)	(hectares)	(acre-feet per acre per day)	(cubic meters per hectare per day)	
Alamitos	On Guadalupe River at confluence of Alamitos and Guadalupe Creeks	2	15	6.0	1	499.2	Local and Imported
Budd	Along San Tomas Expressway near Budd Avenue	3	9	3.6	3	1497.6	Local and Imported
Camden	Along west bank Los Gatos Creek south of San Tomas Expressway	3	62	25.1	0.5	249.6	Local and Imported
Coyote	On Coyote River north of Metcalf Road and east of Highway 101	1	30	12.1	2	998.4	Local
Ford Road	On Coyote River between Ford Road and Tennant Avenue	4	34	13.7	1	499.2	Local
Guadalupe	Along Guadalupe River north of Blossom Hill Road	4	48	19.4	0.5 ^{e/}	249.6 ^{e/}	Local and Imported
Kooser	Within PG&E right-of-way between Kooser Avenue and Tobias Drive	4	2	0.8	5	2496.0	Imported
Los Capitancillos	Along north bank of Guadalupe Creek west of Almaden Expressway	9	63	25.5	0.5	249.6	Local and Imported
McGlincey	Both sides of McGlincey Lane and north of Griffith Street	6	7	2.8	6	2995.2	Local and Imported
Oka	East bank of Los Gatos Creek north of Oka Lane extended	4	17	6.9	1	499.2	Local and Imported
Page	West of Winchester Blvd. between Hacienda Blvd. and Sunnoaks Blvd.	8	14	5.7	2	998.4	Local and Imported
Penitencia	North of Penitencia Creek Road and west of Noble Ave.	6	14	5.7	1	499.2	Local and Imported
Sunnyoaks	West of Winchester Blvd. between Sunnyoaks Ave. and Waldo Road	4	3	1.2	2	998.4	Local and Imported

^{e/} Estimate

Alamitos Percolation Ponds

One offstream pond and one onstream pond receive local runoff from three sources: Alamitos Creek, Guadalupe River, and Coyote Creek by way of the Coyote-Alamitos Canal. In addition, imported water can be delivered from the Almaden Valley Pipeline by way of Guadalupe River. The onstream pond is operated during certain portions of the year by the erection of a flashboard dam on Alamitos Creek. There is no method of measuring the flow into this system except for a water stage recorder located at the flashboard dam.

During the winter, the flashboard dam is removed and a gravel dam is constructed to divert streamflow into the offstream pond. Only water of less than 25 Jackson Turbidity Units is diverted.

This area is not fenced; it is leased to the City of San Jose for development for public use.

Budd Avenue Percolation Ponds

Three ponds in series receive local and imported water via the Upper Page Ditch and Page Pipeline. A low pressure meter measures the total combined flow to the Budd Avenue and adjacent Sunnyoaks Ponds. An overflow pipe in the most northerly Budd Avenue Pond conveys unmeasured excess flow to San Tomas Aquinas Creek through a storm drain.

Imported water can be delivered to this system without using natural stream channels, and the ponds can be operated during the winter. During periods of heavy runoff, the recharge potential of these ponds can be used to infiltrate local water.

The area is fenced and is adjacent to a subdivision.

Camden Percolation Ponds

Local and imported water is delivered to the middle of three connected ponds via the Upper Page Ditch. The combined flow into the Camden, Page, Budd Avenue, and Sunnyoaks recharge areas is measured by a water stage recorder located at the head of the Upper Page Ditch. Flow not diverted into the Camden Ponds is measured by a water stage recorder located at Dell Avenue. An overflow pipe located in the most northerly Camden Pond returns unmeasured flow to Los Gatos Creek. Some seepage occurs along the east bank of the ponds; this seepage flows to Los Gatos Creek.

Imported water can be delivered to this system without using natural channels, and the system is operated during winter months to a limited degree without consideration of local runoff conditions. During periods of heavy runoff, however, the recharge potential of those ponds can be used to infiltrate local water.

The area is not fenced; it is leased by the Santa Clara County Parks and Recreation Department for development as a recreational facility.

Coyote Percolation Pond

One large onstream pond is formed and regulated by the Coyote Percolation Dam, which receives local water from the Anderson-Coyote watershed via Coyote Creek and Coyote Canal, which parallels the creek. The canal is used instead of the creek to prevent high ground water conditions in areas adjacent to the creek. Water stage recorders are located both upstream and downstream of this system.

During periods of high runoff, the water level in this pond is lowered in order to prevent degradation of the infiltration rate by the spreading of turbid water.

The area is not fenced; it is a part of Coyote Park.

Ford Road Percolation Ponds

Three onstream ponds that are formed by gravel dams, and one off-stream pond receiving water from the uppermost onstream pond, receive water from Anderson Reservoir. Inflow and outflow cannot be measured.

During winter months, water levels in these ponds are lowered and gravel dams are removed to prevent turbid water from affecting recharge rates and also as a flood protection measure. Delivery cannot be made to the offstream pond if the gravel dam forming the upstream pond is not in operation.

The area is not fenced; it is a part of Coyote Park.

Guadalupe Percolation Ponds

Three offstream ponds, and one onstream pond that is used during a portion of the year by the construction of two gravel dams in the Guadalupe River, receive local water from Almaden, Calero, or Guadalupe Reservoirs. Imported water can be delivered from the Almaden Valley Pipeline via Guadalupe River.

Two ponds are on the west side of the river and one is on the east side. Water is introduced into the southerly pond on the west side of the river by the construction of a small diversion dam near the southeast corner of the pond. A pipe is located between the two westerly ponds. Farther to the north on the Guadalupe River, a gravel dam is used to divert water to the easterly pond.

During periods of local runoff, the gravel dams are removed and turbid waters are not diverted to the offstream ponds. The area is fenced.

Kooser Percolation Ponds

A series of four ponds receive only imported water from the Almaden Valley Pipeline. A low pressure meter measures all flows into these ponds. Weirs between the ponds are used to measure interpond flow. There is no overflow to handle surplus flows. The area is fenced.

Los Capitancillos Percolation Ponds

A series of nine ponds receive local runoff from the Guadalupe watershed area and imported water from the Almaden Valley Pipeline. Water enters the most westerly pond from Masson Dam. This westerly pond also serves as a desilting pond and has cross levees to provide about one hour detention time. Chemicals can be introduced to decrease turbidity of the water. Some of this water returns to the Guadalupe River by way of bank seepage. All water entering the system is measured by a water stage recorder located at a Parshall flume between the uppermost pond area and the second pond. There is no measurement made of reintroduced water. At the northeasterly corner of the ninth pond, there is a pipeline that can be used to convey water to the Alamitos Pond.

Imported water can be delivered to this system without using natural channels, and the system can be operated during winter months, to a limited degree, without consideration of local runoff conditions. During periods of heavy runoff, when water in Guadalupe River is going to waste, the recharge potential of these ponds could be used to infiltrate local water.

The area is fenced. The City of San Jose and the County of Santa Clara plan to lease portions of this area to develop it for public recreational use.

McGlincey Percolation Ponds

A group of six ponds receive local and imported water by way of Kirk Canal. The flow into the ponds is measured by a water stage recorder located just north of Camden Avenue. An overflow pipe located in the most easterly pond allows excess flow to return via a storm drain to Los Gatos Creek. Some seepage also returns to Los Gatos Creek.

Imported water can be delivered to this system without using natural channels, and the system can be operated during winter months without consideration of local runoff conditions. During periods of heavy runoff, the recharge potential of these ponds can be used to infiltrate local water. The area is completely enclosed.

Oka Lane Percolation Ponds

A group of four ponds receive local and imported water by way of Kirk Ditch and Central Pipeline. Each pond has a separate connection to the Kirk Ditch, and the amount of water delivered to each pond is not measured. The most southeasterly pond is used as a desilting pond. The combined flow into the Oka and McGlincey Ponds is measured by a water stage recorder located at the head of Kirk Creek. Flow not diverted into the Oka System is measured by a water stage recorder located just north of Camden Avenue on the Kirk Ditch. Some water can be returned to Los Gatos Creek by wasteways located downstream of the Oka Ponds and above the recorder station. In addition, an overflow pipe located in the most northerly pond returns excess flows to Los Gatos Creek. Flows in the wasteway and overflow pipe are not measured. Considerable seepage occurs along the west bank of the ponds.

Imported water can be delivered to this system without using natural channels. The system can be operated during the winter months to a limited degree without consideration of local runoff conditions. During periods of heavy runoff, the recharge potential of these ponds can be used to infiltrate local water.

The area is not fenced. The Santa Clara County Parks and Recreation Department leases this area and will develop it for recreational use.

Page Percolation Ponds

A group of eight ponds receive local and imported water by way of Page Pipeline. The combined flow into the Page Ponds, Sunnyoaks Ponds, and Budd Avenue Ponds is measured by a water stage recorder located on Upper Page Ditch at Dell Avenue. Flows not diverted to Page, Budd, or Sunnyoaks Ponds are conveyed via Page Canal past the Page Percolation System to Smith Creek, then to San Tomas Aquinas Creek. This flow is measured by a water stage recorder located at Sonuca Avenue.

Imported water can be delivered to this system without using natural channels. The system can be operated during the winter months without consideration of local runoff conditions. During periods of heavy runoff, the recharge potential of these ponds can be used to infiltrate local water. The area is fenced.

Penitencia Percolation Ponds

A series of five ponds and a canal containing 22 check structures receive local water from Penitencia Creek during limited periods of time in the winter and spring. During the remainder of the year, imported water is placed in the ponds from the South Bay Aqueduct via the Penitencia Water Treatment Plant.

Because of the location of these ponds in relationship to the imported water system, the ponds also are operated to hold minor surges in flows. Each of the five ponds has an overflow spillway that is capable of carrying 185 cfs (5.24 cumecs) to Penitencia Creek. Water in the ponds can be released to supply irrigation and recharge demands along Sierra and Berryessa Creeks.

Flow into this system is measured by a water stage recorder located at the head of the diversion. Outflows from the ponds are not measured.

The ponds are only partially fenced; the canal is completely fenced. The City of San Jose plans to use the five ponds as a park.

Sunnyoaks Percolation Ponds

A group of four ponds receive local and imported water via the Upper Page Ditch and by the Page Pipeline. A low pressure meter measures the total combined flow to those ponds and the Budd Avenue Ponds. There is no overflow or return flow drain from these ponds.

Imported water can be delivered to this system without using natural stream channels and can be operated during periods of high stream-flow without consideration of local runoff conditions. During periods of heavy runoff, the recharge potential of these ponds can be used to infiltrate local water.

The area is fenced. The pond next to the fire station, located at the south end of the ponds, is used by the Fire Department for training purposes. There are no plans to develop this area for public use.

Agricultural Water Use

Detailed records on amounts of ground water pumped and surface water delivered for agricultural purposes are available for the years 1966 through 1970. These records also include the net acreage to which the water is applied. The records do not indicate if the surface diversions were applied to areas also receiving ground water. For the purpose of this study, it is assumed that there is no application of both surface and ground water to the same acreage during the same six-month period.

Depths of water applied to various crops during each of the years 1967 through 1971 were determined from records of ground water pumpage and lands receiving ground water irrigation. The depths computed on the basis of net irrigated lands are shown in Table 8. Gross acres include the irrigated plot, related farm facilities, and adjacent streets. For the study area, the net irrigated lands are taken as 85 percent of the gross irrigated lands. Depths of applied water corrected to a gross acreage basis are shown in Table 9.

Depths of applied irrigation water per gross acre for the years 1962 through 1966 shown in Table 9 are based on four factors: (1) analysis of all years 1962 through 1970 to determine which years were wet, normal, or dry (based mainly on rainfall in March and April and secondly on rainfall in February); (2) determination of annual applied water for wet, normal, and dry conditions for the period 1967 through 1970; (3) assumption that applied water after 1966 was decreased for most crops due to the pump tax; and (4) calculation of unit values for the wet, normal, and dry years in the period 1962 through 1966 by adding one irrigation to values obtained from years 1967 through 1970.

Land Use

The annual amounts of land use for the lands overlying the ground water model area are shown on Table 10, and are based on land use surveys made in 1961, 1965, and 1967 by the Department and/or Santa Clara County, and from records of the District on water use and irrigated acreage. The various types of land use are irrigated agricultural lands, urban lands, native or nonirrigated lands, and water surface areas.

The amounts of irrigated agricultural land mapped in the 1967 land use survey were greater than recorded acreage of agricultural land being supplied by wells and surface water diversions. Analysis of the discrepancy revealed that the depths of applied water obtained from the District's water use data appeared to be on the low side of a reasonable range of values. Therefore the acreage irrigated by the metered water should not be increased. Many orchards in the area are mature and can survive for a period of years without irrigation. These same orchards still have irrigation facilities and would appear to be irrigated orchard. It

TABLE 8

UNIT VALUES OF APPLIED IRRIGATION WATER: NET ACREAGE^{1/}

Crop	Calendar Year			
	1967	1968	1969	1970
	<u>(Feet)</u> ^{2/}			
Alfalfa	2.05	2.48	2.09	2.55
Apricots	0.90	0.91	1.01	1.13
Berries	3.56	4.41	4.73	5.33
Cherries	1.13	1.47	1.31	1.43
Corn (Sweet)	1.72	1.32	1.79	1.17
Flowers	3.50	3.74	3.85	3.48
Mixed Row Crop	2.19	2.37	2.48	2.51
Onions	2.51	2.27	2.12	1.87
Mixed Orchard	1.10	1.12	1.06	1.18
Pears	1.62	2.13	1.90	2.00
Pasture	1.70	2.02	1.63	1.69
Prunes	0.94	1.20	1.10	1.44
Tomato (Bush)	1.81	1.71	1.72	1.89
Walnuts	0.94	1.08	1.17	1.09
Vineyards	0.33	0.91	0.72	0.57
	<u>(Meters)</u> ^{3/}			
Alfalfa	0.62	0.76	0.64	0.78
Apricots	0.27	0.28	0.31	0.34
Berries	1.09	1.34	1.44	1.62
Cherries	0.34	0.45	0.40	0.44
Corn (Sweet)	0.52	0.40	0.54	0.36
Flowers	1.07	1.14	1.17	1.06
Mixed Row Crop	0.67	0.72	0.76	0.77
Onions	0.77	0.69	0.64	0.57
Mixed Orchard	0.33	0.34	0.32	0.36
Pears	0.49	0.65	0.58	0.61
Pasture	0.52	0.62	0.50	0.52
Prunes	0.27	0.37	0.33	0.44
Tomato (Bush)	0.55	0.52	0.52	0.58
Walnuts	0.27	0.33	0.36	0.33
Vineyards	0.10	0.28	0.22	0.17

^{1/} Net acreage is irrigated portion of farm only^{2/} Acre-feet per net acre.^{3/} Cubic meters per net hectare.

TABLE 9

UNIT VALUE OF APPLIED IRRIGATION WATER: GROSS ACREAGE^{1/}

Crop	Water Year								
	1961-2	1962-63	1963-4	1964-5	1965-6	1966-7	1967-8	1968-9	1969-70
	(Feet) ^{2/}								
Alfalfa	2.75	2.25	2.75	2.50	2.75	1.74	2.10	1.94	2.17
Apricots	1.25	1.17	1.58	1.58	1.58	0.77	0.77	0.86	0.96
Berries	4.00	3.50	4.50	3.75	4.50	3.03	3.75	4.02	4.53
Cherries	1.50	1.33	1.83	1.83	1.83	0.96	1.25	1.11	1.22
Corn	2.00	1.75	2.25	1.92	2.25	1.46	1.12	1.52	0.99
Flowers	3.25	3.00	3.50	3.25	3.50	2.98	3.18	3.27	2.96
Mixed Row	2.50	2.17	2.50	2.00	2.25	1.86	2.01	2.10	2.13
Mixed									
Orchard	1.33	1.25	1.58	1.58	1.58	0.94	0.95	0.90	1.00
Onions	2.25	1.17	1.67	1.67	1.67	2.13	1.92	1.80	1.59
Pears	2.00	1.75	2.33	2.33	2.33	1.38	1.81	1.62	1.70
Pasture	2.25	1.75	2.58	2.33	2.58	1.45	1.72	1.39	1.44
Prunes	1.33	1.17	1.67	1.67	1.67	0.80	1.02	0.94	1.22
Tomatoes	2.00	1.75	2.25	1.92	2.25	1.54	1.45	1.46	1.61
Walnuts	1.25	1.17	1.58	1.58	1.58	0.80	0.92	0.99	0.93
Vineyard	0.67	0.33	0.84	0.67	0.84	0.28	0.77	0.61	0.48
	(Meters) ^{3/}								
Alfalfa	0.84	0.69	0.84	0.76	0.84	0.53	0.64	0.59	0.66
Apricots	0.38	0.36	0.48	0.48	0.48	0.23	0.23	0.26	0.29
Berries	1.22	1.07	1.37	1.14	1.37	0.92	1.14	1.23	1.38
Cherries	0.46	0.41	0.56	0.56	0.56	0.24	0.38	0.34	0.37
Corn	0.61	0.53	0.69	0.59	0.69	0.46	0.34	0.46	0.30
Flowers	0.99	0.91	1.07	0.99	1.07	0.91	0.97	1.00	0.90
Mixed Row	0.76	0.66	0.76	0.61	0.69	0.57	0.61	0.64	0.65
Mixed									
Orchard	0.41	0.38	0.48	0.48	0.48	0.29	0.29	0.27	0.30
Onions	0.76	0.36	0.51	0.51	0.51	0.65	0.59	0.55	0.48
Pears	0.61	0.53	0.71	0.71	0.71	0.42	0.55	0.49	0.52
Pasture	0.76	0.53	0.79	0.71	0.79	0.44	0.52	0.42	0.44
Prunes	0.41	0.36	0.51	0.51	0.51	0.24	0.31	0.29	0.37
Tomatoes	0.61	0.53	0.76	0.59	0.76	0.47	0.44	0.45	0.49
Walnuts	0.38	0.36	0.48	0.48	0.48	0.24	0.28	0.30	0.28
Vineyard	0.20	0.10	0.26	0.20	0.26	0.09	0.23	0.19	0.15

1/ Gross acreage includes irrigated and nonirrigated portions of farm.

2/ Acre-feet per gross acre.

3/ Cubic meters per gross hectare.

TABLE 10

LAND USE

Year	Irrigated Agriculture	Dry Farm	Total Agriculture and Native	Urban	Water Surface
<u>(Acres)</u>					
1962	62,440	17,770	79,210	77,130	19,960
1963	58,070	18,420	76,490	80,850	19,960
1964	53,720	19,080	72,800	84,540	19,960
1965			68,970	88,220	20,110
1966			66,890	90,300	20,110
1967			64,550	92,640	20,110
1968			61,540	95,650	20,110
1969			59,080	98,450	19,770
1970			56,640	101,220	19,440
<u>(Hectares)</u>					
1962	25,270	7,160	32,430	31,210	8,080
1963	23,500	7,450	30,950	32,720	8,080
1964	21,740	7,720	29,460	34,210	8,080
1965			27,910	35,700	8,140
1966			27,070	36,540	8,140
1967			26,120	37,500	8,140
1968			24,910	38,710	8,140
1969			23,910	39,840	7,870
1970			22,920	40,960	7,790

was concluded that some of the agricultural lands mapped as irrigated in the 1967 land use survey were probably nonirrigated. One of the major factors affecting irrigation of agricultural lands was the imposition of a pump tax in the mid-1960's. For this study, it was assumed that the irrigated agricultural land use data in Table 10 is reliable for years 1961 through 1964 and can be used as a basis to determine agricultural applied water. Because the amount of irrigated land from 1965 on probably contains significant amounts of underirrigated or nonirrigated orchard and pasture lands, the acreage of irrigated and nonirrigated lands have been combined with native lands in Table 10. Changes in land use from 1967 through 1970 are based on data on lands subdivided during each year. General land use is shown on Figure 12.

Ground Water Pumpage

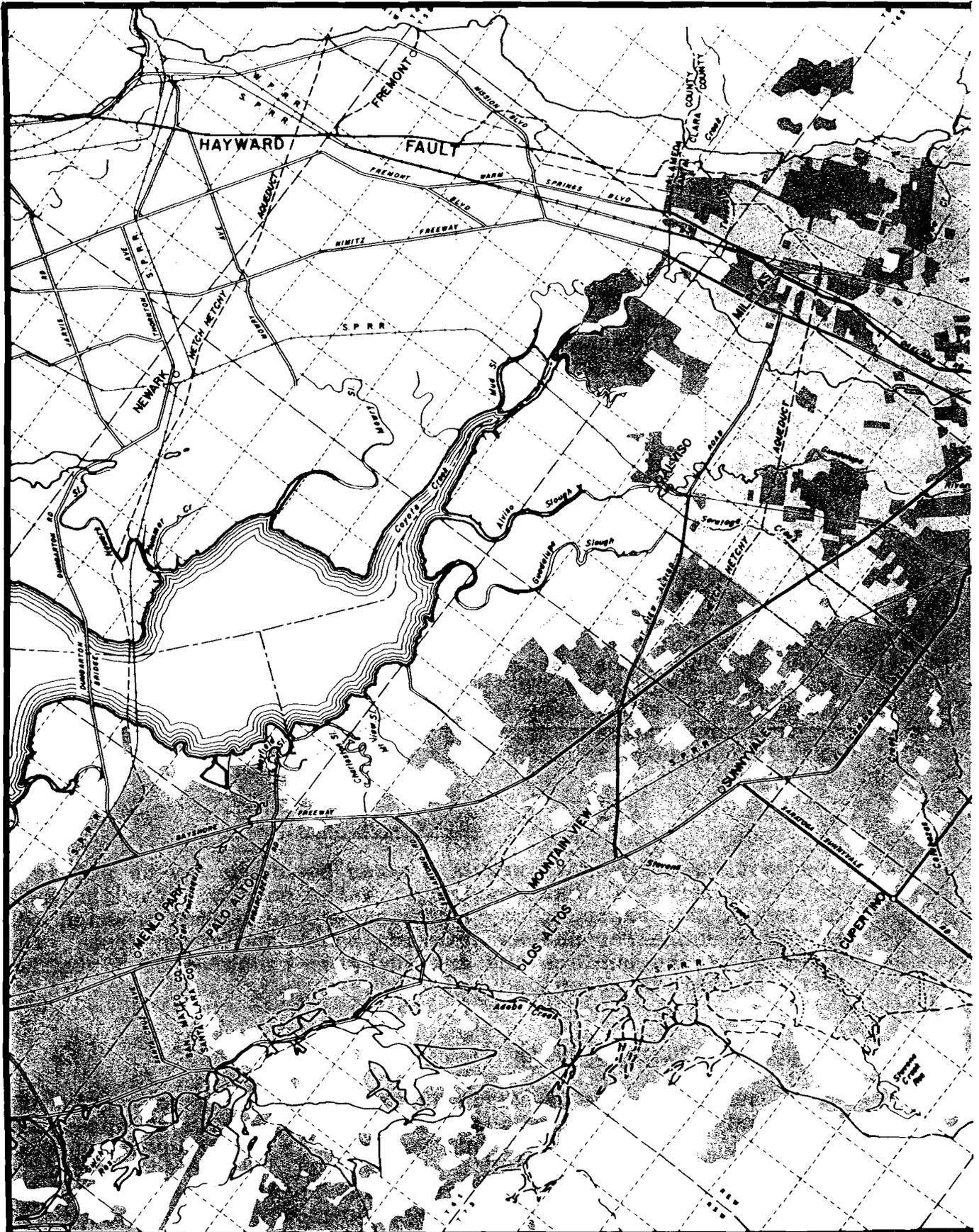
The annual amounts of ground water pumped during the study period are shown on Table 11. Water pumped by private and public utilities is based on metered flows. Water produced by individual domestic and industrial wells has been metered from 1964 to date, and was assumed to be constant for 1962 through 1964. The amounts of irrigation water pumped during 1962-63 and 1963-64 were computed as the difference between demand (irrigated acreage multiplied by depth of applied water) and surface water diversions. From 1966 on, the actual metered pumpage was used. The first full year of metering was 1965, and may not include all agricultural pumpage. To compensate for possible missing data in 1965, the agricultural pumpage for 1965 was taken as the greater of 1965 and 1966 pumpage in each nodal area.

Water Quality

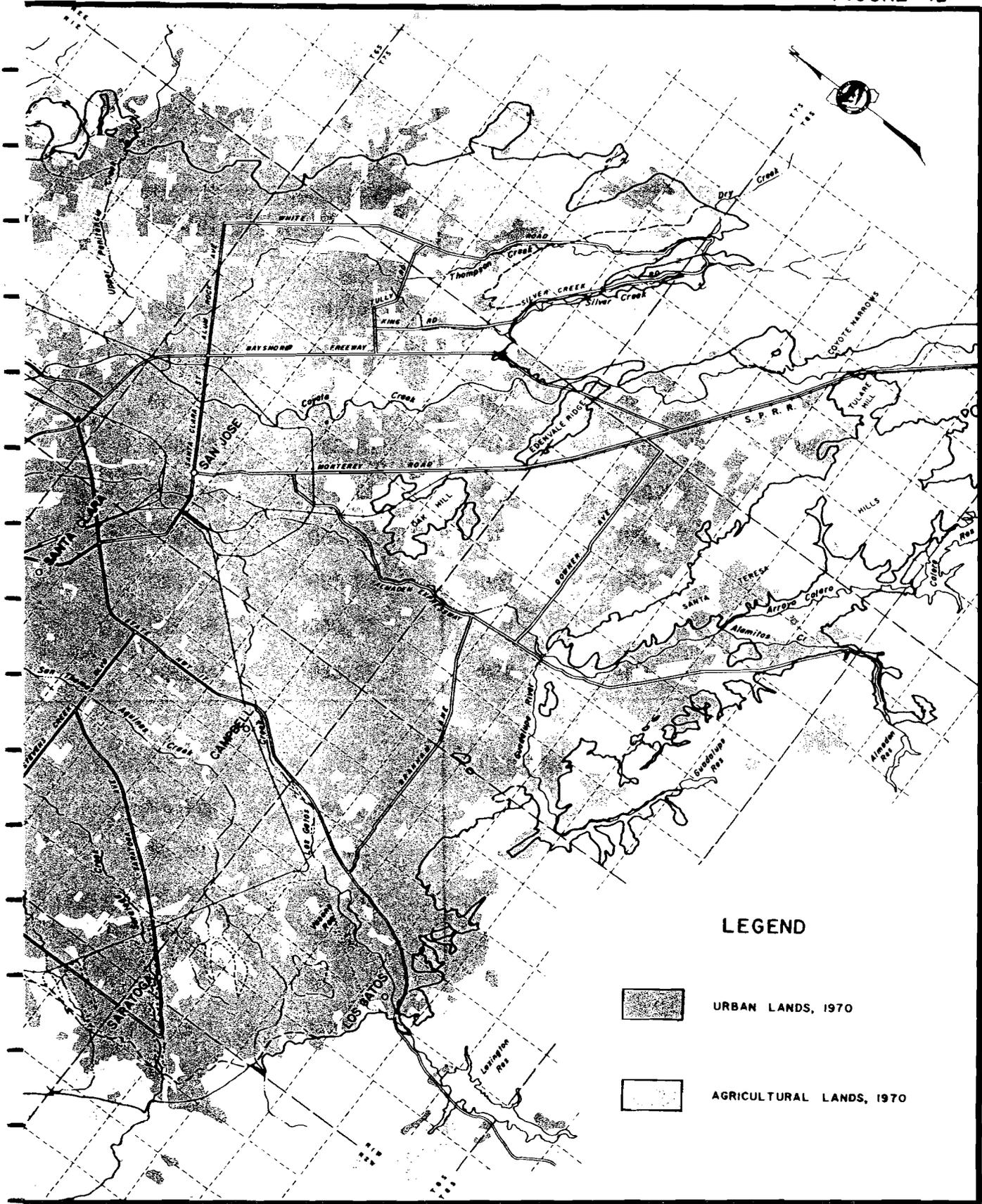
The variety of uses to which a water resource may be put is limited by the quality of that resource. Water suitable for irrigation of crops, for example, may contain certain elements which make it undesirable for use as drinking water and vice versa. The quality of the surface and ground water resource of North Santa Clara Valley is described below.

Quality of Surface Water

Local surface water in North Santa Clara Valley is mostly of excellent quality, highly suitable for agricultural and domestic purposes. In some areas, the hardness is considered excessive at times, but tends toward lower overall averages by mixing in reservoir. Poor quality water occurs in the lower reaches of the tidal inlet channels due to incursion of saline water from



LAND USE 1970



SANTA CLARA VALLEY

TABLE 11
GROUND WATER PUMPAGE

Calendar Year	Agriculture	Municipal	Domestic	Individual Industries	Total
<u>(Acre-Feet)</u>					
1962	91,710	70,320	760	19,460	182,250
1963	74,680	67,230	750	19,460	162,120
1964	94,090	82,830	750	19,460	197,130
1965	53,980	76,020	510	18,380	148,890
1966	41,110	87,820	890	23,010	152,830
1967	23,790	79,940	1,110	22,080	126,920
1968	32,830	113,820	1,090	23,480	171,220
1969	27,740	100,870	950	22,660	152,220
1970	27,010	97,670	950	22,660	148,290
<u>(Cubic Hectometers)^{1/}</u>					
1962	113.12	86.74	0.94	24.00	224.80
1963	92.12	82.93	0.93	24.00	199.98
1964	116.06	102.17	0.93	24.00	243.16
1965	66.58	93.77	0.63	22.67	183.65
1966	50.71	108.33	1.10	28.38	188.52
1967	29.34	98.61	1.37	27.24	156.56
1968	40.50	140.40	1.34	28.96	211.20
1969	34.22	124.42	1.17	27.95	187.76
1970	33.32	120.48	1.17	27.95	182.92

^{1/} Million cubic meters

the Bay, and abnormally high boron concentrations have occurred in Penitencia Creek. Other than in these instances, there does not appear to be any generally consistent and substantial quality variation in surface waters of the area.

The total dissolved solids (TDS) content of the water ranges from about 200 to 400 milligrams per liter (mg/l), while its chemical character is calcium-magnesium bicarbonate. However, while neither consistent nor substantial, the upper range of TDS content in streams on the western side of the valley tend to be about 100 mg/l higher than those on the eastern side. This may be a reflection of geologic conditions on the western side which form the watersheds for these streams. There also is another geologically derived water quality condition which must be noted, even though it does not constitute a direct problem except when associated with the biological food chain which includes edible game fish.

In 1970, evidence of mercury from abandoned mercury mines was found in some surface water in Santa Clara Valley. Samples of water collected from Alamitos Creek were determined to contain mercury concentrations generally in the order of 0.5 micrograms per liter ($\mu\text{g}/\text{l}$), which is well below the Environmental Protection Agency tentative mercury concentration limit of 2.0 $\mu\text{g}/\text{l}$ for public drinking water supplies. Subsequently, samples of fish were collected from Almaden and Calero Reservoirs which receive water from Alamitos Creek. Analysis of fish flesh samples showed mercury concentrations greater than 0.5 micrograms per gram ($\mu\text{g}/\text{g}$) which is 1,000 times greater than the concentrations generally found in the water. The maximum acceptable limit of mercury concentrations in fish flesh, as established by the U. S. Food and Drug Administration (Sport Fishing Institute, 1973), is 0.5 $\mu\text{g}/\text{g}$. As a result of the findings, signs warning of mercury contamination were posted at Calero and Almaden Reservoirs, and mercury analyses of water, sediment, and fish flesh samples collected from other surface waters in Santa Clara County were made by several agencies. The wide interest by state and federal agencies in this problem was spurred by the fact that it presented one of the few, if not the only, opportunities for a case study of mercury contamination of fish in inland waters not associated with industrial pollution. Development of procedures for biological sample preparation, as well as analytical techniques in the micro-concentration range, were of major interest to some agencies, while finding a solution to the physical problem and making management decisions regarding it was the priority interest of other agencies. Some of the results of these studies are included below in the discussion of Calero, Lexington, and Anderson Reservoirs, each of which impounds water that flows into the area of investigation from watersheds with differing geochemical characteristics.

Calero Reservoir. In four samples of water collected from this reservoir in 1971, TDS ranged from 180 to 290 mg/l and the water was hard to very hard (160 to 320 mg/l as CaCO₃). Mercury concentration in the flesh of a largemouth bass (*Micropterus salmoides*) collected from the reservoir in April 1971 was 5.1 µg/g, which is above the acceptable limit of 0.5 µg/g. Most of the other fish flesh analyzed also exceeded this limit. Warnings of mercury contamination were posted at the reservoir.

Lexington Reservoir. This reservoir on Los Gatos Creek, which is geochemically similar to Alamitos Creek, also was sampled four times in 1971. TDS varied from 170 to 360 mg/l and total hardness from 160 to 310 mg/l. In 1971 and 1972, mercury was detected in the tissue of nearly all fish sampled. About 40 percent of the tissue samples exceeded the mercury concentration limit of 0.5 µg/g, with the highest concentration of mercury being 0.9 µg/g.

Anderson Reservoir. This reservoir impounds Coyote Creek water derived from a geochemical province quite different from the foregoing two. The reservoir was sampled four times in 1971, showing TDS from 200 to 230 mg/l and hard water 160 to 180 mg/l as CaCO₃). Mercury concentrations in fish flesh were below the acceptable limit of 0.5 µg/g.

Quality of Imported Water

The quality of water imported from the Sacramento-San Joaquin Delta is influenced by climatic conditions, irrigation return flow, municipal and industrial waste discharges, and tidal inflow from the Bay. There is a marked seasonal variation. TDS, for example, range from less than 200 mg/l in spring and early summer to more than 400 mg/l in fall and winter. There is also a seasonal change in the predominant ions. For example, in December 1968 chloride was the predominant anion; in August 1969 bicarbonate predominated. Typically, the sodium content ranges from about 30 to 60 percent.

Water imported by the City of San Francisco and served in the Santa Clara Valley is a mixture from two sources: the Hetch Hetchy Project on the upper Tuolumne River and surface water from Alameda and Santa Clara Counties. Both water types are of calcium-bicarbonate character, but the TDS of Hetch Hetchy water is about 30 mg/l, and that of Alameda County water ranges from 150 to 450 mg/l. Based upon the usual proportions of these sources served in the Santa Clara Valley, the average of the delivered water from the City of San Francisco is about 60 mg/l of TDS.

Quality of Ground Water

Ground water in most of the major producing aquifers, although hard, is of good to excellent mineral quality and suitable for most uses. It is generally bicarbonate in type, with sodium and calcium the predominant cations. TDS in most ground water ranges from about 300 to 600 mg/l. Ground water of inferior quality occurs in the saline water intrusion zone, in formations containing connate water, and in the Penitencia Creek alluvial fan.

The saline water intrusion zone extends inland from the Bay to approximately the Bayshore and Nimitz Freeways. Generally, shallow aquifers, those less than 100 feet (30 meters) deep and adjacent to tidal inlet streams, have been affected. Some degradation of deeper aquifers also has occurred, probably by interchange of water between the upper and lower aquifers through improperly constructed or abandoned wells. At some locations, chloride concentrations in the shallow aquifers exceed 1,000 mg/l. With properly constructed wells, ground water of good quality can be obtained from the deeper aquifers, and that of satisfactory quality from the shallow aquifers in a considerable portion of the area near the Bay.

Formations which yield connate water are the marine deposits of Cretaceous and Tertiary Age. These underlie the fresh ground water body in much of the valley floor area. The Evergreen area is one in which connate water with chloride exceeding 1,000 mg/l has been found at normal production depths of between 300 and 800 feet (100 to 240 meters). This saline water is under artesian head with the potentiometric surface at about the same elevation as the overlying fresh water aquifer. There is also evidence of connate water-bearing deposits at other locations in the valley at depths from about 500 to 1,000 feet (150 to 300 meters).

Ground water containing boron in excess of 1 mg/l has been found in the Penitencia Creek alluvial fan. At least part of this boron can be attributed to the recharge of water from Penitencia Creek which often contains high boron concentrations in excess of 1 mg/l. Although a maximum of 0.5 mg/l is recommended for irrigation, this ground water has been used for agricultural and domestic purposes with no apparent adverse effects.

Minor Elements

A study of minor elements in water of the Santa Clara Valley was conducted by Averett and others (1971). Samples were collected from wells, springs, streams, reservoirs, and imported water. Spectrographic analyses showed wide ranges in concentration of

some minor elements, especially aluminum (.0014 to 1.875 mg/l), iron (.0025 to 1.6 mg/l), manganese (.0014 to 3.23 mg/l), and zinc (.0057 to 3.0 mg/l). Wide variations occurred both within a given sampling station and between different sampling stations. This is not uncommon with minor elements in these concentration ranges and under the heterogeneous environmental conditions which exist in the area. These wide variations can be attributed to a combination of factors including ground and surface water hydrology, geologic variations, effects of well casings and screens, and sampling and analytical procedures. Because of these uncertainties, the report stated that the results must be used with caution.

Data from the comprehensive study by the Geological Survey confirm the general ranges of concentration of minor elements which have been detected in occasional samplings of ground and surface waters by the Department of Water Resources in the area during the past 10 to 15 years. In general, the observed concentrations of minor elements in these waters would not be considered to constitute water quality problems. However, the high values in the ranges of iron and manganese are excessive for domestic water, and those of zinc and manganese would not be recommended for continuous use on agricultural soils.

Consumptive Use and Recharge of Rain and Delivered Water

A basic part of a water inventory is the development of annual values for the depth of consumptive use and recharge of rain and delivered water applied to various land use classes within northern Santa Clara County. Consumptive use is defined as the amount of water used by the vegetative growth of a given area in transpiration, building of plant tissue, and evaporated from adjacent soil. It also includes the water evaporated in industrial processes, household use, or permanently incorporated in a product. Delivered water is that delivered by man-made works to a given land use. A portion of the rainfall on the alluvial surfaces becomes consumptive use or recharge. The remaining is runoff out of the area.

A computerized method of determining the disposition of precipitation and delivered water applied to irrigated lands was used in this study. The method compared the available moisture against the demand for water in the root zone on a monthly basis during the winter season and as a lump sum for the growing season.

Evaporation

The first demand on available moisture is evaporation. Daily evaporation data are available from Weather Bureau evaporation stations in the study area for years since 1960. The measured evaporation pan rates have been corrected to water surface evaporation rates by use of monthly pan evaporation constants.

From the evaporation record, average rates of evaporation are determined for each month of each year for storm periods and non-storm periods. Daily evaporation rates are shown on Table 12.

Evaporation from individual storms on the valley floor is computed in the following manner.

1. An individual storm is considered to be a period of rainfall that is separated from another by at least two days of zero precipitation.
2. The daily rate of evaporation from all surfaces during and after storm periods is assumed equal to the average daily pan rate during like periods.
3. On pervious areas, the evaporation computation consisted of two parts: (1) during storm periods, the evaporation is computed using the daily evaporation rates shown on Table 12 for storm periods for the number of days in which precipitation occurred; and (2) after storm periods, the evaporation is computed using the after-storm rate, up to a total of 0.060 inch (1.53 mm), if available, or until another storm occurred. The sum of the two parts is the total evaporation for an individual storm from pervious areas. The 0.060 inch (1.53 mm) maximum is based on data published in State Division of Water Resources Bulletin No. 33, which notes that the average evaporation loss from the topsoil is one-half acre-inch per acre (17.7 cm) after each rainstorm, although the total evaporation after a storm may amount to 0.070 inch (1.77 mm).
4. On impervious areas, the evaporation is computed using the daily evaporation rate for storm periods for the number of days in which precipitation occurred; and (2) after storm periods, the evaporation is computed using the after-storm rate until the sum of the two parts amounts to a maximum of 0.050 inch (1.27 mm) or until another storm occurs. The maximum of 0.050 inch (1.27 mm) is exceeded only when the storm period is sufficiently long so that the evaporation during the storm exceeds 0.050 inch (1.27 mm). In such instances the evaporation after storms is considered to be zero.
5. When the evaporation rate exceeds the daily precipitation, the amount of the latter is taken as the daily evaporation.

TABLE 12
AVERAGE DAILY EVAPORATION RATES

Month	During Storm	Non-Storm	Month	During Storm	Non-Storm
<u>(Inches)</u>					
October	0.023	0.598	April	0.067	0.154
November	0.026	0.031	May	0.052	0.175
December	0.014	0.015	June	0.053	0.207
January	0.027	0.026	July	0.043	0.180
February	0.045	0.068	August	0.043	0.163
March	0.057	0.102	September	0.043	0.134
<u>(Millimeters)</u>					
October	0.59	1.51	April	1.70	3.91
November	0.66	0.79	May	1.32	4.45
December	0.35	0.38	June	1.35	5.25
January	0.94	0.66	July	1.09	4.55
February	1.14	1.73	August	1.09	4.15
March	1.45	2.59	September	1.09	3.40

Evapotranspiration

The potential amounts of moisture that can become evapotranspiration are affected by both climatic and plant factors. Monthly evapotranspiration rates for various crops have been determined for the Central Valley area and published in DWR Bulletin No. 113-2, "Vegetative Water Use", August 1967. The values in the bulletin were modified for use in the Santa Clara area by applying the ratios of the mean temperatures and the percentage of daylight hours for the two areas. The resulting evapotranspiration values for the Santa Clara area are presented in Table 13.

TABLE 13
AGRICULTURAL WATER USE FACTORS
Monthly Evapotranspiration

Month	Improved Pasture*		Alfalfa		Sugar Beets		Deciduous Orchard		Rice		Nonirrigated Barley	
	(in.)	(cm)	(in.)	(cm)	(in.)	(cm)	(in.):(cm)	(in.):(cm)	(in.)	(cm)	(in.)	(cm)
October	3.5	8.89	3.5	8.89	3.5	8.89	2.7	6.86	3.2	8.13	2.0	5.08
November	1.7	4.32	1.7	4.32	1.7	4.32	1.1	2.79	1.5	3.81	1.7	4.32
December	0.9	2.28	0.9	2.28	0.9	2.28	0.9	2.28	0.9	2.28	0.9	2.28
January	1.1	2.79	1.1	2.79	1.0	2.54	1.1	2.79	0.9	2.28	1.1	2.79
February	1.9	4.83	1.9	4.83	1.3	3.30	1.4	3.56	1.6	4.06	1.9	4.83
March	3.1	7.87	2.9	7.37	--	--	2.1	5.33	1.4	3.56	3.1	7.87
April	4.6	11.68	4.1	10.41	--	--	3.2	8.13	4.3	10.92	3.4	8.64
May	5.7	14.48	5.1	12.95	1.7	4.32	4.6	11.68	7.1	18.03	1.2	3.05
June	7.3	18.54	6.5	16.51	5.6	14.22	6.2	15.75	8.9	22.61	0.4	1.02
July	7.4	18.80	6.8	17.27	7.7	19.56	6.8	17.27	9.0	22.86	0.0	0.00
August	6.5	16.51	6.2	15.75	6.6	16.76	5.8	14.73	7.7	19.56	0.0	0.00
September	4.9	12.45	4.8	12.19	5.3	13.46	4.3	10.92	6.1	15.49	0.3	0.76

*Improved pasture considered equivalent to potential evapotranspiration.

AVAILABLE WATER-HOLDING CAPACITY OF SOILS^{1/}

Soil Type	Cubic inches per foot of depth		Cubic centimeters per meter of depth		Soil Type	Cubic inches per foot of depth		Cubic centimeters per meter of depth	
Sand	1.0		578.9		Silty Clay	1.7		984.1	
Clay	1.0-1.5		578.9-868.4		Silty Clay Loam	2.0		1157.8	
Clay Loam	1.4		810.5		Silt Loam	2.3		1331.5	
Loam	1.7		984.1		Silt	2.9		1678.8	

^{1/} H. Schulbach, in "Soil and Water", University of California, Agricultural Extension, Winter 1971.

EFFECTIVE ROOTING DEPTH

Irrigated Crop	Effective Root Depth (in.):(cm)		Irrigated Crop	Effective Root Depth (in.):(cm)	
Pasture	24	61	Misc. Truck	36	91
Alfalfa	72	183	Tomatoes	60	152
Sugar Beets	60	152	Orchard, Mixed	72	183
General Field	48	122	Vineyard	60	152
Walnuts	96	244			

Soil Moisture and Effective Root Depth

Soil texture influences the rate of evapotranspiration through its effect on the available water-holding capacity (AWC) of the soil. AWC is defined as the capacity of a soil to retain water that can be readily absorbed by plant roots. It is considered to be water held in the soil against a pressure of 15 bars and is expressed as a percentage of the oven-dry weight of a soil. AWC also can be thought of as the difference between the field capacity and permanent wilting point of a soil.

The effective root depth of crops is variable and is affected by soil depth, moisture penetration, and plant rooting characteristics. Table 13 presents data developed by this Department and by the University of California Agricultural Extension on AWC and rooting depth used in the Santa Clara area. ~~than coarse coarse-textured soils.~~

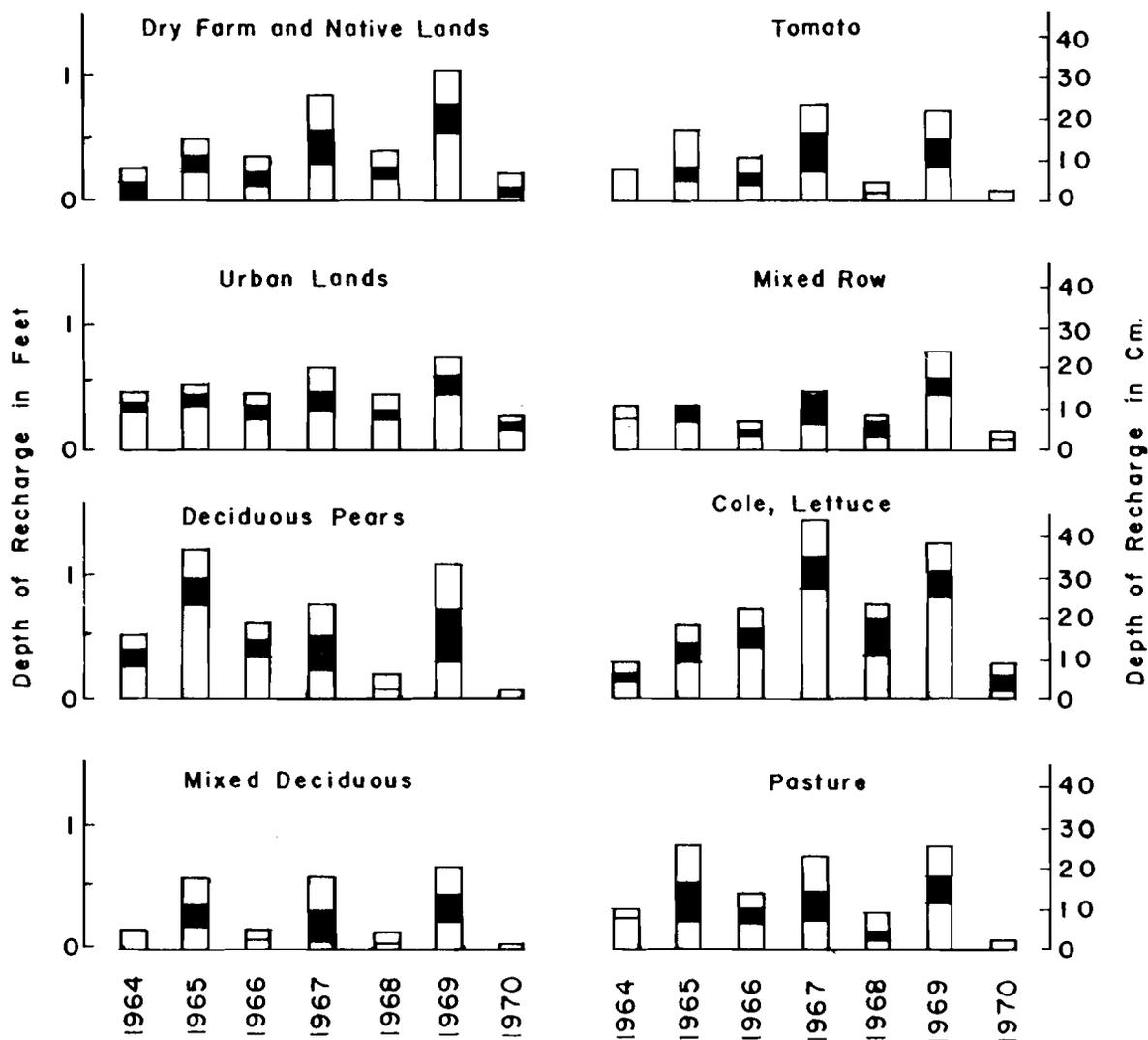
Direct Recharge from Rain and Applied Water

The depth of rain and applied water which becomes recharge was computed for various groups of crop areas. The crops were grouped as follows:

<u>Group</u>	<u>Crops</u>
1	Pears
2	Other deciduous fruit and nut
3	Tomato, sugar beets, asparagus, melons
4	Beans, carrots, peppers, mixed row, and other truck crops
5	Onions, cole, corn, lettuce, potato
6	Flowers, berries
7	Pasture, alfalfa, lawn
8	Vineyards
9	Nonirrigated deciduous fruit and nut
10	Urban
11	Native

? The resulting depths of recharge by the relative wetness of the above groups are shown on Figure 13. The values for the irrigated agricultural groups are combined to obtain the depths of recharge for each node for each year of the study period. The basis for combining values is the crop distribution existing within each node during 1957, which is assumed to exist during the entire study period. For urban areas, the average depth of applied water was assumed to be 3 feet (1 m). The depth of recharge for urban areas and for dry farm or native areas is shown on Figure 13.

Annual amounts of recharge from the combination of rain and applied water was computed for each node as the product of the depth of recharge (in feet) and the area of land use (in acres). The total amount of direct recharge from rain and applied water for the ground water basin is listed in the basin inventory in Table 14.



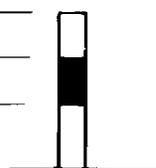
LEGEND

Index of Wetness

140

120

100



DEPTH OF RECHARGE FROM RAIN
AND APPLIED WATER

TABLE 14
GROUND WATER BASIN INVENTORY

Year	Recharge					Pumpage					Net
	Direct	Stream and Pond	Over-land	Compaction	Total	Agri-culture	Water Company	Dom-estic	Indust-rial	Total	
(thousand acre-feet)											
62-63	91.1	118.3	8.2	20.6	238.2	74.7	67.3	0.8	19.5	162.1	76.1
63-64	54.9	62.9	5.9	20.0	143.6	94.1	82.8	0.8	19.5	197.2	-53.6
64-65	68.1	116.3	6.2	20.0	210.6	54.0	76.0	0.5	18.4	148.9	61.7
65-66	49.2	80.5	5.4	20.0	155.1	41.1	87.8	0.9	23.0	152.8	2.3
66-67	73.7	131.4	6.8	20.0	231.9	28.8	79.9	1.1	22.1	131.9	100.0
67-68	44.9	125.0	6.2	10.9	187.0	32.8	113.8	1.1	23.5	171.2	15.8
68-69	95.2	124.8	6.9	0.0	226.9	27.7	100.9	0.9	22.7	152.2	74.7
69-70	47.6	146.5	6.9	0.0	201.0	27.7	97.7	0.9	22.7	148.3	52.7
(cubic hectometers)											
62-63	112.4	145.9	10.1	25.4	293.8	92.1	83.0	0.9	24.1	200.1	93.7
63-64	67.7	77.6	7.3	24.7	177.3	116.1	102.1	0.9	24.1	243.2	-65.9
64-65	84.0	143.5	7.6	24.7	259.8	66.6	93.7	0.6	22.7	183.6	76.2
65-66	60.7	99.3	6.6	24.7	191.3	50.7	108.3	1.1	28.4	188.5	2.8
66-67	90.9	162.1	8.4	24.7	286.1	35.5	98.6	1.4	27.3	162.8	123.3
67-68	55.4	154.2	7.6	13.4	230.6	40.5	140.4	1.4	29.0	211.3	19.3
68-69	117.4	153.9	8.5	0.0	279.8	34.2	124.5	1.1	28.0	187.8	92.0
69-70	58.7	180.7	8.5	0.0	247.9	34.2	120.5	1.1	28.0	183.8	64.1

Stream and Pond Recharge

In the study area, reservoirs in the tributary hill areas store runoff for later release to permeable valley areas for recharge. In addition, a portion of the imported water is delivered to ponds for recharge. The flow in streams on the valley floor is computed by estimating streamflow tributary to the ground water area (see Table 5) and adding local runoff from drainage areas within the ground water area.

The method used to estimate recharge of streamflow and imported water percolating in stream channels and percolation pond areas is described in following paragraphs. In addition to recharge

in streams and ponds, some of the local runoff infiltrates on its overland path from the area where direct recharge occurs to the main channels. Based on detailed analysis in Alameda County by the Department of Water Resources (1973), 30 percent of the rain and applied water remaining (after deductions for direct recharge and evapotranspiration) was estimated to be recharge during overland flow. The annual amounts are listed as part of the basin inventory in Table 14.

Recharge was estimated for each node using information on the type and size of drainage channels shown on Figure 14, analysis of flow duration and percolation rate data in District files, and where possible, was checked for aggregations of nodes by use of stream gages up and downstream from such aggregations. Stream recharge was apportioned to a node in terms of the area of the stream reach contained within the node, the estimated percolation rate for the reach, and the flow duration.

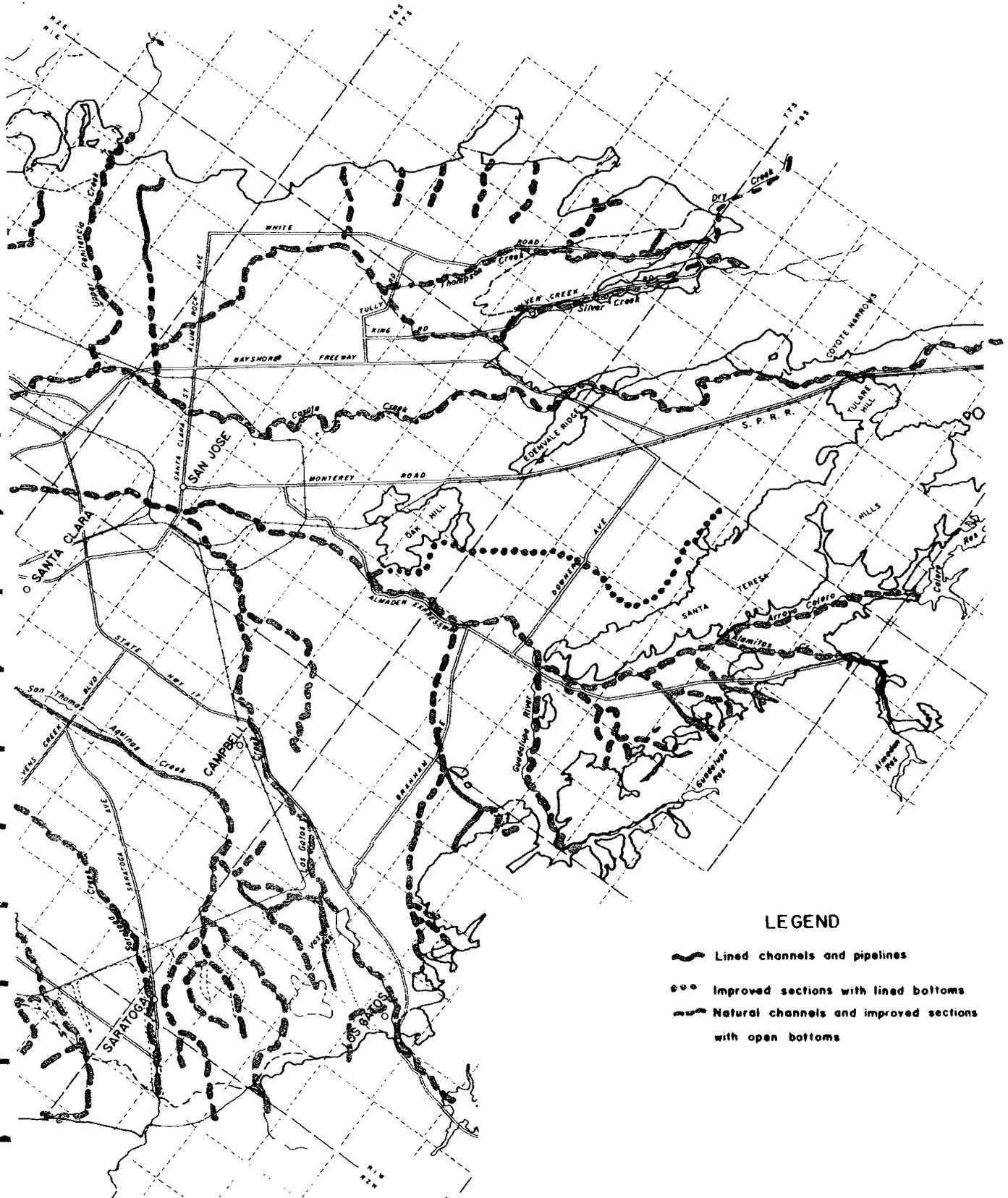
$$\begin{aligned} \text{Nodal Percolation (Ac-Ft)} &= \text{Stream Area within Node} \\ &\quad (\text{Ac}) \times \text{Perc. Rate (Ac-Ft/} \\ &\quad \text{Ac/Day)} \times \text{Flow Duration} \\ &\quad \text{(Days)} \end{aligned}$$

Subject to the condition that the streamflow rate is greater than or equal to the percolation rate, if the streamflow rate is less than the percolation rate, then the percolation rate was assumed to be equal to streamflow rate.

For streams on the west side of the valley, percolation rates were estimated on the basis of gaged data at upstream and downstream locations and estimates of local inflow between the two gaging stations. For streams that do not have gaging stations, nodal percolation rates were based on corresponding values at neighboring nodes, and flow durations were based on gaging stations having drainage area characteristics similar to the area under consideration.

For streams on the east side of the valley, the percolation was obtained as a difference between estimated runoff from the hills and estimated flows reaching the major creeks. Most of smaller streams on the east side do not have well defined channels; the runoff from these streams is mostly spread over the valley floor and is infiltrated, except during periods of heavy rainfall when some runoff would reach the major creeks.

Total recharge in the streams and ponds is the sum of natural recharge and recharge of imported water. These amounts are listed in the basin inventory in Table 14.



LEGEND

-  Lined channels and pipelines
-  Improved sections with lined bottoms
-  Natural channels and improved sections with open bottoms

SANTA CLARA VALLEY

Water from Compaction

The addition of water to aquifers from the compaction of clay members results from the lowering of water levels (and pressures) in these aquifers. The clay members achieve equilibrium through a reduction in pore pressure which causes a reduction of the volume of the clays. The resultant reduced volume is equal to the amount of water released and is reflected in the amount of overlying land subsidence. The amount of land subsidence for the period 1960-67, as developed by the USGS, is shown on Figure 15. A review of well hydrographs and subsidence data was made, and it is concluded that the subsidence rate could be considered a constant for the 1960-67 period, that subsidence stopped in 1969, and that the rate for 1968 could be considered one half of that for previous years. Annual amounts of water from compaction are listed in the basin inventory, Table 14.

Ground Water Basin Inventory

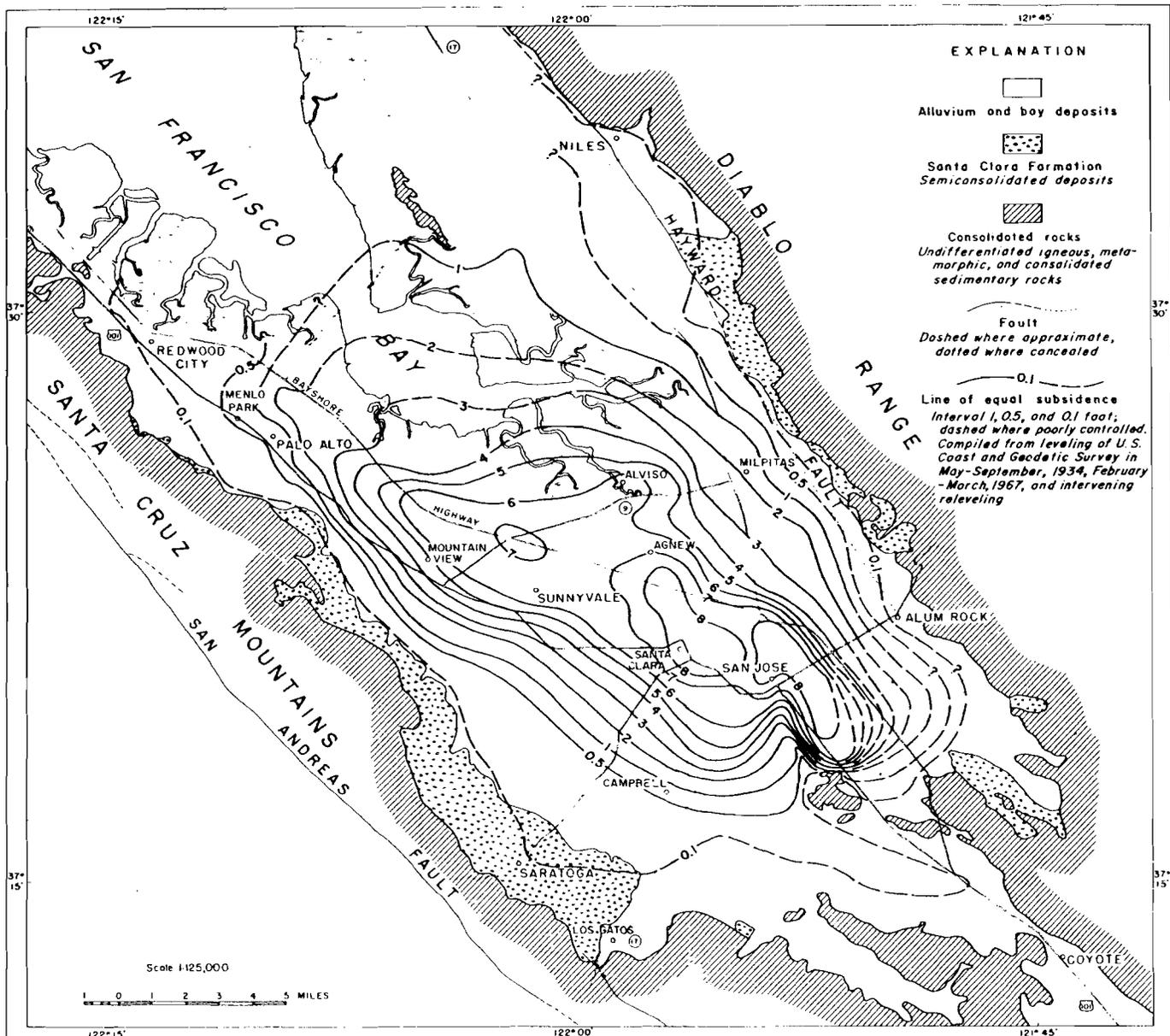
The combination of annual amounts of recharge to and withdrawals from the ground water system is an inventory of the ground water basin and is shown in Table 14. For this study, inflow from and outflow to adjacent areas was assumed to be zero.

Change in Storage

The annual change in the amounts of water in storage in the ground water basin are computed as the product of specific yield and water level changes. The calculations are made for each node and are aggregated to the basin total shown in Table 14. Change in storage calculations are based on water level data for the March through May period to represent the recovered water levels and to eliminate pumping effects as much as possible.

Use of the Ground Water Model

The objective of developing a ground water model is to have a means of testing the effect of changes in recharge and pumping patterns on the ground water system. The model is also useful in verifying the accuracy of the ground water inventory. The fair agreement between the basin inventory and change in storage is shown in Table 15 and on Figure 16 by the comparison of accumulated change in storage and net recharge. It should be noted that each is plotted with respect to its computation period, and what appeared to be a poor match in Table 15 becomes a fair match when time differences are taken into account. To be assured that the hydrology used



DEPARTMENT OF INTERIOR
UNITED STATES GEOLOGIC SURVEY

Compiled by J. F. Poland and R. L. Ireland, March 1968

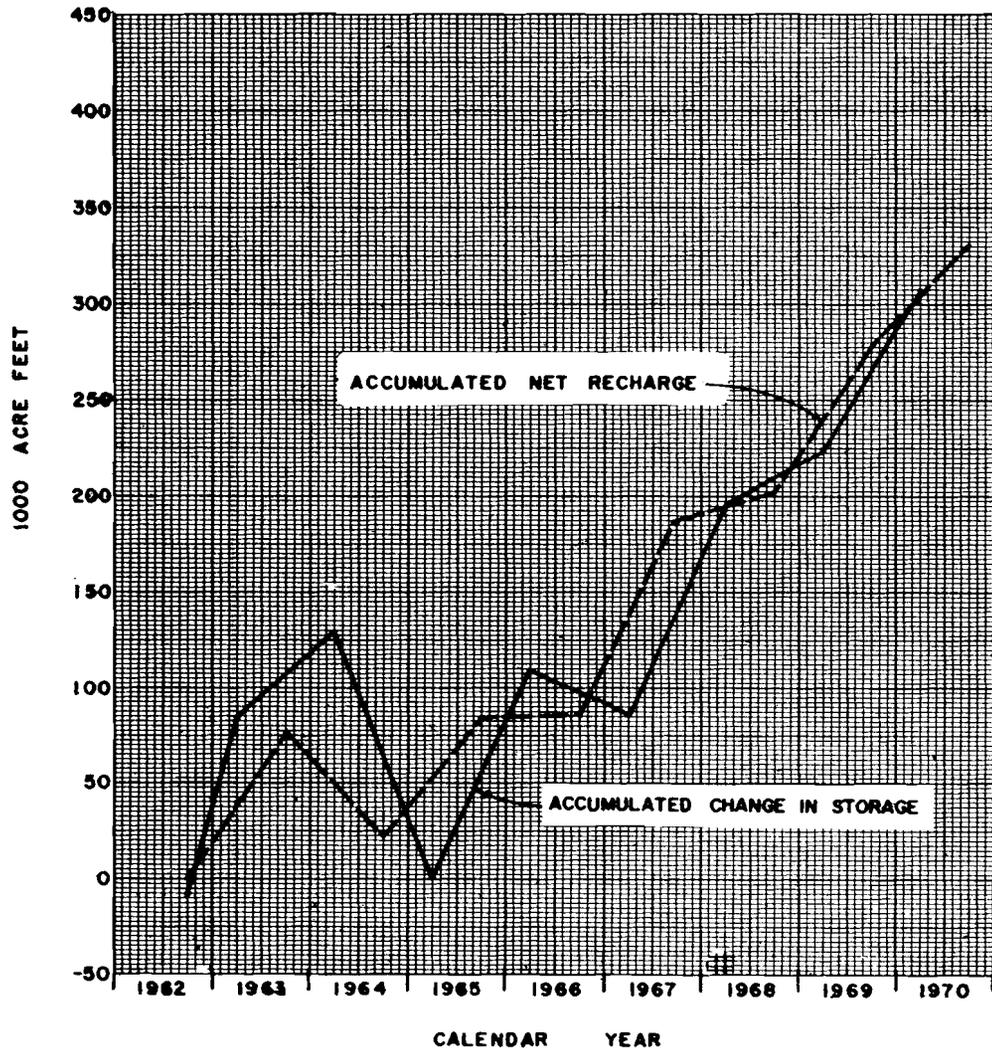
**LAND SUBSIDENCE IN THE SANTA CLARA VALLEY,
ALAMEDA, SAN MATEO, AND SANTA CLARA COUNTIES, CALIFORNIA**

TABLE 15
ACCUMULATED NET RECHARGE AND CHANGE IN STORAGE

Year	Annual Net Recharge ^{a/}	Annual Change in Storage ^{b/}	Accumulated Net Recharge ^{a/}	Accumulated Change in Storage ^{a/}
<u>(thousand acre-feet)</u>				
61-62		-105.5		-105.5
62-63	76.1	194.5	76.1	89.0
63-64	-53.6	40.1	22.5	129.0
64-65	61.7	-128.1	84.2	0.9
65-66	2.3	107.6	86.5	108.5
66-67	100.0	-21.9	186.5	86.6
67-68	15.8	105.3	202.3	191.8
68-69	74.7	31.6	277.0	223.4
69-70	52.7	84.1	329.7	307.5
<u>(cubic hectometers)</u>				
61-62		-130.1		-130.1
62-63	93.9	239.9	93.9	109.8
63-64	-66.1	49.5	27.8	159.1
64-65	76.1	-158.0	103.9	1.1
65-66	2.8	132.7	106.7	133.8
66-67	123.4	-27.0	230.0	106.8
67-68	19.4	129.9	249.5	236.6
68-69	92.1	39.0	341.7	275.6
69-70	65.0	103.7	406.7	379.3

a/ Computed on water year, October 1.

b/ Computed on April 1.



ACCUMULATED NET RECHARGE
AND CHANGE IN STORAGE

is accurate, it is also necessary to obtain a fair match between historic water levels and model output water levels for most of the nodal areas of the model (Figure 7).

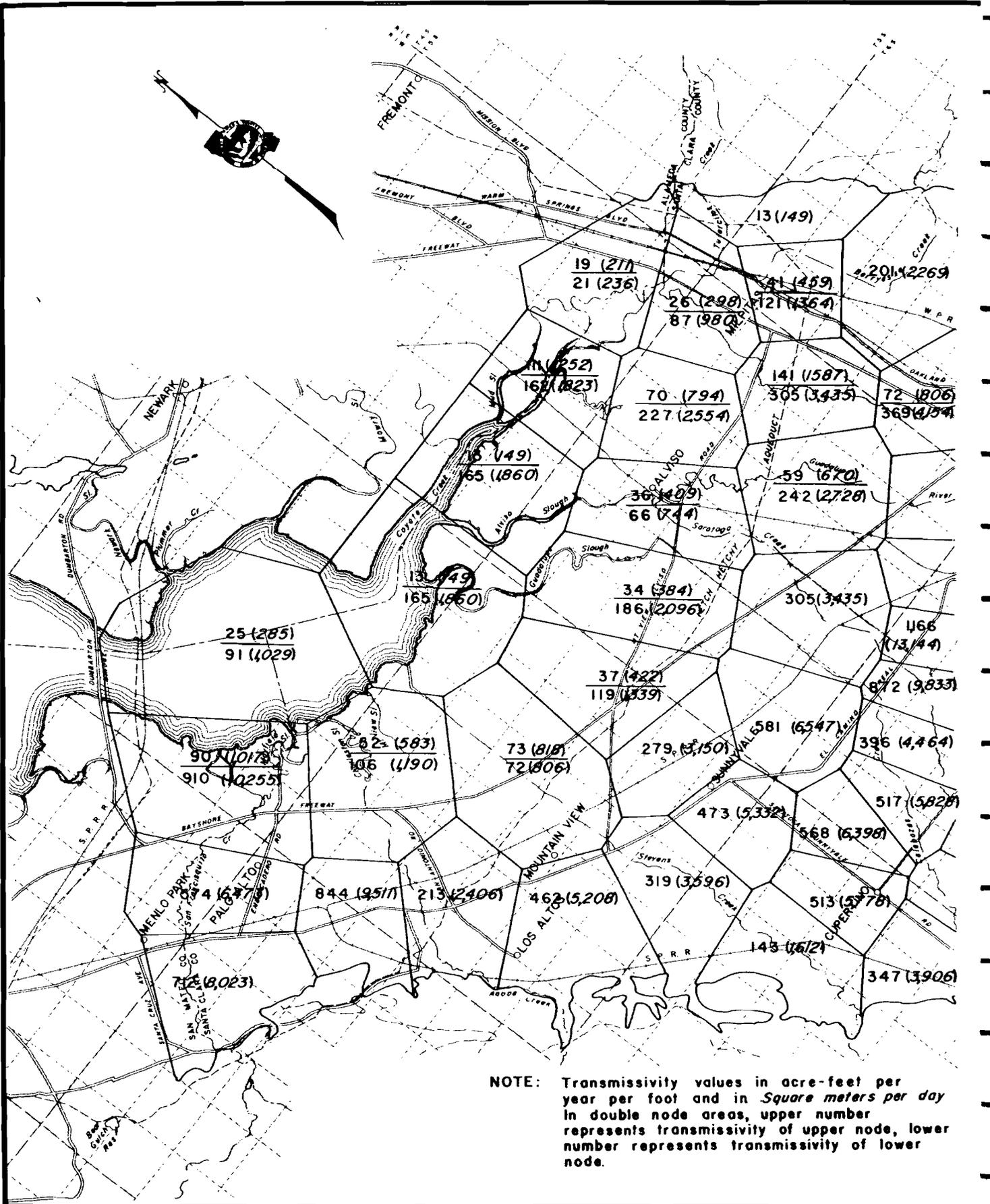
The development of input for each node of the model is identical to computation of net recharge previously described. In addition, during the verification process, some of the transmissivity values between nodes were reduced from the maximum values obtained for the full depth of alluvium to a value that takes into account the effects of faults on ground water movement. The initial transmissivity values used for each node are shown on Figure 17. These values were then modified to obtain the estimated transmissivities along each branch of the nodal system. Branch transmissivities were adjusted for each computer run until the computer output approximated the historic water levels. Table 16 shows the final branch transmissivities; Figure 18 shows the branch numbers used in the model.

The comparison of computed water levels and historic water levels for several nodes is shown on Figure 19. Agreement between these two levels was not possible for many nodes because of a lack of water level data for the study period. Historic water levels probably were affected throughout the study period by potentiometric pressures exerted by the deeper semi-confined and fully-confined aquifers. In addition, changes in pumping patterns during the early part of the study period probably caused significant pressure changes in the deeper aquifers.

Table 16

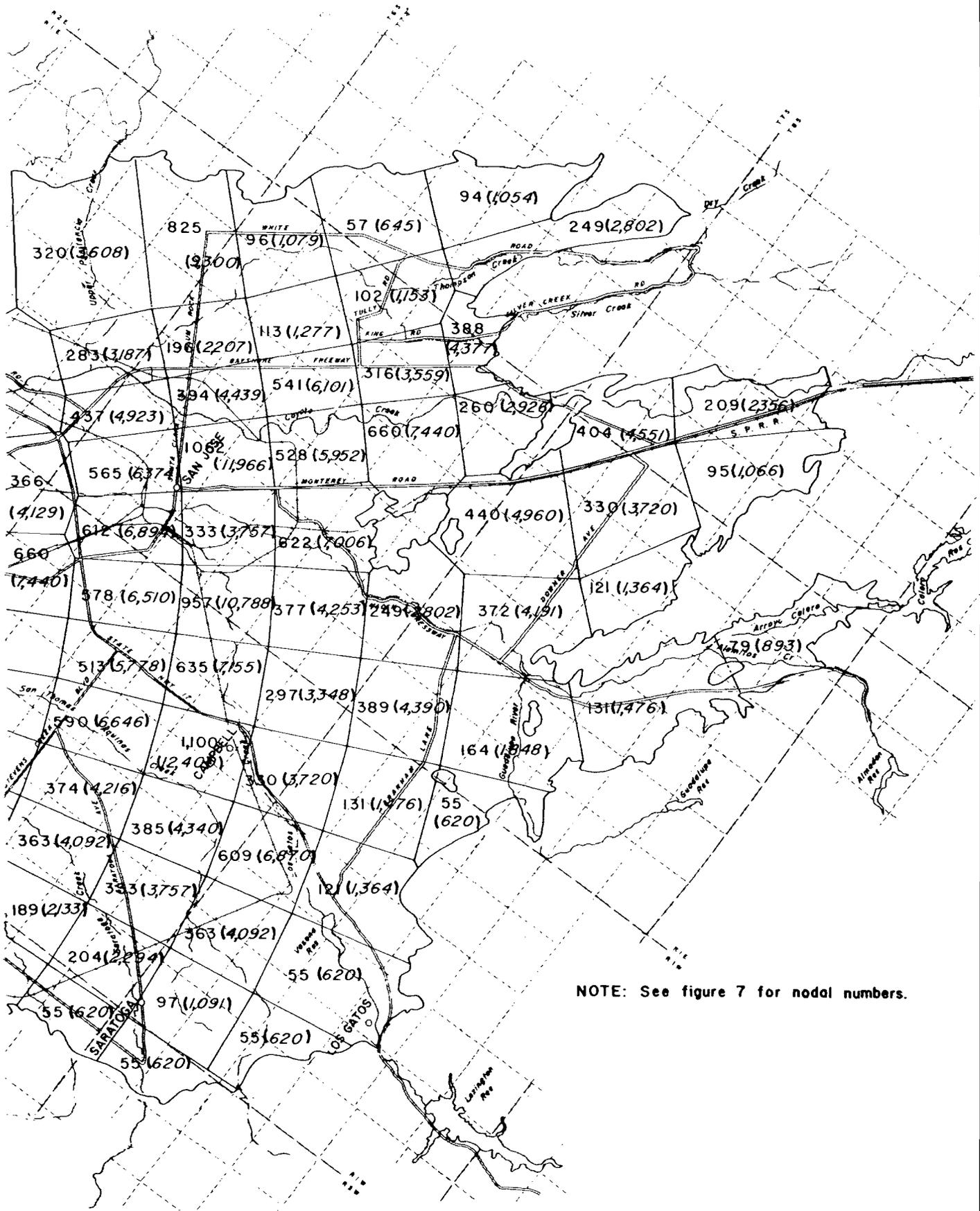
FINAL BRANCH TRANSMISSIVITY USED IN GROUND WATER MODEL

Transmissivity			Transmissivity			Transmissivity			Transmissivity		
Branch No.	Acre-Feet : Per Foot	Square Meters : Per Day	Branch No.	Acre-Feet : Per Foot	Square Meters : Per Day	Branch No.	Acre-Feet : Per Foot	Square Meters : Per Day	Branch No.	Acre-Feet : Per Foot	Square Meters : Per Day
1	3.00	33.26	71	350.00	3880.45	141	15.00	166.30	211	20.00	221.74
2	3.00	33.26	72	515.00	5709.80	142	20.00	221.74	212	10.00	110.87
3	3.00	33.26	73	600.00	6652.20	143	20.00	221.74	213	400.00	4434.80
4	6.00	66.52	74	485.00	5377.19	144	100.00	1108.70	214	300.00	3326.10
5	3.00	33.26	75	77.00	853.69	145	150.00	1663.05	215	350.00	3880.45
6	20.00	221.74	76	77.00	853.69	146	345.00	3825.01	216	350.00	3880.45
7	5.00	55.44	77	50.00	554.35	147	200.00	2217.40	217	10.00	110.87
8	30.00	332.61	78	43.00	476.74	148	350.00	3880.45	218	4.00	44.34
9	10.00	110.87	79	37.00	410.22	149	460.00	5100.02	219	20.00	221.74
10	14.00	155.21	80	37.00	410.21	150	200.00	2217.40	220	95.00	1053.26
11	20.00	221.74	81	13.00	144.13	151	15.00	166.30	221	260.00	2882.62
12	10.00	110.87	82	50.00	554.35	152	15.00	166.30	222	255.00	2827.18
13	10.00	110.87	83	34.00	376.95	153	15.00	166.30	223	350.00	3880.45
14	10.00	110.87	84	280.00	3104.36	154	20.00	221.74	224	500.00	5543.50
15	10.00	110.87	85	220.00	2439.14	155	15.00	166.30	225	200.00	2217.40
16	2.00	22.17	86	450.00	4989.15	156	150.00	1663.05	226	350.00	3880.45
17	6.00	66.52	87	200.00	2217.40	157	15.00	166.30	227	235.00	2605.44
18	30.00	332.61	88	450.00	4989.15	158	250.00	2771.75	228	4.00	44.34
19	55.00	609.78	89	200.00	2217.40	159	20.00	221.74	229	180.00	1995.66
20	40.00	443.48	90	480.00	5321.76	160	550.00	6097.85	230	55.00	609.78
21	15.00	166.30	91	500.00	5543.50	161	300.00	3326.10	231	155.00	1718.48
22	55.00	609.78	92	595.00	6596.76	162	400.00	4434.80	232	60.00	665.22
23	18.00	199.56	93	550.00	6097.85	163	360.00	3991.32	233	260.00	2882.62
24	2.00	22.17	94	400.00	4434.80	164	500.00	5543.50	234	45.00	498.91
25	10.00	110.87	95	575.00	6375.02	165	20.00	221.74	235	180.00	1995.66
26	1.00	11.08	96	210.00	2328.27	166	20.00	221.74	236	160.00	1773.93
27	25.00	277.17	97	150.00	1663.05	167	15.00	166.30	237	300.00	3326.10
28	13.00	144.13	98	280.00	3104.36	168	15.00	166.30	238	125.00	1385.87
29	23.00	255.00	99	340.00	3769.58	169	15.00	166.30	239	170.00	1884.79
30	125.00	1385.87	100	350.00	3880.45	170	5.00	55.43	240	250.00	2771.75
31	31.00	343.69	101	335.00	3714.14	171	1.00	11.08	241	145.00	1607.61
32	155.00	1718.48	102	640.00	7095.68	172	15.00	166.30	242	210.00	2328.27
33	26.00	288.26	103	670.00	7428.29	173	20.00	221.74	243	185.00	2051.09
34	215.00	2383.70	104	700.00	7760.90	174	470.00	5210.89	244	120.00	1330.44
35	36.00	399.13	105	660.00	7317.42	175	15.00	166.30	245	150.00	1663.05
36	100.00	1108.70	106	660.00	7317.42	176	15.00	166.30	246	85.00	942.39
37	120.00	1330.44	107	800.00	8869.60	177	1.00	11.08	247	90.00	997.83
38	87.00	964.56	108	400.00	4434.80	178	5.00	55.43	248	120.00	1330.44
39	60.00	665.22	109	110.00	1219.57	179	25.00	277.17	249	205.00	2272.83
40	75.00	831.52	110	135.00	1496.74	180	80.00	886.96	250	125.00	1385.87
41	70.00	776.09	111	4.00	44.34	181	56.00	620.87	251	65.00	720.65
42	72.00	798.26	112	125.00	1385.87	182	72.00	798.26	252	88.00	975.65
43	57.00	631.95	113	50.00	554.35	183	124.00	1374.78	253	65.00	720.65
44	45.00	498.91	114	300.00	3326.10	184	48.00	532.17	254	500.00	5543.50
45	80.00	886.96	115	200.00	2217.40	185	77.00	853.69	255	125.00	1385.87
46	65.00	720.65	116	435.00	4822.84	186	50.00	554.35	256	145.00	1607.61
47	75.00	831.52	117	825.00	9146.77	187	55.00	609.78	257	550.00	6097.85
48	50.00	554.35	118	600.00	6652.20	188	25.00	277.17	258	685.00	7594.59
49	20.00	221.74	119	575.00	6375.02	189	75.00	831.52	259	259.00	2871.53
50	100.00	1108.70	120	800.00	8869.60	190	35.00	388.04	260	265.00	2938.05
51	350.00	3880.45	121	700.00	7760.90	191	90.00	997.83	261	215.00	2383.70
52	100.00	1108.70	122	600.00	6652.20	192	70.00	776.09	262	170.00	1884.79
53	375.00	4157.62	123	500.00	5543.50	193	75.00	831.52	263	495.00	5488.06
54	300.00	3326.10	124	245.00	2716.31	194	65.00	720.65	264	75.00	831.52
55	410.00	4545.67	125	45.00	498.91	195	45.00	498.91	265	.08	0.88
56	285.00	3159.79	126	55.00	609.78	196	110.00	1219.57	266	.04	0.44
57	145.00	1607.61	127	40.00	443.48	197	200.00	2217.40	267	.05	0.55
58	200.00	2217.40	128	30.00	332.61	198	57.00	631.95	268	.05	0.55
59	400.00	4434.80	129	5.00	55.43	199	30.00	332.61	269	.03	0.33
60	450.00	4989.15	130	4.00	44.34	200	62.00	687.39	270	.04	0.44
61	200.00	2217.40	131	20.00	221.74	201	40.00	443.48	271	.04	0.44
62	105.00	1164.13	132	50.00	554.35	202	300.00	3326.10	272	.04	0.44
63	415.00	4601.10	133	125.00	1385.87	203	25.00	277.17	273	.04	0.44
64	200.00	2217.40	134	200.00	2217.40	204	90.00	997.83	274	.01	0.11
65	290.00	3215.23	135	700.00	7760.90	205	495.00	5488.06	275	.02	0.22
66	600.00	6652.20	136	770.00	8536.99	206	80.00	886.96	276	.04	0.44
67	300.00	3326.10	137	440.00	4878.28	207	590.00	6541.33	277	.03	0.33
68	720.00	7982.64	138	670.00	7428.29	208	80.00	886.96	278	.04	0.44
69	350.00	3880.45	139	580.00	6430.46	209	57.00	631.95	279	.03	0.33
70	810.00	8980.47	140	200.00	2217.40	210	225.00	2494.57	280	.02	0.22
									281	.02	0.22



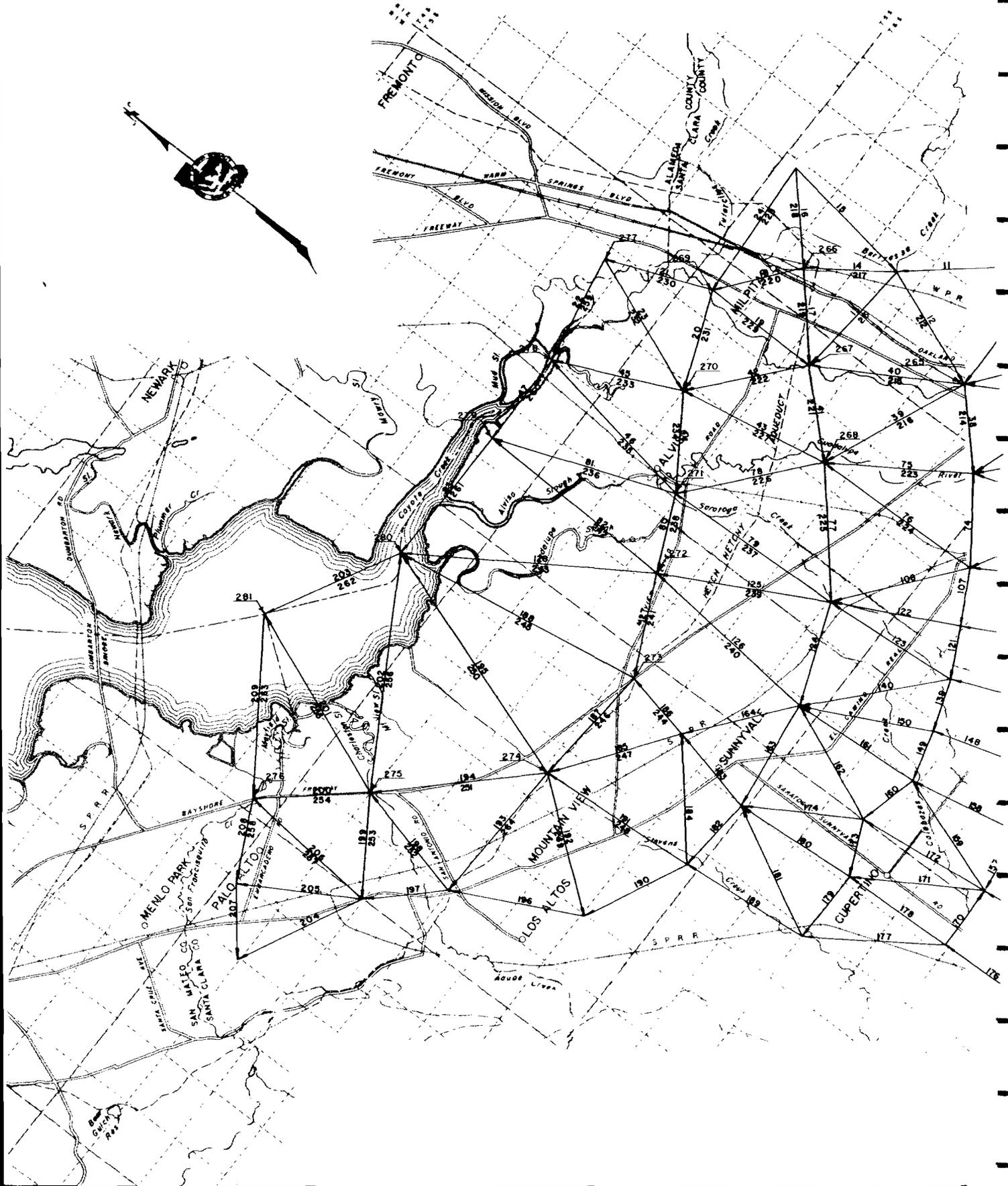
NOTE: Transmissivity values in acre-feet per year per foot and in Square meters per day in double node areas, upper number represents transmissivity of upper node, lower number represents transmissivity of lower node.

INITIAL TRANS-

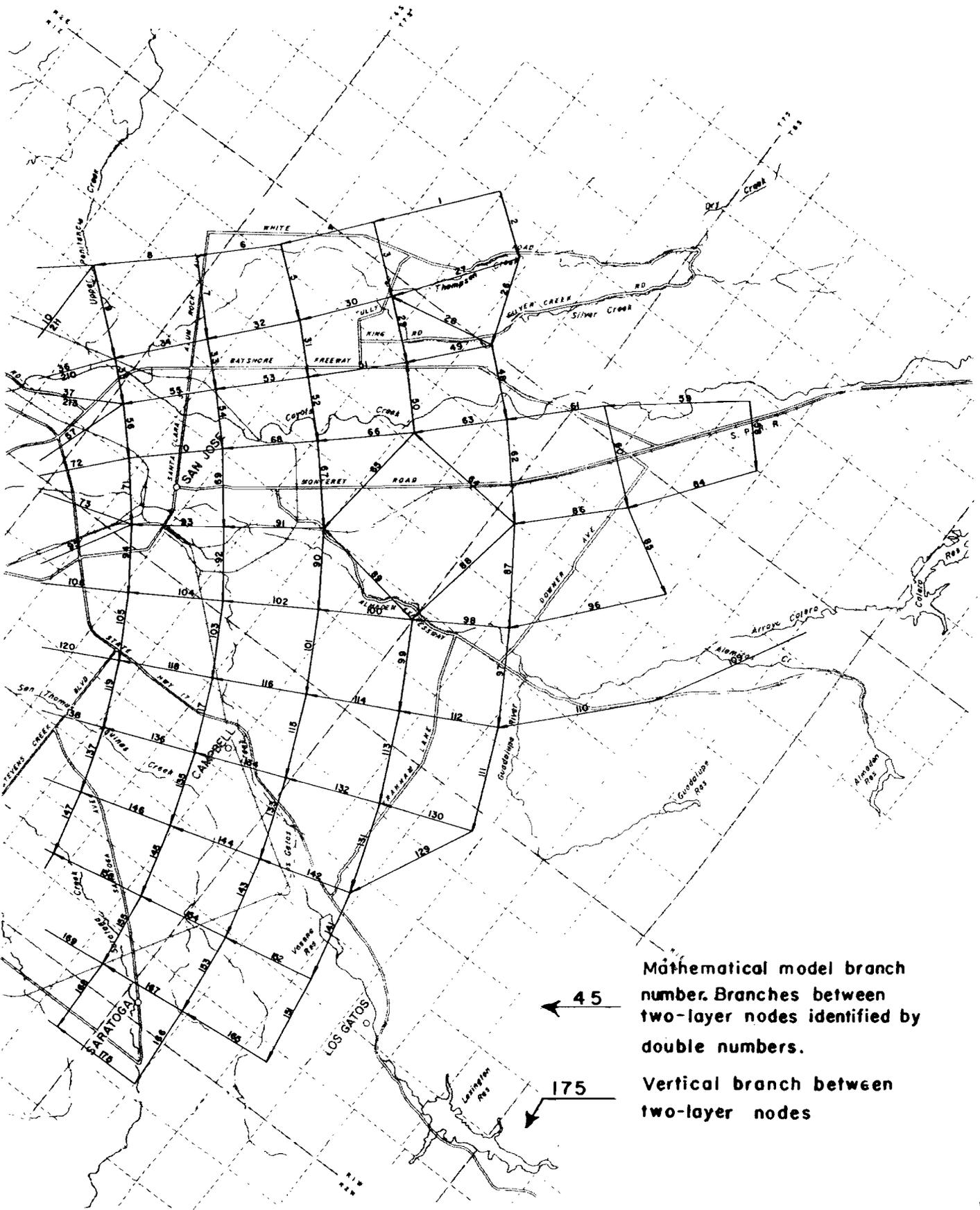


NOTE: See figure 7 for nodal numbers.

MISSIVITY VALUES



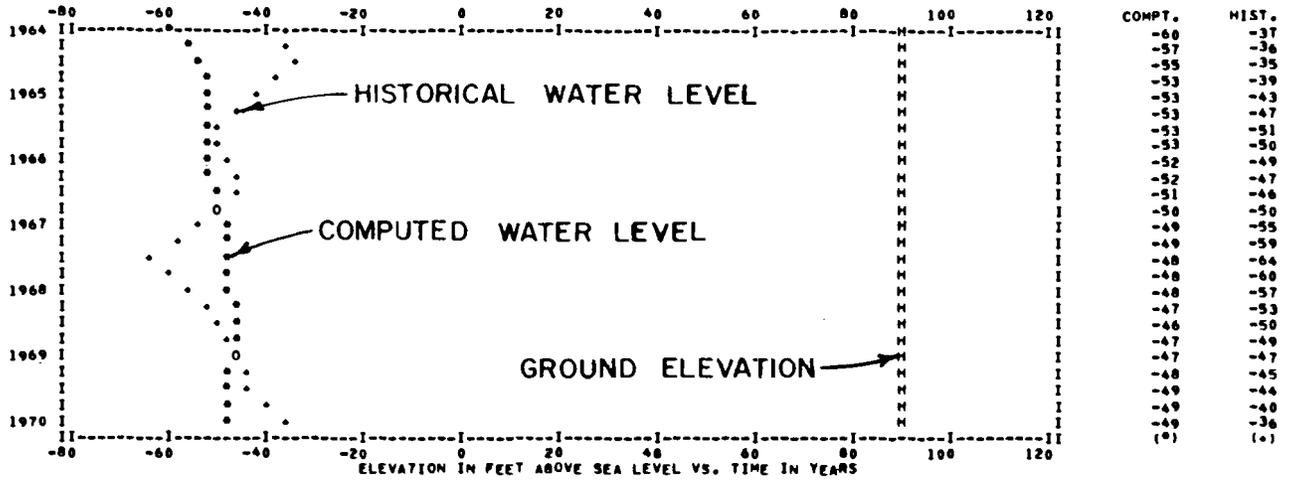
MATHEMATICAL MODEL



BRANCH NUMBERS

NODE 20

NORTH SANTA CLARA GROUND WATER MODEL WITH ORIGINAL WATER LEVELS



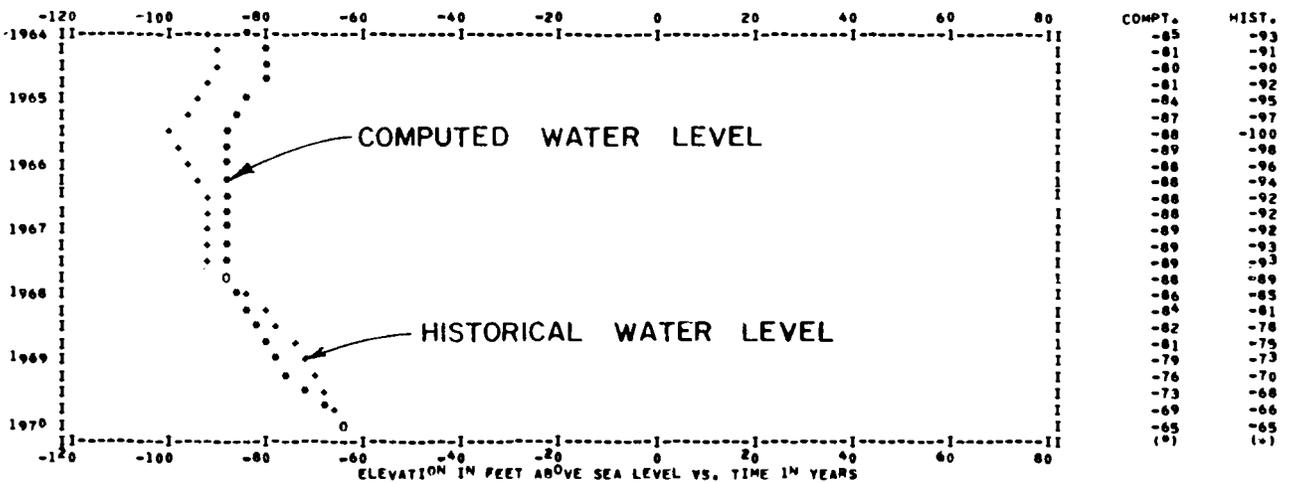
BOTTOM AQUIFER ELEVATION= -500

TOP AQUIFER ELEVATION= 90

(COMPT)-(HIST)= -13

NODE 70

NORTH SANTA CLARA GROUND WATER MODEL WITH ORIGINAL WATER LEVELS



BOTTOM AQUIFER ELEVATION= -670

TOP AQUIFER ELEVATION= 150

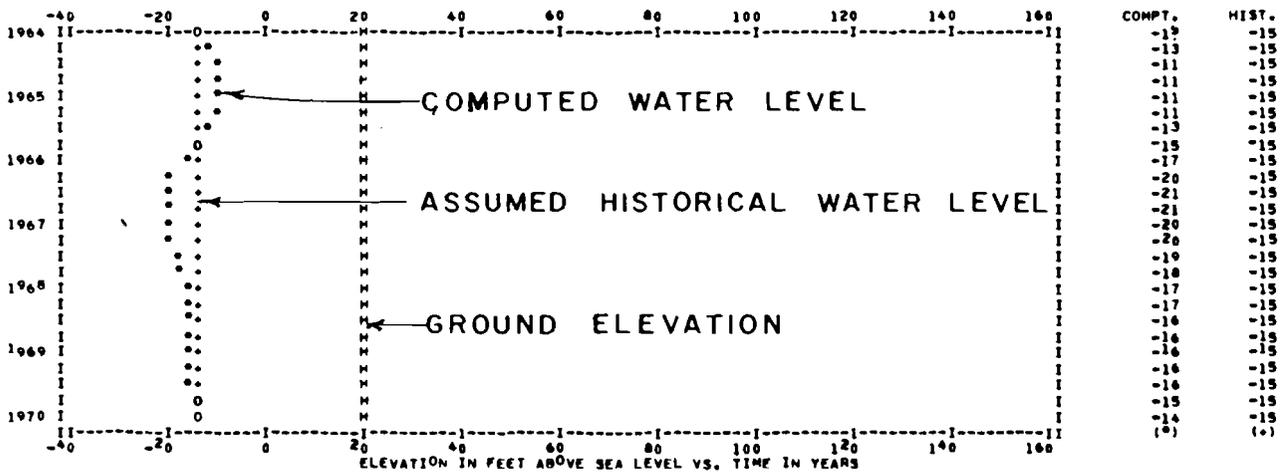
(COMPT)-(HIST)= 0

For nodal locations, see figure 7

FINAL COMPUTER

NODE 10 (UPPER NODE)

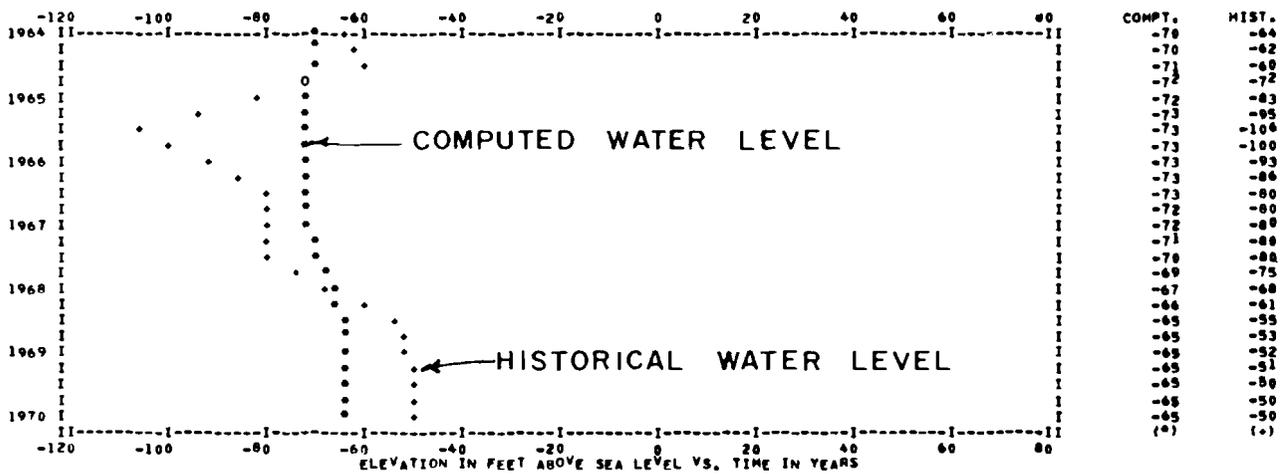
NORTH SANTA CLARA GROUND WATER MODEL WITH ORIGINAL WATER LEVELS



BOTTOM AQUIFER ELEVATION= -100 TOP AQUIFER ELEVATION= 20 (COMPT)-(HIST)= 1

NODE 102 (LOWER NODE)

NORTH SANTA CLARA GROUND WATER MODEL WITH ORIGINAL WATER LEVELS



BOTTOM AQUIFER ELEVATION= -650 TOP AQUIFER ELEVATION= -190 (COMPT)-(HIST)= -15

NOTE: Nodes 10 and 102
comprise a two layer
node.

OUTPUT



CHAPTER V. GROUND WATER BASIN SURVEILLANCE SYSTEM

During the 1950's, surveillance of ground water in Santa Clara County consisted of measuring the static and pumping depths to the water surface and analysis of the water being pumped. Because the intent of the program was only to monitor the water coming from the well, little attention was given to the individual aquifer, or group of aquifers, producing the water. Since that time, however, increasing interest and concern has been placed on all of the ground water resources of California. As a result, there was and is a need to know considerably more about the ground water resource -- how water infiltrates to the ground water body, how and by what paths it moves from point to point through the ground water body, how it can become polluted or degraded, and the effects of its removal from the ground water body. This last item was of particular importance in Santa Clara County because overpumping of the ground water basin had caused land subsidence, and there was an urgent need to develop plans to prevent further subsidence.

Data required to adequately monitor the Santa Clara Valley ground water basin include the following eight items:

1. Pumpage. Metered ground water pumpage by water year (October through September) is necessary to enable the accurate determination of an annual water balance; metered pumpage by season will be necessary in formulating operational plans because the ground water resource is intensely used and responds rapidly to changes in pumping rates.
2. Unconfined Water Levels. Periodic ground water elevation data for selected locations in the unconfined ground water zone will be necessary to accurately determine change in storage. Most elevation determinations can be seasonal, but a few continuous recorders are necessary in order to determine if the seasonal measurements were taken during periods of maximum recovery and lowering of water levels.
3. Confined Water Levels. Elevation data of the confined potentiometric surface should be developed on a seasonal basis. These data are needed to help define the degree of ground water movement between the various confined aquifer systems by providing data on pressure differences between aquifers.
4. Surface Inflow. A sufficient number of gaging stations along the perimeter of the ground water basin are required to form reliable estimates of flow, by correlation, of all ungaged streams. A reliable streamflow station at Coyote Narrows will provide much-needed data on surface inflow to the basin.

5. Local Runoff. A series of areas representing differing natural and developed areas should be instrumented with precipitation and flow instruments to determine contribution of valley areas to streamflow. Such areas could also be used to develop and test methods of increasing recharge on urban lands by use of landscaping techniques. These techniques would include use of native plants to reduce water use and grading to retain storm waters on pervious areas.
6. Artificial Recharge. Accurate inflow and outflow measurements for all percolation facilities, including both ponds and streams, are necessary to provide reliable data on the quantity of water recharged artificially to the basin.
7. Surface Outflow. A sufficient number of gages on streams draining into the Bay are required to provide reliable estimates of quantities of surface water leaving the basin. Along with data from 4, 5, and 6, reasonable estimates of total recharge can be made.
8. Transmissivity. A program of field testing of selected water wells would provide accurate data on aquifer transmissivities.
9. Water Quality. Monitoring of both surface and ground water quality is necessary to determine the health of the basin and to detect possible threats before they proceed beyond control. Quality data for each surface water measuring station, taken for a wide range of flows, will provide information on fluctuations of mineral constituents entering and leaving the basin. Similar data from each monitoring well will provide data on the mineral characteristics of the various parts of the aquifer system. The frequency of sampling and the analyses for specific mineral constituents will vary widely depending on location and development pattern.

During the conduct of the study, it was apparent that of all the above data requirements, the two needing immediate attention are the unconfined water levels (No. 2) and water quality (No. 9).

The balance of this chapter discusses design of a basic ground water measurement network and implementation of such a network for the unconfined zone. Design for water quality purposes is more complicated than design of a quantity measurement network since it must incorporate the influences of soils, vegetation, geology, geomorphology, hydrology, and land use. The design of a water quality surveillance network is not discussed in this report but is the objective of a separate cooperative study.

Water Level Measurements

A data gathering system which will provide information on the elevation of the upper surface of the free (unconfined) ground water body must be based on the following: (1) adequate knowledge

of the subsurface geology, (2) adequate knowledge of the subsurface hydrology, and (3) adequate knowledge of construction details of each monitoring well. The first two requirements have been met by the study reported on in this bulletin. An appraisal of the existing ground water level network was made in order to evaluate the third requirement. All of the wells used for measuring ground water levels during the period 1962 through 1972 were reviewed. So that a meaningful relationship between water levels and aquifers can be developed, it is necessary that both a driller's log and construction details be available for each well that is measured. Of the 482 wells from which water level data were available for the study period, only 183 had construction details available. Of the remaining, water level data were available from 95 wells for which total depth was unknown.

A further requirement in the determination of the configuration of the unconfined ground water surface is that the monitoring wells should tap only those aquifers which do not have any significant degree of confinement. In North Santa Clara Valley, wells that are generally deeper than about 300 feet will be drawing water from aquifers that are under some degree of confinement. A review of the monitoring well data indicated that there were very few wells being measured that have logs and are less than 300 feet deep. This lack of qualified measuring wells and meaningful water level data was the prime reason that the mathematical model could not be fully verified. Table 17 lists wells that were measured during the study period and those measured through 1974. Shown in the table is information on the availability of construction data. Because of the general lack of adequate construction data for the wells measured, it is not possible to incorporate the majority of them into a meaningful water-level measurement network. Hence, a new water level measurement network should be implemented.

Well Qualification

The first step in selecting wells for a new measurement network is determining what aquifer, or group of aquifers, the measurements of the well would represent. This step is called well qualification. A qualified well is defined as being one that meets all of the following criteria:

1. Well is accurately located. This is essential, because where several wells are grouped in a cluster, measurements may not always be for the same well.
2. Well log is available and on file with agency performing monitoring operations. Electric log of well, although not entirely necessary, is desirable.
3. Well construction data are available to agency performing monitoring operations.

TABLE 17

NORTH SANTA CLARA WELL QUALIFICATION LISTING

WELL LOCATION NUMBER	PERIOD OF RECORD	DEPTH IN FEET	PERFORATED INTERVAL IN FEET	REMARKS
5S 1E31E01	62-71	200		DESTROYED
5S 1E31R01	62-71	160		NO CONSTRUCTION DATA
5S 1W36E01	71-	392		CONFIDENTIAL LOG
5S 2W32F10	71-	218	185-198	
5S 2W34N01	71-	84	77-82	
5S 2W34N02	71-	262	177-184	
5S 2W35R01	71-	280	190,280	
5S 2W35R02	71-	80	60	
6S 1E04Q01	70-			NO CONSTRUCTION DATA
6S 1E05P01	70-72	752		NO CONSTRUCTION DATA
6S 1E05Q02	53-	200		NO CONSTRUCTION DATA
6S 1E06N01	70-			NO CONSTRUCTION DATA
6S 1E06P02	59-	125		NO CONSTRUCTION DATA
6S 1E15Q01	53-71	414		DESTROYED
6S 1E16K03	69-	830		CONFIDENTIAL LOG
6S 1E17B01	39-71	565		DESTROYED
6S 1E17G06	69-	652		CONFIDENTIAL LOG
6S 1E17M01	59-	300		NO CONSTRUCTION DATA
6S 1E17P03	70-	450		NO CONSTRUCTION DATA
6S 1E17Q01	70-	81		NO CONSTRUCTION DATA
6S 1E17R01	59-	450		NO CONSTRUCTION DATA
6S 1E17R02	54-71			DESTROYED
6S 1E18K01	70-			NO CONSTRUCTION DATA
6S 1E20H01	69-71			DESTROYED
6S 1E20J01	36-	500		NO CONSTRUCTION DATA
6S 1E20Q02	70-	100		NO CONSTRUCTION DATA
6S 1E21R01	51-	580	186-552	
6S 1E23P01	36-	295		NO CONSTRUCTION DATA
6S 1E27B01	52-	476		NO CONSTRUCTION DATA
6S 1E27E01	69-	400		NO CONSTRUCTION DATA
6S 1E27M02	70-			NO CONSTRUCTION DATA
6S 1E27N02	57-	300		NO CONSTRUCTION DATA
6S 1E27P02	36-	400		NO CONSTRUCTION DATA
6S 1E27Q02	70-			NO CONSTRUCTION DATA
6S 1E28H03	52-	444	215-434	
6S 1E29G06	59-	560	288-535	
6S 1E29J05	36-71	475	181-469	
6S 1E30D10	69-	800		NO CONSTRUCTION DATA
6S 1E30D02	70-	130		NO CONSTRUCTION DATA
6S 1E30M01	36-	206		NO CONSTRUCTION DATA
6S 1E30N01	69-	625	427-615	TOO DEEP FOR NETWORK
6S 1E30R01	51-	238		NO CONSTRUCTION DATA
6S 1E31A02	70-			NO CONSTRUCTION DATA
6S 1E31K02	57-	667	388-642	
6S 1E31M02	70-	86		NO CONSTRUCTION DATA
6S 1E32G01	69-	800	315-745	
6S 1E32M05	70-	110		NO CONSTRUCTION DATA
6S 1E32R01	69-	310		NO CONSTRUCTION DATA
6S 1E33F06	69-	612	267-603	

TABLE 17 (CONTINUED)

NORTH SANTA CLARA WELL QUALIFICATION LISTING

WELL LOCATION NUMBER	PERIOD OF RECORD	DEPTH IN FEET	PERFORATED INTERVAL IN FEET	REMARKS
6S 1E34B01	71-	380	221-367	
6S 1E34B02	36-	400	125-379	
6S 1E34D01	71-			NO CONSTRUCTION DATA
6S 1E34D02	70-			NO CONSTRUCTION DATA
6S 1E34K01	70-			NO CONSTRUCTION DATA
6S 1E34M01	67-	300		NO CONSTRUCTION DATA
6S 1E35M10	69-	550		CONFIDENTIAL LOG
6S 1W01F03	68-			NO CONSTRUCTION DATA
6S 1W05L01	71-	84	74-84	
6S 1W05L02	71-	252	220-252	
6S 1W05L03	71-	336	310-336	
6S 1W09G02	70-	370		CONFIDENTIAL LOG
6S 1W10K01	70-	500		NO CONSTRUCTION DATA
6S 1W10M01	70-	560	228-545	
6S 1W11G02	52-64	570		DESTROYED
6S 1W11P01	57-	525		NO CONSTRUCTION DATA
6S 1W12M02	59-	320		NO CONSTRUCTION DATA
6S 1W12M05	69-	620		NO CONSTRUCTION DATA
6S 1W12R01	39-	280		NO CONSTRUCTION DATA
6S 1W13E01	70-	619	240-586	TOO DEEP FOR NETWORK
6S 1W14L04	70-	90		NO CONSTRUCTION DATA
6S 1W14Q02	57-	516	214-516	
6S 1W15B01	69-			NO CONSTRUCTION DATA
6S 1W15H01	36-	392	228-378	
6S 1W15N01	55-	469	200-460	
6S 1W15Q01	69-	60		NO CONSTRUCTION DATA
6S 1W17M01	60-	600	319-580	TOO DEEP FOR NETWORK
6S 1W19C02	59-	420	165-413	
6S 1W21J01	42-	612	208-602	TOO DEEP FOR NETWORK
6S 1W21R02	62-	492	252-458	
6S 1W21R04	36-	175		NO CONSTRUCTION DATA
6S 1W22B01	69-	650		CONFIDENTIAL LOG
6S 1W22C01	62-71			DESTROYED
6S 1W22H01	69-	750		NO CONSTRUCTION DATA
6S 1W23F02	69-	90		CONFIDENTIAL LOG
6S 1W23K01	60-	340	210-337	
6S 1W23Q01	69-			NO CONSTRUCTION DATA
6S 1W24H04	69-	131		NO CONSTRUCTION DATA
6S 1W24H08	39-	588		NO CONSTRUCTION DATA
6S 1W24K02	70-			NO CONSTRUCTION DATA
6S 1W25C02	45-70	282		DESTROYED
6S 1W26D02	69-	700		CONFIDENTIAL LOG
6S 1W26F03	71-			NO CONSTRUCTION DATA
6S 1W26H02	70-	100		NO CONSTRUCTION DATA
6S 1W26P02	70-	460	190-430	
6S 1W27E02	70-	501	184-497	TOO DEEP FOR NETWORK
6S 1W27K01	69-			NO CONSTRUCTION DATA
6S 1W27K04	69-	100		NO CONSTRUCTION DATA
6S 1W27N04	63-	432	170-394	

TABLE 17 (CONTINUED)

NORTH SANTA CLARA WELL QUALIFICATION LISTING

WELL LOCATION NUMBER	PERIOD OF RECORD	DEPTH IN FEET	PERFORATED INTERVAL IN FEET	REMARKS
6S 1W27P01	69-	376	234-363	
6S 1W27P02	36-	607		NO CONSTRUCTION DATA
6S 1W28F01	70-	375	312-362	
6S 1W28R02	69-	700		NO CONSTRUCTION DATA
6S 1W29Q02	51-	500		NO CONSTRUCTION DATA
6S 1W31E01	70-	450		NO CONSTRUCTION DATA
6S 1W32C10	70-			NO CONSTRUCTION DATA
6S 1W32F10	69-			NO CONSTRUCTION DATA
6S 1W32H01	69-	650		NO CONSTRUCTION DATA
6S 1W32L04	70-	90		NO CONSTRUCTION DATA
6S 1W32M02	70-71			DESTROYED
6S 1W33N01	69-	528		NO CONSTRUCTION DATA
6S 1W34A03	70-	672		CONFIDENTIAL LOG
6S 1W35K01	60-	445		CONFIDENTIAL LOG
6S 1W35L01	69-	458		CONFIDENTIAL LOG
6S 1W36A01	57-	300		NO CONSTRUCTION DATA
6S 2W03N01	70-	185		NO CONSTRUCTION DATA
6S 2W08H01	68-	284		NO CONSTRUCTION DATA
6S 2W09Q01	49-	683	180-632	TOO DEEP FOR NETWORK
6S 2W10G02	68-	455		NO CONSTRUCTION DATA
6S 2W13F01	68-	615		NO CONSTRUCTION DATA
6S 2W13R01	69-	700	182-680	TOO DEEP FOR NETWORK
6S 2W15L18	69-			NO CONSTRUCTION DATA
6S 2W17P01	58-			NO CONSTRUCTION DATA
6S 2W17R01	69-	572	270-572	
6S 2W18J01	70-	54	30-53	
6S 2W19B02	70-	465	110-292	
6S 2W19G01	56-	240		NO CONSTRUCTION DATA
6S 2W19H03	70-	377		CONFIDENTIAL LOG
6S 2W20F04	70-			NO CONSTRUCTION DATA
6S 2W20L01	70-	472	224-448	
6S 2W20N01	69-	470		NO CONSTRUCTION DATA
6S 2W21D08	69-	572		CONFIDENTIAL LOG
6S 2W22G01	70-	817		CONFIDENTIAL LOG
6S 2W22H04	69-			NO CONSTRUCTION DATA
6S 2W22M01	69-	206		NO CONSTRUCTION DATA
6S 2W22M02	69-	439	237-405	
6S 2W23Q02	59-	428		NO CONSTRUCTION DATA
6S 2W25C02	36-	500		NO CONSTRUCTION DATA
6S 2W27B01	58-71			DESTROYED
6S 2W28D01	69-	410		NO CONSTRUCTION DATA
6S 2W28F01	70-			NO CONSTRUCTION DATA
6S 2W28N01	69-	400		NO CONSTRUCTION DATA
6S 2W28N02	69-	600	254-577	
6S 2W29F02	61-	695	230-570	
6S 2W29J02	69-	596		NO CONSTRUCTION DATA
6S 2W29K05	69-	600		NO CONSTRUCTION DATA
6S 2W29M05	69-	700		CONFIDENTIAL LOG
6S 2W32Q01	69-	515		NO CONSTRUCTION DATA

TABLE 17 (CONTINUED)

NORTH SANTA CLARA WELL QUALIFICATION LISTING

WELL LOCATION NUMBER	PERIOD OF RECORD	DEPTH IN FEET	PERFORATED INTERVAL IN FEET	REMARKS
6S 2W32D02	69-	950		NO CONSTRUCTION DATA
6S 2W33A02	69-	500	257-489	
6S 2W33B01	69-72	400		NO CONSTRUCTION DATA
6S 2W33B99	36-71	347		DESTROYED
6S 2W33C01	69-	1120	290-1120	
6S 2W33H01	69-	520		CONFIDENTIAL LOG
6S 2W34B02	40-			NO CONSTRUCTION DATA
6S 2W34B03	67-	408		CONFIDENTIAL LOG
6S 2W34G02	69-	402		NO CONSTRUCTION DATA
6S 2W34K02	69-	746		CONFIDENTIAL LOG
6S 2W34N01	69-	423		NO CONSTRUCTION DATA
6S 2W34N03	69-	620		CONFIDENTIAL LOG
6S 2W36J01	71-71			NO CONSTRUCTION DATA
7S 1E01G01	36	400		NO CONSTRUCTION DATA
7S 1E01N01	71	695		CONFIDENTIAL LOG
7S 1E02J01	69-71	420		NO CONSTRUCTION DATA
7S 1E02J02	71-			NO CONSTRUCTION DATA
7S 1E02J06	71	608	280-310	
7S 1E02L02	69	443		NO CONSTRUCTION DATA
7S 1E03A01	69	620	440-531	
7S 1E03A02	69-	598	290-591	
7S 1E03H01	57	356	258-351	
7S 1E03L01	36-	150	106-148	
7S 1E04F02	71	500		NO CONSTRUCTION DATA
7S 1E06L01	69	398		NO CONSTRUCTION DATA
7S 1E06M01	36	803	430-753	
7S 1E06N02	70	100		NO CONSTRUCTION DATA
7S 1E07F01	68	501		NO CONSTRUCTION DATA
7S 1E07N01	53-	800	430-753	TWO DEEP FOR NETWORK
7S 1E07R05	70-	831	528-707	
7S 1E07R99	69			NO CONSTRUCTION DATA
7S 1E08Q10	69-	512		NO CONSTRUCTION DATA
7S 1E09D03	69	560	295-467	
7S 1E09D06	36	742	526-708	
7S 1E09D99	69	548		NO CONSTRUCTION DATA
7S 1E10P01	68	300		CONFIDENTIAL LOG
7S 1E13D01	71	160		NO CONSTRUCTION DATA
7S 1E13E03	52-71	410		DESTROYED
7S 1E13E06	68	510	156-425	
7S 1E14P01	50	240		NO CONSTRUCTION DATA
7S 1E15E02	36	253		NO CONSTRUCTION DATA
7S 1E15L04	71	301		NO CONSTRUCTION DATA
7S 1E15N03	69	800	300-780	
7S 1E16C05	69	725	526-682	
7S 1E16C06	69	716	508-697	
7S 1E16C99	36-			NO CONSTRUCTION DATA
7S 1E16L01	69	580		CONFIDENTIAL LOG
7S 1E17F01	71	715	378-698	
7S 1E17H06	71	470		CONFIDENTIAL LOG

TABLE 17 (CONTINUED)

NORTH SANTA CLARA WELL QUALIFICATION LISTING

WELL LOCATION NUMBER	PERIOD OF RECORD	DEPTH IN FEET	PERFORATED INTERVAL IN FEET	REMARKS
7S 1E18A03	69	795		CONFIDENTIAL LOG
7S 1E18C02	69	190		NO CONSTRUCTION DATA
7S 1E18K03	71	760		CONFIDENTIAL LOG
7S 1E20B03	69	469		NO CONSTRUCTION DATA
7S 1E21A02	59	200		
7S 1E21E02	40	752	389-738	
7S 1E21E03	69	803	406-785	
7S 1E21E99	69			NO CONSTRUCTION DATA
7S 1E21K02	70	468	100-450	
7S 1E22H06	69-	756	314-737	
7S 1E22K01	52	312		CONFIDENTIAL LOG
7S 1E23B01	69			NO CONSTRUCTION DATA
7S 1E23D01	70	430	314-360	
7S 1E23E01	62	200	80-200	
7S 1E23F04	69	306		CONFIDENTIAL LOG
7S 1E23K01	51-63	550		DESTROYED
7S 1E24F02	69-			NO CONSTRUCTION DATA
7S 1E25A02	54-72	350		DESTROYED
7S 1E25E04	61	298	168-248	
7S 1E25M04	70	268		NO CONSTRUCTION DATA
7S 1E26R01	51	264		NO CONSTRUCTION DATA
7S 1E27F01	45			NO CONSTRUCTION DATA
7S 1E27G05	64	325		NO CONSTRUCTION DATA
7S 1E29A02	69-	438	210-332	CONFIDENTIAL LOG
7S 1E29J03	69			NO CONSTRUCTION DATA
7S 1E29Q01	48	280	75-280	
7S 1E30B04	52-71	217		DESTROYED
7S 1E31A01	36	360		NO CONSTRUCTION DATA
7S 1E32B01	70	250		NO CONSTRUCTION DATA
7S 1E32G01	71	460	185-400	
7S 1E32J03	69	315		NO CONSTRUCTION DATA
7S 1E32R02	69	350	135-300	
7S 1E33M03	57	116	45-110	
7S 1E33P04	53	250		NO CONSTRUCTION DATA
7S 1E35E01	36	300		NO CONSTRUCTION DATA
7S 1E35G01	36	450		NO CONSTRUCTION DATA
7S 1E36G01	62			NO CONSTRUCTION DATA
7S 1E36L03	51-			NO CONSTRUCTION DATA
7S 2E06N04	69	500	225-455	
7S 2E07B02	53	410		NO CONSTRUCTION DATA
7S 2E07M01	57	525		NO CONSTRUCTION DATA
7S 2E07Q01	59	500		NO CONSTRUCTION DATA
7S 2E17D01	69	600	375-560	
7S 2E17G02	39	400		NO CONSTRUCTION DATA
7S 2E17K02	70			NO CONSTRUCTION DATA
7S 2E17Q02	39	375		NO CONSTRUCTION DATA
7S 2E17R04	70			NO CONSTRUCTION DATA
7S 2E18B02	69	520	203-280	
7S 2E18B05	57	242		NO CONSTRUCTION DATA

TABLE 17 (CONTINUED)

NORTH SANTA CLARA WELL QUALIFICATION LISTING

WELL LOCATION NUMBER	PERIOD OF RECORD	DEPTH IN FEET	PERFORATED INTERVAL IN FEET	REMARKS
7S 2E19B02	53	215		NO CONSTRUCTION DATA
7S 2E19E01	45	275		NO CONSTRUCTION DATA
7S 2E19E02	71-72			DESTROYED
7S 2E19J01	53	275		NO CONSTRUCTION DATA
7S 2E20C04	69	760	300-760	
7S 2E20E05	68	408	65-405	
7S 2E20H02	51	310		CONFIDENTIAL LOG
7S 2E20R01	69	315	110-310	
7S 2E21G01	39	358	88-353	
7S 2E28F01	68			NO CONSTRUCTION DATA
7S 2E29B01	69			NO CONSTRUCTION DATA
7S 2E33C01	55	61		NO CONSTRUCTION DATA
7S 2E33C03	69	370		NO CONSTRUCTION DATA
7S 2E33C05	53	32		NO CONSTRUCTION DATA
7S 1W01N02	62-	604		CONFIDENTIAL LOG
7S 1W02A01	60-62	600		CONFIDENTIAL LOG
7S 1W02G01	36-	320		NO CONSTRUCTION DATA
7S 1W02G02	69	864	660-814	
7S 1W02G03	69	792	361-717	
7S 1W02P02	69	520		CONFIDENTIAL LOG
7S 1W03H01	69	650		NO CONSTRUCTION DATA
7S 1W03Q01	69	784	651-771	
7S 1W04D01	69	580		NO CONSTRUCTION DATA
7S 1W04E02	69	570		CONFIDENTIAL LOG
7S 1W04N01	69	600		CONFIDENTIAL LOG
7S 1W04N02	50	594	310-563	
7S 1W04Q01	69	600	306-497	
7S 1W05P02	69	770		CONFIDENTIAL LOG
7S 1W06D01	56	550	179-517	
7S 1W06P01	69	706		CONFIDENTIAL LOG
7S 1W07K01	68	435	231-415	
7S 1W07N01	69	760		NO CONSTRUCTION DATA
7S 1W08B02	69-	800		NO CONSTRUCTION DATA
7S 1W08N01	69	604	302-586	
7S 1W09E02	71			NO CONSTRUCTION DATA
7S 1W09G01	50	300		NO CONSTRUCTION DATA
7S 1W09J01	69	500		CONFIDENTIAL LOG
7S 1W09N02	69-	815		CONFIDENTIAL LOG
7S 1W09Q01	69	570		CONFIDENTIAL LOG
7S 1W10D01	69	865		NO CONSTRUCTION DATA
7S 1W11E01	40-62	236		DESTROYED
7S 1W13E01	36	618	568-614	
7S 1W13J07	69	800		CONFIDENTIAL LOG
7S 1W13K04	69	550	315-507	
7S 1W14B01	56	367	213-360	
7S 1W14N01	49-71	440		DESTROYED
7S 1W15D01	69	660		CONFIDENTIAL LOG
7S 1W15E01	69	490		CONFIDENTIAL LOG
7S 1W17A01	69	666		CONFIDENTIAL LOG

TABLE 17 (CONTINUED)

NORTH SANTA CLARA WELL QUALIFICATION LISTING

WELL LOCATION NUMBER	PERIOD OF RECORD	DEPTH IN FEET	PERFORATED INTERVAL IN FEET	REMARKS
7S 1W17E01	69	599		NO CONSTRUCTION DATA
7S 1W17P01	69-	716	321-712	
7S 1W18K01	69	820	310-800	
7S 1W18R01	69-	612		NO CONSTRUCTION DATA
7S 1W20L02	69	850	360-834	
7S 1W20L03	69	913	400-890	
7S 1W21A01	69	500		NO CONSTRUCTION DATA
7S 1W21N99	39-67	607		DESTROYED
7S 1W21P01	65-71	360		DESTROYED
7S 1W22E02	61	568	301-552	
7S 1W22E06	69	750	308-712	
7S 1W22E09	69	800	360-775	
7S 1W22E14	69	800	334-786	
7S 1W24A01	69	202	132-196	
7S 1W24E02	71-			NO CONSTRUCTION DATA
7S 1W24H02	61	360		NO CONSTRUCTION DATA
7S 1W24J03	61-62	838	336-822	
7S 1W24N01	71-71			DESTROYED
7S 1W25C01	67-	400		NO CONSTRUCTION DATA
7S 1W25L01	36	404		NO CONSTRUCTION DATA
7S 1W26E01	61-62	536		CONFIDENTIAL LOG
7S 1W26Q10	70			NO CONSTRUCTION DATA
7S 1W26R02	69-74	915		CONFIDENTIAL LOG
7S 1W27E02	69-71	600		DESTROYED
7S 1W27G01	69	685		NO CONSTRUCTION DATA
7S 1W30E03	59	450		CONFIDENTIAL LOG
7S 1W31H03	36-71	400		DESTROYED
7S 1W31J02	69	880	304-858	
7S 1W32A01	68			NO CONSTRUCTION DATA
7S 1W33K01	69	607		CONFIDENTIAL LOG
7S 1W33M02	69	747		NO CONSTRUCTION DATA
7S 1W34F01	69	810	360-785	
7S 1W34F02	69	846	370-828	
7S 1W35H01	57-	390		NO CONSTRUCTION DATA
7S 1W36B01	60	500		NO CONSTRUCTION DATA
7S 2W01H01	69	615		NO CONSTRUCTION DATA
7S 2W01E02	69	845	300-820	
7S 2W01H01	69	708		NO CONSTRUCTION DATA
7S 2W02E04	70-71			DESTROYED
7S 2W02G01	69	690		CONFIDENTIAL LOG
7S 2W02K02	69	640		CONFIDENTIAL LOG
7S 2W03A02	69	692	345-672	
7S 2W03C02	69	639		NO CONSTRUCTION DATA
7S 2W03D01	69	498		NO CONSTRUCTION DATA
7S 2W03D02	69-	640		CONFIDENTIAL LOG
7S 2W03H01	69	630		CONFIDENTIAL LOG
7S 2W03R01	52	520	303-514	
7S 2W04G01	31	450		NO CONSTRUCTION DATA
7S 2W09A01	68	240		CONFIDENTIAL LOG

TABLE 17 (CONTINUED)

NORTH SANTA CLARA WELL QUALIFICATION LISTING

WELL LOCATION NUMBER	PERIOD OF RECORD	DEPTH IN FEET	PERFORATED INTERVAL IN FEET	REMARKS
7S 2W13C01	69	715		CONFIDENTIAL LOG
7S 2W14H02	66	470		NO CONSTRUCTION DATA
7S 2W22A01	36-	620		NO CONSTRUCTION DATA
7S 2W23C01	40-71	300		DESTROYED
7S 2W25M02	36	465		NO CONSTRUCTION DATA
7S 2W36A01	67-			NO CONSTRUCTION DATA
8S 2E06P02	36	200		NO CONSTRUCTION DATA
8S 2E07AG3	36	203		NO CONSTRUCTION DATA
8S 2E07F01	59	300		CONFIDENTIAL LOG
8S 2E08K99	52-	300		NO CONSTRUCTION DATA
8S 2E16E98	36	91		
8S 2E16N01	69-			NO CONSTRUCTION DATA
8S 2E17L01	52	60		NO CONSTRUCTION DATA
8S 2E17N01	53	106		NO CONSTRUCTION DATA
8S 2E18E01	36	120		NO CONSTRUCTION DATA
8S 2E18L01	36	200		NO CONSTRUCTION DATA
8S 2E19A01	36-	200		NO CONSTRUCTION DATA
8S 2E20B02	70	225		NO CONSTRUCTION DATA
8S 2E20F01	48	305		NO CONSTRUCTION DATA
8S 2E22D01	36	86		NO CONSTRUCTION DATA
8S 2E22F01	68			NO CONSTRUCTION DATA
8S 2E26M02	62	150		NO CONSTRUCTION DATA
8S 2E27G01	68			NO CONSTRUCTION DATA
8S 2E28H02	68			NO CONSTRUCTION DATA
8S 2E31Q01	69	56		NO CONSTRUCTION DATA
8S 2E34E01	68			NO CONSTRUCTION DATA
8S 2E35G01	69	150		NO CONSTRUCTION DATA
8S 2E35M01	59	90		NO CONSTRUCTION DATA
8S 1E01Q01	48	120		NO CONSTRUCTION DATA
8S 1E02C02	62	165		NO CONSTRUCTION DATA
8S 1E02H01	69	200		NO CONSTRUCTION DATA
8S 1E02R01	70			NO CONSTRUCTION DATA
8S 1E03N01	69-			NO CONSTRUCTION DATA
8S 1E04A05	62	200		NO CONSTRUCTION DATA
8S 1E04P01	51-	130		
8S 1E04P98	62-71	235		DESTROYED
8S 1E04Q05	71-	224		CONFIDENTIAL LOG
8S 1E05D01	68			NO CONSTRUCTION DATA
8S 1E05H06	69	440	82-340	
8S 1E05H07	69	440	100-415	
8S 1E05K02	62	320		NO CONSTRUCTION DATA
8S 1E05N01	62	200		NO CONSTRUCTION DATA
8S 1E07A01	71-71			DESTROYED
8S 1E07D01	45	327		NO CONSTRUCTION DATA
8S 1E07G02	71			NO CONSTRUCTION DATA
8S 1E07J01	50	200		NO CONSTRUCTION DATA
8S 1E08G02	70-			NO CONSTRUCTION DATA
8S 1E08H01	67-	220		NO CONSTRUCTION DATA
8S 1E08P03	71	225		NO CONSTRUCTION DATA

TABLE 17 (CONTINUED)

NORTH SANTA CLARA WELL QUALIFICATION LISTING

WELL LOCATION NUMBER	PERIOD OF RECORD	DEPTH IN FEET	PERFORATED INTERVAL IN FEET	REMARKS
8S 1E08R01	62-	255	40-180	
8S 1E09H01	50	298		NO CONSTRUCTION DATA
8S 1E09L03	48	50		NO CONSTRUCTION DATA
8S 1E09M03	71			NO CONSTRUCTION DATA
8S 1E10D06	62	285		NO CONSTRUCTION DATA
8S 1E10G02	69	372	87-186	
8S 1E10J01	38			
8S 1E10K03	69	382	56-252	
8S 1E10K04	69	226	84-200	
8S 1E10L04	36			NO CONSTRUCTION DATA
8S 1E11N01	59	86		NO CONSTRUCTION DATA
8S 1E11Q01	69	160		NO CONSTRUCTION DATA
8S 1E12C01	63	250		NO CONSTRUCTION DATA
8S 1E12G02	59-72	220		NO CONSTRUCTION DATA
8S 1E13H03	36-			NO CONSTRUCTION DATA
8S 1E13J02	71-			DESTROYED
8S 1E14R01	62-69	168		CONFIDENTIAL LOG
8S 1E14D02	70			NO CONSTRUCTION DATA
8S 1E14D04	71-	108		DESTROYED
8S 1E15C02	64-	148		NO CONSTRUCTION DATA
8S 1E15E02	62	148		NO CONSTRUCTION DATA
8S 1E16N07	70	36		NO CONSTRUCTION DATA
8S 1E17A01	36	165		NO CONSTRUCTION DATA
8S 1E17D01	69	480		NO CONSTRUCTION DATA
8S 1E17R02	61	125		NO CONSTRUCTION DATA
8S 1E20Q01	62	38		NO CONSTRUCTION DATA
8S 1E27C02	62-	70		NO CONSTRUCTION DATA
8S 1E27C99	68-69	36		DESTROYED
8S 1W03H01	69-71	700		DESTROYED
8S 1W03K01	69	246		NO CONSTRUCTION DATA
8S 1W03K03	63	94		NO CONSTRUCTION DATA
8S 1W04K01	70	600		NO CONSTRUCTION DATA
8S 1W05A01	56	230		NO CONSTRUCTION DATA
8S 1W05K04	68-			NO CONSTRUCTION DATA
8S 1W08J05	68-	150		NO CONSTRUCTION DATA
8S 1W10F02	60-74	458		CONFIDENTIAL LOG
8S 1W11R01	36-	384		NO CONSTRUCTION DATA
8S 1W12Q02	62	200		NO CONSTRUCTION DATA
8S 1W15C01	68			NO CONSTRUCTION DATA
8S 2W01C01		500		NO CONSTRUCTION DATA

4. Fairly long period of record of measurements. Although not as essential as first three criteria, a well with a historic water level record is preferable to a new well.

With the above data available, personnel with an understanding of the subsurface conditions (preferably a Certified Engineering Geologist) can certify that water level measurements from a particular well reflect the potentiometric surface of a specific aquifer, or group of aquifers. When this is done, fluctuations of the water levels in the particular well become meaningful data.

Qualified monitoring wells should be identified through the use of information on the buried stream channels contained on Figure 5. Thus, the ideal monitoring net will contain not only those representative wells that tap principal ground water conduits, but additional wells reflecting effects of the principal faults.

Proposed Network

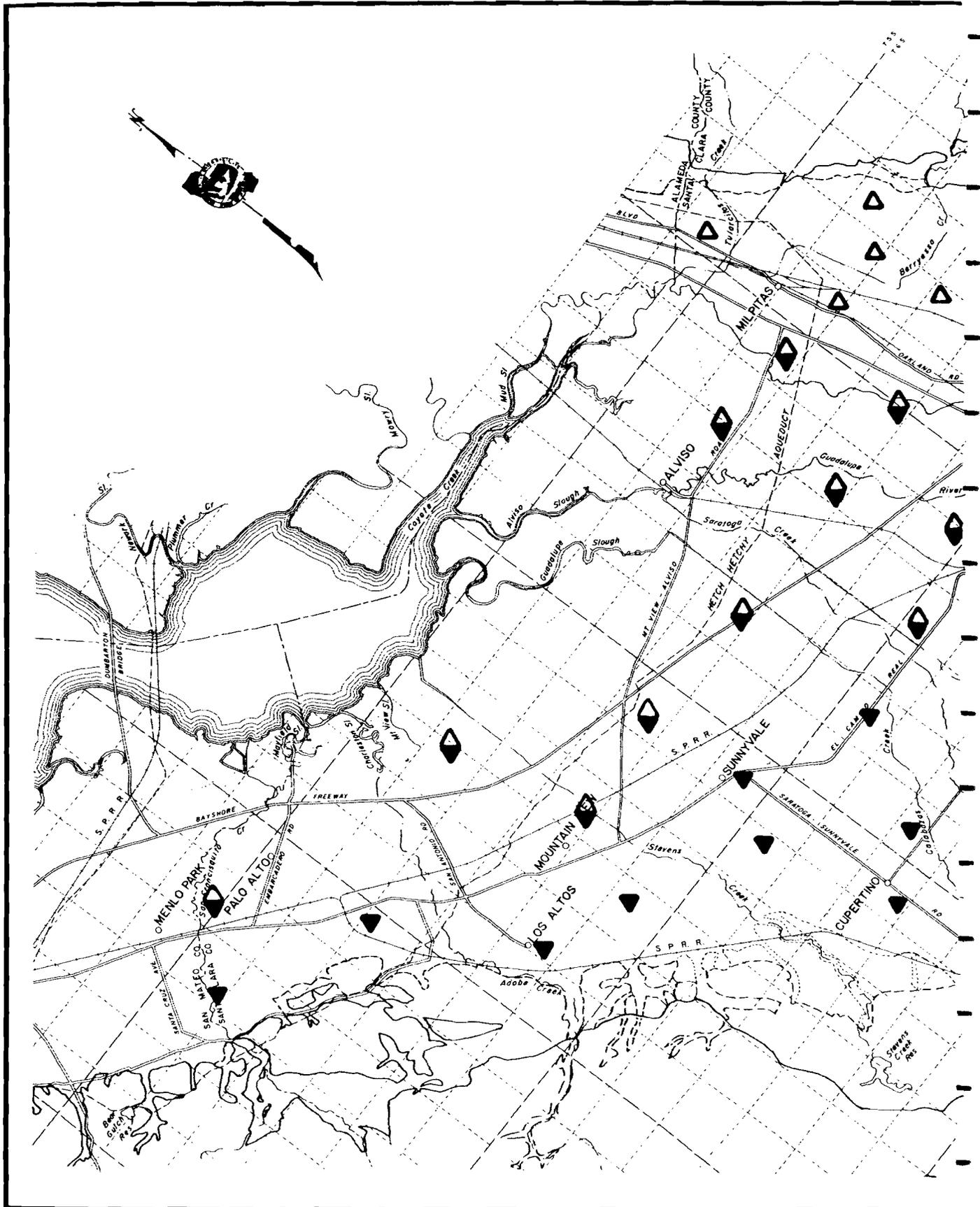
A Proposed new network of monitoring wells was developed from examination of the detailed buried-channel maps which were discussed in Chapter III. Examination of these maps indicated that there were discreet areas where certain buried channels overlay each other. This afforded the identification of areas where monitoring wells could be located so as to reflect water levels for a given zone.

Evaluation of the geohydrology of the area revealed that the bayward portion of the valley (north of Bayshore Freeway and west of Nimitz Freeway) contains an upper, or essentially unconfined, ground water zone and a lower, or confined, ground water zone. These two zones are separated by a relatively impermeable clay layer. Upgradient from these two zones is a relatively broad forebay that, for modeling purposes, is considered to be essentially unconfined. Thus, there are three types of monitoring wells that are recommended. The first are the shallow wells, those ranging to depths of about 400 feet (120 meters) in the forebay zone and to depths of about 150 feet (45 meters) in the bayward zone. The second are the deeper wells; these range to depths of about 600 feet (180 meters) in both zones. To reflect the deeper, or confined zones, these deeper wells must be perforated only in the lower interval. Finally, there are the composite wells. These normally will be gravel-envelope wells (as opposed to selective-perforation wells) and will tap all zones down to a depth of about 600 feet (180 meters).

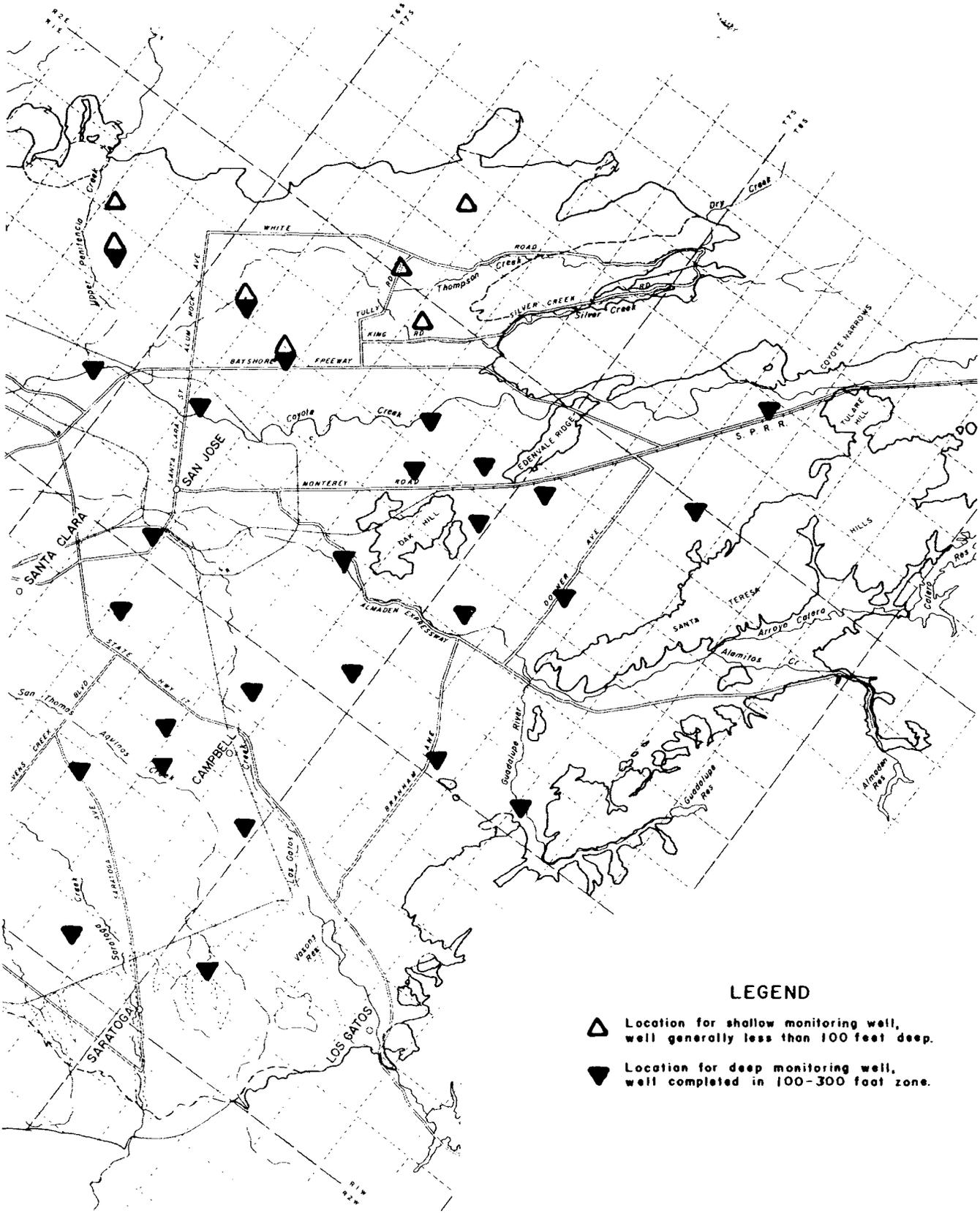
In all, locations for 34 shallow wells, 8 deep wells, and 5 composite wells have been selected as a minimum network. Table 18 presents location and completion interval data for proposed monitoring wells; Figure 20 shows the areal distribution of the proposed monitoring well network.

Implementation of Network

There are several steps that should be taken in establishing the new network:



PROPOSED MONITORING



LEGEND

- △ Location for shallow monitoring well, well generally less than 100 feet deep.
- ▼ Location for deep monitoring well, well completed in 100-300 foot zone.

WELL NETWORK

Table 18

PROPOSED GROUND WATER SURVEILLANCE NETWORK
FOR UPPER AQUIFERS

Well Location			Well	Monitoring Elevation		Well Location			Well	Monitoring Elevation	
Twp.	Rge.	Sec.	Type ^{1/}	(feet)	(meters)	Twp.	Rge.	Sec.	Type ^{1/}	(feet)	(meters)
5S	1E	31L	S	+10 to -80	+3 to -24	7S	1E	9C	D	-5 to -205	-2 to -62
5S	3W	35P	C	+30 to -250	+9 to -76			10R	C	+90 to -190	+27 to -58
6S	1E	7Q	S	+10 to -80	+3 to -24			24B	S	+125 to +45	+38 to +14
		8Q	S	70 to -30	+21 to -9			26C	D	+50 to -150	+15 to -48
		9F	S	+120 to +10	+36 to +3			27K	D	+45 to -155	+14 to -47
		20B	S	+80 to -35	+24 to -11			29H	D	+30 to -170	+12 to -52
		26D	S	+210 to +120	+64 to +37			31K	D	+60 to -140	+18 to -43
		27L	C	+130 to -180	+39 to -55			34Q	D	+55 to -145	+17 to -44
		32J	D	-75 to -225	-23 to -69			35F	D	+65 to -135	+20 to -41
6S	1W	10R	C	-10 to -295	-3 to -90	7S	1W	3F	C	+50 to -230	+15 to -70
		12Q	C	0 to -285	0 to -87			5K	D	0 to -200	0 to -61
		20Q	C	+5 to -275	+1 to -84			13D	D	+10 to -190	+3 to -58
		23M	C	0 to -285	0 to -87			18C	D	+80 to -120	+24 to -37
		24R	C	+10 to -270	+3 to -82			21B	D	+55 to -145	+17 to -44
		35R	C	+140 to -140	+43 to -43			23N	D	+70 to -130	+21 to -40
6S	2W	9H	C	-15 to -295	-5 to -90			25L	D	+70 to -130	+21 to -40
		22P	C	+70 to -210	+21 to -64			27B	D	+70 to -130	+21 to -40
		24L	C	+30 to -250	+9 to -76			30K	D	+175 to -25	+53 to -8
		29L	D	+70 to -130	+21 to -40			34Q	D	+120 to -80	+37 to -24
		33H	D	+50 to -150	+15 to -46	7S	2W	2G	D	+80 to -120	+24 to -37
		36L	D	+40 to -160	+12 to -49			13P	D	+150 to -50	+46 to -15
6S	3W	3N	D	0 to -200	0 to -61	8S	2E	17H	D	+120 to -80	+37 to -24
		13A	D	-50 to -250	-15 to -76	8S	1E	2G	D	+70 to -130	+21 to -40
7S	2E	17K	S	+340 to +260	+103 to +79			4F	D	+65 to -135	+20 to -41
		18E	S	+120 to +40	+36 to +12			7L	D	+125 to -75	+38 to -23
7S	1E	2N	C	+85 to -195	+26 to -59			10L	D	+75 to -125	+23 to -38
		7P	D	-10 to -210	-3 to -64			13H	D	+80 to -120	+24 to -37
								19C	D	+180 to -20	+55 to -6
						8S	1W	5L	D	+210 to +10	+64 to +3

^{1/} S - Shallow well: Completed in depth interval from 20 to 100 feet (6 to 30 m).

D - Deep well: Completed in depth interval from 100 to 300 feet (30 to 90 m).

C - Composite well: Contains two piezometers; one each completed in shallow and deep zones.

1. Search records and make a field canvas to locate all wells and data on wells in the vicinity of a proposed monitoring well locations.
2. Determine if an existing well can be used or modified for use as a monitoring well.
3. If Step 2 is negative, or cost is excessive, drill and install a monitoring well. In some areas, a single drill hole may be designed to contain several piezometers, each monitoring a different depth.
4. Monitoring wells should be located beyond the local influence of large municipal and industrial wells. Conversely, consideration should be given to restricting the placement of such new wells that would adversely affect monitoring wells.
5. The continuity of existing water level measurements should not be broken until there is some overlap of record.

Many of the water level measurements now available are measurements taken by the agency that operates the well. Such measurements will probably be continued by such agencies for their own operating reasons.

APPENDIX A

GEOLOGY

(Published separately, August 1967)

APPENDIX B

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APPENDIX C

ENGLISH - METRIC EQUIVALENTS

Each unit with its abbreviation is followed by its equivalent in one or other units of the same quantity. In the text, the metric equivalents are shown only to the number of significant figures consistent with the values for the English units.

Length	Inch (in) - 2.54 centimeter (cm) Centimeter (cm) - 0.3937 inch (in) Millimeter (mm) - 0.1 centimeter (cm); 0.039 inch (in) Foot (ft) - 0.3048 meter (m) Meter (m) - 3.2808 feet (ft); 39.37 inches (in) Mile (mi) - 1.6094 kilometer (km) Kilometer (km) - 0.6214 mile (mi)
Area	Acre (a) - 43,560 square feet (ft ²); 0.4047 hectare (ha) Hectare (ha) - 10,000 square meters (m ²); 2.471 acres (a) Square mile (mi ²) - 640 acres (a); 259 hectares (ha); 2.59 square kilometers (km ²) Square kilometer (km ²) - 100 hectares (ha); 0.384 square mile (mi ²)
Volume	Gallon (gal) - 3.7853 liters (l); 0.00378 cubic meter (m ³) Liter (l) - 0.2642 gallon (gal); 1.057 quarts (qt) Cubic meter (m ³) - 264.173 gallons (gal); 1,000 liters (l)
Discharge	Million gallons per day (MGD) - 3780 cubic meters per day (m ³ /d) 1,000 cubic meters per day (m ³ /d) - 0.26 million gallons per day (MGD)
Ground Water Storage	Acre-foot (ac-ft) - 1,233.5 cubic meters (m ³) Thousand acre-feet (ac-ft) - 1,233,500 cubic meters (m ³); 1.23 cubic hectometers (hm ³) Cubic hectometer (hm ³) - Million cubic meters (m ³); 810.71 acre-feet (ac-ft)
Percolation	Acre-foot per acre per day (ac-ft/ac/day) - 499.2 cubic meters per hectare per day (m ³ /ha/d) Cubic meter per hectare per day (m ³ /ha/d) - 0.002 acre-foot per acre per day (ac-ft/ac/day)
Concentration	Milligram per liter (mg/l) - 1 part per million (ppm) Microgram per liter (µg/l) - 0.001 milligram per liter (mg/l), 0.001 part per million (ppm)
Permeability	Gallon per day per square foot (gal/day/ft ²) - 0.055 darcys (D) Darcy (D) - 18.2 gallons per day per square foot (gal/day/ft ²)
Transmissivity	Gallon per day per foot (gpd/ft) - 0.134 square feet per day (ft ² /day); 0.0124 square meters per day (m ² /day) Square meter per day (m ² /day) - 10.76 square feet per day (ft ² /day); 80.5 gallons per day per foot (gpd/ft)
Capacity	Cubic inch per foot (in ³ /ft) - 53.76 cubic centimeters per meter (cm ³ /m) Cubic centimeter per meter (cm ³ /m) - 0.018 cubic inch per foot (in ³ /ft)

