IN THE SUPERIOR COURT OF THE STATE OF CALIFORNIA
IN AND FOR THE COUNTY OF LOS ANGELES

THE CITY OF LOS ANGELES, a Municipal Corporation, *Plaintiff,* vs. CITY OF SAN FERNANDO, a Municipal Corporation, et al., *Defendants.*	No. 650079

REPORT OF REFEREE

Volume II

APPENDIXES

By

STATE WATER RIGHTS BOARD
REFEREE

July, 1962

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GEOLOGY

The geology reported herein has been limited primarily to those geologic features and conditions within the watershed of the Los Angeles River above its confluence with the Arroyo Seco, insofar as they affect the occurrence and movement of ground water. The features and formations described herein are shown on Plate 4, Areal Geology, and on Plates 5, and 5A through 5H, Geologic Cross Sections.

Previous Investigation

Several bulletins and papers have been published dividing the area under investigation into numerous basins and subbasins. For the most part these divisions were made at or near locations where there is a change in ground water storage capacity, a drainage divide and/or structures that delay to varying degrees the flow of underground water toward the Los Angeles Narrows.

These bulletins and papers dealing with the geology in the vicinity of the area of investigation pertain mainly to the sedimentary and crystalline rocks in the hills and mountains around the edges of the valley fill.

Division of Water Resources Bulletin No. 45[1/] contains a detailed and broad coverage on the geology of the area of investigation and its effect on ground water. Particular reference is made to the geologic features of the valley fill and to the water-bearing series. This work has been studied in detail and data pertaining to specific yield and storage capacity have been modified and utilized in the present investigation as shown in Appendixes D and Q respectively. The modifications are based on an additional 25 years of records and data.

Regional Geology

The main valley floor is in general an alluvial-filled basin approximately 23 miles long and 12 miles wide. Based on physiography and/or geologic features, the valley fill contained within the hydrologic boundary of the basin has been divided into four hydrologic subareas (see Chapter III). Little is known of the depth of valley fill in the central and eastern part of the San Fernando Hydrologic Subarea where the depth of fill may exceed 1,000 feet in the area to the west of the City of Burbank.

The geologic events which affected the valley floor and the bordering hills and mountains as a whole during the formation of the structural features must be considered as well as features now expressed by surface topography in order to depict their effect on the occurrence and movement of ground water.

Geologic Formations

The geologic formations may be divided into two groups, the nonwater-bearing series and the water-bearing series.

The nonwater-bearing series do not absorb, transmit or yield water readily. They are the Basement Complex rocks and the Cretaceous and

Tertiary sediments of the Chico, Martinez, Domengine, Topanga, Modelo (Puente), Repetto and Pico formations.

The water-bearing series which absorb, transmit and yield water readily, consist of the alluvial deposits of Quaternary age occurring in the area and are classified as the Saugus formation, Older alluvium (terrace deposits), and Recent alluvium. This study deals mainly with the character and extent of the water-bearing series.

The stratigraphy of the area of investigation is shown in Table A-1.

The geological mapping performed by many previous workers has been compiled and supplemented where necessary by work of the staff of the Board and is presented as Plate 4, entitled "Areal Geology". The references utilized in the compilation of the map are listed in the bibliography as Nos. 1 through 18, inclusive.

General Geologic History

The metamorphosed pre-Jurassic sedimentary and igneous rocks found in the Basement Complex in the mountains and hills to the north, east and south of San Fernando Valley indicate that these rocks were intruded, faulted, and metamorphosed prior to the intrusion of the pre-Cretaceous granitics.

The Cretaceous rocks found in the hills and mountains in the southern and western portion of the area and their absence in the eastern portion indicate the presence of a sea in the western portion of the valley

TABLE A-1

STRATIGRAPHY WITHIN LOS ANGELES RIVER WATERSHED ABOVE CONFLUENCE WITH ARROYO SECO

	Age	Geologic formation	Description	Remarks	Thickness, in feet
Quaternary (water-bearing)	Recent	Alluvium	Poorly sorted, unconsolidated, coalescing alluvial fan deposits of sand, gravel and clay. Generally undissected and undeformed.	More gravels in eastern part of valley and fine grained with high clay content in western portion of valley.	0-100±
			Local unconformity		
	Upper Pleistocene	Older alluvium, terrace deposits, and slightly folded Pacoima formation.	Alluvial terrace deposits around basin margin and thick series of poorly consolidated continental gravels, sands and clays. Characteristic red or brown weathered surface. Deformation generally slight at surface but increases with depth. Some layers of fossil soils.	Generally more clayey and compacted than Recent alluvium. More gravelly in east and more clayey in west.	0-2000±
			Local unconformity		
	Lower Pleistocene	Saugus formation (Sunshine Ranch formation included)	Continental and marine poorly consolidated folded conglomerates, sands, silts and clays.	Continental alluvial fan deposits along north central portion of valley; marine finer sediments to west. Not found along southern or eastern portion of valley.	0-6000±
			Local unconformity		
Tertiary (nonwater-bearing)	Upper Pliocene	Pico formation	Blue sandy shale and siltstone with sandstone and conglomerate lenses. Principally marine. Consolidated and cemented.	Found only along northern portion of valley.	1500-3000±
	Lower Pliocene	Repetto formation	Marine blue and brown siltstone and mudstone, arkose, sandstone and conglomerate. Some fossiliferous and petroliferous beds.	Found only along northern portion of valley.	400-3000±
			Local unconformity		
	Upper Miocene	Modelo formation (called Puente formation at Los Angeles River Narrows, Bulletin 45)	Alternating marine shale and sandstone members. Thin-bedded cherty siliceous shale, diatomaceous shale and diatomite varying to clayey and sandy facies. Thick coarse massive arkosic sandstone and conglomerate with interbedded fine sandstone and shales. Sharp local variations. Associated with intrusive and extrusive basalt and other igneous rocks.	Found around the perimeter of the valley and probably underlies whole valley.	4000-7000±
			Local unconformity		
	Middle and/or Lower Miocene	Topanga formation	Northern portion of valley continental arkose, conglomerate, red and yellow beds. Interbedded andesite and basalt flows. Southern and western portion of valley principally marine with some continental beds in lower part.		700-7500±
			Unconformity		
	Middle Eocene	Domengine formation (Meganos formation Bulletin 45)	Marine gray to greenish hard calcareous sandstone and conglomerate.	Small outcrops in hills and mountains in northwestern portion of valley.	650±
			Local unconformity		
	Lower Eocene	Martinez formation	Marine greenish-black sandstone, dark shale, coarse conglomerate.	Found along DeMille fault in San Gabriel Mountains and in Simi Hills at western tip of valley.	250-900±
			Unconformity		
Cretaceous (nonwater-bearing)	Upper Cretaceous	Chico formation	Upper portion marine massive hard coarse conglomerate with some sandstone and shale; lower portion soft red conglomerate and sandstone probably continental deposit.	Found in hills and mountains around western portion of valley.	250-900±
			Unconformity		
Pre-Upper Cretaceous (nonwater-bearing) Basement Complex	Lower Cretaceous or Jurassic	Granodiorite Granite Quartz Diorite, etc.	Granitic intrusion		
	Triassic?	Santa Monica Slate	Black slates with schist facies	Santa Monica Mountains southerly of Encino Reservoir	5000-7000±
	Pre-Cretaceous	Pelona schist, Placerita series, etc.	Undifferentiated metamorphic and granitic rocks, schists, gneiss and variety of crystalline rocks.	Found in San Gabriel Mountains, Santa Monica Mountains, Verdugo Hills and San Rafael Hills	

during the Cretaceous. It is quite probable that during this period of submergence the eastern portion of the valley was above sea level and undergoing erosion.

For the most part the whole area was undergoing erosion during Eocene time, with the exception of portions of the Santa Monica Mountains, Simi Hills and the Santa Susana Mountains where relatively thin sections of Martinez and Domengine were deposited.

During lower to middle Miocene time, continental deposits of red and yellow arkose, conglomerate, and interbedded volcanic flows were deposited in the northern and eastern portion of the valley. These beds appear to grade westward and southward into shallow water deposits of the Topanga formation. Fragments of Santa Monica slate (Triassic ?) are found in the Topanga formation along the southern portion of the valley, indicating that these sediments were derived from the ancestral Santa Monica Mountains.

In middle Miocene time, seas of the Ventura Basin extended over most of the area and by upper Miocene time had extended to a shoreline on the foothills of the ancestral mountain ranges around the margin of the basin now existing as the San Fernando Valley. In these seas were deposited the sediments of the Modelo formation. The upper Miocene marine deposits (Puente formation) found in the Los Angeles Narrows area are similar to and are the same age as the Modelo but were probably deposited by an arm of the sea extending from the south.

At the close of the Miocene epoch, some movement took place on the San Gabriel and related faults and the Modelo seas receded slightly.

It was in this relatively shallow sea that the nonwater-bearing Repetto and Pico formations were deposited. During middle and upper Pliocene time there was significant uplift of the area, accompanied by some faulting and folding. Middle Pliocene seas extended eastward from the Ventura Basin as far as Sunland. Pliocene deposits are noticeably lacking in the Santa Monica Mountains.

Rise of the San Gabriel Mountains and other ranges and hills was accelerated during lower Pleistocene time. The water-bearing Saugus formation (including Sunshine Ranch formation - Oakeshott, 1958)[2/] is represented by fluviatile and alluvial-fan sediments derived during the lower Pleistocene from the then existing San Gabriel Mountains which merge into marine sediments derived from the Santa Susana Mountains to the west. There is no evidence of a similar deposit along the base of the Santa Monica Mountains, indicating that during Saugus time this portion of the area was undergoing erosion.

The mid-Pleistocene orogeny was the major event in building of the modern mountain ranges and hills around the perimeter of the valley. At that time, the Saugus and all older formations were intensely folded and large movements took place in the San Gabriel and other fault zones at the northern edge of the valley. The Santa Monica Mountains, Simi Hills and Santa Susana Mountains were elevated with the latter two cutting off the San Fernando Valley from the Ventura Basin. The major streams accelerated their erosion and incised deep canyons in the mountains. Some of the first products of post-Saugus erosion are represented in the dark brown and reddish fanglomerate of the Pacoima formation (Oakeshott, 1958).[2/] Strata of this formation have been locally folded in and near fault zones, particularly in the fault zone west of the Veterans Hospital north of the City of San Fernando.

Post-Saugus erosion of the higher lands has continued through upper Pleistocene to the present time. Erosion during this time has been modified, accelerated, or interrupted by repeated near-vertical elevation of the mountain masses. A succession of terraces produced by deposition from the various streams have been developed and then incised or eroded as the stream gradient was modified. Most of the terrace deposits parallel present drainage courses and were, therefore, quite evidently left by these streams in earlier cycles of erosion.

Erosion and elevation of the land mass has continued to the present time. The alluvial fill during this time has been derived from two types of material which have a profound effect on the permeability of the aquifers and on the quality of the water. West of the vicinity of San Fernando Reservoir and along the southern portion of the valley, local streams from the hills have deposited debris from predominantly sedimentary rocks of that region forming relatively tight deposits that have low specific yields. Easterly of San Fernando Reservoir, Pacoima, Little and Big Tujunga, Verdugo, and other streams along the northern edge of the valley have deposited alluvial cones consisting almost entirely of coarse crystalline debris of high specific yields from the San Gabriel and Verdugo Mountains.

The coalescing alluvial fans from the major tributaries to the north have pushed the Los Angeles River to the southern edge of the valley and indications are that these conditions existed in the past.

Nonwater-Bearing Series

The nonwater-bearing series, which is made up of relatively impervious formations that underlie and surround the more pervious formations differs from the water-bearing series essentially in three respects: (1) the nonwater-bearing series is for the most part relatively impervious and, therefore, stores comparatively little water which it yields to wells very slowly; (2) where pervious beds or zones occur within the nonwater-bearing series the movement of ground water and recharge from surface outcrops is generally so restricted by faults, structural position, or physical character of the materials that supplies obtained from such beds or zones are too limited and of too uncertain permanence to be comparable to ground water supplies obtainable from the water-bearing series; and (3) the quality of the water found in these formations is usually poor to unusable.

Several types of openings occur in the nonwater-bearing series, the principal ones being: (1) original interstices in porous beds of the sedimentary rocks; (2) interstices in the weathered zone; (3) fractures and joint openings below the surface (including openings along bedding planes and planes of schistosity); and (4) openings caused or enlarged by solution of the country rock.

In most places both the sedimentary and crystalline rocks are so tight that they yield very little water to wells and consequently are of no value except for domestic or stock-watering purposes. The limited amount of water contained in the nonwater-bearing series in the hill and mountain areas is available for transpiration and evaporation and support of effluent stream flow. Since the rate of movement of water through the nonwater-bearing series is generally slow, water derived from one season's precipitation may be held over for use in ensuing years. In a few places pervious strata or fracture zones in the nonwater-bearing series may yield water freely to wells. However, in most cases such production is short lived because of the relatively small storage capacity and inadequate recharge.

Basement Complex

Basement complex is a term applied to the old, pre-Cretaceous series of crystalline and metamorphic rocks that comprise the basal formation within the region. It is chiefly composed of igneous granitic rocks and various intrusive dikes, together with their related metamorphic phases, such as schists, gneisses and slates. It comprises the main mass of the San Gabriel Range and Verdugo Hills to the north, as well as portions of the San Rafael Hills to the east of the area, and the Santa Monica Mountains to the south. These rocks have an average porosity of less than one percent. The permeable openings have developed since the formation of the rocks. Below the soil mantle, the openings are principally joint fractures, cracks along the planes of schistosity and fractured materials near faults. Joint cracks are confined chiefly to the zone of weathering and die out rapidly with depth. Cracks along planes of schistosity diminish in number and become tighter below the weathered zone.

The schistose rock, which includes gneisses, schists and slates, has a relatively poor yield of ground water but is better than the more massive granites. Rocks of these types crop out principally in the Santa Monica and San Gabriel Mountains. Small continuous flows are obtained from a number of tunnels which have been driven into these rocks along the southern base of the San Gabriel Mountains. Water seeps into the tunnels from cracks in crushed zones or along planes of schistosity. Experience in driving tunnels into these banded crystalline rocks has shown that water pockets exist in crushed zones with water stored under rather high heads. As the stored water drains, the flow gradually diminishes. Permanent flows from tunnels up to 700 feet long in this rock unit seldom exceed 20 to 30 gallons per minute.

Upper Cretaceous Sediments

The Chico formation[3/] found in the hills and mountains around the northwestern perimeter of the valley floor consists of compacted and cemented marine deposits of massive, hard, coarse conglomerate with some sandstone and shale in the upper portion and soft, red conglomerate and sandstones of probable continental origin in the lower portion. In most cases the original pores have been closed, making these rocks similar in water-bearing properties to the Basement Complex. Widely spaced jointing, cracks along planes of bedding, and fractures furnish practically the only avenues for percolation of ground water and most of these die out with depth.

Lower and Middle Eocene Sediments

The lower Eocene Martinez formation and middle Eocene Domengine formation found in small outcrops in the mountains around the western and northern portion of the valley floor are for the most part cemented marine shales, sandstones and conglomerates. Their water-bearing properties are similar to the upper Cretaceous Chico formation. These formations are not extensive and for the most part are impervious, therefore are unimportant as possible sources of water.

Miocene Volcanics

Throughout the Topanga formation, volcanic flows and breccias associated with intrusive sills and dikes are common. The flows and sills, like the Basement Complex, are crystalline rocks but the breccias are clastic deposits with high original porosity. Thin beds of impervious bentonitic tuff are relatively common in the Modelo formation.

Jointing due to shrinkage that accompanied cooling and subsequent deformation of the solid lavas has shattered many of them to such an extent that they have become more or less permeable. The breccias and tuffs are not completely cemented and are also permeable. It is possible that where lavas lie beneath the water table but are within reach of shallow wells, good domestic supplies, and in a few instances sufficient water for local irrigation purposes, may be obtained.

Distribution of the volcanics, which generally occur in comparatively thin beds and often in positions unfavorable for storage of water, limits the usefulness of these rocks as ground water reservoirs in the area. Supplies available from this source are relatively small and in terms of total water available are considered negligible.

Upper Miocene, Shales, Sandstone and Conglomerates

The Modelo (Puente) shales which crop out over a large part of the intermediate hills and Santa Monica Mountains are characterized topographically by moderate to low relief with comparatively gentle slopes. The soil mantle is only a few feet thick, is very clayey and overlies a relatively thin weathered zone. The original pore spaces in the shales have in large part been closed by cementation but where they still exist they are too small to permit percolation of water through them. Production of water from the shales is very limited. Some deep wells obtain small quantities of water from the Modelo in the Calabasas area. Water from this source is of poor quality as it exceeds the recommended limits for total dissolved solids (1,000 ppm) sulfates (250 ppm) and magnesium (125 ppm) as set forth by the U. S. Public Health Service.

The Modelo (Puente) sandstones are interbedded with the shale members. Their outcrops are bolder and their slopes are steeper than the shale but otherwise their topography is similar. The sandstones as a rule are rather massive and well cemented. At the surface their weathered outcrops are yellowish brown with prominent partings along contacts between beds and are cut by widely spaced joints. Generally the unweathered sandstone is gray, well cemented and has such a low porosity and permeability as to be considered impervious. There are some sandstone beds that are poorly cemented. These beds permit the storage and movement of small quantities of ground water. Ground water in the sandstones, like that in the shales, originates from rainfall. The conglomerates of the Modelo formation are generally confined to the lower portion of the formation. A basal graywacke is well developed where the Modelo formation overlies the Santa Monica slate. The graywacke is massive and is resistant to weathering. It commonly crops out in a vertical wall 20 to 30 feet high.[10/] The conglomerates are well indurated and have a relatively low permeability.

Although the greater part of the Modelo sandstones and conglomerates are comparable to the shales in their lack of water-bearing properties, outcrops of pervious sandy and gravelly beds indicate that the sandstones are not entirely impervious throughout.

The presence of many faults and enclosed structures, together with the lenticular nature of the permeable beds, prevents deep circulation and replacement of the original (connate) salt waters of the formation by fresh surface water.

Pliocene Deposits

Pliocene deposits of the Repetto and Pico formations consist of clay and silty shales, and soft, fine sandstones which underlie the water-bearing series beneath portions of the valley floor and are exposed at various places in the hills in the northern portion of the area.

Generally, the pore spaces of the Repetto and Pico formations are too small to permit any appreciable movement of ground water through them; however, poorly consolidated marine sandstones and conglomerates with high porosity are present. Although the Saugus beds of this type (Sunshine Ranch formation) are considered to be a part of the water-bearing series, these beds are separated from the water-bearing portion of the Saugus formation by thick shale members, and belong to the nonwater-bearing series.

The ground water contained in the pervious beds near the surface is derived principally from rainfall, and percolation from stream beds. Pervious beds of the Repetto and Pico formations beneath the water-bearing series, but separated from them by shale bodies, generally contain waters too high in dissolved solids to be used for domestic or irrigation purposes. Because these beds outcrop as lenses between finer deposits and have both small recharge of usable water and limited storage capacities, they are unimportant sources of ground water.

Water-Bearing Sediments

Ground water occurs in three principal water-bearing series: the Pleistocene Saugus formation (including upper Pliocene Sunshine Ranch formation), late Quaternary Older alluvium (including Pacoima formation and terrace deposits), and Recent alluvium.

Lower Pleistocene Saugus Formation

The Saugus formation in the San Fernando Valley is generally restricted to marine and terrestrial deposits of probable lower Pleistocene age (Oakeshott, 1958)[2/] usually lying with angular unconformity on formations of all ages from the Basement Complex to the Pico formation.

The Saugus formation crops out in the hills and southern flanks of the mountains along the northern portion of the valley floor and underlies the other water-bearing sediments. The maximum thickness is 6,400 feet as measured on the east side of Lopez Canyon. Two miles east of Little Tujunga Canyon the formation thins rapidly to 2,000 feet. The formation also thins in a southwesterly direction to about 3,000 feet at San Fernando Reservoir. There are no outcrops of the Saugus formation in the Santa Monica Mountains, Simi Hills or Verdugo Mountains, indicating that the formation is restricted to the northern portion of the valley.

The water-bearing portion of the Saugus formation consists of light-colored, poorly sorted, loosely consolidated conglomerate and coarse sandstone, commonly crossbedded, which were deposited as fluviatile and alluvial-fan sediments. Throughout the Saugus formation layers and lenses of clayey gravel were formed by in-place weathering of the original materials.

In general, the water-bearing capacity of the Saugus formation is somewhat lower than the Older alluvium (terrace deposits).

Upper Pleistocene Older Alluvium (Terrace Deposits)

The lower, more folded portions of the Older alluvium have been differentiated by some investigators from the less folded deposits and the name, Pacoima formation, (Oakeshott, 1958),[2/] has been proposed for this early-to-middle Pleistocene deposit. Except for the more pronounced folding and overthrusting of Basement Complex, there is little difference between this unit and the remainder of the Older alluvium.

The Older alluvium was derived from deposits left by modern streams in earlier cycles of erosion with the sources little different from those of the present streams. With the exception of the remnants uplifted and partially eroded around the periphery of the valley floor, deposition has been nearly continuous to the present time.

Lithologically, the materials in all the Older alluvium and terraces are broadly similar, consisting of brownish-to-grayish, dirty, unsorted, angular-to-subangular detritus entirely of local origin. There are numerous breaks in the deposition of the material during which time extensive weathering took place, forming horizons of ancient soils. Consolidation is poor and the deposits are only locally cemented. Deposition of alluvial materials now taking place indicates that topography and drainage were closely similar when the Older alluvial deposits were being laid down. The belts of terrace deposits are broader than present stream deposits in some places and were probably formed by streams flowing at slightly lower gradients and in broader valleys. This would be a logical explanation, in part, for the finer-grained nature of some of the Older alluvium as compared to the Recent deposits. The main explanation for the higher clay content is the formation of residual clays by weathering.

The water-bearing character of these deposits is variable, depending upon the source area. West of the vicinity of San Fernando Reservoir and along the southern boundary of the valley, local streams from the hills have deposited fine debris from the predominantly sedimentary rocks of that region. East of San Fernando Reservoir, Pacoima, Big Tujunga, Little Tujunga, Verdugo, and other streams have deposited alluvial cones which consist almost entirely of coarse crystalline debris from the mountains to the north.

Recent Alluvium

Rejuvenation and increased gradient of the streams tributary to the Los Angeles River at the close of Pleistocene time have accelerated erosion from the mountains and deposition in the valley. Recent deposits east of Pacoima Wash and north of the Los Angeles River consist of predominantly coarse, thick accumulations of boulders, gravels, and sands in coalescing alluvial fans, becoming finer grained as distance increases from the canyon mouths. West of Pacoima Wash and south of the Los Angeles River the sediments are derived from predominantly sedimentary rocks and are finer grained, and deposited in much the same manner as the underlying Older alluvium.

Character of Quaternary Water-Bearing Alluvium

As previously stated, the sediments in the western portion of the valley floor are of a different nature than those found in the eastern portion and, therefore, have different water-bearing characteristics.

From the logs of wells available, it was not possible to distinguish the Saugus formation from the Older alluvium, with the exception of the Sylmar Hydrologic Subarea, so it was assumed that in all other areas the two formations had similar water-bearing characteristics.

Well logs show the western part of the valley floor to have an average of about 75 percent clay, 5 percent sand, and 20 percent gravel. Although the smaller streams of this area probably bring down considerable fine material, the low percentage of sand compared to gravel suggests the finer grained components have been decomposed to clay. These sedimentary materials probably break down more readily under the influence of weathering than do the crystalline rocks in the eastern portion of the valley. An average analysis of material from wells of the coarser crystalline material in the eastern portion of the valley floor shows 20 percent clay, 35 percent sand, and 45 percent gravel. These deposits were originally coarser than those farther west and apparently do not break down as quickly through weathering.

Structural Features

The structure of the Upper Los Angeles River area is rather complicated. The rough surface topography of the Basement Complex and extensive folding and faulting of the rocks in the hills and mountains indicate that the older rocks beneath the alluvium of the valley are folded and possibly faulted; therefore, the overlying alluvium has a variable thickness. With the exception of the faulting and folding along the northern half of the valley, there is no definite evidence that any of the other faults or folds have influenced the Recent alluvium.

Faulting

Structure of the area is dominated by the San Gabriel fault system. The north dipping, reverse or thrust faults of the Sierra Madre fault zone of the San Gabriel Mountains and Santa Susana thrust fault in the Santa Susana Mountains on the north, and the faulted anticlinal structure of the Santa Monica Mountains on the south, are also important features. The locations of the faults described herein are shown on Plate 4 and appear in the cross sections shown on Plates 5, and 5A through 5H.

San Gabriel Fault Zone. The San Gabriel fault zone has strong topographic expression, the faults appearing prominently on aerial photographs because of displaced geologic units, offset drainage, strike valleys, notched ridges, subparallel faulting, fracturing and folding. The major fault plane can be seen in Pacoima Canyon along Little Tujunga Road where the fault zone is marked by slivers of the lower Eocene Martinez formation sliced into crystalline rocks. There is no evidence to indicate activity on the San Gabriel fault in Recent time, and even late Quaternary terrace deposits seem unaffected.

Verdugo Fault Zone. The Verdugo fault zone along the south edge of the Verdugo Mountains, approximately parallel to San Fernando Road, and the Eagle Rock fault to the east appear to be a part or related to the San Gabriel fault system. Good exposures of the Verdugo fault can be seen at the base of the mountains just north of Burbank. It is plainly exposed on either side of a ravine for 50 to 75 feet; it dips 70 degrees south. Older reddish brown consolidated Quaternary gravelly sand is sharply down faulted against Basement Complex. Brecciation, gouge and calcitic vein material all occur in the fault. This fault extends under the alluvium along a line extending along the southern foot of the Verdugo Hills to the south of the Pacoima Hills, an outlier of the Verdugo block.

Subordinate to this major fault, but possibly important to controlling ground water movement, is another fault that strikes along the course of La Tuna Canyon and apparently merges with the Verdugo fault near the intersection of San Fernando Road and Sheldon Street.

Sierra Madre Fault Zone. The Sierra Madre fault zone is a series of discontinuous reverse or thrust faults from the Santa Susana fault on the west to the Rowley fault zone on the east. These comprise, from west to east, the Santa Susana, Grapevine, Sombrero, Hospital, Buck Canyon-Watt, an unnamed fault in upper Kagel Canyon, Lopez, Sunland, and Rowley fault.[2/] "Sierra Madre" comes from an old name for the San Gabriel Mountains, not from the town of Sierra Madre.

The fault zone is a series of curved, convex southward, reverse faults, which separate nonwater-bearing sedimentary and pre-Tertiary crystalline rocks on the north from the Cenozoic sedimentary formations on the south. The faults are discontinuous and of variable dip from 15 degrees to vertical; all dip northward with the older sedimentary and crystalline rocks thrust upward toward the south over sediments as late as the mid-Pleistocene Pacoima formation of the water-bearing series. Displacements have essentially been of the dip-slip type and are as great as 2,000 feet on any one fault. Displacement rapidly dies out as a strike of each of these reverse faults changes from the general east-west trend to a more northerly trend.

Northridge Hills Fault. The Northridge Hills fault is a high-angle fault. Its existence is based primarily on the numerous oil test holes which have been drilled in the Northridge Hills. Logs of these wells indicate that the Modelo formation has been displaced between 500 and 1,000 feet along the dip of the fault. The apparent movement along the fault has been dip-slip with the north block down. Numerous small drag folds in the form of anticlines and synclines have been formed along the fault. The apparent surface trace of the fault can be found in the Cretaceous Chico formation northerly of the town of Chatsworth. Sparse information indicates an effect on the movement of ground water west of Sepulveda Boulevard. There is no apparent effect of the fault east of Sepulveda Boulevard. This could be explained by the removal of materials and subsequent deposition of the coarse-grained deposits by Pacoima and Tujunga Washes. The Northridge Hills fault may be an extension of the Verdugo fault or the La Tuna Canyon fault as the structural pattern suggests; however, there are no data to substantiate this hypothesis.

Mission Hills Fault. A minor fault zone comprising three faults is perfectly exposed in Sepulveda Boulevard road cuts just east of Lower San Fernando Reservoir in the Mission Hills. It is believed that these faults are related to both the San Gabriel and the Sierra Madre fault system. Most southerly of these fault planes is a 60-degree south dipping reverse fault with rocks of the Modelo formation on the north limb of the Pacoima Hill anticline thrust over the lower Pliocene Repetto formation. The next fault north dips 55-degrees south and has thrust Repetto sandstone over fossiliferous sandstone of the middle Pliocene lower member of the

Pico formation. The most northerly of the group is a normal fault dipping 75-degrees north, with upper Pliocene beds down dropped. A north dipping Mission Hills thrust fault south of Lower San Fernando Dam is postulated on the basis of an anomalous geologic section reported for Universal Consolidated Oil Company Panorama 1 (Oakeshott, 1958).[2/] If such a fault exists, it might be expected to have similar features to faults of the Sierra Madre zone. That is, its trace should be convex southward, its trend should turn to the north around the eastern end of Mission Hills, it should dip about 40 to 50 degrees, and it should die out within a mile or two, both east and west.

Pacoima Hills Fault. A well-exposed east trending normal fault dipping 50 degrees north in the Pacoima Hills has brought Basement Complex up on the south side against sedimentary and volcanic rocks of the Topanga formation. Four miles east in the Verdugo Mountains, these formations are in unconformable contact. It is believed that this fault may be of small displacement. Bailey and Jahns (1954)[4/] projected this fault five miles east as a buried extension along the south side of Tujunga Valley. However, the most reasonable structural section shows no necessity for a Tujunga Valley fault (Oakeshott, 1958).[2/]

Raymond Fault. The Raymond fault separates the Topanga formation in the northern upthrown block from the Puente formation in the south block. It is mostly concealed by the Older alluvium along York Boulevard but evidence of its approximate location is given by outcrops near the fault zone. This fault is very likely a high-angle reverse fault, as shown by overturned beds in the Topanga formation along the Arroyo Seco. Overturned beds are also present east of the area of investigation at Raymond Hill. Immediately east of the Arroyo Seco the fault forms an escarpment 50 to 100 feet high in Older alluvium; however, the surface of the alluvium west of the Arroyo Seco apparently has not been displaced. Recent studies in the Eagle Rock Subarea seem to indicate that Older alluvium may have been displaced and deformed by movement on the Raymond fault. The throw on this fault may be in excess of 10,000 feet; however, only a small portion of this has occurred in post alluvial time.

Studies made of the bedrock configuration of the Los Angeles River channel indicate that movement along the Raymond fault has formed a small knob in the center of the channel to the north of the fault and a down-dropped area to the south. This is shown on Plate 6, entitled "Contours on the Base of Valley Fill". This feature may cause a constriction and may be the cause of the rising water which has been noted in the past in the vicinity of Los Feliz Boulevard.

Eagle Rock Fault. The Eagle Rock fault separates the Basement Complex rocks to the north from the Topanga formation to the south. It is a vertical or high-angle reverse fault with the north block up.[5/] No alluvium has been displaced by the Eagle Rock fault, indicating that movement on this fault stopped before movement stopped on the Raymond fault. The questionable extension of the Eagle Rock fault westerly to the Verdugo fault is based on a step-like ground water cascade in the mouth of Verdugo Canyon. The general structural pattern also suggests that the Eagle Rock fault may be related to the Verdugo fault system.

Effects of Faulting on Ground Water Movement. There are numerous ways in which faulting may affect the movement of ground water. Some of the more important are listed as follows:

1. Impervious rock may be brought into contact with the water-bearing series thus reducing the underflow cross-sectional area.

2. Continuous pervious strata in the alluvium may be offset and made discontinuous.

3. Impervious gouge may be formed as a result of the grinding action during a recurrent movement along the fault.

4. Repeated uplift and depression of one or both sides of a fault block may allow alternate weathering of the surface deposits with resultant formation of large quantities of impervious residual clay in the vicinity of the fault.

5. Strata may be folded or overturned so that their position is unfavorable for percolation of water through them.

6. Fault fractures may be sealed by chemical deposits.

7. Brittle material may become cracked or brecciated thus creating a more permeable condition along the line of faulting which allows the zone to act as a conduit and carry water. This condition has been observed to exist to a minor extent in the vicinity of the water supply tunnels in the Verdugo Subarea.

A combination of all but the first and last phenomena is believed to have resulted in the formation of an impediment along the

Verdugo and La Tuna Canyon faults. Extensive research and work has been done by the Los Angeles County Flood Control District on the effect of these faults on their spreading operation of water from Hansen Dam.[6]

Folding

In the San Fernando Valley regional dips of the sedimentary formations are away from the pre-Cretaceous crystalline rocks which form the hills around the valley. Unconformities between the successive Cretaceous, Tertiary and Quaternary formations show that orogenic movements took place locally at various times, but the mid-Pleistocene orogeny overshadowed all of the others in intensity. During the faulting and the accompanying folding the crystalline rocks behaved essentially as a competent block undergoing intermittent elevation with adjustments within the block accompanied by faulting, shearing and fracturing. Around the margins of the Basement Complex the sedimentary strata reacted according to their competence and the local intensity of the stresses applied by developing a series of discontinuous folds closely related to the faults. Commonly, local synclines are developed on the down-dropped fault blocks and anticlines on the upthrown blocks.

The dominant fold structures affecting the storage and flow of underground water in the San Fernando Valley are located only along the northern border of the valley. Inasmuch as the other folds have little or no effect on the ground water, no extensive study was made of them.

The Little Tujunga syncline (Plate 5J), located between the Verdugo Mountains and the San Gabriel fault, is one of the principal structural features along the north edge of the valley. The axis of this fold closely parallels the trace of the Sierra Madre fault zone, following it with a west northwest trend in the area from Tujunga to the Veterans Hospital at Pacoima Canyon, where it has been overridden by the crystalline rocks along the Hospital fault. Continuing westward, the axis changes to a southwest trend paralleling the northeastern end of the Santa Susana fault. Formations along the south limb dip northward at angles from 25 degrees to 80 degrees; the north limb is very steep to overturned and has minor folds superimposed on it. Saugus beds are overturned in several places along the Lopez fault, particularly in upper Lopez Canyon. Overturning of the Saugus formation is general along the Sunland fault where the north limb of the syncline has been almost completely cut out by the fault.

The Verdugo Mountains, Pacoima Hills and Mission Hills comprise the remnants of an elevated, faulted anticlinal block trending north 75 degrees west across the northern part of the valley. Structurally, the highest part of this block is in the central part of the Verdugo Mountains, where granitic rocks are exposed. This structure is flanked by the Topanga and Modelo formations, plunges westward to the vicinity of Hansen Flood Control Dam, is faulted up to expose granitic rocks and the Topanga formation in the Pacoima Hills, and plunges west downward to an estimated 8,600 feet in the next four miles (Oakeshott, 1958).[2/]

The most prominent fold of the Mission Hills is the east trending Mission Hills anticline just south of lower San Fernando Reservoir, which exposes diatomaceous shale of the Modelo formation at the southeast end of the reservoir. This fold may be the result of drag on the Mission Hills thrust fault. The strong westward plunge of this structure is indicated by Repetto, lower Pico and upper Pico beds which successively overlie exposures of the Modelo formation on the north, west and south limbs of the anticline. The north and south limbs are faulted and complicated by numerous minor folds in the incompetent Modelo shale. For two miles northwest of the Mission Hills anticline, Saugus beds dip continuously northward on the south limb of the western expression of the Little Tujunga syncline. To the west of San Fernando Reservoir, the sediments of the water-bearing Saugus formation are folded into a series of anticlines and synclines trending about north 70 degrees west.

Geophysical studies of nonwater-bearing formations in the western portion of the San Fernando Hydrologic Subarea made by various oil companies show a series of three synclines with two intervening anticlines in the nonwater-bearing formations that have an easterly plunge. This structure is somewhat simpler than was originally postulated by Eckis in Bulletin 45.[1/]

The Elysian Hills anticline, which is located on the southerly side of the Los Angeles River Narrows, is of interest in that continued movement on this feature after the mid-Pleistocene orogeny may have caused the "reversed gradient" on the base of the water-bearing series in the Narrows area; however, there is no evidence of movement in Recent time. This "reversed gradient" feature shows the profile on the base of water-bearing materials lower in elevation near Colorado Boulevard than at Figueroa Street or Gage F-57. This is shown on Geologic Cross Section M-M' and Plate 6, Contours on the Base of the Valley Fill. Another explanation of this feature could be that the Arroyo Seco flowed northerly into the San Fernando Subarea for a period of time in the mid-Pleistocene.

A small anticline in the Modelo formation in the Hidden Hills area north of Calabasas is worthy of description. This fold is fairly tight and is best traced by a sandstone bed. This fold plunges steeply toward the north. Water wells drilled into the flanks of the anticline yield very little water, while wells drilled along the crest encounter fractured rock and have much better production (80-100 gpm). This water is of poor quality. Continued production of water in this area has resulted in an abnormally high decline in water levels.

Configuration of Base of Valley Fill

The configuration of the base of the valley fill is shown by the contours on Plate 6. The contour locations were developed from logs of approximately 200 wells in which elevations of the base of the water-bearing materials could be determined. The determination was made by subtracting the thickness of the water-bearing materials indicated in the well logs from the surface elevation of the well. The elevation of the well was determined either by survey methods or interpolated from the U.S.G.S. 7-1/2 minute quandrangles that cover the valley area. The nonwater-bearing materials noted in the well logs were shale, sandstone, conglomerate or granite. Since it was not possible to locate the poorly consolidated Saugus formation from the well logs it is assumed that this formation is included in the volume of water-bearing materials in the San Fernando Hydrologic Subarea. The Sylmar Hydrologic Subarea is entirely underlain by the Saugus formation, which extends, in the northern part of the subarea, to a depth in excess of 6,000 feet.

No Saugus formation has been detected at depth in the Verdugo or Eagle Rock Hydrologic Subareas.

San Fernando Hydrologic Subarea

The contours on the base of the valley fill (Plate 6) in the western portion of the subarea in the vicinity of Arroyo Calabasas and Bell Creek seem to indicate the existence of an old drainage system which was located somewhat southerly of the present drainage channels. This ancient drainage appears to have flowed northerly, east of Aliso Canyon Wash into the deep portion of the basin which is traversed by the Southern Pacific Railroad (S.P.R.R.).

The depth of water-bearing material is unknown in the central and eastern portion of the subarea, but probably extends to depths of 1,000 to 1,500 feet. An anomalous dome-like feature is present in the vicinity of Lankershim Boulevard and Vanowen Street. The cause of this feature is unknown; however, its presence is indicated on Figure H-1, Appendix H. Geophysical gravity studies by Corbato,[7/] also show this anomaly. The Tujunga Wash area is underlain by nonwater-bearing formations at depths to about 90 feet below ground surface. South of Hansen Dam, well 4904A, which is 226 feet deep, failed to reach nonwater-bearing formations. The exploratory work performed for Hansen Dam[8/] indicates the presence of Modelo formation at depths of 90 to 170 feet along the axis of the dam.

The amount of offset in the nonwater-bearing materials along the Verdugo fault south of Hansen Dam is not known due to a lack of deep wells with logs. In the Sunland area, which is adjacent to Big Tujunga Wash, there is an offset in the nonwater-bearing formations amounting to about 30 feet. The location of this offset is in grid coordinates 4983. This feature may be due to faulting which is evident in the hills to the northeast and southwest of this feature.

In the vicinity of the confluence of Verdugo Wash and the Los Angeles River, the depths to nonwater-bearing material rapidly decreases as the Los Angeles River enters the Los Angeles River Narrows. The reason for this rapid change in the bedrock profile is not known; however, it has been postulated that this feature is caused by a westerly extension of the Eagle Rock fault, the scarp of which was modified by erosion prior to burial. This feature is located in grid coordinates 3904, 3914, 3924 and 3934 and shown on Plate 6.

Sylmar Hydrologic Subarea

The subarea is almost entirely underlain by the folded Saugus formation which extends to great depth. Immediately below the Saugus formation are the nonwater-bearing Repetto and Pico formations. The Repetto formation is exposed in both banks of Pacoima Wash at the Pacoima submerged dam, located in the vicinity of well 5989A. These outcrops and their westerly extension constitute the eastern portion of the southern boundary of the subarea. Although the Saugus is underlain by the Pico formation in the Mission Hills, the western portion of the southern boundary is believed to be within the lower Saugus formation where impervious beds prevent lateral movement of ground water. The Repetto, Pico and Saugus formations dip approximately 60 degrees to the north and drop rapidly in elevation under the water-bearing materials.

The Stetson Sombrero No. 1,[19] drilled by Sunray Oil Corporation (1950) in the proximity of well 5937 in the northern part of the subarea, penetrated 12,027 feet of sediments reported to be continental Saugus. Dipmeter records of the hole indicate formation dips of about 45 degrees. These data indicate that the thickest section of Saugus in the area is in the vicinity of this test hole. The Little Tujunga syncline plunges toward this location from both the east and west.

Verdugo Hydrologic Subarea

Contours of the base of the valley fill (Plate 6) in the Verdugo Hydrologic Subarea show several interesting features. The most important of these is the existence of the buried channel eroded into the Basement Complex of an ancestral Pickens Wash draining easterly into the Monk Hill area. Under low water table conditions this buried channel carries all tributary subsurface water. Under high water table conditions the southwesterly bank is overtopped and subsurface flow in a westerly direction is presumed to occur.

A second feature is the depression in the buried bedrock surface in the vicinity of well 5058J. The bedrock elevation at this location is somewhat lower than the bedrock surface in Verdugo Canyon. This depression may be due to displacement on the La Crescenta Valley fault. It is interesting to note that the maximum depth of water-bearing materials is about 54 feet at Verdugo well (3963) adjacent to the Verdugo submerged dam, while upstream approximately 1-1/2 miles the depth of fill material has increased to a maximum of 190 feet. This decrease in the thickness of the water-bearing materials is related to tilting associated with movement on the Verdugo fault and/or the normal thinning of deposits at the toe of an alluvial fan.

Eagle Rock Hydrologic Subarea

The configuration of the base of the valley fill in the Eagle Rock Hydrologic Subarea is not shown in detail on Plate 6 due to the small area involved and to the 100-foot contour interval which was utilized on the plate. A more graphic representation of the subarea is shown on Geologic Cross Section S-S' on Plate 5H. This section shows the deepest portion of the basin to be located in the vicinity of the Raymond fault and in the area of extraction from the confined artesian portion of the basin. The configuration of the base of the valley fill along Colorado Boulevard in the subarea is not known; however, the depth to bedrock for a well located just northwest of the intersection of Colorado Boulevard and Eagle Rock Boulevard was stated as 140 feet (well No. 333, U.S.G.S. Water Supply Paper 219 field notes).[20] The depth of the water-bearing materials near the Raymond fault is about 200 feet.

Geologic Conditions Affecting Occurrence and Movement of Ground Water

Geologic features greatly influence the occurrence and movement of ground water within the Upper Los Angeles River Basin. Features such as faults, folds and lithologic variations have pronounced effects on the water surface elevation and direction of movement.

The source of ground water supply to the hydrologic subareas is percolation of direct rainfall, surface runoff from valley areas and hill and mountain areas, spread waters, imported waters, and a minor amount of underground percolation of water from the mountain masses to the alluvium. Disposal of the supply, other than by export, evaporation, consumptive use and surface runoff, is by relatively small amounts of underflow out of the area at the Los Angeles Narrows and in the Pickens Canyon area.

Both the Basement Complex pre-Quaternary sediments and volcanics, which are known to underlie the area, are deep-seated and relatively impervious and any contribution by ground water movement from them must therefore be small. The investigation has revealed no evidence of subsurface outflow conduits other than through the Los Angeles Narrows to the Los Angeles forebay of the Central Basin, and the subsurface underflow from the Pickens Canyon area to the Monk Hill Basin of the Arroyo Seco drainage system.

San Fernando Hydrologic Subarea

For purposes of discussion the San Fernando Hydrologic Subarea is best divided into two general units on the basis of the type of alluvial-fill material present in each part. The valley fill of the western portion of the area is essentially fine-grained material derived from the surrounding sedimentary rocks. The fine-grained nature of these materials allows water to be transmitted at a relatively slow rate, whereas the eastern portion of the subarea has high yields and high permeabilities and is composed of coarse detritus eroded mainly from the granitic Basement

Complex. This eroded debris is generally very coarse; in places boulders up to three feet in diameter are relatively common. The deposits are essentially sand and gravel with some fines in the interstices. These materials constitute about one-third of the surface area of the ground water reservoir and contain about two-thirds of the water in storage in the San Fernando Hydrologic Subarea.

Western Portion. In the western portion of the subarea, there are several faults which may or may not have an effect on the movement of ground water in the vicinity of Devonshire Street and Topanga Canyon Boulevard in the proximity of the town of Chatsworth. The most prominent of these faults extends northeasterly beneath the valley fill. This fault has displaced the nonwater-bearing materials forming a ground water cascade on the order of 80 feet in height. The area is underlain at shallow depths by Cretaceous sandstones northwest of the fault and the Modelo shale at greater depth south of the fault. The small northwesterly trending fault in the water-bearing series in this area must be inferred in order to contour the ground water elevations in a logical manner. It is not known whether the water-bearing materials have been affected. This feature is parallel to the Northridge Hills fault and lies south of it. Both faults have cut the nonwater-bearing Cretaceous sandstones to the north.

The effect of the Northridge Hills fault on the movement of ground water is unknown; however, the fault forms a barrier or partial barrier to the movement of ground water either by offsetting permeable beds or by bringing less permeable materials closer to the surface. The upper portion of the easterly extension of the fault has presumably been removed by erosion by the combined action of Pacoima and Tujunga Creeks.

The small arcuate fault shown westerly of the intersection of Balboa Boulevard and Ventura Boulevard has no known effect on the movement of ground water. The existence of this fault is based primarily on the apparent vertical offset of the upper member of the Modelo formation that crops out on the north side of the fault.

An area of shallow ground water levels is present in the western portion of the hydrologic subarea. The area is bounded on the east by Reseda Boulevard, on the south by the Los Angeles River and to the west by De Soto Avenue. The northern boundary is somewhat L-shaped following Saticoy Street to the vicinity of Tampa Avenue then northerly to Parthenia Street. This area was studied in detail by the United States Department of Agriculture Soil Conservation Service, Research, during the period 1947 through 1950.[21/]

Their investigation pointed out the following conclusions: water level fluctuations in the piezometers installed by the Soil Conservation Service are cyclic with precipitation; these water levels also respond to irrigation water applied in excess of the consumptive use; and deep artesian and/or pressure wells within the area leak into the shallow zone to the extent that small ground water mounds were developed around certain wells. The source of the confined water appears to be from aquifers in the Saugus formation. The Saugus formation presumably underlies the alluvium at relatively shallow depths. These aquifers are recharged by precipitation on the surface exposure of the Saugus formation to the north.

Small localized pressure effects found in the western portion of the subarea are due to gravel lenses confined by clay strata.

Eastern Portion. The permeable character of the alluvial-fan deposits below Hansen Dam has been altered by faulting. Gravel beds displaced by thin clay seams in the fault planes have been observed at the 130 foot level in the Arrow Rock Products gravel pit south of well 4916B. These sheared gravels do not represent the main trace of the Verdugo fault; however, they illustrate how the associated faults may act as partial barriers to the movement of ground water.

There are two steps in the water surface in this area. The first step is immediately below Hansen Dam and appears to be a ground water cascade flowing over the northerly dipping Modelo sandstones and into the deeper portion of the area near the gravel pits. Well 4914, located about 1,000 feet south of Hansen Dam, and the exploratory drill holes for the dam indicate that water-bearing rocks are at about 900 feet elevation, whereas approximately 10,000 feet south of Hansen Dam near the Verdugo fault zone the base of the water-bearing series is about 600 feet deeper, lying between elevation 200 and 300 feet above sea level. The water surface drops about 300 feet in elevation between the axis of the dam and wells in grid 4916.

As of January 20, 1945, there was a 75-foot difference in the elevation of the water table observed between wells 4895 and 4905A. These wells straddle the Verdugo fault and are 3,000 feet apart. The difference in ground surface elevation between the wells is 28 feet. Considering the high permeability of the aquifers tapped by these wells and the lack of heavy draft in the area, a water table with an overall slope of 150 feet per mile, about 2-1/2 times as great as the surface slope, seems improbable when compared to the normal water table slope in the northern part of San Fernando Valley which is about 15 feet per mile or about one-third the surface slope. These facts alone warrant the assumption that the Verdugo fault zone is a partial barrier to the free underflow of water. Observations of this condition were initially reported by Warren N. Thayer of the Los Angeles County Flood Control District in a report dated March 15, 1945, entitled "A Resume of Present Knowledge of Ground Water Conditions in the Vicinity of Hansen Spreading Grounds".[6/]

Between the southeastern corner of the Mission Hills and the southwestern side of the Pacoima Hills, there is a very sharp break in the water surface of approximately 250 feet. This discontinuity in water levels is discernible between wells 4841 and 4842. This feature is assumed to be a ground water cascade due to a difference in the elevation of the nonwater-bearing materials. Very little is known about this feature due to a lack of well data in the vicinity.

Another ground water cascade is present in the Sunland area adjacent to Tujunga Wash. This cascade apparently is due to faulting in the nonwater-bearing series with the water surface being about 50 feet lower on the Tujunga Wash side of the feature.

A step-like water surface is present below the Verdugo submerged dam of the City of Glendale. The steps in the water surface are due to offsets in the Basement Complex along the Verdugo fault zone. No evidence of the faults forming a barrier to the movement of ground water has been found. The water surface elevation at Verdugo well 3963A is generally about 90 feet higher than well 3963, which is located about two-thirds of a mile downstream, and the water levels at well 3954 are 250 feet lower than at well 3963. Well 3954 is about two-thirds of a mile downstream from well 3963.

The water-bearing deposits of the Los Angeles River Narrows are very permeable. The City of Los Angeles has two well fields in the area. Due to heavy pumping, large depressions or pumping holes have been created in the ground water surface. The largest of these pumping depressions is located at the large bend in the Los Angeles River where the river begins its southerly course through the Narrows. This well field, called the Crystal Springs well field, and the City of Glendale Grandview wells immediately north of the Crystal Springs well field, have created the pumping depression indicated on Plate 30. The second pumping hole, created by heavy pumping of the Pollock well field of the City of Los Angeles, is not shown on the plate due to its being developed during 1959 and 1960.

The rising water which has occurred historically is due in part to the reduction in the cross-sectional area as the stream approaches the

F-57 gage. The maximum depth of water-bearing materials at Huron Street (Gage F-57) is about 110 feet, whereas the maximum depth at the Pollock well field is 260 feet. A comparison of the two areas is shown by sections K-K' and L-L' on Plate 5D.

Some instances of rising water have been noted in the past in the vicinity of Los Feliz Boulevard. This occurrence is probably due in part to a constriction or reduction of the cross-sectional area of water-bearing materials. The constriction is caused by the small buried hill of nonwater-bearing material which is depicted on Plate 6, Contours on the Base of the Valley Fill, and is located just downstream from Los Feliz Boulevard.

<u>Movement of Ground Water</u>. The slope of the water surface and direction of ground water movement in the unconfined zones of the San Fernando Hydrologic Subarea is easterly toward the Los Angeles River Narrows. Ground water contours for the fall of 1931, 1938, 1944 and 1958 are shown on Plates 27, 28, 29 and 30, respectively. The direction of movement of ground water is normal to the contours and downslope therefrom.

The waters in general move away from the surrounding hill and mountain groups where the runoff percolates into the porous portions of the alluvial fans. The water then in transit moves downward to the main water body.

Water level fluctuations in the San Fernando Subarea are depicted by the hydrographs of wells shown on Plates 34A and 34B. The location of the following wells utilized are shown on Plate 18:

2771H	3740	3914H
3600	3753	3938B
3691A and C	3830B	4838

Sylmar Hydrologic Subarea

Formations. The nonwater-bearing rocks that form the northern boundary of the subarea are composed essentially of Basement Complex; however, in the northwestern portion of the area, rocks of the sedimentary Repetto formation are faulted against the Basement Complex. The Repetto formation also occurs along the southeastern boundary and again in the Mission Hills (see Plate 4), where it is overlain by a thin section of nonwater-bearing Pico formation.

The water-bearing deposits in the Sylmar Subarea consist of the Saugus formation, Older alluvium and Recent alluvium. The Saugus formation is about 6,400 feet in thickness and is composed of strata that vary greatly in terms of porosity and permeability. Some members of the formation make good aquifers while others are aquicludes. The Older alluvium may have a maximum thickness of between 500 and 1,000 feet west of the San Fernando Veterans Hospital. These materials are composed of coarse detritus derived from the Basement Complex; however, in some places residual clays have developed as a result of weathering. The Recent alluvium attains a thickness of 50 to 60 feet in Pacoima Wash where the erosive action of the stream has incised the previously mentioned water-bearing units and then backfilled the eroded area with very coarse granitic debris. In the remainder of the subarea, where Recent alluvium occurs it constitutes only a thin veneer on top of Older alluvium and Saugus formation.

Structure. The geology of the Sylmar Subarea is greatly complicated by faulting and folding. The nonwater-bearing materials to the north of the subarea have been faulted and in part thrust southerly over portions of the water-bearing Saugus formation. The compressive forces that are related to the thrust faulting are also related to the formation of the Little Tujunga syncline,(Plate 5J)the most important feature of the subarea. At least 6,000 feet of Saugus formation and an even greater thickness of older nonwater-bearing sediments have been folded into an asymmetric syncline with the north limb overturned. This syncline has been truncated by erosion and covered by a veneer of Older and Recent alluvium. The southeastern boundary of the subarea, as hereinbefore noted, is formed by the steep, north-dipping beds of the nonwater-bearing Repetto formation that is part of the same synclinal structure. The Repetto formation is exposed in both banks of the Pacoima Wash at the topographic constriction, which is the site of the Pacoima submerged dam located about 2.5 miles south of Pacoima Dam. These strata continue westerly under the cover of Older alluvium and are exposed in roadcuts near the intersections of Gladstone Avenue and Maclay Avenue, and Foothill Boulevard and Fernmont Street (see Figure A-1). All of the previously mentioned outcrops have similar attitudes. From the intersection of Foothill Boulevard and Fernmont Street to the Mission Hills there are no outcrops of the Repetto formation; however, the logs of wells 5969B and 4850B, located in this section indicate materials thought to be Repetto formation at depths of 310 and 321 feet, respectively. These depths indicate that the wells are located westerly of the projected trace of the Repetto strata and are within the Sylmar Subarea.

Field Investigation. Within the section between Foothill Boulevard and Mission Hills there is a very marked discordance in water levels. In order to locate more accurately the break in the water surface, 20 bucket auger holes were drilled. Nine of the twenty holes were drilled under the direction of and at the expense of the City of San Fernando, five by the City of Los Angeles, and the remaining six by the Referee. Representatives of the Board were present at the drilling of all holes and prepared detailed logs of each boring. The location of the test holes is shown on Figure A-1. The logs of the test holes are included in the well log section of the basic data. The results of the drilling program were utilized to construct a peg model which aided the analysis. The boundary of the subarea was delineated in the gap area on the basis of water levels. The analysis of available water level data, data obtained from the test holes and the geology of the area indicate the following:

1. Water levels northwesterly of the break in the water surface are about 50 feet higher than those to the southeast of the break (see Plate 30).

2. Water levels northwesterly of the break are related to the eroded ends of confined aquifers in the Saugus formation.

3. Water levels southeasterly of the break are free ground water levels and are associated with coarse alluvial deposits which had the Pacoima drainage as a source area.

4. The discordance in water levels is related to the eroded south flank of the Little Tujunga syncline which has been covered with a thin veneer of alluvium.

SAN FERNANDO VALLEY REFERENCE

LOCATION OF TEST HOLES AND IMPEDIMENTS TO FLOW OF GROUND WATER

STATE WATER RIGHTS BOARD

5. Subsurface flow from the Sylmar Subarea to the San Fernando Subarea has been found to occur only at two places: namely, the Sylmar and Pacoima Notches (see Plates 5 and 5H). There is hydraulic continuity between the confined aquifers and the veneer of alluvium that overlies the eroded south flank of the Little Tujunga syncline.

6. Continuity exists between the Sylmar and San Fernando Subareas through the saturated alluvium in the two notches.

7. The configuration of the break in water surface through the Sylmar and Pacoima Notches is not sharp as would be caused by a fault but is a steep gradient which is similar to that found in a ground water cascade.

Occurrence and Movement of Ground Water. The information obtained from the test holes greatly aided the understanding of the occurrence and movement of ground water within the subarea. The noticeable pressure rise of the water surface which took place in several of the test holes during and immediately after drilling, coupled with the fact that there are historic records of artesian flows for the Mission well field and the City of San Fernando well field at Fourth and Hubbard Streets, indicate that a confined water system exists within the Sylmar Subarea. A free ground water area is present between the aforementioned well fields as determined during the test drilling. All wells in the subarea derive their water supplies from the confined aquifers of the Saugus formation. In 12 of the test holes, the Saugus formation was penetrated before saturated materials were reached.

There is a decline in water levels in the free ground water area in the Sylmar Subarea coincident with heavy pumping of the Mission well field.

Therefore, on the basis of the short period of record available, it is concluded that the free ground water area is in hydraulic continuity with the confined aquifer.

The Sylmar and Pacoima Notches (Plate 5H) are the principal areas of subsurface escape from the subarea. The slope of the water surface through the Sylmar Notch is suggestive of a ground water cascade where small quantities of water are spilling over a relatively impermeable lip or barrier. Data on the slope of the water surface below the Pacoima Notch are not available. These two features are described in detail in Appendix P.

The exact location and extent of the forebay or recharge area for the confined aquifers are not definitely known; however, the porous alluvial deposits in Pacoima Wash are in a favorable position to recharge the dipping aquifers of the Saugus formation which are in contact with the stream gravels in the incised and backfilled portion of Pacoima Wash. These permeable deposits act as a sponge, holding water for release into the aquifers of the Saugus formation. Ground water contours (Plates 27 through 30) indicate that there is a slope of the water surface from Pacoima Wash toward the lower portion of the subarea where the majority of extractions are made. Routing studies made by the staff of the Board on the Sylmar Subarea indicate that the water supply from Pacoima Creek that could remain in the water-bearing materials above the Pacoima submerged dam would not be sufficient to maintain the water levels in the area through a period of wet and dry years. Deep percolation of precipitation, applied water and runoff from hill and mountain areas are also major sources of recharge. Such recharge would percolate through the alluvial blanket and enter some of the truncated aquifers of the Saugus formation.

The hydraulic gradient under static conditions indicates that it is improbable that Lower San Fernando Reservoir contributes water to the subarea. Records of well 4830, about 2,000 feet east of the reservoir, show that water levels have dropped below elevation 1,120 feet (high water surface of Lower San Fernando Reservoir) only six times between 1932 and 1954. Under pumping conditions, the water levels are lowered about 90 feet and a favorable gradient can be developed in various aquifers that strike between the Mission well field and the Lower San Fernando Reservoir. Information now available is insufficient to support a conclusion that flow occurs under pumping conditions.

It is possible that movement of ground water in a westerly direction can occur in the Saugus formation from the vicinity of Kagel and Lopez Canyons which lie immediately to the east of Pacoima Wash, since a favorable hydraulic gradient exists and the synclinal structure of the Saugus formation plunges westerly. The amount of water that could be derived from the Kagel-Lopez area would be relatively small since the area of tributary drainage adjacent to the permeable formation is small. Wells of the Glenhaven Cemetery, located in the upper Kagel Canyon area, penetrated the Saugus formation to depths of approximately 900 feet. Since the yields of these wells are very poor and water levels are declining, it may be inferred that a ground water mining operation exists.

Since the recharge from the Pacoima Wash area, coupled with deep percolation of precipitation and delivered water on the remaining surface of the subarea, appears to have been of sufficient magnitude to maintain water levels at their historic levels, historic recharge from Lower San Fernando Reservoir or Kagel and Lopez Canyons is improbable. However, substantial withdrawal from the subarea might bring about conditions more favorable to recharge from Lower San Fernando Reservoir.

Water level fluctuations within the Sylmar Subarea are represented by hydrographs of wells 5939, 5969 and 5989A, which are shown on Plate 34C. Water levels in the lower portion of the subarea have only declined about 25 feet below the 1944 high water level.

Verdugo Hydrologic Subarea

The water-bearing materials of the Verdugo Subarea are surrounded by a complex of granitic and metamorphic rocks which have been highly fractured. Previous geologic work by Miller (1934)[11/] mapped the rocks in two main groups, the Wilson granodiorite and the San Gabriel formation. These units have been, for purposes of the report, called Basement Complex because of their general lithologic similarity and nonwater-bearing characteristics. The Basement Complex yields only small amounts of water to springs and tunnels from fracture systems which in turn are supplied by infiltration of precipitation. The overall average flow from each of these tunnels and springs was estimated to be about 20 gpm during September 1959.

The valley fill is composed essentially of coarse detritus which has been deposited in a series of coalescing fans. The principal source area has been the San Gabriel Mountains. Well logs indicate a fairly high content of sand, gravel and boulders; however, numerous notations indicate that there is considerable clay in the matrix of some of these materials. It should be noted that the material in the area north of Foothill Boulevard has a lower specific yield. Wells in this portion of the basin have much lower production than those located in the lower portion of the basin (vicinity of Verdugo City and Montrose).

The northern portion of the ground water basin is traversed by a member of the Sierra Madre fault zone. This fault is not known to have displaced any of the valley fill materials. The La Crescenta Valley fault bounds the southern portion of the valley fill. This fault is inferred on the basis of topography. The depression in the bedrock surface as shown on Plate 6, Base of Water-Bearing Series, may be related to the existence of this inferred feature.

Numerous faceted spurs along the Verdugo Mountains furnish additional criteria for postulating the existence of the fault. Miller (1934)[11] extends this fault down into Verdugo Canyon; however, evidence for such an extension appears to be tenuous.

The main portion of the Verdugo Basin represents a graben between the Sierra Madre and La Crescenta Valley faults. This graben has been modified by erosion and connected to the San Fernando Basin by Verdugo Canyon. In the canyon, bedrock is much nearer to ground surface at the submerged dam than at the Glorietta well field, which is located in the upper reach of Verdugo Canyon. This may be related to tilting caused by movements of the

Verdugo fault. Historically, the occurrence of springs in the area above the present day submerged dam is probably related to this reduction in cross-sectional area of permeable material.

The Verdugo and La Crescenta Valley faults are not known to have affected the water-bearing series. There are no known natural impediments to ground water movement other than a bedrock ridge which extends between the mouth of Goss Canyon and the granitic outcrop located at the intersection of Foothill Boulevard and Briggs Avenue in the Verdugo Subarea.

A series of cross sections and bedrock contours drawn through the subarea indicate that the bedrock is lower in the La Canada-Pickens Canyon area and that a buried ancestral Pickens Wash slopes to the Monk Hill Basin. Available ground water levels indicate that the ridge obstructs the flow of ground water to the Verdugo Subarea under low water table conditions such as in the fall of 1958; however, the water is above the ridge in high water table years such as 1944.

Geologic studies to date do not indicate that there are any sources of native ground water other than that which is derived from precipitation. No indications of juvenile water or water transported from outside the watershed along faults or fracture systems have been found.

<u>Direction of Ground Water Movement</u>. The ground waters in the Verdugo Subarea move southerly from the mouths of canyons in the San Gabriel Mountains toward Verdugo Canyon. The majority of extractions of ground water are made by wells of Crescenta Valley County Water District along the southwest side of the area, by the City of Glendale in Verdugo Canyon

at the Glorietta well field (3971), at the Verdugo submerged dam and finally by the Verdugo well (3963A). There is also some movement of ground water from the Pickens Canyon area into the Monk Hill Basin, which is discussed in more detail in Appendix F.

Water level fluctuations within the Verdugo Subarea are represented by the hydrograph of well 5058, which is shown on Plate 34C.

Eagle Rock Hydrologic Subarea

The Eagle Rock Hydrologic Subarea is treated herein as a separate ground water unit; however, it should be noted that the computation description of hydrologic items for this subarea were included with the data for the San Fernando Subarea.

The Eagle Rock Subarea is located in the eastern portion of the Los Angeles River drainage basin adjacent to the Los Angeles River Narrows. The surface drainage flows generally towards the vicinity of Eagle Rock Boulevard then southwesterly to the Los Angeles River. The total tributary drainage of the area above the Raymond fault and its intersection with Eagle Rock Boulevard is about 2,910 acres.

The subarea is an artesian basin in which all present-day pumping is located at the lower end of the pressure area in the vicinity of York Boulevard.

Formations. Topanga and Puente (Modelo) formations are the principal nonwater-bearing rock units cropping out in the area surrounding the water-bearing series. Highly fractured Basement Complex is present in the hill area north of the Eagle Rock fault and a small severely broken knob of the same material occurs on the north side of York Boulevard between Mt. Pleasant Street and Avenue 49.

The water-bearing materials are essentially composed of older alluvial deposits of sand, gravel and considerable clay. Recent alluvium only constitutes a thin veneer along the stream channels.

The Eagle Rock and Raymond faults are the main fault features of the area. The Eagle Rock fault separates the Basement Complex to the north from the Topanga formation to the south and is a vertical or high-angle reverse fault with the vertical movement in the magnitude of several hundred feet. No alluvium has been displaced by the Eagle Rock fault.[5/]

The Raymond fault separates the Topanga formation in the northern upthrown block from the Puente formation in the south block. The trace of the fault is concealed by the Older alluvium along York Boulevard but an approximate location is indicated by outcrops near the fault zone. This fault is very likely a high-angle reverse fault as indicated by the deformed beds in the Topanga formation along the Arroyo Seco. There is no surface indication that movement on the Raymond fault has affected the Older alluvium; however, some movement must have occurred prior to the deposition of the gravelly aquifer materials to cause the change from the essentially fine-grained materials of the lower aquiclude. It is quite probable that traces of such movement have been buried during the deposition of the upper aquiclude material (see Plate 5H, section S-S').

Occurrence and Movement of Ground Water. A detailed study of well logs, water level data and geology has lead to the conclusion that a simple artesian basin exists in the Eagle Rock Subarea. The lower end of the aquifer abuts against the Raymond fault and the nonwater-bearing Puente formation. The pressure area extends northerly toward Colorado Boulevard. Evidence for hydraulic continuity was established between well 3986B located on Ridgeview Avenue and the only active wells (3987A, 3987B, 3987C, 3987D, 3987E and 3987F) in the subarea, which are located 3,000 feet to the south along the north side of the Raymond fault. A water level recorder was installed on well 3986B during 1937 and 1938 by the Los Angeles Department of Water and Power. These records indicate a definite recovery pattern when the active wells were not pumping over week ends and holidays. The recorder charts for the weeks ending March 1, 1938 and March 8, 1938 are interesting in that they show a recovery of 2.85 feet in 40 hours during the storm of March 2, 1938. This recovery took place during the period of the storm and indicates that the forebay or recharge area for the pressure aquifer is in the near vicinity. Another water level recorder was installed by the Referee on the same well from June 3 to June 6, 1960 and a record was obtained that verified the earlier recovery pattern exhibited by the Los Angeles Department of Water and Power recorder charts as being due to cessation of pumping over a week end. The starting or stopping of the pumps of the wells at the lower end of the area affected the piezometric surface in well 3986B within one hour.

Due to a lack of data in the upper portion of the pressure area northerly of well 3986B and in the forebay, an accurate determination of the extent of the pressure area cannot be made at this time. For the purposes of this study, it is estimated that the pressure area has an area of approximately 250 acres and the forebay has an area of about 530 acres. Based on the above 250 acres in the pressure area, a thickness of 10 feet and a specific yield of 19 percent, the storage in the pressure aquifer is estimated to be 475 acre-feet. All wells located within the assumed pressure area have had a record of artesian flows.

Study of the U. S. Department of Agriculture Soil Survey of the Los Angeles Area, California, 1919,[22/] indicates a long, narrow area of Chino clay loam extending northerly in the vicinity of Eagle Rock Boulevard.

This organic soil probably represents an area in which there were phreatophytes and hydrophytes. The water to sustain these plants would represent the overflow from a full pressure aquifer. The aquifer being full and having no additional capacity for the storing of water, any additional water would be rejected and would occur as effluent flow near the upper limit of the pressure area. Pumping by the various defendants in the lower portion of the pressure area would in effect create available storage and would decrease the amount of effluent flow, thus decreasing the amount of water that would be lost in evapotranspiration or consumptive waste. Another area of Chino clay loam is located on York Boulevard to the east of the area covered in this report. It is not considered to be related to the Eagle Rock Subarea as it is adjacent to the Avenue 50 drainage which is tributary to the Arroyo Seco. This feature is of interest in that its presence has been caused by a constriction in the Older alluvium which would exclude any appreciable amount of underflow from the east along York Boulevard. Any underflow entering the Eagle Rock Subarea would have to pass through a limited cross-sectional area that has a low average permeability and under a very low hydraulic gradient of 0.003 which may or may not exist between the Arroyo Seco and well 3987F.

The Eagle Rock artesian system is supplied from percolation of runoff and deep percolation of applied water into the forebay area. This area extends along Colorado Boulevard and easterly of Eagle Rock Boulevard along Yosemite Drive. These waters recharge the pressure aquifer which has lost about four feet of pressure head since 1941 (measured at well 3986B). This indicates that the draft on the system has not been excessive and that the subarea probably has not been pumped in excess of the safe yield within the base period.

Direction of Ground Water Movement. The ground waters in the Eagle Rock Subarea move southerly from the forebay areas into the pressure area. The direction of movement within the pressure aquifer is southerly to the vicinity of the pumping wells located along York Boulevard. There is no known subsurface escape of ground water from the pressure aquifer.

Water level fluctuations in the Eagle Rock area are represented by the hydrograph of well 3986B, which is the only well in the subarea with a long period of well measurements.

Geologic Defenses

In compliance with Item I, 2, of the Order of Reference, a detailed geologic study has been made in connection with those affirmative defenses, hereinafter referred to as geologic defenses, claimed by certain defendants. The defenses are listed as follows:

A - Defendant has independent water sources below bedrock.

B - Defendant has independent water sources in stratigraphic traps.

C - Defendant has independent water sources in fault block reservoirs.

D - Defendant takes water from source unrelated to the Los Angeles River.

For purposes of this investigation, the preceding geologic defenses have been analyzed and defined in accordance with accepted geologic definitions.

Bedrock has been defined in Appendix A as constituting the formations grouped within the nonwater-bearing series. The formations within the nonwater-bearing series do not absorb, transmit or yield water readily. These formations are:

Basement Complex rocks.
Cretaceous and Tertiary sediments of the Chico, Martinez, Domegine (Meganos), Topanga, Modelo (Puente), Repetto and Pico formations.

Stratigraphic trap is defined in the American Geological Institute Glossary of Geology and Related Sciences, 1957, as "A type of trap which results from variation in lithology of the reservoir rock, a termination of the reservoir (usually on the updip extension) or other interruption of continuity."

The American Geological Institute further defines trap as "A body of reservoir rock completely surrounded by impervious rock; a closed reservoir. Some traps are structural, having been formed by movements of the earth's crust; others are varying permeability ('stratigraphic') traps in which the change in permeability is due to original sedimentation, ground water activity, or by truncation and sealing. Many traps are created by a combination of varying permeability and structural agencies."

Fault block is defined in the American Geological Institute glossary as "A mass bounded on at least two opposite sides by faults; it may be elevated or depressed relatively to the adjoining region, or it may be elevated relatively to the region on one side and depressed relatively to that on the other." For purposes of this investigation fault block reservoir is defined in terms of a reservoir within a fault block.

It should be noted at this point that the terms "stratigraphic trap" and "fault block reservoir" are not generally accepted as terms applicable to ground water geology. These terms are widely used and accepted in petroleum geology and it must be appreciated that differences arising from the very distinct and different respective properties of oil and water can result in entirely different concepts and meanings in the interpretation of geologic features.

In the application of the terms "stratigraphic" and "fault block trap", as used in the affirmative defenses with respect to ground water geology, it is tacitly assumed that the traps are sealed above, below and laterally. It is then further assumed that waters within a trap are not replenished from any external source after entrapment.

In each of the geologic defenses, the defendants have claimed "independent water sources" deep in the earth, completely unrelated to water sources of meteoric origin originating within the Upper Los Angeles River Basin. This is interpreted to mean that the waters within the alleged "stratigraphic" and "fault block traps" claimed by the defendants, originated at sources topographically outside of the Upper Los Angeles River area or from deep-seated sources developing Juvenile or similar water (see Appendix H).

The tabulation and brief summary in Table A-2 include a list of defendants claiming geologic defenses, their well numbers including well numbers of test holes or other wells (active or inactive), the geologic defense claimed indicated by "X", and summary of the physical facts found in connection with the defendants' geologic defenses.

TABLE A-2

SUMMARY OF PHYSICAL FACTS FOUND IN
CONNECTION WITH GEOLOGIC DEFENSES

Defendant number	Defendant name	Affirmative defense claimed A: B: C: D	Well number and diversion	Date of field inspection	Total depth of well	Depth to nonwater-bearing material	Perforations	Summary remarks
7	La Canada Irrigation District	- - - X	5069D	6-21-59	323	310		1. The defendant's wells are situated within the Verdugo Hydrologic Subarea, which is a part of the Upper Los Angeles River area. 2. The defendant's wells are located in the valley fill which, when saturated, would be in direct hydraulic connection with surface and/or subsurface flow which, under natural conditions, would flow toward the Los Angeles River Narrows. 3. The defendant derives water from tunnels that penetrate joints, fractures and other openings in the Basement Complex. 4. The total length of each of the defendant's tunnels is entirely within the topographic boundaries of the Upper Los Angeles River area. 5. Production from each of the defendant's tunnels appears to vary with precipitation. 6. To the extent that water is extracted from sources other than the valley fill, additional water is required to replenish the same. Such recharge occurs from precipitation on the area which might otherwise be available to provide surface runoff to the valley fill.
			5069G		221	208		
			5077A		401	401?		
			5078		116			
			5078A		264	139		
			5078C		124	97		
			Pickens Canyon					
			Snover Canyon					
			Hall Beckley Canyon					
8	Crescenta Valley County Water District	- - - X	5036A	6-21-59				1. Same as those listed for Defendant No. 7.
			5036B					
			5047					
131	Aurora Carlson) Well No. 5069J	- - - X	5047B					
171	Irene Minkler)	- - - X	5047D		262	262?	100-123 127-164 227-254	
201	Steve Urquidez)	- - - X	5058		124			
202	William Urquidez)	- - - X	5058A					
			5058B		192			
			5058C					
			5058D		205		90-192	
			5058E		211		82-134 160-168	
			5058F					
			5058H		276	265	112-258	
			5058J		615	615?		
			5066A		205	140		
		- - - X	5069F					
			5069H		285	295	195-275	
			5069J					
			5077					
			Pickens Canyon					
			Dunsmore Canyon					
12	American Security and Fidelity)	X X X -	3947	6-20-60	173	167		1. The defendants' wells are extracting water from water-bearing sediments within the Upper Los Angeles River area. 2. The defendants' wells Nos. 3874G through 3884S are located at the defendants' Hollywood Hills Cemetery, where the water table has been lowered as a result of pumping in the Headworks area. 3. The defendants' wells are located in the valley fill which, when saturated, would be in direct hydraulic connection with surface and/or subsurface flow which, under natural conditions, would flow toward the Los Angeles River Narrows.
38	Forest Lawn Cemetery)	X X X -	3947A		179.6	179		
39	Forest Lawn Company)	X X X -	3947B		162	160		
40	Forest Lawn Memorial Park)	X X X -	3947C		176	160		
			3947D		160	160?		
			3947E		150	134		
			3874G		195	195?	50-173	
			3874H		172	172?	67- 94 100-147	
			3884I		193	192	60-170	
			3884Q		195	185	60- 98	
			3884R					
			3884S		160		40-136	
			3884T		205	205?	50-167	

Table A-2

SUMMARY OF PHYSICAL FACTS FOUND IN CONNECTION WITH GEOLOGIC DEFENSES (continued)

Defendant number	Defendant Name	Affirmative defense claimed A: B: C: D:	Well number and diversion	Date of field inspection	Total depth of well	Depth to nonwater-bearing material	Perforations	Summary remarks
141 142	Maxine Duckworth) John W. Duckworth, Jr.)	- - - X - - - X	5997A 5998 5998A Surface diversion	6-20-60	464 437.5		190-450 210-620	1. The defendants' wells are in the Pacoima Wash area, within the Sylmar Hydrologic Subarea, in the Upper Los Angeles River area. 2. The defendants' wells extract water from the water-bearing series. 3. The defendants' wells are located in the valley fill which, when saturated, would be in direct hydraulic connection with surface and/or subsurface flow which, under natural conditions, would flow toward the Los Angeles River Narrows.
164 165	E. E. Mahannah) Hazel Mahannah)	X X X - X X X -	5076	2-10-60	445			1. Same as those listed for defendant No. 122.
168	Celest McCabe	- - - X	3852 3852D	11-15-58	233		150-227	1. The defendant's wells are situated within the Upper Los Angeles River area. 2. The defendant's wells extract water from the water-bearing series. 3. The defendant's wells are located in the valley fill which, when saturated, would be in direct hydraulic connection with surface and/or subsurface flow which, under natural conditions, would flow toward the Los Angeles River Narrows.
37 64	Frank X. Enderle, Inc.) Oakwood Cemetery)	X X X - X X X -	4674 4674A 4684B 4684C	5- 5-60	900 1,000 345	0 4 3	0-1,000	1. The defendants' wells are situated within the topographic boundaries of the Upper Los Angeles River area. 2. The defendants' wells penetrate and derive water from joints, fractures, cracks along bedding planes, and other openings in the nonwater-bearing Chico formation. 3. The recharge areas for these wells cannot be determined, however, every likelihood indicates that they are within the Upper Los Angeles River Basin. 4. To the extent that water is extracted from sources other than the valley fill, additional water is required to replenish the same. Such recharge occurs from precipitation on the area which might otherwise be available to provide surface runoff to the valley fill.
41 185 Doe 16 Doe 17	Fresh-Puro (Pur-O-Spring)) Julia Nathan) L. W. Block) M. J. Block)	X X X - X X X - X X X - X X X -	3987E	2-10-60 5- 5-60				1. Same as those listed for Defendant No. 34.
43	Glen Haven Memorial Park	X X X -	6028 6028A 6028C 6028D 6028E 6029 6029A	6-20-60	784 1,214 700 653 600 775 798		 814-1,214 410-608 180-543 543- ? 30-350 350-720 720-750 750-790	1. The defendant's wells are situated within the Upper Los Angeles River area. 2. The defendant's wells derive water from the water-bearing Saugus formation. 3. The defendant's wells are very poor producers. 4. The lowering of the water levels in these wells by pumping, indicates that the ground waters in this area are being mined. 5. To the extent that water is extracted from sources other than the valley fill, additional water is required to replenish the same. Such recharge occurs from precipitation on the area which might otherwise be available to provide surface runoff to the valley fill.
49	Lakeside Golf Club	X X X -	3845A 3845B 3845C 3855D	6-16-60	140 140 205			1. The defendant's wells are situated within the Upper Los Angeles River area. 2. The defendant's wells extract water from the water-bearing series. 3. The defendant's wells are located in the valley fill which, when saturated, would be in direct hydraulic connection with surface and/or subsurface flow which, under natural conditions, would flow toward the Los Angeles River Narrows.

Table A-2

SUMMARY OF PHYSICAL FACTS FOUND IN CONNECTION WITH GEOLOGIC DEFENSES (continued)

Defendant number	Defendant Name	Affirmative defense claimed A	B	C	D	Well number and diversion	Date of field inspection	Total depth of well	Depth to nonwater-bearing material	Perforations	Summary remarks
34 186 187	Deep Rock Artesian Water) Company) Paul Pendelton) Evelyn Pendelton)	X X X	X X X	X X X	- - -	3987C 3987D	2-10-60 5- 5-60				1. The defendants' wells are situated in the Eagle Rock Hydrologic Subarea, the surface drainage of which is tributary to the San Fernando Hydrologic Subarea. 2. See Appendix A of the Report of Referee under Eagle Rock Hydrologic Subarea. 3. To the extent that water is extracted from sources other than the valley fill, additional water is required to replenish the same. Such recharge occurs from precipitation on the area which might otherwise be available to provide surface runoff to the Los Angeles Narrows.
82	Technicolor Corporation	X	X	X	-	3864C	12-18-59	315		114-129 133-144 202-219 242-272 277-303	1. The defendant's wells are situated within the Upper Los Angeles River area. 2. The defendant's wells extract water from the water-bearing series. 3. The defendant's wells are located in the valley fill which, when saturated, would be in direct hydraulic connection with surface and/or subsurface flow which, under natural conditions, would flow toward the Los Angeles River Narrows.
						3864D		351		134-163 205-224 241-264 278-335	
						3864G					
97	Toluca Lake Property Owners	X	X	X	-	3845P	6-16-60	200	185		1. Same as those listed for Defendant No. 49
						3855A		150		50- 55 68- 98 103-145	
100 101 102	Valhalla Mausoleum Park) Valhalla Memorial Park) Valhalla Properties)	X X X	X X X	X X X	- - -	3830F	6-15-60				1. Same as those listed for Defendant No. 49.
						3830H		800		290-360 528-560 570-608 724-756	
						3830J		380		175-293 316-358	
						3830K 3830L 3830M					
104	Van de Kamps Holland Dutch Bakers	X	X	X	-	3958C	5- 6-60	202		172-196	1. Same as those listed for Defendant No. 49.
106	Warner Bros. Pictures, Inc.	X	X	X	-	3864A	6-15-60				1. Same as those listed for Defendant No. 49.
						3864B		156	156?	44- 92 92-142	
						3865					
117 140	William Bartholomaus) Ellen DuBois)	X X	X X	X X	- -	4921	6-27-60 7-28-60 8-23-60	296	286	200-213 221-286	1. Same as those listed for Defendant No. 49.
122 123	E. M. Bishop) W. E. Bishop)	X X	X X	X X	- -	5077B	2-10-60				1. The defendants' well is situated within the Verdugo Hydrologic Subarea, which is a part of the Upper Los Angeles River area. 2. The defendants' well extracts water from the underflow to the Monk Hill Basin (See Appendix P).

Table A-2

SUMMARY OF PHYSICAL FACTS FOUND IN
CONNECTION WITH GEOLOGIC DEFENSES
(continued)

Defendant number	Defendant Name	Affirmative defense claimed A	B	C	D	Well number and diversion	Date of field inspection	Total depth of well	Depth to nonwater-bearing material	Perforations	Summary remarks
54	Lockheed Aircraft Corporation	X	X	X	X	3840G	6-15-60	125			1. Same as thoselisted for Defendant No. 49.
						3850E		760		215-308 546-568 589-603 623-638 654-689 719-724 729-736	
						3850F		302		180-250 270-288	
						3871E		235		68- 76 90-124 173-178 190-192 223-228	
						3871F		200		73-129 154-158 165-178	
78	Sparkletts Drinking Water Corporation	-	-	-	X	3987A 3987B 3987F	2-10-60 5- 5-60 6- 4-60 9-28-60	214 278		69-214 126-130 145-151 216-266	1. Same as those listed for Defendant No. 34. 2. Two wells in addition to those listed here, were drilled to the rear of the present day plant to a depth of approximately 600 feet and were completely dry (as per Mr. Max Alex of Sparkletts Corporation).
172 173	D. P. Moordigan) Kisag Moordigan)	X X	X X	X X	- -	5939	5- 5-60	184			1. The defendants' well is situated in the Sylmar Hydrologic Subarea, which is within the Upper Los Angeles River area. 2. The defendants' well extracts water from the water-bearing series. 3. See Appendix A of the Report of the Referee, under Sylmar Hydrologic Subarea. 4. The defendants' wells are located in the valley fill which, when saturated, would be in direct hydraulic connection with surface and/or subsurface flow which, under natural conditions, would flow toward the Los Angeles River Narrows.
198	Sidney Smith	-	-	-	X	Pickens Canyon	6-21-59				1. The defendant derives water from a tunnel that penetrates joints, fractures and other openings in the nonwater-bearing Basement Complex. 2. The total length of the defendant's tunnel is entirely within the Upper Los Angeles River area. 3. Production from the defendant's tunnel appears to vary with precipitation. 4. To the extent that water is extracted from sources other than the valley fill, additional water is required to replenish the same. Such recharge occurs from precipitation on the area which might otherwise be available to provide surface runoff to the valley fill.
204	Warner Ranch Company, Inc.	X	X	X	-	3590 3600 3601	6-15-60	246 264 300	74 119 185		1. Same as those listed for Defendant No. 49.

Note: Defense numbers A, B, C, and D listed on page A-59.

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APPENDIX B

SOILS

APPENDIX B

SOILS

Soil surveys of the San Fernando Valley area have been made in considerable detail by the United States Department of Agriculture. The results of the surveys are contained in two reports, entitled "Soil Survey of the San Fernando Valley Area, California", 1917, and "Soil Survey of the Los Angeles Area, California", 1919. These reports have been reviewed and the maps and data contained therein used in a broad classification of the soils of the basin.

The soils which are described in the above noted publications were placed into three groups according to their relative infiltration capacities. The system used to group the soils is similar to that utilized by Musgrave (Water, The Yearbook of Agriculture, 1955, U.S.D.A., page 151) and takes into account the depth of soil, relative drainage, ability to retain moisture and degree of permeability based on grain size. The three groups and the soils included therein are as follows:

A = High Infiltration Group

- Riverwash
- Holland stony loam
- Holland coarse sandy loam
- Holland loam
- Ramona stony, sandy loam
- Hanford stony, sandy loam
- Hanford gravelly, sandy loam
- Hanford loamy, coarse sand
- Tujunga stony sand
- Tujunga gravelly sand
- Tujunga sand
- Tujunga sandy loam
- Tujunga fine, sandy loam

B = Medium Infiltration Group

- Ramona sandy loam
- Hanford sandy loam
- Hanford fine, sandy loam
- Hanford silty loam
- Yolo gravelly, sandy loam
- Yolo gravelly loam
- Yolo sandy loam
- Yolo fine, sandy loam

C = Low Infiltration Group

Altamont clay, loam	Yolo silty loam
Diablo clay, adobe	Yolo clay, loam
Diablo clay, loam	Yolo silty clay, loam
Ramona fine, sandy loam	Dublin loam
Ramona loam	Dublin clay, loam
Sites sandy loam	Dublin clay, adobe
Yolo loam	Chino clay, loam

The areal distribution of the soils within the foregoing three groups, based on the aforementioned soil surveys of the United States Department of Agriculture, is delineated on Plate 3. The general extent of each group with respect to its source material is described below.

The coarse-grained soils of High Infiltration Group A are in general derived from source areas in the Basement Complex rocks. The principal streams depositing such material are Pacoima, Little Tujunga and Big Tujunga Creeks. These deposits cover much of the valley floor surface in the vicinity of North Hollywood and Burbank. The riverwash classification, found along the channels of these streams, has the highest relative infiltration capacity of soils within the group. Materials deposited by Verdugo Wash in the vicinity of Glendale are also derived from Basement Complex rocks but have been included in the Medium Infiltration Group B because they are older deposits and have been subject to a long period of weathering.

The soils of the Medium Infiltration Group B appear to be derived from the harder sedimentary rock units, and in part result from the reworking of the coarse-grained Pleistocene deposits such as Older alluvium and Saugus formation. Areas in this soil group are found in close proximity to the Cretaceous sandstones in the vicinity of Chatsworth and northerly of the Encino Reservoir where Topanga conglomerate is a source. A north-south band of soils in this group, located in the vicinity of Pacoima Wash, appears to result from an interfingering of the fine alluvial materials of the western portion of the valley with the coarser-grained deposits of the eastern portion of the area.

The fine-grained soils of Low Infiltration Group C occur in the western portion of the San Fernando Valley westerly of Pacoima Wash. Soils in the vicinity of Reseda are typical of this group. These materials are derived for the most part from sedimentary rocks which are relatively fine-grained.

The Eagle Rock area overlies alluvial materials derived from the coarse-grained sources. However, because of the higher degree of weathering of soils in this area there is a greater proportion of clay with a resultant lower infiltration rate. Soils in this area were placed in the medium infiltration group.

The finer soils of Group A predominate within Sylmar Subarea, whereas the coarser soils in Group A are found along the Tujunga and Pacoima Washes where they traverse the San Fernando Subarea.

APPENDIX C

CHARACTERISTICS OF SOILS AND THEIR RELATIONSHIP TO PAST VEGETATIVE AND WATER TABLE CONDITIONS IN SAN FERNANDO CIENAGA AREA

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING

CHARACTERISTICS OF SOILS AND THEIR RELATIONSHIP TO PAST VEGETATIVE AND WATER TABLE CONDITIONS IN SAN FERNANDO CIENAGA AREA

SAN FERNANDO, CALIFORNIA

November, 1960

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CHARACTERISTICS OF SOILS AND THEIR RELATIONSHIP TO PAST VEGETATIVE AND WATER TABLE CONDITIONS IN SAN FERNANDO CIENAGA AREA

Authorization for Investigation

This report was prepared by the Department of Water Resources in response to a request for technical assistance from the State Water Rights Board. This request, outlined in State of California Interagency Agreement No. 60-SWRB-23 dated December 11, 1959, calls for the following:

1. Accomplish the necessary field and laboratory work required to ascertain existence and extent of old swamp conditions in Sylmar Subarea in vicinity of City of San Fernando, as evidenced by determinations of proportionate amounts of carbonaceous material and other soils information pertaining to such a condition in said vicinity.

2. Methods and procedures used and scope of work done under the agreement to be approved by representatives of the State Water Rights Board.

3. Results of investigation to be set forth in a report to the State Water Rights Board including copies of all pertinent measurements and observations.

Purpose and Scope of Report

This report describes the investigation made to determine the past location and extent, and probable vegetative and water table conditions in an old "cienaga"* occurring near the westerly corner of the

* Cienaga--a term, probably of Spanish origin, indicating a limited area showing growth of water-loving plants in otherwise arid surroundings, occasionally giving rise to flowing springs. As discussed throughout this report, the term "cienaga" is used to include all areas or soils apparently affected by a water table. See "Glossary of Geology and Related Sciences" published by the American Geological Institute, 1957.

City of San Fernando (Figure C-1). Soil formation and development processes are discussed as they relate to morphology of soils found in the general area. The investigation included a detailed soil survey of the general area to a 5-foot depth, supplemented by a limited study of deeper strata to a 14-foot depth. Also included is a discussion and interpretation of the results of some 1,700 laboratory determinations made on 200 soil samples taken in the investigational area. The analyses are included in the basic data section of this report.

In addition, 20 holes drilled in a geological investigation of the area were logged by the State Water Rights Board and were available for study. These data are not included here, but are available in the Basic Data filed with the Report of Referee.

Soil Formation, Development, and Morphology in Relation to the Investigational Area

In order to interpret the significance of findings of the soil survey of the investigational area, it is helpful to review the basic concepts concerning soil formation and morphology which are pertinent to analysis of soil characteristics revealed in the study.

The character of a natural soil is determined by six broad influences. These are: (1) parent material from which the soil is formed, (2) climate, (3) relief (particularly as this influences erosion and deposition), (4) vegetative and animal life, (5) depth of water table, and (6) the length of time these factors have been acting together. To these six factors, in the case of the San Fernando cienaga area, a seventh must be added--the effects of man's activities.

The total effect of these influences varies with depth and this tends to produce differences within the soil. Such differences give rise to layers called "horizons" and the sequence of horizons taken together is called the "soil profile" to any specified depth. Very young soils have had too little time to develop horizons, but as they become older their horizons become increasingly distinct. A significant aspect of soil horizon formation is that it is a developmental process, requiring a considerable time duration under the particular physical, chemical, and biological conditions occurring at a site. This developmental process may occur either on rock material weathered in place or upon materials that have been transported by water or otherwise and deposited at some new location. Soils too youthful to have developed horizons may be highly stratified (layered) due to the depositional process by which they were laid down. True horizons are distinguished from such layers by structural and chemical features associated with soil developmental processes. Thus, while depositional strata may strongly affect moisture, fertility, tillage, and other characteristics, they do not reveal the trend of soil forming forces with time.

In the formation of the surface horizon, referred to as the "A" horizon, the accumulation of plant remains tends to enrich the mineral soil in organic matter. At the same time, weathering forces are apt to be most active at the surface. Mineral matter is weathered into clay and soluble material which, in turn, is leached downward by rain or flood water. The subsoil or "B" horizon is formed by accumulation of material leached from the surface and added to any clay that may have formed at this depth. Beneath the subsoil are horizons of partially weathered ("C" horizon) and unweathered parent material.

Characteristics of the horizons thus depend upon factors such as the rate of formation and decomposition of organic material, the amount and depth of leaching, and the type and solubility of the mineral parent material. Downward leaching is reduced or prevented where the ground water table is shallow. If the water table is close to the surface, upward water movement caused by evaporative forces may far exceed downward movement due to rainfall. The exact depth to water table at which upward movement begins to exceed downward movement varies with the climate and the soil profile but in general, under conditions similar to those in the cienaga area, may be expected to occur at about 4 to 6 feet. Vegetation may considerably increase this depth by root extraction of water from the moist soil, thereby increasing the upward hydraulic gradient as well as by consumptively using rainfall before it has a chance to leach downward to the water table.

Salts of various kinds accumulate in the soil above the water table when upward movement exceeds downward leaching, affecting both chemical and physical characteristics. The amount and kind of salts that accumulate depend upon the quality of ground water, the depth to water, the length of time the high water conditions persist, and the amount of downward leaching that occurs from time to time by rainfall.

In warm humid climates weathering is intense and wherever drainage is not limiting, soils are leached to great depths at a relatively rapid rate, leaving only the least soluble and generally less fertile material behind. In arid climates, weathering is slow and soils are leached only a few inches in depth unless excess water from sources other than rainfall happens to be present.

The San Fernando Valley falls between the two climatic extremes. Weathering is relatively slow and only the very oldest soils in the valley have been leached extensively. Under this climate, natural vegetation is rather sparse and organic matter decomposes rapidly so that the soils are normally low in humus. Where moisture conditions are such as to permit more lush growth, organic matter (humus) accumulates in the soil. The darker colors commonly associated with soils in the moist areas in a dry climate zone are due to increased humus. It should be pointed out, however, that the accumulation of humus in soils under natural conditions takes many years since by far the greater portion of all plant remains decomposes into gases, water, or soluble material and thus disappears. More detailed discussion of various aspects of soil formation and morphological processes can be found in reference 6 through 11 at the end of this report.

A consideration of soil formation and developmental processes in the investigational area would be incomplete without reference to man's activities. During the period of agricultural use some minor leveling of the soil surface by cuts and fills occurred in areas which were irrigated. Development of the area as an urban site increased cutting and filling activity and has permanently obscured an important fraction of the soil surface area with buildings, streets and railroads. Fill material from outside the investigational area has been spread over or mixed with the surface soil in a few places. Frequent and liberal use of fertilizers and soil amendments of every description, applied by owners of small plots and yards, has unquestionably affected chemical soil characteristics in some places. Finally, soil moisture conditions in the investigational area have been altered by a lowering of the water table. As discussed later in this report, the influence of some of these activities could explain certain variations in the data.

The Soil Survey

Soil surveys classify soils into "soil series" on the basis of their profile characteristics. A soil series is a group of soils alike in position, mode of formation, parent material, sequence of horizons, age, degree of development, color, and all other morphological features except surface texture. Texture refers to the proportion of sand, silt, and clay that occurs in the soil. Variations that occur in the surface texture within the series are separated as "types". On the map, delineations are made on the basis of soil types, each different separation having a combination name giving the series and type, as "Chino (series) fine sandy loam (type)", "Hanford sandy loam", or "Diablo loam".

Methods

The soil survey was made by examining the soil profile to a five-foot depth, at a large number of locations, by hand boring with an orchard type auger. Sites for borings were selected to reduce as far as possible effects of cuts, fills, and other unnatural circumstances. Simple field tests for texture, structure, color, presence of calcium carbonate, etc., were applied to each auger full of soil. Information thus gained was interpreted in terms of soil series and types and was plotted on a large scale (1"=400') aerial photograph. The investigation shows that many of the soil profiles in the vicinity are closely similar to soil series already established and described as occurring under similar sites in California by soil correlation staffs of the University of California and the U. S. Department of Agriculture.

In addition to the large number of holes studied to determine the soil series characteristics and the soil boundaries, 33 special holes were drilled for collection of soil samples for laboratory studies. These holes were located to form a series of approximately straight lines or transects* across those parts of the investigational area that appeared to have been most strongly affected by a high water table. Location of these transects is shown on Plate 7. Plate 8 indicates the surface elevation

* Transect--a line drawn across any chosen area, along which, at intervals, any soil property is measured and graphically presented. See Reference No. 6, Page 29 (C-33).

profile of each transect, with a graphical presentation of significant chemical data plotted above each hole location. Logs of these holes and the laboratory data on the samples are included in the basic data section of this report. Logs of several deeper holes drilled during a preliminary reconnaissance of the area are also included in the basic data section.

The limits of the survey were arbitrarily fixed by determining which areas appeared to have been affected by a water table and then extending the mapping far enough into adjacent unaffected areas to establish relationships between the soils.

Description and Extent of Soils in the Cienaga Area

Plate 7 is the soil survey map and shows the major separate soil bodies as delineated in the field investigation. Table C-1 summarizes the data on the soils shown on Plate 7. From examination of the profiles and consideration of topographic relationships, it is apparent that the cienaga area soils are predominantly derived from granitic alluvium washed in from higher-lying deposits to the northwest, north, and northeast.

The normal soils developed up-slope on this alluvium are deep, well-drained, and show little or no profile development. Too little time has elapsed for the relatively stable minerals to break down due to weathering and thus there is no accumulation of any physical or chemical weathering products at any place in the profile. Because a water table has not been close to the surface, soluble minerals have not accumulated from that source. Under the climatic conditions prevailing, natural vegetation consists of a relatively sparse cover of grasses and shrubs.

TABLE C-1

CHARACTERISTICS OF SOILS IN
THE SAN FERNANDO CIENAGA AREA

Soil type	Approximate acreage	Characteristics
Soils strongly affected by a water table		
Chino fine sandy loam	190	Calcareous throughout, very strong $CaCO_3$ in subsoil, high in organic carbon, dark color, dominant soil within cienaga area, strongly affected by water table.
Merrill fine sandy loam	2.3	Calcareous throughout, $CaCO_3$ hardpan in subsoil, high in organic carbon, dark in color, represents a further stage of Chino development, strongly affected by water table.
Foster sandy loam	3.2	Calcareous throughout, $CaCO_3$ variable in amount, several bodies too small to map, dark color, represents more recent deposits in the cienaga area, strongly affected by water table.
Grangeville fine sandy loam	93	Calcareous throughout, $CaCO_3$ usually less than in Chino, little accumulation of $CaCO_3$ in subsoil, relatively high in organic carbon, dark color, moderately to strongly affected by water table.
Subtotal	288	Strongly affected by water table.
Transitional soils, slightly affected by a water table		
Hesperia	157	Slightly to moderately calcareous in subsoil, little or no organic carbon accumulation beyond that in Hanford, light color, slightly affected by water table.
TOTAL Acreage	445	

Natural organic matter is thus low. They are mapped as typical Hanford series soils, light brown to light grayish brown in color and neutral throughout in reaction. The map symbol (Plate 7) is "F-1". The Hanford soils extend for considerable distances in all directions around the cienaga area, with the exception of the area occupied by the Mission Hills, and no attempt was made to map a particular area or acreage.

The dominant soils within the area considered to have been affected most prominently by a high water table are of the Chino series. This series, as established by the correlation staffs of the University of California and the U. S. Department of Agriculture, is described as occupying a semibasin or gently sloping position and belonging to the Wiesenboden Great Soil Group. Wiesenboden, or gley, soils owe their distinctive characteristics to the presence of a ground water table at or near the surface. Accumulation of calcareous material occurs in the profile due to the upward movement of water and precipitation of the salts as evaporation or evapotranspiration by plants takes place.

The Chino soils in the cienaga area have a dark gray or dark brownish gray surface which is basic or slightly calcareous. They are slightly developed, the subsoil or "B" horizon having been enriched in clay by action of water. This accumulation of clay changes the texture of the "B" horizon at most by only one textural class from that of the surface. Structure of the subsoil usually changes from granular to subangular blocky. The "B" horizon is gray and has a strong accumulation of carbonates. Carbonate concretions are common in the lower portion of this horizon.

Three separate bodies of Chino soils are delineated on Plate 7, each being indicated by the symbol "B-1". The main body covers about 173 acres and extends all the way from the vicinity of the Mission well field to San Fernando Reservoir, indicating that in times past a high water table extended from the so-called "east" cienaga to the "west" cienaga. This includes several small areas of Foster soils (see below).

The second and much smaller area of Chino soils occurs near Fourth and Hubbard Streets and covers approximately 13 acres.

A third (3.7 acres) body of Chino occurs just south of the southeast corner of the main Chino area. This is separated from the main body by recent deposits of Foster-like soils along San Joaquin Ravine.

The Foster soils occur in association with the Chino soils. They are found in and near the water courses where relatively recent deposition has occurred. In this area some bodies are so small and thin that sites were noted but no effort was made to delineate the extent. The Foster series is recent granitic alluvium having a dark gray basic surface and dark brownish gray calcareous subsoil. It is also classed as Wiesenboden, or gley, soil. The single body delineated, 3.2 acres in extent, is located at the southeast edge of the main Chino body and is indicated by the symbol "B-3".

A small area of the Merrill series, about 2.3 acres in extent, occurs near the large drainage which crosses San Fernando Road about one-fourth of a mile north of Hubbard Street. The mapping symbol is "B-2". These soils are similar to the Chino soils, but are more strongly developed

AB

and have a calcium-magnesium carbonate hardpan. This pan probably was formed slightly above the top of a high water table by precipitation of $CaCO_3$ and $MgCO_3$ as a result of capillary rise of water containing calcium, magnesium, and bicarbonate ions.

Along the northeastern edge of the main body of Chino soils is an area of soils with characteristics similar to the Grangeville series. The Grangeville soils are recent alluvial deposits from granitic sources which are light gray to light brownish gray in color, and have developed under restricted drainage conditions. The color and presence of carbonates in the profile indicate that this land was moist for considerable periods due to capillary rise of water occurring beneath it, although apparently it was less strongly affected by the water table than the Chino soils. The single body, carrying the symbol "SB-1" on Plate 2, covers approximately 93 acres.

Running across the entire northern edge of the cienaga there is a transitional strip of land between the well-drained Hanford soils lying up-slope, and the Chino-Grangeville body. Soils in this strip are the Hesperia, Pachappa, Hanford over Chino, and Hanford over Pachappa. This group has a common characteristic, in that the surface soils do not contain carbonates, whereas carbonates are found in the subsoils or "B" horizons (horizon of accumulation) at depths less than five feet. On the map they are indicated as "Tl". The Hesperia soils differ from the Hanford soils in that there is a slight accumulation of carbonates found in the subsoil. Pachappa soils represent a stage development slightly greater than the Hesperia.

The transition zone was influenced by the flow of underground water to the degree that capillary rise resulted in the precipitation and accumulation of carbonates below the surface of the soil but above a depth of 60 inches. The main body of these transition soils covers approximately 150 acres. A smaller body of similar soil occurs near Second and Hubbard Streets and includes about seven and a half acres.

In contrast to this transition zone north of the cienaga is the situation to the south along San Fernando Ravine and Hubbard Street at the railroad. Here there is an abrupt change from the soils developed under wet conditions to the Hanford or Greenfield soils. There is also an abrupt change in the depth to water as determined by drilling investigations and in wells. The deep deposit of coarse material, south of what geological studies by the Referee have indicated, is in effect, a constriction of the alluvium, allows water to penetrate to such depths that surface soils are well-drained and free of carbonates. Hanford soils are mapped with the symbol "F1" and Greenfield with "F2". No effort was made to find the areal extent of these soils.

Unrelated Soils Adjacent to the Cienaga

Immediately south and west of the study area the Mission Hills rise abruptly above the alluvial fill that comprises the cienaga. These hills have contributed a few small alluvial bodies lying above the basin, but only a little material has washed into the cienaga area itself. The hills are largely occupied by residual soils formed in place on the Saugus formation or by elevated old terrace soils. None of these soils show any close relation to soils in the cienaga. Although the different series are separated on the map, the soil bodies were not closed off so that areal extent was not determined.

The residual soils on sedimentary material are the Altamont and Diablo soils. They are similar to each other, but Diablo soils (symbol "U5") have a dark gray surface and Altamont (symbol "U4") have brown surfaces. The parent material sometimes contains carbonates but not consistently. Both soils are free of carbonates in the surface.

Zamora soils are found on small alluvial fans deposited by drainage from the Altamont soils. These soils are dull brown in color, slightly developed and generally free of carbonates. However, occasional profiles do contain small carbonate concentrations in the lower portion of the "B" horizon due to weathering of the soft, occasionally calcareous, parent materials and increased leaching by runoff from surrounding hills. They are mapped as "U1".

Chualar soils, indicated by "U2" on the soil survey, are dark brown, moderately developed on older granitic alluvium, and are found in terrace positions between the residual Altamont and Diablo soils and the lower-lying cienaga. Included are some areas of Ramona soils, similar to the Chualar but with a slightly redder color. All are free of carbonates. On one or two of the higher terraces Placentia soils were found. These represent an older, more advanced, stage of weathering than the Chualar-Ramona, and have a strong clay accumulation in the "B" horizon and occasionally some calcium carbonate beneath the "B". Their symbol is "U3".

Laboratory Studies

Physical Analyses

Physical analyses of soil samples in the laboratory were confined to tests of particle size distribution (mechanical analyses). Table C-2 summarizes the limited data obtained. Detailed data are contained in the basic data section of this report. There is a definite tendency for the well-drained soils (Hanford and Greenfield) and the most recent deposits in the wet area (Foster) to have a higher proportion of coarser fractions, while the Chino, Merrill, and Grangeville soils tend to be higher in fines. This interpretation is consistent with field observations and is also apparent when the data are analyzed in conjunction with field logs. It is probable that some of these textures have been artifically modified through activities such as cutting, filling, or incorporating fill material from outside the area. The data are too limited to be in any sense conclusive and serve principally to support the numerous field tests which established the trends mentioned.

It may be pointed out, that in theory, the wet area soils might be expected to be slightly finer than related Hanford, Hesperia, or Greenfield soils because of the tendency for soils that are more or less moist and carry a heavy vegetative cover to "weather" and break down at a more rapid rate. However, during the limited period that these soils have been in place, not enough time has elapsed for the rather stable granite minerals to break down very extensively.

TABLE C-2

MECHANICAL ANALYSES OF REPRESENTATIVE SOILS
IN THE CIENAGA AREA

(in percent of total dry weight)

Soil series	Sample hole number	Depth	Particle size in microns						Texture designation
			More than 39	Less than 39	Less than 18	Less than 5	Less than 2	Less than 1	
Chino	4	0-2.5'	25	75	57	37	21	14	Silt loam
		4-5	48	52	39	26	17	14	Loam
		7-9	21	79	46	49	33	27	Silty clay loam
		12.3-12.7	17	83	72	55	40	33	Silty clay
		12.7-13.8	69	31	18	10	7	5	Sandy loam
Hanford	8	0-1'	67	33	16	11	8	8	Sandy loam
		1-3.5	75	25	17	12	8	8	Sandy loam
		3.5-5.5	75	25	15	10	7	6	Sandy loam
		5.5-7.5	69	31	20	13	9	9	Sandy loam
Chino	9	0-6'	47	53	38	25	14	10	Loam
		6-9.5	51	49	31	19	13	9	Loam
		9.5-11.2	52	48	44	30	22	17	Sandy clay loam
		12.5-13	47	53	41	32	27	25	Sandy clay loam
Greenfield	25	0-1'	66	34	21	13	10	7	Sandy loam
		1-2	67	33	21	13	10	8	Sandy loam
		2-3	68	32	22	14	11	10	Sandy loam
		3-4	67	33	23	17	12	12	Sandy loam
		4-5	66	34	22	16	12	11	Sandy loam
~~Foster~~ Hanford	26	0-1'	66	34	23	15	10	9	Sandy loam
		1-2	71	29	19	13	9	8	Sandy loam
		2-3	75	25	18	12	9	8	Sandy loam
		3-4	74	26	17	12	9	8	Sandy loam
		4-5	76	24	16	11	7	6	Sandy loam
Chino	27	0-1'	59	41	30	20	14	10	Sandy loam
		1-2	57	43	31	21	15	11	Sandy loam
		2-3	58	42	31	20	14	10	Sandy loam
		3-4	71	29	21	15	11	9	Sandy loam
		4-4.5	78	22	15	11	7	7	Sandy loam
Merrill	28	0-1'	55	45	26	13	7	6	Sandy loam
		1-2	53	47	27	13	7	4	Sandy loam
		2-3	50	50	32	16	9	5	Loam
		3-4.2	40	60	45	25	12	9	Loam
		4.2-5	41	59	51	27	16	11	Loam
Merrill	29	0-1'	59	41	25	12	8	5	Sandy loam
		1-2	53	47	29	13	8	6	Sandy loam
		2-3	44	56	39	22	13	8	Loam
		3-3.5	41	59	42	25	15	9	Loam
		3.5-4	47	53	39	23	14	8	Loam
		4-5	41	59	45	26	16	10	Loam
Chino	30	0-1'	75	25	24	13	8	6	Sandy loam
		1-2	58	42	26	13	8	5	Sandy loam
		2-3	51	49	34	21	13	9	Loam
		3-4	56	44	32	21	13	9	Sandy loam
		4-5	61	39	28	17	11	8	Sandy loam
Grangeville	31	0-1'	57	43	27	15	11	9	Sandy loam
		1-2	56	44	29	18	12	9	Sandy loam
		2-3	56	44	32	21	15	11	Sandy loam
		3-4	57	43	31	19	14	12	Sandy loam
		4-5	58	42	29	18	13	11	Sandy loam
Hesperia	32	0-1'	70	30	19	11	8	8	Sandy loam
		1-2	67	33	22	13	10	9	Sandy loam
		2-3	61	39	26	16	12	10	Sandy loam
		3-4	64	36	22	14	11	10	Sandy loam
		4-5	66	34	22	15	11	10	Sandy loam
Hanford	33	0-1'	77	23	13	7	5	5	Sandy loam
		1-2	70	30	20	13	9	7	Sandy loam
		2-3	66	34	23	15	11	9	Sandy loam
		3-4	68	32	22	15	11	9	Sandy loam
		4-5	68	32	22	15	11	9	Sandy loam

Chemical Analyses

Laboratory chemical determinations were made on samples from 35 profiles. Analyses included organic carbon, calcium carbonate, cation exchange capacity, and determination of principal cations and anions in saturated extracts. Organic carbon was determined by the wet combustion process described by Allison (Reference 1) using the "direct" procedure. Calcium carbonate was determined by the manometric pressure method described by D. E. Williams (Reference 12). Other determinations were made by standard methods described in Agriculture Handbook 60 (Reference 11). Detailed data are included in the basic data section of this report.

Study of the above data indicated that the organic carbon, calcium carbonate, and total salt concentration in the saturation extract showed several important relationships between the soil groups. Table C-3 summarizes most of the data in such a manner that significant differences and similarities between the various soil groups are readily apparent.

The laboratory method of determining the organic content of the soil gives results in terms of organic carbon expressed as a percentage of dry soil weight. These results may be converted to terms of total organic material (a method of expression sometimes used) by multiplying by the constant 1.8.

Discussion and Interpretation of Soil Survey and Laboratory Studies

Analyses of data presented in Table C-3 brings out important differences between the Chino-Merrill-Grangeville soils and the related alluvial soils up-slope and down-slope from the cienaga area.

Significance of Organic Carbon

As previously mentioned in this report, organic matter in soil comes chiefly from decomposition of plants that once grew on the land. Plant cover and density depend largely on moisture, temperature, and soil characteristics. If conditions for vegetative growth improve, organic matter gradually accumulates until it reaches a constant value with decomposition equaling accumulation. If, however, the vegetative cover is removed (for example by plowing, or removal of the moisture supply) the bulk of organic material decomposes very rapidly, compared to the time required for its accumulation. After the initial rapid decline the more stable fractions, often called "humus", will continue to decompose at a much slower rate. It would take a very long time for these latter fractions to completely disappear even if no new material were added.

Comparison of the organic carbon content in Chino, Merrill, Grangeville, and Foster samples with that in samples from adjacent soils, indicates that at one time plant cover was considerably more lush in the cienaga area than in surrounding areas. Accruals of organic material to these cienaga area soils for the past few years approximate those to adjacent Hanford soils and are thus too small to cause or maintain their

TABLE C-3

SUMMARY OF SIGNIFICANT CHEMICAL ANALYSES DATA ON SOIL SAMPLES
TAKEN IN THE SAN FERNANDO CIENAGA INVESTIGATION AREA

Sample depth, in inches	Soil series and hole number			Soil series and hole number			Soil series and hole number			Soil series and hole number			Soil series and hole number		
	$CaCO_3$ in percent	Organic carbon[a]	Electrical conductivity[b]	$CaCO_3$ in percent	Organic carbon[a]	Electrical conductivity[b]	$CaCO_3$ in percent	Organic carbon[a]	Electrical conductivity[b]	$CaCO_3$ in percent	Organic carbon[a]	Electrical conductivity[b]	$CaCO_3$ in percent	Organic carbon[a]	Electrical conductivity[b]
	Soils strongly affected by water table														
	Merrill (28)			Merrill (29)			Foster (22)			Foster-Hanford (26)			Chino (12)		
0-12	12	2.06	0.58	12	1.74	0.55	40	5.80	0.97	0.8	1.18	1.37	0.1	1.40	0.74
12-24	17	1.82	0.51	17	1.45	0.60	66	4.41	1.03	0.4	0.61	0.52	1.7	1.09	0.88
24-36	20	1.84	0.59	24	1.66	0.65	72	5.35	1.20	0.1	0.40	0.45	3.5	1.11	0.56
36-48	27	1.67	1.06	29	1.96	0.73	38	4.09	2.64	0.0	0.26	0.42	8.7	0.90	0.57
48-60	28	1.27	1.23	34	2.20	0.94	4.1	1.55	5.04	0.0	0.16	0.43	9.7	0.66	0.64
	Chino (17)			Chino (21)			Chino (27)			Chino (30)			Chino (36)		
0-12	0.2	1.85	0.49	0.1	1.65	0.57	3.5	1.95	0.67	7.1	1.64	0.76	10	1.40	0.66
12-24	2.1	1.38	0.57	2.2	1.46	0.54	2.2	1.53	0.60	12	1.29	1.89	21	1.42	0.78
24-36	3.4	1.19	0.35	12	0.75	0.75	7.1	1.28	0.65	18	0.90	1.00	25	1.67	1.72
36-48	7.9	0.87	0.41	16	0.81	0.54	9.0	0.44	0.51	15	0.96	0.72	24	1.54	2.67
48-60	10	0.96	0.42	16	0.51	0.48	0.9	0.15	0.50	13	0.66	0.64	20	1.30	3.71
	Grangeville (31)			Grangeville (37)			Grangeville (38)								
0-12	1.4	1.28	0.66	1.4	1.17	0.68	7.1	2.01	1.30						
12-24	2.9	1.09	0.47	1.3	0.95	1.40	1.1	1.07	0.87						
24-36	7.7	0.54	0.42	6.1	0.58	0.78	0.2	0.77	0.84						
36-48	3.9	0.44	0.40	5.5	0.31	0.61	0.0	0.59	0.87						
48-60	3.9	0.34	0.39	4.8	0.27	0.55	0.0	0.39	0.95						
	Transitional soils, slightly affected by water table														
	Hesperia (13)			Hesperia (20)			Hesperia (32)			Hesperia (35)			Hanford-Pachappa (16)		
0-12	0.1	0.93	No data	0.2	1.12	No data	0.1	0.60	0.35	0.0	0.97	No data	0.0	0.87	No data
12-24	0.0	0.73	No data	0.1	1.10	No data	0.0	0.51	0.29	0.0	0.63	No data	0.0	0.78	No data
24-36	0.0	0.65	No data	0.7	0.45	No data	0.5	0.32	0.44	0.0	0.35	No data	0.1	0.61	No data
36-48	0.1	0.43	No data	4.2	0.34	No data	1.9	0.18	0.35	0.0	0.25	No data	0.6	0.52	No data
48-60	0.5	0.25	No data	3.3	0.22	No data	1.7	0.11	0.35	0.6	0.18	No data	1.4	0.39	No data
	Related soils, unaffected by water table														
	Hanford (14)			Hanford (15)			Hanford (19)			Hanford (33)			Hanford (34)		
0-12	0.2	0.68	No data	0.1	No data	No data	0.1	0.95	No data	0.0	0.71	0.60	0.0	0.98	No data
12-24	0.1	0.56	No data	0.0	No data	No data	0.2	0.70	No data	0.0	0.52	0.51	0.0	0.67	No data
24-36	0.0	0.50	No data	0.0	No data	No data	0.2	0.44	No data	0.0	0.50	0.74	0.0	0.52	No data
36-48	0.0	0.47	No data	0.0	No data	No data	0.1	0.36	No data	0.0	0.38	0.42	0.0	0.31	No data
48-60	0.1	0.43	No data	0.1	No data	No data	0.2	0.30	No data	0.0	0.29	0.54	0.0	0.38	No data
	Hanford (39)			Greenfield (25)											
0-12	0.0	0.68	No data	0.1	0.74	2.38									
12-24	0.0	0.48	No data	0.0	0.47	2.50									
24-36	0.0	0.39	No data	0.0	0.30	1.06									
36-48	0.0	0.27	No data	0.1	0.20	0.66									
48-60	0.0	0.22	No data	0.1	0.15	0.53									
	Unrelated soils, unaffected by water table														
	Zamora (11)			Zamora (24)			Zamora (42)			Chualar (18)			Placentia (10)		
0-12	0.0	1.05	1.12	0.1	No data	No data	0.0	0.77	0.49	0.2	0.72	No data	0.1	No data	No data
12-24	0.0	0.81	0.45	0.1	No data	No data	0.0	0.68	0.35	0.1	0.54	No data	0.1	No data	No data
24-36	0.1	0.31	0.66	0.0	No data	No data	0.0	0.57	0.32	0.1	0.52	No data	0.1	No data	No data
36-48	0.9	0.14	1.13	0.2	No data	No data	0.1	0.29	0.61	0.1	0.21	No data	0.4	No data	No data
48-60	1.2	0.06	0.89	No data	No data	No data	0.1	0.21	0.82	0.2	0.12	No data	0.0	No data	No data
	Placentia (41)			Altamont (23)			Diablo (40)								
0-12	0.1	0.58	0.80	0.1	1.23	0.49	0.0	2.31	0.55						
12-24	0.1	0.40	0.26	0.1	0.39	0.30	0.1	1.56	0.48						
24-36	0.1	0.23	0.26	0.1	0.19	0.34	0.1	0.97	0.37						
36-48	0.1	0.11	0.34	---	---	---	14	0.75	0.46						
48-60	0.1	0.11	0.35	---	---	---	15	0.36	0.52						

a. Organic carbon in percent.
b. Electrical conductivity in millimhos per cubic centimeter of saturation extract.

relatively high organic content. For this reason, it can only be a fraction of what was present at one time.

The distribution of the organic material with depth in the Chino and Merrill (and to a lesser extent in the Grangeville) soils may also be considered indicative of a difference in moisture source to the vegetation when compared with the depth distribution in Hanford-Greenfield soils. The average surface foot organic content in Chino and Merrill is 1.71 percent while from two to three feet it is 1.30 percent or 76 percent of the surface amount. In the Hanford-Greenfield soils the surface foot averaged only 0.81 percent and the two to three foot depth only 0.44 percent or 54 percent of the surface content. The greater actual and relative abundance of organic carbon in the deeper layers of Chino-Merrill soils indicates that the plants were probably getting water from a water table, while water for plant use on the well-drained soils probably penetrated from the surface downward following rainfall or overland flow.

Significance of Calcium Carbonate

Under the prevailing climate in the San Fernando Valley, calcium carbonate could accumulate in the soil profile under only three types of natural processes. These are: (1) weathering of calcium-bearing parent materials; (2) periodic flooding of soil with calcium-bearing waters followed by transpiration and evaporation; and (3) precipitation resulting from transpiration and evaporation of calcium-bearing water from a high water table. A fourth possible process, not a natural one, is addition through man's activities. However, the nature, amount, and distribution of the material eliminates this method as a major cause within the cienaga area.

The first process, in granitic alluvium, requires long periods of time during which other soil morphological changes occur. These include accumulations of clay size particles and development of pronounced "B" horizons and structural patterns. Neither the parent material, the soil morphology, nor the age of material in the cienaga area indicate that such a process caused an appreciable part of the calcium carbonate found there.

The second process that might cause accumulation of calcium carbonate is flooding the soil periodically with calcium-bearing waters, followed by evaporation. Salts more soluble than calcium carbonate, which would also accumulate in this process, could be leached from the soil by subsequent rainfall. This process may account for a small part of the accumulation, but is not a major factor for the following reasons: (1) areas up-slope and down-slope from the cienaga which were also subject to such flooding should have accumulated calcium carbonate, but both field and laboratory tests show this did not occur; (2) surface slopes in the cienaga area are not flat enough to trap surface water flowing down from above, so that this factor could not have caused appreciable increases in the amount of water entering the soil; and (3) the accumulation in many places is so large that very great quantities of water were required to supply the calcium carbonate. A high flood frequency over long ages would be required for this process, and other features of the soil morphology as well as the physiographic relief would have been considerably modified under such conditions.

The preponderance of evidence indicates that the calcium carbonate present in these soils must have accumulated principally by the third process mentioned, evaporation or transpiration from a high water table. The conclusion that such a water table existed is further substantiated by the historical record of springs and artesian wells in the area.

Since evaporation and transpiration are greatest near the soil surface, maximum salt accumulation also may be expected in the surface zone. However, the vertical distribution pattern of $CaCO_3$, shown for cienaga area soils in Table C-3, indicates higher concentrations in the subsoil than in the surface. This pattern may be related to the tendency of this salt to precipitate from solution because of small pH or concentration changes. Such changes result from normal activity of roots at depths where samples were secured. In addition, downward leaching probably occurred intermittently during wet periods and may have caused part of the subsoil accumulation. During the years the water table has been at considerable depth a small additional amount of leaching also has occurred.

While quantitative data on accumulation below the 5-foot depth are not available, some qualitative observations made during the study are shown in Table C-4. It is evident that considerable accumulation did occur below 5 feet in at least part of the area.

Variations in chemical and physical characteristics within the same soil body, as well as between the different bodies, suggest that water table depth and depth fluctuations were not consistent throughout the area. In some places, such as the vicinity of the old San Fernando Mission water gathering works, where it may be assumed that the water table must have been close to surface, calcium carbonate accumulations below the surface foot are negligible because free water was always present. The first twelve inches in that location, obviously modified to an indeterminate extent by man's activities, is very high in calcium carbonate. That the accumulation is still not as great as occurs in some other places is probably due to more frequent leaching, either upwards or downwards in this very wet location. Thus if an attempt was made to correlate calcium carbonate content and evapo-transpiration, it would be necessary to evaluate such local conditions separately before deriving averages.

Soluble Salts

Soluble salts also tend to accumulate while calcium carbonate is building up. However, the electrical conductivity of saturation extracts (recognized as a basic measure of soil salinity) of samples from 14 of the profiles shows values in the range for normal soil unaffected by salts (Table C-3). This is explained in part by the much greater tendency of calcium carbonate to precipitate from solution because of its low solubility. It is probable, however, that these more soluble salts did accumulate in the soil during the periods these soils were subjected to

TABLE C-4

SUMMARY OF CHEMICAL DATA OBTAINED ON SOIL SAMPLES FROM DEEP HOLES IN THE SAN FERNANDO CIENAGA AREA

Soil series and hole number	Depth, in feet	$CaCO_3$, in percent	Electrical conductivity*	Remarks
Chino Hole No. 1	0-1	12	1.94	
	2-3	0.2	1.12	
	3-4.5	0.6	1.26	
	6.5-8	0.2	2.87	Limonite mottlings.
	10.8-12.3	0.0	0.99	Sand, limonite mottlings.
	13-14.5	1.2	1.43	Saugus formation, limonite mottlings.
Chino Hole No. 4	0-2.5	18	1.05	
	4-5	18	3.72	
	7-9	25	2.40	
	12.3-12.7	0.2	No data	Some limonite mottlings.
	12.7-13.7	0.8	3.98	Saugus formation, limonite mottlings.
Chino Hole No. 6	0-10.5	Calcareous	No data	Strong $CaCO_3$ by field test. No laboratory test.
	10.5-13.5	Noncalcareous	No data	
	13.5-14	Noncalcareous	No data	Saugus formation, limonite mottlings.
Chino Hole No. 9	0-6	14	1.09	
	7-9.5	0.4	1.33	Some limonite mottlings.
	9.5-11.2	0.2	0.80	Very slight limonite mottlings.
	12.5-13.0	0.4	0.55	Saugus formation, limonite mottlings.
Hanford Hole No. 5	0-1	0.2	0.79	Little or no calcium carbonate or limonite mottlings in this profile by field tests.
	1-2.3	0.2	0.71	
	2.3-5.5	0.2	0.45	
	7-10	0.4	0.37	
	10-11.5	0.4	0.31	
	12-14.5	0.0	0.31	Saugus formation, limonite mottlings.
Hanford Hole No. 8	0-1	0.0	0.30	Some gravels in profile. Appears recent deposit coarser with depth.
	1-3.5	0.0	0.42	
	3.5-5.5	0.0	0.32	
	5.5-7.5	0.0	0.51	Stopped by gravels - hand auger.

* Electrical conductivity of saturation extract in millimhos per centimeter.

high water table conditions and varied in concentration in accordance with any fluctuation of the water table. These highly soluble salts were subsequently leached away during periods of above normal surface water supplies following a lowering of the water table. Some surface salts would be washed away by surface flows down San Fernando Ravine while the majority would be leached and removed by underflow through the Sylmar Notch. In an unpublished report by the Soil Conservation Service, in 1941 (Reference 4), mention is made of the fact that a few small saline spots were noted in this vicinity. Apparently these spots have been leached free of salts since they were not found in this investigation.

At the request of the Referee a comparison was made of the chemical data obtained on cienaga soils with similar data on samples taken from a nearby presently high water table area. The comparison area, Elizabeth Lake, is an intermittently flooded dry lake bed about 30 miles northeast of San Fernando. Climate is reasonably similar to that in San Fernando and the water table is believed to have been within a few feet of the surface for many years.

Soil samples were taken both in the dry lake bed and on an adjacent alluvial fan where the water table was influenced by the lake, but has probably seldom been within five feet of the surface of the soil. Analyses of these samples are included in Table C-5.

TABLE C-5

SUMMARY OF CHEMICAL DATA OBTAINED ON ELIZABETH LAKE SOIL SAMPLES AND SELECTED COMPARATIVE SAMPLES FROM SAN FERNANDO CIENAGA

Depth in feet	$CaCO_3$	Organic carbon[a]	Electrical conductivity[b]	Sodium adsorption ratio	
Elizabeth Lake Fan - 80 feet from Dry Lake Bed					
0-2	7.2	0.78	1.21	4.1	Bermuda and salt grass pasture.
2.5-3.5	7.0	0.61	0.94	10	No salinity or alkali problem to this depth.
4-5	15	0.75	15.6	27	Very severe saline alkali problem at this depth.
Elizabeth Lake Dry Bed - Lake Intermittently Flooded					
0-1	21	1.23	45.4	74	White salt surface crust - no vegetation.
1-2.5	20	1.45	27.5	65	
2.5-4	22	1.28	25.8	60	Free water seeping through this layer.
4-5	22	1.46	24.9	61	Very heavy clay - restricted permeability at this depth.
San Fernando Cienaga Area Foster Soil - Hole 22					
0-1	40	5.8	0.97	0.4	Profile influenced by fluctuating level of San Fernando Reservoir. Also receives runoff from above.
1-2	66	4.41	1.03	0.4	
2-3	72	5.35	1.20	1.1	
3-4	38	4.09	2.64	3.2	
4-5	4.1	1.55	5.04	5.0	
San Fernando Cienaga Area Chino Soil - Hole 36					
0-1	10	1.40	0.66	0.5	
1-2	21	1.42	0.78	2.8	
2-3	25	1.67	1.72	4.3	
3-4	24	1.54	2.67	2.3	

a. Organic carbon in percent.
b. Electrical conductivity in millimhos per centimeter.

Due to the high water table conditions and lack of subsurface outflow, leaching has not removed the highly soluble salts from the dry lake bed. On the alluvial fan, leaching from rainfall (and probably some irrigation) has moved the soluble salts into the subsoil. Because subsurface outflow at the lower end of the alluvial fan adjacent to the lake, where the samples were taken, is also limited, considerable soluble salt has accumulated at the greatest depth sampled. Calcium carbonate content in the dry lake samples is similar to that found in the subsoils of several of the Chino and Merrill profiles so that the concentrations of this salt found in the cienaga area are believed to be representative of values found under extreme conditions of evaporation from a high water table.

Included in Table C-5 are results of analyses of samples from cienaga area hole No. 22. This hole was drilled near the margin of San Fernando Reservoir and represents the extreme values of both $CaCO_3$ and organic carbon found in the investigation area. The values found are so extreme that it is possible some additional unknown causative factor is involved. Additional samples would be necessary to determine whether the values shown are representative of a mapable area.

Transects

Areal distribution of soil series in the cienaga area has been shown on the soil survey map (Plate 7). Topographic relationships are indicated on Plate 8 showing a series of profiles or transects across the area. Soil sampling holes were chosen along the transects, and data on organic carbon and $CaCO_3$ from these samples were plotted above each sample hole located on the transect. Plate 8 graphically illustrates the degree to which different areas were affected by the water table and the topographic relationships among these areas.

Conclusions

1. As a result of a soil survey described herein, 445 acres of soils located near the City of San Fernando, in the Sylmar Subarea of the Upper Los Angeles River area, were found to have appreciable accumulation of calcium carbonate as compared with surrounding areas which were practically devoid of calcium carbonate accumulations.

2. A relatively high concentration of organic carbon was also found in soils having a high concentration of calcium carbonate, indicating that a high vegetative density existed within this area.

3. The large amount of calcium carbonate found in the soils of this area resulted from evaporation and transpiration of calcium-bearing water from a high ground water table.

4. An area of 445 acres in the Sylmar Subarea of the Upper Los Angeles River area has been affected at some time and to some extent by a high ground water table as evidenced by appreciable accumulation of calcium carbonate and organic carbon not found in soils of surrounding areas.

5. Included in the total area of 445 acres of soils which have been affected at some time and to some extent by a high water table, there are 288 acres which have been strongly affected, as evidenced by a relatively larger accumulation of calcium carbonate and organic carbon therein.

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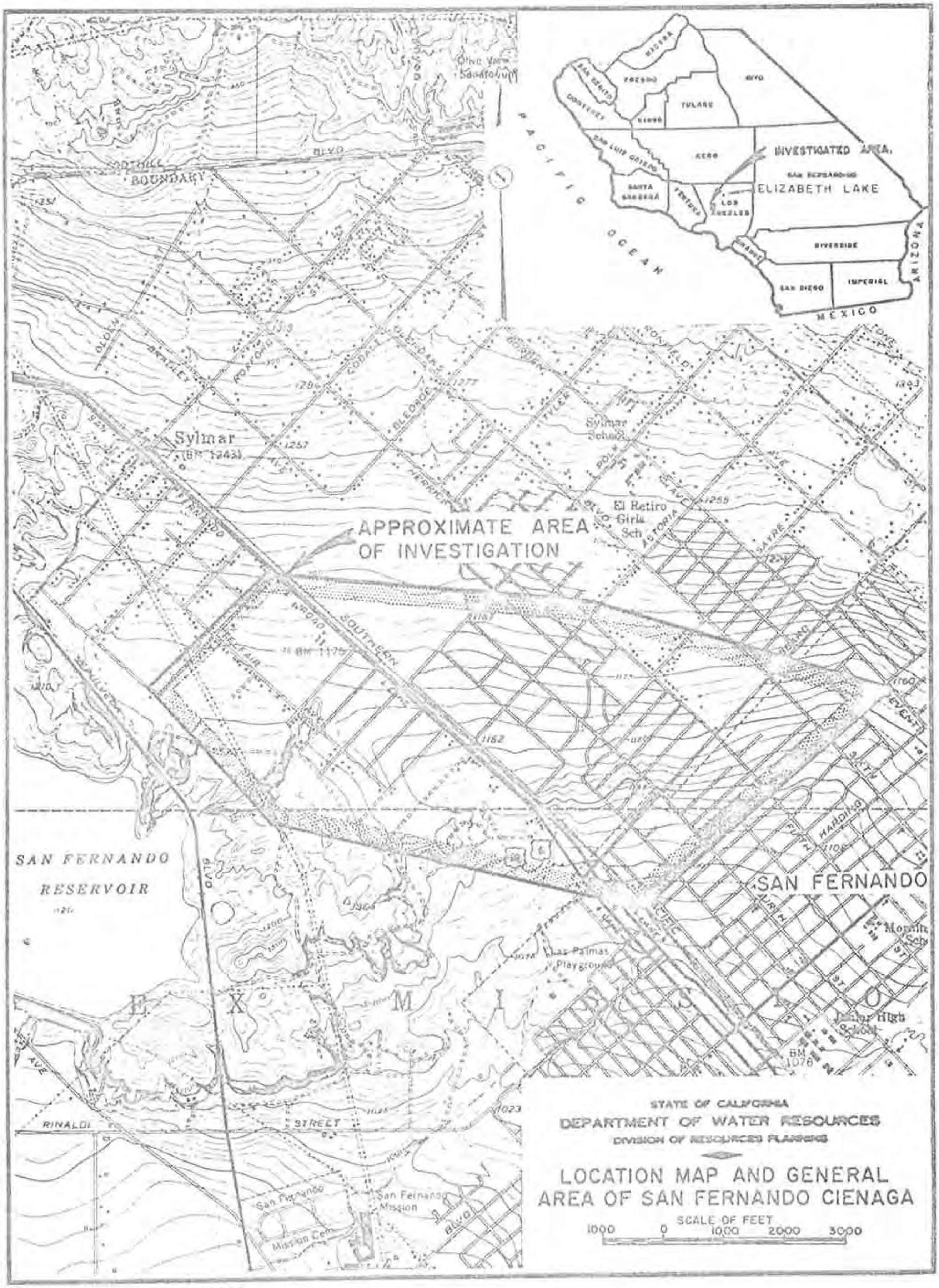

STATE WATER RIGHTS BOARD

APPENDIX D

SELECTION OF SPECIFIC YIELD VALUES

APPENDIX D

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APPENDIX D

SELECTION OF SPECIFIC YIELD VALUES

To select specific yield values applicable to the various materials described in driller's logs in the area of investigation, the Referee made a detailed study of previous investigations. To show the reasons for and data considered in the selection of the specific yield values for computing change in storage, this appendix is broken into three sections: Definitions, Previous Determinations and Selection of Specific Yield Values for the San Fernando Valley area. The application of specific yield in evaluating change in storage is discussed in detail in Appendix Q.

Definitions

The specific yield of a rock or soil is defined herein as: The volume of water drained by the force of gravity from a saturated material over a reasonably long period of time, expressed as a percentage of the total volume of the saturated material. The specific retention of a material is the ratio, expressed as a percentage, of the volume of water which after the saturated material is drained will be retained by it against the force of gravity to the total volume of such material.

Previous Determinations

The following are extracts of information concerning evaluation of specific yield as determined in previous investigations.

Basic information concerning the various types of water-bearing material must be derived from well logs in which the materials encountered are described by the driller. Because of the variety of individuals involved and the fact that the driller in many instances is primarily interested in the relative permeability of the materials penetrated, there results a great number of descriptions for similar types of materials. These circumstances, when combined with the paucity of measurements of specific yield, require that considerable judgment be experienced in the evaluation of the extent and storage capacity of equivalent types of water-bearing materials.

The purpose in presenting the following information concerning other investigations is to set forth the scope and circumstances of those in which specific yield has been measured and to indicate the various categories to which measured values have been applied. Thus, by comparison, the degree of judgment exercised by the Referee in selection and application of the specific yield values utilized in this report will be apparent.

South Coastal Basin Investigation[1/]

The South Coastal Basin of California includes the coastal plain areas of Los Angeles and Orange Counties, together with the inland drainage areas of the Los Angeles, San Gabriel and Santa Ana Rivers, exclusive of the San Jacinto River drainage area which is tributary to the Santa Ana River.

The geological investigation included several lines of study. These are outlined briefly as follows:

1. Experimental Work - Several hundred samples of typical gravels, sands and clays of the South Coastal Basin were dug from surface exposures and obtained from post hole borings. About 2,000 samples of similar materials were collected from wells as they were being drilled. Porosity determinations were made of the samples taken in place and of those which came intact from wells. Further experimental work was done to determine the water-yielding capacity of various materials. The coarser sediments were classified by mechanical analysis.

2. Subsurface Studies - About 5,000 well logs from all parts of the South Coastal Basin were collected. Nearly 300 wells were observed as they were being drilled. The well logs were grouped and the materials classified with the aid of notes from wells observed during drilling. Thus by grouping the well logs and averaging the materials, the vertical and horizontal distribution of water-bearing materials was estimated. Combining this information with yield values obtained by the experimental work, storage capacities of the basins were computed.

The unaltered materials upon the alluvial cone surfaces were studied in detail. Distribution of the various types (sands, gravels and clays) was noted, and the water-yielding properties were estimated by field and laboratory investigation. The water-yielding properties of these unaltered materials were classified according to coarseness, the maximum 10 percent grade size being used as an index of coarseness.

The nature and amount of alteration by weathering that the water-producing deposits have undergone was studied, and the effect of this alteration upon the specific yield was evaluated. All subsurface materials were considered to have undergone some alteration.

The specific yields of weathered altered materials could not be successfully classified from measurements on actual samples because of the nature of variation. Therefore, specific yields were assigned by making an arbitrary divsion according to the degree of alteration. Tight gravel was given a yield value of two-thirds that of unweathered subsurface gravel and gravelly clay one-third the specific yield value of unweathered surface gravel. Probably the typical residual clay which does not occur in this area has a yield of zero, but since it is highly variable in composition it undoubtedly contains streaks of more permeable materials that will yield small quantities of water. It was, therefore, assigned a specific yield of one to indicate a probable slight yield throughout the well section. These yields are set forth in Table D-1

TABLE D-1

ESTIMATED SPECIFIC YIELD VALUES FOR SEDIMENTS OF THE SOUTH COASTAL BASIN

(After Table 5)[1/]

		Percent yield, gravel				Percent yield, sand		Percent yield, clay	
		256+ mm., boulders	64-256 mm., coarse	16-64 mm., medium	8-16 mm., fine	1/2-8 mm., coarse: medium	1/8-1/2 mm., fine	Sandy	Clay
Unweathered-									
Surface alluvial	(1)	13.6	14.2	20.5	26.5	30.9	21.2	10	1
Subsurface alluvial	(2)	13	14	20	25	28	16	5	1
Weathered subsurface-									
Tight[a]	(3)	9	9	13	17	16			
Clayey[b]	(4)	4	5	7	8	5			
Residual clay[c]	(5)	1	1	1	1	1		1	

a. Lime cemented gravels are included in tight gravels.
b. Lime cemented sands are included in clayey sand.
c. The yield of one makes allowance for small sandy or gravelly streaks.

In the San Fernando Valley area, contours of specific yield for a zone averaging 100 feet thick for 50 feet above and 50 feet below the water of January, 1933, show the highest yields to be in the eastern and southeastern parts of the basin where a peak of about 16 percent is reached. The yield decreases to about three percent along the south and west margins, and to seven and eight percent along the north and northwest margins of the basin.

Mokelumne Area Investigation[2/]

In the Mokelumne investigation, intensive field studies were undertaken to determine the specific yield of water-bearing materials.

Two methods were used to determine specific yield. In the first method, the volume of material saturated and unwatered by alternate addition and withdrawal of measured volumes of water from columns of undisturbed soil was determined for materials from 13 localities. This is a direct volumetric method for determining specific yield. In the second method, the difference between the porosity and the specific retention of undisturbed material was determined on 16 samples, in duplicate, after drainage periods as long as 390 days. This is an indirect method similar to those employed by Eckis[1/]. In general, these averages agree with the values obtained for the specific yield of valley fill in the South Coastal Basin,[1/] although that intensive study dealt chiefly with coarser materials. The specific yield values for three general classes of material obtained by the foregoing methods and the averages for the two methods are set forth in Table D-2.

TABLE D-2

SPECIFIC YIELD
MOKELUMNE INVESTIGATION

Material	Specific yield in percent		
	Direct method	Indirect method	Average
Gravel and coarse sand	35	34.5	34.8
Medium and fine sand	26	22.6	24.2
Very fine sand, silt and clay	3.5	5.0	4.2

Salinas Basin Investigation[3/]

The indicated average specific yield for a change in ground water storage of 50,000 acre-feet in the free ground water areas at the water levels prevailing 1944-45 is approximately 13.8 percent.

Sacramento Valley Investigation[4/]

On the basis of the South Coastal Basin Investigation[1/] and Mokelumne Area Investigation,[2/] together with less detailed studies by others, the specific yield values shown in Table D-3 were assigned to the five groups of material classified in the well logs of the Sacramento Valley.

TABLE D-3

SPECIFIC YIELDS OF SEDIMENTS IN SACRAMENTO VALLEY

Material	Specific yield (percent)
Gravel	25
Sand	20
Fine sand	10
Clay and gravel	5
Clay, silt, sandy clay, lava rock	3

Ventura County Investigation[5]

With slight variations, the values determined in the South Coastal Basin Investigation[1] were used. Estimated weighted average specific yields by basins are: Piru Basin, 16.7 percent; Fillmore Basin, 12.2 percent; Santa Paula Basin, 10.0 percent; Oxnard Forebay Basin, 16.5 percent. The specific yield values utilized in the Ventura County Investigations are listed in Table D-4.

TABLE D-4

SPECIFIC YIELDS OF SEDIMENTS
IN VENTURA COUNTY
(After Table B-1)[5]

Material	Specific yield (percent)
Soil, including silty clay	3
Clay, including adobe and hard pan	0
Clayey sand, including sandy silt	5
Clayey gravel	7
Sand	25
Tight sand, including cemented sand	18
Gravel, including gravel and sand	21
Tight gravel, including cemented gravel	14

Santa Margarita River Investigation[6]

The values of specific yield assigned are those set forth in Table D-5 and were derived largely from the laboratory investigations of the South Coastal Basin Investigation.[1]

TABLE D-5

ASSIGNED SPECIFIC YIELD VALUES,
SANTA MARGARITA INVESTIGATION
(After Table B-4)[6]

Type	Description of material		Specific yield value assigned
Clay	Carbonaceous-silt Decomposed granite Hill formation	Hard pan Adobe	1
Soil	Loam	Lake bed	4
Clay-sand	Sand and clay Muck Sea mud and packed sand Silty clay	Clay with lime rocks Cemont Sandy clay Cemented sediment	5
Silt	Sandy soil		10
Sand	Fine sand Coarse sand	Quicksand	28
Tight sand	Sandy-soil Silty-sand Unsorted angular sand Sand with trace of clay	Sand and mud Cemented sand Dirty sand	16
Gravel	Gravel and sand Boulders	Cobbles and sand Fill	22
Tight gravel	Cemented gravel Gravel with clay layers Dirty gravel	Sandy clay with gravel Packed sand with rocks	15
Gravel-clay	Conglomerate (partially cemented) Clay and boulders		7

Tia Juana Basin Report[7]

Specific yield values have been assigned to the sediments in the Tia Juana Basin based upon previous studies of similar materials in South Coastal Basin.[1] A direct determination of specific yield was made by the drainage of core samples within essentially homogenous materials of the Tia Juana Basin in order to ascertain the degree of correlation existing between the samples taken and those of the South Coastal Basin[1] sediments based on maximum ten percent grade sizes. Two indirect determinations of specific yield were also made in this investigation by pumped well methods, the results of which compared fairly well with the direct determinations. Although the origin and mode of deposition of sediments in Tia Juana and South Coastal Basins differ, the specific yields of sediments sampled in Tia Juana Basin were found to be only slightly higher than those in the South Coastal Basin. Values so selected are indicated in Table D-6

TABLE D-6

SPECIFIC YIELD VALUES
APPLIED TO SEDIMENTS IN TIA JUANA BASIN
(After Table C-2)[7/]

Differentiated description of material	Average specific yield, in percent[a]	Undifferentiated description of material[b]	Average specific yield value used, in percent
Clay	1	Clay	1
Sandy clay	5	Sandy clay	5
Silt	10	Silt	10
Very fine sand	17	Fine sand	21
Fine sand	25		
Medium sand	30		
Coarse sand	32	Sand	30
Very coarse sand	31		
Gravelly sand	28		
Fine gravel	26		
Medium gravel	23	Gravel	22
Coarse gravel	18		
Very coarse gravel and boulders	14	Boulders	14

a. Determined from maximum 10 percent grade size of cored samples.
b. As contained in drillers' logs.

San Joaquin Valley Investigation[8/]

Data collected by the Geological Survey on the character of materials underlying the San Joaquin Valley include drillers' logs of nearly 6,000 water wells that were field located, geologists' logs and core records of 64 Bureau of Reclamation test holes, and more than 1,000 electric logs of water wells and oil wells. The logs were used for two important purposes; a study of the geology of the materials penetrated by the wells, and classification of the materials according to their specific yields for the purpose of estimating ground water storage capacity.

A total of 300 drillers' terms were grouped into five principal classes and one minor class of material for use in the storage estimate. A distinction between ill-sorted gravelly material and ill-sorted sand was important at many places in the geologic studies, although the specific yields of the two types of materials were considered sufficiently similar so that they could be combined in a single category in the storage study.

Facilities were not available in this investigation for making either aquifer-rating (pumping) tests or field or laboratory drainage tests of samples to determine specific yield. As in the Sacramento Valley and in most other ground water basins in California where storage studies have been made by the Geological Survey, it was necessary to assign estimated specific yields to the various classes of materials reported in well logs. The values chosen for specific yield were based largely on previous work by other investigators in California, with certain rational modifications to fit conditions in the San Joaquin Valley.

The grouping of drillers' terms into the five major and one minor specific yield categories are listed in Table D-7.

TABLE D-7

GROUPING OF DRILLERS' TERMS USED IN ESTIMATING SPECIFIC YIELD (After Table 3)[8/]

Crystalline Bedrock (fresh)

Specific yield zero

- Granite
- Hard boulders
- Hard granite
- Hard rock
- Graphite and rocks
- Rock (if in area of known crystalline rocks)

Clay and Related Materials

Specific yield 3 percent

- Adobe
- Brittle clay
- Caving clay
- Cement
- Cement ledge
- Choppy clay
- Clay
- Clay, occasional rock
- Crumbly clay
- Cube clay
- Decomposed granite
- Dirt
- Good clay
- Gumbo clay
- Hard clay
- Hardpan (H.P.)
- Hardpan shale
- Hard shale
- Hard shell
- Joint clay
- Lava
- Loose shale
- Muck
- Mud
- Packed clay
- Poor clay
- Shale
- Shell
- Slush
- Soapstone
- Soapstone float
- Soft clay
- Squeeze clay
- Sticky
- Sticky clay
- Tiger clay
- Tight clay
- Tule mud
- Variable clay
- Volcanic rock

Clay and Gravel, Sandy Clay, and Similar Materials

Specific yield 5 percent

- Cemented gravel (cobbles)
- Cemented gravel and clay
- Cemented gravel, hard
- Cement and rocks (cobbles)
- Clay and gravel (rock)
- Clay and boulders (cobbles)
- Clay, pack sand, and gravel
- Cobbles in clay
- Conglomerate
- Dry gravel (below water table)
- Gravel and clay
- Gravel (cement)
- Gravel and sandy clay
- Gravel and tough shale
- Gravelly clay
- Rocks in clay
- Rotten cement
- Rotten concrete mixture
- Sandstone and float rock
- Silt and gravel
- Soil and boulders

- Cemented sand
- Cemented sand and clay
- Clay sand
- Dry hard packed sand
- Dry sand (below water table)
- Dry sand and dirt
- Fine muddy sand
- Fine sand, streaks of clay
- Fine tight muddy sand
- Hard packed sand, streaks of clay
- Hard sand and clay
- Hard set sand and clay
- Muddy sand and clay
- Packed sand and clay
- Packed sand and shale
- Sand and clay mix
- Sand and tough shale
- Sand rock
- Sandstone
- Sandstone and lava
- Set sand and clay
- Set sand, streaks of clay
- Cemented sandy clay
- Hard sandy clay (tight)
- Sandy clay
- Sandy clay with small sand streaks, very fine
- Sandy shale
- Set sandy clay
- Silty clay
- Soft sandy clay
- Clay and fine sand
- Clay and pumice streaks

- Clay and sandy clay
- Clay and silt
- Clay, cemented sand
- Clay, compact loam and sand
- Clay to coarse sand
- Clay, streaks of hard packed sand
- Clay, streaks of sandy clay
- Clay, water
- Clay with sandy pocket
- Clay with small streaks of sand
- Clay with some sand
- Clay with streaks of fine sand
- Clay with thin streaks of sand
- Porphyry clay
- Quicksandy clay
- Sand--clay
- Sand shell
- Shale and sand
- Solid clay with strata of cemented sand
- Sticky sand and clay
- Tight muddy sand
- Very fine tight muddy sand

- Dry sandy silt
- Fine sandy loam
- Fine sandy silt
- Ground surface
- Loam
- Loam and clay
- Sandy clay loam
- Sediment
- Silt
- Silt and clay
- Silty clay loam
- Silty loam
- Soft loam
- Soil
- Soil and clay
- Soil and mud
- Soil and sandy shale
- Surface formation
- Top hardpan soil
- Topsoil
- Topsoil and sandy silt
- Topsoil--silt

- Decomposed hardpan
- Hardpan and sandstone
- Hardpan and sandy clay
- Hardpan and sandy shale
- Hardpan and sandy stratas
- Hard rock (alluvial)
- Sandy hardpan
- Semi-hardpan
- Washboard

Clay and Gravel, Sandy Clay, and Similar Materials (continued)

- Ash
- Caliche
- Chalk
- Hard lava formation
- Hard pumice
- Porphyry
- Seepage soft clay
- Volcanic ash

Fine Sand, Tight Sand, Tight Gravel, and Similar Materials

Specific yield 10 percent

- Sand and clay
- Sand and clay strata (traces)
- Sand and dirt
- Sand and hardpan
- Sand and hard sand
- Sand and lava
- Sand and pack sand
- Sand and sandy clay
- Sand and soapstone
- Sand and soil
- Sand and some clay
- Sand, clay, and water
- Sand crust
- Sand-little water
- Sand, mud, and water
- Sand (some water)
- Sand streaks, balance clay
- Sand, streaks of clay
- Sand with cemented streaks
- Sand with thin streaks of clay

- Coarse, and sandy
- Loose sandy clay
- Medium sandy
- Sandy
- Sandy and sandy clay
- Sandy clay, sand, and clay
- Sandy clay--water bearing
- Sandy clay with streaks of sand
- Sandy formation
- Sandy muck
- Sandy sediment
- Very sandy clay

- Boulders, cemented sand
- Cement, gravel, sand, and rocks
- Clay and gravel, water bearing
- Clay and rock, some loose rock
- Clay, sand, and gravel
- Clay, silt, sand, and gravel
- Conglomerate, gravel, and boulders
- Conglomerate, sticky clay, sand and gravel
- Dirty gravel
- Fine gravel, hard
- Gravel and hardpan strata
- Gravel, cemented sand
- Gravel with streaks of clay
- Hard gravel
- Hard sand and gravel
- Packed gravel
- Packed sand and gravel
- Quicksand and cobbles
- Rock sand and clay
- Sand and gravel, cemented streaks
- Sand and silt, many gravel
- Sand, clay, streaks of gravel
- Sandy clay and gravel
- Set gravel
- Silty sand and gravel (cobbles)
- Tight gravel

- Sandy loam
- Sandy loam, sand, and clay
- Sandy silt
- Sandy soil
- Surface and fine sand

- Cloggy sand
- Coarse pack sand
- Compacted sand and silt
- Dead sand
- Dirty sand
- Fine pack sand
- Fine quicksand with alkali streaks
- Fine sand
- Fine sand, loose
- Hard pack sand
- Hard sand
- Hard sand and streaks of sandy clay

- Hard sand rock and some water sand
- Hard sand, soft streaks
- Loamy fine sand
- Medium muddy sand
- Milk sand
- More or less sand
- Muddy sand
- Pack sand
- Poor water sand
- Powder sand
- Pumice sand
- Quicksand
- Sand, mucky or dirty
- Set sand
- Silty sand
- Sloppy sand
- Sticky sand
- Streaks fine and coarse sand
- Surface sand and clay
- Tight sand

- Brittle clay and sand
- Clay and sand
- Clay, sand, and water
- Clay with sand
- Clay with sand streaks
- More or less clay, hard sand and boulders
- Mud and sand
- Mud, sand, and water
- Sand and mud with chunks of clay
- Silt and fine sand
- Silt and sand
- Soil, sand, and clay
- Topsoil and light sand
- Water sand sprinkled with clay

- Float rock (stone)
- Laminated
- Pumice
- Seep water
- Soft sandstone
- Strong seepage

Gravel, Sand, Sand and Gravel, and Similar Materials

Specific yield 25 per cent

- Boulders
- Coarse gravel
- Coarse sand
- Cobbles
- Cobble stones
- Dry gravel (if above water table)
- Float rocks
- Free sand
- Gravel
- Loose gravel
- Loose sand
- Rocks
- Water gravel
- Gravel and sand
- Gravel and sandrock
- Medium sand
- Rock and gravel
- Running sand
- Sand
- Sand, water
- Sand and boulders
- Sand and cobbles
- Sand and fine gravel
- Sand and gravel
- Sandy gravel

San Luis Obispo County Investigation[9]

With slight variations, the values determined in Bulletin No. 45 were adopted for computing the change of storage estimates in this area.

The task of assigning specific yield values to the sediments appearing in drill logs was simplified by dividing all basin sediments into eight general categories. These included soil, clay, clay and sand, clay and gravel, tight sand, tight gravel and gravel. Sand, gravel, and clay which constitute the bulk of the basin sediments were generally found to be well differentiated on the drillers' logs. Combinations of these materials, however, were frequently described by such unique or local terms as "ooze", "muck", "cement", etc. Materials so described were placed, based on the judgment of a geologist, into one of the above eight categories. The Paso Robles formation is generally more compacted and weathered than the alluvium and some specific yield values were lowered accordingly. Estimated weighted mean specific yield of the Paso Robles formation and alluvium is eight percent. The specific yield of the alluvium of the Salinas River is estimated to average 15 percent.

The specific yield values assigned to the general categories of material encountered are shown in Table D-8.

TABLE D-8

SPECIFIC YIELDS OF SEDIMENTS
(After Table B-2)[9]

Material	Specific yield (percent) Alluvium	Specific yield (percent) Paso Robles formation
Soil, including silty clay	5	5
Clay, including adobe and hard pan	3	3
Clay and sand, including sandy silt	5	5
Clay and gravel	7	7
Sand	25	20
Tight sand, including cemented sand	18	15
Gravel, including gravel and sand	21	18
Tight gravel, including cemented gravel	14	13

Selection of Specific Yield Values

Review by the Referee of the results of prior investigations and consultation with the Engineering Advisory Committee resulted in an agreement to base the specific yield values on data presented in Bulletin 45, South Coastal Basin Investigation,[1] and the work sheets used in preparation of that bulletin. The specific yield values so selected by the Referee are shown in Table D-9 and are based on results of the Bulletin 45 investigation with the following modifications:

Ground water inventories such as developed in Bulletin 12, Ventura County Investigation,[5] utilizing the specific yield values as published in Bulletin 45, have been found to be out of balance with insufficient water going in and out of storage for corresponding fluctuation of the water surface. The lack of balance indicates that the specific yield may be too small.

TABLE D-9

SPECIFIC YIELD VALUES SELECTED FOR USE
IN SAN FERNANDO VALLEY REFERENCE

0 Percent	
Hard granite rock	Soil rock
3 Percent	
Adobe	Hard pan
Boulders in clay	Hard sandy shale
Cemented clay	Hard shell
Clay	Muck
Clay loam	Sandy clay loam
Decomposed shale	Shale
Dirt	Shaley clay
Granite clay	Shell rock
Hard clay	Soapstone
5 Percent	
Cemented sand	Sandstone
Clay and gravel	Sand and clay
Clayey sand	Sandy clay
Clayey silt	Sandy silt
Conglomerate	Sediment
Decomposed granite	Shaley gravel
Gravelly clay	Silt
Loam	Silty clay
Rotten conglomerate	Silty loam
Rotten granite	Soil
Sand rock	Soft sand
10 Percent	
Cemented boulders	Hard sand
Cemented gravel	Heavy rocks
Cemented sand and gravel	Sandy loam
Dead gravel	Soft sandstone
Dead sand	Tight boulders
Dirty pack sand	Tight coarse gravel
Hard gravel	
14 Percent	
Boulders	Large gravel
Broken rocks	Rocks
Coarse gravel	Sand and gravel, silty
Cobbles and gravel	Tight fine gravel
Gravel and boulders	Tight medium gravel
16 Percent	
Fine sand	Sand and boulders
Heaving sand	Tight sand
Quicksand	
19 Percent	
Sand and gravel	
21 Percent	
Dry gravel	Medium gravel
Gravel	Sand
Gravelly sand	Water gravel
Loose gravel	
26 Percent	
Coarse sand	Medium sand
Fine gravel	

Based on the foregoing indications and the fact that specific yield for fine materials suggested by Bulletin 45 were not supported by experimental data, the Referee has utilized a higher value of three percent for clay as being more appropriate than the value of one percent used in the prior investigation.

The value of sand and gravel, not mentioned in Bulletin 45, was set at 19 percent through a trial and error method. This method consisted of utilizing a series of assumed values for the specific yield of sand and gravel and working out the average specific yield values for well groups identical with those of the work sheets of Bulletin 45, until the average of the reworked groups closely approximated the average specific yield values indicated by the Bulletin 45 studies. During this work it was noted that in numerous places on the Bulletin 45 work sheets pertaining to the San Fernando Valley the value of sand and gravel was arbitrarily assigned a value of 19 percent. Study of these same work sheets also noted that the majority of gravel strata mentioned were reduced from 25 percent specific yield to values of 19, 20 and 22 percent. No explanation of this devaluation was found in the work sheets and the text of the bulletin does not reflect such a change.

The values for medium and coarse sand were reduced from 28 percent to 21 and 26 percent, respectively, since it was felt that a 28 percent value was more applicable to poorly graded or more uniform sediments found in the lower basins of the South Coastal area. The sediments in the lower basins were subject to a better degree of sorting over the longer distance of travel from the source area, while the sediments in the San Fernando Valley area show a better gradation allowing the finer particles to fit between the coarse ones, thus reducing the amount of voids with a resultant decrease in specific yield.

Slichter's classical study of the Theoretical Investigation of the Motion of Ground Water,10/ points out that when dealing with uniform spheres arranged in a cubic fashion, which is considered loose packing, the porosity is equal to 47.64 percent. When the same spheres are arranged in a rhombohedron in the most compact or tightly packed condition, the porosity is reduced to 25.95 percent. Observation of a great number of samples taken from wells and in deep cuts indicates that well-graded fairly compact materials are the most prevalent in the San Fernando Basin.

During the investigation of storage capacity reported in Bulletin 45, there were 350 samples procured and analyzed primarily from shallow surface pits; about 29 of these were obtained in the San Fernando Valley. Mean specific yield was determined at 34 well groups from about 200 well logs. Data gathered for the present investigation comprise 560 usable well logs which were utilized in 52 well groups or storage units. A comparison of mean specific yield values for three typical well groups computed, using the Bulletin 45 values and the values used in the San Fernando Valley Reference, show very little difference as indicated in Table D-10.

TABLE D-10

COMPARISON OF MEAN SPECIFIC YIELD VALUES FOR SELECTED WELL GROUPS

Well group	Mean Specific Yield Bulletin 45 Work Sheets in Percent	Mean Specific Yield San Fernando Reference in Percent
3600	5.72	6.57
3800	12.58	12.23
3752	6.70	6.96

It should be noted that in Well Group 3600 the mean specific value increased from 5.72 percent to 6.57 percent. This is due primarily to the increase in specific yield of clay materials from one percent to three percent. A comparision of the specific yield values selected by the Referee with those utilized in other investigations is shown in Table D-11.

TABLE D-11

COMPARISON OF SPECIFIC YIELD VALUES SELECTED BY REFEREE WITH PREVIOUS INVESTIGATIONS

Material	DWR Bulletin 45, 1934	U.S.G.S. WSP 780, 1939	State Water Resources Board Bulletin 1, 1951	DWR Bulletin 12, 1956	DWR Bulletin 57, 1956	State Water Rights Board: Tia Juana, 1956	U.S.G.S. San Joaquin, 1957	DWR Bulletin 18, 1958	Referee San Fernando Valley Reference, 1960
Clay	1	4	3	0	1	1	3	3	3
Silty clay	1	4	3	3	5	5	5	5	5
Clayey sand	5	4	3	5	5	5	5	5	5
Fine sand	16	24	10	25	28	25	10	25	16
Medium sand	28	24	20	25	28	30	25	25	21
Coarse sand	28	34	20	25	28	32	25	25	26
Fine gravel	25	34	25	21	22	26	25	21	26
Medium gravel	20	34	25	21	22	23	25	21	21
Coarse gravel	14	34	25	21	22	18	25	21	14

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APPENDIX E

PRECIPITATION

APPENDIX E

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APPENDIX E

PRECIPITATION

Quantities of precipitation on the valley fill and on the hill and mountain areas were evaluated separately. The valley fill area was divided into three sections, referred to as the San Fernando, Sylmar and Verdugo Hydrologic Subareas and the precipitation was evaluated separately for each subarea. Precipitation on the hill and mountain areas was evaluated separately for the watersheds of Big Tujunga, Pacoima Creek and Sycamore Canyon, for which runoff records are available, and for each of 12 subdivisions of the remaining hill and mountain areas (see Appendix F). Each of the latter units is comprised of small watersheds having one or more outlets at the edge of the valley fill.

Precipitation Stations and Records

The 85-year Isohyetal Map of Los Angeles County, prepared by the Los Angeles County Flood Control District for the period 1872-73 through 1956-57, is based on 130 master precipitation stations, of which 37 are within or are immediately adjacent to the Upper Los Angeles River area. Three factors were considered in the selection of master stations; (1) length of record, (2) location and (3) accuracy of record. The minimum length of record of the valley fill stations used was 20 seasons and of the mountain area stations 14 seasons. Master stations were also selected to give representative areal distribution of precipitation on the entire county. The 85-year isohyets, derived from the records of these stations are shown on Plate 9.

The Los Angeles and Pasadena precipitation stations are the only stations that have continuous records for the 85-year period. The records of the other master stations have been extended by the Los Angeles County Flood Control District to 85 years, based on indices of selected longer record stations, taking the stations in descending order of their length of record.

The extended 85-year rainfall of a station was computed by a direct proportion, using the indices of wetness of a known master station for the corresponding years of unknown record at the station being extended. The formula used is as follows:

$$R = \frac{B}{8{,}500 - A} \times 8{,}500$$

where: R = estimated total rainfall for 85-year period at station being extended.

A = sum of indices of wetness of longer record station for unknown period of station being extended.

B = Sum of rainfall for period of record of station being extended.

When more than one station was used to extend a record, the indices of wetness used were either averaged or weighted inversely with respect to the distance of each from the station being extended.

Table E-1 lists 37 of a county-wide total of 130 master stations which are within or adjacent to the Upper Los Angeles River area along with

TABLE E-1

LOS ANGELES COUNTY FLOOD CONTROL DISTRICT MASTER RAINFALL STATIONS
WITHIN OR ADJACENT TO SAN FERNANDO VALLEY

Los Angeles County Flood Control District station number	Name	Period of record	Station used for extension of record[a]
715	Los Angeles	1872-58	
610	Pasadena	1872-58	
32	Newhall-Soledad Division Headquarters	1876-58	Los Angeles
28	San Fernando Lemon Association	1877-58	Los Angeles (0.66)
185	Glendora - west	1880-58	Pasadena
634	Santa Monica - City Hall	1885-58	Los Angeles
394	Highland Park	1897-58	Pasadena (0.36) and Los Angeles (0.15)
179	Sierra Madre	1886-58	Pasadena (0.36) and Glendora (0.15)
261	Acton-Escondido Canyon	1896-58	Average of Pasadena and Newhall
119	Sawtelle - Soldier's Home	1896-58	Average of Los Angeles and Santa Monica City Hall
250	Acton Camp	1879-99 1929-32 1933-37 1938-58	Acton-Escondido Canyon
53[b]	Colby's Ranch	1897-58	Average of Pasadena, Sierra Madre and Haines Canyon - Lower
13[b]	North Hollywood	1906-58	Average of Los Angeles and San Fernando Lemon Association
517	Andersen Ranch	1909-32 1942-58	Valyermo
295[b]	Glendale	1909-58	Average of Los Angeles and Highland Park
478	Valyermo	1911-58	Acton-Escondido Canyon
177	La Canada	1912-58	Pasadena
21[b]	Brant Rancho-Girard	1912-58	Average of Los Angeles and San Fernando Lemon Association
33[b]	Pacoima Dam	1915-58	San Fernando Lemon Association
364[b]	Haines Canyon - Lower	1917-58	Los Angeles (0.17), San Fernando Lemon Association (0.10) and Pasadena (0.19)
373	Briggs Terrace	1915-16 1918-58	Average of La Canada and Haines Canyon - Lower
54[b]	Loomis Ranch - Alder Creek	1917-19 1920-22 1923-58	Colby's Ranch
155	Little Rock Creek	1920-22 1928-58	Average of Valyermo and Acton Camp
25[b]	Northridge-Andrews	1920-58	Average of San Fernando Lemon Association and Brant Ranch
259[b]	Chatsworth Patrol Station	1929-58	Northridge
23[b]	Chatsworth Reservoir	1925-58	Average of Brant Ranch and Northridge
15[b]	Van Nuys - City warehouse	1925-58	Average of North Hollywood and Northridge
46	Big Tujunga Dam	1917-21	Average of Haines Canyon-Lower and Colby's
14[b]	Roscoe-Merrill	1927-58 1927-58	Average of North Hollywood, San Fernando Lemon Association and Pacoima Dam
11	Upper Franklin Reservoir	1927-58	Sawtelle (0.20) and North Hollywood (0.25)
210[b]	Brand Park	1928-58	Glendale
17[b]	Sepulveda Canyon	1928-58	Upper Franklin Reservoir
395	Olive View Sanitorium	1934-58	Average of Pacoima Dam and San Fernando Lemon Association
695	Tujunga Canyon - Vogel Flat	1935-58	Big Tujunga Dam
405	Soledad Canyon-Eckles	1936-58	Average of Acton-Escondido Canyon and Acton Camp
423	Acton-Aliso Canyon	1937-58	Average of Mount Gleason, Acton Camp and Little Rock Creek
419[b]	Santa Clara Ridge Mount Gleason	1937-58	Average of Big Tujunga Dam, Pacoima Dam and Soledad Canyon

The following stations used by the Referee as controlling stations are not Master Rainfall Stations, as designated by the Los Angeles County Flood Control District, but the 85-year mean precipitation was computed for each by the District for use in deriving the 85-year Isohyetal Map.

12[b]	Franklin Canyon	1927-58	Sawtelle (0.17) and North Hollywood (0.33)
29[b]	Granada Pump Plant	1927-58	Average of San Fernando Lemon Association and Chatsworth Patrol Station
30[b]	Sylmar	1919-58	Average of San Fernando Lemon Association and Olive View Sanitorium
47[b]	Clear Creek-City School	1927-58	Big Tujunga Dam
251[b]	La Crescenta	1929-58	Briggs Terrace
470[b]	Tujunga-Mill Creek	1941-58	Average of Loomis Ranch and Acton-Aliso Canyon
705[b]	Alder Creek-Paradise Ranch	1942-58	Average of Loomis Ranch and Acton-Aliso Canyon

a. Numbers in parenthesis are weighted coefficients used by Los Angeles County Flood Control District to determine indices of wetness for the unknown record of the station.
b. Controlling stations used by the Referee in computing quantities of precipitation.

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the stations which were used to extend the record of the master stations. Seven additional stations, utilized by the Referee in computing the annual amounts of precipitation, are also listed in Table E-1 along with the master stations of the Los Angeles County Flood Control District heretofore mentioned.

In computing mean annual precipitation for the Upper Los Angeles River area, 22 precipitation stations, all located within the watershed, were utilized in conjunction with the 85-year isohyets of the Los Angeles County Flood Control District. These stations are identified in Table E-1 and their locations shown on Plate 9. These stations were selected to reflect areal distribution as well as representative depth of precipitation. The minimum length of record for stations on the valley fill was 29 seasons (through 1957-58) and 16 seasons (through 1957-58) in the hill and mountain areas. Table E-2 gives the elevation, period of record, 85-year mean precipitation, and the recorded maximum and minimum precipitation of the 22 stations utilized.

Quantity of Precipitation

In computing the 85-year mean seasonal precipitation, the Isohyetal Method was used within polygons of a Thiessen network. The Thiessen network determined the area of influence of each controlling station and was used to facilitate annual precipitation computations. It was constructed by locating the stations on a map and drawing the perpendicular bisectors to the lines connecting the stations. The polygons thus formed around each station are the boundaries of the area considered controlled by its station

TABLE E-2

MEAN, MAXIMUM AND MINIMUM SEASONAL PRECIPITATION
OF CONTROLLING STATIONS USED BY THE REFEREE

Los Angeles County Flood Control District station number	Station name	Elevation, in feet[a]	Period of record	Computed 85-year mean seasonal precipitation, in inches	Recorded maximum and minimum	
					Season	Inches
12	Franklin Canyon	1,100	1927-28 1957-58	18.71	1940-41 1947-48	46.15 8.88
13	North Hollywood	593	1906-07 1957-58	16.90	1940-41 1947-48	39.68 7.40
14	Roscoe-Merrill	1,050	1927-28 1957-58	14.61	1940-41 1947-48	35.99 7.25
15	Van Nuys Warehouse	695	1925-26 1957-58	15.20	1940-41 1950-51	39.77 7.07
17	Sepulveda Canyon	1,425	1928-29 1957-58	19.22	1940-41 1947-48	47.9[illegible] 8.36
21	Brant Ranch-Girard	891	1912-13 1957-58	14.38	1940-41 1947-48	36.29 6.57
23	Chatsworth Reservoir	865	1925-26 1957-58	14.12	1940-41 1947-48	36.65 6.68
25	Northridge-Andrews	795	1920-21 1957-58	14.59	1940-41 1923-24	38.34 6.69
29	Granada Pump Plant	1,150	1927-28 1957-58	17.10	1940-41 1948-49	40.55 6.47
30	Sylmar	1,250	1919-20 1957-58	16.70	1940-41 1948-49	38.77 8.17
33	Pacoima Dam	1,500	1915-16 1957-58	18.94	1940-41 1947-48	40.41 9.46
47	Clear Creek-City School	3,200	1927-28 1957-58	32.41	1940-41 1950-51	61.72 10.53
53	Colby's Ranch	3,675	1897-98 1957-58	30.13	1921-22 1898-99	61.75 [illegible].13
54	Loomis Ranch - Alder Creek	4,300	1917-18 1957-58	20.90	1940-41 1950-51	40.5[illegible] 8.75
210	Brand Park	1,250	1928-29 1957-58	19.15	1940-41 1947-48 1950-51	43.[illegible] 8.91 8.91
251	La Crescenta	1,565	1929-30 1957-58	23.64	1940-41 1947-48	48.14 10.62
259	Chatsworth Patrol	1,254	1929-30 1957-58	17.77	1940-41 1948-49	42.02 6.77
295	Glendale	530	1917-18 1957-58	17.93	1940-41 1923-24	41.63 8.04
364	Haines Canyon-Lower	2,450	1917-18 1957-58	24.30	1940-41 1947-48	53.07 11.12
419	Santa Clara Ridge-Mount Gleason	5,450	1937-38 1957-58	24.48	1940-41 1950-51	52.98 10.15
470	Tujunga-Mill Creek	4,600	1941-42 1957-58	17.63	1951-52 1950-51	28.99 8.00
705	Alder Creek-Paradise Ranch	2,330	1942-43 1957-58	20.70	1951-52 1950-51	35.55 10.26

a. As of September 1958.

because any point in such a polygon is closer to the controlling station than to any other station.

The 85-year mean seasonal isohyets were superimposed on the Thiessen network and the Isohyetal Method was then applied to each polygon in computing the mean seasonal precipitation. The area between successive isohyets in each polygon was determined with a planimeter. The areas of each subarea or watershed were kept separate and designated by station number and letter when more than one existed within the polygon. The area in acres between two isohyets multiplied by their weighted precipitation in feet gave the quantity of mean precipitation on the area between the two isohyets in acre-feet. The weighted value used was the average of the boundary isohyets except in the few instances where the area was controlled by the previously noted arbitrary boundaries. The summation of all these increments within a polygon or portion thereof was taken as the 85-year mean seasonal precipitation in the polygon or portion thereof. The area and mean seasonal precipitation of each polygon are presented in Table E-3 and of each hydrologic subarea and drainage unit in Table E-4.

The precipitation for a specific season in a polygon was computed by multiplying the 85-year mean seasonal precipitation of the polygon or a portion of the polygon by the index of wetness of the controlling station for the specific year. The indices of wetness for each controlling station are presented in Table E-5. To arrive at the annual precipitation in subareas of the valley fill and in hill and mountain watersheds, the precipitation in the appropriate polygons or portion of polygons were

TABLE E-3

85-YEAR MEAN PRECIPITATION BY THEISSEN POLYGONS

L.A.C.F.C.D. number for controlling station in polygon	85-year-mean precipitation, in acre-feet	Area, in acres	Precipitation by polygon		L.A.C.F.C.D. 85-year mean precipitation, in inches
			Feet	Inches	
12	6,452	4,238	1.52	18.27	18.71
13	17,562	12,720	1.38	16.57	16.90
14	32,155	24,110	1.33	16.00	14.61
15	29,083	22,262	1.31	15.68	15.20
17	9,593	6,231	1.54	18.47	19.22
21	32,774	24,462	1.34	16.08	14.38
23	12,281	10,331	1.19	14.26	14.12
25	30,126	23,609	1.28	15.31	14.59
29	10,619	6,673	1.59	19.10	17.10
30	28,691	19,455	1.47	17.70	16.70
33	23,934	14,812	1.62	19.39	18.94
47	31,403	12,852	2.44	29.32	32.41
53	36,388	15,726	2.31	27.77	30.13
54	38,096	17,925	2.13	25.50	20.90
210	14,763	9,021	1.64	19.64	19.15
251	11,086	5,709	1.94	23.30	23.64
259	21,898	13,898	1.58	18.91	17.77
295	35,534	24,559	1.45	17.36	17.93
364	27,867	13,791	2.02	24.25	24.30
419	37,448	16,616	2.25	27.04	24.48
470	13,378	7,694	1.74	20.86	17.63
705	43,715	22,443	1.95	23.37	20.70
TOTAL	544,846	329,137			

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TABLE E-4

85-YEAR MEAN PRECIPITATION
BY SUBAREAS AND DRAINAGE UNITS

Unit	Area, in acres	85-year mean precipitation, in acre-feet
Hydrologic Subarea		
San Fernando and Eagle Rock	112,854	149,884
Sylmar	5,565	8,149
Verdugo[a]	5,009	9,706
Subtotal	123,428	167,739
Drainage Unit[b]		
Lower Tujunga	21,833	37,085
Big Tujunga	68,111	151,059
Pacoima	18,090	38,714
Unit I	19,238	28,520
Unit II	6,446	9,336
Unit III	17,594	23,573
Unit IV	17,582	27,892
Unit V	5,873	10,639
Unit VI	1,786	2,587
Haines Canyon	971	2,115
Sycamore Canyon	1,733	2,890
Unit VII	13,104	19,042
Unit VIII	4,928	7,057
Unit IX	1,391	2,418
Unit X	7,029	14,180
Subtotal	205,709	377,107
TOTAL	329,137	544,846

a. Includes precipitation on the portion of Monk Hill Basin within the Upper Los Angeles River Area.
b. See Appendix F for description of drainage units.

TABLE E-5

ANNUAL PERCENT OF 85-YEAR MEAN PRECIPITATION
OF CONTROLLING STATIONS

Year	Los Angeles County Flood Control District number										
	12	13	14	15	17	21	23	25	29	30	33
	Franklin Canyon	North Hollywood	Roscoe-Merrill	Van Nuys	Sepulveda Canyon	Brant Ranch	Chatsworth Reservoir	Northridge-Andrews	Granada pump plant	Sylmar	Pacoima Dam
1928-29	60	67	69	68	79	70	79	75	79	81	69
29-30	62	71	69	73	71	76	78	78	82	90	82
1930-31	96	90	93	102	101	95	101	91	94	101	97
31-32	123	120	135	126	129	120	119	123	128	126	128
32-33	87	91	84	88	84	72	78	72	69	76	82
33-34	105	115	81	84	100	67	90	81	86	88	87
34-35	127	130	126	119	117	115	135	125	119	125	133
1935-36	82	72	70	65	86	78	87	83	86	92	94
36-37	153	141	144	144	153	150	161	144	146	152	155
37-38	171	163	147	157	176	152	154	151	142	149	172
38-39	117	121	131	136	137	136	118	142	130	135	116
39-40	93	94	110	104	97	110	105	111	104	104	96
1940-41	247	236	246	261	250	252	260	263	237	232	213
41-42	85	83	90	87	77	86	80	80	78	79	77
42-43	153	151	157	159	161	148	145	155	149	153	160
43-44	133	129	165	154	135	164	162	172	145	147	148
44-45	86	78	95	74	83	95	92	93	87	92	97
1945-46	83	78	87	81	88	86	87	85	85	89	89
46-47	95	80	103	93	85	82	89	87	88	99	110
47-48	47	44	50	51	40	46	47	47	50	49	50
48-49	53	45	56	47	53	47	50	47	54	59	63
49-50	65	59	60	57	65	66	78	69	78	80	74
1950-51	56	50	53	47	44	51	65	57	69	67	62
51-52	189	192	180	188	194	187	194	192	186	197	193
52-53	76	61	68	73	71	74	84	79	80	80	69
53-54	83	78	76	81	89	83	94	85	86	87	84
54-55	76	84	85	89	78	90	93	88	84	84	76
1955-56	97	96	93	94	84	115	114	111	119	121	94
56-57	70	76	84	79	76	73	88	83	83	83	83
57-58	146	141	151	156	153	204	212	190	194	184	161
29-year TOTAL	2,990	2,895	3,007	2,981	3,006	2,986	3,127	3,069	3,023	3,117	3,053
29-Year Average 1929-57	103.1	99.8	103.7	102.8	103.7	103.0	107.8	105.8	104.2	107.5	105.3

ANNUAL PERCENT OF 85-YEAR MEAN PRECIPITATION
OF CONTROLLING STATIONS
(continued)

Year	Los Angeles County Flood Control District number										
	47	53	54	210	251	259	295	364	419	470	705
	Clear Creek-City School	Colby's Ranch	Loomis Ranch-Alder Creek	Brand Park	La Crescenta	Chatsworth Patrol	Glendale	Haines Canyon-Lower	Santa Clara Ridge	Tujunga-Mill Creek	Alder Creek-Paradise Ranch
1928-29	65	58	63	82	75[a]	78[b]	82	69	65[c]	65[c]	65[c]
29-30	66	63	86	65	67	81	67	66	73[c]	73[c]	73[c]
1930-31	77	61	80	87	74	89	66	75	78[c]	78[c]	78[c]
31-32	102	102	109	115	114	134	117	121	112[c]	112[c]	112[c]
32-33	85	55	66	78	76	70	76	90	76[c]	76[c]	76[c]
33-34	75	69	56	105	105	98	110	82	74[c]	74[c]	74[c]
34-35	120	121	116	128	129	132	116	120	122[c]	122[c]	122[c]
1935-36	83	61	58	81	82	84	83	70	73[c]	73[c]	73[c]
36-37	151	135	139	139	145	159	134	143	145[c]	145[c]	145[c]
37-38	158	137	155	150	174	160	143	155	193	155[c]	155[c]
38-39	98	91	108	117	112	105	114	114	109	105[c]	105[c]
39-40	73	63	73	81	88	99	83	84	94	78[c]	78[c]
1940-41	190	185	194	229	204	236	232	218	216	200[c]	200[c]
41-42	60	67	72	77	74	72	71	71	81	84	69[c]
42-43	152	165	165	145	178	167	137	164	162	141	148
43-44	121	137	147	122	124	140	125	150	175	154	154
44-45	80	94	96	89	102	98	86	85	106	102	98
1945-46	90	89	94	78	83	90	82	95	110	88	88
46-47	107	93	103	94	102	87	98	112	121	94	99
47-48	48	47	57	47	45	49	47	46	59	58	51
48-49	65	45	49	50	61	57	53	61	65	67	59
49-50	64	62	53	55	77	79	67	72	61	55	69
1950-51	32	34	42	47	50	63	48	48	41	45	50
51-52	162	153	143	191	177	185	186	183	151	164	172
52-53	49	43	55	70	57	83	61	56	48	64	55
53-54	85	76	70	76	95	92	79	75	83	79	78
54-55	65	62	65	78	73	88	79	79	60	79	76
1955-56	79	62	64	87	93	113	95	86	75	77	84
56-57	71	64	60	74	75	83	77	79	58	66	70
57-58	167	156	142	146	152	202	141	165	148	144	150
29-year TOTAL	2,673	2,494	2,638	2,837	2,911	3,071	2,839	2,869	2,886	2,773	2,776
29-Year Average 1929-57	92.2	86.0	91.0	97.8	100.4	105.9	97.9	98.9	99.5	95.6	95.7

a. Average index of Stations 14, 30, 33 and 295.
b. Average index of Stations 23, 25 and 29.
c. Average index of Stations 33, 47, 53, 54 and 364.

totaled. The annual amounts of precipitation derived in this manner are tabulated by year in Chapter IV of this report. Percent of normal precipitation on the valley fill, hill and mountain areas and entire watershed for each year of the base period are also shown in Chapter IV.

Monthly precipitation was computed only for the San Fernando, Sylmar and Verdugo Hydrologic Subareas on the valley fill and shown in Table E-6. The product of the monthly recorded precipitation in percent of the seasonal record at each controlling station and the annual precipitation in its respective polygon, resulted in the monthly precipitation used for each polygon. The monthly amounts of precipitation in each polygon were totaled by subareas and converted to average depths of monthly precipitation in inches.

TABLE E-6

MONTHLY PRECIPITATION ON VALLEY FILL AREA

In Inches

Year	San Fernando and Eagle Rock Subareas								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May through Sept.	Total
1928-29	0.3	1.6	2.2	1.7	1.8	1.6	1.9	0.6	11.7
29-30	0.1	0	0	5.6	0.7	4.3	0.1	1.2	12.0
1930-31	0.2	2.0	0.2	3.6	5.0	0.3	2.6	1.1	15.0
31-32	0.2	2.7	6.1	2.1	7.5	0.1	0.7	0.4	19.8
32-33	0.2	0	1.3	9.8	0.4	0.1	0.5	0.6	12.9
33-34	0.2	0.2	4.8	6.0	2.3	0.2	0	0.5	14.2
34-35	1.6	2.4	4.6	3.3	1.8	3.4	2.1	0.4	19.6
1935-36	0.2	1.2	0.3	0.6	7.5	1.3	0.9	0.1	12.1
36-37	1.5	0.3	6.8	3.0	6.2	4.6	0.3	0.2	22.9
37-38	0	0	3.2	1.2	8.7	10.3	0.8	0.3	24.5
38-39	0.1	0	9.5	3.6	1.2	1.5	0.3	5.0	21.2
39-40	0.1	0.2	0.7	6.0	6.2	1.5	1.7	0.2	16.6
1940-41	1.3	0.3	8.2	2.7	12.7	10.0	3.8	0.6	39.6
41-42	1.8	0.1	5.2	0.6	1.0	1.3	2.4	0.7	13.1
42-43	1.0	0.3	1.2	13.1	3.5	4.5	0.9	0	24.5
43-44	0.3	0.2	8.1	0.9	11.1	3.0	0.7	0.3	24.6
44-45	0.1	4.8	0.7	0.5	4.1	3.4	0.2	0.1	13.9
45-46	0.6	0.6	5.7	0.3	1.4	3.8	0.9	0.2	13.5
46-47	0.7	7.5	3.9	0.5	0.4	1.2	0.3	0.2	14.8
47-48	0.1	0	1.7	0	1.4	3.1	0.7	0.5	7.5
48-49	0.2	0	2.8	2.2	1.0	1.2	0	0.7	8.1
49-50	0	1.1	2.8	2.6	1.8	0.8	0.9	0.5	10.5
1950-51	0.3	1.5	0.1	3.1	1.1	0.6	1.3	0.6	8.6
51-52	0.6	1.4	5.6	12.2	0.3	8.2	1.7	0.1	30.1
52-53	0	4.3	4.0	1.3	0	0.4	1.3	0.3	11.6
53-54	0	1.2	0.2	4.9	2.9	3.2	0.7	0	13.1
54-55	0	1.7	1.2	4.8	1.2	0.9	1.7	2.4	13.9
1955-56	0	1.4	1.9	6.9	1.0	0	3.9	1.2	16.3
56-57	0.3	0	0.1	6.3	2.0	1.6	1.2	1.2	12.7
57-58	1.9	0.5	4.9	1.8	7.4	5.3	4.4	0.4	26.6

TABLE E-6
(continued)

MONTHLY PRECIPITATION ON VALLEY FILL AREA

In Inches

Year	Sylmar Subarea								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May through Sept.	Total
1928-29	0.4	1.9	2.6	1.9	2.1	1.6	2.3	0.6	13.4
29-30	0.1	0	0	6.7	1.1	5.3	0.6	1.4	15.2
1930-31	0.8	2.9	0.5	4.1	5.4	0	2.4	1.3	17.4
31-32	0.2	3.0	6.4	2.6	7.9	0.3	1.4	0.4	22.2
32-33	0.1	0	1.5	9.6	0.4	0.3	0.8	1.1	13.8
33-34	0.2	0.6	7.6	3.3	2.7	0.2	0	0.9	15.5
34-35	2.1	2.6	6.0	3.5	2.0	3.7	2.2	0.4	22.5
1935-36	0.5	1.2	0.3	0.9	10.6	1.9	0.9	0.1	16.4
36-37	1.6	0.3	7.5	3.8	7.6	4.8	0.6	0.6	26.8
37-38	0	0	4.7	1.6	9.1	10.2	1.4	0.8	27.8
38-39	0.2	0	11.3	3.8	1.4	1.7	0.3	3.5	22.2
39-40	0.2	0.2	1.0	6.6	6.1	1.5	2.2	0.1	17.9
1940-41	1.4	0.2	7.6	3.4	12.7	9.3	4.2	0.7	39.5
41-42	1.9	0.1	5.2	0.8	0.9	1.1	3.0	0.7	13.7
42-43	1.1	0.9	1.2	13.7	4.3	5.3	1.0	0	27.5
43-44	0.2	0.3	7.5	1.4	10.9	4.0	1.0	0.5	25.8
44-45	0.4	4.7	1.1	0.2	5.1	4.1	0.4	0.6	16.6
1945-46	0.8	1.0	6.4	0.3	1.3	4.8	0.9	0.3	15.8
46-47	1.6	7.8	5.3	0.6	0.2	1.4	0.6	0.5	18.0
47-48	0.3	0	1.6	0	1.6	3.3	1.5	0.5	8.8
48-49	0.2	0	3.1	2.8	1.5	1.6	0.1	1.5	10.8
49-50	0	1.9	3.3	2.9	2.4	1.1	1.1	1.0	13.7
1950-51	0.7	1.9	0.2	4.3	0.9	0.7	1.9	0.8	11.4
51-52	0.7	2.0	7.8	12.0	0.5	8.8	2.2	0.3	34.3
52-53	0	4.4	3.9	1.8	0.2	0.9	1.8	0.3	13.3
53-54	0	1.0	0.2	6.4	2.7	3.8	0.9	0.1	15.1
54-55	0	1.6	1.3	4.3	1.4	0.8	2.1	2.8	14.3
1955-56	0	1.9	2.7	7.5	1.3	0	4.7	1.3	19.4
56-57	0.7	0	0.2	6.3	1.9	2.4	1.3	1.9	14.7
57-58	2.3	0.6	6.0	2.4	7.6	5.9	5.5	0.4	30.7

TABLE E-6
(continued)

MONTHLY PRECIPITATION ON VALLEY FILL AREA

In Inches

Year	Verdugo Subarea[a]								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May through Sept.	Total
1928-29	0.7	2.3	3.4	2.5	2.6	2.6	2.7	0.7	17.5
29-30	0.1	0	0	6.1	0.7	5.1	0.3	3.2	15.5
1930-31	0.1	2.9	0.2	3.9	4.8	0	4.0	1.5	17.4
31-32	0.3	3.3	7.9	1.9	11.3	0	1.4	0.4	26.5
32-33	0.1	0	1.7	13.5	0.4	0.2	0.6	1.2	17.7
33-34	0.2	0.7	11.5	7.5	3.7	0.3	0.1	0.5	24.5
34-35	2.4	2.9	7.2	4.7	3.4	4.0	4.0	1.2	29.8
1935-36	0.5	1.5	0.3	0.7	12.5	2.1	1.2	0.2	19.0
36-37	2.4	0.5	10.3	4.4	8.6	6.4	0.3	0.5	33.4
37-38	0	0	4.9	1.9	13.9	16.9	1.6	0.8	40.0
38-39	0.3	0	9.8	4.4	1.3	3.0	0.5	6.8	26.1
39-40	0.3	0.2	1.0	6.7	7.9	1.8	2.4	0.2	20.5
1940-41	1.7	0.7	6.6	3.2	17.2	11.7	6.0	0.8	47.9
41-42	2.7	0.1	6.6	0.3	1.7	1.6	3.0	1.2	17.2
42-43	1.2	0.5	1.3	23.7	6.1	7.1	1.0	0	40.9
43-44	0.2	0.1	8.4	1.0	13.5	3.8	1.0	0.8	28.8
44-45	0	8.0	1.8	0	7.5	5.1	0.5	0.5	23.4
1945-46	0.6	0.7	9.0	0.2	2.2	5.5	0.9	0.3	19.4
46-47	2.5	10.4	6.4	0.8	0.6	1.9	0.3	0.8	23.7
47-48	0	0	2.3	0	2.2	4.1	1.6	0.3	10.5
48-49	0.4	0	3.6	3.5	2.2	2.7	0.1	1.7	14.2
49-50	0.2	3.1	4.5	3.3	2.6	1.8	1.1	1.1	17.7
1950-51	0.5	2.0	0	3.8	1.7	0.8	2.2	0.7	11.7
51-52	1.5	2.1	8.2	16.2	0.9	9.1	2.8	0.5	41.3
52-53	0	4.2	4.6	1.5	0.1	1.2	1.3	0.3	8.6
53-54	0	1.4	0.3	9.1	5.0	5.1	0.8	0.1	21.8
54-55	0	2.0	1.4	6.0	1.2	1.2	2.9	2.3	17.0
1955-56	0	1.6	1.9	10.3	1.3	0	4.9	1.6	21.6
56-57	0.6	0	0.2	7.1	3.2	1.5	1.6	3.2	17.4
57-58	2.6	0.8	5.8	3.1	9.6	6.7	6.1	0.4	35.1

a. Includes the portion of Monk Hill Basin in Upper Los Angeles River Area.

APPENDIX F

HILL AND MOUNTAIN RUNOFF

APPENDIX F

TABLE OF CONTENTS

TABLES

TABLES
(continued)

FIGURES

APPENDIX F

HILL AND MOUNTAIN RUNOFF

The hill and mountain areas producing runoff that flows onto the valley fill are comprised of 205,709 acres. The location of hill and mountain masses is shown on Plate 2, Physiography. The ungaged hill and mountain areas are composed primarily of small canyons and low hills. To facilitate computations, adjacent watersheds which had similar geologic and runoff characteristics and were tributary to the same hydrologic subarea, were grouped together into "Hill and Mountain Groups". The location and extent of these groups are shown on Figure F-1.

<u>Availability of Data Used</u>

The only watersheds gaged throughout the base period are those of Big Tujunga Creek above Gold Canyon and Pacoima Creek above Pacoima Dam, their combined area being equal to 86,201 acres. Of the remaining 119,508 acres, only two small watersheds, Sycamore and Haines, have reliable gaging records of significant duration. Haines Canyon data were not used because of the existence of several unmeasured diversions from the watershed.

The available data within the watershed consist of:

1. Measured runoff from Big Tujunga and Pacoima Creeks during the period 1917-1958, inclusive.

2. Measured runoff from Sycamore Canyon during the period 1938-1958, inclusive.

3. Precipitation on all hill and mountain areas. (Extension of records by Los Angeles County Flood Control District covered an 85-year period back to 1872).

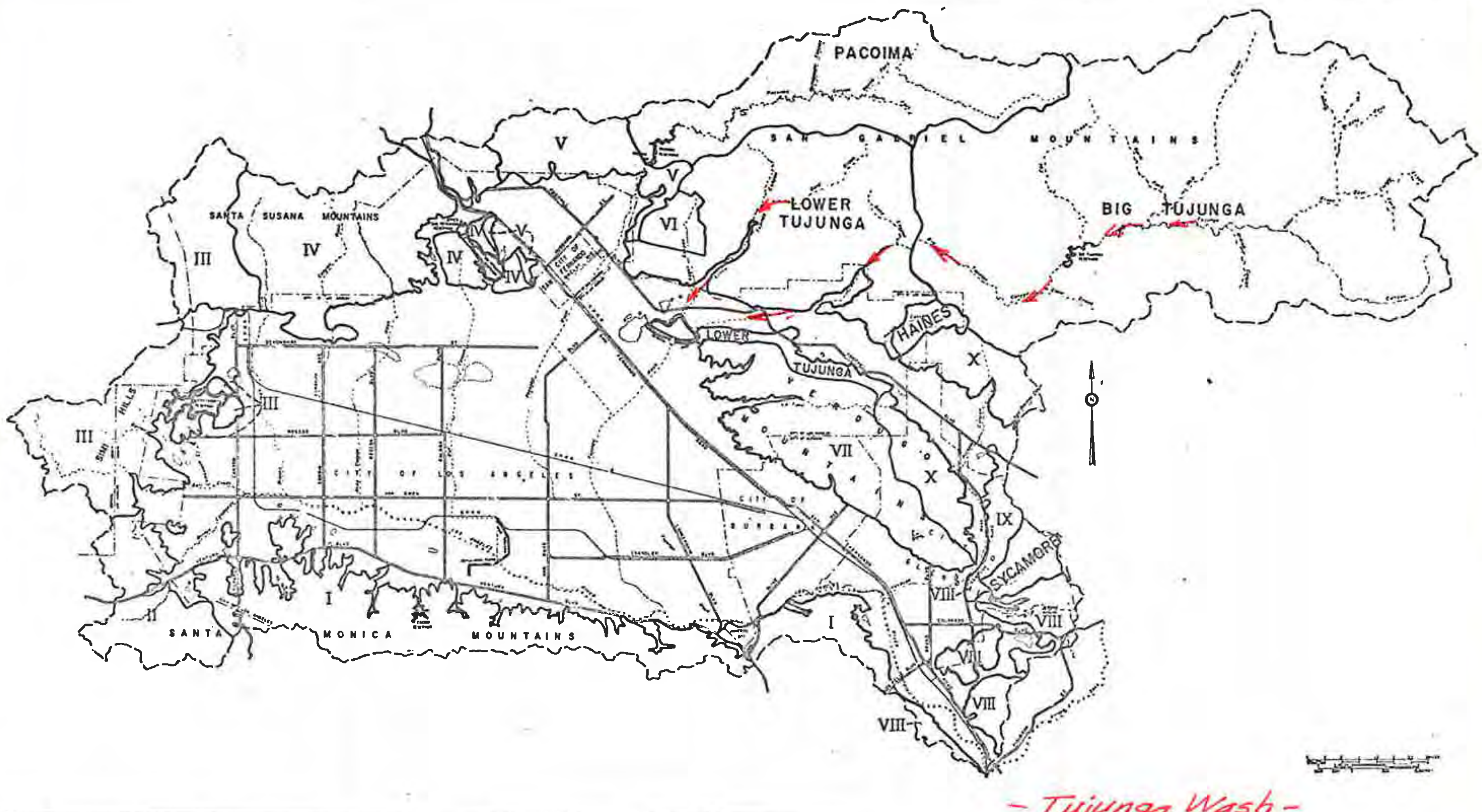
4. Culture survey of hill and mountain areas made by the Referee in 1958.

The method of computing precipitation on hill and mountain groups is described in Appendix E. Annual precipitation so determined is listed in Table F-1.

Runoff measurements and records of dam operations were obtained from the Los Angeles County Flood Control District, U. S. Geological Survey and City of Los Angeles Department of Water and Power.

In order to have all runoff data on the same basis, the Big Tujunga runoff was corrected to unimpaired runoff by adjusting for change in storage in Big Tujunga Dam. The precipitation and runoff data for Tujunga, Pacoima and Sycamore watersheds are shown in Table F-2. The area of each watershed gaged is shown in Table F-3.

The three gaged watersheds in the area were not considered a sufficient number on which to base a study. The gaged watershed determined to be most similar to the hill and mountain areas of the area of investigation was Spunky Canyon, which is tributary to Bouquet Canyon and in the Santa Clara River watershed. Runoff and precipitation records for this gaged area of 1,230 acres have been maintained by the City of Los Angeles since 1932. The 85-year mean water crop for the Spunky watershed was determined from the Los Angeles County Flood Control District's 85-year isohyetal map.



SAN FERNANDO VALLEY REFERENCE
LOCATION AND EXTENT
OF
HILL AND MOUNTAIN GROUPS

STATE WATER RIGHTS BOARD

TABLE F-1

PRECIPITATION, HILL AND MOUNTAIN GROUPS*

In Acre-Feet

Year	I + II	III	IV	V	VI	VII	VIII + Sycamore	IX	X	Lower Tujunga + Haines	Pacoima	Big Tujunga	Total
1928-29	28,596	18,280	21,847	7,852	1,785	14,310	8,157	1,983	10,365	26,121	25,551	95,167	260,014
29-30	26,946	18,722	23,293	9,065	2,121	12,744	6,664	1,585	9,309	28,199	28,648	108,762	276,058
1930-31	36,162	22,458	26,146	10,491	2,509	16,801	8,554	2,097	11,299	31,348	31,358	111,784	331,007
31-32	46,337	29,735	36,211	13,533	3,311	23,652	11,638	2,794	16,416	48,914	44,521	163,144	440,206
32-33	29,571	17,485	19,814	8,468	2,121	15,550	7,559	1,873	12,024	31,593	29,810	107,252	283,120
33-34	33,088	22,096	25,400	9,299	2,251	17,667	10,942	2,571	12,664	30,470	29,423	104,231	300,102
34-35	44,549	31,471	34,976	13,809	3,441	23,910	11,567	3,017	17,413	48,149	48,005	181,271	461,578
1935-36	30,799	20,165	24,169	9,915	2,432	14,344	8,256	1,971	10,796	29,098	29,423	102,720	284,088
36-37	56,482	37,720	42,507	16,363	4,010	26,891	13,329	3,328	20,246	57,021	56,910	214,504	549,311
37-38	60,874	36,974	41,991	17,319	4,450	28,397	14,721	3,614	21,786	61,278	66,975	237,153	595,542
38-39	49,276	26,372	33,919	13,150	3,001	23,311	11,340	2,809	15,950	43,031	41,811	154,080	418,050
39-40	37,975	24,083	28,474	10,554	2,484	17,842	8,256	1,971	11,508	32,554	33,681	113,294	322,675
1940-41	93,903	58,592	65,667	23,471	5,510	44,792	23,077	5,556	30,846	81,658	80,525	297,586	811,183
41-42	30,894	17,966	21,181	8,277	1,992	15,518	7,062	1,823	10,118	27,999	29,036	107,252	279,118
42-43	57,058	36,650	43,745	16,724	4,139	28,860	13,627	3,454	21,987	60,275	60,394	240,184	587,097
43-44	55,391	35,722	40,041	15,703	3,829	27,285	12,434	2,970	19,164	59,955	62,330	219,036	553,850
44-45	33,790	22,363	25,771	10,107	2,509	17,316	8,554	2,133	12,142	37,019	39,101	141,995	352,800
1945-46	32,359	20,844	24,508	9,468	2,302	15,964	8,157	1,912	12,484	35,213	37,553	141,995	342,759
46-47	32,953	20,751	25,163	11,234	2,846	19,029	9,748	2,299	14,842	40,625	42,585	155,591	377,666
47-48	17,240	11,303	13,774	5,277	1,294	9,172	4,675	1,136	6,621	19,434	20,906	80,061	190,893
48-49	19,049	12,570	15,711	6,532	1,630	10,258	5,272	1,229	8,175	23,426	24,003	84,593	212,449
49-50	24,874	18,490	21,995	8,129	1,914	11,357	6,635	1,408	9,164	27,362	25,938	90,635	247,901
1950-51	18,810	15,088	18,473	6,809	1,604	9,465	4,774	1,142	6,390	19,944	18,583	58,913	179,995
51-52	71,541	44,716	52,497	20,704	4,993	35,266	18,501	4,586	25,876	69,525	64,652	234,141	646,998
52-53	27,219	19,682	22,634	7,810	1,785	12,783	6,068	1,634	8,493	22,487	21,293	77,040	228,928
53-54	31,800	21,926	24,694	9,065	2,173	14,489	7,858	1,857	10,919	30,477	31,358	116,315	30[illegible],931
54-55	31,478	21,360	23,856	8,426	1,966	15,449	7,845	1,892	10,831	30,275	27,100	99,699	280,177
1955-56	38,418	26,761	32,683	11,151	2,432	17,126	9,450	2,155	12,098	33,713	31,745	107,252	324,984
56-57	27,925	20,172	23,150	8,831	2,147	15,031	7,659	1,809	10,765	29,147	25,938	98,188	270,762
57-58	65,504	48,847	54,306	18,109	4,165	28,522	14,025	3,498	22,453	60,756	58,458	229,610	608,253
Average 1928-57	38,804	25,190	29,458	11,294	2,723	19,123	9,737	2,366	13,817	38,493	38,247	139,443	368,698

* Area contained in hill and mountain groups:

Group	Area in Acres
I + II	25,684
III	17,594
IV	17,582
V	5,873
VI	1,786
VII	13,104

Group	Area in Acres
VIII + Sycamore	6,661
IX	1,391
X	7,029
Lower Tujunga + Haines	22,804
Big Tujunga	68,111
Pacoima	18,070
Total	205,709

PRECIPITATION, RUNOFF, RETENTION, AND INDICES OF WETNESS
FOR
PACOIMA, TUJUNGA, SYCAMORE, AND SPUNKY WATERSHEDS

Year	PACOIMA WATERSHED Precipitation, in inches	Unimpaired runoff, in inches	Rainfall retention, in inches	Annual index of wetness: Based on 85-year mean	Annual index of wetness: Based on 29-year mean	TUJUNGA WATERSHED Precipitation, in inches	Unimpaired runoff, in inches	Rainfall retention, in inches	Annual index of wetness: Based on 85-year mean	Annual index of wetness: Based on 29-year mean
1917-18	28.31	3.19	25.12	110	110	29.68	3.91	25.77	112	121
18-19	19.48	0.76	18.72	76	76	19.88	1.01	18.87	75	81
19-20	24.74	6.50	18.24	96	97	27.69	2.92	24.77	104	113
1920-21	28.39	4.84	23.55	111	111	28.12	1.85	26.27	106	115
21-22	44.73	25.69	19.04	174	175	49.50	18.15	31.35	186	202
22-23	24.37	5.22	19.15	95	95	25.96	2.59	23.37	98	106
23-24	13.32	0.36	12.96	52	52	14.36	0.65	13.71	54	59
24-25	18.00	0.62	17.38	70	70	19.91	0.65	19.26	75	81
1925-26	34.29	5.17	29.12	134	134	37.63	3.44	34.19	141	154
26-27	28.67	3.80	24.87	112	112	29.03	3.77	25.26	107	119
27-28	16.26	0.40	15.86	63	63	16.73	0.85	15.88	63	68
28-29	16.95	0.58	16.37	66	67	16.76	0.73	16.03	63	68
29-30	19.00	0.74	18.26	74	75	19.16	0.77	18.39	72	78
1930-31	20.80	0.72	20.08	81	82	19.69	0.54	19.15	74	80
31-32	29.53	5.80	23.73	115	116	28.74	3.15	25.59	108	117
32-33	19.77	1.43	18.34	77	78	18.90	1.30	17.60	71	77
33-34	19.52	2.29	17.23	76	77	18.36	1.46	16.90	69	75
34-35	31.84	3.69	28.15	124	126	31.93	2.84	29.09	120	130
1935-36	19.52	2.05	17.47	76	77	18.09	1.15	16.94	68	74
36-37	37.75	10.43	27.32	147	149	37.79	6.61	31.18	142	154
37-38	44.43	17.16	27.27	173	175	41.78	14.76	27.02	157	170
38-39	27.73	2.34	25.39	108	109	27.14	2.55	24.59	102	111
39-40	22.34	2.13	20.21	87	88	19.96	1.91	18.05	75	81
1940-41	53.41	17.11	36.30	208	211	52.42	13.91	38.51	197	213
41-42	19.26	1.27	17.99	75	76	18.89	1.78	17.11	71	77
42-43	40.06	13.73	26.33	156	158	42.31	13.39	28.92	159	172
43-44	41.34	9.95	31.39	161	163	38.58	10.32	28.26	145	157
44-45	25.94	3.23	22.71	101	102	25.01	3.23	21.78	94	102
1945-46	24.91	3.05	21.86	97	98	25.01	2.87	22.14	94	102
46-47	28.25	2.89	25.36	110	111	27.41	3.37	24.04	103	112
47-48	13.87	0.25	13.62	54	55	14.10	0.66	13.44	53	57
48-49	15.92	0.48	15.44	62	63	14.90	0.52	14.38	56	61
49-50	17.21	0.71	16.50	67	68	15.97	0.54	15.43	60	65
1950-51	12.33	0.09	12.24	48	49	10.38	0.20	10.18	39	42
51-52	42.89	11.14	31.75	167	169	41.25	7.49	33.76	155	168
52-53	14.12	0.64	13.48	55	56	13.57	0.90	12.67	51	55
53-54	20.80	1.96	18.84	81	82	20.49	1.47	19.02	77	83
54-55	17.98	0.50	17.48	70	71	17.56	0.69	16.87	66	72
1955-56	21.06	0.97	20.09	82	83	18.89	0.76	18.13	71	77
56-57	17.21	0.38	16.83	67	68	17.30	0.46	16.84	65	70
57-58	38.78	10.49	28.29	151	153	40.45	6.94	33.51	152	165
29-Year Average 1929-57	25.37	4.06	21.31	99	100	24.56	3.46	21.10	92	100

Year	SYCAMORE WATERSHED Precipitation, in inches	Unimpaired runoff, in inches	Rainfall retention, in inches	Annual index of wetness: Based on 85-year mean	Annual index of wetness: Based on 29-year mean	SPUNKY CANYON Precipitation, in inches	Unimpaired runoff, in inches	Rainfall retention, in inches	Annual index of wetness: Based on 85-year mean	Annual index of wetness: Based on 29-year mean
1928-29	16.41			82	83					
29-30	13.41			67	68					
1930-31	17.21			86	88					
31-32	23.41			117	120					
32-33	15.21			76	78	10.19	0	10.19	61	62
33-34	22.01			110	112	12.39	0.04	12.35	74	76
34-35	23.41			117	120	19.84	0.37	19.47	119	121
1935-36	16.61			83	85	14.04	0.11	13.93	84	86
36-37	26.81			134	137	22.73	2.12	20.61	136	139
37-38	29.61			148	151	25.48	5.21	20.27	153	155
38-39	22.81	0.97	21.84	114	116	19.11	1.23	17.88	114	117
39-40	16.61	0.69	15.92	83	85	13.34	0.26	13.08	80	81
1940-41	46.42	5.98	40.44	232	237	31.54	5.34	26.20	189	192
41-42	14.21	0.72	13.49	71	73	12.59	0.83	11.76	75	77
42-43	27.41	7.88	19.53	137	140	26.10	5.54	20.56	156	159
43-44	25.01	2.69	22.32	125	128	26.64	7.28	19.36	160	162
44-45	17.21	0.73	16.48	86	88	15.19	1.94	13.25	91	93
1945-46	16.41	0.37	16.04	82	84	16.96	0.78	16.18	102	103
46-47	19.61	0.84	18.77	98	100	17.02	0.60	16.42	102	104
47-48	9.40	0.06	9.34	47	48	8.01	0.01	8.00	48	49
48-49	10.61	0.05	10.56	53	54	9.99	0.03	9.96	60	61
49-50	13.21	0.23	12.98	66	67	13.03	0.01	13.02	78	79
1950-51	9.60	0.19	9.41	48	49	7.14	0	7.14	43	44
51-52	37.22	7.75	29.47	186	190	28.92	3.89	25.03	173	176
52-53	12.21	0.60	11.61	61	62	9.15	0.25	8.90	55	56
53-54	15.81	0.48	15.33	79	81	14.37	0.38	13.99	86	88
54-55	15.61	0.32	15.29	78	80	11.61	0.04	11.57	70	71
1955-56	19.01	0.85	18.16	95	97	14.02	0.04	13.98	84	85
56-57	15.41	0.54	14.87	77	79	13.36	0.03	13.33	80	81
57-58	28.21	2.42	25.79	141	144	31.17	3.27	27.90	187	190
29-Year Average 1929-57	19.58	--	--	98	100					

Extension of Data

In order to compare runoff characteristics of Spunky watershed with other watersheds during the selected 29-year base period, it was necessary to estimate the appropriate 29-year mean precipitation for the Spunky watershed.

A summary of the relationship of the average precipitation during the 29-year period 1928 through 1957, the 26-year period 1932 through 1958 and the 18-year period 1940 through 1958, to the normal precipitation and the average precipitation during the 29-year base period is shown in Table F-3 for the Sycamore and Spunky watersheds.

TABLE F-3

MEAN PRECIPITATION FOR SYCAMORE AND SPUNKY WATERSHEDS

Watershed	Mean precipitation, in inches			
	85-year	1928-57	1932-58	1940-58
Sycamore, 1,733 acres	20.01	19.58	20.22	19.59
percent of 85-year mean		98	101	98
percent of 29-year mean			103	100
Spunky, 1,230 acres	16.7	(16.4)[a]	17.07	17.05
percent of 85-year mean		(98)[b]	102	102
percent of 29-year mean			(104)[a]	(104)[a]

a. Computed values.
b. Assumed.

Since the characteristics of the Sycamore and Spunky watersheds were not greatly dissimilar, it was assumed that the relationship between the 29-year and the 85-year mean precipitation for both watersheds would be the same. Therefore, in Table F-3 the 29-year mean for Spunky was taken as 98 percent of the 85-year mean.

Precipitation - Runoff Relationships

In investigating the relationship between precipitation and runoff a review was made of Bulletin 5 of the State Department of Public Works, entitled "Flow in California Streams", 1923. In Bulletin 5 the relationship between wetness and runoff as shown graphically on Plates XVIII to LIII, entitled "Curves of Probable Runoff" is shown as index of wetness versus runoff wherein:

$$\text{Index of wetness} = \frac{\text{Annual precipitation}}{\text{Mean precipitation}} \times 100$$

The relationships depicted by these curves are described in Bulletin 5 as follows:

> "These curves show the trend of the relation between the 'index of seasonal wetness' and the run-off from each drainage basin. They pass through many of the plotted points, but due to the variable weather in successive seasons which causes different fractions of the precipitation to evaporate before running off the collecting area into the stream channels, some of the points fall to the side of the mean curves. The sequence of the storms, their intensity, the weather conditions between the occurrence of storms, and the character of successive seasons, all influence this relation to an indeterminate degree. For seasons in which these conditions favor a greater fractional part of the meteoric waters evaporating to the atmosphere, the points tend to lie on the lower side of the mean curve, and for seasons favoring a small evaporation, the points tend to lie on the upper side. Successive seasons of drought or heavy floods may also influence the position of the points, for the quantity of ground water feeding the streams does not change immediately with variations in the annual precipitation. Instead, there is a certain tardiness in response which places these points on either side of the mean curve, according to very recondite relations that obtain in the sequence of seasonal rains and snows, and any one seasonal precipitation may affect the quantity of ground water reaching a stream for a period as long as three years.

"Although there are these minor influences which tend to make the relation between the 'index of seasonal wetness' and run-off an approximate one, nevertheless the data reveal that when a reasonable number of measurements of seasonal run-off are at hand, a mean curve may be drawn which will not change much in position by procuring and plotting additional measurements."

The above approach has the distinct advantage of allowing comparison of runoff characteristics of different watersheds and was adopted by the Referee to determine by a set of curves the annual mean runoff which might be expected from a given amount of precipitation under conditions of native culture.

The first step was to reduce precipitation to a dimensionless number. The index of wetness based on the mean of the 29-year base period, 1928-1957, was utilized for this purpose and is listed for each year and hill and mountain group in Table F-4.

The second factor utilized in the study is rainfall retention; i.e., the amount of precipitation that does not pass out of hill and mountain areas as runoff.

The runoff, rainfall retention and indices of wetness for the four study watersheds are listed in Table F-2.

The above data were plotted for each of the four watersheds with the index of wetness (based on a 29-year mean) as the abscissa and runoff and rainfall retention as the ordinate. The lines of best fit were drawn simultaneously for runoff and for rainfall retention and then adjusted so that the following requirements were met:

1. For the base period (1928-29 through 1956-57), the summation of the annual runoff values obtained from the curve equaled the summation of annual measured runoff values.

2. For a specific year the sum of the runoff and rainfall retention values for the curve equaled the precipitation (index of wetness multiplied by mean precipitation).

The plots of those data and the resultant curves are shown on:

Figure F-2	Pacoima
Figure F-3	Tujunga
Figure F-4	Sycamore
Figure F-5	Spunky

Review of the above curves led to the conclusion that when precipitation is below an index of wetness of 40 no runoff would normally be produced, and, therefore, the rainfall retention curves would become tangent to a line of 100 percent rainfall retention at an index wetness of 40.

The scattering of the plot of points above an index of wetness of between 150 to 200 indicates that during extremely wet years the mean rainfall retention tends to reach an optimum value and become a constant. This results in the runoff curves becoming a tangent above the index of wetness of between 150 to 200, with the tangent representing 100 percent runoff of all additional precipitation.

For comparison, the rainfall retention and runoff curves for the four watersheds were plotted together as shown on Figure F-6. The result

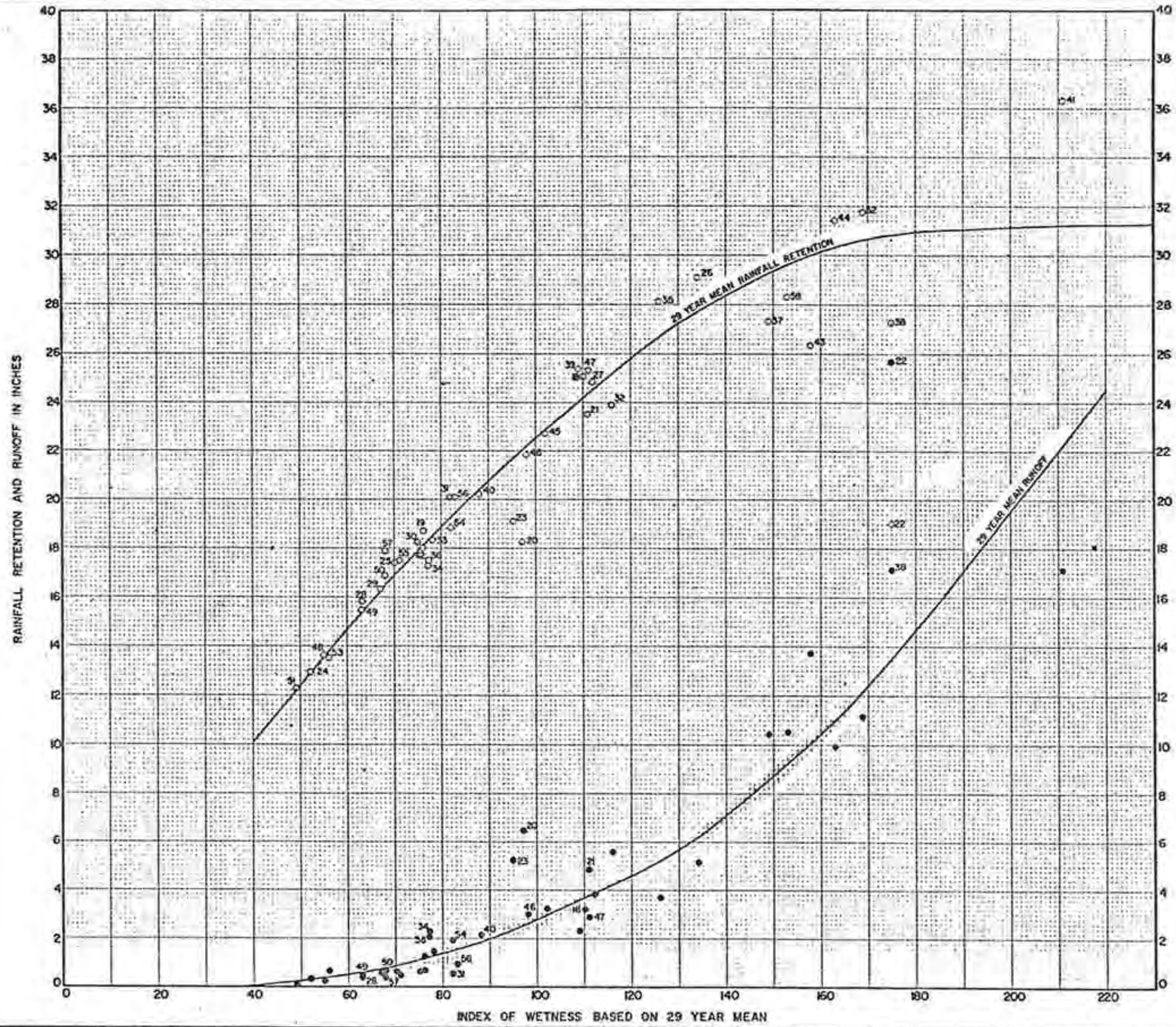
TABLE F-4

INDICES OF WETNESS FOR HILL AND MOUNTAIN GROUPS

BASED ON 29-YEAR AVERAGE*

Year	I + II	III	IV	V	VI	VII	VIII + Sycamore	IX	X	Lower Tujunga + Haines	Pacoima	Big Tujunga
1928-29	74	72	74	70	66	75	84	84	75	68	67	68
29-30	69	74	79	80	78	67	68	67	67	73	75	78
1930-31	93	89	89	93	92	88	88	89	82	81	82	80
31-32	119	118	123	120	122	124	119	118	119	127	116	117
32-33	76	69	67	75	78	81	78	79	87	82	78	77
33-34	85	88	86	82	83	93	112	109	92	79	77	75
34-35	115	125	119	122	126	125	119	128	126	125	126	130
1935-36	79	80	82	88	89	75	85	84	78	76	77	74
36-37	146	150	144	145	147	141	137	141	147	148	149	154
37-38	157	147	143	153	163	149	151	153	158	159	175	170
38-39	127	105	115	116	110	122	116	119	116	112	109	111
39-40	98	96	97	93	91	93	85	84	83	85	88	81
1940-41	242	233	223	208	202	235	237	235	223	212	211	213
41-42	80	71	72	73	73	81	73	77	73	73	76	77
42-43	147	145	148	148	152	151	140	146	159	157	158	172
43-44	143	142	136	139	141	143	128	126	139	156	163	157
44-45	87	89	87	90	92	91	88	90	88	96	102	102
1945-46	83	83	83	84	85	84	84	81	90	91	98	102
46-47	85	82	85	100	104	100	100	97	108	106	111	112
47-48	44	45	47	47	47	48	48	48	48	50	55	57
48-49	49	50	53	58	60	54	54	52	59	61	63	61
49-50	64	72	75	72	70	59	68	60	66	71	68	65
1950-51	48	59	63	60	59	50	49	48	46	52	49	42
51-52	184	178	178	183	183	185	190	194	187	181	169	168
52-53	70	78	77	69	66	67	62	69	62	58	56	55
53-54	82	85	84	80	80	76	81	79	79	79	82	83
54-55	81	84	81	75	72	81	80	80	78	79	71	72
1955-56	99	106	111	99	89	90	97	91	88	88	83	77
56-57	72	80	79	78	79	79	79	77	78	76	68	70
57-58	169	194	184	160	153	149	144	148	163	158	153	165

*29-year average precipitation for the period 1928-29 through 1956-57.



SAN FERNANDO VALLEY REFERENCE

PACOIMA WATERSHED

RAINFALL RETENTION AND RUNOFF VS. INDEX OF WETNESS

FIGURE F-2

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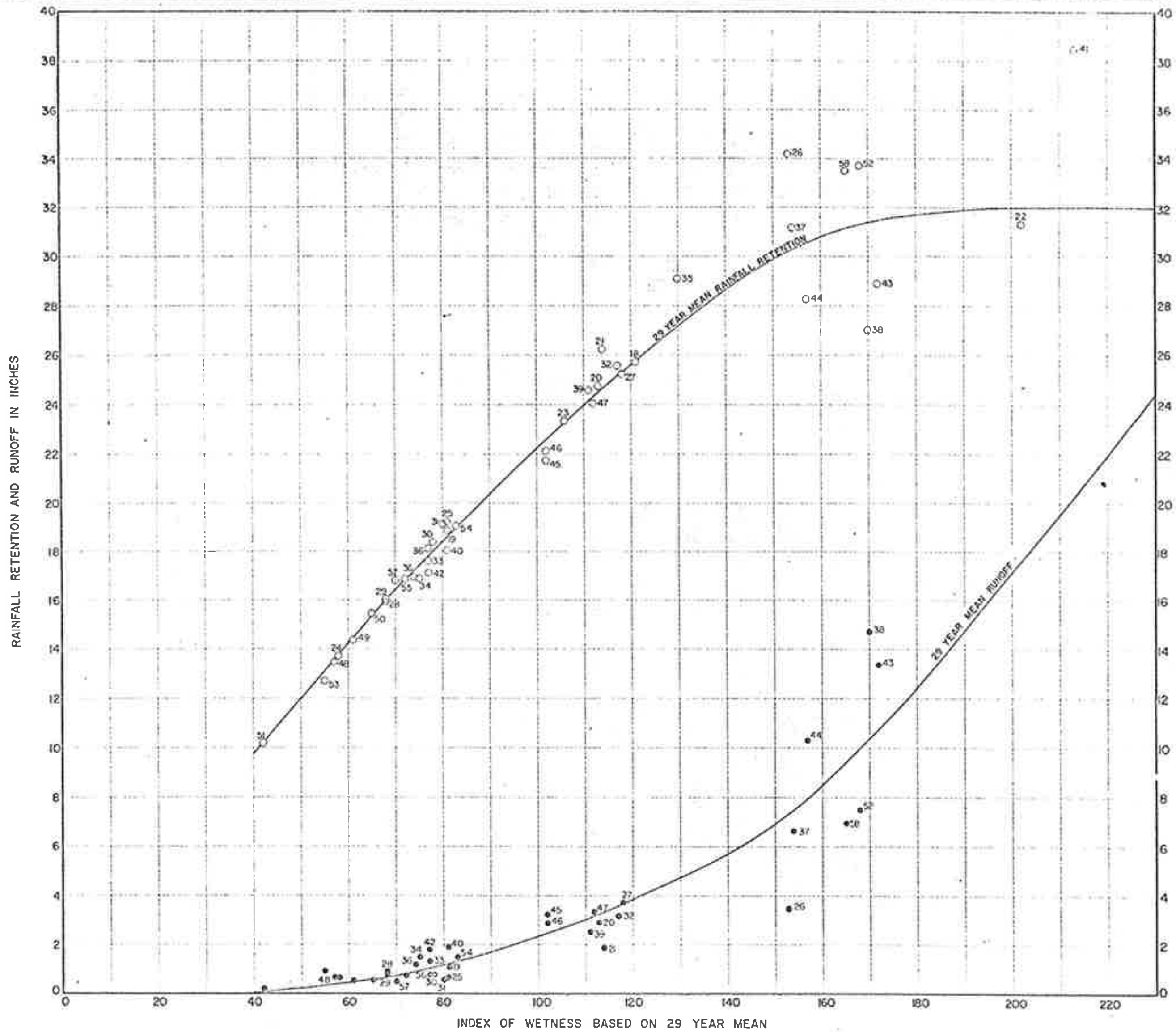
FIGURE F-3



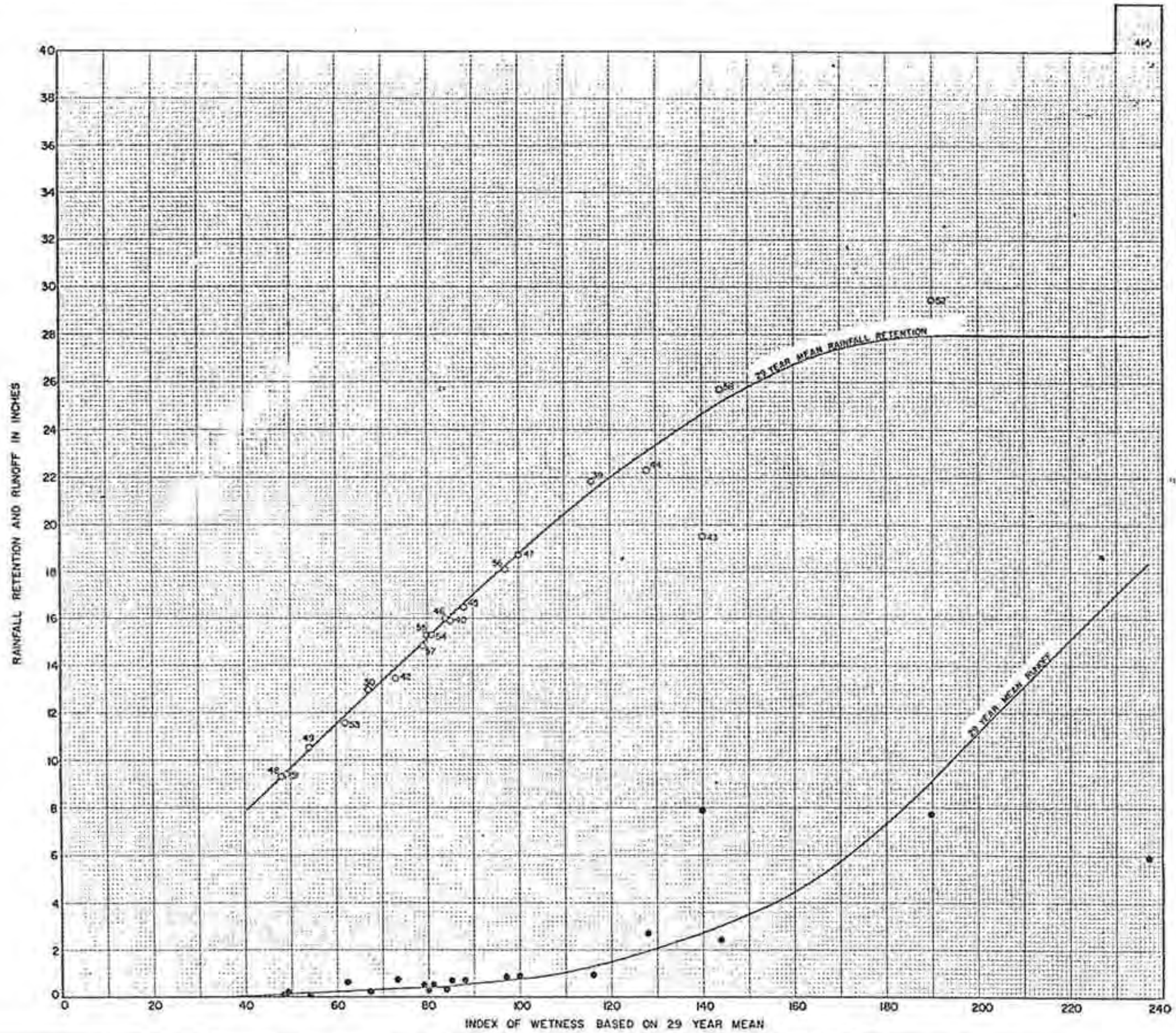
SAN FERNANDO VALLEY REFERENCE

TUJUNGA WATERSHED

RAINFALL RETENTION AND RUNOFF VS. INDEX OF WETNESS

STATE WATER RIGHTS BOARD

85



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SYCAMORE WATERSHED

RAINFALL RETENTION AND RUNOFF VS. INDEX OF WETNESS

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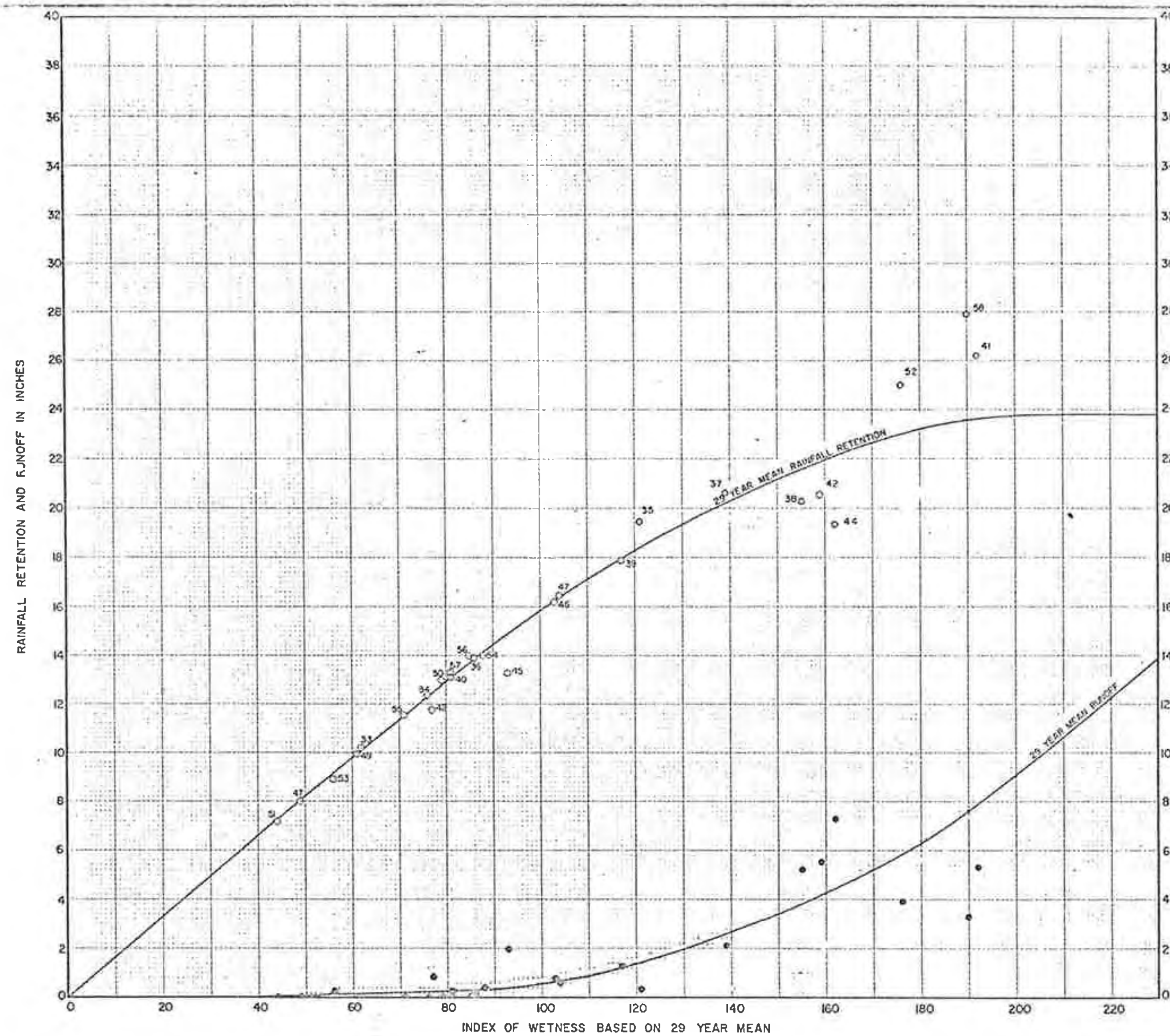

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SPUNKY WATERSHED

RAINFALL RETENTION AND RUNOFF VS. INDEX OF WETNESS

FIGURE F-5

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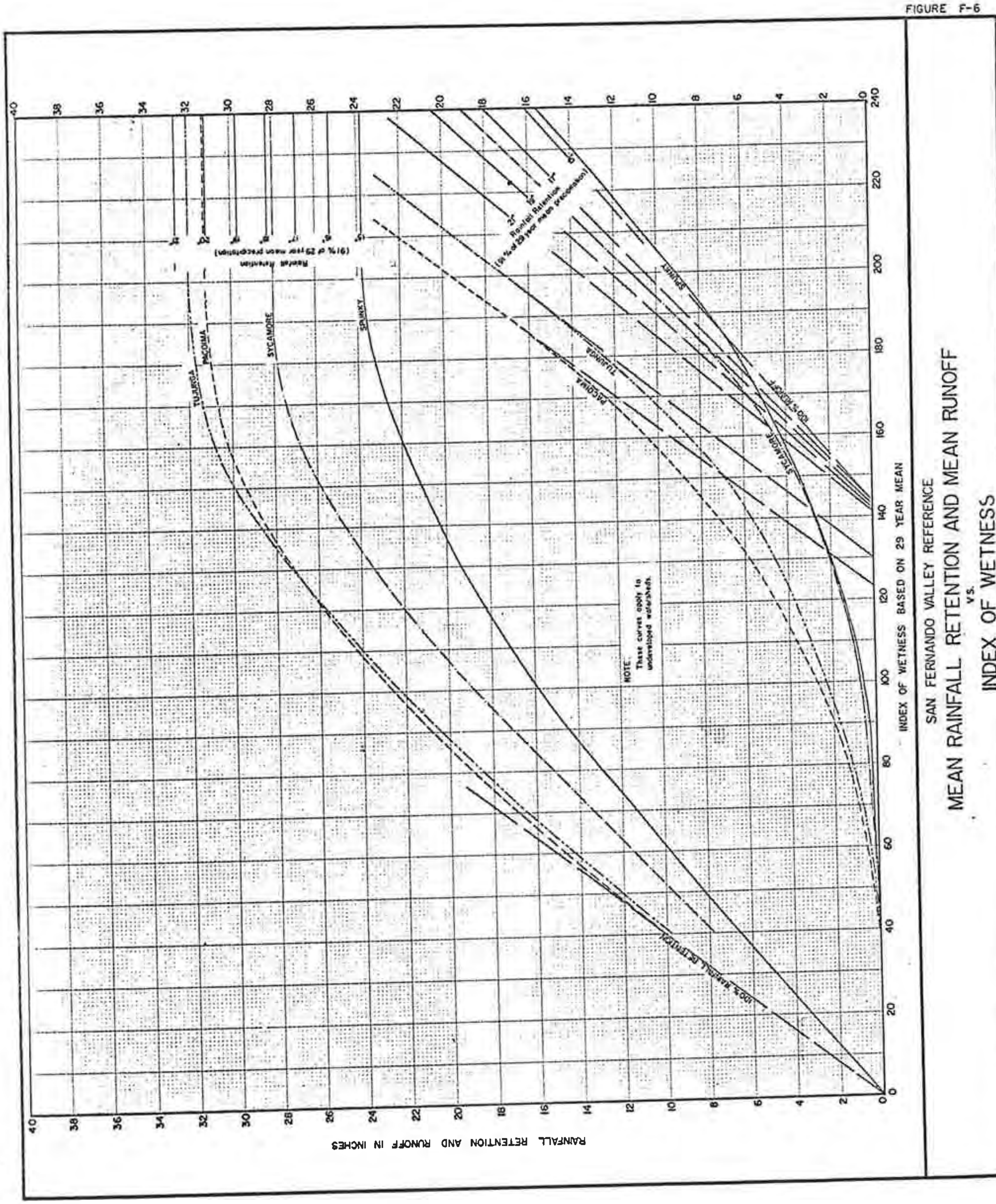
FIGURE F-6



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is a family of curves having similar shapes and being controlled by these factors:

1. Rainfall retention curves tangent to the line of 100 percent rainfall retention at index of wetness of 40. This indicates that on the long-time average no runoff can be expected below an index of wetness of 40.

2. Runoff curves tangent to the line of 100 percent runoff at index of wetness of 200.

3. The intercept of the 100 percent runoff lines with the abscissa, or index of wetness at zero runoff for a given watershed is equal to maximum mean rainfall retention divided by the 29-year mean precipitation.

Construction of Runoff Curves for Hill and Mountain Groups

The set of curves in Figure F-6 was used as the basis to construct the curves for runoff of hill and mountain groups.

The first step was to select a parameter to space the rainfall retention curves. The mean retention of precipitation is an indication of the ability of a watershed to retain water and was found to be 91 percent for the two smaller watersheds of Sycamore and Spunky. The 29-year mean rainfall retention, based on 91 percent of mean precipitation, was selected as the parameter to space the portion of the mean rainfall retention curves above index of wetness of 200. The parameters are shown on Figure F-6. Utilizing these parameters, a mean maximum rainfall retention was obtained for the hill and mountain group. The intercept of the 100 percent runoff line with the abscissa was obtained by dividing the mean maximum rainfall retention by the 29-year mean precipitation. The 100 percent runoff line for the group was then constructed and is used as the tangent for the upper portion of the runoff curve.

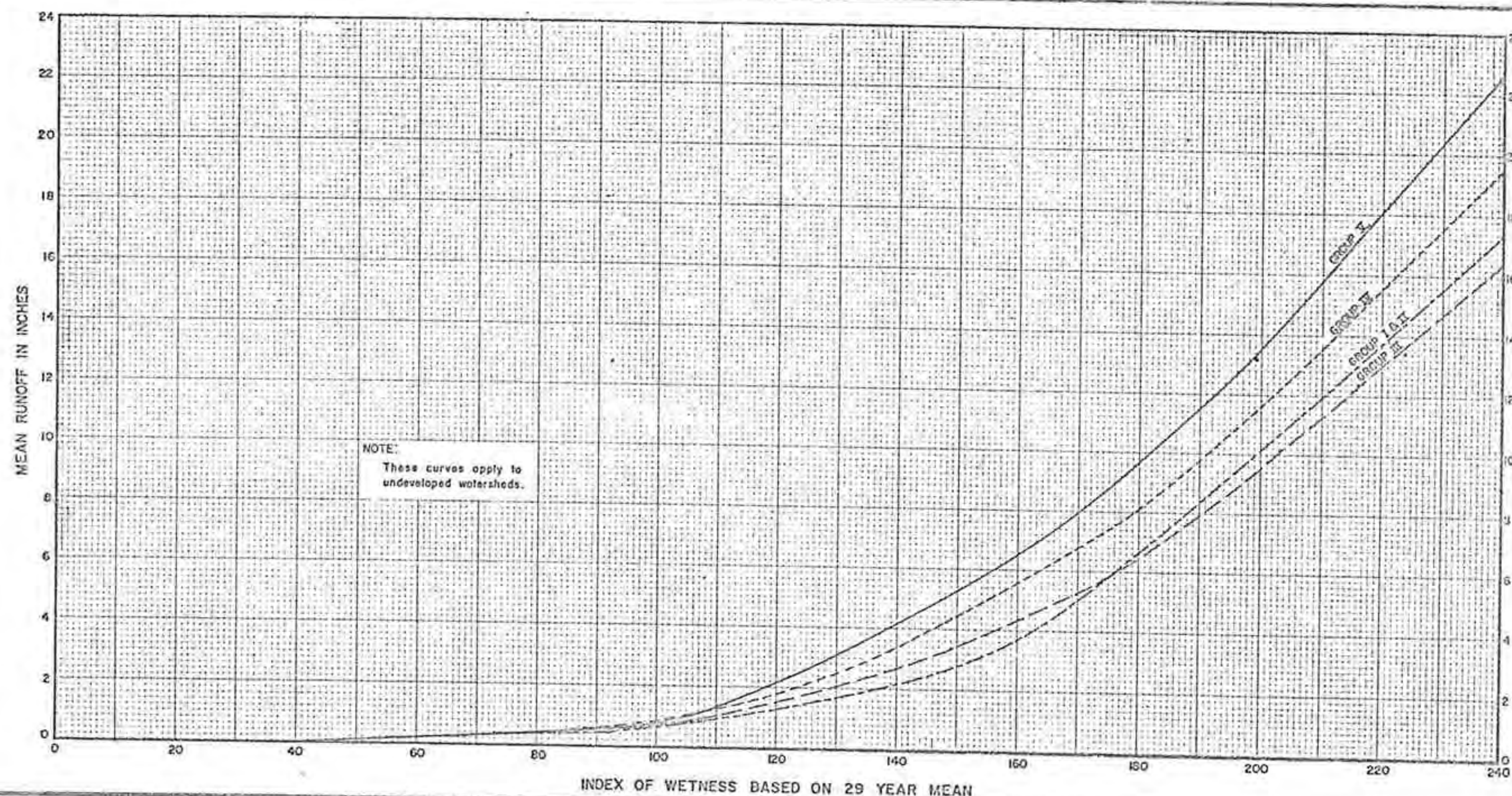
The lower portion of the runoff curve for the group is drawn tangent to the abscissa at index of wetness of 40. The middle portion of the runoff curve was then drawn in preliminary location by using the curves of the four gaged watersheds as a guide. The final position of the middle portion of the curve was fixed so that the sum of the annual mean runoff values for the base period obtained from the curve equaled nine percent of the mean precipitation for the same period. The final curves for mean runoff are shown on Figure F-7 for groups I through V and Figure F-8 for the remainder of the groups.

Correction of Mean Runoff to Final Runoff

To obtain runoff values that could be used in an annual hydrologic inventory, it was necessary to determine what deviation from the mean runoff values could be expected in each of the years in the 1928-58 period. Corrections to the mean runoff were made by applying the weighted average deviation of Sycamore and Spunky watersheds expressed as a percent of the 29-year mean precipitation to the mean runoff of the groups.

Deviations for the four gaged watersheds are shown on Table F-5. Deviations for Sycamore and Spunky watersheds in years having no runoff records were estimated by correlation to the deviation of Pacoima and then

FIGURE F-7



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HILL AND MOUNTAIN GROUPS
MEAN RUNOFF VS. INDEX OF WETNESS

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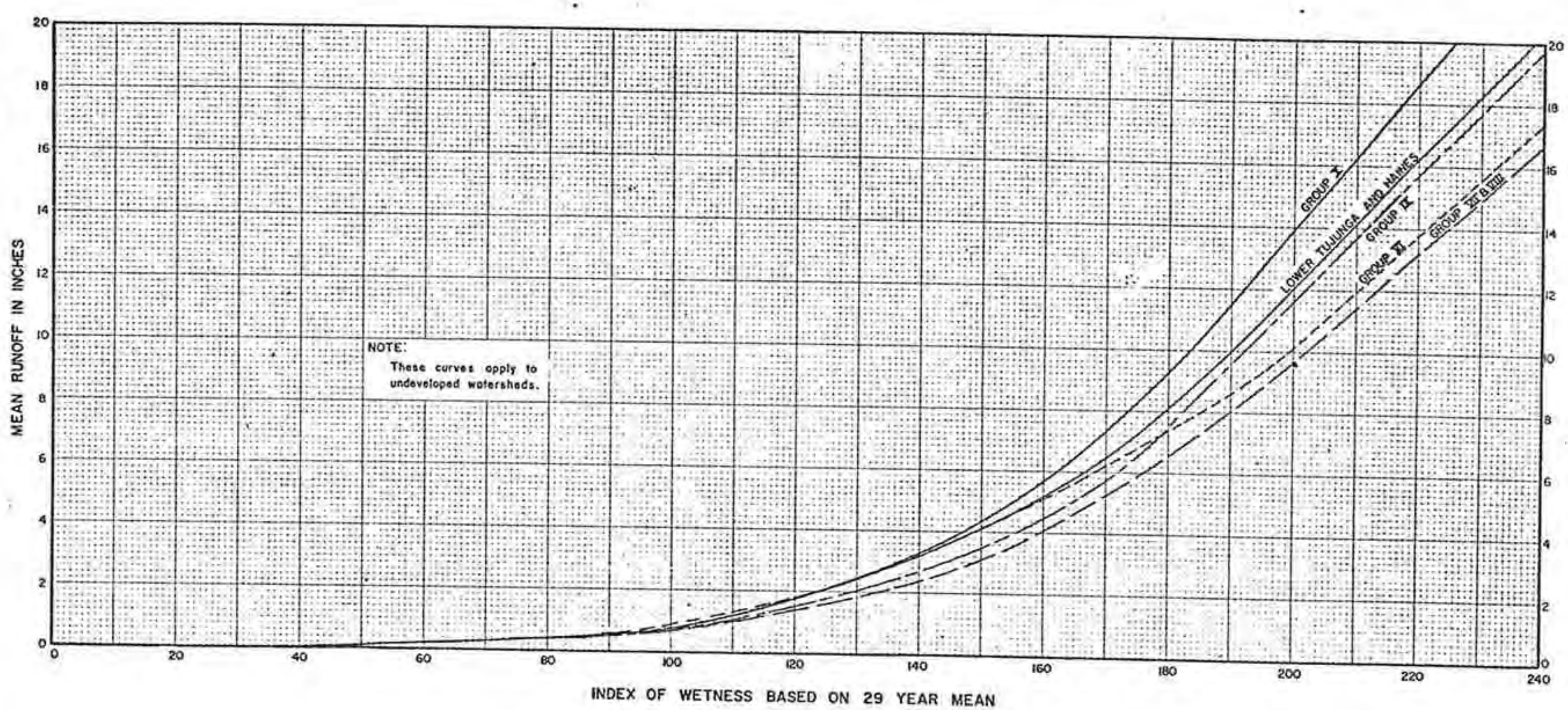
FIGURE F-8



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HILL AND MOUNTAIN GROUPS
MEAN RUNOFF VS. INDEX OF WETNESS

STATE WATER RIGHTS BOARD

further adjusted by trial and error so that the summation of deviations for each watershed during the 29-year base period was equal to zero.

The deviations of Sycamore and Spunky were then converted to percent of 29-year precipitation and averaged to obtain the correction factor to be applied to mean runoff. The correction factor multiplied by the 29-year mean runoff gave the correction in inches to be added or subtracted from the mean runoff to obtain the final runoff value. Table F-6 shows for each year (1928-1958) and for each group, the precipitation, mean runoff and adjusted runoff.

The final unit runoff multiplied by the acreage of each unit resulted in the annual runoff for native conditions as shown in Table F-7.

Additional Runoff Due to Development

As hill and mountain areas become transformed from native culture to residential areas the runoff from these areas will increase with the additional amount of impervious area resulting from this transformation.

The method of determining additional runoff was to compute runoff from impervious areas and then to subtract the runoff previously determined for native conditions. The resulting additional runoff is considered due to drainage conditions to be for the most part carried to the valley floor without opportunity for percolation.

Table F-8 lists the yearly values of items used in the estimation of additional runoff, the method of computation and the amount of additional runoff for the hill and mountain areas.

TABLE F-5

ADJUSTMENT OF MEAN RUNOFF VALUES

Year	Deviation[a] (in inches)				Deviation: In percent of 29-year mean precipitation		
	Tujunga	Pacoima	Sycamore	Spunky	Sycamore	Spunky	Correction factor[b]
1928-29	0.1	-0.2	No Record	No Record	- 1[c]	- 1[c]	- 1
29-30	-0.3	-0.4	No Record	No Record	- 2[c]	- 2[c]	- 2
1930-31	-0.8	-0.6	No Record	No Record	- 3[c]	- 3[c]	- 3
31-32	-0.4	1.6	No Record	No Record	8[c]	8[c]	8
32-33	0.2	0.1	No Record	-0.1	1[c]	- 1	0
33-34	0.6	1.1	No Record	-0.1	5[c]	- 1	2
34-35	-1.8	-1.5	No Record	-1.2	- 7[c]	- 6	- 7
1935-36	0.4	0.9	No Record	-0.2	4[c]	- 1	2
36-37	-1.0	1.8	No Record	-0.5	9[c]	- 3	3
37-38	4.3	3.7	No Record	1.4	18[c]	9	14
38-39	-0.4	-1.3	- 0.4	0	- 2	0	- 1
39-40	0.5	0.3	0.2	0	1	- 1	0
1940-41	-6.5	-5.1	-12.4	-2.6	-63	-16	-39
41-42	0.7	0.1	0.5	0.6	3	4	3
42-43	2.6	3.6	5.2	1.3	27	8	17
43-44	2.3	-1.0	0.8	2.8	4	17	10
44-45	0.8	0.2	0.2	1.5	1	9	5
1945-46	0.5	0.4	0	0.1	0	1	0
46-47	0.3	-0.8	0.1	-0.1	0	- 1	0
47-48	0.2	-0.1	0	-0.1	0	- 1	0
48-49	0.1	-0.1	- 0.2	-0.2	- 1	- 1	- 1
49-50	0	-0.1	- 0.2	-0.3	- 1	- 2	- 1
1950-51	0	-0.1	0.1	0	0	0	0
51-52	-2.5	-1.1	- 1.5	-2.0	- 8	-12	-10
52-53	0.5	0.2	0.3	0.2	2	1	1
53-54	0	0.5	0.1	0.1	0	- 1	0
54-55	-0.1	-0.5	- 0.1	-0.2	0	- 1	0
1955-56	-0.3	-0.5	0.1	-0.3	0	- 2	- 1
56-57	-0.3	-0.4	0.2	-0.2	1	- 1	0
57-58	-2.5	1.3	- 0.6	-4.3	- 3	-26	-14

a. Actual runoff - mean runoff (from Figures F-2 through F-5).
b. Weighted average composed of 1 part Sycamore and 1 part Spunky.
c. Based on deviation of Pacoima and summation of deviations for 29-year base period = 0.

TABLE F-6

PRECIPITATION AND RUNOFF, HILL AND MOUNTAIN GROUPS*

In Inches

Year	I + II Precipitation	I + II Runoff Mean	I + II Runoff Adjusted	III Precipitation	III Runoff Mean	III Runoff Adjusted	IV Precipitation	IV Runoff Mean	IV Runoff Adjusted	V Precipitation	V Runoff Mean	V Runoff Adjusted	VI Precipitation	VI Runoff Mean	VI Runoff Adjusted	VII Precipitation	VII Runoff Mean	VII Runoff Adjusted
1928-29	13.4	0.4	0.2	12.5	0.3	0.1	14.9	0.4	0.2	16.0	0.3	0.1	12.0	0.3	0.1	13.1	0.4	0.2
29-30	[illegible]	0.3	0.0	12.8	0.4	0.1	15.9	0.4	0.0	18.5	0.4	0.0	14.3	0.4	0.0	11.7	0.3	0.0
1930-31	15.9	0.6	0.0	15.3	0.5	0.0	17.8	0.5	0.0	21.4	0.6	0.0	16.9	0.6	0.0	15.4	0.5	0.0
31-32	21.7	1.3	2.7	20.3	1.3	2.7	24.7	2.0	3.6	27.7	2.2	4.0	22.3	1.9	3.3	21.7	1.5	2.9
32-33	13.6	0.4	0.4	11.9	0.3	0.3	13.5	0.3	0.3	17.3	0.4	0.4	14.3	0.4	0.4	14.2	0.4	0.4
33-34	19.5	0.5	0.9	15.1	0.5	0.8	17.3	0.5	0.9	19.0	0.4	1.9	15.1	0.4	0.8	16.2	0.6	1.0
34-35	20.8	1.1	0.0	21.5	1.7	0.5	23.9	1.7	0.3	28.2	2.4	0.8	23.1	2.1	0.8	21.9	1.5	0.3
1935-36	14.4	0.4	0.8	13.8	0.4	0.7	16.5	0.4	0.8	20.3	0.5	1.0	16.3	0.5	0.9	13.1	0.4	0.8
36-37	26.4	2.5	3.2	25.7	3.3	4.0	29.0	3.8	4.6	33.4	4.8	5.7	26.9	3.8	4.5	24.6	2.4	3.1
37-38	28.4	3.3	5.8	25.2	3.1	5.5	28.7	3.7	6.5	35.4	5.7	8.9	29.9	5.4	7.9	26.0	3.0	
38-39	23.0	1.6	1.4	18.0	0.8	0.6	23.1	1.5	1.3	26.9	1.9	1.7	20.2	1.3	1.1	21.4	1.4	1.2
39-40	17.7	0.6	0.5	16.4	0.6	0.6	19.4	0.7	0.7	21.6	0.6	0.6	16.7	0.5	0.5	16.3	0.6	0.6
1940-41	43.9	17.7	10.6	40.0	14.9	8.2	44.8	16.2	8.4	48.0	15.4	6.4	37.0	10.5	3.4	41.0	15.8	9.0
41-42	14.4	0.4	0.9	12.3	0.3	0.8	14.5	0.3	0.9	16.9	0.4	1.1	13.4	0.3	0.8	14.2	0.4	0.9
42-43	26.7	2.6	5.7	25.0	3.0	5.9	29.9	4.2	7.6	34.2	5.1	9.0	27.8	4.3	7.4	26.4	3.1	6.1
43-44	25.9	2.4	4.2	24.4	2.8	4.5	27.3	3.0	5.0	32.1	4.1	6.4	25.7	3.2	5.0	25.0	2.5	4.3
44-45	15.8	0.5	1.4	15.2	0.5	1.4	17.6	0.5	1.5	20.7	0.5	1.7	16.9	0.6	1.5	15.9	0.5	1.4
1945-46	15.1	0.4	0.4	14.2	0.4	0.4	16.7	0.4	0.4	19.3	0.4	0.4	15.5	0.4	0.4	14.6	0.4	0.4
46-47	15.4	0.4	0.4	14.2	0.4	0.4	17.2	0.5	0.5	23.0	0.8	0.8	19.1	1.0	1.0	17.4	0.7	0.7
47-48	8.1	0.1	0.1	7.7	0.1	0.1	9.4	0.1	0.1	10.8	0.1	0.1	8.7	0.1	0.1	8.4	0.1	0.1
48-49	8.9	0.1	0.0	8.6	0.1	0.0	10.7	0.1	0.0	13.3	0.2	0.0	11.0	0.2	0.0	9.4	0.2	0.0
49-50	11.6	0.3	0.1	12.6	0.4	0.2	15.0	0.4	0.2	16.6	0.4	0.2	12.9	0.3	0.1	10.4	0.2	0.0
1950-51	8.8	0.1	0.1	10.3	0.2	0.2	12.6	0.2	0.2	13.9	0.2	0.2	10.8	0.2	0.2	8.7	0.1	0.1
51-52	33.4	7.2	5.4	30.5	5.9	4.2	35.8	7.8	5.8	42.3	10.2	7.9	33.6	7.7	5.9	32.3	7.2	[illegible]
52-53	12.7	0.3	0.5	13.4	0.4	0.6	15.5	0.4	0.6	16.0	0.3	0.5	12.0	0.3	0.5	11.7	0.3	0.5
53-54	14.9	0.4	0.4	15.0	0.5	0.5	16.9	0.4	0.4	18.5	0.4	0.4	14.6	0.4	0.4	13.3	0.4	0.4
54-55	14.7	0.4	0.4	14.6	0.4	0.4	16.3	0.4	0.4	17.2	0.4	0.4	13.2	0.3	0.3	14.1	0.4	0.4
1955-56	18.0	0.7	0.5	18.3	0.9	0.7	22.3	1.3	1.1	22.8	0.8	0.6	16.3	0.5	0.3	15.7	0.5	0.1
56-57	13.1	0.3	0.3	13.8	0.4	0.4	15.8	0.4	0.4	18.0	0.4	0.4	14.4	0.4	0.4	13.8	0.4	0.4
57-58	30.6	4.8	2.3	33.3	8.2	5.8	37.1	8.8	6.1	37.0	6.6	3.4	28.0	4.4	1.8	26.1	3.0	0.5
29-Year Average																		
1929-57	18.1	1.6	1.6	17.2	1.5	1.5	20.1	1.8	1.8	23.1	2.1	2.1	18.3	1.7	1.7	17.5	1.6	1.6

PRECIPITATION AND RUNOFF, HILL AND MOUNTAIN GROUPS*
(continued)

In Inches

Year	VIII - Sycamore Precipitation	VIII - Sycamore Runoff Mean	VIII - Sycamore Runoff Adjusted	IX Precipitation	IX Runoff Mean	IX Runoff Adjusted	X Precipitation	X Runoff Mean	X Runoff Adjusted	Lower Tujunga - Haines Precipitation	Lower Tujunga - Haines Runoff Mean	Lower Tujunga - Haines Runoff Adjusted	Pacoima Precipitation	Pacoima Gage runoff	Big Tujunga Precipitation	Big Tujunga Gage runoff
1928-29	14.7	0.4	0.2	17.1	0.4	0.2	17.7	0.4	0.2	13.7	0.3	0.1	17.0	0.6	16.8	0.7
29-30	12.0	0.3	0.0	13.7	0.3	0.0	15.9	0.3	0.0	14.8	0.4	0.0	19.0	0.6	19.2	0.8
1930-31	15.4	0.5	0.0	18.1	0.5	0.0	19.3	0.4	0.0	16.5	0.4	0.0	20.8	0.6	19.7	0.5
31-32	21.0	1.4	2.8	24.1	1.4	3.0	28.0	1.6	3.5	25.7	2.2	3.9	29.5	0.6	28.7	3.2
32-33	13.6	0.4	0.4	16.2	0.4	0.4	20.5	0.5	0.5	16.6	0.4	0.4	19.8	1.4	18.9	1.3
33-34	19.7	1.1	1.5	22.2	1.0	1.4	21.6	0.6	1.1	16.0	0.4	0.8	19.5	2.3	18.4	1.5
34-35	20.8	1.4	0.2	26.0	1.9	0.5	29.7	2.1	0.5	25.3	2.0	0.6	31.8	3.7	31.9	2.8
1935-36	14.9	0.4	0.8	17.0	0.4	0.8	18.4	0.4	0.9	15.3	0.4	0.8	19.5	2.1	18.1	1.2
36-37	24.0	2.2	2.9	28.7	2.7	3.5	34.6	4.0	4.9	30.0	3.9	4.7	37.8	10.4	37.8	6.6
37-38	26.5	3.2	5.7	31.2	3.8	6.7	37.2	5.3	8.6	32.2	5.1	7.9	44.4	17.2	41.8	14.8
38-39	20.4	1.3	1.1	24.2	1.5	1.3	27.2	1.4	1.2	22.6	1.2	1.0	27.7	2.3	27.1	2.6
39-40	14.9	0.4	0.4	17.0	0.4	0.4	19.6	0.4	0.4	17.1	0.5	0.5	22.3	2.1	20.0	1.9
1940-41	41.6	16.1	9.3	47.9	18.7	10.7	52.7	19.3	10.1	43.0	14.5	6.4	53.4	17.1	52.4	13.9
41-42	12.7	0.3	0.8	15.7	0.4	1.0	17.3	0.3	1.0	14.7	0.4	1.0	19.3	1.3	18.9	1.8
42-43	24.6	2.4	5.4	29.8	3.2	6.7	37.5	5.5	9.5	31.7	4.9	6.3	40.1	13.7	42.3	13.4
43-44	22.4	1.7	3.5	25.6	1.6	3.8	32.7	3.2	5.6	31.5	4.8	6.9	41.3	10.0	38.6	10.3
44-45	15.4	0.5	1.4	18.4	0.5	1.5	20.7	0.5	1.7	19.5	0.6	1.6	25.9	3.2	25.0	3.2
1945-46	14.7	0.4	0.4	16.5	0.4	0.4	21.3	0.5	0.5	18.5	0.5	0.5	24.9	3.1	25.0	2.9
46-47	17.6	0.7	0.7	19.8	0.7	0.7	25.3	1.0	1.0	21.4	0.9	0.9	28.3	2.9	27.4	3.4
47-48	8.4	0.1	0.1	9.8	0.1	0.1	11.3	0.1	0.1	10.2	0.1	0.1	13.9	0.3	14.1	0.7
48-49	9.5	0.2	0.0	10.6	0.1	0.0	14.0	0.2	0.0	12.3	0.2	0.0	15.9	0.5	14.9	0.5
49-50	12.0	0.3	0.1	12.2	0.2	0.0	15.6	0.3	0.1	14.4	0.3	0.1	17.2	0.7	16.0	0.5
1950-51	8.6	0.1	0.1	9.9	0.1	0.1	10.9	0.1	0.1	10.5	0.1	0.1	12.3	0.1	10.4	0.2
51-52	33.3	8.0	6.2	39.6	10.4	8.4	44.2	10.8	8.4	36.6	8.3	6.2	42.9	11.1	41.3	7.5
52-53	10.9	0.2	0.4	14.1	0.3	0.5	14.5	0.2	0.4	11.8	0.2	0.4	14.1	0.6	13.6	0.9
53-54	14.2	0.4	0.4	16.0	0.4	0.4	18.6	0.4	0.4	16.0	0.4	0.4	20.8	2.0	20.5	1.5
54-55	14.1	0.4	0.4	16.3	0.3	0.3	18.5	0.4	0.4	15.9	0.4	0.4	18.0	0.5	17.6	0.7
1955-56	17.0	0.7	0.3	18.6	0.6	0.4	20.7	0.5	0.3	17.7	0.5	0.3	21.1	1.0	16.9	0.8
56-57	13.8	0.4	0.4	15.6	0.4	0.4	18.4	0.4	0.4	15.3	0.4	0.4	17.2	0.4	17.3	0.5
57-58	25.3	2.6	0.1	30.2	3.3	0.4	38.3	6.1	2.8	32.0	5.0	2.1	38.8	10.5	40.5	6.9
29-Year Average																
1929-57	17.5	1.6	1.6	20.4	1.8	1.8	23.6	2.1	2.1	20.2	1.9	1.9	25.4	3.9	24.6	3.5

* Runoff under conditions of native culture.

TABLE F-7

RUNOFF FROM HILL AND MOUNTAIN GROUPS BASED ON NATIVE LAND USE

In Acre-Feet

Year	Tributary to San Fernando and Eagle Rock Subareas								
	I + II	III	IV	VI	VII	VIII + Sycamore	Lower Tujunga + Haines	Big Tujunga	Subtotal
1928-29	430	150	290	20	220	110	190	4,130	5,540
29-30	0	150	0	0	0	0	0	4,350	4,350
1930-31	0	0	0	0	0	0	0	3,070	3,070
31-32	5,780	3,960	5,270	490	3,170	1,550	7,410	17,900	45,530
32-33	860	440	440	60	440	220	760	7,550	10,770
33-34	1,930	1,290	1,320	120	1,090	830	1,520	7,680	15,780
34-35	0	730	440	120	330	110	1,140	14,840	17,710
1935-36	1,710	1,030	1,170	130	870	440	1,520	7,640	14,510
36-37	6,850	5,860	6,740	670	3,390	1,610	8,930	36,260	70,310
37-38	12,410	8,060	9,520	1,180	6,010	3,160	15,010	83,960	139,310
38-39	3,000	880	1,910	160	1,310	610	1,900	13,690	23,450
39-40	1,280	880	1,030	80	660	220	950	10,990	16,090
1940-41	22,680	12,020	12,310	510	9,830	5,160	12,160	78,840	153,510
41-42	1,930	1,170	1,320	120	980	440	1,900	10,690	18,550
42-43	12,200	8,650	11,130	1,100	6,660	3,000	15,770	76,040	134,550
43-44	8,990	6,600	7,330	750	4,700	1,940	13,110	57,990	101,410
44-45	3,000	2,050	2,200	220	1,530	780	3,040	17,370	30,190
1945-46	860	590	590	60	440	220	950	17,160	20,870
46-47	860	590	730	150	760	390	1,710	18,960	24,150
47-48	210	150	150	20	110	60	190	4,640	5,530
48-49	0	0	0	0	0	0	0	2,460	2,460
49-50	210	290	290	20	0	60	190	2,960	4,020
1950-51	210	290	290	30	110	60	190	1,500	2,680
51-52	11,560	6,160	8,500	880	5,900	3,440	11,780	41,320	89,540
52-53	1,070	880	880	80	550	220	760	6,510	10,950
53-54	860	730	590	60	440	220	760	8,240	11,900
54-55	860	590	590	50	440	220	760	3,580	7,090
1955-56	1,070	1,030	1,610	50	110	170	570	4,700	9,310
56-57	640	590	590	60	440	220	760	2,290	5,590
57-58	4,920	8,500	8,940	270	550	60	3,990	39,420	67,550
29-Year Average									
1929-57	3,500	2,270	2,660	250	1,740	880	3,580	19,560	34,440

RUNOFF FROM HILL AND MOUNTAIN GROUPS BASED ON NATIVE LAND USE
(Continued)

In Acre Feet

Year	Tributary to Sylmar Subarea			Tributary to Verdugo Subarea			Hill and mountain total
	V	Pacoima	Subtotal	IX	X	Subtotal	
1928-29	50	880	930	20	120	140	6,610
29-30	0	960	960	0	0	0	5,310
1930-31	0	860	860	0	0	0	3,930
31-32	1,960	8,390	10,350	350	2,050	2,400	58,280
32-33	200	1,790	1,990	50	290	340	13,100
33-34	440	2,530	2,970	160	640	800	19,550
34-35	390	5,140	5,530	60	290	350	23,590
1935-36	490	3,040	3,530	90	530	620	18,660
36-37	2,790	14,530	17,320	410	2,870	3,280	90,910
37-38	4,350	27,250	31,600	780	5,040	5,820	176,730
38-39	830	3,060	3,890	150	700	850	28,200
39-40	290	3,180	3,470	50	230	280	19,840
1940-41	3,130	25,830	28,960	1,240	6,270	7,510	189 980
41-42	540	1,980	2,520	120	590	710	21,780
42-43	4,400	20,390	24,790	780	5,570	6,350	165,690
43-44	3,130	15,490	18,620	440	3,280	3,720	123,750
44-45	830	4,910	5,740	170	1,000	1,170	37,100
1945-46	200	2,890	3,090	50	290	340	24,300
46-47	390	6,020	6,410	80	590	670	31,230
47-48	50	340	390	10	60	70	5,990
48-49	0	740	740	0	0	0	3,200
49-50	100	1,020	1,120	0	60	60	5,200
1950-51	100	70	170	10	60	70	2,920
51-52	3,860	14,360	18,220	970	4,920	5,890	113,650
52-53	250	3,500	3,750	60	230	290	14,990
53-54	200	2,940	3,140	50	230	280	15,320
54-55	200	740	940	40	230	270	8,300
1955-56	290	1,250	1,540	50	180	230	11,080
56-57	200	770	970	50	230	280	6,840
57-58	1,660	15,880	17,540	50	1,640	1,690	86,780
29-Year Average							
1929-57	1,020	6,030	7,050	220	1,260	1,480	42,970

Note: San Fernando Subarea includes Eagle Rock Subarea.

Verdugo Subarea includes the portion of Monk Hill Basin within the Upper Los Angeles River Area.

TABLE F-8

ADDITIONAL RUNOFF FROM HILL AND MOUNTAIN AREAS DUE TO URBANIZATION

Tributary to San Fernando and Eagle Rock Hydrologic Subarea

Year	Precipitation Station 295, in inches (1)	Evaporation[a], in inches (2)	Gross runoff, in inches (3)=(1)-(2)	Native runoff[b], in inches (4)	Additional runoff, in inches (5)=(3)-(4)	Developed area, in acres (6)	Percent impervious (7)	Additional runoff, in acre-feet (5)x(6)x(7)=(8)
1928-29	14.7	5.0	9.7	0.2	9.5	1,500	35	420
29-30	12.0	3.3	8.7	0.0	8.7	1,530	35	390
1930-31	15.4	4.1	11.3	0.0	11.3	1,560	35	510
31-32	21.0	5.2	15.8	2.7	13.1	1,600	35	610
32-33	13.6	2.5	11.1	0.4	10.7	1,630	35	510
33-34	19.8	2.4	17.4	1.2	16.2	1,670	35	810
34-35	20.8	6.4	14.4	0.1	14.3	1,710	35	710
1935-36	14.8	4.4	10.4	0.8	9.6	1,740	35	490
36-37	24.1	5.9	18.2	3.0	15.2	1,780	35	790
37-38	26.5	5.1	21.4	5.7	15.7	1,810	35	830
38-39	20.5	4.4	16.1	1.2	14.9	1,850	35	800
39-40	14.9	4.9	10.0	0.5	9.5	1,890	35	520
1940-41	41.6	6.4	35.2	9.9	25.3	1,930	35	1,420
41-42	12.7	5.9	6.8	0.8	6.0	1,980	35	350
42-43	24.5	4.8	19.7	5.5	14.2	2,040	35	850
43-44	22.5	4.9	17.6	3.8	13.8	2,090	35	840
44-45	15.4	4.6	10.8	1.4	9.4	2,190	35	600
1945-46	14.8	4.4	10.4	0.4	10.0	2,300	40	770
46-47	17.5	5.0	17.0	0.5	16.5	2,440	40	1,340
47-48	8.5	3.4	5.1	0.1	5.0	2,620	40	440
48-49	9.5	4.6	4.9	0.0	4.9	2,830	40	460
49-50	12.0	4.5	7.5	0.1	7.4	3,160	40	780
1950-51	8.6	4.6	4.0	0.1	3.9	3,510	45	510
51-52	33.4	6.9	26.5	5.8	20.7	3,930	45	3,050
52-53	11.0	5.1	5.9	0.4	5.5	4,450	45	920
53-54	14.7	4.0	10.2	0.4	9.8	5,070	45	1,860
54-55	14.2	6.5	7.7	0.4	7.3	5,740	45	1,570
1955-56	17.0	4.8	12.2	0.4	11.8	6,510	50	3,200
56-57	13.8	3.8	10.0	0.3	9.7	7.340	50	2,970
57-58	25.2	6.5	18.7	1.2	17.5	8,330	50	6,070

Tributary to Verdugo Hydrologic Subarea

Year	Precipitation Station 251, in inches (1)	Evaporation[c], in inches (2)	Gross runoff, in inches (3)=(1)-(2)	Native runoff[d], in inches (4)	Additional runoff, in inches (5)=(3)-(4)	Developed area, in acres (6)	Percent impervious (7)	Additional runoff, in acre-feet (5)x(6)x(7)=(8)
1949-50	18.2	5.4	12.8	0.1	12.7	70	40	30
1950-51	11.7	5.8	5.9	0.1	5.8	100	45	20
51-52	41.9	7.4	34.5	8.4	26.1	130	45	130
52-53	13.6	5.4	8.2	0.4	7.8	160	45	50
53-54	22.3	4.7	17.6	0.4	17.2	200	45	130
54-55	17.3	7.2	10.1	0.4	9.7	240	45	90
1955-56	22.0	5.0	17.0	0.3	16.7	270	50	190
56-57	17.6	5.2	12.4	0.4	12.0	330	50	170
57-58	35.9	6.9	29.0	2.8	26.2	380	50	420

Tributary to Total Valley Fill[e]

Year	Runoff, in acre-feet	Year	Runoff, in acre-feet	Year	Runoff, in acre-feet
1928-29	420	1940-41	1,420	1950-51	530
29-30	390	41-42	350	51-52	3,180
		42-43	850	52-53	970
1930-31	510	43-44	840	53-54	1,990
31-32	610	44-45	600	54-55	1,560
32-33	510				
33-34	810	1945-46	770	1955-56	3,390
34-35	710	46-47	1,340	56-57	3,140
		47-48	440	57-58	6,490
1935-36	490	48-49	460		
36-37	790	49-50	810	29-year average 1929-57	1,040
37-38	830				
38-39	800				
39-40	520				

a. Evaporation on impervious areas on valley floor in San Fernando Hydrologic Subarea.
b. Average of groups I + II and VII + Sycamore from Table F-6.
c. Evaporation on impervious areas on valley floor in Verdugo Hydrologic Subarea.
d. Group X, Table F-6.
e. Development of areas tributary to Sylmar Hydrologic Subarea was minor and additional runoff due to urbanization of these areas was nil.

Runoff into Reservoirs

Surface runoff into San Fernando, Chatsworth and Encino Reservoirs becomes a part of the amount of water available for use in the Owens water service area. This additional amount of supply to the reservoirs, computed as described herein, is utilized in the accounting made of Owens River water in Appendix J. The amount of surface runoff attributable to hill and mountain areas is also computed, since this amount of runoff would not be available for percolation in the stream system above Gage F-57.

The areas tributary to each of the three reservoirs are listed in Table F-9.

TABLE F-9

AREAS TRIBUTARY TO SAN FERNANDO, CHATSWORTH AND ENCINO RESERVOIRS

Hydrologic subarea	Reservoir	Hill and mountain group	Tributary area, in acres		Tributary period
			Hill	Valley	
San Fernando	San Fernando	IV	5,311	804	1915-1942
TOTAL - 1915 through 1942			6,115		
Sylmar	San Fernando	V	986	778	1915-1958
San Fernando	Chatsworth	III	1,940	0	1919-1958
San Fernando	Encino	I + II	1,040	0	1921-1958
TOTAL - 1921 through 1958			4,744		

Annual runoff from hill and mountain areas tributary to the reservoirs was computed as runoff per acre for the hill and mountain group in which the area was located times the acreage of the area. Annual amounts of runoff from each hill and mountain group are set forth in Table F-7. This amount was then corrected for any difference between the 85-year mean rainfall for the entire group and for the tributary area by the ratio between the 85-year precipitation on the two areas. The hill and mountain areas tributary to the reservoirs are undeveloped; hence no correction for urbanization is necessary.

Runoff from valley lands was estimated as equal to the residual rain on impervious areas determined as set forth in Appendix L. This amount was corrected for differences between the 85-year mean precipitation of the entire valley fill and of the tributary area in the same manner as hill and mountain runoff described above. Correction factors utilized were: ten percent increase for valley runoff in San Fernando Hydrologic Subarea tributary to San Fernando Reservoir; ten percent decrease in hill and mountain runoff tributary to Chatsworth; and ten percent increase in runoff tributary to Encino Reservoir. Other tributary areas did not require correction. Culture maps shown on Plates 22 through 25 were used to determine the culture on the valley fill areas during the periods involved. The portion of the tributary valley fill in the Sylmar Hydrologic Subarea was found to be ten percent impervious (1928-1958), while the portion in the San Fernando Hydrologic Subarea was five percent impervious (1928-1942).

Percolation of the combined flows of hill and mountain runoff and residual rain on valley fill areas enroute to the reservoirs was estimated as follows:

1. Area of percolation was limited to stream channels plus roadside ditches.

2. Percolation rate during flow was 0.4 inch per hour.[1/]

3. Flow occurred only during days when rain exceeded 0.50 inch.

Estimated areas in which percolation of runoff could take place was approximately six acres in each of the valley fill areas tributary to San Fernando Reservoir. This acreage used with a percolation rate of 0.4 inch per hour was used to determine percolation of runoff, which was then subtracted from total runoff to yield the net surface inflow to reservoirs. The total runoff from hill and mountain and valley fill areas tributary to the reservoirs less the percolation is shown in Table F-10.

The total surface inflow from each tributary area was split into that originating in hill and mountain and in valley fill areas in the same ratio as runoff developed in hill and mountain and in valley fill areas. Surface inflow due to runoff from hill and mountain areas is shown in Table F-11.

1/ United States Department of Agriculture 1955 Year Book of Water, page 157.

TABLE F-10

ESTIMATED TOTAL SURFACE INFLOW
INTO OWENS RIVER SYSTEM RESERVOIRS

In Acre-Feet

Year	San Fernando Hydrologic Subarea Reservoir			Sylmar Hydrologic Subarea	Total
	San Fernando (1)	Chatsworth (2)	Encino (3)	San Fernando Reservoir (4)	(5)
1928-29	60	20	20	0	100
29-30	0	0	0	10	10
1930-31	0	0	0	20	20
31-32	1,530	400	250	370	2,550
32-33	130	40	40	70	280
33-34	400	130	80	120	730
34-35	100	70	0	80	250
1935-36	320	120	80	100	620
36-37	1,990	590	300	550	3,430
37-38	2,840	800	550	880	5,070
38-39	580	90	130	230	1,030
39-40	280	90	60	70	500
1940-41	3,640	1,200	1,000	630	6,470
41-42	370	120	80	80	650
42-43		870	540	910	2,320
43-44		660	400	650	1,710
44-45		210	130	170	510
1945-46		60	40	70	170
46-47		60	40	90	190
47-48		20	10	10	40
48-49		0	0	0	0
49-50		30	10	30	70
1950-51		30	10	10	50
51-52		620	510	810	1,940
52-53		90	50	40	180
53-54		70	40	40	150
54-55		60	40	30	130
1955-56		100	50	90	240
56-57		60	30	10	100
57-58		850	220	360	1,430
29-Year TOTAL 1929-1957	12,240	6,610	4,490	6,170	29,510

TABLE F-11

ESTIMATED SURFACE INFLOW INTO OWENS RIVER SYSTEM RESERVOIRS FROM RUNOFF ORIGINATING IN HILL AND MOUNTAIN AREAS

In Acre-Feet

Year	San Fernando Hydrologic Subarea Reservoir			Sylmar Hydrologic Subarea	Total
	San Fernando	Chatsworth	Encino	San Fernando Reservoir	
1928-29	40	20	20	0	80
29-30	0	0	0	0	0
1930-31	0	0	0	0	0
31-32	1,480	400	250	290	2,420
32-33	100	40	40	30	210
33-34	360	130	80	60	630
34-35	70	70	0	30	170
1935-36	290	120	80	60	550
36-37	1,930	590	300	450	3,270
37-38	2,780	800	550	760	4,890
38-39	520	90	130	130	870
39-40	250	90	60	30	430
1940-41	3,530	1,200	1,000	460	6,190
41-42	340	120	80	60	600
42-43		870	540	770	2,180
43-44		660	400	530	1,590
44-45		210	130	120	460
1945-46		60	40	30	130
46-47		60	40	40	140
47-48		20	10	0	30
48-49		0	0	0	0
49-50		30	10	10	50
1950-51		30	10	0	40
51-52		620	510	650	1,780
52-53		90	50	20	160
53-54		70	40	10	120
54-55		60	40	10	110
1955-56		100	50	40	190
56-57		60	30	0	90
57-58		850	220	240	1,310
29-Year TOTAL 1929-1957	11,690	6,610	4,490	4,590	27,380

APPENDIX G

IMPORT TO UPPER LOS ANGELES RIVER AREA BY
CITY OF LOS ANGELES

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IMPORT TO UPPER LOS ANGELES RIVER AREA BY CITY OF LOS ANGELES

Water Supply of City of Los Angeles Department of Water and Power Los Angeles Aqueduct System

The Los Angeles aqueduct system of the City of Los Angeles Department of Water and Power, the general plan and profile of which is shown on Plate 14, was constructed to utilize the water supply of Owens River and Mono Basin in serving the demands of the City of Los Angeles. Construction on the aqueduct began in 1907 and the first water was delivered to Los Angeles from the Owens Basin in November 1913, but distribution within San Fernando Valley did not begin until May 1915. In 1940 the aqueduct system was extended to include the Mono Basin and since that time aqueduct diversions have been made from both basins. Conditions and capacities stated herein are as of 1959 unless otherwise noted.

Description of Project

Mono Basin is a closed basin east of the Sierra Nevada Mountain Range draining into Mono Lake. Owens Basin is a closed basin draining into Owens Lake and is separated from the Mono Basin by a low flat divide. Diversion of the entire flow of Owens River into the aqueduct during the dry period from about 1920 to 1936 caused the bed of Owens Lake to become almost completely dry. Since that time, except for the period from 1936-37 through 1938-39, the flows into Owens Lake have been small.

The upper part of the aqueduct system starts in Mono Basin at Leevining Creek with a covered conduit to Walker Creek having a capacity of 300 cubic feet per second (cfs), as indicated on Plate 14. Walker Creek may be diverted across or into the conduit. The capacity of the conduit from Walker Creek to Parker Creek is 325 cfs. Parker Creek may also be diverted across or into the conduit. The capacity of the conduit from Parker Creek to Grant Lake is 350 cfs. Rush Creek flows directly into Grant Lake. The storage capacity of Grant Lake Reservoir is 47,525 acre-feet and facilities are provided by which water may be returned to Rush Creek below the reservoir. A covered conduit conveys the diverted water from Grant Lake to the Mono Craters Tunnel through which the Mono Basin water reaches Owens River Basin. The capacity of Mono Craters Tunnel is 365 cfs. Existing municipal water rights under Application 8042, Permit 5555, of the City of Los Angeles to waters in Mono Basin are conditioned so that simultaneous diversions shall not exceed 200 cfs from the four sources consisting of Leevining, Walker, Parker and Rush Creeks.

The City of Los Angeles has no controls on Owens River above Long Valley Reservoir; however, by agreement it is restrained from releasing water through the Mono Craters Tunnel when such release would cause the flow of the Owens River between the outlet of the tunnel and Long Valley Reservoir to exceed 400 cfs.

The capacity of Long Valley Reservoir is 183,465 acre-feet. Water from the reservoir passes through a series of three power plants located in the Owens River Gorge (see Plate 14). The power plants have a capacity of 690 cfs, but when use is made of the spillway and auxiliary outlet the discharge capacity from the reservoir is unlimited. Pleasant Valley Reservoir, located downstream from the power plants, has a storage capacity of 3,885 acre-feet and is used as an afterbay for regulating hydroelectric power peaking flows. Flow from this reservoir is usually steady. From Pleasant Valley Reservoir to Tinemaha Reservoir water is conveyed in the natural river course and there are no flow limitations other than minimum and rate of change restrictions imposed in the interest of fish life. The capacity of Tinemaha Reservoir is 16,405 acre-feet and is used to regulate flow into the Aberdeen intake of the aqueduct by holding valley runoff during shutdown for maintenance and by controlling flood waters. It is not used as a long-term storage reservoir.

The aqueduct below Aberdeen intake, which is situated downstream of Tinemaha Reservoir, is open canal in earth section to the Alabama Hills and concrete lined from there to Haiwee Reservoir (see Plate 14). The maximum capacity in this section is 700 cfs. There are numerous streams intercepted in this area and also several waste gates that are used to dewater the aqueduct for maintenance. Haiwee Reservoir, with a capacity of 58,525 acre-feet, is the lowermost reservoir in the aqueduct system in Owens Valley. Its storage is utilized to equalize flows into the conduit which delivers the water into the City of Los Angeles.

From Haiwee Reservoir to Fairmont Reservoir, which has a storage capacity of 7,507 acre-feet, the aqueduct is covered conduit or pipe section having a maximum capacity approaching 500 cfs. The conduit requires careful operation and maintenance to sustain this capacity. From Fairmont Reservoir to Dry Canyon Reservoir the capacity of the aqueduct is approximately 1,000 cfs. The Fairmont Reservoir outflow is varied to meet power peaking demands at the San Francisquito Power Plants of the City of Los Angeles and reregulated at Dry Canyon Reservoir to the constant rate required by downstream aqueduct capacity. The capacity of Dry Canyon Reservoir is 751 acre-feet. Bouquet Reservoir, with a capacity of 36,505 acre-feet, is on a spur from the aqueduct between Fairmont Reservoir and the San Francisquito Power Plants (see Plate 14). It is used as a reserve supply when the aqueduct between Haiwee Reservoir and Fairmont Reservoir is out of service. Between Dry Canyon Reservoir and San Fernando Reservoir inlet, the latter being the terminus of the aqueduct system, the maximum capacity is 485 cfs. This capacity establishes the maximum rate at which water can be delivered to Los Angeles.

Historical operation of the aqueduct indicates that all sections of the system are shut down approximately seven percent of the time for inspections and repairs. This out-of-service period must be taken into consideration in computing annual capacities.

For a limited period, the City of Los Angeles extracted water from deep wells in Owens Valley to augment its aqueduct supply. These wells were pumped continuously from May 1928 to December 1931 and were last used in January 1935. The record of Owens Valley deep wells includes all pumped and free flowing artesian water from city-owned and operated wells reaching the aqueduct from January 1918 through March 1959. There is no recorded differentiation between pumping and nonpumping periods, but inspection of the available records indicates that during pumping periods the rate of flow is considerably greater than during nonpumping periods. During the pumping periods the total quantity taken into the aqueduct system was approximately 398,000 acre-feet. During years in which there was no pumping, in the period 1918 to 1958, the annual artesian flow from wells reaching the aqueduct varied from 4,848 to 30,880 acre-feet with the average for such years approximating 11,500 acre-feet.

Since the initial aqueduct project was completed in 1913, the following improvements have been added:

Time or period of installation	Description of improvement
October 1928	Tinemaha Reservoir was completed and initial storage of water began in March 1929.
1930-33	Smooth lining was placed in the closed section of the aqueduct below Haiwee to increase the capacity.
April 1934	Bouquet Reservoir placed in service.
December 1940	Mono Basin Extension completed.
April 1941	Storage began in Long Valley Reservoir.
1952	Owens River Gorge power plants completed.
July 1956	Pleasant Valley Reservoir placed in service.

Quantity Diverted and Used

The quantity of water diverted by the City of Los Angeles from the Mono Basin-Owens River system is considered to be the inflow to Haiwee Reservoir, which is the sum of the diversion from the Owens River measured in the vicinity of Cartago at the Cottonwood Power Plant gates plus the

Cartago Station and Haiwee Reservoir. This quantity is also considered as the inflow to Haiwee Reservoir.

Diversion by the city into the aqueduct system, measured as described above for each hydrologic year of the period of record, is shown in column 1 of Table G-1. The annual amounts of water diverted from Mono Basin through the Mono Craters Tunnel are tabulated in column 6 of Table G-2. The amounts of water released from Haiwee Reservoir for delivery to the city ranged from 34,290 acre-feet in 1913-14 to 358,470 acre-feet in 1957-58. The Mono diversion from the Mono Basin into the Owens River system ranged from about 600 to 108,415 acre-feet during the period of its operation from 1934-35 through 1957-58.

Also shown in Table G-1 is the disposition of aqueduct water between Haiwee Reservoir and San Fernando Valley. Haiwee Reservoir outflow prior to July 1931 was measured at Little Lake and subsequent thereto at the Haiwee Reservoir outlet (see Plate 20). There are several unaccountable factors which may cause a difference in values of the Haiwee Reservoir outflow and the City of Los Angeles import shown in Table G-1. These factors are listed as follows:

1. Seepage and evaporation losses from the aqueduct and reservoirs. (The evaporation from Fairmont, Bouquet Canyon and Dry Canyon Reservoirs is approximately 4,800 acre-feet a year).

2. In measuring large quantities of water, the accuracy of a meter may vary by two percent, more or less. These measuring differences have been aggravated at times in the past when the flow into San Fernando Valley was the combination of three measurements.

TABLE G-1

QUANTITIES DIVERTED AND USED BY THE CITY OF LOS ANGELES
FROM OWENS VALLEY AND MONO BASIN

In Acre-Feet

Year	Amounts diverted into Haiwee Reservoir (1)	Outflow from Haiwee Reservoir (2)	Change in storage[a] (3)	Spill into Santa Clara River Basin (4)	Import into Los Angeles (5)	Unaccounted-for water[b] (2)-(3)-(4)-(5)-(6)
1913-14	34,290		- 30			
14-15	44,650		+ 10			
1915-16	66,290		- 60		43,710	
16-17	95,930	81,910	+ 140		68,180	13,590
17-18	194,730	159,840	+ 4,150		129,330	26,360
18-19	194,820	193,840	- 430		176,030	18,240
19-20	211,980	186,990	+ 1,410		202,260	-16,680
1920-21	191,860	169,950	+ 220		187,720	-17,990
21-22	245,310	207,470	+ 160		204,620	2,690
22-23	194,800	203,240	- 1,160		186,110	18,290
23-24	167,790	158,340	+ 1,070		149,660	7,610
24-25	172,790	131,020	- 3,910		127,820	7,110
1925-26	191,360	205,570	+12,310		169,700	23,560
26-27	244,260	204,860	+18,630		173,490	12,740
27-28	220,780	225,730	-26,800		194,710	57,850[c]
28-29	204,760	206,920	+ 1,700		190,100	15,120
29-30	245,550	204,310	+ 30		198,130	6,150
1930-31	245,650	225,900	+ 90		215,750	10,060
31-32	258,200	241,100	- 640		238,200	3,540
32-33	243,800	239,780	- 330		228,430	11,680
33-34	236,920	274,750	+17,810		185,580	21,360
34-35	251,230	231,760	+14,700		194,920	22,140
1935-36	247,680	257,540	- 2,120	2,040	236,940	20,680
36-37	239,250	229,620	+ 1,160	0	206,670	21,790
37-38	283,090	247,670	+ 950	2,910	209,080	34,730
38-39	261,510	293,200	- 6,240	19,860	237,250	42,330
39-40	240,870	244,710	- 860	440	217,160	27,970
1940-41	279,540	243,840	+ 5,669	8,070	200,980	29,130
41-42	293,610	298,560	- 2,700	16,860	246,350	38,050
42-43	297,270	286,070	- 7,020	1,320	264,400	27,370
43-44	307,580	303,760	+ 9,120	1,310	274,500	18,830
44-45	286,210	289,660	+ 330	2,150	267,240	19,940
1945-46	307,060	306,680	- 1,600	10	283,970	24,300
46-47	338,040	329,170	- 950	11,270	291,020	27,830
47-48	326,670	320,480	+ 2,210	0	306,460	11,810
48-49	308,940	311,780	- 2,900	0	298,460	16,220
49-50	316,050	323,180	+ 6,160	0	305,400	11,620
1950-51	356,610	323,400	- 2,410	50	317,370	8,390
51-52	330,690	335,120	- 2,160	3,970	316,570	16,740
52-53	339,950	331,870	+ 3,880	0	320,920	7,070
53-54	322,180	329,600	+ 1,320	0	318,590	9,690
54-55	339,430	331,410	- 1,260	0	316,320	16,350
1955-56	342,730	338,490	+ 660	0	321,260	16,570
56-57	324,330	332,690	- 700	170	318,390	14,830
57-58	358,470	333,850	- 6,220	40	325,390	14,640

a. Summation of Fairmont, Bouquet, Dry Canyon and St. Francis Reservoirs. Plus indicates water into storage and minus water from storage.
b. Unaccounted for water includes seepage and evaporation losses, inaccuracies of measuring devices, operational losses and distribution along the aqueduct.
c. Includes 37,990 acre-feet spilled from St. Francis Reservoir.

TABLE G-2

STREAM RUNOFF TRIBUTARY TO LOS ANGELES AQUEDUCT DIVERSION
WORKS IN MONO BASIN IN EXCESS OF HISTORIC DIVERSIONS

In Acre-Feet

Year	Leevining Creek (1)	Walker Creek (2)	Parker Creek (3)	Rush Creek (4)	Sub-total (5)	Flow through Mono Craters Tunnel[a] (6)	Runoff in excess of diversion from Mono Basin (5)-(6)=(7)
1934-35	50,535	3,709	8,280	59,113	121,637	622[b]	
1935-36	57,048	4,682	7,684	67,453	136,867	2,738	
36-37	51,895	4,909	7,761	56,734	121,299	2,412[c]	
37-38	82,034	8,614	10,919	99,564	201,131	5,568[c]	
38-39	43,665	4,279	7,261	45,567	100,772	7,376[d]	
39-40	62,160	5,053	8,039	53,167	128,419	15,268[e]	
1940-41	65,873	7,480	9,466	79,538	162,357	50,775	111,582
41-42	65,774	6,943	9,882	76,681	159,280	18,395	140,885
42-43	76,329	6,579	8,918	64,570	156,396	23,829	132,567
43-44	46,933	4,358	7,168	47,714	106,173	70,240	35,933
44-45	51,383	6,090	9,100	73,608	140,181	26,286	113,895
1945-46	52,506	5,209	8,627	62,869	129,211	13,853	115,358
46-47	34,124	4,058	6,849	45,890	90,921	25,759	65,162
47-48	37,793	3,630	6,272	46,493	94,188	92,265	1,923
48-49	30,738	3,675	6,593	53,979	94,985	104,443	0
49-50	37,317	3,154	5,750	49,141	95,362	104,598	0
1950-51	53,168	6,117	7,826	48,030	115,141	107,473	7,668
51-52	66,282	6,941	9,978	83,783	166,984	40,521	126,463
52-53	43,789	4,530	6,786	52,433	107,538	75,870	31,668
53-54	25,155	3,506	5,598	38,993	73,252	64,730	8,522
54-55	29,081	3,345	6,079	44,748	83,253	85,259	0
1955-56	56,377	7,663	9,872	83,826	157,738	108,415	49,323
56-57	45,318	4,791	7,391	56,786	114,286	61,908	52,378
57-58	50,790	6,974	10,428	70,362	138,554	32,689	105,865

a. Includes tunnel make varying from 16 to 23 cfs, of which 60 percent originates on the Mono Basin side of the hydrologic divide.
b. June through September only.
c. No record for August, September and October of 1937.
d. Tunnel holed through near the end of April. Mono Basin water could not enter Owens Valley before this time.
e. Tunnel lining completed February 1940. Before completion Owens Valley as well as Mono Basin water was pumped from shaft adits and flowed back into Mono Basin. Computations by the City of Los Angeles have been made to the "Balance Point" which was found to be in February 1940. At this time the accumulated total of Mono Basin water transferred to Owens Valley exceeded the accumulated Owens Valley water pumped into Mono Basin.

3. Varying amounts of water are lost in operational procedures. These losses are small and, with the exception of the water spilled into the Santa Clara Basin, are not measured. An additional unmeasured quantity of water was discharged in the Antelope Valley desert area during the period 1940-46 under a Court injunction to do everything possible to prevent water from reaching the Owens Lake bed. These losses have been kept to a minimum since 1947 when demands have necessitated keeping the aqueduct flow at a maximum.

4. Some water is distributed to customers directly from the aqueduct.

Quantity Available for Diversion and Use

The quantity of water available for diversion and use by the City of Los Angeles was considered to be the sum of the following four quantities:

1. Flow in aqueduct measured at the Cartago Station.

2. Flow into Owens Lake measured in Owens River at the Mt. Whitney Bridge from July 1908 through October 1918 and at the Keeler Bridge from January 1927 throughout the period of study (see Plate 14 for location of stations).

3. Change in storage in Long Valley, Pleasant Valley and Tinemaha Reservoirs. Plus change was added and negative change subtracted.

4. Runoff in Mono Basin in excess of historic diversions by the City of Los Angeles.

It is possible for the City of Los Angeles to divert with its existing works the entire Mono Basin supply from Leevining, Walker, Parker and Rush Creeks, as measured above points of diversion on these streams (see Plate 14). The city owns all of the affected irrigated lands and water rights pertaining thereto, which are situated below the points of diversion. Therefore, the estimated amount of water available for diversion by the City of Los Angeles from Mono Basin in excess of historic diversions was considered to be the combined supply of the four creeks measured as described above minus the amount entering Owens Valley through Mono Craters Tunnel. The measured flow through Mono Craters Tunnel includes a tunnel make varying from 16 to 23 cfs, of which 40 percent is Owens Valley water and has not been separated in this computation. Table G-2 shows the computation and the stream runoff in excess of the city's diversion in Mono Basin. Supply values are shown for the period of record but computations of the amounts available began in 1940 when the tunnel lining was completed and it was placed in service.

Table G-3 indicates the total quantity of water so estimated to be available in the Owens and Mono Basins for diversion by the City of Los Angeles through its aqueduct system.

TABLE G-3

STREAM RUNOFF TRIBUTARY TO LOS ANGELES AQUEDUCT DIVERSION WORKS IN OWENS VALLEY AND MONO BASIN

In Acre-Feet

Year	Diversion into: Haiwee Reservoir (1)	Flow into Owens Lake (2)	Change in storage[a] (3)	Available from Mono Basin (4)	Stream runoff tributary to diversion works (1)+(2)±(3)+(4)=(5)
1913-14	34,290	343,610			377,900
14-15	44,650	227,340			271,990
1915-16	66,290	311,720			378,010
16-17	95,930	236,080			332,010
17-18	194,730	69,140			263,870
18-19	194,820	6,420[b]			201,240
19-20	211,980	c			--
1920-21	191,860	c			--
21-22	245,310	c			--
22-23	194,800	c			--
23-24	167,790	c			--
24-25	172,790	c			--
1925-26	191,360	c			--
26-27	244,260	17,630[d]			261,890
27-28	220,780	10,750			231,530
28-29	204,760	3,110			207,870
29-30	245,550	3,330			248,880
1930-31	245,650	1,920	0		247,570
31-32	258,200	2,580	+ 850		261,630
32-33	243,800	2,450	+ 7,550		253,800
33-34	236,920	2,590	- 8,400		231,110
34-35	251,230	6,190	0		257,420
1935-36	247,680	13,650	+ 1,110		262,440
36-37	239,250	48,250	+ 7,500		295,000
37-38	283,090	221,370	- 4,410		500,050
38-39	261,510	89,280	- 90		350,700
39-40	240,870	4,830	+ 2,250		247,950
1940-41	279,540	7,280	+89,760	111,580	488,160
41-42	293,510	9,440	+12,220	140,890	456,160
42-43	297,270	9,400	+ 8,200	132,570	447,440
43-44	307,580	6,980	-16,410	35,930	333,980
44-45	286,210	6,570	+50,200	113,900	456,880
1945-46	307,060	9,720	- 1,360	115,360	430,780
46-47	338,040	7,200	-72,820	65,160	337,580
47-48	326,670	3,620	+24,310	1,920	356,520
48-49	308,940	4,070	+16,860		329,870
49-50	315,050	3,540	+ 2,470		322,060
1950-51	356,610	3,790	+26,520	7,670	394,590
51-52	330,690	5,400	+32,570	126,460	495,120
52-53	339,950	5,120	-17,210	31,670	359,530
53-54	322,180	3,760	-35,160	8,520	299,300
54-55	339,430	3,670	+ 7,470		350,570
1955-56	342,730	4,090	+56,910	49,320	453,050
56-57	324,330	4,490	-16,430	52,380	364,770
57-58	358,470	4,920	+ 7,320	105,870	476,580

a. Summation of Long Valley, Pleasant Valley and Tinemaha Reservoirs. Plus indicates water into storage and minus water from storage. Lake evaporation was not taken into consideration.
b. Month of October 1918 (station discontinued October 31, 1918).
c. No record.
d. January through September.

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APPENDIX H

WATER QUALITY

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WATER QUALITY

A general water quality evaluation of the Upper Los Angeles River area was made in compliance with Item I, 2, E, of the Order of Reference. The purpose of the study was to ascertain the quality of surface and ground water and effect of import thereon.

Source of Data

All available water analyses were collected from California State Department of Water Resources, Los Angeles County Flood Control District, Department of Engineering of Los Angeles County, the Plaintiff and the defendants. Additional analyses were obtained from various other individuals during the well survey conducted by the Referee. Supplemental analyses were also made by the Referee.

Compilation of Data

Surface water analyses were collected and arranged in stream mile order beginning at the confluence of the Los Angeles River with the Arroyo Seco. The stream mile numbering is shown on Plate 12 and was taken from the Official Stream Mile Maps of the California State Department of Water Resources. The ground water analyses collected were tabulated in numerical order by location number. The well location number system and the location of wells are shown on Plate 18.

Complete analyses utilized generally contained the following determinations: Specific electrical conductance, concentrations of total dissolved solids, hydrogen ion content (pH), calcium, magnesium, sodium, potassium, carbonate, bicarbonate, sulfate, chloride, nitrate, fluoride, boron and total hardness as $CaCO_3$.

Specific electrical conductance measures the ability of water to conduct an electrical current and is a measure of the salts in solution. The standard determination of this value is given as electrical conductance (EC) x 10^6 at 25° centigrade and is expressed as micromhos. Some of the older analyses are stated as EC x 10^5. These values have been increased by a factor of ten to adjust them to the present day standard of EC x 10^6 in the tabulations. When total dissolved solids are not given in an analysis an approximate amount can be calculated by multiplying the EC x 10^6 by 0.62.

Hydrogen ion concentration (pH) shown in the tabulation is that made in the laboratory. Where field and laboratory values were indicated on collected data, only the laboratory values have been utilized although field (pH) may more accurately represent field water conditions.

Bicarbonate values reported in analyses made by the City of Los Angeles Department of Water and Power were in terms of alkalinity as $CaCO_3$. To make the sums of cations and anions more nearly balance the reported values were adjusted to ppm of HCO_3 by dividing the reported value by 50.05, the equivalent weight of $CaCO_3$, and multiplying by 61.02, the equivalent weight of HCO_3.

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Some of the analyses collected and not utilized in the study were in terms of hypothetical combinations in grains per gallon.

Methods of Classifying Waters

The most widely used criteria for determining the suitability of water for domestic and municipal use are the 1946 U. S. Public Health Service Drinking Water Standards[1] (U.S.P.H.S.). The standards have also been adopted by the California State Department of Public Health. Limits for mineral constituents in water are divided into mandatory and recommended criteria and are shown in Table H-1.

Total hardness is a significant factor in the determination of the suitability of a water for domestic and municipal use. Waters containing 100 ppm or less of hardness (as $CaCO_3$) are considered "soft" while those with more than 200 ppm are considered "very hard".

The quality of delivered water has effects on both plant growth and ground water quality. A detailed discussion of water quality effects is contained in California State Department of Water Resources Bulletin 78.[3]

Methemoglobinemia has been related to nitrate in water supply and is a basis for the California State Department of Public Health recommended tentative limit of 10 parts per million nitrate nitrogen (44 ppm NO_3) for safe domestic waters.

TABLE H-1

QUALITY CRITERIA FOR DOMESTIC WATER BASED ON DRINKING WATER STANDARDS, U. S. PUBLIC HEALTH SERVICE, 1946[1]

Mandatory limits:

Lead (Pb)	0.1 ppm
Fluoride (F)	1.5 ppm
Arsenic (As)	0.05 ppm
Selenium (Se)	0.05 ppm
Hexavalent chromium (Cr^{6+})	0.05 ppm

Nonmandatory, but recommended, limits:

Copper (Cu)	3.0 ppm
Iron (Fe) and Manganese (Mn) together	0.3 ppm
Magnesium (Mg)	125 ppm
Zinc (Zn)	15 ppm
Chloride (Cl)	250 ppm
Sulfate (SO_4)	250 ppm
Total dissolved solids (TDS)	
Desirable	500 ppm
Permitted	1,000 ppm

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Ground Water

Thomas and White[4] point out that " ... a basic distinction between meteoric and nonmeteoric waters is suggested by the fact that the hydrologic cycle includes a distillation process of vaporization and precipitation that has no counterpart in the development of nonmeteoric waters except volcanic steam. Thus meteoric water is more likely to be fresh and fresh water is much more likely to be meteoric than nonmeteoric."

Approximately 1,500 ground water analyses which were obtained from various sources and 32 analyses which were made by the Referee have been studied in detail. The chemical character of these waters indicates that they are meteoric in origin; that is, water of the hydrologic cycle which involves evaporation, atmospheric circulation, precipitation, runoff and subsurface movement. None of the analyses indicate any sources of juvenile or magmatic waters that originate deep within the earth, the latter two types being generally recognized by their highly mineralized character. Volcanic waters are distinguished by a higher temperature and by relatively high contents of fluorine, silica, boron, sulfur, carbon dioxide and antimony and by a relatively low content of calcium and magnesium as compared to waters of meteoric origin.

The ground waters occurring in the valley fill of the area of investigation are generally within the recommended limits as set forth in the U. S. Public Health Service Drinking Water Standards, 1946. The principal exceptions are those waters in the vicinity of Calabasas, which are derived from wells that penetrate the Modelo formation, and some wells in the lower part of the Verdugo Hydrologic Subarea. The nitrate content of ground water in the Verdugo Subarea has increased at a rapid rate during recent years. This phenomenon is discussed in detail later in this appendix.

The ground waters of the hydrologic subareas in general would be classed as moderately hard to very hard. The character of the water in the western portion of the San Fernando Hydrologic Subarea is predominantly calcium sulfate while in the eastern portion and in the Verdugo and Sylmar Hydrologic Subareas it is calcium bicarbonate. Plate 15 represents geochemical charts on which the percentage characteristic of waters in various locations in the basin have been plotted. These plots show that all of the natural waters are the calcium, magnesium, sulfate, bicarbonate or "hardness" group. A comparison of the plots for 1932 and 1956-57 indicates that the ground waters have remained in the same hardness group during the 24-year period.

The ground water in the Calabasas area which is pumped from the Modelo formation has total dissolved solids values ranging from 1,000 to 3,242 ppm, magnesium values as high as 150 ppm and sulfate values as high as 1,392 ppm. All of these values exceed the U. S. Public Health Service Drinking Water Standards, 1946, recommended limits.

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Sources of Nitrates in Ground Water

Elemental nitrogen exists throughout nature in combination with other elements. It occurs in very slight quantities in igneous rocks, it constitutes about four-fifths of the atmosphere, and it is an essential constituent of living organisms. These nitrogen sources often form nitrates through bacterial action or when subjected to weathering processes.

In water, nitrogen can occur in several forms depending on its state of oxidation. These forms are listed as follows:[5/]

1. Gaseous nitrogen (N_2), dissolves in water to some extent but has no major significance in water quality.
2. Organic nitrogen (N--).
3. Nitrite (NO_2-) as (N+++).
4. Nitrate (NO_3-) as (N+++++). Nitrogen exists in its highest oxidized and most stable form as nitrate.

An extensive review of available literature establishes that the significant sources of nitrate contributions to ground water are sewage, organic wastes, fertilizer, rainfall and the nitrogen fixation processes. A discussion of sources is presented as follows.

Rain Water

An analysis of rain water at Riverside, California, as published in the Division of Water Resources Office Report on the El Cajon Valley, 1955,[6/] revealed, as shown in Table H-2, a total nitrogen concentration of 0.803 parts per million and a nitrate concentration of 0.388 parts per million. It was also noted that these values may be as low as one-tenth the values reported in other areas, the difference being dependent upon the occurrence of atmospheric electrical discharges.

TABLE H-2

AVERAGE RAINFALL AND AMOUNTS OF VARIOUS NITROGEN FRACTIONS (AS NO_3) IN RAIN WATER, 1933-34[6/]

(At Riverside, California)

Average yearly rainfall, in inches	Constituents in parts per million			
	NH_3	NO_2	NO_3	Total
12.98	0.402	0.013	0.388	0.803

Igneous Rocks

The occurrence of nitrates in igneous rocks was reported by Clarke, 1924[7/] and by Lord Rayleigh, 1939.[8/] According to Lord Rayleigh, igneous rocks contain on an average 0.00463 percent nitrogen. This nitrogen appears to be mainly in chemical combination, perhaps as ammoniacal nitrogen.

TABLE H-3

NITROGEN IN IGNEOUS ROCKS

(After Lord Rayleigh)[8/]

Rock	N-(ml/g)
Dunite, average	0.045
Gabbro	0.037
Granite, average	0.037

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Research conducted by Stevenson, 1959,[9/] revealed that the nitrogen content of granitic rocks is generally lower than the values reported by Rayleigh for igneous rocks as shown in Table H-3.

Several arguments have been set forth in an effort to explain the presence of ammonium salts found in volcanic emanations. Clarke, 1924,[7/] reports that the nitrogen in lava is an original constituent, and not a result of organic origin. Rankama, 1950,[8/] on the other hand, reports that nitrogen in lava may be of secondary origin, formed in the reaction between hot lava and atmospheric nitrogen.

No detailed information is available on the exact manner or mode of occurrence of nitrates found in some magmatic rocks. It is believed doubtful that nitrates occurring in igneous rocks can be of any material significance to the pollution of ground water in the area of investigation.

Sedimentary Rocks

Noble and Mansfield, 1922,[10/] report that in certain desert areas of California, nitrate deposits as sodium nitrate have been found. These deposits occur in caliche layers about five inches thick and are associated with other water soluble salts, primarily sodium in character. Generally the nitrate deposits are associated with shale or clay formations laid down in lakes during Tertiary and Quaternary ages, and occur as a result of physical conditions reflecting climate and soil character rather than from a unique geologic formation or condition.

The sodium nitrate occurring in the caliche deposits found in California, particularly those of the Amargosa region, average less than 2.5 percent of sodium nitrate.

Nitrogen Fixation

Nitrogen fixation is defined as the process by which certain soil bacteria, such as those living symbiotically within the root nodules of various leguminous plants, have the power of bringing free nitrogen into combination. The bacteria in these root nodules first produce proteins which later decompose and ultimately yield nitrates.

Nitrogen fixation is not limited to this special case. Nearly all soils contain bacteria, both aerobic and anaerobic species, which assist in the decomposition or rotting of vegetable and animal matter with the ultimate formation of ammonia. The ammonia is converted to nitrites by nitrosifying bacteria, and then to nitrates by nitrifying bacteria, both of which are found in soils. Both of these steps are actually oxidations of the nitrogen compounds and they occur in connection with the life cycle of the bacteria. An example is farm manure which contains nitrogen as urea ($CO(NH_2)_2$) and proteins. When the manure is spread on soil, bacteria in the air and in the soil act to decompose the manure. The urea is hydrolyzed to ammonium carbonate and the proteins are changed by aerobic bacteria into ammonia. The final result is the development of nitrates.

Fertilizers

Commercial fertilizers used for agricultural purposes have been found responsible for nitrate pollution in several agricultural areas.

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Nitrate concentrations have been reported in the Redlands area in California as high as 160 ppm.[11]

The State Water Pollution Control Board's Publication No. 9[12] reports that commercial fertilizers develop nitrate by percolation through soils with some decrease in total nitrogen and that ammoniacal nitrogen, applied to soils on the surface, appears to be oxidized to nitrite and nitrate while passing through the soil. The report also notes that the passage of nitrogen through soils takes place in two steps. First, the ammonium ion is absorbed on any colloidal matter present, and secondly, if the pH is above 5.0, bacteria operates to oxidize the ammonium ion to nitrate.

Cesspool and Septic Tank Effluent

Nitrate development in septic tanks and cesspools is described as the mineralization of nitrogenous organic matter, or as the final product of the biochemical oxidation of ammonia. The nitrate concentration is generally thought to be low or nonexistent in septic tanks and cesspools because of anaerobic conditions existing in this environment. Nitrates appear to develop under the aerobic conditions existing after the sewage effluent is discharged from the cesspool or septic tank and allowed to percolate through soils, where oxygen is available. (An analysis made of fresh cesspool liquor sampled by the Referee in Verdugo City revealed the complete absence of nitrates).

Studies conducted by the Sanitary Engineering Research Project of the University of California at Lodi, California,[13/] indicate that nitrate accumulation did not begin until a depth of four feet below the bottom of spreading basins filled with sewage effluent.

As a result of nitrification, nitrate concentration increased several hundred percent during the percolation through 13 feet of alluvial materials. The nitrogen available in the form of ammonia and nitrites plus the presence of oxygen would lead to conditions favorable to the biological oxidation of reduced forms of nitrogen. Nitrites present on the surface rapidly disappeared with depth, this being consistent with the appearance of nitrates.

According to data presented in the State Water Pollution Control Board Publication No. 9,[12/] the average nitrate concentration of sewage in sewer mains attributable to domestic use of water is 20 to 40 parts per million total nitrogen or 88 to 176 parts per million nitrate.

Synthetic Detergents in Ground Water

Synthetic detergents have largely taken the place of soap as the household cleaner since their advent on the market after World War II. In 1948, syndets represented only 16 percent of the total annual soap and detergent sales; however, in 1957 syndets represented over two-thirds of the total sales and comprise approximately 75 percent or more of the sales today. This wholesale use of syndets in homes today has introduced a new product into sewage effluent. Unlike soap, surface active agents utilized in synthetic detergents are biologically resistant organic material.

The normal wash day synthetic detergent[14] is generally a heavily built synthetic powder and usually consists of 20 to 22 percent of surface active matter compound with about 35 to 40 percent phosphates, mainly sodium tripolyphosphate; up to 10 percent silicates; 5 percent of sodium perborate; 1 to 2 percent of sodium carboxymethylcellulose; and the remainder of various other compounds, including foam stabilizers, corrosion inhibitors, etc.

Of the basic synthetic detergents available commercially, approximately 80 percent of the total volume marketed utilized the sulphonate type surface active agent, more specifically alkyl benezene sulfonates (ABS). Most of the ABS are derived from propylene. They are inexpensive and possess excellent deterging properties making them popular in household detergent formulas.

BOD studies conducted on polypropylene benezene sulphonates by Sawyer and Ryckman, 1957,[15] show them to be extremely resistant to biological attack.

Water pollution problems related to ABS have been found responsible for foaming, taste, and odor at about one part per million. Cohen, 1959,[16] reports that as little as 0.8 parts per million syndets will foam water and that colorimetric procedures have proved to be the most valuable method for determining the microquantities of ABS concentrations in water. In most analytical procedures for ABS, methylene blue is added to a water sample and compared to a previously calibrated concentration with a spectrophotometer.

The basic weakness with this colorimetric method is low specificity. Naturally occurring materials also react to the dyes, which can lead to erroneously high results. Certain organic sulfates, sulfonates, carboxylates, phosphates and phenols react to methylene blue. Inorganic compounds, such as cyanates, nitrates, thiosulfates and thiocyanates, also interfere with this method; however, these interferences have not proved too inconvenient since the concentration of interfering substances is generally low. To make ABS values comparable with other reported values, a standard reference surfactant material is made available by the Association of American Soap and Glycerine Producers.

A longer, more complex infrared method for determining ABS concentrations has been developed; however, no laboratories in this area are equipped to handle this type of analysis.

All available evidence points out the fact that synthetic detergents in water originate only in sewage, and their presence in well water definitely establishes contamination by sewage discharge.

In addition to the contamination problems related to ABS, the large percentage of phosphates used in household synthetic detergents may afford a medium for bacterial survival in ground water and their presence in ground water should be considered.

What overall relationship, if any, synthetic detergents have with nitrates is not known; however, their introduction to the domestic household coincides with the advent of increasing nitrate ion concentrations in the study area.

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Interpretation of Analyses

The tabulated data were utilized in several methods of interpreting changes in water quality. These methods included line graphs, trilinear geochemical charts, and isoplethic (lines of equal value) maps.

Isochlors (variety of isoplethic) were drawn for two separated periods, namely 1931-32 and 1951-53. These periods were selected as having the best general basin-wide coverage. The results did not show any conclusive change in chloride concentrations.

The historic presence of the boron ion was investigated since relatively high boron waters were imported from the Owens Valley for a period of time during 1932. At that time there was concern that these waters, in which the boron content reached a reported maximum of 1.44 ppm, might have adversely affected sensitive crops in the area of use.

The relative presence of boron was gaged by utilizing the boron factor (boron in ppm/EC x 10^3). This factor was conceived by J. S. Logan of the United States Bureau of Reclamation in studies in the southern part of the San Joaquin Valley and was employed as a tool to separate waters from different sources. The following is a tabulation of various boron factors from diverse sources as compiled by Logan:

Source	Boron Factor, Fb
Ocean water	0.09
Major San Joaquin streams	1.30
Petroleum brines (average)	1.30
Petroleum brines (maximum)	3.90
Sulphur Bank Hot Springs	62.00
Highest boron in water well in Arvin area	6.73

Maps showing lines of equal boron factors were prepared for 1931-32 and 1951-53. The boron factors in the 1931-32 period varied from 0.03 to 1.62 and averaged 0.41. Variation for the 1951-53 period was from 0.008 to 1.61 with an average of 0.33. A comparison of the two periods indicated no pattern of increase or decrease and no appreciable change in the boron content of the ground water.

The ground waters of the western portion of the San Fernando Hydrologic Subarea are predominately sulfate type, while those in the eastern portion are bicarbonate type. In an attempt to delineate the areas of the two types of water, an isoplethic map of sulfate-bicarbonate ratios was prepared. The ratio is expressed as:

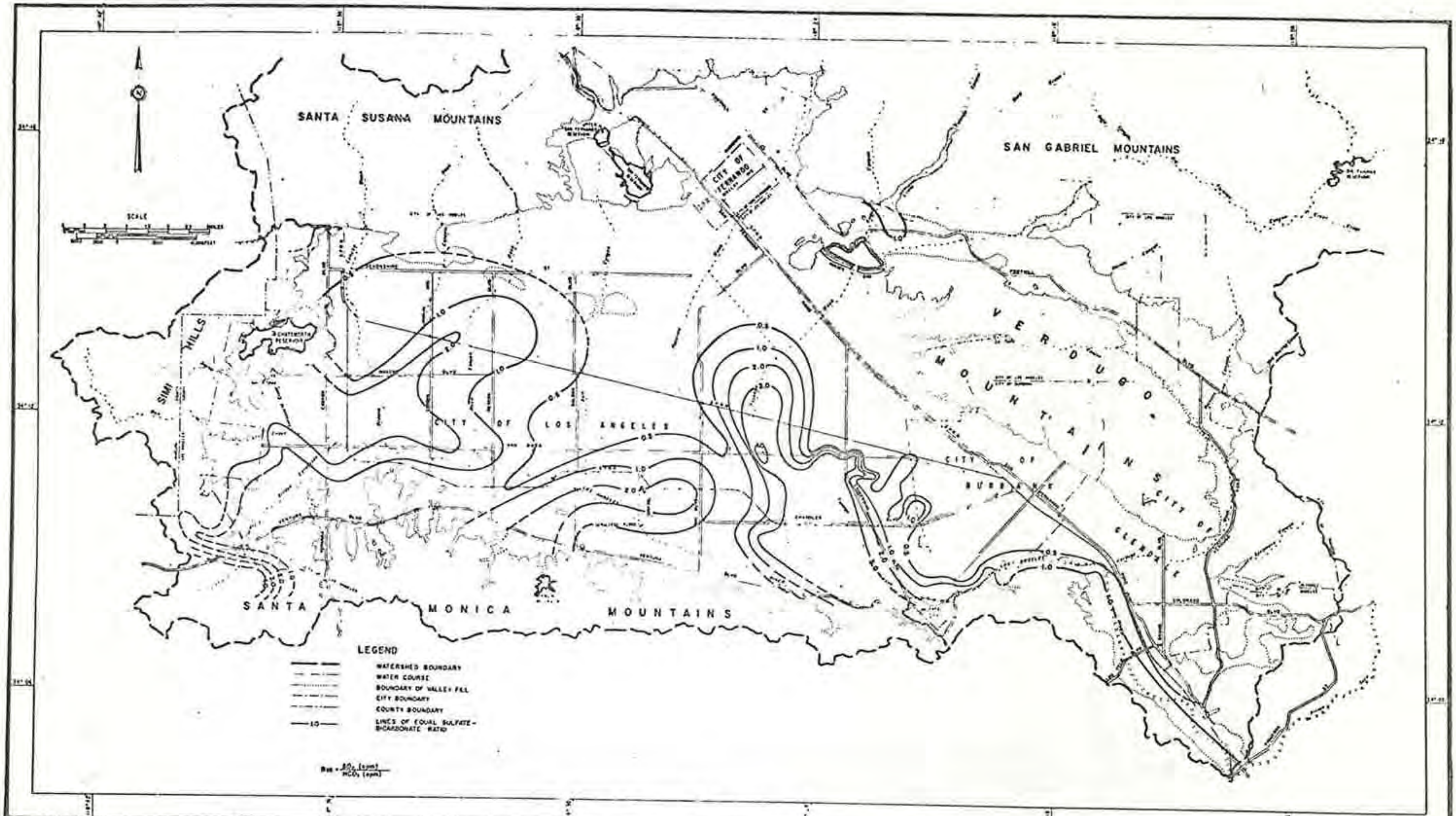
$$R_{sb} = \frac{SO_4 \text{ (epm)}}{HCO_3 \text{ (epm)}}$$

A value of one would be obtained when the constituents were equal. Numbers greater than one indicate a greater amount of sulfate present in the water, while numbers less than one indicate a dominance of bicarbonate.

The computed ratios were plotted in their proper location on a map and lines of equal sulfate-bicarbonate ratio (R_{sb}) were drawn as shown on Figure H-1. This study indicated that the distribution of the two mentioned types is much more complex than originally assumed.

Graphs, plotting parts per million versus years, were made of wells with records of analyses for a period of years at selected locations throughout the area of investigation. These graphs (Plates 17-A, 17-B, 17-C, 17-D) show the variation in total dissolved solids (TDS), sulfate (SO_4), chloride (Cl) and in some instances where records were available, nitrate (NO_3).

The constituents plotted were selected as being those important in domestic and municipal water systems. The graphs indicate that in general there has been no substantial change in ground water quality other than would normally occur due to return of irrigation water. An exception to this is found in the Verdugo Hydrologic Subarea where large increases in nitrate concentrations have taken place. This problem is discussed in detail in the following section. In other portions of the area of investigation analyses of ground waters indicate that some wells have abnormal concentrations of nitrate. Wells with nitrate concentrations of 20 ppm or greater are listed in Table H-4.



SAN FERNANDO VALLEY REFERENCE

LINES OF EQUAL SULFATE — BICARBONATE RATIO

GROUND WATER QUALITY

STATE WATER RIGHTS BOARD

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TABLE H-4

NITRATE ION CONCENTRATIONS OF WELLS, SAN FERNANDO AND SYLMAR HYDROLOGIC SUBAREAS

Well number	Nitrate concentration ppm	Date sampled
3566	30.4	8-15-54
3701B	20	10- 8-57
3785A	37	7-31-57
3790	20	6-11-58
3790D	20	6-11-58
3832J	41	7-26-57
3833F	35	9-24-57
3845A	30.8	2- 8-52
3845F	32.4	7- 2-56
3934	23	12- 4-56
3947A	62	7-11-56
3947B	44	7-11-60
3949B	20	4- 9-58
3954	32	1-15-60
3958C	34	5- 6-60
3987A	31	1-29-60
3987B	35	1-29-60
3987C	23	5- 5-60
3987D	21	2-10-60
3987E	23	2-10-60
3987F	35	1-29-60
4694	34.4	7-31-58
4735B	22	12- 4-56
4735C	24	5-27-54
4896A	30	6-12-57
4973J	93	6-27-58
4983F	28.5	9-15-53
5988A	34	7-24-57

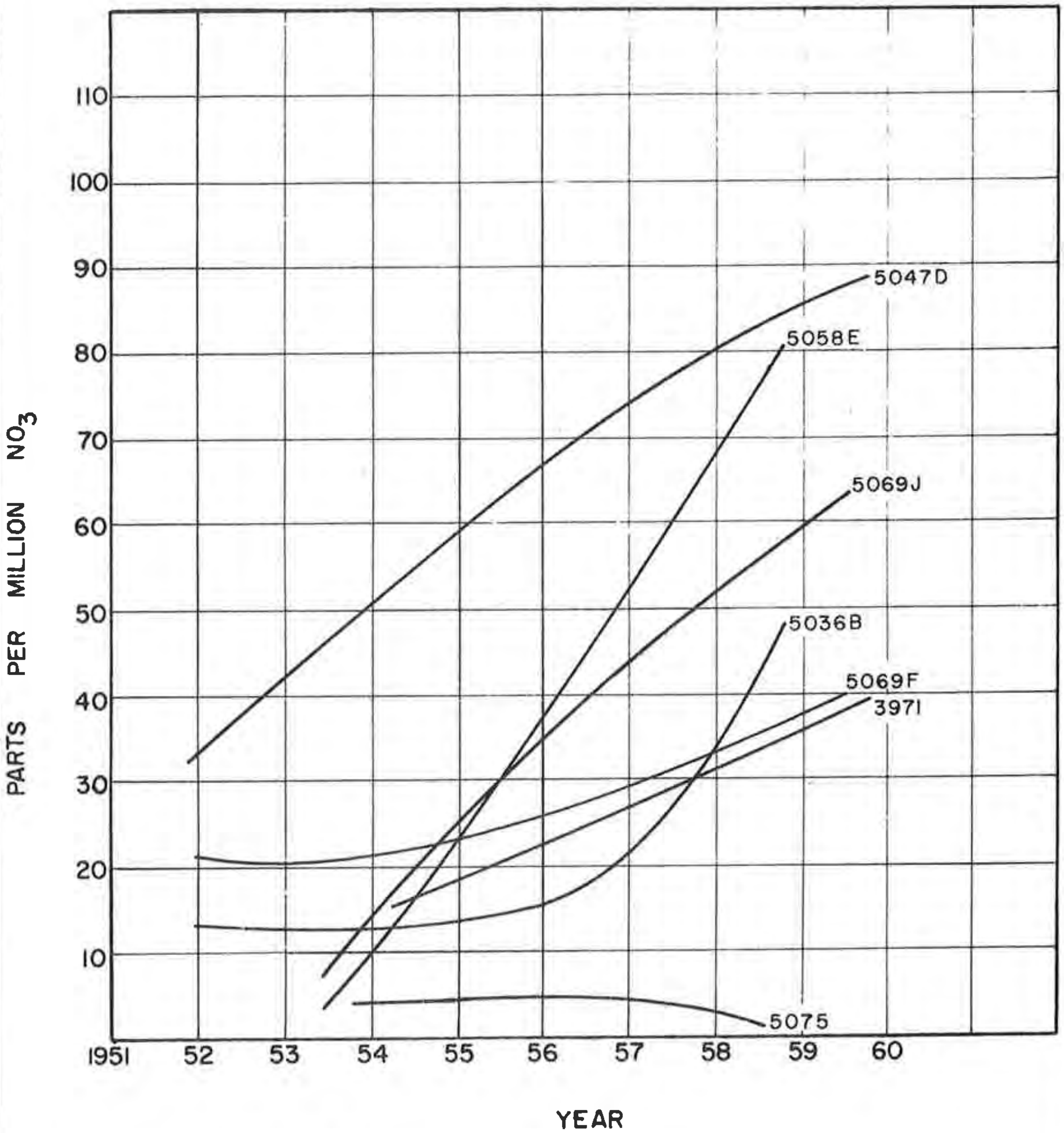
Occurrence of Nitrates in the Verdugo Hydrologic Subarea

The analyses used in this study were made by various laboratories. The methods and laboratory techniques used by these laboratories vary considerably. The Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio, reports in the 1958 "Analytical Reference Service" that the "phenoldisulfonic acid method", used by most laboratories, gives results that are almost uniformly low and that this method does not give reliable results for most operators. Statistical data presented indicate that the results of the PDA method may vary as much as 27.81 percent from the actual value. Hem,[5] reports that the "phenoldisulfonic acid method" is best adapted for nitrate concentrations under 30 ppm, although the procedure may give rather tenuous results. For values over 30 ppm the method is inaccurate. All of the analyses available to the Referee are by the PDA method or an earlier method of similar reliability.

The nitrate ion concentrations of wells having nitrate records in the Verdugo Hydrologic Subarea have been plotted for the period 1951-52 to 1958-59 on Figure H-2 on the following page. The plots indicate sharp increases in nitrates except for well 5075, which is in the upper portion of the subarea. Since the increases in nitrates are recent they cannot be of natural causes and must therefore be due to:

1. Fertilizers applied to lawns, gardens and golf courses.

2. Oxidized cesspool and septic tank effluent.



SAN FERNANDO VALLEY REFERENCE
VERDUGO HYDROLOGIC SUBAREA
NITRATE ION INCREASE IN SELECTED WELLS

STATE WATER RIGHTS BOARD

Fertilizer as a Source of Nitrate

A general reconnaissance of the study area revealed that commercial fertilizers are being used to some extent on small private lawns and gardens and very extensively on the Oakmont Country Club turf and golf greens. The quantity of fertilizer used on private lawns and gardens is very small and no abnormal fertilizing practice was obvious in any of the residential areas.

At the Country Club, a direct relationship between fertilizers and ground water might exist. This area is sewered and serviced by Glendale Public Services. Well water pumped by the City of Glendale from well No. 3971 reflects a present nitrate concentration of 40 ppm. An irrigated turf of 110 acres located 1,500 feet upstream is fertilized with 20 tons of a 20 percent ammonia fertilizer three times per year. An additional acre and a half is treated with sulfate of ammonia, a 21 percent nitrogen fertilizer, every two weeks.

An average of about 30.5 acre-feet per month of water is applied to the golf course and greens. This figure represents about 0.25 acre-foot per acre per month.

The nitrates developed in soils through nitrogen fixation and fertilization are available to vegetation for consumption and/or reduction to nitrogen by denitrifying bacteria and released to the atmosphere, or they may be leached from the soil by irrigation water and rainfall percolating to ground water.

The amount of nitrates leached from a soil is governed by the soil-type method of fertilization, cropping practice, climate and the amount of applied water and rainfall. A review of the preceding practices suggests that sufficient nitrates are developed on the golf course to effectively contribute some nitrates to the ground water of the study area. However, sufficient water is applied through irrigation and rainfall to continually leach applied concentrations of nitrates on the ground surface and in the root zone, thereby eliminating the possibility of any very concentrated slugs reaching the water table.

Sewage as a Source of Nitrate

The portion of the Verdugo Hydrologic Subarea discharging sewage into cesspools and septic tanks was occupied by approximately 35,800 persons in 1951 and 55,300 persons in 1958.

Average nitrate concentration attributable to the domestic use of water in the study area may reach 88 to 176 parts per million.[11/] Thus, if the disposal of effluent from domestic sewage through septic tanks and cesspools constitutes a continuing major source of ground water recharge, the ground water concentration will be influenced accordingly.

A study was made to determine the relationship between pumped water and cesspool effluent within a 500-foot radius (estimated average cone at depression of a pumping well) of six wells in the Verdugo Hydrologic Subarea. A house count was made on large-scale aerial photographs within the established radius and the cesspool effluent determined on the basis of 3.7 persons per dwelling. These results were compared to the pumpage of the respective well and indicated that from four to eight percent of the water pumped could be cesspool effluent falling within the assumed cone of depression around each well. What effect this volume of effluent has on the nitrate concentration in water produced in the various wells is not known exactly; however, it does suggest that cesspool effluent with a nitrate concentration in the range previously indicated may have an appreciable influence on concentration of nitrates in this water supply.

Noting the location of the high nitrate wells it is seen that these wells are situated parallel to Verdugo Wash. Topographically, and by an inspection of Plate 6, Base of Water-Bearing Series, it becomes apparent that these wells are situated so as to effectively intercept a portion of the subsurface drainage of the upper portion of the subarea. This area is coincident with the unsewered portion of the study area. Further, the area immediately around the high nitrate wells is served by the high nitrate waters pumped from these same wells.

From the preceding it is concluded that the high nitrate ion concentrations found in the Crescenta Valley County Water District wells are definitely related to the physiography and this explains the absence or very small nitrate ion concentration in wells 5076 and 5077B, located upstream.

The review of chemical analyses of well waters in the study area also revealed an increase in chloride ion, a general decrease in pH, and a recent occurrence of synthetic detergents.

The chloride increase supports the conclusions that the nitrate pollution is originating from sewage effluent or re-use. Analysis of well No. 5058E shows a chloride concentration of 11 ppm in 1949 and 33 ppm in 1958. The nitrate concentration for this same well was 15 ppm in 1949 and 81 ppm in 1958. The decrease in pH would be expected as a result of the increase in acid salts, e.g. nitrate and chloride. A brief study on this point indicates that considerably more salts are being deposited in the subarea since 1950 than are being exported. This situation also corresponds to the rapid increase in nitrate ion concentration in the subarea.

Traces of synthetic detergents detected in all of the wells in the study area appear to establish sewage effluent as the source of nitrate pollution. A recent analysis of water from well No. 5047D noted a concentration of 0.37 parts per million synthetic detergent determined as alkyl benzene sulphonate. Most of the other wells in the study area, particularly those with high nitrate concentrations, also have concentrations of syndets.

Conclusions

Research and investigation by the Referee leads to the following conclusions regarding the Verdugo Hydrologic Subarea:

1. Nitrate concentrations occurring in the native ground waters of the Verdugo Hydrologic Subarea prior to 1950 were substantially below the California Department of Public Health recommended limit.

2. A review of existing well logs and geology indicates that nitrate yielding rocks or formations do not occur in significant quantity anywhere in the subarea.

3. The abnormal increase of nitrate ion concentrations in the ground water of the subarea is coincident with the postwar residential development of the subarea.

4. High nitrate concentrations in the well waters of the subarea are coincident with the topographic lows in the subarea.

5. The present high nitrate ion concentrations appear to be a result of cesspool effluent and the recirculation of high nitrate well water pumped within the subarea. These conclusions are corroborated by the coincident increase in chloride concentration and existence of synthetic detergents in the well waters.

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APPENDIX I

HISTORY OF DEVELOPMENT OF WATER SOURCES BY PARTIES, METHODS OF DETERMINING CAPACITY OF DIVERSION WORKS AND METHODS OF ESTIMATING AND MEASURING EXTRACTIONS AND DIVERSIONS

APPENDIX I

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TABLES

APPENDIX I

HISTORY OF DEVELOPMENT OF WATER SOURCES BY PARTIES,* METHODS OF DETERMINING CAPACITY OF DIVERSION WORKS AND METHODS OF ESTIMATING AND MEASURING EXTRACTIONS AND DIVERSIONS

The information contained herein was obtained primarily by interviewing representatives of the various parties and together with the basic data sections form the basis for the tables in Chapter V, which list the capacity, extractions and diversions of diversion works and joint interest in sources of the parties.

Method of Determining Capacity of Diversion Works

The capacity of the diversion works has been interpreted to be the maximum rate of extraction or diversion for each entity. Whenever possible these values were determined from actual tests made by the representatives of the Board, or if recent tests had been made by other persons who in the opinion of the Board staff were qualified to perform such tests, the data were accepted.

The production rates of most of the entities, whose annual extractions amounted to 100 acre-feet or more, were measured by the Board staff in 1959. Due to pecularities of a few systems which extract over 100 acre-feet, the capacity of these systems could not be measured without undue hardship or damage to the system.

* Plaintiff and all defendants named in the Amended Complaint and in subsequent actions prior to July 1, 1960.

In measuring the production rate of a system an attempt was made to perform the test under the same conditions under which that system would normally operate. Two basic methods were utilized to measure the production rate of a system.

The principal method used was measurement with a Simplex or Cox pitot tube and manometer. Measurements made with these instruments were in accordance with the operational manual supplied by the manufacturer. The second method utilized was by noting the time required to fill a known volume.

Due to the complexity and operational difficulties involved, the pumping capacity of the City of Los Angeles in the Upper Los Angeles River area could not be measured directly and was taken at its rated capacity of 350 cubic feet per second. To check the rated capacity, the maximum monthly extraction of each of the City of Los Angeles' well fields during the period 1954-55 through 1957-58 was obtained. The sum of these monthly maximum amounts was 280 cubic feet per second.

For small plants, estimates were based on the owner's statement of the production rate or the manufacturer's rated capacity for the pump.

Methods of Estimating and Measuring Extractions and Diversions

Where actual records of the volume of water extracted or diverted were not available, estimates were made based on average duties, hours of pump operation, power consumption, water sales or plant production, depending upon the particular data available. In many cases more than one method was utilized for the same party in accordance with information available for the respective period of time.

Metered Extractions and Diversions

A number of entities measure their water extractions and diversions directly. Where the amount has been metered with a reliable device, the measured quantities were considered to be the best information available and those records have been used.

Production Rate and Hours of Operation

An estimate of the amounts diverted by certain entities was made by using the production rate of the system determined by representatives of the Board and the number of hours of operation. The hours of operation were obtained from logs maintained by the plant operator. If logs were not available, the number of hours of operation of the plant was obtained from the plant operator.

In cases where estimated amounts diverted, computed by duty of water and by production rate, gave widely differing results, the amount based on duty of water was considered more reliable.

Duty of Water

Frequently, when the only data available were type of use, area of crop irrigated, number of units served, and number of people or livestock served, an estimate of the amount extracted or diverted was based on the average values of duty of water for each use. Duty figures applicable to San Fernando Valley conditions have been developed from a study of local water use by the Board staff, in conjunction with the collection of data from the parties. These values were utilized in estimating the amount extracted or diverted by the parties. The average values of duty of water utilized are shown in Table I-1.

TABLE I-1

AVERAGE VALUES OF DUTY OF WATER

Use	Duty
Alfalfa	3.5 acre-feet per acre
Berries	4.5 acre-feet per acre
Citrus	2.8 acre-feet per acre
Permanent pasture	4.5 acre-feet per acre
Truck	2.8 acre-feet per acre
Vineyard	1.0 acre-feet per acre
Hay and barley	0.8 acre-feet per acre
Nursery	2.8 acre-feet per acre
Per capita (inside use only)	50 gallons per day
Dairy cows	30 gallons per day per head
Poultry	0.25 gallons per day per head
Range cattle and horses	15 gallons per day per head
Hosing out dairy barn	35 gallons per day per head

The type of use was determined from data obtained from the parties or from the culture data noted in Appendix K.

The average values listed in Table I-1 were used when no other data were available. In many instances, when the amount of water diverted by a party was determined for a short period from measurements of production rate and hours of operation, a duty of water was computed for this period. This value was then applied to those years when only the size of the service area or the number of units served was known.

Power Consumption

The electrical power supplied to a well was used to compute the production of a well for a few entities. This method was possible only when the power meter readings and billings were made specifically for the well. Based on the records, the amount of water extracted per kilowatt hour was computed from pump tests made by the power company or the Board staff.

Estimates of the production of a well prior to its being abandoned were made where power records were available by assuming a plant efficiency and pumping head. The make, type of pump and operating conditions were obtained from the owner or plant operator. The plant efficiency was then estimated by the Board staff, based on a comparison with similar plants of known efficiency.

History of Use and Development of Water

Plaintiff - City of Los Angeles

The Pueblo of Los Angeles was established on the west bank of Porciuncula River now known as the Los Angeles River in 1781. The first water system was a brush "toma" or dam across the river which diverted water into the "Zanja Madre" or mother ditch, and other open canals delivering water to irrigated fields. The water system was a gravity system with the dam being located at a place on the river upstream from the town.

On April 4, 1850, the Pueblo of Los Angeles was incorporated as the City of Los Angeles (see Plate 36). The primitive water system which had changed very little since its conception was inherited by the city. In 1854, a water department was established in the city and the water system was placed in charge of a "zanjero" or water overseer. Various improvements to the water system were initiated including the construction of reservoirs, water wheels and distribution mains.

From 1865 through 1867 the domestic water works were leased to private individuals for the distribution of water. In 1868, the city entered into a 30-year lease with four individuals to manage the distribution of water in the city. Additional water supply to the city was developed in 1886 when water was diverted from the river at Crystal Springs and conveyed to Buena Vista Reservoir.

In 1902, following expiration of the 30-year lease and negotiation for the purchase of the Los Angeles City Water Company, the City of Los Angeles acquired title to all properties of the company and affiliate corporations. At this time the city's water supply was obtained from a ditch which diverted the surface water of the Los Angeles River located near the present Headworks Spreading Grounds, and infiltration galleries located above the present Los Feliz Boulevard. The infiltration galleries were used for domestic supply while the water diverted by the ditch was used for irrigation. By this time the city had grown to an area of 43.26 square miles with a population of greater than 100,000 persons.

In 1903, the Zanja system which had been in operation for 123 years was officially discontinued. Between 1903 and 1915 additional wells were drilled in and above the Los Angeles Narrows and in the southern portion of the city at the Slauson Avenue property near Compton Avenue. Additional infiltration gallery capacity was also provided.

During the years 1911, 1912 and 1913, nineteen private water systems were acquired. From 1910 to 1940 the city acquired 198 private systems. Small portions of some of these private systems were outside the city and its annexations and required the city to serve water outside its boundaries.

In 1906 the Reclamation Service of the United States Government abandoned its Owens Valley Project in favor of the city. This cleared the way for Los Angeles to obtain rights of way and control of surface waters in the Owens Valley. Work first started on the Los Angeles Aqueduct at the south portal of the Elizabeth Lake Tunnel on September 20, 1907.

The first Los Angeles Aqueduct water reached the San Fernando Valley on November 5, 1913. By June 30, 1914, the aqueduct was delivering between 18 and 20 second-feet directly into the distribution mains in the area south of the Santa Monica mountains; however, it was 1915 before delivery of water for irrigation within the valley was started. With the completion of Lower San Fernando Reservoir and Franklin Reservoir, service was extended through the San Fernando Valley by means of the 72-inch City Trunk to Franklin Reservoir in April 1915. The area south of the Santa Monica Mountains was then served Owens Valley water from Franklin Reservoir.

Completion of the Chatsworth High Line in 1916 provided a supply for the northwest portion of the Owens service area. In 1917, the Maclay High Line and Reservoir extended the service area of Owens Valley water to the northeast portion of the Owens service area in the San Fernando Valley. Chatsworth Reservoir was completed in 1919 to provide storage. Encino Reservoir was added to provide annual regulation in 1921. Stone Canyon Reservoir and Lower Hollywood Reservoir, completed in 1921 and 1924, respectively, provided regulating storage for the area south of the Santa Monica Mountains.

During the fiscal year 1925, a total of fourteen 20-inch wells called the North Hollywood Wells were drilled in the vicinity of Vanowen Street from Fulton Avenue to Foster Avenue. In 1930, the North Hollywood Wells were first pumped into Hollywood Reservoir. A 51-inch pipeline was added to the system from the North Hollywood Pumping Plant to Hollywood Reservoir in 1931 to convey both ground water and Owens Valley water.

To further develop ground water resources in the San Fernando Valley, the River Supply Conduit (1944) and Extension (1949) were constructed. The River Supply Conduit Extension transports water from North Hollywood Wells, Verdugo Wells (1949), Whitnall Wells (1952), and Erwin Wells (1955) to Silver Lake Reservoir. In addition, the River Supply Conduit and Extension may be used to convey Owens Valley water to that reservoir.

Colorado River water was first delivered to Los Angeles in 1941. With the completion of the Eagle Rock Reservoir and the Eagle Rock-Hollywood Conduit in 1954 (see Plate 21) it became possible to deliver Colorado River water into Hollywood, Silver Lake and Baldwin Hills Reservoirs.

Presently, the Los Angeles area south of the Santa Monica Mountains receives a mixed supply of native ground water, Owens River water and Colorado River water. Areas being supplied with unmixed Owens River water are the San Fernando Valley, excepting the Narrows, Sunland-Tujunga and Mission Wells service areas, and a portion of West Los Angeles which is supplied exclusively from Lower Stone Canyon and Franklin Reservoirs.

The Upper Los Angeles River area remains the major source of ground water supply for the city. Development of this source has continued since 1902 when the city regained management of the waterworks. As of 1958, the city was operating 95 wells and two gravity diversions within the area of investigation and ten well plants outside the area of investigation.

Defendant No. 1 - City of San Fernando

At the time the City of San Fernando was incorporated on August 31, 1911, two water companies were supplying the area. One of these was the Maclay Rancho Water Company which operated under the name of Consolidated Securities Company. The other company was the San Fernando Mission Land Company whose predecessor prior to 1905 was the Porter Land and Water Company. In 1919 the City of Los Angeles purchased the Mission Land Company. In 1920 the City of San Fernando acquired that portion of San Fernando Mission Land Company and the Maclay Rancho Water Company systems lying within its boundaries. A total of seven wells have been operated by the City with six active in 1958.

Defendant No. 2 - City of Glendale

In 1883 the Verdugo Canyon Water Company was incorporated and distributed water to various smaller companies serving the Glendale area. In 1906 a portion of the Verdugo Canyon Water Company and other water companies serving the Glendale area merged to form the Glendale Consolidated Water Company. The City of Glendale was incorporated on February 16, 1906. On September 29, 1914, the Glendale Consolidated Water Company was purchased, at which time the city began operation of its own water department. The city has since purchased the distribution and supply systems of the following water companies: (1) Miradero Water Company (that portion supplying City of Glendale) in 1915; (2) Verdugo Springs Water Company in 1915; (3) Verdugo Pipe and Reservoir Company in 1915; (4) North Glendale Distributing Company in 1916; (5) Tropico Water System in 1915; (6) Forest Grove Water Company in 1924; and (7) Sparr Water Company in 1927. By 1932, the city had purchased interest from all of the shareholders in the Verdugo Canyon Water Company. In 1954, the Highway Highlands Mutual Water Company, which served that area annexed by the city, was purchased. A total of 22 wells have been operated by the city with 14 wells presently in operation in addition to one gravity diversion in Verdugo Canyon.

Defendant No. 3 - City of Burbank

The City of Burbank was incorporated on July 15, 1911. In July 1913, the city purchased that portion of the Miradero Water Company within its boundaries along with the company's one well. In August 1913, the city drilled its first well. A total of 18 wells have been operated by the city. Eleven wells were active in 1958.

Defendent No. 4 - Burbank City Unified School District

The well listed for this defendant was completed in about 1907. It was used for the irrigation of berry and truck crops and was operated by Mr. C. A. Thomson until 1938. When the property was acquired by the defendant this well was abandoned.

Defendant No. 5 - Glendale Junior College District of Los Angeles County

The well for which this defendant has been named as having an interest is owned and operated by the City of Glendale, Defendant 2.

Defendant No. 6 - Los Angeles County Flood Control District

This defendant acquired the property on which the listed well is located by condemnation. The well was last operated by the City of San Fernando in 1927 and has not been used since.

Defendant No. 7 - La Canada Irrigation District

The District was formed on April 24, 1924. On January 31, 1925, the La Canada Water Company was leased by the District and in November 1929, it accepted the deed to the company together with the ownership to

Pickens Canyon surface diversion. On December 1, 1925, the District acquired the Snover Canyon Water Company and its diversion in Snover Canyon.

Within the Upper Los Angeles River area the District operated two wells and diversions in Pickens and Snover Canyons. Presently the diversions and one well, 5069D (designated 5069 in Raymond Basin Report of Referee), are in use.

Defendant No. 8 - Crescenta Valley County Water District

The Crescenta Valley County Water District was formed in 1950 and included the service area of the Crescenta Mutual Water Company and the Mountain Water Company which were organized in 1916 and 1924, respectively.

As of 1958, the District was obtaining its supply from twelve wells and three surface diversions. Eight of the wells were previously owned by Crescenta Mutual Water Company, two wells and three surface diversions by the Mountain Water Company. Of the remaining wells in operation one was obtained from Verdugo Woods Estate in 1954 and the other drilled by the District in 1951.

Defendant No. 9 - State of California

This defendant acquired the property on which a well operated by the Mollin Investment Corporation, Defendant Doe Corporation 4 is located, by condemnation. For remarks concerning use of water, refer to Defendant Doe Corporation 4.

Defendant No. 10 - Aetna Life Insurance Company

This defendant was named as having an interest in property owned by George A. and Louise J. Burns, Defendants 128 and 129.

Defendant No. 11 - American Savings and Loan Association

This defendant was named as having an interest in property owned by Lester R. Schwaiger, Defendant 195.

Defendant No. 12 - American Security and Fidelity Corporation

This defendant was named as having an interest in property owned by Forest Lawn Company, Defendant 39.

Defendant No. 13 - The Andrew Jergens Company

The defendant drilled two wells in 1943 to obtain water for cooling purposes. Water was extracted from one well and the other well was used for the injection of waste water into the ground water basin. This method proved unsatisfactory since warm waste water was being recycled. The injection well was abandoned and the waste water discharged into the Los Angeles River system.

In 1947 water was obtained from the City of Burbank to supplement the supply from the well. The use of well water was discontinued in 1956 and the well destroyed in 1958.

Defendant No. 14 - Bank of America National Trust and Savings Association

This defendant was named as having an interest in the property on which the City of Glendale drilled a test well. Defendant was also named as having an interest in a well owned and operated by Livingston Rock and Gravel Company, Defendant 53.

Defendant No. 15 - Beatrice Foods Company

A well operated by the Meadow Gold Dairies, a Division of Beatrice Foods Company, was first used in 1939 by the Valley Dairy Company. The well and purchased water from the City of Glendale were used in the operation of a dairy plant. Since 1956, the well has only been used for watering a small lawn area.

Defendant No. 16 - California Bank

The defendant has held a trust deed on the property owned by the Sportsmen's Lodge Banquet Corporation, Defendant 80.

Defendant No. 17 - California Bank

Same as Defendant 16.

Defendant No. 18 - California Materials Company

The defendant has owned and operated this well since 1941. The water from this well and water purchased from the City of Los Angeles is used in processing rock and gravel. Used water is dumped into a sump located within the gravel pit area.

Defendant No. 19 - California Trust Company

This defendant was named as having an interest in property owned by Drewry Photocolor Corporation, Defendant 36.

Defendant No. 20 - California Trust Company

Same as Defendant 19.

Defendant No. 21 - Carnation Company

McGraw Colorgraph Company, a division of Carnation Company, operates a well which has been used since 1940. The water from this well together with water purchased from the City of Burbank is used for a cooling system and in plant operation. Industrial waste water is returned to the ground by use of an injection well. When the capacity of the return well is exceeded, excess water discharges into a storm drain.

Defendant No. 22 - Citizens National Trust and Savings Bank of Los Angeles

This defendant was named as having an interest in property owned by the City of Glendale, Beatrice Foods Company, Desco Corporation, Oakmont Country Club and G. Henry Stetson, Defendants 2, 15, 35, 63 and 200, respectively.

Defendant No. 23 - Citizens National Trust and Savings Bank of Los Angeles

Same as Defendant 22.

Defendant No. 24 - Citizens National Trust and Savings Bank of Los Angeles

Same as Defendant 22.

Defendant No. 25 - Citizens National Trust and Savings Bank of Los Angeles

Same as Defendant 22.

Defendant No. 26 - Citizens National Trust and Savings Bank of Los Angeles

Same as Defendant 22.

Defendant No. 27 - Citizens National Trust and Savings Bank of Los Angeles

Same as Defendant 22.

Defendant No. 28 - Citizens National Trust and Savings Bank of Los Angeles

Same as Defendant 22.

Defendant No. 29 - Color Corporation of America

Color Corporation of America is the former name of Houston Fearless Corporation which is the parent company of the Houston Color Film Laboratories, Inc., of California, Defendant 46.

Defendant No. 30 - Consolidated Rock Products Company

Three wells, operated by the Consolidated Rock Products Company, are owned by the Valley Park Company, successor to the Los Angeles Land and Water Company. Water from the wells is used to wash gravel and is then discharged into a sump in the gravel pit. The Consolidated Rock Products Company has been in operation since 1924.

Defendant No. 31 - Corporation of America

This defendant was named as having an interest in property on which a test well was drilled by City of Glendale and a well owned by Livingston Rock and Gravel Company, Defendant 53.

Defendant No. 32 - Corporation of America

Same as Defendant 31.

Defendant No. 33 - Corporation of America

Same as Defendant 31.

Defendant No. 34 - Deep Rock Artesian Water Company

The company is presently owned by Paul E. and Evelyn M. Pendleton, Defendants 186 and 187. The original owner was Manuel Rattner who started the company in 1927 and sold it to the Pendletons in 1947. The water obtained from two wells is bottled and sold. Los Angeles city water is also used in the plant.

Defendant No. 35 - Desco Corporation

The well was drilled in 1940 by the previous owner of the property now owned by Desco Corporation. The present owner used the well for one year and then capped the well in 1954. Water from the well was used for filling a swimming pool.

Defendant No. 36 - Drewry Photocolor Corporation

Beginning in 1946 the defendant has used the water from one well in the operation of a film processing plant. Waste water is discharged into the sewer.

Defendant No. 37 - Frank X. Enderle, Inc., Ltd.

This defendant is the owner of three wells operated by the Oakwood Cemetery Association, Defendant 64.

Defendant No. 38 - Forest Lawn Cemetery Association

This defendant is a user of the water extracted by Forest Lawn Company, Defendant 39.

Defendant No. 39 - Forest Lawn Company

The Forest Lawn Company owns and operates various wells for the irrigation of cemetery lawns. The company supplies the water for irrigation for Forest Lawn Memorial Park Association and Forest Lawn Cemetery Association at two locations.

The oldest well, dating back to 1914, delivered water to the cemetery located in the southeasterly portion of the City of Glendale. Water extracted from five wells has been used to supply the cemetery at this location. In 1958, the company had three active wells supplying the water for irrigation of the lawns.

The company also supplied irrigation water for its cemetery located north of Griffith Park. Seven wells were drilled at this location with only one well placed in production in 1951. Production of this well was discontinued in 1958. The water presently used for irrigation is purchased from the City of Los Angeles.

Defendant No. 40 - Forest Lawn Memorial Park Association

This defendant is a user of the water extracted by the Forest Lawn Company, Defendant 39.

Defendant No. 41 - Freshpuro Water Company

The Freshpuro Water Company has been purchased by Leonard W. and Margery J. Block, Defendants Doe 16 and Doe 17, and the name has been changed to Pur-O-Spring Water Company. These companies have sold bottled water since 1930. Water is obtained from one well located on the premises.

Defendant No. 42 - Glendale Towel and Linen Supply Company

The Glendale Towel and Linen Supply Company is owned by Donald G. and Dorothy N. Cowlin, Defendants 135 and 136. Water extracted from this well is used for laundry processing and all waste water is discharged into the sewer. This well was placed in operation in 1941.

Defendant No. 43 - Glenhaven Memorial Park, Inc.

Prior to 1943 the land now occupied by Glenhaven Memorial Park, Inc., was devoted to farming. Beginning in 1943 the land was converted to a cemetery. A total of six wells have been used to irrigate cemetery lawns. Presently only four wells are in operation.

Defendant No. 44 - Hidden Hills Corporation

In 1950, the Hidden Hills Corporation established a water supply in conjunction with the development of a residential subdivision. In 1957, this corporation relinquished its interest in the wells and distribution system to the Hidden Hills Mutual Water Company, Defendant 45.

Defendant No. 45 - Hidden Hills Mutual Water Company

This mutual water company was established in 1957 to relieve the Hidden Hills Corporation, Defendant No. 44, of the responsibility of supplying water. In 1958, this company had twelve producing wells, two of which are outside the watershed of the Upper Los Angeles River area. These wells supply water for domestic use to approximately 230 services.

Defendant No. 46 - Houston Color Film Laboratories, Inc. of California

The defendant is a division of the Houston Fearless Corporation and uses the water from a well owned by Benjamin B. Smith, Defendant 197. The well and City of Burbank water was used for processing color film from 1940 through 1954. The well was abandoned in 1955 and water supplied from the City of Burbank is being used exclusively. Industrial waste water from the plant is discharged into spreading ponds.

Defendant No. 47 - Intervalley Savings and Loan Association

This defendant was named as having an interest in property owned by Lester R. Schwaiger, Defendant 195, and property owned by E. E. Mahannah, Defendant 164.

Defendant No. 48 - Knickerbocker Plastic Company, Inc.

The well owned by the defendant has been in use since 1953. The water is used for cooling machinery in a manufacturing plant. Los Angeles city water is also used in a closed air conditioning system. Waters from both sources are injected into two return wells.

Defendant No. 49 - Lakeside Golf Club of Hollywood

Three wells were drilled for the irrigation of a golf course. Two of these wells have since been abandoned. From 1928 through 1948 a golf course was irrigated with well water. After 1948, City of Los Angeles water and well water have been used by the defendant.

In addition to the above wells the defendant operated a well previously used for truck farming in 1936. This well was used to maintain the water level in the easterly portion of Toluca Lake. This well was destroyed in 1953.

Defendant No. 50 - Lakewood Water and Power Company

This defendant was named as having an interest in wells owned by the George E. Platt Company, Defendant 67; however, defendant states they do not operate in the San Fernando Valley.

Defendant No. 51 - Land Title Insurance Company

This defendant is the trustee of property owned by Donald G. and Dorothy N. Cowlin, Defendants 135 and 136.

Defendant No. 52 - Land Title Insurance Company

Same as Defendant 51.

Defendant No. 53 - Livingston Rock and Gravel Company

Mary L. and Peter J. Akmadzich, Defendants 111 and 112, are the previous owners of the property and well now owned by Livingston Rock and Gravel Company. This well was drilled in 1932 and the water used primarily for processing gravel. Waste water from the processing is discharged into one of the gravel pits and is re-used.

The company acquired another well drilled in 1951 by the Arrow Rock Company which is owned by M. F. Joyce. The water extracted from this well is also used for processing gravel.

Defendant No. 54 - Lockheed Aircraft Corporation

Since 1940, the defendant has operated four wells. Two of the defendant's wells are located on property owned by the Federal Government. The water from two wells was used in a closed air cooling system and the waste water discharged into return wells. Recently only one well used for air cooling was active.

The remaining two wells were used as a standby water supply for fire protection. These wells are presently abandoned.

Defendant No. 55 - Los Angeles Land and Water Company

This defendant is the previous owner of property on which the Consolidated Rock Products Company, Defendant 30, operates three wells.

Defendant No. 56 - Los Angeles Pet Cemetery

Two wells have been drilled by the defendant, one in 1929 and the other in about 1938. The water from these wells has been used to irrigate a pet cemetery.

Defendant No. 57 - Los Angeles Trust and Safe Deposit Company

The defendant is trustee for the heirs and devisees of Harry Kiener, deceased, former owner of property owned by Maxine Duckworth, Defendant 141, and John W. Duckworth, Jr., Defendant 142.

Defendant No. 58 - Los Angeles Trust and Safe Deposit Company

Same as Defendant 57.

Defendant No. 59 - Metropolitan Life Insurance Company

This defendant formerly held a trust deed on property owned by Elton and Florence H. George, Defendants 146 and 147. The City of Glendale, Defendant 2, has an easement on this property on which the city can drill and operate a well.

Defendant No. 60 - Metropolitan Savings and Loan Association of Los Angeles

This defendant was named as having an interest in property on which a well is owned by Kisag Moordigian, Defendant 173.

Defendant No. 61 - Monteria Lake Association

A well was drilled in 1953 by the defendant and is used to maintain the water level in Monteria Lake. This lake is a privately-owned recreational site.

Defendant No. 62 - Mulholland Orchard Company

The defendant drilled two wells in 1925 and two additional wells in 1926 and 1949. These were used in conjunction with Los Angeles city water to irrigate walnut and citrus orchards. Presently one well is active and the remaining wells have been capped.

Defendant No. 63 - Oakmont Country Club

The well for which the defendant was named is owned and operated by the City of Glendale, Defendant 2.

Defendant No. 64 - Oakwood Cemetery Association

Three wells owned by Frank X. Enderle, Inc. have been operated by the Oakwood Cemetery Association to irrigate cemetery lawns. One well was drilled in 1932 and abandoned in 1953. Two additional wells were drilled in 1946 and are presently operating.

Defendant No. 65 - Pacific Fruit Express Company

The defendant operates wells owned by the Southern Pacific Company, Defendant 76.

Defendant No. 66 - Pacific Lighting and Gas Supply Company

The defendant operated one well from 1928 until 1950 for the domestic supply of two houses. The well was abandoned in 1950 and since that time Los Angeles city water has been used.

Defendant No. 67 - George E. Platt Company

From 1915 to 1955 the defendant operated a total of 10 wells for domestic, irrigation, stockwatering, and industrial uses in the operation of a dairy. Since 1955 only one domestic well has been operated for the domestic supply for three houses. In 1958 another well was drilled to replace the domestic well.

Defendant No. 68 - Polar Water Company

The defendant purchased the property and a well from Andre Borgia. The well was completed in approximately 1888 and was used until 1947, at which time a replacement well was drilled.

From 1888 until 1923 the well was used to irrigate truck crops. Since 1923, well water has been bottled and sold by the Polar Water Company.

Defendant No. 69 - Richfield Oil Corporation

This defendant was named as having an interest in wells owned by Walt Disney Productions, Defendant 105.

Defendant No. 70 - Riverwood Ranch Mutual Water Company

A well was drilled about 1912 for oil. From 1924 to 1936 the well was owned by Judge Garvin Craig and used for irrigation. In 1933 the well was abandoned and water was diverted from Big Tujunga Wash. The surface diversion was destroyed during the 1938 flood and the well was reactivated. The property was owned by Michael J. O'Meara from 1936 to about 1941 and Hal B. Hayes, Defendant 151, from about 1941 to 1947. The well has been owned by Riverwood Ranch Mutual Water Company since 1949 and is used as a domestic supply for 35 residences.

Defendant No. 71 - Roger Jessup Farms

A well was drilled in 1931 to supply the Roger Jessup dairy. In 1943 a second well was drilled to replace the original well which caved in. In about 1955 use of Los Angeles city water was initiated to supplement well water. In 1959 the well was abandoned and city water has been used exclusively since then.

Defendant No. 72 - Sealand Investment Corporation

This defendant was named as having an interest in property owned by Kisag Moordigian, Defendant 173.

Defendant No. 73 - Sealand Investment Corporation

Same as Defendant 72.

Defendant No. 74 - Sears, Roebuck and Company

A well owned by Sidney M. Barton was drilled in 1938 and has been operated by the defendant since that time. Well water is used in a closed cooling system at the Sears, Roebuck and Company store in Glendale. Used water is discharged into return wells.

Defendant No. 75 - Southern California Edison Company

The defendant obtained possession of a well drilled in 1931 by the Wildwood Trout Resort since the well was located within the defendant's transmission lines rights of way. Wildwood Trout Resort used the water extracted from this well and from one drilled in 1890 to supply water for a fish pond and hatchery. In 1937 and 1938 these wells were inactive.

In 1939, Pop's Willow Lake commenced operation at this site. Both wells were reactivated to supply water to a lake and swimming pool until about 1952 when Pop's Willow Lake was abandoned. The defendant's well was destroyed in 1957 and the other well has since been capped and used for observation of the ground water levels.

Defendant No. 76 - Southern Pacific Railroad

Five wells owned by the Southern Pacific Company have been operated by Pacific Fruit Express Company, Defendant 65. The first well was drilled in 1920 and subsequent wells were drilled in 1923, 1939, 1942 and 1945. Water is used at an ice plant and in the defendant's shops. One well is used as a standby and for fire protection. Industrial waste water is discharged into the channel of the Los Angeles River.

Defendant No. 77 - Southern Service Company, Ltd.

The defendant doing business as the Premier Laundry owns a well which was drilled in 1940. The well has been used to supply the laundry. The laundry waste water is discharged into the sewer.

Defendant No. 78 - Sparkletts Drinking Water Corporation

Sparkletts Drinking Water Corporation began operating in 1925, purchasing water from a well that was drilled in 1880. The defendant drilled three additional wells in 1928, 1934 and 1946, respectively. All of these wells have been replaced by three replacement wells which are presently in operation. Part of the water is bottled and sold and part is used to wash and backflush the water treatment system. Los Angeles city water is also used in the plant's operation. All of the water not sold is discharged into the sewer.

Defendant No. 79 - Spinks Realty Company

Two wells are located on the defendant's property. One well was originally drilled in 1898 for oil and since no oil was found the well was perforated at a level from which water flows under pressure. In 1914 another well was drilled for water. Both wells are used for irrigation in addition to a supply obtained from the City of Los Angeles. The defendant acquired the property about 1936.

Defendant No. 80 - Sportsmen's Lodge Banquet Corporation

The defendant and predecessor have operated two wells at the location. One well was drilled in 1914 and abandoned in 1948. The second well drilled in 1938 is presently active.

The property is presently owned by the defendant and is used to supply water to the trout ponds. Used water in the ponds is discharged into the Los Angeles River channel.

Defendant No. 81 - Sun Valley National Bank of Los Angeles

This defendant was named as having an interest in property owned by Florence S. Plemmons, Defendant 188.

Defendant No. 82 - Technicolor Corporation

The original well, which supplied a ranch, was drilled prior to 1938. Beginning in 1938 it was used to supply water for film processing. In 1946 and 1947 two wells were drilled and the original well was abandoned. Presently water from both wells and City of Burbank water are used. Industrial waste water is discharged into the Los Angeles River. Previous owner of the property was Color Corporation of America, Defendant 29.

Defendant No. 83 - Title Insurance and Trust Company

This defendant was named as having an interest in property owned by the Hidden Hills Mutual Water Company, Defendant 45.

Defendant No. 84 - Title Insurance and Trust Company

This defendant was named as having an interest in property owned by George A. Burns, Defendant 128.

Defendant No. 85 - Title Insurance and Trust Company

This defendant was named as having an interest in property owned by Paul E. Lancaster, Defendant 161.

Defendant No. 86 - Title Insurance and Trust Company

This defendant was named as having an interest in property owned by the Hidden Hills Mutual Water Company, Defendant 45.

Defendant No. 87 - Title Insurance and Trust Company

This defendant was named as having an interest in property owned by Valhalla Memorial Park, Defendant 101.

Defendant No. 88 - Title Insurance and Trust Company

This defendant was named as having an interest in property owned by E. E. Mahannah and Hazel E. Mahannah, Defendants 164 and 165.

Defendant No. 89 - Title Insurance and Trust Company

This defendant was named as having an interest in property owned by Knickerbocker Plastic Company and Leo L. White, Defendants 48 and 208.

Defendant No. 90 - Title Insurance and Trust Company

This defendant was named as having as interest in property owned by Donald G. and Dorothy N. Cowlin, Defendants 135 and 136.

Defendant No. 91 - Title Insurance and Trust Company

This defendant was named as having an interest in property owned by Florence S. Plemmons, Defendant 188.

Defendant No. 92 - Title Insurance and Trust Company

This defendant was named as having an interest in property on which a well owned and operated by the City of Glendale, Defendant 2, is located.

Defendant No. 93 - Title Insurance and Trust Company

Same as Defendant 92.

Defendant No. 94 - Title Insurance and Trust Company

This defendant was named as having an interest in property owned by Lester R. Schwaiger, Defendant 195.

Defendant No. 95 - Title Insurance and Trust Company

This defendant was named as having an interest in property owned by the Hidden Hills Mutual Water Company, Defendant 45.

Defendant No. 96 - Title Insurance and Trust Company

This defendant was named as having an interest in property owned by Benjamin B. Smith, Defendant 197.

Defendant No. 97 - Toluca Lake Property Owners Association

The defendant owns two wells, drilled in 1931 and 1949. The wells have been operated to maintain the water level in Toluca Lake, a privately-owned recreational park. The outflow from the lake discharges into the Los Angeles River. Presently only one well is active.

Defendant No. 98 - Union Bank and Trust Company of Los Angeles

This defendant was named as having an interest in property owned by Leonard W. and Margery J. Block, Defendants Doe 16 and Doe 17.

Defendant No. 99 - Universal Pictures Company

Two wells operated by Universal Pictures Company are located on property owned by the Lakeside Golf Club of Hollywood. Both wells were drilled in 1916 and were used until 1958 to supply the Universal Pictures Studio. Use of Los Angeles city water commenced in 1957 to supplement the well supply and has been used exclusively since the fall of 1958.

Defendant No. 100 - Valhalla Mausoleum Park

This defendant was named as having an interest in property owned by Valhalla Memorial Park, Defendant 101.

Defendant No. 101 - Valhalla Memorial Park

The defendant has presently two wells in operation to supply water for irrigating a cemetery. The property was acquired by Valhalla Memorial Park in 1922. A total of six wells have been developed and operated by the defendant.

Defendant No. 102 - Valhalla Properties

The defendant was named as having an interest in property owned by Valhalla Memorial Park, Defendant 101.

Defendant 103 - Valley Lawn Memorial Park

This defendant was named as having an interest in wells listed under George E. Platt Company, Mark Boyar and Michael Diller, Defendants 67, 126 and 139, respectively.

Defendant 104 - Van de Kamp's Holland Dutch Bakers, Inc.

The defendant owns one well which was drilled in 1941. The water from this well is used to supply the bakery. A supplemental water supply is obtained from the City of Los Angeles.

Defendant No. 105 - Walt Disney Productions

The major portion of water pumped from two wells, drilled in 1938, is used in a closed air conditioning system and discharged to the old river bed adjacent to the lined channel of the Los Angeles River. The remaining portion of the well water together with City of Burbank water is used for miscellaneous purposes throughout the motion picture studios.

Defendant No. 106 - Warner Bros. Pictures, Inc.

The property on which the picture studio is located was acquired in 1927. An existing well placed on the property in 1901 supplied a ranch operated by S. A. Martin. This well was used by the defendant until 1944. A replacement well was drilled in 1947 and was used until 1952, when it was abandoned. Both of these wells supplied a reservoir used in taking underwater pictures.

A well used primarily for air conditioning was drilled in 1937 and operated until 1953. Water from this well was discharged into the Los Angeles River.

Defendant No. 107 - Western Mortgage Company

This defendant was named as having an interest in property owned by Elton and Florence H. George, Defendants 146 and 147, on which a well owned and operated by the City of Glendale, Defendant 2, is located.

Defendant No. 108 - Leo W. Adair

The property on which a well existed belongs to the City of Glendale. The well was drilled in 1941 and used for irrigation until 1944. During the period 1944 to sometime following 1951 the well was used by the defendant to water several horses and supply a single residence. The date on which the well was last used is unknown. The well is now destroyed.

Defendant No. 109 - Catherine Adams

This defendant was named as having an interest in properties owned by Maxine Duckworth, Defendant 141, and John E. and Marvel Elizabeth Mullin, Defendants 181 and 182.

Defendant No. 110 - Catherine Adams, Guy Knupp, Security First National Bank of Los Angeles

Same as Defendant 109.

Defendant No. 111 - Mary L. Akmadzich

The defendant is the previous owner of property of the Livingston Rock and Gravel Company, Defendant 53.

Defendant No. 112 - Peter J. Akmadzich

Same as Defendant 111.

Defendant No. 113 - Margaret E. Arine

This defendant was named as having an interest in property owned by Celeste Louise McCabe, Defendant 168.

Defendant No. 114 - Helen Babikian

This defendant was named as having an interest in property owned by Kisag Moordigian, Defendant 173.

Defendant No. 115 - B. A. Bannan

This defendant was named as having an interest in property owned by Benjamin B. Smith, Defendant 197.

Defendant No. 116 - Clotilde R. Bannan

Same as Defendant 115.

Defendant No. 117 - William O. Bartholomaus

The defendant owns one-quarter interest in the property and Ellen S. Dubois owns three-quarter interest. Three wells were drilled in 1885, 1899 and 1906 and used to irrigate various crops. The well drilled in 1906 is still active.

Defendant No. 118 - Barbara Becker

This defendant is a previous owner of property owned by Leonard W. and Margery J. Block, Defendants Doe 16 and Doe 17.

Defendant No. 119 - Bert Becker

Same as Defendant 118.

Defendant No. 120 - Henry W. Berkemeyer

The defendant acquired the property in 1942. A well drilled in 1920 has been used for irrigation and domestic purposes. The property was previously owned by Mr. Andrews.

Defendant No. 121 - Hildur M. Berkemeyer

Same as Defendant 120.

Defendant No. 122 - Elfrieda M. Bishop

In 1944 the defendant acquired the property from C. E. Crosby. A well located on the property was drilled in 1933. The well was used for irrigating pasture and watering stock until 1955. Since 1955 the well has been used for watering the yard of one residence.

Defendant No. 123 - W. E. Bishop

Same as Defendant 122.

Defendant No. 124 - Andrea Borgia

The defendant is a former owner of the Polar Water Company, Defendant 68.

Defendant No. 125 - Frances Borgia

This defendant was named as having an interest in property owned by the Polar Water Company, Defendant 68.

Defendant No. 126 - Mark Boyar

The well which was drilled in 1948 is owned by the defendant, Michael Diller, Defendant 139 and Frank Knapp, Jr., nondefendant. Water is used by the three residences for domestic purposes.

Defendant No. 127 - Stella M. Brown

The well located on the defendant's property was drilled in about 1905. Previous owner of the property was R. P. Waite. Since 1936 the well has been used to irrigate pasture. Prior use is unknown.

Defendant No. 128 - George A. Burns

The well was drilled in 1948 by the defendant for domestic use and was abandoned in 1955. Los Angeles city water replaced the well water.

Defendant No. 129 - Louise J. Burns

The defendant was named as having an interest in property owned by George A. Burns, Defendant 128.

Defendant No. 130 - Rodney E. Busk

This defendant was named as having an interest in property owned by Paul E. and Evelyn M. Pendleton, Defendants 186 and 187.

Defendant No. 131 - Aurora Carlson

This defendant was named as having an interest in property on which a well operated by Crescenta Valley County Water District, Defendant 8, is located.

Defendant No. 132 - William M. Chace

The well was drilled in about 1910 to supply the Bruckman Ranch. The defendant acquired the property in about 1939 from Louis Julius. Since 1915 the well has been used to supply a laundry. Industrial waste water is discharged into the sewer.

Defendant No. 133 - William M. Chace

Same as Defendant 132.

Defendant No. 134 - Emma S. Clauson

Two wells have been drilled on the defendant's property, one in about 1900 and the date of the other is unknown. Both wells were used for domestic purposes and abandoned about 1947.

Defendant No. 135 - Donald G. Cowlin

The defendant is co-owner of Glendale Linen and Supply Company, Defendant 42.

Defendant No. 136 - Dorothy N. Cowlin

Same as Defendant 135.

Defendant No. 137 - Josephine McC. Cowlin

The defendant is holder of trust deed on Glendale Linen and Supply Company, Defendant 42.

Defendant No. 138 - Cecil B. De Mille

The De Mille property consists of four separate parcels of land located in Little Tujunga Canyon, all of which are supplied by wells and springs.

In 1920 the defendant acquired a parcel of land on which a well existed. This well together with another well drilled in 1938 has been used to irrigate a citrus orchard and supply a single dwelling. Since 1955 water has been purchased from the City of Los Angeles to irrigate a portion of the orchard.

A portion of another parcel was acquired in 1937 from John W. Ross and the remainder acquired from Dorothy Bennett in 1955. Two wells located on this parcel existed prior to acquisition of the property by the defendant. A spring supplies three houses and together with the two wells is used for irrigation of pasture and stockwatering.

Another parcel receives water for domestic use from a spring developed in about 1908. A well drilled in 1938 was operated until 1950 to irrigate a citrus orchard on this property.

On the fourth parcel, a well was drilled in 1951 and has been used for domestic purposes.

Defendant No. 139 - Michael Diller

Same as Defendant 126.

Defendant No. 140 - Ellen S. DuBois

Same as Defendant 117.

Defendant No. 141 - Maxine Duckworth

A well located on the property referred to as the Davis Ranch and later known as the Keiner Ranch was acquired by the defendant. Three wells have been drilled on the property, the first of which was drilled in 1926. All three wells are presently active. One serves as a domestic supply and the others are used when insufficient water can be diverted from Pacoima Wash for irrigating citrus orchards (see Defendant Doe Corporation 4). Use of water prior to 1937 is unknown. The defendant also supplies water to the adjacent land owners referred to under Defendant 181.

Defendant No. 142 - Maxine Duckworth

Same as Defendant 141.

Defendant No. 143 - Richard Erratchuo

One well located on the property owned by the defendant was drilled in 1933 and used for domestic purposes until 1953.

Defendant No. 144 - Ada H. Fitz-Patrick

This defendant was named as having an interest in property owned by Valhalla Memorial Park, Defendant 101.

Defendant No. 145 - C. C. Fitz-Patrick

Same as Defendant 144.

Defendant No. 146 - Elton George

The defendant has no interest in water diversions in the area of investigation. A well owned and operated by the City of Glendale is located on the defendant's property.

Defendant No. 147 - Florence H. George

Same as Defendant 146.

Defendant No. 148 - Howard Barton Griffith

A well was drilled by the defendant in 1953 and has been in use since then for irrigation. Previous owner of the property was Nelson Gray.

Defendant No. 149 - Irene W. Guyer

This defendant was named as having an interest in property owned by Florence S. Plemmons, Defendant 188.

Defendant No. 150 - George Hanna

The defendant has no interest in water diversions in the area of investigation.

Defendant No. 151 - Hal B. Hayes

The defendant is former owner of property owned by Riverwood Ranch Mutual Water Company, Defendant 70. The defendant has also operated a gravity diversion since about 1954 for domestic use.

Defendant No. 152 - Forrest W. Hicks

This defendant was named as having an interest in property owned by Donald G. and Dorothy N. Cowlin, Defendants 135 and 136.

Defendant No. 153 - Neva Bartlett Holmgrin

The well owned by Neva Bartlett Holmgrin was drilled in approximately 1949, and has been used since for domestic purposes.

Defendant No. 154 - Marguerite Rice Jessup

The defendant is a member of a copartnership with the Roger Jessup Farms, Defendant 71.

Defendant No. 155 - Marguerite Rice Jessup

Same as Defendant 154.

Defendant No. 156 - Roger Jessup

Same as Defendant 154.

Defendant No. 157 - Nathan Kates

The defendant is coexecutor of the estate of John W. Duckworth.

Defendant No. 158 - June Kelley

The defendant has no interest in water diversions in the area of investigation.

Defendant No. 159 - Victor H. Kelley

Same as Defendant 158.

Defendant No. 160 - Samuel P. Krown

This defendant was named as having an interest in property on which a well operated by the Crescenta Mutual Water Company was located. The well was abandoned in 1937.

Defendant No. 161 - Paul E. Lancaster

This defendant was named as having an interest in property owned by Florence S. Plemmons, Defendant 188.

Defendant No. 162 - William Lancaster

Same as Defendant 161.

Defendant No. 163 - Lucille Mack

The defendant is a member of the copartnership, the Mulholland Orchard Company, Defendant 62.

Defendant No. 164 - E. E. Mahannah

One well owned by the defendant and his wife, Hazel E. Mahannah, Defendant 165, has been operated since 1953 for domestic purposes. Prior to 1953, water was obtained from the Briggs Terrace Mutual Water Company.

Defendant No. 165 - Hazel E. Mahannah

Same as Defendant 164.

Defendant No. 166 - Blanche M. Mangan

The defendant has no interest in water diversions in the area of investigation.

Defendant No. 167 - Nicholas Mangan

Same as Defendant 166.

Defendant No. 168 - Celeste Louise McCabe

A well was drilled in about 1910 and since 1931 has been used for bottled drinking water. Another well was drilled in 1951 to replace the original one and is used for the same purpose. The property is leased from the defendant by the Magnolia Bottled Water Company who operates the well.

Defendant No. 169 - Marian Y. McDougal

The defendant has no interest in water diversion in the area of investigation.

Defendant No. 170 - Murray McDougal

Same as Defendant 169.

Defendant No. 171 - Irene Minkler

The defendant is a joint owner of property on which a well is owned and operated by Crescenta Valley County Water District, Defendant 8.

Defendant No. 172 - Dean Peter Moordigian

The defendant was named as having an interest in property owned by Kisag Moordigian, Defendant 173.

Defendant No. 173 - Kisag Moordigian

The property was acquired in 1938 from the Porter Estate. One well is located on the property which was drilled in 1933 for irrigation.

Since 1938 the defendant has operated the well for irrigation. In 1958 the well was idle.

Defendant No. 174 - Eloise V. Mosher

The defendant is co-owner of Polar Water Company, Defendant 68.

Defendant No. 175 - W. E. Mosher

The defendant is co-owner of Polar Water Company, Defendant 68.

Defendant No. 176 - Perry Mulholland

The defendant is a member of the copartnership, the Mulholland Orchard Company, Defendant 62.

Defendant No. 177 - Perry Mulholland

Same as Defendant 176.

Defendant No. 178 - Rose Mulholland

Same as Defendant 176.

Defendant No. 179 - Rose Mulholland

Same as Defendant 176.

Defendant No. 180 - Thomas Mulholland

Same as Defendant 176.

Defendant No. 181 - John E. Mullin

This well was drilled in 1949 and is owned by John E. and Marvel E. Mullin and E. R. and Irene Gill. Use is for irrigation and domestic purposes. Water is also used from the diversion systems owned by Maxine Duckworth, Defendant 141.

Defendant No. 182 - Marvel Elizabeth Mullin

Same as Defendant 181.

Defendant No. 183 - Charles Mureau

The well was drilled in 1885. From 1945 until 1952 it served a public school in the Las Virgenes School District. Use prior to 1945 is unknown. In 1953 the property was acquired by the defendant. From 1953 to 1957 it was used for domestic purposes. From 1957 to present a private school, the Marie Culter Preschool, is served by the well.

Defendant No. 184 - Marie Murray

This defendant was named as having an interest in property owned by Florence S. Plemmons, Defendent 188.

Defendant No. 185 - Julia N. Nathan

The defendant was formerly trustee of property purchased by Leonard W. and Margery J. Block, Defendants Doe 16 and Doe 17.

Defendant No. 186 - Paul E. Pendleton

This defendant was named as co-owner of the Deep Rock Artesian Water Company, Defendant 34.

Defendant No. 187 - Evelyn M. Pendleton

Same as Defendant 186.

Defendant No. 188 - Florence S. Plemmons

A well was drilled in 1920 and supplied water to an olive processing plant until 1953 when the property was acquired by the defendant. The well was capped in 1955.

In 1952 the defendant acquired another well which was drilled in 1930. Water from this well was used for recreation through 1955. In 1957 the well was capped.

Defendant No. 189 - John R. Plemmons

This defendant was named as having an interest in property owned by Florence S. Plemmons, Defendant 188.

Defendant No. 190 - Charles Pryor

This defendant was named as having an interest in property owned by Eloise V. and W. E. Mosher, Defendants 174 and 175.

Defendant No. 191 - Pleasant Thomas Renfrow

This defendant was named as having an interest in property owned by Drewry Photocolor Corporation, Defendant 36.

Defendant No. 192 - Mary Mildred Renfrow

Same as Defendant 191.

Defendant No. 193 - Helen Rushworth

Same as Defendant 194.

Defendant No. 194 - Lester Rushworth

In 1943 the defendant and his wife, Helen Rushworth, Defendant 193, purchased the property on which a well was located from Warren and Merritt Hull. The well was dug in 1940 and in 1947 another well was drilled to replace the original well. Both wells have been used for irrigation and domestic purposes.

Defendant No. 195 - Lester R. Schwaiger

The well was drilled in 1928 and little is known of its use except that in 1955 it was used to fill a duck pond. In 1956 the well was destroyed.

Defendant No. 196 - Cecil A. Schwaiger

This defendant was named as having an interest in property owned by Lester R. Schwaiger, Defendant 195.

Defendant No. 197 - Benjamin B. Smith

The defendant is owner of property on which a well was operated by Houston Color Film Laboratories, Inc., Defendant 46.

Defendant No. 198 - Sidney Smith

The defendant owns a one-fourth interest in the flow of water from a tunnel in Pickens Canyon. The remaining interest is owned by Crescenta Valley County Water District, Defendant 8. Water is used by the defendant as a domestic supply for several residences.

Defendant No. 199 - Walter W. Stavert

This defendant was named as having an interest in property owned by the Desco Corporation, Defendant 35.

Defendant No. 200 - G. Henry Stetson

One well was drilled in 1915 and a second in 1927. The well water is used in conjunction with Los Angeles city water for irrigation of a citrus orchard and for domestic purposes.

Defendant No. 201 - Steve Urquidez

The defendant is a joint owner of property on which a well is owned and operated by the Crescenta Valley County Water District, Defendant 8.

Defendant No. 202 - William Urquidez

Same as Defendant 201.

Defendant No. 203 - Grace C. Valliant

This defendant was named as having an interest in a well which is owned and operated by City of Glendale, Defendant 2.

Defendant No. 204 - H. M. Warner

One well was drilled in 1910 and a second in 1924 on property of the Brant Ranch. Operation of the wells was discontinued in 1935. In 1951 the defendant began using the wells in conjunction with Los Angeles city water. In 1957 interest in the property was transferred to the Warner Ranch Company. Both wells were last used in 1958, at which time they were abaondoned. The wells have been operated to supply water for irrigation and stockwatering.

Defendant No. 205 - Elizabeth A. Wheeland

The defendant owns and operates a well drilled in 1924 by the former owner Juan Erratchuo. The well has been used for irrigation and domestic purposes.

Defendant No. 206 - H. W. Wheeland

The defendant was named as having an interest in property owned by Elizabeth A. Wheeland, Defendant 205.

Defendant No. 207 - Constance Ray White

This defendant was named as having an interest in property of the Knickerbocker Plastic Company, Defendant 48.

Defendant No. 208 - Leo L. White

The defendant has an interest in property of the Knickerbocker Plastic Company, Defendant 48.

Defendant No. 209 - Ray C. Wilcox

The defendant was a previous co-owner of property owned by Benjamin B. Smith, Defendant 197.

Defendant No. 210 - E. C. Woodward

This defendant was named as having an interest in property owned by Beatrice Foods Company, Defendant 15.

Defendant No. 211 - Alice M. Wright

A well was drilled in 1940 for the defendant and the co-owner, J. Marion Wright, Defendant 212. It has been used since then for irrigation and stockwatering.

Defendant No. 212 - J. Marion Wright

Same as Defendant 211.

Defendant No. 213 - Donald M. Young

This defendant was named as having an interest in property owned by the City of Glendale, Defendant 2.

Defendant No. 214 - Marcia S. Young

Same as Defendant 213.

Defendant No. Doe Corporation 1 - Security First National Bank of Los Angeles

This defendant was named as having an interest in property formerly owned by Lester R. Schwaiger, Defendant 195.

Defendant No. Doe Corporation 2 - Southern California Service Corporation

Same as Doe Corporation 1.

Defendant No. Doe Corporation 3 - Verdugo Savings and Loan Association

Same as Doe Corporation 1.

Defendant No. Doe Corporation 4 - Mollin Investment Corporation

The property on which the well is located was formerly known as the Ford-Craig Ranch. Operation of the first well began in 1896 with operation of other wells commencing in 1907 and 1926. In addition to well water a surface diversion from Pacoima Wash was operated when water was available until about 1953 when its use was discontinued. First use of the diversion was prior to 1934. In addition to the above diversions, sewage effluent from the United States Veterans Hospital has also been used.

All sources of water have been used for irrigation of a citrus orchard. Since 1940 only one of the wells has been operated. Use of this well was discontinued in 1958 and replaced by water purchased from the City of Los Angeles. This well is located on property owned by the State of California.

Defendant No. Doe Corporation 5 - Equitable Life Assurance Society of U. S.

This defendant was named as having an interest in property owned by the City of Glendale, Defendant 2.

Defendant No. Doe Corporation 6 - Title Insurance and Trust Company

Same as Defendant Doe Corporation 5.

Defendant No. Doe Corporation 7 - Northwestern Mutual Life Insurance Corporation

Same as Defendant Doe Corporation 5.

Defendant No. Doe Corporation 8 - Title Insurance and Trust Company

Same as Defendant Doe Corporation 5.

Defendant No. Doe Corporation 9 - Fidelity Federal Savings and Loan Association

Same as Doe Corporation 5.

Defendant No. Doe 1 - Emily Louise Hermann

In 1940 the defendant acquired the property on which a well was located. The well was used for domestic purposes until 1959 at which time it was capped.

Defendant No. Doe 2 - Henry R. Wheeland

This defendant was named as having an interest in property owned by Elizabeth A. Wheeland, Defendant 205.

Defendant No. Doe 3 - Kenneth M. Morgan

This defendant was named as having an interest in property previously owned by Lester R. Schwaiger, Defendant 195.

Defendant No. Doe 4 - William M. Bell

Same as Defendant Doe 3.

Defendant No. Doe 5 - Sallie C. Bell

Same as Defendant Doe 3.

Defendant No. Doe 6 - Anne Morgan

Same as Defendant Doe 3.

Defendant No. Doe 7 - Irene Evelyn Wright

Same as Defendant Doe 3.

Defendant No. Doe 8 - Ralph Carver Wright

Same as Defendant Doe 3.

Defendant No. Doe 9 - Thelma M. Meeker

This defendant was named as having an interest in property owned by City of Glendale, Defendant 2.

Defendant No. Doe 10 - Carl H. Meeker

Same as Defendant Doe 9.

Defendant No. Doe 11 - Laura J. LeGuay

Same as Defendant Doe 9.

Defendant No. Doe 12 - Gladys J. Amador

Same as Defendant Doe 9.

Defendant No. Doe 13 - Joseph E. Amador

Same as Defendant Doe 9.

Defendant No. Doe 14 - Lester Townes Hope

A well owned by the defendant was drilled in 1951 and has been operated to irrigate the lawn of a golf driving range. The well was abandoned in 1959.

Defendant No. Doe 15 - Dolores Defina Hope

Same as Defendant Doe 14.

Defendant No. Doe 16 - Leonard W. Block

The defendant and Defendant Doe 17 are owners of the Freshpuro Water Company, Defendant 41.

Defendant No. Doe 17 - Margery J. Block

Same as Defendant Doe 16.

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APPENDIX J

DELIVERED WATER IN
UPPER LOS ANGELES RIVER AREA

APPENDIX J

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APPENDIX J

DELIVERED WATER IN UPPER LOS ANGELES RIVER AREA

Delivered water consists of the amount of water utilized in a water supply distribution system. It is comprised of ground water extractions, surface water diversions, water imported into the area and rain and surface runoff which is captured by terminal distribution storage reservoirs. Gross delivered water is defined herein as the total of the foregoing items in contrast to net delivered water, which equals the gross reduced by the amount of water system losses and reservoir evaporation involved in delivering the water to its place of use. Gross and net amounts of delivered water and water system losses for the Upper Los Angeles River area and the valley fill area thereof are evaluated in Chapter V. This appendix deals mainly with determination of delivered water by water service area and contains detailed computations in support of Chapter V.

Water Service Areas

A major portion of the water delivered within the area of investigation is distributed by six agencies. The area served by these agencies includes land within the boundary of the valley fill as well as hill and mountain areas. The location and extent of these water service areas, the names of which appear below, are shown on Plate 19.

1. City of Burbank
2. City of Glendale
3. City of San Fernando

4. City of Los Angeles
   a. Owens Service Area
   b. Narrows Service Area
   c. Mission Wells Service Area
   d. Sunland-Tujunga Service Area

5. Crescenta Valley County Water District

6. La Canada Irrigation District

The place of use of 77 other entities, including individuals, corporations and small water companies extracting ground water, operating within and outside the major water service areas, is shown on Plate 20.

Available Data

The extent of data available concerning gross and net amounts of delivered water for the foregoing six agencies is shown in Table J-1. The amount of water delivered from private wells and small companies was obtained from field investigations by the Referee as detailed in Appendix I. Amounts of extractions and diversions by parties are described individually in Chapter V.

TABLE J-1

EXTENT OF DATA CONCERNING
GROSS AND NET DELIVERED WATER

Service area	Total gross	Total net	Metered sales			
			Residential	Commercial	Industrial	Irrigation
City of Los Angeles west of Burbank	10-1-28 to 9-30-58	10-1-28 to 9-30-58	10-1-28 to 9-30-58	10-1-28 to 9-30-58	a	10-1-28 to 9-30-58
Owens	10-1-28 to 9-30-58	----	----	----	----	----
Mission Wells	10-1-28 to 9-30-58	----	----	----	----	----
Sunland-Tujunga	1-1-31 to 9-30-58	----	----	----	----	----
Narrows[b]	10-1-28 to 9-30-58	----	----	----	----	----
City of Burbank	10-1-28 to 9-30-58	10-1-28 to 9-30-58	10-1-36 to 9-30-58	10-1-36 to 9-30-58	10-1-36 to 9-30-58	10-1-36 to 9-30-58
City of Glendale	10-1-28 to 9-30-58	10-1-28 to 9-30-58	----	----	----	----
City of San Fernando[c]	10-1-28 to 9-30-58	----	----	----	----	----
Crescenta Valley County Water District	10-1-55 to 9-30-58	1-1-36 to 9-30-58	----	----	----	----
La Canada Irrigation District	----	10-1-28 to 2-28-41	----	----	----	----
	----	1-1-43 to 9-30-58	----	----	----	----

a. Included with commercial.
b. Estimated.
c. Partially estimated.

Gross Delivered Water

The gross delivered water shown in Table 20, page 138 is the sum total of the amounts of ground water extractions, surface water diversions, imported waters that remain in the basin, annual fluctuation in terminal storage, rain on reservoirs and runoff into reservoirs that is available for use. The gross delivered water by service areas was determined for each of the service areas in the area of investigation. Service areas located solely outside the valley fill as delineated on Plate 2 are not included herein; however, extractions and diversions by individuals and companies in these areas are listed in Chapter V.

Within a service area, gross delivered water is defined herein as the water produced from within the service area by pumpage or surface diversion plus water entering the service area derived from imported supplies, less any waters transferred out of the service area. Annual amounts of gross deliveries by service areas, derived from information contained in Appendix M and Chapter V, are listed in Table J-3. The summation of the gross amounts of water for the Owens water service area is equal to the sum of the various supplies less water transferred out of the service area and is itemized as follows:

1. Water extracted by the City of Los Angeles measured at the wells within the Owens service area of the City of Los Angeles.

2. Owens River water imported by the City of Los Angeles measured near its point of entry into the service area.

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3. Water extracted by private wells and small water companies in the area.

Less the sum of:

1. Ground water transferred out of the service area by the City of Los Angeles and others.

2. Owens River water transferred out of the service area by the City of Los Angeles.

Gross Available for Distribution

The gross water available for distribution differs from the gross delivered water by the amount of evaporation which takes place at San Fernando, Chatsworth and Encino Reservoirs. The City of Los Angeles water system is the only system which has an appreciable amount of reservoir evaporation. To obtain a uniform delivered water value for each service area and to put the values of each service area on a par with each other, the gross available for distribution was adapted for this purpose. With the exception of the Owens service area of the City of Los Angeles the gross delivered water is equal to the gross available for distribution.

Net Delivered Water

Net delivered water is defined herein as the amount of deliveries which are ultimately applied to the culture within the area. This amount of water is delivered to the consumers or inhabitants and is disposed of through consumptive use, deep percolation, sewage or waste. Net deliveries have been primarily evaluated from the amounts of metered water sales to individual consumers when water is transported to the consumer through a distribution system, as in a municipal water system. However, where the system is not extensive, such as an individual well or small company, the gross delivered amount is utilized since in these instances the water system losses are minor.

Water System Losses

The difference between the gross available for distribution and the sum of net amounts of delivered water, import spread and operational spills, are defined as water system losses. These losses are made up of meter slippage, leaks and breaks in water mains and unmetered water for municipal uses such as construction, sewer flushing and fire protection.

As noted in Table J-1, only the Cities of Burbank and Glendale water service areas and the City of Los Angeles west of Burbank have records of metered water sales throughout the base period. The remainder of the water service areas have only a limited number of years when the amount of net delivered water is available. For periods in which the net delivered water is not measured, an estimate was made based on the gross delivered and the average water system losses for the period of available records.

The water system loss for the entire City of Los Angeles has been computed by the City of Los Angeles, Department of Water and Power, Water Control Section. These values are available only from 1950 through 1959. The average water system losses so determined during this period were 6.1 percent. The water system losses for the four water service areas of the city in the investigation area were computed utilizing the percent loss for the entire city for the period of known record and the average percentage loss for period of no record.

The water system losses have been expressed herein as a percent of the gross delivered water. The annual water system losses for the various water service areas varied from 0 to 25 percent. The mean water system losses for these areas with the number of years of data for which the percent losses could be computed are shown on Table J-2.

TABLE J-2

MEAN WATER SYSTEM LOSSES

Service area	Mean percent loss for period of record	Period of data, years	Mean percent loss for period 1949-58
City of Burbank	7.0	30	5.5
City of Glendale	12.5	30	18.6
City of San Fernando	11.5	16	a
City of Los Angeles[b]	6.1	9	6.1
Crescenta Valley County Water District	13.0	3	a
La Canada Irrigation District	12.7	15	a

a. Incomplete data during the period.
b. Includes all service areas within entire City of Los Angeles.

For small or private water systems where the place of use is small and adjacent to the well or point of diversion the water system losses have been considered as negligible.

Delivered Water by Water Service Areas

Tables J-3, J-4 and J-5 are compilations of the gross and net delivered water and the estimated water system losses for nine major water service areas including a breakdown of the City of Los Angeles into its four component service areas within the Upper Los Angeles River area.

Table J-3 shows the amount of water delivered to the water service areas encompassing the combined San Fernando-Eagle Rock Hydrologic Subareas. Tables J-4 and J-5 list similar information for the Sylmar and Verdugo Hydrologic Subareas. The determination of the gross and net delivered water and the water system losses in each water service area was compiled from the available data shown in Table J-1 unless otherwise noted. The general equation for determining the three categories is as follows:

gross delivered water or gross available for distribution = net delivered + water system losses

The method used to determine the gross and net delivered water and the water system losses for each water service area is tabulated in Table J-6. With the exception of the Owens water service area, the gross delivered water is equal to the sum of the net delivered water plus the water system losses. In the Owens water service area gross delivered water is equal to the sum of net delivered water, spread water, spilled water, water system losses and reservoir evaporation. The various items entering into the delivered water and water system losses in the Owens water service area are discussed in Appendix M.

TABLE J-3

DELIVERED WATER
IN SAN FERNANDO AND EAGLE ROCK HYDROLOGIC SUBAREAS AND TRIBUTARY AREAS

In Acre-Feet

Year	City of Los Angeles											
	Owens Water Service Area									Mission Wells Water Service Area		
	Gross			Net			Spread Owens	Spilled Owens	Water system losses	Gross		
	Owens	Ground water[b]	Total	Owens	Ground water[b]	Total				Ground water[a]	Owens	Total
1928-29	101,990	5,990	107,980	89,490	5,990	95,480	590	8,250	2,680	2,460		2,460
29-30	109,800	5,360	115,160	92,820	5,360	98,180	0	11,460	4,550	2,080		2,080
1930-31	115,280	5,160	120,440	89,190	5,160	94,350	7,280	4,680	13,000	1,500		1,500
31-32	122,330	5,950	128,280	68,010	5,950	73,950	31,740	3,290	15,380	1,170		1,170
32-33	115,220	6,500	121,720	71,070	6,500	77,570	33,430	1,920	7,680	560		560
33-34	101,970	6,080	108,050	76,380	6,080	82,460	20,860	2,010	1,020	1,270		1,270
34-35	100,690	6,470	107,160	68,320	6,470	74,790	30,800	490	- 580	2,040		2,040
1935-36	120,830	6,610	127,440	89,440	6,610	96,050	22,720	560	6,500	2,260		2,260
36-37	95,880	6,260	102,140	80,500	6,260	86,760	9,310	1,920	- 990	2,010		2,010
37-38	90,680	6,980	97,660	70,680	6,980	77,660	7,320	1,760	4,190	2,380		2,380
38-39	101,270	7,460	108,730	77,420	7,460	84,880	14,910	3,420	3,070	2,270		2,270
39-40	83,250	6,990	90,240	68,740	6,990	75,730	3,410	760	8,690	2,220		2,220
1940-41	75,050	5,410	80,460	63,590	5,410	69,000	3,450	0	- 1,130	2,700		2,700
41-42	114,840	5,900	120,740	83,270	5,900	89,170	11,290	6,270	12,490	2,430		2,430
42-43	125,820	5,020	130,840	92,200	5,020	97,220	12,130	8,700	8,820	2,230		2,230
43-44	108,340	5,370	113,710	89,690	5,370	95,060	3,190	2,860	9,210	2,500		2,500
44-45	113,150	5,720	118,870	95,470	5,720	101,190	0	1,310	14,860	2,540		2,540
1945-46	123,670	4,990	128,660	103,240	4,990	108,230	0	7,870	11,420	2,900		2,900
46-47	129,180	3,690	132,870	105,210	3,690	108,900	1,690	7,680	13,360	2,990		2,990
47-48	136,620	3,650	140,270	115,230	3,650	118,880	0	2,940	17,880	2,900		2,900
48-49	135,970	3,300	139,270	119,930	3,300	123,230	0	1,460	13,970	2,540		2,540
49-50	134,740	3,210	137,950	115,730	3,210	118,940	760	1,340	15,970	2,460		2,460
1950-51	154,710	2,640	157,350	129,420	2,640	132,060	2,350	3,940	18,220	2,170	430	2,600
51-52	136,580	3,330	141,910	115,570	3,330	118.900	7,280	2,830	8,800	2,320	0	2,320
52-53	152,840	3,400	156,240	129,830	3,400	133,230	0	5,410	16,530	2,440	650	3,090
53-54	148,820	3,710	152,530	126,600	3,710	130,310	0	3,180	17,910	2,160	510	2,670
54-55	147,920	3,810	151,730	122,810	3,810	126,620	0	7,860	16,160	2,190	650	2,840
1955-56	144,720	3,580	148,300	124,520	3,580	128,100	1,610	4,000	13,040	1,930	1,160	3,090
56-57	156,240	3.690	159,930	140,550	3,690	144,240	0	1,570	13,090	2,430	1,230	3,660
57-58	151,620	3,040	154,660	135,610	3,040	138,650	0	0	12,420	1,690	1,880	3,570

DELIVERED WATER
IN SAN FERNANDO AND EAGLE ROCK HYDROLOGIC SUBAREAS AND TRIBUTARY AREAS
(continued)

In Acre-Feet

Year	City of Los Angeles																
	Mission Wells Water Service Area						Sunland-Tujunga Water Service Area										
	Net			Water system losses			Gross				Net				Water system losses		
	Ground water[a]	Owens	Total	Ground water[a]	Owens	Total	Ground water[a]	Owens	Ground water[b]	Total	Ground water[a]	Owens	Ground water[b]	Total	Ground water[a]	Owens	Total
1928-29	2,360		2,360	100		100	530		50	580	510		50	560	20		20
29-30	2,000		2,000	80		80	590		50	640	570		50	620	20		20
1930-31	1,440		1,440	60		60	650		50	700	620		50	670	30		30
31-32	1,120		1,120	50		50	720		50	770	690		50	740	30		30
32-33	530		530	30		30	730		50	780	700		50	750	30.		30
33-34	1,210		1,210	60		60	770		20	790	730		20	750	40		40
34-35	1,940		1,940	100		100	640		20	660	610		20	630	30		30
1935-36	2,140		2,140	120		120	720		20	740	680		20	700	40		40
36-37	1,910		1,910	100		100	780		20	800	740		20	760	40		40
37-38	2,250		2,250	130		130	950		20	970	900		20	920	50		50
38-39	2,140		2,140	130		130	1,010		20	1,030	950		20	970	60		60
39-40	2,090		2,090	130		130	990		20	1,010	930		20	950	60		60
1940-41	2,540		2,540	160		160	970		20	990	910		20	930	60		60
41-42	2,280		2,280	150		150	1,140		20	1,160	1,070		20	1,090	70		70
42-43	2,100		2,100	130		130	1,420		20	1,440	1,330		20	1,350	90		90
43-44	2,350		2,350	150		150	1,470		20	1,490	1,380		20	1,400	90		90
44-45	2,360		2,360	180		180	1,550		20	1,570	1,440		20	1,460	110		110
1945-46	2,730		2,730	170		170	1,880		20	1,900	1,770		20	1,790	110		110
46-47	2,840		2,840	150		150	1,900		20	1,920	1,800		20	1,820	100		100
47-48	2,720		2,720	180		180	2,330		20	2,350	2,190		20	2,210	140		140
48-49	2,360		2,360	180		180	2,440		20	2,460	2,270		20	2,290	170		170
49-50	2,300		2,300	160		160	2,460		20	2,480	2,300		20	2,320	160		160
1950-51	2,010	400	2,410	160	30	190	1,950	570		2,520	1,800	530		2,330	150	40	190
51-52	2,140	0	2,140	180	0	180	1,940	380		2,320	1,790	350		2,140	150	30	180
52-53	2,240	600	2,840	200	50	250	2,270	1,590		3,860	2,090	1,460		3,550	180	130	310
53-54	2,000	470	2,470	160	40	200	2,160	1,340		3,500	2,000	1,240		3,240	160	100	260
54-55	2,030	600	2,630	160	50	210	2,140	1,080		3,220	1,980	1,000		2,980	160	80	240
1955-56	1,760	1,060	2,820	170	100	270	2,530	1,020		3,550	2,310	930		3,240	220	90	310
56-57	2,220	1,120	3,340	210	110	320	2,500	1,080		3,580	2,280	990		3,270	220	90	310
57-58	1,540	1,710	3,250	150	170	320	3,030	630		3,660	2,760	570		3,330	270	60	330

TABLE J-3

DELIVERED WATER
IN SAN FERNANDO AND EAGLE ROCK HYDROLOGIC SUBAREAS AND TRIBUTARY AREAS
(continued)

In Acre-Feet

Year	City of Los Angeles, Narrows Water Service Area													
	Gross					Net					Water system losses			
	Ground water[a]	M.W.D.	Owens	Ground water[b]	Total	Ground water[a]	M.W.D.	Owens	Ground water[b]	Total	Ground water[a]	M.W.D.	Owens	Total
1928-29	8,160			2,430	10,590	7,900			2,430	10,330	260			260
29-30	8,200			2,890	11,090	7,940			2,890	10,830	260			260
1930-31	9,460			2,740	12,200	9,160			2,740	11,900	300			300
31-32	8,870			2,260	11,130	8,580			2,260	10,840	290			290
32-33	8,860			2,360	11,220	8,560			2,360	10,920	300			300
33-34	9,080			2,790	11,870	8,760			2,790	11,550	320			320
34-35	8,120			2,890	11,010	7,820			2,890	10,710	300			300
1935-36	8,600			2,820	11,420	8,290			2,820	11,110	310			310
36-37	9,430			2,780	12,210	9,100			2,780	11,880	330			330
37-38	10,410			2,530	12,940	10,040			2,530	12,570	370			370
38-39	11,580			2,430	14,010	11,160			2,430	13,590	420			420
39-40	11,020			2,670	13,690	10,600			2,670	13,270	420			420
1940-41	10,320			2,670	12,990	9,900			2,670	12,570	420			420
41-42	11,340			2,450	13,790	10,830			2,450	13,280	510			510
42-43	11,590			2,800	14,390	11,080			2,800	13,880	510			510
43-44	11,460			2,790	14,250	10,940			2,790	13,730	520			520
44-45	11,760	150		2,810	14,720	11,130	140		2,810	14,080	630	10		640
1945-46	13,430	870		3,280	17,580	12,890	820		3,280	16,990	540	50		590
46-47	11,860	1,270		3,410	16,540	11,400	1,210		3,410	16,020	460	60		520
47-48	12,400	1,330		3,400	17,130	11,830	1,250		3,400	16,480	570	80		650
48-49	12,650	1,340		3,500	17,490	12,000	1,250		3,500	16,750	650	90		740
49-50	12,300	480	1,300	3,440	17,520	11,720	450	1,220	3,440	16,830	580	30	80	690
50-51	11,660	660	2,160	3,370	17,850	11,050	610	2,000	3,370	17,030	610	50	160	820
51-52	10,610	890	2,460	3,470	17,430	10,020	820	2,270	3,470	16,580	590	70	190	850
52-53	11,340	1,180	2,270	3,360	18,150	10,660	1,080	2,090	3,360	17,190	680	100	180	960
53-54	8,440	4,500	1,520	3,310	17,770	8,030	4,170	1,410	3,310	16,920	410	330	110	850
54-55	5,740	6,530	1,590	3,260	17,120	5,520	6,050	1,470	3,260	16,300	220	480	120	820
1955-56	6,350	5,190	1,770	3,360	16,670	6,010	4,740	1,620	3,360	15,730	340	450	150	940
56-57	5,600	6,370	2,250	3,580	17,800	5,350	5,820	2,050	3,580	16,800	250	550	200	1,000
57-58	3,170	7,050	2,540	3,010	15,770	3,080	6,420	2,310	3,010	14,820	90	630	230	950

DELIVERED WATER
IN SAN FERNANDO AND EAGLE ROCK HYDROLOGIC SUBAREAS AND TRIBUTARY AREAS
(continued)

In Acre-Feet

Year	City of Glendale Water Service Area											City of San Fernando Water Service Area				
	Gross				Net				Water system losses			Gross		Net		Water system losses
	Ground water[e]	M.W.D.	Ground water[f]	Total	Ground water[e]	M.W.D.	Ground water[f]	Total	Ground water[e]	M.W.D.	Total	Ground water[g]	Total	Ground water[g]	Total	
1928-29	8,140		220	8,360	7,560		220	7,780	580		580	1,000	1,000	880	880	120
29-30	9,140		260	9,400	8,140		260	8,400	1,000		1,000	1,030	1,030	910	910	120
1930-31	9,660		280	9,940	8,460		280	8,740	1,200		1,200	1,070	1,070	940	940	130
31-32	8,850		280	9,130	7,480		280	7,760	1,370		1,370	1,080	1,080	950	950	130
32-33	8,660		280	8,940	7,400		280	7,680	1,260		1,260	1,160	1,160	1,010	1,010	150
33-34	9,100		250	9,350	7,830		250	8,080	1,270		1,270	1,200	1,200	1,030	1,030	170
34-35	7,940		210	8,150	7,000		210	7,210	940		940	1,100	1,100	950	950	150
1935-36	9,280		260	9,540	8,120		260	8,380	1,160		1,160	1,300	1,300	1,150	1,150	150
36-37	9,130		230	9,360	8,310		230	8,540	820		820	1,310	1,310	1,130	1,130	180
37-38	9,730		260	9,990	8,740		260	9,000	990		990	1,280	1,280	1,110	1,110	170
38-39	10,790		270	11,060	9,770		270	10,040	1,020		1,020	1,400	1,400	1,200	1,200	200
39-40	10,740		260	11,000	9,770		260	10,030	970		970	1,390	1,390	1,240	1,240	150
1940-41	10,640		270	10,910	9,760		270	10,030	880		880	1,380	1,380	1,210	1,210	170
41-42	11,550		280	11,830	10,590		280	10,870	960		960	1,590	1,590	1,350	1,350	240
42-43	12,520		310	12,830	11,640		310	11,950	880		880	1,700	1,700	1,470	1,470	230
43-44	12,810		280	13,090	12,110		280	12,390	700		700	1,630	1,630	1,440	1,440	190
44-45	13,360		300	13,660	12,350		300	12,650	1,010		1,010	1,700	1,700	1,570	1,570	130
1945-46	15,170	270	330	15,770	13,670	240	330	14,240	1,500	30	1,530	1,790	1,790	1,640	1,640	150
46-47	16,100	1,000	420	17,520	13,940	870	420	15,230	2,160	130	2,290	1,880	1,880	1,660	1,660	220
47-48	17,800	510	410	18,720	14,900	430	410	15,740	2,900	80	2,980	2,160	2,160	1,910	1,910	250
48-49	18,590	60	470	19,120	15,240	50	470	15,760	3,350	10	3,360	2,290	2,290	2,140	2,140	150
49-50	16,030	270	450	16,750	13,770	230	450	14,450	2,260	40	2,300	2,240	2,240	2,010	2,010	230
1950-51	16,460	920	400	17,780	14,010	780	400	15,190	2,470	140	2,610	2,230	2,230	2,010	2,010	220
51-52	15,400	1,230	370	17,000	13,240	1,060	370	14,700	2,120	170	2,290	2,110	2,110	1,950	1,950	160
52-53	17,620	1,080	330	19,030	14,540	890	330	15,760	3,080	190	3,270	1,800	1,800	1,590	1,590	210
53-54	17,590	1,550	310	19,450	14,340	1,270	310	15,920	3,250	280	3,530	1,760	1,760	1,560	1,560	200
54-55	19,630	780	300	20,710	14,700	580	300	15,580	4,970	200	5,170	2,160	2,160	1,910	1,910	250
1955-56	17,790	1,960	330	20,080	13,550	1,500	330	15,380	4,240	460	4,700	2,730	2,730	2,410	2,410	320
56-57	19,910	2,050	390	22,350	15,010	1,550	390	16,950	4,900	500	5,400	2,320	2,320	2,060	2,060	260
57-58	15,390	1,260	320	16,970	13,160	1,080	320	14,560	2,230	180	2,410	2,580	2,580	2,280	2,280	300

TABLE J-5

DELIVERED WATER
IN SAN FERNANDO AND EAGLE ROCK HYDROLOGIC SUBAREAS AND TRIBUTARY AREAS
(continued)

In Acre-Feet

Year	City of Burbank Service Area										
	Gross				Net				Water system losses		
	Ground water[c]	M.W.D.	Ground water[d]	Total	Ground water[c]	M.W.D.	Ground water[d]	Total	Ground water	M.W.D.	Total
1928-29	2,560		790	3,350	2,380		790	3,170	180		180
29-30	2,900		810	3,710	2,540		810	3,350	360		360
1930-31	2,810		810	3,620	2,550		810	3,360	260		260
31-32	2,460		810	3,270	2,280		810	3,090	180		180
32-33	2,510		810	3,320	2,310		810	3,120	200		200
33-34	2,820		950	3,770	2,580		950	3,530	240		240
34-35	2,740		790	3,530	2,490		790	3,280	250		250
1935-36	3,030		750	3,780	2,730		750	3,480	300		300
36-37	3,140		980	4,120	2,940		980	3,920	200		200
37-38	3,840		1,250	5,090	3,520		1,250	4,770	320		320
38-39	5,380		1,280	6,660	4,800		1,280	6,080	580		580
39-40	6,250	70	1,560	7,880	5,710	60	1,560	7,330	540	10	550
1940-41	7,420	250	1,480	9,150	7,040	240	1,480	8,760	380	10	390
41-42	10,220	420	1,370	12,010	9,590	390	1,370	11,350	630	30	660
42-43	11,570	1,200	1,520	14,290	10,890	1,150	1,520	13,560	680	50	730
43-44	12,710	710	1,470	14,890	12,140	680	1,470	14,290	570	30	600
44-45	13,740	610	1,560	15,910	12,930	570	1,560	15,060	810	40	850
1945-46	13,590	1,070	1,480	16,140	12,710	1,000	1,480	15,190	880	70	950
46-47	13,220	2,200	1,680	17,100	12,590	2,090	1,680	16,360	630	110	740
47-48	15,730	700	1,690	18,120	13,860	620	1,690	16,170	1,870	80	1,950
48-49	16,050	330	1,840	18,220	15,330	320	1,840	17,490	720	10	730
49-50	16,340	210	1,850	18,400	15,650	200	1,850	17,700	690	10	700
1950-51	17,760	840	1,920	20,520	16,680	790	1,920	19,390	1,080	50	1,130
51-52	18,020	1,660	2,250	21,930	17.080	1,570	2,250	20,900	940	90	1,030
52-53	19,900	2,570	2,530	25,000	18,010	2,330	2,530	22,870	1,890	240	2,130
53-54	20,780	2,430	2,660	25,870	19,930	2,330	2,660	24,920	850	100	950
54-55	21,520	1,430	2,630	25,580	20,290	1,350	2,630	24,270	1,230	80	1,310
1955-56	20,760	1,700	2,370	24,830	19,800	1,620	2,370	23,790	960	80	1,040
56-57	20,670	3,070	2,090	25,830	19,780	2,940	2,090	24,810	890	130	1,020
57-58	19,050	3,320	2,470	24,840	18,040	3,140	2,470	23,650	1,010	180	1,190

a. Extracted by City of Los Angeles.
b. Extracted by other than City of Los Angeles.
c. Extracted by City of Burbank.
d. Extracted by other than City of Burbank.
e. Extracted by City of Glendale.
f. Extracted by other than City of Glendale.
g. Extracted by City of San Fernando.

Note: Minor amounts of surface water diversions are included under the columns entitled ground water.

Year	Outside major service area	
	Ground water	
	Gross	Net
1928-29	300	300
29-30	300	300
1930-31	300	300
31-32	300	300
32-33	300	300
33-34	450	450
34-35	390	390
1935-36	350	350
36-37	330	330
37-38	370	370
38-39	400	400
39-40	510	510
1940-41	430	430
41-42	570	570
42-43	490	490
43-44	580	580
44-45	940	940
1945-46	1,010	1,010
46-47	980	980
47-48	960	960
48-49	980	980
49-50	990	990
1950-51	1,070	1,070
51-52	1,080	1,080
52-53	1,130	1,130
53-54	1,130	1,130
54-55	420	420
1955-56	640	640
56-57	880	880
57-58	1,050	1,050

TABLE J-4

DELIVERED WATER
IN SYLMAR HYDROLOGIC SUBAREA AND TRIBUTARY AREAS

In Acre-Feet

Year	Owens Water Service Area							City of San Fernando Water Service Area						
	Gross			Net			Water system losses	Gross			Net			Water system losses
	Owens	Ground water[a]	Total	Owens	Ground water[a]	Total		Ground water[b]	Ground water[c]	Total	Ground water[b]	Ground water[c]	Total	
1928-29	3,760	1,270	5,030	3,610	1,270	4,880	150	100	70	170	90	70	160	10
29-30	3,210	1,270	4,480	3,080	1,270	4,350	130	110	70	180	100	70	170	10
1930-31	3,010	1,270	4,280	2,880	1,270	4,150	130	110	70	180	100	70	170	10
31-32	2,490	1,270	3,760	2,380	1,270	3,650	110	110	70	180	100	70	170	10
32-33	3,390	1,140	4,530	3,230	1,140	4,370	160	120	70	190	110	70	180	10
33-34	2,980	1,350	4,330	2,840	1,350	4,190	140	120	70	190	100	70	170	20
34-35	2,960	1,100	4,060	2,810	1,100	3,910	150	110	70	180	90	70	160	20
1935-36	4,080	960	5,040	3,870	960	4,830	210	140	70	210	120	70	190	20
36-37	3,390	1,130	4,520	3,210	1,130	4,340	180	140	80	220	120	80	200	20
37-38	2,570	1,670	4,240	2,430	1,670	4,100	140	130	80	210	110	80	190	20
38-39	3,080	1,640	4,720	2,910	1,640	4,550	170	150	80	230	130	80	210	20
39-40	2,680	1,590	4,270	2,520	1,590	4,110	160	140	80	220	120	80	200	20
1940-41	2,800	1,710	4,510	2,630	1,710	4,340	170	140	50	190	120	50	170	20
41-42	3,590	1,800	5,390	3,370	1,800	5,170	220	160	50	210	140	50	190	20
42-43	4,380	1,730	6,110	4,120	1,730	5,850	160	180	50	230	160	50	210	20
43-44	4,530	1,720	6,250	4,260	1,720	5,980	270	170	50	220	150	50	200	20
44-45	4,790	1,690	6,480	4,450	1,690	6,140	340	180	50	230	170	50	220	10
1945-46	5,290	1,710	7,000	4,980	1,710	6,690	310	190	50	240	170	50	220	20
46-47	6,160	1,650	7,810	5,850	1,650	7,500	310	200	50	250	180	50	230	20
47-48	6,500	1,650	8,150	6,100	1,650	7,750	400	220	50	270	200	50	250	20
48-49	6,410	1,690	8,100	5,960	1,690	7,650	450	240	50	290	220	50	270	20
49-50	5,750	1,590	7,340	5,380	1,590	6,970	370	230	50	280	210	50	260	20
1950-51	5,990	1,610	7,600	5,540	1,610	7,150	450	230	0	230	210	0	210	20
51-52	5,120	1,310	6,430	4,730	1,310	6,040	390	220	0	220	200	0	200	20
52-53	6,150	1,060	7,210	5,650	1,060	6,710	500	190	0	190	170	0	170	20
53-54	5,350	1,060	6,410	4,950	1,060	6,010	400	180	0	180	160	0	160	20
54-55	5,650	1,060	6,710	5,230	1,060	6,290	420	220	0	220	200	0	200	20
1955-56	5,480	1,040	6,520	5,000	1,040	6,040	480	280	0	280	250	0	250	30
56-57	6,530	1,030	7,560	5,960	1,030	6,990	570	240	0	240	210	0	210	30
57-58	5,620	930	6,550	5,120	930	6,050	500	270	0	270	240	0	240	30

Note: Minor amounts of surface water diversions are included under the columns entitled "ground water".

a. Extracted by Defendants and nonparties. Includes total amounts extracted by Defendants Numbers 141 and 181 who are partially outside the service area.

b. Extracted by City of San Fernando.

c. Extracted by other than City of San Fernando.

TABLE J-5

DELIVERED WATER
IN VERDUGO HYDROLOGIC SUBAREA AND TRIBUTARY AREAS

In Acre-Feet

Year	Crescenta Valley County Water District Service Area										
	Gross				Net				Water system losses		
	Ground water[a]	M.W.D.	Ground water[b]	Total	Ground water[a]	M.W.D.	Ground water[b]	Total	Ground water[a]	M.W.D.	Total
1928-29	750			750	650			650	100		100
29-30	750			750	650			650	100		100
1930-31	750			750	650			650	100		100
31-32	710			710	620			620	90		90
32-33	730			730	640			640	90		90
33-34	890			890	770			770	120		120
34-35	660			660	570			570	90		90
1935-36	640			640	560			560	80		80
36-37	690			690	600			600	90		90
37-38	750			750	650			650	100		100
38-39	800			800	700			700	100		100
39-40	850			850	740			740	110		110
1940-41	790			790	690			690	100		100
41-42	1,020			1,020	890			890	130		130
42-43	940		20	960	820		20	840	120		120
43-44	1,110		30	1,140	970		30	1,000	140		140
44-45	1,040		20	1,060	900		20	920	140		140
1945-46	1,360		20	1,380	1,180		20	1,200	180		180
46-47	1,640		20	1,660	1,430		20	1,450	210		210
47-48	2,210		20	2,230	1,920		20	1,940	290		290
48-49	1,900		20	1,920	1,650		20	1,670	250		250
49-50	2,000		20	2,020	1,740		20	1,760	260		260
1950-51	2,210		20	2,230	1,920		20	1,940	290		290
51-52	2,400		20	2,420	2,090		20	2,110	310		310
52-53	2,760		20	2,780	2,400		20	2,420	360		360
53-54	2,960		20	2,980	2,580		20	2,600	380		380
54-55	2,340	490	20	2,850	2,030	430	20	2,480	310	60	370
1955-56	2,250	890	10	3,150	1,940	770	10	2,720	310	120	430
56-57	2,290	1,010	20	3,320	2,020	890	20	2,930	270	120	390
57-58	2,670	620	10	3,300	2,310	540	10	2,860	360	80	440

DELIVERED WATER
IN VERDUGO HYDROLOGIC SUBAREA AND TRIBUTARY AREAS
(continued)

In Acre-Feet

Year	City of Glendale Water Service Area									La Canada Irrigation District Water Service Area								
	Gross			Net			Water system losses			Gross			Net			Water system losses		
	Ground water[c]	M.W.D.	Total	Ground water[c]	M.W.D.	Total	Ground water[c]	M.W.D.	Total	Ground water[d]	M.W.D.	Total	Ground water[d]	M.W.D.	Total	Ground water[d]	M.W.D.	Total
1928-29	500		500	460		460	40		40	140		140	120		120	20		20
29-30	570		570	510		510	60		60	150		150	130		130	20		20
1930-31	630		630	550		550	80		80	150		150	130		130	20		20
31-32	640		640	540		540	100		100	150		150	120		120	30		30
32-33	710		710	610		610	100		100	150		150	130		130	20		20
33-34	940		940	810		810	130		130	150		150	130		130	20		20
34-35	930		930	820		820	110		110	120		120	110		110	10		10
1935-36	990		990	870		870	120		120	160		160	140		140	20		20
36-37	1,130		1,130	1,030		1,030	100		100	160		160	140		140	20		20
37-38	1,180		1,180	1,060		1,060	120		120	180		180	150		150	30		30
38-39	1,250		1,250	1,130		1,130	120		120	210		210	190		190	20		20
39-40	1,430		1,430	1,300		1,300	130		130	200		200	170		170	30		30
1940-41	1,350		1,350	1,240		1,240	110		110	210		210	180		180	30		30
41-42	1,560		1,560	1,430		1,430	130		130	240		240	210		210	30		30
42-43	1,700		1,700	1,580		1,580	120		120	280		280	240		240	40		40
43-44	1,700		1,700	1,610		1,610	90		90	290		290	250		250	40		40
44-45	1,800		1,800	1,660		1,660	140		140	270		270	230		230	40		40
1945-46	2,070		2,070	1,870		1,870	200		200	350		350	300		300	50		50
46-47	2,180		2,180	1,890		1,890	290		290	380		380	330		330	50		50
47-48	2,160		2,160	1,810		1,810	350		350	430		430	370		370	60		60
48-49	2,190		2,190	1,800		1,800	390		390	470		470	410		410	60		60
49-50	2,300		2,300	1,980		1,980	320		320	500		500	440		440	60		60
1950-51	2,490	70	2,560	2,140	60	2,200	370	10	380	470	80[f]	550	410	70[f]	480	60	10[f]	70
51-52	2,090	80	2,170	2,030	70	2,100	330	10	340	540	30	570	470	30	500	70	0	70
52-53	2,810	80	2,890	2,410	60	2,470	510	20	530	610	110	720	530	100	630	80	10	90
53-54	3,340	150	3,490	2,810	120	2,930	640	30	670	640	120	760	560	100	660	80	20	100
54-55	3,460	60	3,520	2,690	40	2,730	910	20	930	450	280	730	400	250	650	50	30	80
1955-56	4,080	310	4,390	3,130	240	3,370	970	70	1,040	280	510	790	250	450	700	30	60	90
56-57	4,430	350	4,780	3,340	270	3,610	1,090	80	1,170	440	400	840	390	360	750	50	40	90
57-58	5,060	350	5,410	4,330	300	4,630	730	50	780	350	450	800	310	410	720	40	40	80

TABLE J-5

DELIVERED WATER
IN VERDUGO HYDROLOGIC SUBAREA AND TRIBUTARY AREAS
(continued)

In Acre-Feet

Year	Sunland-Tujunga Water Service Area								
	Gross			Net			Water system losses		
	Ground water[e]	Owens	Total	Ground water[e]	Owens	Total	Ground water[e]	Owens	Total
1928-29	70		70	70		70			
29-30	80		80	80		80			
1930-31	90		90	90		90			
31-32	100		100	100		100			
32-33	100		100	100		100			
33-34	110		110	100		100	10		10
34-35	90		90	90		90	0		0
1935-36	100		100	90		90	10		10
36-37	110		110	100		100	10		10
37-38	130		130	120		120	10		10
38-39	140		140	130		130	10		10
39-40	140		140	130		130	10		10
1940-41	130		130	120		120	10		10
41-42	160		160	150		150	10		10
42-43	190		190	180		180	10		10
43-44	200		200	190		190	10		10
44-45	210		210	200		200	10		10
1945-46	260		260	240		240	20		20
46-47	260		260	250		250	10		10
47-48	320		320	300		300	20		20
48-49	330		330	310		310	20		20
49-50.	330		330	310		310	20		20
1950-51	270	80	350	250	70	320	20	10	30
51-52	270	50	320	250	50	300	20	0	20
52-53	310	220	530	280	200	480	30	20	50
53-54	290	180	470	270	170	440	20	10	30
54-55	290	150	440	270	140	410	20	10	30
1955-56	350	140	490	320	130	450	30	10	40
56-57	340	150	490	310	140	450	30	10	40
57-58	410	90	500	370	80	450	40	10	50

a. Extracted by Crescenta Valley County Water District.
b. Extracted by other than Crescenta Valley County Water District.
c. Extracted by City of Glendale.
d. Extracted by La Canada Irrigation District.
e. Extracted by City of Los Angeles.
f. Imported from Monk Hill Basin.

Note: Minor amounts of surface water diversions are included under the columns entitled ground water.

TABLE J-6

METHOD OF DETERMINING GROSS, NET DELIVERED WATER AND WATER SYSTEM LOSSES

Service area	Gross	Net	Water system losses
Mission Wells	Extractions and measured Owens River water entering the service area.	Estimated by subtraction of water system losses.	Percent of the average annual water system losses for the City of Los Angeles
Sunland-Tujunga	Extractions, surface diversions and measured Owens River water entering the service area.	Estimated by subtraction of water system losses.	Percent of the average annual water system losses for the City of Los Angeles.
Owens	Owens River water remaining in service area plus change in reservoir storage, rain and surface runoff into reservoirs.	Measured metered sales for City of Los Angeles west of Burbank plus spilled and spread Owens River water less the net delivered to the Mission Wells and Sunland-Tujunga service areas.	Difference between gross available for distribution and net delivered plus spread and spilled Owens River water.
Narrows	Measured amounts of water entering the area from various City of Los Angeles reservoirs plus extractions from private wells.	Estimated as discussed in Appendix M.	Percent of the average annual water system losses for the City of Los Angeles.
Burbank	Ground water extractions by the city and private wells plus imports.	Measured metered sales.	Difference between gross and net delivered water.
Glendale	Ground water extractions by the city and private wells plus imports.	Measured metered sales	Difference between gross and net delivered water.
San Fernando	Ground water extractions by the city and private wells plus imports.	Partially measured and partially estimated.	Average percentage water system losses for years when the net delivered water is not measured.
Crescenta Valley County Water District	Ground water extractions by the District and private wells plus imports.	Partially measured and partially estimated.	Average percentage water system losses for years when the net delivered water is not measured.
La Canada Irrigation District	Ground water extractions by the District and private wells plus imports.	Partially measured and partially estimated.	Average percentage water system losses for years when the net delivered water is not measured.

Consumer's Use of Water

The net delivered water to the consumer may be divided into three groups:

1. Irrigation.
2. Domestic (including water used for irrigation of lawns and gardens in residential areas).
3. Commercial and industrial.

The City of Los Angeles tabulates its billings according to irrigation, domestic, commercial and industrial; however, the billings are based more on the type of electrical service supplied rather than on land use classifications utilized by the Referee.

Commercial billings include multiple dwellings where the water service is measured on a master meter and paid for by the landlord or proprietor. Such dwellings would be classified in the residential category in the Referee's culture survey and should be considered as such from a water use viewpoint.

The City of Los Angeles' industrial classification includes services supplying water to industrial plants which manufacture products from raw materials. The definition for industrial classification by the City of Los Angeles is more restrictive than the definition used by the Referee. Because of these differences in definition no distinction is made herein between commercial and industrial delivered water.

The City of Los Angeles west of Burbank is the only area where the records of the monthly amounts of water delivered for domestic,

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irrigation and commercial classifications, compiled from billings, are available and complete throughout the base period.

Irrigation

The use of water for irrigation at the beginning of the base period constituted a major portion of the total net delivered water. With the increase in urbanization the use of water for irrigation diminished until today it represents only a small part of the net delivered water.

In 1928-29, the City of Los Angeles west of Burbank contained approximately 97 percent of the total irrigated crop acreage in the San Fernando and Sylmar Hydrologic Subareas. In 1957-58, it still contained 94 percent of the total acreage in irrigated crops even though the total acreage was greatly reduced. Water is supplied for irrigation in the area by the City of Los Angeles and by pumpage from private wells.

The total amount of irrigation water used in the San Fernando and Sylmar Hydrologic Subareas was determined as the sum of three parts. The first of these parts is the metered irrigation water delivered in the City of Burbank and in the portion of the City of Los Angeles west of Burbank. Second is the amounts of extractions from private wells used for the purpose of irrigation. The third part is irrigation water used in service areas in which irrigation water is not separately metered. In these areas the amounts were estimated based on the adjusted duty of water for each crop in the service area (see Table J-9, page J-27).

The adjusted duty of water for irrigated crops was derived from data compiled by Frank Carr, an employee of the Los Angeles Department of Water and Power. From 1925 through 1942, the acreage and amount of water delivered to the farmer's headgates were recorded by Mr. Carr for the City of Los Angeles west of Burbank. His records, extending from 1927 through 1942, were utilized to obtain an average duty of water for various crops. The period from 1927 through 1942 was selected because the precipitation cycle during this period represented a more normal rainfall than the 1928 through 1942 period. The average monthly depth of application of irrigation water on crops determined by the use of the Frank Carr's data is shown below in Table J-7.

TABLE J-7

AVERAGE MONTHLY DEPTH OF APPLICATION
OF IRRIGATION WATER*

In Feet

Crop	Month								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May through Sept.	Total
Deciduous	0.24	0.18	0.19	0.11	0.12	0.17	0.25	1.55	2.81
Citrus	0.32	0.29	0.22	0.18	0.17	0.19	0.24	1.81	3.42
Walnuts	0.24	0.30	0.26	0.16	0.14	0.19	0.24	1.58	3.11
Truck	0.34	0.26	0.20	0.21	0.22	0.25	0.31	2.09	3.88
Alfalfa and pasture	0.30	0.25	0.20	0.20	0.22	0.25	0.31	2.02	3.75
Vineyard	0.17	0.11	0.06	0.03	0.03	0.11	0.22	1.38	2.11

* Based on Frank Carr's monthly records of water delivered and acreage served.

The average monthly depths of irrigation water shown in Table J-7 were utilized to prorate the total available water used for irrigation to each crop irrigated in the San Fernando and Sylmar Hydrologic Subareas. The amount of water applied to each crop was then adjusted to an annual depth of irrigation water. The annual adjusted depth of irrigation water for each crop was further proportioned to the percentage of the total annual irrigation water delivered during each month from October through April and during the summer season from May through September.

The amount of irrigation water for each crop and each year in the base period was adjusted by the above method. Sample Calculation A for the year 1928-29 illustrates the method of distributing the available water between the various crops.

SAMPLE CALCULATION A

Adjustment of Delivered Irrigation Water
(Based on Frank Carr's Average Monthly Depth of
Application for San Fernando and Sylmar Hydrologic Subareas)
Year 1928-29

Crop	Deciduous	Citrus	Walnuts	Truck	Alfalfa and pasture	Vineyard	Total
Acreage, in acres	4,470	9,960	8,480	23,920	8,050	1,490	
Average annual depth of irrigation, in feet (from Table J-7)	2.81	3.42	3.11	3.88	3.75	2.11	
Calculated irrigation water, in acre-feet = (1) x (2)	12,560	34,060	26,370	92,810	30,190	3,140	199,130
Adjusted duty,* in feet	1.26	1.54	1.40	1.75	1.69	0.95	
Adjusted duty, in inches	15.1	18.5	16.8	21.0	20.3	11.4	

* Total irrigation water delivered to Owens Service Area by City of Los Angeles = 89,090 acre-feet.

$$\text{Adjustment factor} = \frac{89,090}{199,130} = 0.45$$

0.45 x 2.81 = 1.26 feet for deciduous

The adjusted monthly depths of applied irrigation water were computed as shown in Sample Calculation B and are compiled in Table J-8 for each crop and each year in the base period and 1957-58.

SAMPLE CALCULATION B

Monthly Distribution of Delivered Irrigation Water
City of Los Angeles West of Burbank

Year 1928-29	Metered sales, in acre-feet	Percentage of[a] annual delivery		Depth of irrigation[b] for deciduous, in inches	
October	5,662	6.8		1.0	
November	2,530	3.0		0.5	
December	601	0.7		0.1	
January	1,110	1.3		0.2	
February	168	0.2		0.1	
March	1,050	1.3		0.2	
April	3,540	4.3		0.6	
May	9,513	11.4)			
June	11,925	14.3)			
July	19,015	22.9)	82.4		12.4
August	18,137	21.8)			
September	9,977	12.0)			
TOTAL	83,228	100.0		15.1	

a. Monthly delivered water divided by annual delivered water.
b. Annual duty times percent of water delivered,
(i.e. 15.1" x 6.8% = 1.0").

TABLE J-8

MONTHLY DEPTHS OF DELIVERED IRRIGATION WATER FOR IRRIGATED CROPS

In Acre-Inches per Gross Acre

Year	Deciduous										Citrus									
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Sub-total	May-Sept.	Total	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Sub-total	May-Sept.	Total
1928-29	1.0	0.5	0.1	0.2	0.1	0.2	0.6	2.6	12.4	15.1	1.3	0.6	0.1	0.2	0	0.2	0.8	3.2	15.2	18.4
29-30	1.1	0.8	0.6	0.2	0.1	0.1	0.5	3.4	11.4	14.8	1.4	1.1	0.7	0.3	0.1	0.1	0.6	4.3	13.7	18.0
1930-31	1.1	0.8	0.2	0.1	0	0.3	1.7	4.2	10.9	15.1	1.4	1.0	0.3	0.1	0	0.4	2.1	5.3	13.2	18.5
31-32	1.2	0.7	0	0	0	0.2	1.0	3.1	10.1	13.2	1.4	0.8	0	0	0	0.3	1.2	3.7	12.4	16.1
32-33	1.0	1.0	0.3	0.1	0	0.3	0.9	3.6	10.2	13.8	1.2	1.2	0.4	0.1	0.1	0.4	1.1	4.5	12.4	16.9
33-34	1.1	0.8	0.3	0	0.1	0.2	1.1	3.6	10.6	14.2	1.4	0.8	0.3	0.1	0.1	0.2	1.3	4.2	13.1	17.3
34-35	1.1	0.4	0	0	0.1	0.1	0.1	1.8	10.7	12.5	1.3	0.5	0	0	0.1	0.1	0.1	2.1	13.1	15.2
1935-36	1.0	0.5	0.4	0.3	0.2	0.7	0.3	3.4	12.0	15.4	1.2	0.6	0.5	0.3	0.2	1.0	0.4	4.2	14.6	18.8
36-37	1.0	0.7	0.4	0	0	0.1	0.3	2.5	11.3	13.8	1.2	0.8	0.5	0	0	0.1	0.4	3.0	13.7	16.7
37-38	1.2	0.8	0.3	0.1	0	0	0.4	2.8	10.6	13.4	1.4	1.0	0.4	0.1	0	0	0.5	3.4	13.0	16.4
38-39	1.1	0.8	0.5	0	0	0.1	0.6	3.1	11.9	15.0	1.4	1.1	0.6	0	0.1	0.2	0.8	4.2	14.3	18.5
39-40	0.4	0.7	0.5	0.1	0	0.2	0.3	2.2	11.1	13.3	0.5	1.0	0.7	0.1	0	0.2	0.3	2.8	13.5	16.3
1940-41	1.2	0.5	0.5	0	0	0	0.1	2.3	9.8	12.1	1.5	0.6	0.6	0	0	0	0.1	2.8	11.9	14.7
41-42	0.8	0.4	0.2	0.1	0.3	0.5	0.8	3.1	11.6	14.7	1.1	0.5	0.3	0.1	0.3	0.6	1.1	4.0	14.0	18.0
42-43	1.1	0.4	0.8	0.4	0.1	0	0.5	3.3	13.2	16.5	1.7	0.7	0.9	0.7	0.1	0	0.5	4.6	15.2	19.8
43-44	1.5	0.8	0.3	0.1	0	0.3	1.4	4.4	12.2	16.6	2.2	1.3	0.4	0.1	0.1	0.3	1.3	5.7	14.1	19.8
44-45	1.1	0.1	0.3	0.3	0	0	0.9	2.7	14.2	16.9	1.5	0.3	0.3	0.5	0.1	0	0.9	3.6	16.6	20.2
1945-46	0.9	0.8	0.5	0.1	0.3	0.9	0.7	4.2	13.9	18.1	1.3	1.0	0.7	0.3	0.3	1.0	0.7	5.3	16.4	21.7
46-47	1.3	0.4	0	0.1	0.3	0.9	2.5	5.5	14.8	20.3	1.8	0.8	0	0.1	0.4	1.0	2.3	6.4	17.4	23.8
47-48	1.4	0.8	0.3	0.9	0.5	0.9	1.1	5.9	14.6	20.5	1.9	1.1	0.4	1.3	0.8	1.0	1.0	7.5	17.4	24.9
48-49	1.7	1.0	0.7	0	0.1	0.3	2.7	6.5	15.2	21.7	2.3	1.7	0.8	0.1	0.1	0.4	2.7	8.1	17.7	25.8
49-50	1.8	0.8	0.5	0.7	0	0.8	1.9	6.5	7.2	13.7	2.5	1.4	0.5	0.9	0.1	0.8	1.9	8.1	13.3	21.4
1950-51	1.8	0.7	0.7	0.4	0	0.8	2.7	7.1	16.2	23.3	2.5	0.9	0.8	0.5	0	1.0	2.6	8.3	18.8	27.1
51-52	1.9	0.8	0	0	0.1	0.8	0.4	4.0	13.4	17.4	2.7	1.1	0	0	0.3	0.8	0.4	5.3	15.6	20.9
52-53	2.7	0.5	0	0	0.4	1.3	1.7	6.6	13.4	20.0	2.6	0.8	0	0.1	0.7	1.5	1.7	7.4	15.8	23.2
53-54	1.9	0.7	0.9	0.4	0.1	0.3	0.4	4.7	11.5	16.2	2.6	1.0	1.1	0.5	0.3	0.3	0.4	6.2	13.5	19.7
54-55	1.8	0.5	0.3	0	0.1	0.4	1.9	5.0	11.7	16.7	2.5	0.8	0.4	0	0.1	0.4	1.9	6.1	13.7	19.8
1955-56	1.8	0.8	0.1	0.1	0.1	0.7	0.8	4.4	10.9	15.3	2.5	1.0	0.1	0.1	0.1	0.7	0.8	5.3	12.9	18.2
56-57	1.9	1.3	1.5	0.1	0	0.1	0.8	5.7	14.8	20.5	2.6	2.2	1.8	0.3	0.1	0.1	0.8	7.9	17.4	25.3
57-58	0.9	0.4	0.5	0.3	0	0.4	0.4	2.9	14.4	17.3	1.1	0.7	0.7	0.4	0	0.4	0.4	3.7	16.8	20.5

MONTHLY DEPTHS OF DELIVERED IRRIGATION WATER FOR IRRIGATED CROPS
(continued)

In Acre-Inches per Gross Acre

Year	Walnuts										Truck									
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Sub-total	May-Sept.	Total	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Sub-total	May-Sept.	Total
1928-29	1.1	0.5	0.1	0.2	0	0.2	0.7	2.8	13.9	16.7	1.4	0.6	0.1	0.3	0	0.3	0.8	3.5	17.4	20.9
29-30	1.3	1.0	0.7	0.3	0.1	0.1	0.6	4.1	12.3	16.4	1.6	1.2	0.7	0.3	0.2	0.1	0.7	4.8	15.6	20.4
1930-31	1.2	0.8	0.2	0.1	0	0.4	1.9	4.6	12.1	16.7	1.6	1.2	0.3	0.1	0	0.5	2.3	6.0	15.0	21.0
31-32	1.3	0.7	0	0	0	0.3	1.1	3.4	11.1	14.5	1.6	0.9	0	0	0	0.3	1.4	4.2	13.9	18.1
32-33	1.1	1.1	0.3	0.1	0	0.4	1.0	4.0	11.5	15.5	1.4	1.4	0.4	0.1	0.1	0.5	1.2	5.1	14.0	19.1
33-34	1.2	0.8	0.3	0	0.1	0.2	1.2	3.8	11.9	15.7	1.5	1.1	0.4	0.1	0.1	0.3	1.5	5.0	14.6	19.6
34-35	1.2	0.4	0	0	0.1	0.1	0.1	1.9	11.9	13.8	1.5	0.5	0.1	0	0.1	0.1	0.1	2.4	14.9	17.3
1935-36	1.1	0.6	0.5	0.3	0.2	0.8	0.3	3.8	13.3	17.1	1.3	0.7	0.6	0.4	0.3	1.1	0.4	4.8	16.6	21.4
36-37	1.1	0.8	0.4	0	0	0.1	0.3	2.7	12.7	15.4	1.4	1.0	0.5	0	0	0.1	0.4	3.4	15.7	19.1
37-38	1.3	0.8	0.4	0.1	0	0	0.5	3.1	11.7	14.8	1.6	1.1	0.5	0.1	0	0	0.6	3.9	14.7	18.6
38-39	1.3	1.0	0.6	0	0.1	0.2	0.7	3.9	12.9	16.8	1.6	1.3	0.7	0	0.1	0.2	0.9	4.8	16.2	21.0
39-40	0.4	0.8	0.6	0.1	0	0.2	0.3	2.4	12.4	14.8	0.5	1.1	0.6	0.1	0	0.3	0.4	3.0	15.5	18.5
1940-41	1.4	0.5	0.5	0	0	0	0.1	2.5	10.9	13.4	1.7	0.6	0.7	0.1	0	0	0.1	3.2	13.5	16.7
41-42	1.0	0.4	0.2	0.1	0.3	0.6	1.0	3.6	12.8	16.4	1.2	0.6	0.3	0.1	0.4	0.7	1.2	4.5	15.9	20.4
42-43	1.1	0.8	1.1	0.5	0.1	0	0.5	4.1	13.3	17.4	1.7	0.7	0.8	0.7	0.1	0	0.7	4.7	17.6	22.3
43-44	1.5	1.3	0.4	0.1	0.1	0.3	1.3	5.0	12.4	17.4	2.3	1.1	0.3	0.1	0.1	0.4	1.7	6.0	16.3	22.3
44-45	1.1	0.3	0.4	0.5	0.1	0	0.9	3.3	14.5	17.8	1.7	0.3	0.3	0.7	0.1	0	1.3	4.4	19.1	23.5
1945-46	0.9	1.0	0.8	0.3	0.3	1.0	0.7	5.0	14.2	19.2	1.3	0.9	0.5	0.4	0.4	1.4	0.8	5.7	18.8	24.5
46-47	1.3	0.8	0.1	0.1	0.3	1.0	2.3	5.9	15.2	21.1	1.9	0.7	0	0.1	0.5	1.3	2.9	7.4	20.1	27.5
47-48	1.4	1.3	0.4	1.1	0.7	1.0	1.0	6.9	15.1	22.0	2.1	1.0	0.3	1.6	0.8	1.4	1.4	8.6	19.9	28.5
48-49	1.7	1.8	0.8	0	0.1	0.4	2.7	7.5	15.6	23.1	2.5	1.7	0.7	0.1	0.1	0.5	3.5	9.1	20.6	29.7
49-50	1.8	1.4	0.7	0.8	0	0.8	1.9	7.4	7.6	15.0	2.6	1.1	0.5	1.0	0.1	1.0	2.5	8.8	9.9	18.7
1950-51	1.8	0.9	0.8	0.5	0	0.9	2.6	7.5	16.6	24.1	2.5	0.8	0.7	0.7	0	1.1	3.3	9.1	21.9	31.0
51-52	1.9	1.1	0	0	0.3	0.8	0.4	4.5	13.7	18.2	2.8	1.0	0	0	0.4	1.0	0.4	5.6	18.1	23.7
52-53	1.9	0.8	0.1	0	0.5	1.5	1.7	6.5	13.8	20.3	2.6	0.8	0	0.1	0.8	2.1	2.2	8.6	18.3	26.9
53-54	1.9	1.0	1.4	0.5	0.3	0.3	0.4	5.8	11.8	17.6	2.6	0.9	1.0	0.7	0.3	0.4	0.5	6.4	15.6	22.0
54-55	1.8	0.8	0.4	0	0.1	0.4	1.9	5.4	12.0	17.4	2.5	0.8	0.3	0	0.1	0.5	2.5	6.7	15.8	22.5
1955-56	1.8	1.0	0.1	0.1	0.1	0.7	0.8	4.6	11.3	15.9	2.6	0.9	0.1	0.1	0.1	0.9	1.0	5.7	14.8	20.5
56-57	1.9	2.2	2.1	0.3	0.1	0.1	0.8	7.5	15.1	22.6	2.7	1.9	1.5	0.3	0.1	0.3	0.9	7.7	20.1	27.8
57-58	0.9	0.7	0.8	0.3	0	0.4	0.4	3.5	14.7	18.2	1.3	0.5	0.5	0.4	0	0.5	0.5	3.7	19.4	23.1

MONTHLY DEPTHS OF DELIVERED IRRIGATION WATER FOR IRRIGATED CROPS
(continued)

In Acre-Inches per Gross Acre

Year	Alfalfa										Vineyard									
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Sub-total	May-Sept.	Total	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Sub-total	May-Sept.	Total
1928-29	1.4	0.6	0.1	0.3	0	0.3	0.8	3.5	16.7	20.2	0.8	0.3	0.1	0.1	0	0.1	0.5	1.9	9.4	11.3
29-30	1.5	1.2	0.8	0.3	0.2	0.1	0.7	4.8	15.0	19.8	0.8	0.7	0.5	0.2	0.1	0	0.4	2.7	8.3	11.0
1930-31	1.5	1.1	0.3	0.1	0	0.5	2.3	5.8	14.4	20.2	0.8	0.6	0.2	0.1	0	0.3	1.3	3.3	8.0	11.3
31-32	1.6	0.8	0	0	0	0.3	1.3	4.0	13.5	17.5	0.8	0.5	0	0	0	0.2	0.8	2.3	7.4	9.7
32-33	1.3	1.3	0.4	0.1	0.1	0.5	1.2	4.9	13.6	18.5	0.7	0.7	0.2	0.1	0	0.3	0.7	2.7	7.6	10.3
33-34	1.5	1.0	0.4	0.1	0.1	0.3	1.4	4.8	14.3	19.1	0.8	0.6	0.2	0	0.1	0.1	0.8	2.6	7.9	10.5
34-35	1.4	0.5	0.1	0	0.1	0.1	0.1	2.3	14.4	16.7	0.8	0.3	0	0	0	0	0.1	1.2	8.1	9.3
1935-36	1.3	0.7	0.6	0.4	0.3	1.1	0.4	4.8	15.9	20.7	0.7	0.4	0.3	0.2	0.2	0.6	0.2	2.6	8.9	11.5
36-37	1.3	1.0	0.5	0	0	0.1	0.4	3.3	15.2	18.5	0.7	0.6	0.3	0	0	0	0.2	1.8	8.6	10.4
37-38	1.6	1.1	0.5	0.1	0	0	0.6	3.9	14.1	18.0	0.8	0.6	0.3	0.1	0	0	0.3	2.1	7.9	10.0
38-39	1.5	1.2	0.7	0	0.1	0.2	0.8	4.5	15.7	20.2	0.8	0.7	0.4	0	0	0.1	0.5	2.5	8.8	11.3
39-40	0.5	1.0	0.7	0.1	0	0.3	0.4	3.0	15.0	18.0	0.3	0.6	0.4	0.1	0	0.1	0.2	1.7	8.3	10.0
1940-41	1.7	0.6	0.6	0	0	0	0.1	3.0	13.2	16.2	0.8	0.4	0.4	0	0	0	0.1	1.7	7.3	9.0
41-42	1.2	0.5	0.3	0.1	0.4	0.7	1.2	4.4	15.4	19.8	0.7	0.3	0.2	0.1	0.2	0.4	0.7	2.6	8.5	11.1
42-43	1.5	0.7	0.8	0.7	0.1	0.1	0.8	4.7	17.1	21.8	0.8	0.3	0.3	0.1	0	0	0.4	1.9	11.2	13.1
43-44	2.1	1.0	0.3	0.1	0.1	0.4	2.1	6.1	15.8	21.9	1.1	0.5	0.1	0	0	0.1	1.1	2.9	10.9	13.8
44-45	1.4	0.3	0.3	0.5	0.1	0.1	1.5	4.2	18.5	22.7	0.8	0.1	0.1	0.1	0	0	0.9	2.0	12.6	14.6
1945-46	1.1	0.9	0.5	0.4	0.4	1.7	0.9	5.9	18.2	24.1	0.8	0.4	0.1	0	0	0.7	0.7	2.7	11.8	14.5
46-47	1.7	0.7	0	0.1	0.5	1.7	3.6	8.3	19.4	27.7	0.9	0.3	0	0	0.1	0.7	2.2	4.2	12.7	16.9
47-48	1.8	1.0	0.3	1.5	0.8	1.7	1.7	8.8	19.3	28.1	0.9	0.5	0.1	0.3	0.1	0.7	0.9	3.5	12.7	16.2
48-49	2.1	1.4	0.8	0.1	0.1	0.5	4.1	9.1	19.9	29.0	1.1	0.8	0.3	0	0	0.3	2.5	5.0	13.6	18.6
49-50	2.2	1.1	0.5	0.9	0.1	1.3	2.8	8.9	9.6	18.5	1.1	0.5	0.1	0.1	0	0.5	1.8	4.1	6.4	10.5
1950-51	2.2	0.8	0.7	0.7	0	1.5	4.1	10.0	21.1	31.1	1.1	0.4	0.3	0.1	0	0.7	2.5	5.1	14.3	19.4
51-52	2.5	1.0	0	0	0.4	1.3	0.5	5.7	17.5	23.2	1.4	0.5	0	0	0	0.5	0.3	2.7	11.8	14.5
52-53	2.5	0.8	0	0.1	0.8	2.6	2.6	9.4	17.3	26.7	1.3	0.4	0	0	0.1	0.8	1.5	4.1	12.0	16.1
53-54	2.5	0.9	1.0	0.7	0.3	0.4	0.7	6.5	15.0	21.5	1.3	0.4	0.4	0.1	0	0.1	0.4	2.7	10.3	13.0
54-55	2.2	0.8	0.3	0	0.1	0.7	2.8	6.9	15.2	22.1	1.1	0.4	0.1	0	0	0.3	1.7	3.6	10.5	14.1
1955-56	2.3	0.9	0.1	0.1	0.1	1.0	1.1	5.6	14.4	20.0	1.3	0.4	0	0	0	0.4	0.8	2.9	9.7	12.6
56-57	2.5	1.8	1.5	0.3	0.1	0.3	1.1	7.6	19.5	27.1	1.3	0.8	0.5	0.3	0	0.1	0.8	3.8	13.2	17.0
57-58	1.1	0.5	0.5	0.4	0	0.7	0.7	3.9	18.9	22.8	0.8	0.3	0.1	0	0	0.3	0.4	1.9	12.8	14.7

The adjusted duty was computed for each crop for each year in the period 1928-29 through 1957-58 by the method shown in Sample Calculation A. The mean annual adjusted duty for the base period thus derived is shown in Table J-9. These values on the average are slightly higher than those reported in Table 24 of Bulletin No. 51, "Irrigation Requirements of California Crops", California State Division of Water Resources, 1945. Bulletin 51 notes that certain duties such as deciduous appear extremely low and that the values for shallow rooted crops appear more consistent with other crops in California.

TABLE J-9

MEAN ANNUAL ADJUSTED DUTY FOR IRRIGATED CROPS

In Feet

Crop	Adjusted duty	San Fernando Valley Bulletin 51 (1930-37)
Deciduous	1.35	0.54-1.07
Citrus	1.63	1.81
Walnuts	1.20	0.84
Truck	1.85	1.03-2.07
Alfalfa and pasture	1.81	1.86
Vineyards	1.05	0.50

Delivered Water Available for Residential Lawns and Gardens

The portion of water delivered to residential meters for use on lawns and gardens was estimated to determine the consumptive use and deep percolation on residential areas. From 1936-37 through 1957-58, the total sales to residential meters were not tabulated separately except for the City of Los Angeles west of Burbank and the City of Burbank. The amount of water used on residential lawns and gardens was therefore estimated by taking the total net delivered water and deducting the delivered water applied to irrigated crops and commercial and industrial classifications and the net sewage (sewage export plus cesspool recharge minus sewer infiltration). The residual amount was assumed to be applied to the residential lawn and garden areas.

The depths of applied irrigation water for irrigated crops in Table J-8 and the acreage for each crop, as discussed in Appendix K, were utilized to determine the total use on irrigated crops. The amounts of delivered water required by commercial and industrial areas and the portions consumed or percolating are discussed in Appendix L. It is assumed that no deep percolation of delivered water occurred in this classification except in particular instances where it could be evaluated, (i.e. City of Los Angeles Valley Steam Plant and industrial waste discharges to the Los Angeles River) since this classification is primarily impervious.

The available data did not permit the evaluation of sewage contributed from residential, commercial and industrial areas to be separated. The amount of water available for residential lawns and gardens was estimated by subtracting the total sewage and waste, consumptive use and deep percolation of commercial and industrial from the water delivered to residential, commercial and industrial areas.

The annual amount of water estimated as being delivered to residential lawn and garden areas and the estimated component amounts of delivered water are shown in Table J-10. The monthly depth of water applied to lawns and gardens was based on the monthly percentage distribution of the domestic metered sales in the City of Los Angeles west of Burbank. These calculations were made in the same manner as shown in Sample Calculation B for the monthly depth of irrigation water. The monthly percentage of water delivered to domestic meters and the monthly depth of water applied to residential lawns and gardens are shown in Tables J-11 and J-12, respectively. The annual depth of water delivered to residential lawn and garden areas was utilized for the determination of consumptive use and deep percolation on residential areas as discussed in Appendix L.

TABLE J-10

DISPOSITION OF NET DELIVERED WATER BY TYPE OF USE[a]

In Acre-Feet

Year	San Fernando Hydrologic Subarea[b]					Sylmar Hydrologic Subarea					Verdugo Hydrologic Subarea				
	Residential	Commercial and industrial	Irrigation	Sewage	Total	Residential	Commercial and industrial	Irrigation	Sewage	Total	Residential	Commercial and industrial	Irrigation	Sewage	Total
1928-29	16,810	2,490	89,670	10,420	119,390	100	30	4,790	180	5,100	350	30	600	320	1,300
29-30	20,410	2,890	89,940	11,290	124,530	150	30	4,210	190	4,580	420	30	550	370	1,370
1930-31	20,080	3,270	85,920	12,370	121,640	170	30	3,970	210	4,380	450	40	520	410	1,420
31-32	14,110	3,670	68,060	12,990	98,830	120	30	3,530	200	3,880	440	40	510	390	1,380
32-33	13,890	4,070	70,910	13,040	101,910	120	30	4,240	220	4,610	500	40	500	440	1,480
33-34	15,800	4,470	75,530	13,260	109,060	150	30	4,040	200	4,420	590	40	480	600	1,810
34-35	12,500	4,860	69,170	13,380	99,910	130	30	3,760	210	4,130	580	40	460	510	1,590
1935-36	15,610	5,250	88,340	14,190	123,390	170	30	4,680	200	5,080	590	50	500	520	1,660
36-37	16,090	5,650	78,580	15,110	115,430	170	30	4,190	210	4,600	710	50	490	620	1,870
37-38	17,690	6,040	68,730	16,350	108,810	190	30	3,910	220	4,350	780	60	460	680	1,980
38-39	22,460	6,430	73,120	17,950	119,960	290	30	4,240	260	4,820	870	60	450	770	2,150
39-40	22,270	6,830	62,600	19,550	111,250	280	30	3,800	260	4,370	990	70	420	860	2,340
1940-41	19,350	8,490	56,240	21,600	105,680	240	30	4,060	240	4,570	900	70	470	790	2,230
41-42	24,920	10,290	73,300	22,810	131,320	330	30	4,760	300	5,420	1,130	80	480	990	2,680
42-43	29,940	10,820	78,300	23,340	142,400	450	30	5,250	390	6,120	1,200	90	490	1,060	2,840
43-44	31,790	11,360	74,890	23,720	141,760	490	30	5,290	430	6,240	1,330	90	470	1,160	3,050
44-45	34,340	11,800	78,160	25,250	149,630	550	30	5,360	480	6,420	1,310	90	470	1,140	3,010
1945-46	43,120	10,790	81,170	27,060	162,140	710	30	5,620	610	6,970	1,610	100	500	1,400	3,610
46-47	46,000	9,560	78,050	30,360	163,970	850	30	6,190	720	7,790	1,770	110	500	1,540	3,920
47-48	48,300	9,950	81,040	33,500	172,790	940	30	6,260	800	8,030	2,040	120	500	1,760	4,420
48-49	52,670	10,340	79,120	36,620	178,750	1,150	30	5,900	880	7,960	1,920	130	460	1,680	4,190
49-50	56,840	10,490	68,840	39,430	175,600	1,130	40	5,160	950	7,280	2,070	140	440	1,840	4,490
1950-51	60,470	10,650	75,530	44,890	191,540	1,280	50	5,000	1,080	7,410	2,330	140	450	2,020	4,940
51-52	58,210	12,710	58,270	49,300	178,490	1,320	60	3,780	1,120	6,280	2,340	150	480	2,040	5,010
52-53	70,550	12,910	62,540	52,180	198,180	1,640	70	3,830	1,390	6,930	2,870	160	490	2,480	6,000
53-54	72,420	13,640	51,920	58,490	196,470	1,770	80	2,870	1,500	6,220	3,210	180	470	2,770	6,630
54-55	71,010	16,980	41,090	61,700	190,780	1,940	90	2,870	1,640	6,540	3,010	190	450	2,620	6,270
1955-56	71,550	18,160	34,340	68,490	192,540	2,050	110	2,460	1,740	6,360	3,530	200	460	3,050	7,240
56-57	84,740	19,130	35,970	72,140	211,980	2,390	130	2,690	2,030	7,240	3,720	200	610	3,210	7,740
57-58	75,520	19,220	30,230	76,610	201,580	2,110	140	2,290	1,800	6,340	4,210	210	630	3,610	8,660

a. Includes tributary drainage area within major service areas.
b. Includes Eagle Rock Subarea.

TABLE J-11

MONTHLY DISTRIBUTION OF WATER DELIVERED TO DOMESTIC SERVICES IN LOS ANGELES WEST OF BURBANK*

In Percent

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May through Sept.
1928-29	9.6	5.5	3.1	2.7	1.5	2.9	4.7	70.0
29-30	9.3	8.6	5.8	4.0	2.3	2.9	6.0	61.1
1930-31	9.3	7.6	4.2	1.7	1.4	4.9	8.8	62.1
31-32	11.5	7.0	3.5	0.6	0.5	2.0	7.5	67.4
32-33	8.8	6.9	4.9	1.4	0.9	2.9	6.6	67.6
33-34	9.1	6.5	4.8	1.1	1.7	2.3	6.1	68.4
34-35	12.2	5.6	3.5	0.8	0.8	0.0	2.2	74.9
1935-36	7.3	5.2	2.6	2.8	5.1	1.9	4.8	70.3
36-37	10.1	4.1	4.4	1.1	0.2	0.9	2.9	76.3
37-38	11.1	6.4	4.4	1.7	1.0	0.6	4.8	70.0
38-39	9.9	6.0	5.9	1.4	0.2	2.6	4.1	69.9
39-40	8.7	5.2	4.2	2.3	0.2	2.0	4.6	72.8
1940-41	11.9	6.1	4.6	1.6	0.2	0.9	1.6	73.1
41-42	8.9	3.2	2.8	0.6	1.6	3.6	4.1	75.2
42-43	6.0	5.6	3.4	3.0	1.3	1.1	2.9	76.7
43-44	11.1	6.9	3.5	1.7	1.0	2.3	6.1	67.4
44-45	9.1	4.8	2.0	1.4	1.5	2.0	5.0	74.2
1945-46	8.9	5.3	3.2	2.4	2.9	3.8	4.9	68.6
46-47	8.7	4.5	1.7	1.2	2.1	3.5	6.6	71.7
47-48	8.3	5.5	3.8	3.5	3.8	4.0	4.9	66.2
48-49	9.6	6.3	3.7	1.5	0.4	1.7	5.6	71.7
49-50	10.0	6.6	3.3	1.3	1.1	3.2	6.0	68.5
1950-51	8.0	5.2	2.7	1.6	1.4	3.1	5.8	72.2
51-52	11.0	6.5	2.0	0.1	0.3	1.3	3.6	75.2
52-53	9.5	4.9	1.1	0.5	2.6	5.0	6.8	69.6
53-54	10.5	6.8	4.1	3.1	2.4	2.5	3.8	66.8
54-55	10.7	6.4	2.4	0.6	0.5	2.7	5.4	71.3
1955-56	11.9	5.9	1.6	0.0	0.7	3.3	5.2	71.4
56-57	10.3	7.2	5.5	3.2	0.4	0.8	3.4	69.2
57-58	9.1	3.7	2.0	1.5	0.1	0.0	2.4	81.2

* Includes combination services and excludes sewage.

TABLE J-12

DEPTH OF WATER APPLIED TO
RESIDENTIAL LAWNS AND GARDENS*

In Inches

Year	San Fernando and Sylmar Subarea								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May through Sept.	Total
1928-29	2.2	1.3	0.7	0.6	0.3	0.7	1.1	16.0	22.9
29-30	2.3	2.1	1.4	1.0	0.6	0.7	1.5	15.2	24.8
1930-31	2.1	1.7	1.0	0.4	0.3	1.1	2.0	14.1	22.7
31-32	1.5	0.9	0.5	0.1	0.1	0.3	1.0	9.0	13.4
32-33	1.1	0.8	0.6	0.2	0.1	0.4	0.8	8.2	12.2
33-34	1.2	0.9	0.7	0.2	0.2	0.3	0.8	9.4	13.7
34-35	1.2	0.5	0.3	0.1	0.1	0	0.2	7.3	9.7
1935-36	0.9	0.6	0.3	0.3	0.6	0.2	0.6	8.4	11.9
36-37	1.1	0.5	0.5	0.1	0	0.1	0.3	8.4	11.0
37-38	1.3	0.8	0.5	0.2	0.1	0.1	0.6	8.3	11.9
38-39	1.6	1.0	1.0	0.2	0	0.4	0.7	11.4	16.3
39-40	1.3	0.8	0.6	0.3	0	0.3	0.7	10.6	14.6
1940-41	1.4	0.7	0.5	0.2	0	0.1	0.2	8.7	11.8
41-42	1.4	0.5	0.4	0.1	0.2	0.5	0.6	11.4	15.1
42-43	1.2	1.1	0.7	0.6	0.2	0.2	0.6	14.7	19.3
43-44	2.2	1.4	0.7	0.3	0.2	0.5	1.2	13.5	20.0
44-45	2.0	1.0	0.4	0.3	0.3	0.4	1.1	16.0	21.5
1945-46	2.3	1.4	0.8	0.6	0.8	1.0	1.3	18.0	26.2
46-47	2.6	1.3	0.5	0.4	0.6	1.0	2.0	21.4	29.8
47-48	2.6	1.7	1.2	1.1	1.2	1.3	1.6	21.1	31.8
48-49	3.2	2.1	1.3	0.5	0.1	0.6	1.9	24.1	33.8
49-50	3.3	2.2	1.1	0.4	0.4	1.1	2.0	22.7	33.2
1950-51	2.7	1.8	0.9	0.5	0.5	1.1	2.0	24.7	34.2
51-52	3.6	2.1	0.7	0	0.1	0.4	1.2	24.5	32.6
52-53	3.6	1.8	0.4	0.2	1.0	1.9	2.5	26.0	37.4
53-54	4.0	2.6	1.5	1.2	0.9	0.9	1.4	25.3	37.8
54-55	3.7	2.2	0.8	0.2	0.2	0.9	1.9	24.5	34.4
1955-56	4.1	2.1	0.5	0	0.2	1.1	1.8	24.9	34.7
56-57	4.0	2.8	2.2	1.2	0.2	0.3	1.3	26.9	38.9
57-58	2.9	1.2	0.6	0.5	0	0	0.7	26.4	32.3

* Based on percentages in Table J-11.

TABLE J-12

DEPTH OF WATER APPLIED TO
RESIDENTIAL LAWNS AND GARDENS*
(continued)

In Inches

Year	Verdugo Subarea								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May through Sept.	Total
1928-29	1.7	1.0	0.6	0.5	0.3	0.5	0.9	12.7	18.2
29-30	1.9	1.8	1.2	0.8	0.5	0.6	1.2	12.8	20.8
1930-31	2.0	1.6	0.9	0.4	0.3	1.0	1.8	13.0	21.0
31-32	2.3	1.4	0.7	0.1	0.1	0.4	1.5	13.3	19.8
32-33	1.9	1.5	1.1	0.3	0.2	0.6	1.4	14.5	21.5
33-34	2.6	1.8	1.4	0.3	0.5	0.6	1.7	19.3	28.2
34-35	2.8	1.3	0.8	0.2	0.2	0	0.5	17.0	22.8
1935-36	1.6	1.2	0.6	0.6	1.1	0.4	1.1	15.8	22.4
36-37	2.5	1.0	1.1	0.3	0.1	0.2	0.7	19.1	25.0
37-38	2.9	1.6	1.1	0 4	0.3	0.2	1.2	18.0	25.7
38-39	2.7	1.6	1.6	0.4	0.1	0.7	1.1	18.8	27.0
39-40	2.5	1.5	1.2	0.7	0.1	0.6	1.3	20.8	28.7
1940-41	2.8	1.4	1.1	0.4	0	0.2	0.4	17.0	23.3
41-42	2.5	0.9	0.8	0.2	0.4	1.0	1.1	21.1	28.0
42-43	1.6	1.5	0.9	0.8	0.3	0.3	0.8	20.7	26.9
43-44	3.0	1.9	1.0	0.5	0.3	0.6	1.7	18.2	27.2
44-45	2.3	1.2	0.5	0.4	0.4	0.5	1.3	18.4	25.0
1945-46	2.5	1.5	0.9	0.7	0.8	1.1	1.4	19.5	28.4
46-47	2.5	1.3	0.5	0.3	0.6	1.0	1.9	20.5	28.6
47-48	2.5	1.7	1.2	1.1	1.2	1.2	1.5	20.2	30.6
48-49	2.6	1.7	1.0	0.4	0.1	0.5	1.5	19.3	27.1
49-50	2.7	1.8	0.9	0.4	0.3	0.9	1.6	18.5	27.1
1950-51	2.3	1.5	0.8	0.5	0.4	0.9	1.7	20.7	28.8
51-52	3.0	1.7	0.5	0	0.1	0.3	1.0	20.3	26.9
52-53	3.0	1.5	0.3	0.2	0.8	1.6	2.1	21.9	31.4
53-54	3.5	2.2	1.4	1.0	0.8	0.8	1.3	22.0	33.0
54-55	3.1	1.9	0.7	0.2	0.1	0.8	1.6	20.8	29.2
1955-56	3.9	1.9	0.5	0	0.2	1.1	1.7	23.6	32.9
56-57	3.4	2.4	1.8	1.1	0.1	0.3	1.1	22.7	32.9
57-58	3.2	1.3	0.7	0.5	0	0	0.8	28.5	35.0

* Based on percentages in Table J-11.

Delivered Water to Hydrologic Subareas

The amounts of gross delivered water for each subarea are shown in Table 21, page 139 and are obtained by the summation of the amounts shown in Tables J-3, J-4 and J-5. Many water service areas cross over subarea boundaries, thus necessitating a split of the water served in the area.

The southerly boundary of Sylmar Hydrologic Subarea divides the Owens River and the City of San Fernando water service areas into two parts. Although the gross deliveries to both of these water service areas is known (see Table J-1). Gross delivered water within the boundary of the Sylmar Subarea is not measured. Estimates of the amount of the net delivered water to this subarea were based on the historic acreages of areal culture and the adjusted depth of delivered water for each land use classification. The annual amounts of water were then adjusted to include water system losses to obtain the gross delivered water.

Approximately nine percent of the areal extent of the City of San Fernando is in Sylmar Subarea and the remainder in the San Fernando Subarea. The gross delivered water for the City of San Fernando was thus proportioned according to the areal extent within each subarea.

Verdugo Hydrologic Subarea contains all of the Crescenta Valley County Water District service area and portions of the City of Glendale, La Canada Irrigation District and the City of Los Angeles Sunland-Tujunga service areas. The gross delivered water to the service areas, which are partially in Verdugo Subarea, was estimated.

The Crescenta Valley County Water District serves a small portion of the City of Glendale in the La Crescenta area, as shown on Plate 19. The gross delivered water to this area was included with the delivered water for Crescenta Valley County Water District.

The City of Glendale in Verdugo Subarea delivers water from four water service levels or pressure levels because of the large differences in the surface elevation in its service area. A large portion of the two higher levels and a small portion of the next lower pressure level are in Verdugo Hydrologic Subarea. The gross delivered water to the City of Glendale in the Verdugo Hydrologic Subarea is based primarily on the amount of water raised to each service level.

During the earlier part of the base period the two higher pressure levels obtained their water supply from the Glorietta Wells and had to be pumped to a higher elevation through booster pumps. The meter readings of the flow through these booster pumps represented the amount of water delivered to these levels. The gross delivered water to the lower pressure level was estimated by determining the number of meters in this pressure level and multiplying the number of meters by the amount of water delivered per meter based on the gross annual delivery per meter in the City of Glendale. The sum of these quantities represented the total water delivered by the City of Glendale in Verdugo Hydrologic Subarea.

The amount metered by the City of Glendale booster pumps includes water sold to the Crescenta Valley County Water District and the La Canada Irrigation District during periods of drought. These amounts were deducted from the total delivered water to the City of Glendale's service area in Verdugo Subarea and added to the respective districts.

Delivered Water to the Hill Areas

During the latter half of the base period an increasing number of homes were built along the hillsides above the valley floor. In the

1958 Land Use Survey made by the Referee, there were 8,700 acres in the residential classifications in the hill and mountain areas. A large part of this acreage was in the Narrows and the Owens River service areas (see Appendix K).

Due to the limited amount of usable land on which a house can be constructed, the area of lawns and gardens is considerably less than the area of residential lots on the valley floor. It did not appear reasonable to apply a duty of water per acre of residential for the valley floor to the residential acreage in the hill and mountain area.

An estimate of the amount of water delivered to residential areas in the hills was compiled from "Read Books" in the Owens River and Narrows service areas. In the selections of the "Read Books" only areas completely developed and in the hills were utilized, thus eliminating the necessity of any correction. The data from these "Read Books" were compiled for 1956-57 and 1957-58. Data prior to 1956-57 were incomplete since the area covered by each "Read Book" changes from time to time.

The average amount of water delivered to each lot for 1956-57 and 1957-58 was 0.50 acre-foot per lot or approximately 1.5 acre-feet per gross acre. This is 23 percent less than the delivered water per meter in the Owens River service area for the corresponding period, which contains a larger area of lawns and gardens. It was therefore apparent that a large percentage of the residential delivered water was for inside use and the value for delivered water when applied to the hills during the earlier period could be higher than that actually delivered. It was therefore assumed that the values found in the 1956 through 1958 period are more representative of the gross delivered water and were thus utilized in this way to determine the delivered water to the hills over the base period.

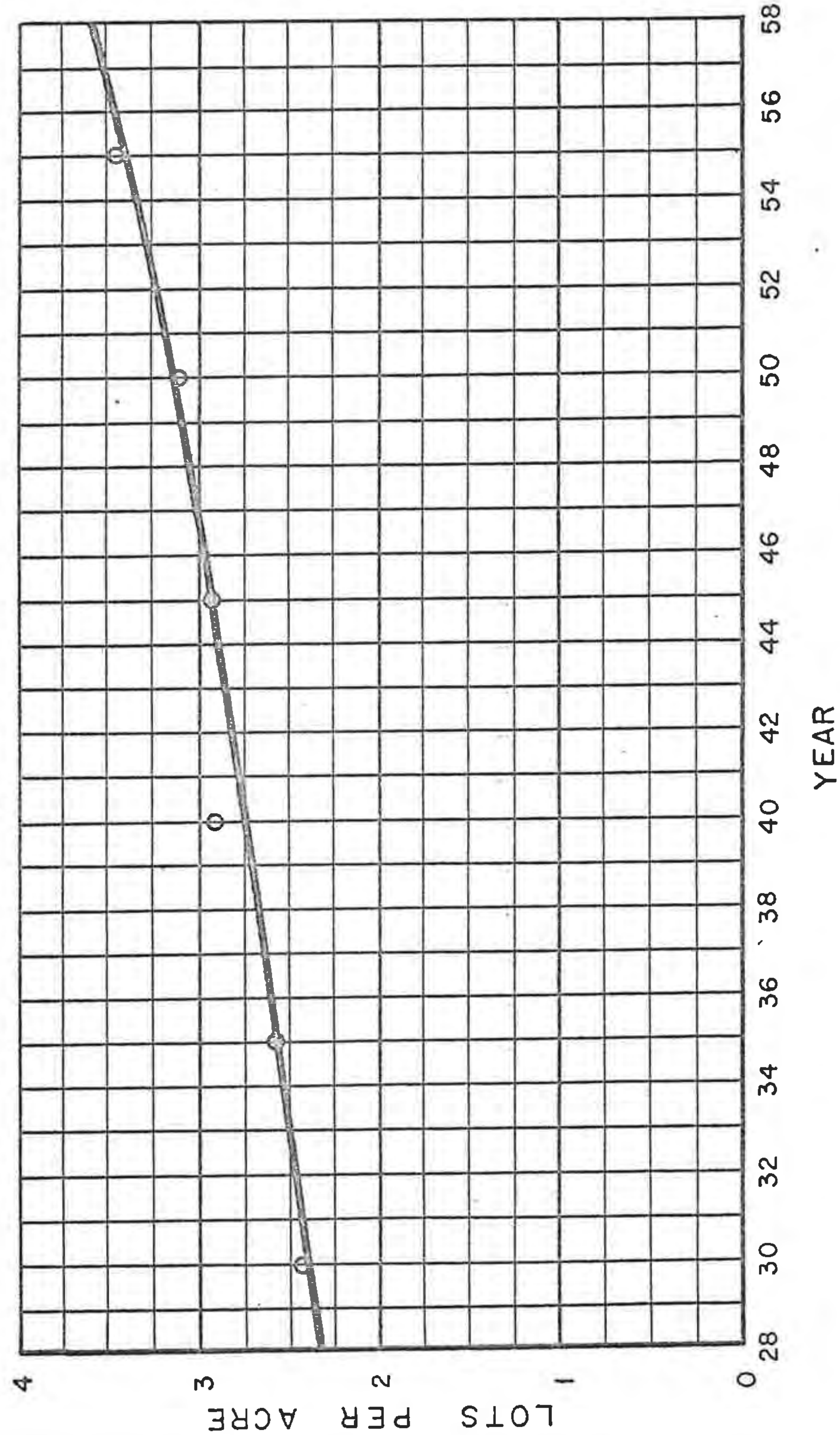
The Owens River service area constitutes another area in which residential development in the hill and mountain area occurred. "Read Book" areas in the Santa Monica Mountains were selected to obtain the gross delivered water per acre of residential. The average depth of water delivered to these areas was 1.57 feet per acre for 1956-57 and 1957-58. This value compared favorably with the value found in the Narrows service area and was applied to the area of residential acreage in each of the service areas with the exception of the Narrows service area where additional data were available.

In the Narrows service area, the acreage of residential in the hill and mountain areas varied from approximately 1,400 acres in 1929 to 2,250 acres in 1958. The density of the number of lots per acre has increased from 2.4 to 3.5 lots per acre during the base period, with an average of 3.0 lots per acre. The density of the number of lots per acre was determined by enumerating the number of sewer house connections for every five years from 1930 to 1955 for the Narrows service area and dividing the number of sewer connections into the acreage in the hill area for the corresponding years. The number of lots per acre determined above are plotted on Figure J-1 showing an increase in density throughout the base period. This increase is in accordance with the increase in population and popularity of hillside homes.

The annual net delivered water to the hill area in the Narrows service area was calculated by multiplying the density by the delivered water per lot and the product multiplied by the acreage of residential in the hills.

The estimated amounts of water delivered to each service area in the hill and mountain areas are shown in Table J-13. Also included in the table are the totals of water delivered to the hill and mountain areas from the valley floor for the remaining land use classifications and extractions from wells outside the major water service areas.

FIGURE J-1



SAN FERNANDO VALLEY REFERENCE

DENSITY OF RESIDENTIAL LOTS IN HILL AREAS

STATE WATER RIGHTS BOARD

TABLE J-13

GROSS DELIVERED WATER TO HILL AREAS BY WATER SERVICE AREAS

In Acre-Feet

Year	Residential areas													Others[c]	Total		Total delivered
	Narrows		Glendale		Burbank		Sunland-Tujunga		Owens	C.V.C.W.D.[b]		La Canada					
	Ground water	Import[a]	Ground water	Import[a]	Ground water	Import[a]	Ground water	Import[a]	Import[a]	Ground water	Import[a]	Ground water	Import[a]	Ground water	Ground water	Import	
1928-29	1,800	0	0	0	0	0	0	0	0	0	0	0	0	500	2,300	0	2,300
29-30	1,850	0	0	0	0	0	0	0	0					1,800	3,650	0	3,650
1930-31	1,890	0	0	0	0	0	0	0	20	0	0	0	0	2,460	4,350	20	4,370
31-32	1,960	0	0	0	0	0	0	0	30	0	0	0	0	2,580	4,540	30	4,570
32-33	2,020	0	0	0	0	0	0	0	50	0	0	0	0	2,650	4,670	50	4,720
33-34	2,090	0	0	0	0	0	0	0	60	0	0	0	0	2,560	4,650	60	4,710
34-35	2,160	0	0	0	0	0	0	0	80	0	0	0	0	2,270	4,430	80	4,510
1935-36	2,200	0	0	0	0	0	0	0	90	0	0	0	0	2,710	4,910	90	5,000
36-37	2,270	0	0	0	0	0	0	0	110	0	0	0	0	3,180	5,450	110	5,560
37-38	2,340	0	0	0	0	0	0	0	130	0	0	0	0	3,860	6,200	130	6,330
38-39	2,390	0	0	0	0	0	0	0	140	0	0	0	0	4,450	6,840	140	6,980
39-40	2,470	0	0	0	0	0	0	0	160	0	0	0	0	4,510	6,980	160	7,140
1940-41	2,530	0	0	0	0	0	0	0	190	0	0	0	0	4,000	6,530	190	6,720
41-42	2,590	0	0	0	0	0	0	0	220	0	0	0	0	4,890	7,480	220	7,700
42-43	2,660	0	0	0	0	0	0	0	280	0	0	0	0	4,000	6,660	280	6,940
43-44	2,740	0	10	0	0	0	0	0	320	0	0	0	0	3,970	6,720	320	7,040
44-45	2,750	50	30	0	0	0	0	0	390	0	0	0	0	3,940	6,720	440	7,160
1945-46	2,600	250	50	0	0	0	10	0	500	0	0	0	0	5,470	8,130	750	8,880
46-47	2,670	300	90	0	10	0	10	0	610	0	0	0	0	3,690	6,470	910	7,380
47-48	2,640	380	160	0	10	0	20	0	780	0	0	10	0	1,770	4,610	1,160	5,770
48-49	2,720	390	240	0	10	0	30	0	960	10	0	10	0	2,060	5,080	1,350	6,430
49-50	2,670	530	340	0	20	0	40	0	1,290	10	0	10	0	4,480	7,570	1,820	9,390
1950-51	2,450	840	440	20	30	0	40	10	1,660	10	0	20	0	4,230	7,220	2,530	9,750
51-52	2,350	1,030	560	40	40	0	60	10	2,090	20	0	20	0	4,300	7,350	3,170	10,520
52-53	2,470	1,010	730	40	40	10	50	40	2,650	20	0	20	0	4,420	7,750	3,750	11,500
53-54	1,730	1,840	880	70	60	10	70	40	3,350	20	0	20	0	4,270	7,050	5,310	12,360
54-55	940	2,770	1,120	40	70	0	90	40	4,080	20	10	20	20	4,620	6,880	6,960	13,840
1955-56	1,360	2,420	1,230	130	70	10	110	50	4,980	30	10	10	30	4,230	7,040	7,630	14,670
56-57	980	2,940	1,440	140	80	10	130	50	5,970	30	10	30	20	4,760	7,450	9,140	16,590
57-58	390	3,640	1,700	130	90	20	170	40	7,150	40	10	30	30	4,480	6,900	11,020	17,920

a. Estimate of import based on the annual percentages of imported waters supplied by the cities and districts to their service areas.
b. Crescenta Valley County Water District.
c. Includes areas outside the major water service areas and deliveries to other land use classes in the hill and mountain areas.

Note: Gross delivered water to hill areas by the service areas of Crescenta Valley County Water District, La Canada and 26.3% of Glendale are tributary to Verdugo Subarea. The remaining amounts of gross delivered water to the hill areas are tributary to San Fernando Subarea.

APPENDIX K

LAND DEVELOPMENT AND USE

APPENDIX K

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APPENDIX K

LAND DEVELOPMENT AND USE

The area of investigation has undergone rapid changes in land use and population during the past 30 years. To determine the variation of culture historically, the Referee has collected data on culture and population from various sources.

Source and Extent of Data

Historical data utilized in the determination of areal culture include:

Land Use Surveys. Land use surveys by the State Department of Public Works, Division of Water Resources, were available for the years 1932 and 1942. The 1932 Land Use Survey was part of the South Coastal Basin Investigation.[1/] In that survey data were obtained as summaries of land use contained within the area covered by the 6 minute series U.S.G.S. quadrangle sheets. The 1942 survey determined the changes that had occurred between the 1932 survey and 1942, and the data were obtained in the form of a map.

The Los Angeles Department of Water and Power conducted a land use survey for the years 1949 and 1954. The 1949 survey was made on overlays of 7-1/2 minute series U.S.G.S. quadrangle sheets while the 1954 survey was made on Los Angeles County index maps at a scale of 1" = 600'. The data collected by these surveys were utilized in State Water Resources

Board Bulletin No. 24.[2/] Both the original survey work sheets for 1949 and 1954 and the tabulations in Bulletin No. 24 were utilized by the Referee.

The types of culture surveyed in 1932, 1942, 1949 and 1954 are tabulated in Table K-1.

Agricultural Crop Survey. Records of the acreage and water applied to various crops in the City of Los Angeles west of Burbank were maintained by the Los Angeles Department of Water and Power for the period 1925 through 1942 on a monthly basis. These records are referred to as Carr's records and also include the same data for lands in the area served by private pumpers. These records are available only on summary sheets, the original field notes no longer being in existence. Representatives of the Referee interviewed Mr. Carr in 1959 to determine the methods he used to obtain the data and as a result concluded that the aforementioned records were representative of Mr. Carr's observations.

Annual crop reports compiled by the Los Angeles County Agricultural Commissioner for the period 1944 through 1958 were utilized to supplement the various land use surveys. The original purpose of these reports was to determine the value of the various crops grown in the San Fernando Valley and Saugus-Newhall area and contained the number of bearing acres in each area. The acreages reported therein were found to agree with the observations made in the land use surveys of 1949, 1954 and 1958 and were considered representative of the full period reported.

TABLE K-1

LAND USE GROUPINGS USED BY
OTHER AGENCIES

Year	Agency conducting survey	Garden and field	Citrus	Walnuts	Deciduous	Alfalfa	Irrigated grass	Domestic, commercial and industrial	Fallow	Truck	Vacant	Residential	Commercial	Roads	River wash	Water surface	Other crops	Native vegetation	Miscellaneous
1932	State Department of Public Works, Division of Water Resources	x	x	x	x	x	x	x	x										
1942	State Department of Public Works, Division of Water Resources		x		x	x	x	x		x	x								
1949	Los Angeles Department of Water and Power*		x	x	x	x				x		x	x	x	x	x	x	x	x
1954	Los Angeles Department of Water and Power*		x	x	x	x				x		x	x	x	x	x	x	x	x

* Reported by State Water Resources Board, Bulletin 24.

Census. The United States Bureau of the Census conducted its general census for the years 1930, 1940 and 1950. Special censuses were made for the City of Los Angeles in 1946, 1953 and 1956 and the Cities of Burbank and Glendale in 1957. An estimate of the population in water service areas, shown in Table K-2, was made from combinations of records of the various census tracts covering the area.

TABLE K-2

POPULATION BY WATER SERVICE AREAS

Year of census	City of Burbank	City of Glendale	City of Los Angeles: Narrows	City of Los Angeles: West of Burbank	City of San Fernando	La Crescenta	Total
1930	16,662	62,736	67,495	54,217	7,567	6,971	215,648
1940	34,337	82,582	77,136	112,001	9,094	10,686	325,836
1946	--	--	Incomplete	176,008	--	--	--
1950	78,577	95,702	91,560	311,116	12,922	37,009	626,886
1953	--	--	89,254	455,872	--	--	--
1956	--	--	83,749	571,563	--	--	--
1957	86,775	114,460	--	--	--	--	--

Aerial Photographs. Aerial photographs of the Upper Los Angeles River area, taken by Fairchild Aerial Surveys, Incorporated, in 1928, 1949 and 1956, were also utilized to determine the acreage of various culture classifications in the area.

1958 Land Use Survey. The land use survey made by the staff of the State Water Rights Board was mapped on overlays of 1956 aerial photographs at a scale of 1" = 400'. In undeveloped hill and mountain areas the mapping was done on U.S.G.S. quadrangles at a scale of 1" = 2,000'.

The field mapping was done in detail utilizing approximately 150 separate classifications. Boundaries of water service areas and hydrologic subareas were added to the overlays as they were determined. Prints of the overlays were made and cut and weighed to determine the area of each classification. In the cutting process, classifications with similar water use characteristics were combined, reducing the number of classifications to 37. Computations of areas within each photograph were controlled by the area computed from the grid coordinates printed on each photograph.

The data on the 37 classifications were coded as to photograph number, water service area, hydrologic subarea, location in valley fill or hill area and type of culture, and punched onto tabulating cards. The areas in acres for each classification within a photograph were computed by machine and the results were then tabulated by water service area and hydrologic subarea. The 37 classifications were then placed into the major groups listed in Table K-3.

Land Use Classifications

The grouping of various land use classes was accomplished by combining on the basis of relative consumptive use the classifications developed by the State Department of Water Resources according to water requirements. Groupings of classes utilized by the Referee are shown in Table K-3. The major groupings do not conform to those utilized in the previous land use surveys referred to in Table K-1; therefore, interpretation of previous surveys was necessary in order to obtain consistent historic culture changes. For example, an area placed in the "fallow" category in the 1932 survey would be placed under "dry farm and native vegetation" in the adopted classification system. Acreages shown herein for each of the land use classes include streets and roads.

Methods of Determining Areal Culture

Table K-4 presents a summary of the methods and data sources utilized in the determination of areal culture on the valley fill. The term areal culture as used herein is synonymous with land use.

Irrigated Crops

Carr's records covered the City of Los Angeles west of Burbank. Since this area contained most of the irrigated crop acreage, the remainder of the valley fill was determined by subtracting Carr's values from the annual values determined by the 1932 and 1942 surveys. Values for the remaining years between 1928 and 1942 were obtained by straight line interpolation and extrapolation of the 1932 and 1942 data.

TABLE K-3

LAND USE CLASSIFICATION

Residential

- Single and duplex
- Multiple
- Motels
- Trailer courts
- Estates
- Farmsteads (1/3 of total acreage)

Commercial and Industrial

- Offices
- Hotels
- Hospitals
- Prisons
- Reformatories
- Asylums
- Schools
- Power receiving stations
- Kennels
- Drive-in theaters
- Wineries
- Brick yards
- Zoo area
- Auditoriums
- Parking lots
- Hard surface earth yards
- Military
- Dairies and feed lots
- Manufacturing
- Assembling
- Processing
- Oil fields
- Rock quarries
- Gravel pits
- Public dumps
- Rock and gravel plants
- Warehouses
- Open storage yards
- Substations
- Railroad marshaling yards
- Truck loading
- Airfields
- Saw mills
- Oil refineries
- Paper mills
- Meat packing plants
- Steel and aluminum mills
- Canneries
- Movie studios
- Power plants

Miscellaneous

- Churches
- Sanitariums
- Circus headquarters
- Rock crushers
- Spreading grounds
- Dams
- Movie sets
- Debris basins
- Paved channels - paved areas
- Freeways

Irrigated Crops

Alfalfa and Irrigated Pasture

- Alfalfa
- Clover
- Mixed pasture
- Native pasture

Citrus

- Grapefruit
- Lemons
- Oranges
- Dates
- Avocados

Deciduous

- Apples
- Apricots
- Olives
- Cherries
- Nectarines
- Peaches
- Pears
- Plums
- Prunes
- Figs
- Miscellaneous deciduous
- Home orchards
- Almonds
- Miscellaneous nuts
- Farmsteads (1/3 of total acreage)

Walnuts

Truck

- Artichokes
- Asparagus
- Beans (green)
- Broccoli
- Cabbage
- Cauliflower
- Corn, green
- Carrots
- Celery
- Lettuce and romaine
- Melons
- Squash
- Cucumbers
- Onions and garlic
- Peas
- Potatoes
- Sweet potatoes
- Spinach
- Tomatoes
- Flowers and nursery
- Home gardens
- Miscellaneous truck
- Bush berries
- Strawberries
- Peppers

Vineyard

- Table grapes
- Wine grapes
- Raisin grapes

Lawn Grass

- Parks
- Cemeteries
- Golf courses

Water Surface

- Lakes
- Reservoirs
- Rivers

Riparian Vegetation

- Swamps
- Meadowland
- Brush in stream channels
- Brush and trees in stream channels

Dry Farm and Native Vegetation

- Grass land
- Brush
- Timber forest
- Barley
- Wheat
- Oats
- Rye
- Grain hay
- Miscellaneous hay
- Vacant lots
- Railway rights of way
- Utility rights of way
- Wash areas
- Mine tailings
- Barren land, rocky
- Idle (being cleared - being leveled)
- Farmsteads (1/3 of total acreage)

TABLE K-4

METHODS AND DATA UTILIZED FOR DETERMINATION OF AREAL CULTURE

Year	Irrigated crops	Residential	Commercial and industrial	Miscellaneous	Riparian vegetation	Water surface	Dry farm and native vegetation
1928-29	a	i	i	k	m	n	o
29-30	a	j	j	k	m	n	o
1930-31	a	j	j	k	m	n	o
31-32	a and b	j and b	j and b	k	m	n	o
32-33	a	j	j	k	m	n	o
33-34	a	j	j	k	m	n	o
34-35	a	j	j	k	m	n	o
1935-36	a	j	j	k	m	n	o
36-37	a	j	j	k	m	n	o
37-38	a	j	j	k	m	n	o
38-39	a	j	j	k	m	n	o
39-40	a	j	j	k	m	n	o
1940-41	a	j	j	k	m	n	o
41-42	a and c	j and c	j and c	k	m	n	o
42-43	d	j	j	k	m	n	o
43-44	e	j	j	k	m	n	o
44-45	e	j	j	k	m	n	o
1945-46	e	j	j	k	m	n	o
46-47	e	j	j	k	m	n	o
47-48	e	j	j	k	m	n	o
48-49	f	f	f	k	m	n	o
49-50	e	j	j	k	m	n	o
1950-51	e	j	j	k	m	n	o
51-52	e	j	j	k	m	n	o
52-53	e	j	j	k	m	n	o
53-54	g	g	g	k	m	n	o
54-55	e	j	j	k	m	n	o
1955-56	e	j	j	k	m	n	o
56-57	e	j	j	k	m	n	o
57-58	h	h	h	h	h	h	h

a. Frank Carr's record for the City of Los Angeles.
b. 1932 Department of Water Resources Land Use Survey. Also used as check on other data.
c. 1942 Department of Water Resources Land Use Survey. Also used as check on other data.
d. Average of the year preceeding and following.
e. Los Angeles County Agricultural Commission's Annual Report.
f. 1949 Land Use Survey by Los Angeles Department of Water and Power, adjusted to include roads.
g. 1954 Land Use Survey by Los Angeles Department of Water and Power, adjusted to include roads.
h. 1958 Land Use Survey by Referee.
i. Planimetered area from 1928 Aerial Photo.
j. Straight line interpolation between years with data.
k. The annual change in acreage of the Miscellaneous classification was determined by deducting the areas of of freeways, paved channels, spreading grounds and dams completed during a given year from the total acreage determined for this class by the 1958 Land Use Survey.
m. Riparian vegetation was determined only in 1958 Land Use Survey. The annual change in riparian vegetation was estimated by adding to the area of riparian vegetation found in 1958 survey, the acreage occupied annually by channel improvements to the Los Angeles River from 1938 through 1958. The area of riparian vegetation from 1928 through 1937 was then assumed constant.
n. Based on 1958 survey, except water surface area back of Hansen Dam was subtracted therefrom to determine the acreage existing in the period 1928-1940.
o. Difference between the sum of the acreage of known culture and the total valley fill area.

Irrigated crops in the Sylmar Subarea were determined from maps prepared by Frank Carr for the Los Angeles Department of Water and Power showing the location and area of the various crops grown in the City of Los Angeles west of Burbank. These maps were available for 1929, 1931, 1936 and 1938. The area of each crop shown on these maps was planimetered to obtain the acreage. Thus, with Carr's data and that from the five land use surveys, including 1958, a total of nine years of record was known. The remaining 21 years were determined by interpolation of the ratio of crop acreage in Sylmar to crop acreage on the valley floor.

To obtain the acreage of irrigated crops in the Verdugo Subarea, the 1932, 1949, 1954 and 1958 land use surveys were utilized and the annual amounts irrigated were obtained by following the annual trend of irrigation for the total valley fill area.

The acreage of irrigated crops in the San Fernando Subarea was taken as the difference between the sum of the acreage in Sylmar and Verdugo Subareas and the total acreage for each crop on the valley floor.

Residential

The rate of growth of residential areas in the Sylmar and Verdugo Hydrologic Subareas has differed throughout the base period. The population data for each subarea indicate that the Verdugo Subarea has increased at a uniform rate while the population of the Sylmar Subarea first grew slowly and then in the late 30's or early 40's had a rapid increase. This relative difference in the rate of population increase in Sylmar and Verdugo Hydrologic Subareas is indicated on Figure K-1 which contains a plot of the population in these areas versus time throughout the base period.

Utilizing the acreage of residential in 1928, 1949, 1954 and 1958, the annual increase in acreage was interpolated between these years to correspond to the rate of increase in population for each subarea.

Commercial and Industrial

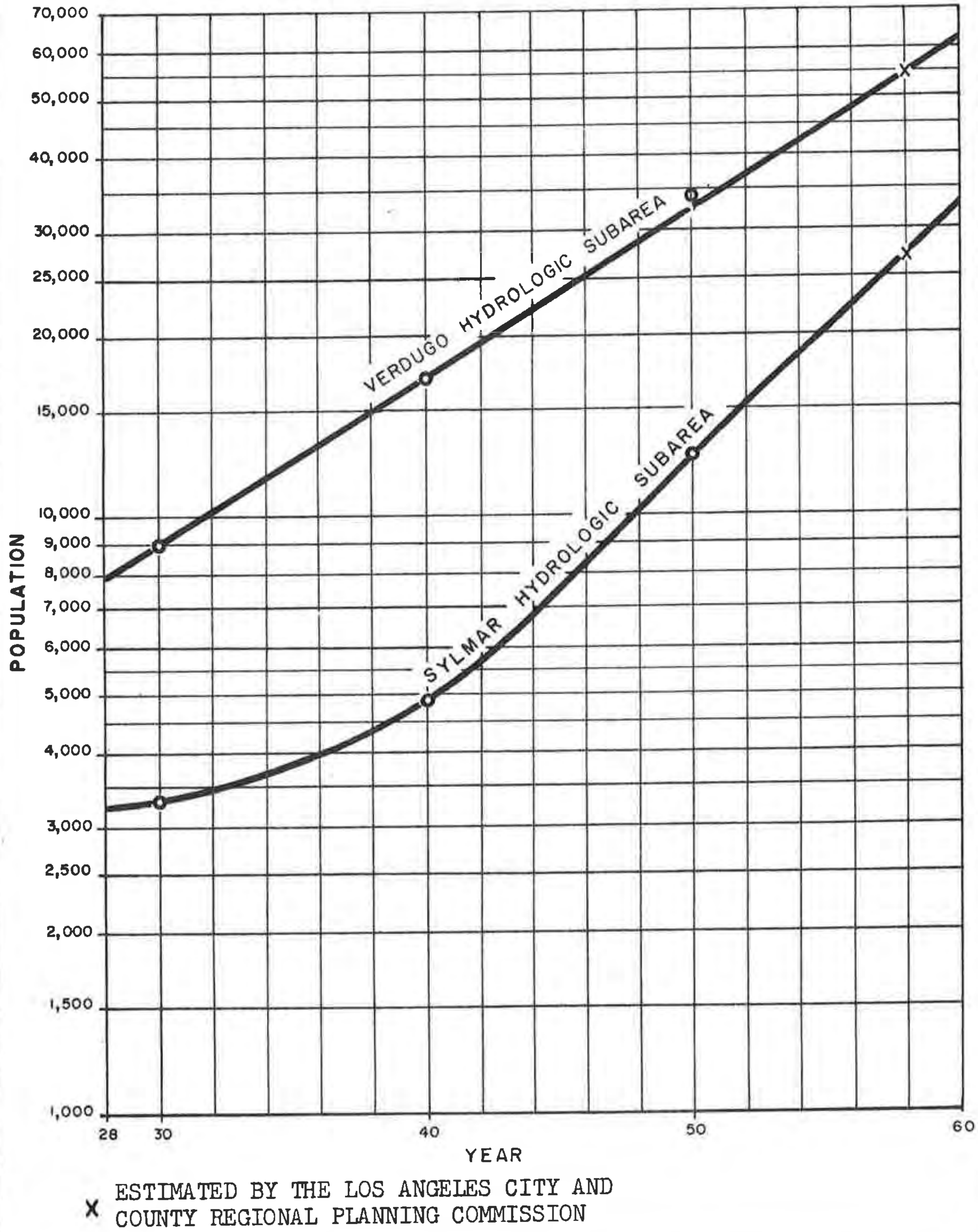
Commercial and industrial acreages were combined to form one classification because of the various interpretations for industrial classifications. Data are available for the years 1928, 1949, 1954 and 1958. The method of interpolating between the years of data for Sylmar and Verdugo Subareas is the same as for residential.

Dry Farm and Native Vegetation

The sum of all acreages in all classifications in the three hydrologic subareas equals the total acreage on the valley floor. The dry farm and native vegetation class was determined as the difference between the sum of the acreages of known culture, evaluated as described heretofore, and the total area in each subarea.

Residential Development in the Hill and Mountain Areas

During the latter part of the base period residential development in the hill and mountain areas has shown a rapid increase. The only land



SAN FERNANDO VALLEY REFERENCE

ESTIMATED POPULATION
SYLMAR AND VERDUGO HYDROLOGIC SUBAREA

STATE WATER RIGHTS BOARD

use survey which extended into the hill areas was the one made by the State Water Rights Board staff in 1958. In the 1958 Land Use Survey, the major portion of the 8,740 acres of residential in the hill areas was in the San Fernando Subarea, primarily in the Santa Monica Mountains and the hills in the Los Angeles Narrows. Residential acreage on the hills within each subarea during 1958 was as follows:

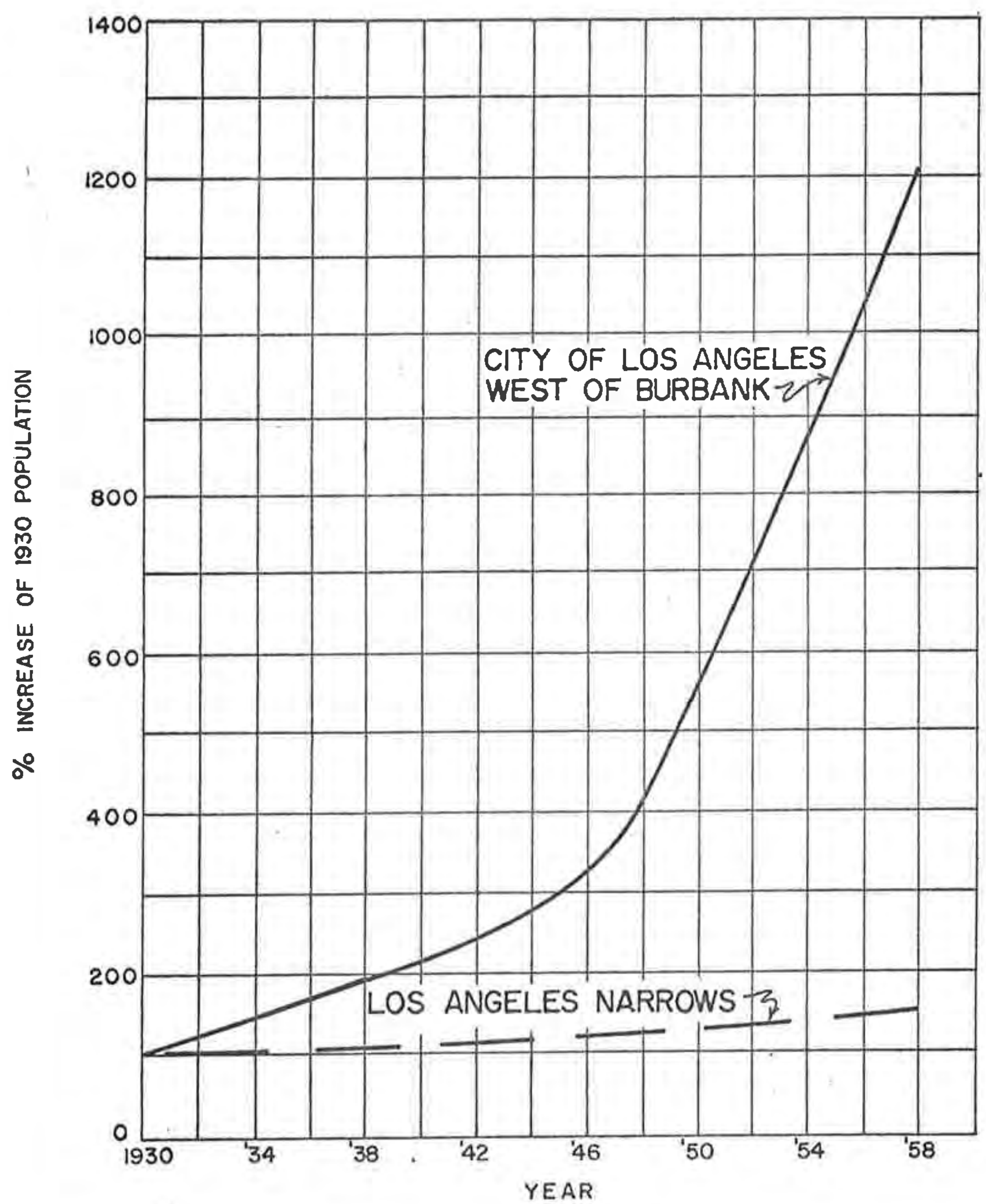
San Fernando	8,274 acres
Sylmar	33 acres
Verdugo	397 acres

Within San Fernando Subarea, 82 percent, or 6,775 acres was in the Owens and Narrows service areas. The latter service area contains one of the oldest residential hill areas in the area of investigation. An estimate of this residential acreage was made by prorating the area surveyed in 1958 on the basis of the population census. The population in the Narrows area has since 1930 increased approximately 40 percent, as shown on Figure K-2. The acreage in residential found in 1958 was thus decreased directly with the percentage change in population, based on the 1930 and recent census values.

In the Owens service area, most of the residential development is in the Santa Monica Mountains. The same method was utilized in this area for estimation of residential acreage in the earlier years as heretofore described for the Narrows service area.

Table K-5 lists values of residential acreage in the hills, estimated in this manner for each year of the base period.

FIGURE K-2



SAN FERNANDO VALLEY REFERENCE

INCREASE IN POPULATION FOR CITY OF LOS ANGELES
WEST OF BURBANK AND NARROWS AREA

STATE WATER RIGHTS BOARD

TABLE K-5

ESTIMATED HILL AND MOUNTAIN RESIDENTIAL AREAS

In Acres

Year	Narrows	Santa Monica	Other hill and mountain groups	Total
1928-29	1,500	0	0	1,500
29-30	1,530	0	0	1,530
1930-31	1,550	10	0	1,560
31-32	1,580	20	0	1,600
32-33	1,600	30	0	1,630
33-34	1,630	40	0	1,670
34-35	1,660	50	0	1,710
1935-36	1,680	60	0	1,740
36-37	1,710	70	0	1,780
37-38	1,730	80	0	1,810
38-39	1,760	90	0	1,850
39-40	1,790	100	0	1,890
1940-41	1,810	120	0	1,930
41-42	1,840	140	0	1,980
42-43	1,860	180	0	2,040
43-44	1,890	200	20	2,110
44-45	1,920	240	30	2,190
1945-46	1,940	300	70	2,310
46-47	1,970	360	130	2,460
47-48	1,990	440	220	2,650
48-49	2,020	530	330	2,880
49-50	2,050	700	480	3,230
1950-51	2,070	900	640	3,610
51-52	2,100	1,120	840	4,060
52-53	2,120	1,420	1,070	4,610
53-54	2,150	1,800	1,320	5,270
54-55	2,180	2,200	1,600	5,980
1955-56	2,200	2,700	1,890	6,790
56-57	2,230	3,250	2,190	7,670
57-58	2,250	3,920	2,540	8,710

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Chronological Summary of Areal Culture on the Valley Floor

Table K-6 is a compilation of the acreages for each classification in San Fernando (including Eagle Rock Subarea), Sylmar and Verdugo Subareas and the total valley fill area. Table K-7 gives the acreages of each land use classification on the valley fill area within each of the major water service areas and with respect to its location in each of the subareas. Due to the small area of Eagle Rock Subarea, the acreages of land use have been combined with San Fernando Subarea.

1/ California State Department of Public Works, Division of Water Resources. "Value and Cost of Water for Irrigation in Coastal Plain of Southern California". Bulletin No. 43, South Coastal Basin Investigation. 1933.

2/ California State Water Resources Board. "Los Angeles County Land and Water Use Survey, 1955". Bulletin No. 24. June, 1956.

TABLE K-6

AREAL CULTURE
WITHIN BOUNDARY OF THE VALLEY FILL

SYLMAR HYDROLOGIC SUBAREA
(5,600 Acres)

In Acres

Year	Irrigated crops													
	Deciduous	Citrus	Walnuts	Truck	Alfalfa and pasture	Lawn grass[a]	Irrigated vineyard	Total	Residential	Commercial and industrial	Miscellaneous	Riparian vegetation	Water surface	Dry farm and native vegetation
1928-29	1,710	1,000	40	330	160	40	80	3,360	120	40	150			1,930
29-30	1,310	1,080	40	300	150	40	40	2,960	160	40	150			2,290
1930-31	1,000	1,160	40	270	140	40	30	2,680	200	40	150			2,530
31-32	1,060	1,200	40	250	120	40	30	2,740	230	40	150			2,440
32-33	1,470	1,230	40	240	110	40	60	3,190	260	40	150			1,960
33-34	1,220	1,260	40	220	100	40	50	2,930	300	40	150			2,180
34-35	1,420	1,290	40	200	90	40	30	3,110	340	40	150			1,960
1935-36	1,540	1,320	40	180	80	40	20	3,220	370	40	150			1,820
36-37	1,430	1,130	40	420	60	40	20	3,140	400	40	150			1,870
37-38	1,180	950	40	650	40	40	20	2,920	440	40	150			2,050
38-39	900	990	40	740	50	40	20	2,780	480	40	150			2,150
39-40	760	1,040	40	820	50	40	20	2,770	510	40	150			2,130
1940-41	1,210	1,080	30	910	40	40	20	3,330	540	40	150			1,540
41-42	920	1,120	30	1,000	40	40	20	3,170	580	40	150			1,660
42-43	980	1,040	30	1,030	40	40	20	3,180	620	40	150			1,610
43-44	1,030	970	30	1,070	30	40	20	3,190	650	40	150			1,570
44-45	1,030	890	30	1,110	30	40	20	3,150	680	40	150			1,580
1945-46	1,030	810	30	1,150	20	40	20	3,100	720	40	150			1,590
46-47	1,030	740	20	1,180	20	40	20	3,050	760	40	150			1,600
47-48	1,010	660	20	1,220	20	40	20	2,990	790	40	150			1,630
48-49	720	580	20	1,260	20	40	20	2,660	820	40	150			1,930
49-50	570	590	20	1,060	30	40	20	2,330	900	50	150			2,170
1950-51	570	600	20	860	50	40	10	2,150	990	60	150			2,250
51-52	760	610	20	660	60	40	10	2,160	1,070	70	150			2,150
52-53	750	620	20	460	80	40	10	1,980	1,150	80	150			2,240
53-54	760	630	10	260	90	40	30	1,820	1,230	90	150			2,310
54-55	780	580	10	260	80	40	30	1,780	1,310	110	130			2,270
1955-56	740	530	10	250	60	40	30	1,660	1,390	130	120			2,300
56-57	480	480	10	240	50	40	30	1,330	1,480	150	100			2,540
57-58	590	430	0	240	40	40	20	1,360	1,560	170	80			2,430

AREAL CULTURE
WITHIN BOUNDARY OF THE VALLEY FILL
(continued)

VERDUGO HYDROLOGIC SUBAREA[b]
(5,000 Acres)

Year	Irrigated crops													
	Deciduous	Citrus	Walnuts	Truck	Alfalfa and pasture	Lawn grass[a]	Irrigated vineyard	Total	Residential	Commercial and industrial	Miscellaneous	Riparian vegetation	Water surface	Dry farm and native vegetation
1928-29	140	50		10		100		300	510	40	320	30		3,800
29-30	110	50		10		100		270	540	40	320	30		3,800
1930-31	80	50		10		100		240	570	50	320	30		3,790
31-32	90	50		10		100		250	590	50	320	30		3,760
32-33	80	50		10		100		240	620	50	320	30		3,740
33-34	70	40		10		100		220	650	50	320	30		3,730
34-35	80	40		10		100		230	680	50	320	30		3,690
1935-36	80	40		10		100		230	700	60	320	30		3,660
36-37	80	40		10		100		230	760	60	320	30		3,600
37-38	60	40		10		100		210	810	70	320	30		3,550
38-39	50	30		10		100		190	860	70	320	30		3,530
39-40	40	30		10		100		180	920	80	320	30		3,470
1940-41	70	30		10		110		220	1,030	80	320	30		3,320
41-42	50	30		10		110		200	1,080	90	320	30		3,280
42-43	50	30		10		110		200	1,190	100	320	30		3,160
43-44	50	20		10		110		190	1,300	100	320	30		3,060
44-45	50	20		10		110		190	1,400	110	320	30		2,950
1945-46	60	20		10		110		200	1,510	120	320	30		2,820
46-47	50	20		10		110		190	1,650	130	320	30		2,680
47-48	50	20		10		110		190	1,780	140	320	30		2,540
48-49	40	10		10		110		170	1,890	150	320	30		2,440
49-50	30	10		10		110		160	2,030	160	320	30		2,300
1950-51	30	10		10		110		160	2,160	170	320	30		2,160
51-52	40	10		10		120		180	2,320	180	320	30		1,970
52-53	40	10		10		120		180	2,430	190	320	30		1,850
53-54	40	10		10		120		180	2,590	210	320	30		1,670
54-55	10	10		20		120		160	2,750	220	260	20		1,590
1955-56	10	10		30		120		170	2,860	230	200	20		1,520
56-57	10	10		40		150		210	3,020	240	140	20		1,370
57-58	10	10		60		150		230	3,200	250	80	20		1,220

TABLE K-6

AREAL CULTURE
WITHIN BOUNDARY OF THE VALLEY FILL
(continued)

SAN FERNANDO AND EAGLE ROCK HYDROLOGIC SUBAREAS
(112,800 Acres)

Year	Irrigated crops: Deciduous	Citrus	Walnuts	Truck	Alfalfa and pasture	Lawn grass[a]	Irrigated vineyard	Total	Residential	Commercial and industrial	Miscellaneous	Riparian vegetation	Water surface	Dry farm and native vegetation
1928-29	2,760	8,960	8,440	23,590	7,890	1,670	1,410	54,720	18,410	2,930	1,110	1,370	840	33,420
29-30	2,130	9,220	7,860	23,210	7,590	1,670	810	52,490	19,560	3,400	1,110	1,370	840	34,030
1930-31	1,610	9,850	7,270	22,970	6,690	1,670	630	50,690	20,710	3,850	1,110	1,370	840	34,230
31-32	1,720	9,580	7,270	18,760	6,780	1,670	470	46,250	21,880	4,320	1,110	1,370	840	37,030
32-33	1,080	9,450	6,570	18,900	7,620	1,670	940	46,230	23,040	4,790	1,110	1,370	840	35,420
33-34	900	9,620	7,260	20,510	6,850	1,670	980	47,790	24,190	5,260	1,470	1,370	840	31,880
34-35	1,050	9,570	7,250	20,600	7,100	1,670	550	47,790	25,330	5,720	1,470	1,370	840	30,280
1935-36	1,120	10,040	7,720	21,610	7,450	1,670	490	50,100	26,500	6,180	1,470	1,370	840	26,340
36-37	1,050	10,640	7,190	21,210	6,520	1,670	400	48,680	27,630	6,650	1,470	1,370	840	26,160
37-38	870	10,930	6,810	16,340	7,750	1,670	410	44,780	28,760	7,100	1,470	1,370	840	28,480
38-39	660	10,930	6,890	14,100	7,970	1,670	340	42,560	29,890	7,570	1,500	560	840	29,880
39-40	550	10,920	6,090	13,530	7,350	1,670	290	40,400	31,020	8,030	1,550	370	840	30,590
1940-41	890	10,750	5,270	14,620	6,170	1,780	280	39,760	32,100	8,490	1,550	370	960	29,570
41-42	680	10,720	5,890	17,160	6,950	1,780	320	43,500	33,230	8,950	1,550	370	960	24,240
42-43	710	11,460	5,700	14,490	7,640	1,780	300	42,080	34,300	9,410	1,550	370	960	24,130
43-44	750	12,200	5,530	11,810	8,330	1,780	290	40,690	35,380	9,880	1,550	370	960	23,970
44-45	750	12,330	5,470	11,010	8,330	1,780	270	39,940	36,460	10,330	1,550	370	960	23,190
1945-46	750	12,400	5,470	8,760	9,990	1,780	260	39,410	37,530	10,790	1,700	370	960	22,040
46-47	750	11,960	5,480	6,170	8,780	1,780	240	35,160	38,570	11,250	1,700	370	960	24,790
47-48	740	12,200	5,480	5,520	9,770	1,780	220	35,710	39,630	11,710	1,730	340	960	22,720
48-49	520	10,510	4,450	5,610	10,430	1,780	210	33,510	40,700	12,160	1,770	300	960	23,400
49-50	420	10,480	4,230	4,870	8,770	1,780	190	30,740	42,060	12,340	1,770	300	950	24,630
1950-51	410	10,210	4,240	5,980	8,970	1,780	190	31,780	43,420	12,530	1,780	290	960	22,040
51-52	550	9,950	3,610	4,980	9,840	1,860	170	30,960	44,760	12,710	1,790	280	960	21,340
52-53	550	9,280	3,600	5,470	7,840	1,860	150	28,750	46,150	12,900	1,800	270	960	21,970
53-54	550	8,460	3,210	5,430	7,940	1,860	120	27,570	47,490	13,070	1,800	270	960	21,640
54-55	510	7,780	2,910	4,350	4,320	1,860	100	21,830	49,840	13,140	1,900	260	960	24,870
1955-56	480	7,060	2,590	3,810	3,240	1,860	90	19,130	52,240	13,210	2,080	260	960	24,920
56-57	310	5,000	1,710	3,660	1,990	2,090	70	14,830	54,570	13,280	2,590	230	960	26,340
57-58	380	4,440	1,160	3,730	2,720	2,090	60	14,580	56,900	13,350	2,720	200	960	24,090

AREAL CULTURE
WITHIN BOUNDARY OF THE VALLEY FILL
(continued)

TOTAL VALLEY FILL AREA
(123,400 Acres)

Year	Irrigated crops: Deciduous	Citrus	Walnuts	Truck	Alfalfa and pasture	Lawn grass[a]	Irrigated vineyard	Total	Residential	Commercial and industrial	Miscellaneous	Riparian vegetation	Water surface	Dry farm and native vegetation
1928-29	4,610	10,010	8,480	23,930	8,050	1,810	1,490	58,380	19,040	3,010	1,580	1,400	840	39,150
29-30	3,550	10,350	7,900	23,520	7,740	1,810	850	55,720	20,260	3,480	1,580	1,400	840	40,120
1930-31	2,690	11,060	7,310	23,250	6,830	1,810	660	53,610	21,480	3,940	1,580	1,400	840	40,550
31-32	2,870	10,830	7,310	19,020	6,900	1,810	500	49,240	22,700	4,410	1,580	1,400	840	43,230
32-33	2,630	10,730	6,610	19,150	7,730	1,810	1,000	49,660	23,920	4,880	1,580	1,400	840	41,120
33-34	2,190	10,920	7,300	20,740	6,950	1,810	1,030	50,940	25,140	5,350	1,940	1,400	840	37,790
34-35	2,550	10,900	7,290	20,810	7,190	1,810	580	51,130	26,350	5,810	1,940	1,400	840	35,930
1935-36	2,740	11,400	7,760	21,800	7,530	1,810	510	53,550	27,570	6,280	1,940	1,400	840	31,820
36-37	2,560	11,810	7,230	21,640	6,580	1,810	420	52,050	28,790	6,750	1,940	1,400	840	31,630
37-38	2,110	11,920	6,850	17,000	7,790	1,810	430	47,910	30,010	7,210	1,940	1,400	840	34,090
38-39	1,610	11,950	6,930	14,850	8,020	1,810	360	45,530	31,230	7,680	1,970	590	840	35,560
39-40	1,350	11,990	6,130	14,360	7,400	1,810	310	43,350	32,450	8,150	2,020	400	840	36,190
1940-41	2,170	11,860	5,300	15,540	6,210	1,930	300	43,310	33,670	8,610	2,020	400	960	34,430
41-42	1,650	11,870	5,920	18,170	6,990	1,930	340	46,870	34,890	9,080	2,020	400	960	29,180
42-43	1,740	12,530	5,730	15,530	7,680	1,930	320	45,460	36,110	9,550	2,020	400	960	28,900
43-44	1,830	13,190	5,560	12,890	8,360	1,930	310	44,070	37,330	10,020	2,020	400	960	28,600
44-45	1,830	13,240	5,500	12,130	8,360	1,930	290	43,280	38,540	10,480	2,020	400	960	27,720
1945-46	1,840	13,230	5,500	9,920	10,010	1,930	280	42,710	39,760	10,950	2,170	400	960	26,450
46-47	1,830	12,720	5,500	7,360	8,800	1,930	260	38,400	40,980	11,420	2,170	400	960	29,070
47-48	1,800	12,880	5,500	6,750	9,790	1,930	240	38,890	42,200	11,890	2,200	370	960	26,890
48-49	1,280	11,100	4,470	6,880	10,450	1,930	230	36,340	43,410	12,350	2,240	330	960	27,770
49-50	1,020	11,080	4,250	5,940	8,800	1,930	210	33,230	44,990	12,550	2,240	330	960	29,100
1950-51	1,010	10,820	4,260	6,850	9,020	1,930	200	34,090	46,570	12,760	2,250	320	960	26,450
51-52	1,350	10,570	3,630	5,650	9,900	2,020	180	33,300	48,150	12,960	2,260	310	960	25,450
52-53	1,340	9,910	3,620	5,940	7,920	2,020	160	30,910	49,730	13,170	2,270	300	960	26,060
53-54	1,350	9,100	3,220	5,700	8,030	2,020	150	29,570	51,310	13,370	2,270	300	960	25,620
54-55	1,300	8,370	2,920	4,630	4,400	2,020	130	23,770	53,900	13,470	2,290	280	960	28,730
1955-56	1,230	7,600	2,600	4,090	3,300	2,020	120	20,960	56,490	13,570	2,400	280	960	28,740
56-57	800	5,490	1,720	3,940	2,040	2,280	100	16,370	59,070	13,670	2,830	250	960	30,250
57-58	980	4,880	1,160	4,030	2,760	2,280	80	16,170	61,660	13,770	2,880	220	960	27,740

a. Does not include residential lawn grass areas.
b. Includes the portion of Monk Hill Basin within the Upper Los Angeles River Area.

TABLE K-7

AREAL CULTURE ON VALLEY FILL AREA
BY WATER SERVICE AREA WITHIN EACH SUBAREA

In Acres

Year	San Fernando and Eagle Rock Hydrologic Subareas															
	City of Burbank Service Area							City of Glendale Service Area								
	Deciduous	Truck	Lawn grass	Residential	Commercial and industrial	Miscellaneous	Dry farm and native vegetation	Deciduous	Citrus	Truck	Lawn grass	Residential	Commercial and industrial	Miscellaneous	Riparian vegetation	Dry farm and native vegetation
1928-29	320	270	80	2,120	1,000	20	4,150	30	50	30	40	3,170	870	50	20	1,490
29-30	250	270	80	2,140	1,010	20	4,190	20	50	30	40	3,210	900	50	20	1,430
1930-31	190	270	80	2,160	1,020	20	4,220	20	50	30	40	3,240	920	50	20	1,380
31-32	200	270	80	2,180	1,030	20	4,180	20	50	30	40	3,280	950	50	20	1,310
32-33	80	260	80	2,210	1,040	20	4,270	20	50	30	40	3,510	980	50	20	1.250
33-34	70	250	80	2,240	1,050	20	4,250	10	50	30	40	3,350	1,010	50	20	1,190
34-35	80	250	80	2,260	1,070	20	4,200	20	50	20	40	3,380	1,040	50	20	1,130
1935-36	80	240	80	2,290	1,080	20	4,170	20	50	20	40	3,420	1,060	50	20	1,070
36-37	80	230	80	2,320	1,090	20	4,140	20	50	20	40	3,450	1,090	50	20	1,010
37-38	60	220	80	2,350	1,100	20	4,130	10	50	20	40	3,490	1,110	50	20	960
38-39	50	210	80	2,380	1,110	20	4,110	10	50	20	40	3,520	1,140	50	20	900
39-40	40	210	80	2,400	1,130	20	4,080	10	50	10	40	3,560	1,150	50	20	860
1940-41	70	200	130	2,430	1,140	20	3,970	10	50	10	40	3,590	1,160	50	20	820
41-42	50	190	130	2,460	1,150	20	3,960	10	50	10	40	3,630	1,170	50	20	770
42-43	30	220	130	2,620	1,260	20	3,680	20	40	10	40	3,670	1,170	50	20	730
43-44	40	240	130	2,790	1,370	20	3,370	20	30	10	40	3,700	1,180	50	20	700
44-45	40	260	130	2,950	1,480	20	3,080	20	20	10	40	3,740	1,190	50	20	660
1945-46	40	280	130	3,120	1,590	20	2,780	20	10	10	40	3,770	1,200	50	20	630
46-47	40	300	130	3,280	1,700	20	2,490	20	0	10	40	3,800	1,200	50	20	610
47-48	40	320	130	3,450	1,810	50	2,160	20	0	10	40	3,840	1,210	50	20	550
48-49	30	340	130	3,610	1,920	50	1,880	10	0	10	40	3,870	1,220	50	20	530
49-50	20	300	130	3,750	1,940	50	1,770	10	0	10	40	3,910	1,220	50	20	490
1950-51	20	270	130	3,900	1,950	50	1,640	10	0	10	40	3,930	1,230	50	10	470
51-52	30	230	160	4,040	1,970	50	1,480	10	0	10	40	3,940	1,240	50	0	460
52-53	30	200	160	4,190	1,980	50	1,350	10	0	10	40	3,970	1,240	50	0	430
53-54	30	160	160	4,330	2,000	50	1,230	10	0	10	40	3,980	1,240	50	0	420
54-55	30	120	160	4,470	2,010	90	1,080	10	0	20	40	3,990	1,250	90	0	350
1955-56	20	90	160	4,610	2,030	120	930	10	0	20	40	4,020	1,260	110	0	290
56-57	20	50	170	4,750	2,040	160	770	10	0	30	80	4,030	1,260	120	0	220
57-58	20	10	170	4,890	2,060	190	620	10	0	30	80	4,040	1,260	130	0	200

AREAL CULTURE ON VALLEY FILL AREA
BY WATER SERVICE AREA WITHIN EACH SUBAREA
(continued)

In Acres

Year	San Fernando and Eagle Rock Hydrologic Subareas														
	Owens Service Area														
	Deciduous	Citrus	Walnuts	Truck	Alfalfa	Irrigated pasture	Lawn grass	Irrigated vineyard	Residential	Commercial and industrial	Miscellaneous	Non-irrigated vineyard	Riparian vegetation	Water surface	Dry farm and native vegetation
1928-29	2,310	8,300	8,440	24,930	7,880		1,270	1,170	10,160	190	800	480	1,150	840	22,190
29-30	1,790	8,560	7,860	22,550	7,580		1,270	670	11,190	290	800	1,090	1,150	840	22,430
1930-31	1,340	9,190	7,270	22,310	6,680		1,270	520	12,230	680	800	1,270	1,150	840	27,520
31-32	1,440	8,920	7,270	18,100	6,770		1,270	390	13,260	1,100	800	1,420	1,150	840	25,340
32-33	860	8,770	6,570	18,260	7,610		1,270	780	14,290	1,520	800	940	1,150	840	24,410
33-34	730	8,920	7,260	19,880	6,840		1,270	820	15,290	1,910	1,160	920	1,150	840	21,080
34-35	830	8,840	7,250	19,990	7,090		1,270	460	16,310	2,310	1,160	1,350	1,150	840	19,220
1935-36	900	9,290	7,720	21,010	7,440		1,270	410	17,320	2,710	1,160	1,420	1,150	840	15,430
36-37	830	9,870	7,190	20,610	6,510		1,270	330	18,330	3,120	1,160	1,500	500	840	16,010
37-38	720	10,160	6,810	15,760	7,740		1,270	340	19,310	3,520	1,160	1,490	450	840	18,500
38-39	530	10,140	6,890	13,530	7,960		1,270	280	20,300	3,930	1,140	1,540	390	840	19,330
39-40	440	10,100	6,090	12,970	7,340		1,270	240	21,300	4,340	1,040	1,580	350	840	20,170
1940-41	720	9,910	5,270	14,080	6,160		1,310	230	22,240	4,750	1,040	1,580	350	960	19,470
41-42	550	9,860	5,890	16,630	6,940		1,310	270	23,220	5,170	1,040	1,540	350	960	14,340
42-43	530	10,660	5,700	13,940	7,630		1,310	250	23,970	5,480	1,040	770	350	960	15,480
43-44	540	11,440	5,530	11,260	8,320		1,310	240	24,730	5,800	1,040	1,530	350	960	15,020
44-45	540	11,630	5,470	10,460	8,320		1,310	220	25,510	6,080	1,040	1,330	350	960	14,850
1945-46	540	11,760	5,470	8,200	9,980		1,310	220	26,260	6,380	1,040	1,040	350	960	14,560
46-47	540	11,380	5,480	5,610	8,770		1,310	200	27,000	6,710	1,040	890	350	960	17,830
47-48	530	11,660	5,480	4,960	9,760		1,310	180	27,740	7,020	1.040	660	320	960	16,450
48-49	370	10,010	4,450	5,050	7,690	2,730	1,310	170	28,490	7,320	1,080	450	280	960	17,710
49-50	310	10,030	4,230	4,360	7,690	1,070	1,310	160	29,560	7,440	1,080	470	280	960	19,120
1950-51	300	9,820	4,240	5,510	7,910	1,040	1.310	160	30,640	7,570	1,090	480	280	960	16,760
51-52	400	9,590	3,610	4,570	8,240	1,580	1,320	140	31.720	7,700	1,100	500	280	960	16,360
52-53	400	8,970	3,600	5,100	4,940	2,870	1,320	120	32,820	7,840	1,110	520	270	960	17,230
53-54	400	8,190	3,210	5,110	5,380	2,520	1,320	100	33,900	7,960	1,110	510	270	960	17,130
54-55	360	7,560	2,910	4,080	2,630	1,640	1,320	80	35,990	7,980	1,130	510	260	960	20,660
1955-56	360	6,890	2,590	3,580	1,640	1.550	1,320	70	38,120	7,990	1,260	480	260	960	21,000
56-57	210	4,870	1,710	3,480	1,480	450	1,340	60	40,190	8,020	1,690	50	230	960	23,330
57-58	270	4,360	1,160	3,600	1,130	1,520	1,340	50	42,270	8,040	1,780	60	200	960	21,330

TABLE K-7

AREAL CULTURE ON VALLEY FILL AREA
BY WATER SERVICE AREA WITHIN EACH SUBAREA
(continued)

In Acres

Year	San Fernando and Eagle Rock Hydrologic Subareas															
	Mission Wells Service Area								Narrows Service Area							
	Deciduous	Citrus	Truck	Lawn grass[a]	Residential	Commercial and industrial	Miscellaneous	Dry farm and native vegetation	Truck	Irrigated pasture	Lawn grass[a]	Residential	Commercial and industrial	Miscellaneous	Riparian vegetation	Dry farm and native vegetation
1928-29	20	310	190	10	300	40	20	1,530	60	0	260	1,440	520	160	200	2,460
29-30	10	310	190	10	320	40	20	1,520	60	0	260	1,450	850	160	200	2,130
1930-31	10	310	190	10	340	50	20	1,490	60	0	260	1,460	860	160	200	2,110
31-32	10	310	190	10	360	50	20	1,470	60	0	260	1,490	870	160	200	2,070
32-33	20	330	190	10	380	50	20	1,420	50	0	260	1,510	880	160	200	2,040
33-34	10	350	190	10	400	60	20	1,380	50	0	260	1,540	900	160	200	2,000
34-35	20	370	190	10	420	60	20	1,330	40	0	260	1,560	910	160	200	1,970
1935-36	20	390	190	10	440	60	20	1,290	40	0	260	1,590	930	160	200	1,920
36-37	20	410	200	10	460	70	20	1,230	40	0	260	1,610	940	160	200	1,890
37-38	10	420	200	10	480	70	20	1,210	30	0	260	1,640	960	160	200	1,860
38-39	10	440	200	10	500	70	20	1,170	30	0	260	1,660	970	210	150	1,830
39-40	10	460	200	10	520	70	20	1,130	30	0	260	1,690	990	360	0	1,780
1940-41	10	480	200	20	540	80	20	1,070	20	0	260	1,710	1,000	360	0	1,760
41-42	10	500	200	20	560	80	20	1,030	20	0	260	1,740	1,020	360	0	1,710
42-43	70	470	190	20	610	90	20	950	20	0	260	1,770	1,040	360	0	1,640
43-44	70	450	180	20	670	100	20	910	20	0	260	1,800	1,060	360	0	1,580
44-45	70	420	170	20	720	110	20	890	10	0	260	1,830	1,080	360	0	1,540
1945-46	70	390	160	20	780	120	20	860	10	0	260	1,860	1,100	510	0	1,340
46-47	70	360	150	20	830	120	20	850	10	0	260	1,890	1,120	510	0	1,290
47-48	70	340	140	20	880	130	20	820	0	0	260	1,920	1,130	510	0	1,260
48-49	50	310	130	20	940	140	20	810	0	0	260	1,950	1,150	510	0	1,220
49-50	40	280	120	20	990	150	20	800	0	0	260	1,980	1,160	510	0	1,190
1950-51	40	250	110	20	1,040	160	20	780	0	10	260	2,010	1,180	510	0	1,130
51-52	50	230	100	20	1,100	170	20	730	0	10	300	2,030	1,190	510	0	1,050
52-53	50	200	90	20	1,150	180	20	710	0	20	300	2,060	1,210	510	0	990
53-54	50	170	80	20	1,210	190	20	680	0	30	300	2,080	1,220	510	0	950
54-55	50	140	70	20	1,260	190	20	670	0	40	300	2,110	1,240	510	0	890
1955-56	50	120	60	20	1,310	200	20	640	0	40	300	2,130	1,250	510	0	870
56-57	30	90	50	20	1,370	210	20	630	0	50	450	2,160	1,270	540	0	630
57-58	40	60	40	20	1,420	220	20	600	0	60	450	2,180	1,280	540	0	590

AREAL CULTURE ON VALLEY FILL AREA
BY WATER SERVICE AREA WITHIN EACH SUBAREA
(continued)

In Acres

Year	San Fernando and Eagle Rock Hydrologic Subareas															
	Sunland-Tujunga Service Area								City of San Fernando Service Area							
	Residential	Commercial and industrial	Miscellaneous	Dry farm and native vegetation	Deciduous	Citrus	Truck	Irrigated vineyard	Citrus	Truck	Alfalfa	Lawn grass[a]	Residential	Commercial and industrial	Miscellaneous	Dry farm and native vegetation
1928-29	830	120	30	970	60	20	50	240	280	60	10	10	390	190	30	190
29-30	860	120	30	1,050	50	20	50	140	280	60	10	10	390	190	30	190
1930-31	890	130	30	1,050	40	20	50	110	280	60	10	10	390	190	30	190
31-32	920	130	30	1,050	40	20	50	80	280	60	10	10	390	190	30	190
32-33	950	130	30	900	80	20	50	160	280	60	10	10	390	190	30	190
33-34	980	140	30	870	70	20	50	160	280	60	10	10	390	190	30	190
34-35	1,010	140	30	890	80	30	50	90	280	60	10	10	390	190	30	190
1935-36	1,050	150	30	850	80	30	50	80	280	60	10	10	390	190	30	190
36-37	1,070	150	30	850	80	30	40	70	280	70	10	10	390	190	30	180
37-38	1,100	150	30	840	60	30	40	70	270	70	10	10	390	190	30	190
38-39	1,140	160	30	810	50	30	40	60	270	70	10	10	390	190	30	190
39-40	1,160	160	30	800	40	40	40	50	270	70	10	10	390	190	30	190
1940-41	1,200	170	30	720	70	40	40	50	270	70	10	20	390	190	30	180
41-42	1,230	170	30	710	50	40	40	50	270	70	10	20	390	190	30	180
42-43	1,250	170	30	710	30	40	40	50	250	70	10	20	410	200	30	170
43-44	1,260	170	30	690	40	40	40	50	240	60	10	20	430	200	30	170
44-45	1,270	180	30	670	40	40	40	50	220	60	10	20	440	210	30	170
1945-46	1,280	180	30	680	40	30	40	40	210	60	10	20	460	220	30	150
46-47	1,300	180	30	660	40	30	40	40	190	50	10	20	470	220	30	170
47-48	1,310	180	30	650	40	30	40	40	170	50	10	20	490	230	30	160
48-49	1,330	180	30	640	30	30	40	40	160	40	10	20	510	230	30	160
49-50	1,340	190	30	640	20	30	40	30	140	40	10	20	530	240	30	150
1950-51	1,360	190	30	630	20	20	40	30	120	40	10	20	540	250	30	150
51-52	1,370	190	30	610	30	20	40	30	110	30	10	20	560	250	30	150
52-53	1,380	190	30	600	30	20	40	30	90	30	10	20	580	260	30	140
53-54	1,390	190	30	600	30	20	40	20	80	30	10	20	600	270	30	120
54-55	1,410	200	30	570	30	20	40	20	60	20	10	20	610	270	30	140
1955-56	1,420	200	30	580	20	10	40	20	40	20	10	20	630	280	30	130
56-57	1,430	200	30	580	20	10	40	10	30	10	10	30	640	280	30	130
57-58	1,440	200	30	570	20	10	40	10	10	10	10	30	660	290	30	120

TABLE K-7

AREAL CULTURE ON VALLEY FILL AREA
BY WATER SERVICE AREA WITHIN EACH SUBAREA
(continued)

In Acres

Year	Sylmar Subarea														
	Owens Service Area													City of San Fernando Service Area	
	Deciduous	Citrus	Walnuts	Truck	Alfalfa	Irrigated pasture	Lawn grass[a]	Irrigated vineyard	Residential	Commercial and industrial	Miscellaneous	Non-irrigated vineyard	Dry farm and native vegetation	Residential	Dry farm and native vegetation
1928-29	1,710	1,000	40	330	160		40	80	80	40	150	30	1,820	40	80
29-30	1,310	1,080	40	300	150		40	40	120	40	150	60	2,150	40	80
1930-31	1,000	1,160	40	270	140		40	30	160	40	150	70	2,380	40	80
31-32	1,050	1,200	40	250	120		40	30	190	40	150	80	2,280	40	80
32-33	1,470	1,230	40	240	110		40	60	220	40	150	60	1,820	40	80
33-34	1,220	1,260	40	220	100		40	50	260	40	150	50	2,050	40	80
34-35	1,420	1,290	40	200	90		40	30	300	40	150	70	1,810	40	80
1935-36	1,540	1,320	40	180	80		40	20	330	40	150	70	1,670	40	80
36-37	1,430	1,130	40	420	60		40	20	360	40	150	80	1,710	40	80
37-38	1,180	950	40	650	40		40	20	400	40	150	80	1,890	40	80
38-39	900	990	40	740	50		40	20	440	40	150	100	1,970	40	80
39-40	760	1,040	40	820	50		40	20	470	40	150	110	1,940	40	80
1940-41	1,210	1,080	30	910	40		40	20	500	40	150	120	1,340	40	80
41-42	920	1,120	30	1,000	40		40	20	540	40	150	120	1,460	40	80
42-43	980	1,040	30	1,030	40		40	20	580	40	150	60	1,470	40	80
43-44	1,030	970	30	1,070	30		40	20	610	40	150	120	1,370	40	80
44-45	1,030	890	30	1,110	30		40	20	630	40	150	100	1,410	50	70
1945-46	1,030	810	30	1,150	20		40	20	670	40	150	80	1,440	50	70
46-47	1,030	740	20	1,180	20		40	20	710	40	150	70	1,460	50	70
47-48	1,010	660	20	1,220	20		40	20	740	40	150	50	1,510	50	70
48-49	720	580	20	1,260	0	20	40	20	770	40	150	40	1,820	50	70
49-50	570	590	20	1,060	0	30	40	20	850	50	150	40	2,060	50	70
1950-51	570	600	20	860	0	50	40	10	930	60	150	40	2,150	60	60
51-52	760	610	20	660	0	60	40	10	1,010	70	150	40	2,050	60	60
52-53	750	620	20	460	0	80	40	10	1,090	80	150	40	2,140	60	60
53-54	760	630	10	260	0	90	40	30	1,170	90	150	40	2,210	60	60
54-55	780	580	10	260	0	80	40	30	1,250	110	130	40	2,170	60	60
1955-56	740	530	10	250	0	60	40	30	1,330	130	120	40	2,200	60	60
56-57	480	450	10	240	0	50	40	30	1,410	150	100	40	2,450	70	50
57-58	590	430	0	240	0	40	40	20	1,490	170	80	40	2,340	70	50

AREAL CULTURE ON VALLEY FILL AREA
BY WATER SERVICE AREA WITHIN EACH SUBAREA
(continued)

In Acres

Year	Verdugo Subarea[b]												
	Crescenta Valley County Water District Service Area								City of Glendale Service Area				
	Deciduous	Truck	Lawn grass[a]	Residential	Commercial and Industrial	Miscellaneous	Riparian vegetation	Dry farm and native vegetation	Lawn grass[a]	Residential	Commercial and industrial	Miscellaneous	Dry farm and native vegetation
1928-29	110	0	10	280	20	120	20	1,640	90	150	10	200	1,220
29-30	90	0	10	280	20	120	20	1,860	90	160	10	200	1,210
1930-31	60	0	10	300	20	120	20	1,870	90	170	20	200	1,190
31-32	70	0	10	310	20	120	20	1,850	90	180	20	200	1,180
32-33	60	0	10	330	20	120	20	1,840	90	180	20	200	1,180
33-34	60	0	10	350	20	120	20	1,820	90	190	20	200	1,170
34-35	60	0	10	360	20	120	20	1,810	90	200	20	200	1,160
1935-36	60	0	10	370	30	120	20	1,790	90	210	20	20	1,150
36-37	60	0	10	390	30	120	20	1,770	90	230	20	200	1,130
37-38	50	0	10	430	30	120	20	1,740	90	240	30	200	1,110
38-39	40	0	10	450	30	120	20	1,730	90	260	30	200	1,090
39-40	30	0	10	490	40	120	20	1,690	90	270	30	200	1,080
1940-41	60	0	10	540	40	120	20	1,610	100	310	30	200	1,030
41-42	40	0	10	570	50	120	20	1,590	100	320	30	200	1,020
42-43	30	0	10	630	50	120	20	1,540	100	350	40	200	980
43-44	30	0	10	690	50	120	20	1,480	100	390	40	200	940
44-45	30	0	10	730	60	120	20	1,430	100	420	40	200	910
1945-46	40	0	10	800	70	120	20	1,340	100	450	40	200	880
46-47	30	0	10	870	70	120	20	1,280	100	490	50	200	830
47-48	30	0	10	950	80	120	20	1,190	100	530	50	200	790
48-49	30	0	10	1,000	90	120	20	1,130	100	560	50	200	760
49-50	20	0	10	1,080	90	120	20	1,060	100	600	60	200	710
1950-51	20	0	10	1,150	100	120	20	980	100	640	60	200	670
51-52	30	0	10	1,230	110	120	20	880	110	690	60	200	610
52-53	30	0	10	1,300	110	120	20	810	110	720	70	200	570
53-54	30	0	10	1,380	120	120	20	720	110	770	80	200	510
54-55	10	10	10	1,460	130	100	10	670	110	820	80	160	500
1955-56	10	20	10	1,520	140	80	10	610	110	850	80	120	510
56-57	10	30	20	1,600	140	60	10	530	130	900	90	80	470
57-58	10	50	20	1,700	150	30	10	430	130	950	90	50	450

TABLE K-7

AREAL CULTURE ON VALLEY FILL AREA
BY WATER SERVICE AREA WITHIN EACH SUBAREA
(continued)

In Acres

Year	Verdugo Subarea[b]								
	La Canada Irrigation District Service Area							Sunland-Tujunga Service Area	
	Deciduous	Citrus	Truck	Residential[a]	Commercial and industrial	Riparian vegetation	Dry farm and native vegetation	Residential	Dry farm and native vegetation
1928-29	30	50	10	60	10	10	440	20	300
29-30	20	50	10	70	10	10	440	30	290
1930-31	20	50	10	70	10	10	440	30	290
31-32	20	50	10	70	10	10	440	30	290
32-33	20	50	10	80	10	10	430	30	290
33-34	10	40	10	80	10	10	450	30	290
34-35	20	40	10	90	10	10	430	30	290
1935-36	20	40	10	90	10	10	430	30	290
36-37	20	40	10	100	10	10	420	40	280
37-38	10	40	10	100	10	10	430	40	280
38-39	10	30	10	110	10	10	430	40	280
39-40	10	30	10	120	10	10	420	40	280
1940-41	10	30	10	130	10	10	410	50	270
41-42	10	30	10	140	10	10	400	50	270
42-43	20	30	10	150	10	10	380	60	260
43-44	20	20	10	160	10	10	380	60	260
44-45	20	20	10	180	10	10	360	70	250
1945-46	20	20	10	190	10	10	350	70	250
46-47	20	20	10	210	10	10	330	80	240
47-48	20	20	10	220	10	10	320	80	240
48-49	10	10	10	240	10	10	320	90	230
49-50	10	10	10	250	10	10	310	100	220
1950-51	10	10	10	270	10	10	290	100	220
51-52	10	10	10	290	10	10	270	110	210
52-53	10	10	10	300	10	10	260	110	210
53-54	10	10	10	320	10	10	240	120	200
54-55	0	10	10	340	10	10	230	130	190
1955-56	0	10	10	360	10	10	210	130	190
56-57	0	10	10	380	10	10	190	140	180
57-58	0	10	10	400	10	10	170	150	170

a. Does not include residential lawn grass areas.
b. Includes the portion of Monk Hill Basin in the Upper Los Angeles River Area.

Note: Areal culture outside of the major water service areas is not included in this tabulation.

APPENDIX L

PROCEDURES FOR ESTIMATING AVERAGE CONSUMPTIVE USE AND DEEP PERCOLATION ON VARIOUS LAND USE CLASSES BY THE INTEGRATION METHOD

APPENDIX L

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APPENDIX L

PROCEDURES FOR ESTIMATING AVERAGE CONSUMPTIVE USE AND DEEP PERCOLATION ON VARIOUS LAND USE CLASSES BY THE INTEGRATION METHOD

The methods described herein are utilized to develop annual values for the depth of consumptive use and deep percolation of rain and delivered water applied on the various land use classes existing within the San Fernando, Eagle Rock, Sylmar and Verdugo Hydrologic Subareas. Unit consumptive use values are determined herein for use in the Integration Method as discussed in Chapter VI. For purposes of this appendix, the Eagle Rock and San Fernando Hydrologic Subareas have been considered as a single unit and the values thus derived for the San Fernando Subarea are intended to also apply to the Eagle Rock Subarea.

The term consumptive use, as utilized in this report, is defined as the amount of water used by the vegetative growth of a given area in transpiration or building of plant tissue and evaporated from adjacent soil. It also includes the evaporation of precipitation intercepted by vegetative growth or impervious area, the water evaporated in industrial processes, household uses, or that which is permanently incorporated in the product. Delivered water as heretofore defined is water delivered by man-made works to a given land use classification and has been discussed in Appendix J. Native waters are defined as precipitation and hill and mountain runoff.

Rainfall on the valley surface is partially disposed of as consumptive use and deep percolation. The remainder, termed residual rain, is runoff from the area on which the precipitation fell and contributes to the total runoff out of the area of investigation. The deep percolation of residual rain and hill and mountain runoff in transit between the point of application and the point of exit from the valley fill area is termed deep percolation in the stream system. Delivered water is disposed of by consumptive use, deep percolation, sewage and waste.

The annual depths of delivered and native waters which become consumptive use, deep percolation and residual rain at the area of application are treated herein. Available data concerning consumptive use comprise average amounts of consumptive use measured under certain climatic and water use conditions in various localities. In certain instances these data have been transposed to the Upper Los Angeles River area by correcting for the average temperature differences between the two localities. However, no satisfactory method has been developed to completely adjust these values for all the effects of variations in seasonal rainfall, rainfall patterns and fluctuations in the methods of applying delivered water in the two respective areas. It is apparent, therefore, that the values will give a relationship as to the relative use of water between various classifications but that the annual consumptive use of water may require adjustment to account for these effects.

The division of rain and delivered water into consumptive use, deep percolation and residual rain within the three basic hydrologic subareas has been estimated for each of the culture classifications listed in Appendix K. The depths of consumptive use, deep percolation and residual rain as well as the sum thereof have been computed on a gross acreage basis; that is, the value derived is applicable to the gross acreage including the proportion which is impervious and hence relatively nonconsumptive. Data utilized herein concerning precipitation, land use and delivered water are from Appendixes E, K, and J, respectively.

Evaporation of Precipitation

Evaporation is a function of vapor pressure which varies with humidity, temperature and wind movement. The evaporation pan is sensitive to these factors and is commonly utilized to determine rates of evaporation from water surfaces. The rate of evaporation from moist surfaces, such as saturated soils and wet impervious areas, has been considered to have an evaporation rate equivalent to that of a water surface. A study of evaporation pan records and meteorological data for various locations on the valley floor indicates that conditions at Encino Reservoir may be considered as representative of the valley floor.

Evaporation records for the 10-year period from 1946-47 through 1955-56 for the 24-inch diameter screened ground evaporation pan located at Encino Reservoir were utilized in determining rates of evaporation of rainfall from the valley floor. During this period the screened pan coefficient was 0.98 as determined by experiments at Encino Reservoir. This period was selected from the longer record available because prior to 1946-47 the evaporation pan was operated under conditions wherein the pan coefficient was uncertain, and subsequent to 1955-56 daily readings were not made.

From the 10-year period of record, average daily pan rates of evaporation were determined for each month of each year for storm periods and for nonstorm periods. In the determination of average daily rates of evaporation during storm periods, small individual storms were neglected when the daily evaporation rate exceeded the rainfall. The average daily evaporation rate during storms was determined by averaging the daily evaporation for the number of days that precipitation occurred. During June, July, August and September, storms were not prevalent but the records indicate that the evaporation rate during storms in these months was approximately 0.10 inch per day. The average daily rates thus determined are used in computing the evaporation of rainfall during the base period and are as follows:

AVERAGE DAILY RATES OF RAINFALL EVAPORATION*

In Inches

Month	During storm	After storm	Month	During storm	After storm
October	0.085	0.182	April	0.065	0.163
November	0.051	0.134	May	0.053	0.195
December	0.031	0.089	June	0.100	0.217
January	0.029	0.078	July	0.100	0.283
February	0.032	0.102	August	0.100	0.274
March	0.057	0.130	September	0.100	0.251

* Based on record of 24-inch diameter screened ground pan at Encino Reservoir.

The monthly evaporation shown in Table L-1 was computed as the sum of the daily evaporation from individual storms occurring in the month. Evaporation from individual storms on the valley floor was computed in the following manner:

1. An individual storm was 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 was 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 was computed using the daily evaporation rates shown on page L-9 for storm periods for the number of days in which precipitation occurred; and (2) after storm periods the evaporation was computed using the after storm rate shown on page L-9 up to a total of 0.60 inch, if available, or until another storm occurred. The sum of the two parts was the total evaporation for an individual storm from pervious areas. The 0.60 inch maximum is based on data published in State Division of Water Resources Bulletin No. 33,[6] which notes that observations made in Southern California indicate that the average evaporation loss from the topsoil is one-half acre-inch per acre after each rainstorm, although the total evaporation after a storm may amount to 0.7 inch.

4. On impervious areas the evaporation computation also consisted of two parts: (1) during storm periods the evaporation was computed using the daily evaporation rate shown on page L-9 for storm periods for the

number of days in which precipitation occurred; and (2) after storm periods the evaporation was computed using the after-storm rate on page L-9 until the sum of the two parts amounted to a maximum of 0.50 inch or until another storm occurred. The maximum of 0.50 inch was exceeded only when the storm period was sufficiently long so that the evaporation during the storm exceeded 0.50 inch. In such instances the evaporation after storms was considered to be zero. A study made of the Seco and Broadway Drains in the Raymond Basin indicated that the average evaporation after individual storms of more than one inch total precipitation on suburban areas is about 0.50 inch.

5. When the evaporation rate exceeded the daily precipitation the amount of the latter was taken as the daily evaporation.

Transpiration Requirements

Transpiration requirements have been determined experimentally for various types of crops in the area of investigation by the U. S. Department of Agriculture, Soil Conservation Service. Winter transpiration requirements for alfalfa and citrus only were available in the Upper Los Angeles River area. Values for the other crops were transposed to the Upper Los Angeles River area from the place of measurement by the ratio of the mean temperature and percentage of daylight hours at the two places.

Determination of monthly values of winter transpiration use by alfalfa and by citrus was based on studies made in the San Fernando Valley by the Soil Conservation Service[1/] [2/] in 1940. Records of rainfall and irrigation water were maintained and the soil moisture depletion was

TABLE L-1

MONTHLY EVAPORATION FOR PERVIOUS AND
IMPERVIOUS AREAS ON THE VALLEY FILL AREA

In Inches

Year	San Fernando Subarea																
	Pervious Areas								Impervious Areas								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May-Sept.	Total
1928-29	0.3	0.8	1.2	0.8	1.3	0.8	1.0	6.7	0.3	0.5	1.0	0.5	1.0	0.5	0.6	0.6	5.0
29-30	0.1	0	0	1.6	0.5	1.7	0.3	4.2	0.1	0	0	1.0	0.5	1.1	0.3	0.3	3.3
1930-31	0.2	1.5	0	0.7	1.2	0	1.1	4.7	0.2	1.0	0	0.7	0.9	0	0.5	0.8	4.1
31-32	0.2	1.7	1.1	1.1	1.5	0.1	0.7	6.4	0.2	1.2	0.9	0.7	1.2	0.1	0.5	0.4	5.2
32-33	0.1	0	1.0	1.0	0	0.1	0.5	2.7	0.1	0	0.7	0.5	0	0.1	0.5	0.6	2.5
33-34	0.3	0	1.0	0.8	1.2	0	0	3.3	0.3	0	0.7	0.4	0.6	0	0	0.4	2.4
34-35	1.0	1.0	1.4	0.9	0.8	2.0	1.3	8.4	0.6	0.6	1.0	0.9	0.7	1.4	1.0	0.2	6.4
1935-36	0.2	1.0	0.7	0.2	1.9	0.6	0.6	5.2	0.2	0.8	0.6	0.2	1.4	0.6	0.5	0.1	4.4
36-37	1.4	0	1.2	1.1	1.8	1.8	0.3	7.6	0.9	0	1.0	1.1	1.4	1.0	0.3	0.2	5.9
37-38	0	0	1.6	0.9	1.3	1.6	0.7	6.1	0	0	1.3	0.6	1.2	1.0	0.7	0.3	5.1
38-39	0.1	0	0.9	1.6	0.9	1.2	0.3	5.0	0.1	0	0.5	1.3	0.5	1.0	0.3	0.7	4.4
39-40	0.1	0.2	0.7	1.4	2.0	0.6	1.6	6.6	0.1	0.2	0.7	1.0	1.4	0.3	1.1	0.1	4.9
1940-41	0.9	0.3	1.1	0.9	1.1	2.0	2.5	8.8	0.5	0.3	1.1	0.9	0.8	1.3	1.2	0.3	6.4
41-42	1.4	0.1	1.8	0.3	0.7	0.9	2.0	7.2	1.1	0.1	1.2	0.3	0.5	0.5	1.7	0.5	5.9
42-43	0.8	0.2	0.7	1.0	0.9	1.6	0.9	6.1	0.5	0.2	0.5	0.9	0.7	1.4	0.6	0	4.8
43-44	0.3	0.2	1.6	0.8	1.2	0.9	0.7	5.7	0.3	0.2	1.3	0.8	1.2	0.5	0.5	0.1	4.9
44-45	0.1	1.5	0.9	0	1.1	2.4	0.2	6.2	0.1	1.1	0.7	0	0.8	1.6	0.2	0.1	4.6
1945-46	0.9	0.3	0.9	0.3	0.7	1.7	0.5	5.3	0.9	0.3	0.7	0.3	0.6	0.9	0.5	0.2	4.4
46-47	0.8	1.8	1.4	0.3	0.3	1.3	0.1	6.0	0.8	1.1	1.0	0.3	0.3	1.2	0.1	0.2	5.0
47-48	0.1	0	0.9	0	0.7	1.5	0.9	4.1	0.1	0	0.6	0	0.5	1.0	0.9	0.3	3.4
48-49	0.2	0	1.3	1.3	1.1	1.1	0	5.0	0.2	0	1.1	0.8	0.9	1.1	0	0.5	4.6
49-50	0	0.9	1.3	1.3	0.9	0.8	0.9	6.1	0	0.5	1.0	1.0	0.5	0.5	0.5	0.5	4.5
1950-51	0.3	1.2	0.1	1.8	0.3	0.6	1.6	5.9	0.3	1.0	0.1	1.4	0.3	0.3	1.0	0.2	4.6
51-52	0.6	0.9	2.2	1.5	0.3	1.7	1.7	8.9	0.5	0.5	2.0	1.3	0.3	1.0	1.2	0.1	6.9
52-53	0	1.7	1.6	0.8	0	0.4	1.3	5.8	0	1.3	1.5	0.8	0	0.4	1.0	0.1	5.1
53-54	0	0.7	0.2	1.4	0.4	1.9	0.2	4.8	0	0.6	0.2	1.2	0.4	1.4	0.2	0	4.0
54-55	0	0.7	1.1	2.1	1.1	0.5	0.8	6.3	0	0.7	0.9	1.5	1.0	0.5	0.8	1.1	6.5
1955-56	0	1.2	1.2	0.9	0.6	0	1.5	5.4	0	0.6	0.9	0.9	0.5	0	1.1	0.8	4.8
56-57	0.4	0	0.1	1.8	0.5	1.6	0.9	5.3	0.4	0	0.1	1.0	0.3	1.3	0.5	0.2	3.8
57-58	1.6	0.6	1.4	0.4	1.2	1.6	1.2	8.0	1.0	0.4	1.0	0.4	1.1	1.6	0.6	0.4	6.5

MONTHLY EVAPORATION FOR PERVIOUS AND
IMPERVIOUS AREAS ON THE VALLEY FILL AREA
(continued)

In Inches

Year	Sylmar Subarea																
	Pervious Areas								Impervious Areas								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May-Sept.	Total
1928-29	0.4	0.7	1.4	0.9	1.4	0.7	1.8	6.2	0.4	0.5	1.0	0.8	1.0	0.5	0.5	0.6	5.3
29-30	0.1	0	0	1.6	0.5	2.0	0.4	4.6	0.1	0	0	1.0	0.5	1.3	0.4	0.5	3.8
1930-31	0.7	1.6	0	1.0	1.0	0	1.0	5.3	0.5	1.2	0	1.0	0.9	0	0.5	1.0	5.1
31-32	0.2	1.8	1.6	0.9	1.7	0.3	0.7	7.2	0.2	1.5	1.5	0.8	1.3	0.3	0.5	0.4	6.5
32-33	0.1	0	1.3	1.3	0	0.3	0.8	3.8	0.1	0	1.0	0.7	0	0.3	0.5	0.9	3.5
33-34	0.6	0.1	0.5	0.7	1.1	0	0	3.0	0.5	0.1	0.5	0.5	0.6	0	0	0.9	3.1
34-35	0.8	1.3	1.6	1.2	0.9	2.3	1.6	9.7	0.5	1.2	1.3	1.2	0.7	1.5	1.4	0.2	8.0
1935-36	0.5	1.0	0.8	0.4	2.0	0.7	0.6	6.0	0.5	0.9	0.7	0.4	1.5	0.7	0.6	0.1	5.4
36-37	1.5	0	1.4	1.6	1.9	2.0	0.6	9.0	1.0	0	1.2	1.4	1.5	1.3	0.5	0.5	7.4
37-38	0	0	1.6	0.9	1.5	1.5	1.5	7.0	0	0	1.2	0.7	1.4	1.3	1.4	0.6	6.6
38-39	0.2	0	1.0	1.6	1.0	1.3	0.4	5.5	0.2	0	0.5	1.4	0.5	1.0	0.4	0.6	4.6
39-40	0.2	0.2	1.0	1.7	2.2	0.3	1.4	7.0	0.2	0.2	0.9	1.0	1.8	0.3	1.2	0	5.6
1940-41	0.8	0.2	1.6	1.7	1.4	2.0	2.7	10.4	0.5	0.2	1.4	1.3	1.1	1.3	1.4	0.2	7.4
41-42	1.5	0.1	2.0	0.3	0.6	0.9	2.5	7.9	1.5	0.1	1.7	0.3	0.5	0.8	2.2	0.5	7.6
42-43	1.0	0.6	0.8	1.1	0.9	2.0	0.9	7.3	1.0	0.6	0.6	1.0	0.7	1.6	0.5	0	5.7
43-44	0.2	0.3	1.8	1.3	1.3	1.0	0.7	6.6	0.2	0.3	1.6	1.3	1.1	0.5	0.5	0.5	6.0
44-45	0.1	1.8	0.8	0	0.9	2.6	0.4	6.6	0.1	1.4	0.7	0	0.7	1.9	0.4	0.6	5.8
1945-46	1.2	0.5	0.8	0.3	0.8	1.5	0.6	5.7	1.0	0.5	0.6	0.3	0.6	1.2	0.6	0.4	5.2
46-47	1.5	1.8	1.4	0.6	0.2	1.7	0.2	7.4	1.0	1.3	1.0	0.5	0.2	1.4	0.2	0.7	6.3
47-48	0.1	0	0.7	0	0.7	1.7	1.5	4.7	0.1	0	0.6	0	0.5	1.1	1.5	0.5	4.3
48-49	0.2	0	1.4	1.3	1.3	1.4	0.1	5.7	0.2	0	1.3	0.9	1.3	1.2	0.1	0.5	5.5
49-50	0	0.8	1.3	1.4	0.7	0.7	0.7	5.6	0	0.5	1.0	1.0	0.7	0.5	0.5	0.7	4.9
1950-51	0.7	1.3	0.2	2.0	0.5	0.6	1.5	6.8	0.5	1.0	0.2	1.5	0.5	0.5	1.3	0.5	6.0
51-52	0.7	0.8	2.4	1.6	0.2	1.5	1.7	8.9	0.5	0.5	1.9	1.3	0.2	1.2	1.0	0.1	6.7
52-53	0	1.1	1.9	1.0	0.2	0.7	1.5	6.4	0	0.9	1.7	0.9	0.2	0.5	1.0	0.2	5.4
53-54	0	0.7	0.2	1.4	0.6	1.9	0.5	5.3	0	0.5	0.2	1.2	0.6	1.4	0.5	0	4.4
54-55	0	0.7	1.1	2.1	1.2	0.3	1.2	6.6	0	0.7	1.0	1.8	1.0	0.3	1.0	1.1	6.9
1955-56	0	1.4	1.6	0.7	0.7	0	1.7	6.1	0	1.3	1.3	0.7	0.5	0	1.1	0.5	5.4
56-57	0.7	0	0.2	2.0	0.6	1.7	0.9	6.1	0.6	0	0.2	1.5	0.6	1.2	0.9	1.4	6.4
57-58	1.7	0.7	1.3	0.6	1.5	2.0	1.1	8.9	1.1	0.5	1.0	0.6	1.1	1.8	0.4	0.4	6.9

TABLE L-1

MONTHLY EVAPORATION FOR PERVIOUS AND IMPERVIOUS AREAS ON THE VALLEY FILL AREA
(continued)

In Inches

Year	Verdugo Subarea																
	Pervious Areas								Impervious Areas								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May-Sept.	Total
1928-29	0.7	0.7	1.4	0.9	1.5	0.6	1.0	6.8	0.5	0.5	1.0	0.7	1.0	0.6	0.6	0.7	5.6
29-30	0.1	0	0	1.4	0.7	1.8	0.1	4.1	0.1	0	0	1.0	0.6	1.2	0.1	1.0	4.0
1930-31	0.1	1.7	0	1.2	1.1	0	1.0	5.1	0.1	1.3	0	1.2	1.0	0	0.5	1.1	5.2
31-32	0.3	1.5	1.7	0.9	1.6	0	1.0	7.0	0.3	1.2	1.7	0.8	1.3	0	0.8	0.4	6.5
32-33	0.1	0	1.3	1.2	0	0.2	0.8	3.6	0.1	0	1.0	0.6	0	0.2	0.7	1.0	3.6
33-34	0.6	0.2	0.5	0.8	1.0	0.1	0.1	3.3	0.5	0.2	0.5	0.6	0.7	0.1	0.1	0.5	3.2
34-35	0.8	1.0	1.4	1.5	0.8	2.2	1.7	9.4	0.5	0.7	1.2	1.5	0.6	1.5	1.2	0.7	7.9
1935-36	0.5	0.9	0.8	0.2	1.9	0.8	0.7	5.8	0.5	0.7	0.6	0.2	1.4	0.8	0.5	0.3	5.0
36-37	1.7	0	1.5	1.9	1.9	1.8	0.3	9.1	1.0	0	1.2	1.5	1.5	1.0	0.3	0.5	7.0
37-38	0	0	1.6	0.8	1.4	1.5	1.3	6.6	0	0	1.2	0.8	1.4	1.0	1.3	0.6	6.3
38-39	0.3	0	0.9	1.5	1.0	1.3	0.5	5.5	0.3	0	0.5	1.3	0.5	1.1	0.5	0.7	4.9
39-40	0.3	0.2	1.0	1.5	2.0	0.3	1.2	6.5	0.2	0.3	0.8	1.0	1.7	0.3	1.0	0.2	5.5
1940-41	0.9	0.7	1.5	1.7	1.4	2.1	2.5	10.8	0.5	0.5	1.5	1.3	1.1	1.3	1.4	0.3	7.9
41-42	1.4	0.1	2.2	0.3	0.7	1.0	2.2	7.9	1.0	0.1	1.5	0.3	0.5	0.5	1.9	0.5	6.3
42-43	1.0	0.4	0.7	1.1	1.3	1.5	1.0	7.0	0.8	0.4	0.5	0.9	1.0	1.4	0.7	0	5.7
43-44	0.2	0.1	2.4	0.8	1.4	1.0	0.7	6.6	0.2	0.1	1.5	0.8	1.1	0.6	0.5	0.7	5.5
44-45	0	1.5	1.1	0	1.5	2.6	0.5	7.2	0	1.1	0.9	0	1.3	1.9	0.5	0.5	6.2
1945-46	0.9	0.3	0.9	0.2	0.9	1.7	0.7	5.6	0.6	0.3	0.6	0.2	0.7	1.1	0.7	0.3	4.5
46-47	1.9	2.1	1.1	0.6	0.3	1.6	0.3	7.9	1.3	1.7	0.8	0.5	0.3	1.4	0.3	0.8	7.1
47-48	0	0	0.9	0	0.9	1.6	1.4	4.8	0	0	0.7	0	0.7	1.2	1.1	0.3	4.0
48-49	0.4	0	1.5	1.2	1.7	2.3	0.1	7.2	0.4	0	1.4	1.0	1.5	1.8	0.1	0.6	6.8
49-50	0.2	0.8	1.2	1.6	0.8	0.7	0.8	6.1	0.2	0.5	1.0	1.0	0.8	0.5	0.5	0.9	5.4
1950-51	0.5	1.3	0	1.9	0.5	0.7	1.7	6.6	0.5	1.0	0	1.5	0.5	0.4	1.5	0.4	5.8
51-52	0.8	0.8	2.4	1.6	0.6	1.4	2.5	10.1	0.5	0.5	2.1	1.3	0.5	0.8	1.5	0.2	7.4
52-53	0	1.6	1.6	0.8	0.1	0.8	1.4	6.3	0	1.2	1.4	0.8	0.1	0.7	1.1	0.1	5.4
53-54	0	0.9	0.3	1.4	0.5	1.9	0.3	5.3	0	0.8	0.3	1.3	0.5	1.4	0.3	0.1	4.7
54-55	0	0.6	1.1	2.1	1.3	0.7	0.9	6.7	0	0.6	0.9	1.9	1.0	0.7	0.8	1.3	7.2
1955-56	0	1.0	1.5	0.8	0.7	0	1.9	5.9	0	0.9	1.0	0.8	0.5	0	1.3	0.5	5.0
56-57	0.6	0	0.2	1.8	0.8	1.1	0.9	5.4	0.5	0	0.2	1.0	0.6	1.1	1.5	1.3	5.2
57-58	1.3	0.8	1.3	0.5	1.6	2.1	1.1	8.7	0.8	0.4	1.0	0.5	1.5	1.8	0.5	0.4	6.9

determined by analyzing soil samples taken with a standard soil tube. These values were used without modification.

Monthly values of winter transpiration use by walnuts in the Upper Santa Ana River Valley[4] were transposed for use in the San Fernando Valley by means of the ratio of mean temperatures and percentage of daylight hours of the two areas. In the San Fernando Valley the U. S. Weather Bureau station in San Fernando, which has a 42-year period of temperature record, was used. In upper Santa Ana River Valley the temperature used was the average of the Pomona and Fontana Kaiser U. S. Weather Bureau stations which have 47 and 37 years of record, respectively. The ratio applied during the winter months was computed as follows:

Mean Temperature
October through April

San Fernando	58.0° F
Pomona	55.0° F
Fontana Kaiser	56.4° F

$$\text{Ratio} = \frac{58.0}{\frac{55.0 + 56.4}{2}} = 1.04$$

Since the percentage of daylight hours is nearly equivalent in the two areas, the values of Upper Santa Ana River Valley were increased by the factor of 1.04 to be applicable in San Fernando Valley.

Monthly values of winter transpiration use by deciduous trees in Upper Santa Ana River Valley[4] were transposed for use in San Fernando Valley by the aforementioned factor of 1.04. The transpiration use by deciduous trees was derived by the Soil Conservation Service[10] from measurements on Tuscan peach trees in the Ontario area, to which was added the transpiration use by the winter cover crops. The transpiration use values for walnuts are average for medium to large trees, considering that 50 percent of the orchard had winter cover crops.

The growing season of double-cropped truck was considered to extend from April through October. Consumptive use during two months of the winter period, October and April, was determined by the consumptive use formula $u = kf$[11] in which u is the monthly consumptive use, k is the monthly consumptive use coefficient and f is the monthly consumptive use factor derived from mean monthly temperature and monthly percent of daytime hours of the year. The value of k was taken to be 0.60 and the f value for October as 5.14 and for April as 5.29, resulting in the following values of u:

u (October) = 0.60 x 5.14 = 3.1 inches consumptive use.

u (April) = 0.60 x 5.29 = 3.2 inches consumptive use.

Transpiration use was then determined by subtracting evaporation which was estimated to be 0.5 inch per month for both October and April. Transpiration use during the remaining five winter months was taken to be 0.7 inch per month as estimated by the Soil Conservation Service.[2]

Monthly values of winter transpiration use by vineyards in Upper Santa Ana River Valley[4] were transposed for use in San Fernando Valley by the aforementioned factor of 1.04. It was considered that 75 percent of the vineyard lands had winter cover crops as was the case in the Upper Santa Ana River Valley.

Annual consumptive use by dry farm and native vegetation applicable to San Fernando Valley was computed by the Soil Conservation Service[5/] from Santa Ana River Valley data.[6/] Annual transpiration use was determined by subtracting the average annual evaporation, estimated to be 5.0 inches, from the annual consumptive use. Monthly values of transpiration use were computed by prorating the annual value in the same proportion as monthly values determined for nonirrigated hay and grain in Upper Santa Ana River Valley.[4/]

Monthly values of winter transpiration use by riparian vegetation, derived from results of a field study by Troxell[12/] on the river bottom lands in Santa Ana River Valley, were transposed for use in San Fernando Valley by the aforementioned factor of 1.04. The average monthly winter season transpiration requirements so determined for the aforementioned culture in the area of investigation are listed in Table L-2:

TABLE L-2

AVERAGE MONTHLY NET UNIT TRANSPIRATION RATES DURING WINTER SEASON

In Inches

Culture classification	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Sub-total
Alfalfa	2.9	2.1	0.9	0.9	1.1	2.1	2.2	12.2
Citrus	2.0	1.5	1.1	0.8	0.9	1.2	1.5	9.0
Walnuts	0.5	0.3	0.2	0.2	0.2	0.4	1.0	2.8
Deciduous	0.5	0.3	0.2	0.2	0.2	0.4	1.0	2.8
Truck - double crop	2.6	0.7	0.7	0.7	0.7	0.7	2.7	8.8
Vineyard	0.5	0.5	0.2	0.2	0.2	0.5	0.9	3.0
Dry farm and native vegetation	1.0	1.2	0.8	0.7	0.7	1.2	1.8	7.4
Riparian vegetation	3.7	3.0	2.1	2.9	1.7	3.7	4.3	21.4

Fall Soil Moisture Deficiency

Available soil moisture has been taken as the difference between the field capacity or the maximum ability of a soil to store water above the capillary fringe against the force of gravity, and the minimum moisture content below which insufficient moisture is available to the plant to support growth.

The fall soil moisture deficiency has been taken as the depth of water in inches required to bring the soil back to field capacity upon reaching the wilting coefficient. For any particular crop this amount may be determined as the crop root depth in feet multiplied by the ability of the soil to hold and release moisture to the roots in inches of water per foot of soil. Except for lawn grass in park and residential areas, it was assumed that this deficiency existed for all irrigated crops in the Upper Los Angeles River area at the end of the irrigation season on September 30.

The ability of soils to hold and release moisture is shown in Table L-3 for representative California soils. Kramer[7/] reports that this ability varies from 0.50 inch per foot to 3.00 inches per foot. The Soil Conservation Service[2/] reports that the ability to hold moisture in the area west of Sepulveda Boulevard varies from 1.22 to 2.01 inches per foot. The depth of rooting for truck crops is shown in Table L-4.

TABLE L-3

AVAILABLE WATER IN SOILS[3/]

Inches Per Foot of Depth

Soil type	Available water
Oakley fine sand	0.34
Salinas fine sandy loam	1.35
Yolo fine sandy loam	1.26
Delano sandy loam	0.80
Fresno sandy loam	1.31
Aiken clay loam	0.71
Salinas silt clay loam	2.53
Salinas clay	2.83
Yolo clay	2.36

TABLE L-4

DEPTH OF ROOTING OF TRUCK CROPS
(After Table 1)[8/]

Shallow-rooted (down to 2 feet)	Moderately deep-rooted (down to 4 feet)	Deep-rooted (down to 6 feet)
Brussels sprouts	Beans, pole	Artichokes
Cabbage	Beans, snap, spring	Asparagus
Cauliflower	Beans, snap, fall	Cantaloupes, inland valleys
Celery	Beets	Cantaloupes, Imperial Valley
Lettuce, winter	Carrots, coastal area	Lima beans
Lettuce, summar and fall	Carrots, Imperial Valley	Parsnips
Lettuce, Imperial Valley	Chard	Pumpkins
Onions, intermediate	Cucumber	Squash, winter
Onions, late	Eggplant	Sweet potatoes
Potatoes, early	Peas, winter	Tomatoes, inland valleys
Potatoes, late	Peas, fall	Tomatoes, coastal areas
Radish	Peas, Imperial Valley	Watermelons
Spinach	Peppers	
Sprouting broccoli	Squash, summer	
Sweet corn	Turnips	

The fall soil moisture deficiencies listed in Table L-5, with the exception of truck crops and lawn grass, are based on measurements made in the area of investigation by the Soil Conservation Service[1] and from agencies in other areas.[4] The fall soil moisture deficiency for truck crops was determined by their rooting depth[8] and the moisture-holding capacity of the soil. For lawn grass,* the fall soil moisture deficiency was adopted as one inch, due to the general practice of applying approximately one inch of water per irrigation with frequent applications. This results in a shallow rooting depth and a small fall soil moisture deficiency.

TABLE L-5

FALL SOIL MOISTURE DEFICIENCIES

In Inches

Crop	Fall soil moisture deficiency
Alfalfa and irrigated pasture	4
Citrus	3
Deciduous	10
Irrigated vineyard	9
Lawn grass (residential areas)	1
Native vegetation and dry farm	8
Truck[8]	5
Walnuts	10

Irrigation Efficiencies

Irrigation efficiency is the ratio of water consumed to water applied expressed as a percentage. Investigations were made by the U. S. Department of Agriculture in 1939 and 1940[1] in cooperation with the City of Los Angeles to determine irrigation efficiencies in the Upper Los Angeles River area. The values listed in Table L-6 show irrigation efficiencies for

*Residential areas.

various crops grown in the area of investigation and were based on results of the investigation as well as conferences with Mr. H. F. Blaney who was in charge of the work. The irrigation efficiencies listed were based on the amount of water delivered to the customer and on consumptive use. Evaporation of irrigation water, which is estimated to be about 15 percent of the total delivered water, is included in the consumptive use.

TABLE L-6

AVERAGE IRRIGATION EFFICIENCIES

In Percent

Crop	Average efficiency
Alfalfa and irrigated pasture	85
Citrus	80
Deciduous	85
Truck	70
Vineyard	80
Walnuts	85

Optimum Consumptive Use of Water by Lawn Grass

Optimum consumptive use of water by lawn grass was determined from measurements of consumptive use by lawn grass made through the use of experimental tanks installed in 1939 in the Raymond Basin.[9/] Available measurements were made during the six-year period starting October 1939 and ending September 1945. Data from only six of the eight tanks were used. Data from tanks Nos. 4 and 5 were not used because these tanks had a wider rim at the surface and the consumptive use measured from these tanks was consistently higher than from the remaining tanks during the growing season. The rims of the tanks were set flush with the outside ground surface and the ground surface inside was one-half inch below the rim. The ground sloped away from the tanks so that with appreciable rainfall, surface runoff from the tanks was possible.

The following criteria were used in determining optimum consumptive use values:

1. Only months where drainage through the tanks occurred were considered because it was believed that for months of zero drainage the supply may have been deficient and the optimum consumptive use not realized.

2. Data were eliminated for months where the preceding month had zero drainage because of the possibility that a portion of the applied water may have gone into soil storage rather than to drainage or consumptive use.

3. Data for months having high rainfall were also eliminated because of probable surface runoff which was not measured.

4. Data for months in which drainage from the preceding month's rain may have occurred were also not used.

5. Data were eliminated for months where the amount of irrigation water shown, including rain, was less than the measured amount of rain because of contradictory observations.

6. Months which had extreme variances between results from the various tanks were not used.

Table L-7 shows the Raymond Basin data from which the optimum values were selected for use in the Upper Los Angeles River area. Table L-8 shows a summary of the optimum values utilized in computing consumptive use by lawn grass.

TABLE L-7

DATA ON CONSUMPTIVE USE OF WATER BY LAWN GRASS FROM
EXPERIMENTAL TANKS AT MANZANITA AND MENTONE STREETS, PASADENA, CALIFORNIA

In Inches

Tank number	Item	1939-40 Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	Irrigation	6.80[b]	4.47	3.71	4.44	4.34	3.48	4.94	5.27	4.91	7.28	7.11	5.54
	drainage	2.93	2.10	2.21	3.54	3.15	0.85	0.95	0.46	0.18	0.41	1.27	1.37
	consumptive use	3.87[b]	2.37	1.50	0.90	1.19	2.63	3.99	4.81	4.73	6.87	5.84	4.17
2	Irrigation	7.11[b]	4.47	3.71	4.44	4.34	3.48	4.94	5.27	4.91	7.28	7.11	5.54
	drainage	3.56	2.18	2.08	3.46	3.18	0.88	1.05	0.63	0.04	0.63	1.29	1.20
	consumptive use	3.55[b]	2.29	1.63	0.98	1.16	2.60	3.89	4.64	4.87	6.65	5.82	4.34
3	Irrigation	6.61[b]	4.47	3.71	4.44	4.34	3.48	4.94	5.27	4.91	7.28	7.11	5.54
	drainage	2.86	2.16	1.98	3.16	3.00	0.90	1.10	0.58	0.08	0.52	1.49	1.47
	consumptive use	3.75[b]	2.31	1.73	1.28	1.34	2.58	3.84	4.69	4.83	6.76	5.62	4.07
6	Irrigation	7.22[b]	4.47	3.71	4.44	4.34	3.48	4.94	5.27	4.91	7.28	7.11	5.54
	drainage	3.31	2.18	2.15	3.32	3.02	0.81	0.98	0.54	0.03	0.06	1.22	1.34
	consumptive use	3.91[b]	2.29	1.56	1.12	1.32	2.67	3.96	4.73	4.88	7.22	5.89	4.20
7	Irrigation	6.52[b]	4.47	3.71	4.44	4.34	3.48	4.94	5.27	4.91	7.28	7.11	5.54
	drainage	2.54	2.11	2.07	2.94	2.67	0.78	1.03	0.89	0.21	0.74	1.83	1.47
	consumptive use	3.98[b]	2.36	1.64	1.50	1.67	2.70	3.91	4.38	4.70	6.54	5.28	4.07
8	Irrigation	7.19[b]	4.47	3.71	4.44	4.34	3.48	4.94	5.27	4.91	7.28	7.11	5.54
	drainage	3.09	2.05	2.26	3.45	3.11	0.91	1.00	0.69	0.27	0.26	1.14	1.29
	consumptive use	4.10[b]	2.42	1.45	0.99	1.23	2.57	3.94	4.58	4.64	7.02	5.97	4.25
Mean consumptive use of Tanks 1, 2, 3, 6, 7 and 8		3.86[a]	2.34[a]	1.59[a]	1.13[d]	1.32[d]	2.62[a]	3.92[a]	May through September 26.2[a]				
4	Irrigation	9.84[b]	5.36	4.59	6.30[c]	5.90[c]	3.84	5.45	6.43	6.06	8.99	8.77	6.43
	drainage	4.78	2.70	3.02	5.17	4.58	1.30	1.66	1.31	0.78	1.47	2.86	2.07
	consumptive use	5.06[b]	2.66	1.57	1.13[c]	1.32[c]	2.54	3.79	5.12	5.28	7.52	5.91	4.36
5	Irrigation	10.06[b]	5.36	4.59	5.82[c]	5.39[c]	3.84	5.45	6.43	6.06	8.99	8.77	6.43
	drainage	5.02	2.37	2.82	4.69	4.07	1.45	1.60	1.14	0.74	0.97	2.83	2.05
	consumptive use	5.04[b]	2.99	1.77	1.13[c]	1.32[c]	2.39	3.85	5.29	5.32	8.02	5.94	4.38
Rainfall		0.38	0.22	0.68	5.84	6.98	1.18	2.24	0.01	0.00	0.00	0.00	0.01

DATA ON CONSUMPTIVE USE OF WATER BY LAWN GRASS FROM
EXPERIMENTAL TANKS AT MANZANITA AND MENTONE STREETS, PASADENA, CALIFORNIA
(continued)

In Inches

Tank number	Item	1940-41 Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	Irrigation	5.54	3.06	8.22	2.59	17.59	11.71	5.89	3.40	4.90	7.01	6.00	5.19
	drainage	1.55	2.08	0.96	2.26	0.98	3.41	3.00	1.98	0.00	1.09	1.33	1.71
	consumptive use	3.99	0.98	7.26	-0.33	16.61	8.30	2.89	1.42	4.90	5.92	4.67	3.48
2	Irrigation	5.54	3.06	8.22	2.59	17.59	11.71	5.89	3.40	4.90	7.01	6.00	5.19
	drainage	1.46	0.99	0.71	5.43	1.37	3.94	3.60	1.33	0.00	0.65	1.12	1.35
	consumptive use	4.08	2.07	7.51	-2.84	16.22	7.77	2.29	2.07	4.90	6.36	4.88	3.84
3	Irrigation	5.54	3.06	8.22	2.59	17.59	11.71	5.89	3.40	4.90	7.01	6.00	5.19
	drainage	1.67	1.95	0.93	3.38	0.90	3.81	3.00	1.36	0.00	1.09	1.46	1.62
	consumptive use	3.87	1.11	7.29	-0.79	16.69	7.90	2.89	2.04	4.90	5.92	4.54	3.57
6	Irrigation	4.37	1.98	7.63	2.59	17.59	11.71	5.77	1.97	2.62	4.12	3.96	3.57
	drainage	0.78	0.78	0.43	5.08	1.32	4.37	3.60	1.02	0.00	0.00	0.00	0.00
	consumptive use	3.59	1.20	7.20	-2.49	16.27	7.34	2.17	0.95	2.62	4.12	3.96	3.57
7	Irrigation	4.37	1.98	7.63	2.59	17.59	11.71	5.77	1.97	2.62	4.12	3.96	3.57
	drainage	1.02	0.40	0.34	5.43	1.43	3.69	3.99	1.15	0.00	0.00	0.00	0.00
	consumptive use	3.35	1.58	7.29	-2.84	16.16	8.02	1.78	0.82	2.62	4.12	3.96	3.57
8	Irrigation	4.37	1.98	7.63	2.59	17.59	11.71	5.77	1.97	2.62	4.12	3.96	3.57
	drainage	0.81	0.87	0.40	5.15	1.46	4.46	3.87	0.65	0.00	0.00	0.00	0.00
	consumptive use	3.56	1.11	7.23	-2.56	16.13	7.25	1.90	1.32	2.62	4.12	3.96	3.57
Mean consumptive use of Tanks 1, 2, 3, 6, 7 and 8		3.74[a]	1.34[e]	7.30[f]	-1.87[i]	16.35[f]	7.76[f]	2.32[f]	May through September 18.2[g]				
4	Irrigation	4.95	2.26	7.66	2.59	17.59	11.71	6.01	4.17	6.04	8.99	7.09	6.39
	drainage	1.15	1.46	4.87	3.63	14.14	13.73	5.10	0.53	0.12	2.36	2.39	2.43
	consumptive use	3.80	0.80	2.79	-1.04	3.45	- 2.02	0.91	3.64	5.92	6.63	4.70	3.96
5	Irrigation	4.95	2.26	7.66	2.59	17.59	11.71	5.86	2.41	3.40	5.08	5.00	4.41
	drainage	1.09	1.49	5.77	3.47	10.42	11.81	5.34	0.28	0.00	0.00	0.00	0.00
	consumptive use	3.86	0.77	1.89	-0.88	7.17	- 0.10	0.52	2.13	3.40	5.08	5.00	4.41
Rainfall		1.73	0.80	7.38	2.59	17.59	11.71	5.41	0.05	0.01	0.02	0.02	T

TABLE L-7

DATA ON CONSUMPTIVE USE OF WATER BY LAWN GRASS FROM
EXPERIMENTAL TANKS AT MANZANITA AND MENTONE STREETS, PASADENA, CALIFORNIA
(continued)

In Inches

Tank number	Item	1941-42 Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	Irrigation	3.73	3.06	6.29	0.28	2.24	3.51	3.39	4.99	6.18	7.63	5.90	5.70
	drainage	0.84	1.12	3.19	1.55	0.56	0.37	0.51	0.28	0.51	0.74	0.78	0.66
	consumptive use	2.89	1.94	3.10	-1.27	1.68	3.14	2.88	4.71	5.67	6.89	5.12	5.04
2	Irrigation	3.82	2.96	6.29	0.28	2.24	3.51	3.39	4.99	6.18	7.63	5.90	5.70
	drainage	0.59	1.15	3.50	1.55	0.06	0.56	0.66	0.16	0.66	1.21	1.27	1.14
	consumptive use	3.23	1.81	2.79	-1.27	2.18	2.95	2.73	4.83	5.52	6.42	4.63	4.56
3	Irrigation	3.76	3.03	6.29	0.28	2.24	3.51	3.39	4.99	6.18	7.63	5.90	5.70
	drainage	0.99	1.30	3.50	1.49	0.00	0.56	0.60	0.22	0.60	1.05	0.93	0.66
	consumptive use	2.77	1.73	2.79	-1.21	2.24	2.95	2.79	4.77	5.58	6.58	4.97	5.04
6	Irrigation	3.11	2.96	6.29	0.53	2.10	3.67	3.15	4.87	6.18	7.63	5.90	5.70
	drainage	0.00	0.00	0.00	1.30	0.17	0.22	0.45	0.22	0.39	0.68	0.62	0.66
	consumptive use	3.11	2.96	6.29	-0.77	1.93	3.45	2.70	4.65	5.79	6.95	5.28	5.04
7	Irrigation	3.11	2.96	6.29	0.53	2.10	3.67	3.15	4.88	6.18	7.63	5.90	5.70
	drainage	0.00	0.00	0.06	1.49	0.25	0.34	0.60	0.28	0.45	0.84	0.81	1.41
	consumptive use	3.11	2.96	6.23	-0.96	1.85	3.33	2.55	4.60	5.73	6.79	5.09	4.29
8	Irrigation	3.11	2.96	6.29	0.53	2.10	3.67	3.15	4.87	6.18	7.63	5.90	5.70
	drainage	0.00	0.00	0.22	1.46	0.28	0.25	0.51	0.25	0.36	0.62	0.56	0.66
	consumptive use	3.11	2.96	6.07	-0.93	1.82	3.42	2.64	4.62	5.82	7.01	5.34	5.04
Mean consumptive use of Tanks 1, 2, 3, 6, 7 and 8		3.04[h]	2.39[h]	4.55[f]	-1.07[i]	1.95[a]	3.21[a]	2.72[a]	May through September 27.1[a]				
4	Irrigation	4.22	3.74	6.33	0.28	2.49	3.98	3.54	6.17	7.65	9.42	7.17	7.05
	drainage	1.46	1.61	3.26	1.92	0.25	0.40	0.90	0.56	0.81	1.24	1.30	1.35
	consumptive use	2.76	2.13	3.07	-1.64	2.24	3.58	2.64	5.61	6.84	8.18	5.87	5.70
5	Irrigation	3.45	3.64	6.33	0.59	2.33	4.17	3.27	5.74	7.65	9.42	7.17	7.05
	drainage	0.00	0.00	2.08	1.98	0.31	0.28	0.81	0.59	0.51	0.84	1.27	0.96
	consumptive use	3.45	3.64	4.25	-1.39	2.02	3.89	2.46	5.15	7.14	8.58	5.90	6.09
Rainfall		1.68	0.11	6.17	0.28	1.15	1.53	2.67	T	T	0.00	0.41	0.00

DATA ON CONSUMPTIVE USE OF WATER BY LAWN GRASS FROM
EXPERIMENTAL TANKS AT MANZANITA AND MENTONE STREETS, PASADENA, CALIFORNIA
(continued)

In Inches

Tank number	Item	1942-43 Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	Irrigation	2.63	0.51	1.76	NR	19.30	12.08	1.62	0.49	0.53	2.85	1.78	3.20
	drainage	0.40	0.01	0.01	NR	0.57	0.82	1.10	0.86	0.02	0.00	0.00	0.00
	consumptive use	2.23	0.50	1.75	NR	18.73	11.26	0.52	-0.37	0.51	2.85	1.78	3.20
2	Irrigation	2.63	0.51	1.76	NR	19.30	12.08	1.62	0.49	0.53	2.85	1.78	3.20
	drainage	0.59	0.01	0.03	NR	0.62	0.73	1.54	0.38	0.06	0.00	0.00	0.00
	consumptive use	2.04	0.50	1.73	NR	18.68	11.35	0.08	0.11	0.47	2.85	1.78	3.20
3	Irrigation	2.63	0.51	1.76	NR	19.30	12.08	1.62	0.49	0.53	2.85	1.78	3.20
	drainage	0.42	0.00	0.00	NR	0.69	0.84	1.45	0.02	0.04	0.00	0.00	0.00
	consumptive use	2.21	0.51	1.76	NR	18.61	11.24	0.17	0.47	0.49	2.85	1.78	3.20
6	Irrigation	2.28	0.22	1.10	NR	19.24	12.02	1.51	0.38	0.42	2.37	1.54	2.73
	drainage	0.50	0.00	0.00	NR	3.15	1.25	1.21	0.31	0.05	0.00	0.00	0.00
	consumptive use	1.78	0.22	1.10	NR	16.09	10.77	0.30	0.07	0.37	2.37	1.54	2.73
7	Irrigation	2.28	0.22	1.41	NR	19.24	12.02	1.51	0.38	0.42	2.37	1.54	2.73
	drainage	0.96	0.03	0.01	NR	0.66	0.90	2.14	0.35	0.04	0.00	0.00	0.00
	consumptive use	1.32	0.19	1.40	NR	18.58	11.12	-0.63	0.03	0.38	2.37	1.54	2.73
8	Irrigation	2.28	0.22	1.41	NR	19.24	12.02	1.51	0.38	0.42	2.37	1.54	2.73
	drainage	0.62	0.05	0.01	NR	0.83	1.15	1.68	0.41	0.05	0.00	0.00	0.00
	consumptive use	1.66	0.17	1.40	NR	18.41	10.87	-0.17	-0.03	0.37	2.37	1.54	2.73
Mean consumptive use of Tanks 1, 2, 3, 6, 7 and 8		1.87[e]	0.35[j]	1.52[j]	NR[k]	18.18[f]	11.10[f]	0.05[l]	May through September 7.7[g]				
4	Irrigation	3.41	0.41	2.54	NR	19.43	12.21	1.88	0.75	0.79	3.82	2.20	3.96
	drainage	1.44	0.06	0.26	NR	19.13	10.86	0.63	0.03	0.00	0.00	0.00	0.00
	consumptive use	1.97	0.35	2.28	NR	0.30	1.35	1.25	0.72	0.79	3.82	2.20	3.96
5	Irrigation	3.41	0.41	2.54	NR	19.43	12.21	1.88	0.75	0.80	3.82	2.20	3.96
	drainage	1.36	0.09	0.13	NR	2.43	3.33	2.05	0.33	0.18	0.30	0.11	0.00
	consumptive use	2.05	0.32	2.41	NR	17.00	8.88	-0.17	0.42	0.62	3.52	2.09	3.96
Rainfall		1.21	0.04	1.34	NR	19.06	11.84	1.15	0.02	0.06	0.00	0.00	T

TABLE L-7

DATA ON CONSUMPTIVE USE OF WATER BY LAWN GRASS FROM
EXPERIMENTAL TANKS AT MANZANITA AND MENTONE STREETS, PASADENA, CALIFORNIA
(continued)

In Inches

Tank number	Item	1943-44 Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	Irrigation drainage	3.17	3.03	NR	8.37	10.55	3.78	1.21	3.05	1.73	1.42	1.66	2.40
	consumptive use	0.00	0.00	NR	0.00	0.33	5.05	0.31	0.00	0.00	0.00	0.00	0.00
		3.17	3.03	NR	8.37	10.22	-1.27	0.90	3.05	1.73	1.42	1.66	2.40
2	Irrigation drainage	3.17	3.03	NR	8.37	10.55	3.78	1.21	3.05	1.73	1.42	1.66	2.40
	consumptive use	0.00	0.00	NR	0.00	0.00	5.52	0.11	0.00	0.00	0.00	0.00	0.00
		3.17	3.03	NR	8.37	10.55	-1.74	1.10	3.05	1.73	1.42	1.66	2.40
3	Irrigation drainage	3.17	3.03	NR	8.37	10.55	3.78	1.21	3.05	1.73	1.42	1.66	2.40
	consumptive use	0.00	0.00	NR	0.00	0.03	3.33	1.02	0.00	0.00	0.00	0.00	0.00
		3.17	3.03	NR	8.37	10.52	0.45	0.19	3.05	1.73	1.42	1.66	2.40
6	Irrigation drainage	2.69	2.55	NR	8.37	10.55	3.78	0.91	2.70	1.38	1.07	1.25	1.81
	consumptive use	0.00	0.00	NR	0.00	0.43	6.75	0.08	0.00	0.00	0.00	0.00	0.00
		2.69	2.55	NR	8.37	10.12	-2.97	0.83	2.70	1.38	1.07	1.25	1.81
7	Irrigation drainage	2.69	2.55	NR	8.37	10.55	3.78	0.91	2.70	1.38	1.07	1.25	1.81
	consumptive use	0.00	0.00	NR	0.00	0.32	5.62	0.06	0.00	0.00	0.00	0.00	0.00
		2.69	2.55	NR	8.37	10.23	-1.84	0.85	2.70	1.38	1.07	1.25	1.81
8	Irrigation drainage	2.69	2.55	NR	8.37	10.55	3.78	0.91	2.70	1.38	1.07	1.25	1.81
	consumptive use	0.00	0.00	NR	0.00	0.00	5.18	0.11	0.00	0.00	0.00	0.00	0.00
		2.69	2.55	NR	8.37	10.55	-1.40	0.80	2.70	1.38	1.07	1.25	1.81
Mean consumptive use of Tanks 1, 2, 3, 6, 7 and 8		2.93[j]	2.79[j]	NR[k]	8.37[f]	10.37[f]	-1.46[i]	0.78[m]	.	May through September 9.2[g]			
4	Irrigation drainage	3.84	3.70	NR	8.37	10.55	4.15	1.86	3.83	2.51	2.20	2.57	3.70
	consumptive use	0.00	0.00	NR	0.98	8.11	6.59	0.08	0.00	0.00	0.00	0.00	0.00
		3.84	3.70	NR	7.39	2.44	-2.44	1.78	3.83	2.51	2.20	2.57	3.70
5	Irrigation drainage	3.84	NR	NR	8.37	10.55	3.78	1.86	3.83	2.51	2.20	2.57	3.70
	consumptive use	0.00	NR	NR	0.10	1.53	5.80	1.58	1.59	0.71	0.39	0.14	0.00
		3.84	NR	NR	8.27	9.02	-2.02	0.28	2.24	1.80	1.81	2.43	3.70
Rainfall		0.32	0.18	NR	8.37	10.55	3.78	0.02	1.63	0.31	0.00	T	0.03

DATA ON CONSUMPTIVE USE OF WATER BY LAWN GRASS FROM
EXPERIMENTAL TANKS AT MANZANITA AND MENTONE STREETS, PASADENA, CALIFORNIA
(continued)

In Inches

Tank number	Item	1944-45 Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	Irrigation drainage	2.43	7.09	1.24	1.43	4.40	3.38	1.08	1.36	1.53	0.95	NR	NR
	consumptive use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	NR	NR
		2.43	7.09	1.24	1.43	4.40	3.38	1.08	1.30	1.53	0.95	NR	NR
2	Irrigation drainage	2.40	7.09	1.24	1.43	4.40	3.38	1.08	1.36	1.53	0.95	NR	NR
	consumptive use	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.21	0.00	0.00	NR	NR
		2.40	7.09	1.24	1.43	4.40	3.38	0.80	1.15	1.53	0.95	NR	NR
3	Irrigation drainage	2.43	7.09	1.24	1.43	4.40	3.38	1.08	1.36	1.53	0.95	NR	NR
	consumptive use	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.10	0.00	0.00	NR	NR
		2.43	7.09	1.24	1.43	4.40	3.38	0.77	1.26	1.53	0.95	NR	NR
6	Irrigation drainage	1.84	6.74	1.00	1.32	4.40	3.38	1.08	1.12	1.18	0.71	NR	NR
	consumptive use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NR	NR
		1.84	6.74	1.00	1.32	4.40	3.38	1.08	1.12	1.18	0.71	NR	NR
7	Irrigation drainage	1.84	6.74	1.00	1.32	4.40	3.38	1.08	1.12	1.18	0.71	NR	NR
	consumptive use	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.17	0.00	0.00	NR	NR
		1.84	6.74	1.00	1.32	4.40	3.38	0.61	0.95	1.18	0.71	NR	NR
8	Irrigation drainage	1.84	6.74	1.00	1.32	4.40	3.38	1.08	1.12	1.18	0.71	NR	NR
	consumptive use	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.22	0.03	0.00	NR	NR
		1.84	6.74	1.00	1.32	4.40	3.38	1.00	0.90	1.15	0.71	NR	NR
Mean consumptive use of Tanks 1, 2, 3, 6, 7 and 8		2.13[j]	6.92[f]	1.12[j]	1.38[j]	4.40[f]	3.38[j]	0.89[j]		May through September[k]			
4	Irrigation drainage	3.73	7.87	1.76	1.69	4.40	3.38	1.08	1.88	2.31	1.47	NR	NR
	consumptive use	0.00	0.00	0.00	0.25	0.24	1.54	0.97	0.29	0.00	0.00	NR	NR
		3.73	7.87	1.76	1.44	4.16	1.84	0.11	1.59	2.31	1.47	NR	NR
5	Irrigation drainage	3.70	7.87	1.76	1.69	4.40	3.38	1.08	1.88	2.31	1.47	NR	NR
	consumptive use	0.00	0.10	0.35	0.27	0.13	0.91	0.48	1.27	0.34	0.16	NR	NR
		3.70	7.77	1.41	1.42	4.27	2.47	0.60	0.61	1.97	1.31	NR	NR
Rainfall		0.06	5.67	0.29	0.96	4.40	3.38	1.08	0.41	0.11	0.00	NR	NR

The following footnotes indicate the utilization of the data from Tanks 1, 2, 3, 6, 7 and 8.

a. Data were utilized. (Value underlined.)
b. Partially estimated by interpolation.
c. Estimated by comparison with Tanks 1, 2, 3, 6, 7 and 8.
d. Data not used because irrigation was less than rainfall.
e. Data not used because of extreme variance between tanks.
f. Data not used because probable surface runoff occurred.
g. Data not used because zero drainage occurred in some months.
h. Data not used because of zero drainage through Tanks 6, 7 and 8.
i. Data not used because of probable drainage from water applied the preceding month.
j. Data not used because of zero or negligible drainage through tanks.
k. Data not used because of incomplete record.
m. Data not used because rainfall did not agree with nearby precipitation stations.

The optimum consumptive use during the winter season could not be accurately separated into evaporation and transpiration uses so that gross values of rain and delivered water were combined before disposal by consumptive use and deep percolation.

TABLE L-8

OPTIMUM CONSUMPTIVE USE OF WATER BY LAWN GRASS
FROM DATA OF RAYMOND BASIN TANKS 1, 2, 3, 6, 7, AND 8

In Inches

Date	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May-Sept.	Annual
1939-40	3.86	2.34	1.59			2.62	3.92	26.2	
41	3.74								
42					1.95	3.21	2.72	27.1	
43									
44									
45									
Average	3.8	2.3	1.6	1.6*	2.0	2.9	3.3	26.7	44.2

* January considered comparable with December.

Irrigation Water

The depth of delivered water for each irrigated crop and the methods by which they were obtained are shown in Appendix J.

Weighting Factors

Weighting factors used for the computation of consumptive use, deep percolation and residual rain on land use classifications were derived from a ratio of the pervious area to the total area. This ratio in effect adjusted the net unit value of consumptive use, deep percolation and residual rain so that the weighted unit values could be directly multiplied by the gross acreage for each classification to determine the disposal of water in acre-feet.

Irrigated Crops, Dry Farm and Native Vegetation

The weighting factor was found to vary with different types of land use and hydrologic subareas. For irrigated crops, dry farm and native vegetation on the valley floor, it was determined that approximately five percent of the area was impervious in San Fernando Hydrologic Subarea and ten percent impervious in Sylmar and Verdugo Hydrologic Subareas. The percent impervious represented the area of roads where no deep percolation could occur and consumptive use of rain limited to evaporation.

The percent impervious was determined for each hydrologic subarea by the use of Frank Carr's maps showing areas for irrigated crops in the City of Los Angeles west of Burbank. It is apparent that farms under cultivation in the San Fernando Subarea are on the average twice as large as those situated in either Sylmar or Verdugo Subareas. Roads in the agricultural area of San Fernando Subarea are generally located every one-half mile. The impervious areas in this one-quarter section include the roadway, shoulder and farmhouse area. The impervious area is approximately five percent of the quarter section.

In Sylmar and Verdugo Subareas, the roads are spaced at approximately every one-quarter mile. Due to the increased roads, the impervious area was increased to ten percent of the total irrigated acreage.

Residential

The landscaping of residential lots has changed within the span of the base period. This change not only affected the percent impervious on lots but also altered the area of the lot under cultivation. These changes are the result of smaller residential lot sizes and the increased beneficial use of the lot.

A representative sampling of residential lots in the four hydrologic subareas was made by the Referee in 1959. The purpose of this survey was to determine the relative amounts of impervious, irrigated lawn and garden, and native culture within the average lot. The age of the house was also obtained to relate these data to the beginning of the base period.

Based on this survey, it was found that the percent impervious had increased due to improvements. The average percent impervious existing in 1959 for homes in the area of investigation is listed in Table L-9.

TABLE L-9

PERCENT OF RESIDENTIAL LOT IMPERVIOUS

Age years	Percent impervious	
	1959	Adjusted
30 and older	42	32.7
15 - 29	49	37.3
10 - 14	53	
5 - 9	50.6	
1 - 4	56.2	

To adjust for improvements made to homes prior to 1945, it was assumed that 75 percent of the impervious area which existed on a lot in 1959 was made subsequent to 1945. The increase in impervious areas due to improvements on older homes was proportioned equally to the three periods established after 1945. The percent impervious for each period was weighted according to the age and acreage of residential in existence in the prior period and the increase in acreage of new residential areas. From the survey, the percentage of lots containing lawn and garden, deciduous and native areas was also determined. The composition and percentage of the residential lots existing within the base period are shown in Table L-10.

TABLE L-10

CULTURE BREAKDOWN OF RESIDENTIAL LOTS

In Percent

Period	Impervious	Lawn and garden	Deciduous	Native
1928-45	35	25	20	20
1946-50	40	30	15	15
1951-55	45	30	15	10
1956-58	50	35	10	5

Commercial and Industrial

Commercial and industrial acreages were assumed to be 100 percent impervious.

Miscellaneous

Miscellaneous contains land use classifications which are pervious and impervious. Based on the 1958 land use survey made by the

Referee, it was found that approximately 50 percent of the area was impervious and 50 percent native vegetation.

Disposal of Water by Irrigated Crops

Computation of the disposal of rain and delivered water by irrigated crops is performed monthly in the winter season by use of evaporation, transpiration and soil moisture deficiency values. Disposal during the summer season is accomplished by use of the irrigation efficiency and the soil moisture carry-over values.

The procedure used on the irrigated crops listed in Table L-5 is described by use of the sample computation made for alfalfa and irrigated pasture for the year 1940-41. The sample computation and accompanying detailed explanation are shown on Figure L-1.

Weighted disposal values shown at the end of the sample computation are the end product of the computations. These were obtained by weighting the disposal values according to the percent pervious and impervious for each land use classification.

Disposal of Water by Dry Farm and Native Vegetation

This computation is done in the same manner as that for irrigated crops. Values for delivered water are all zero since the only supply of water to this classification is rain.

FIGURE L-1

DISPOSAL OF WATER BY ALFALFA AND IRRIGATED PASTURE

In Inches Except as Noted

San Fernando Hydrologic Subarea for 1940-41 — 85 Percent Irrigation Efficiency - 5 Percent Impervious - 95 Percent Pervious

	Winter season									Growing season		Total to September 30		Weighting factor	Weighted values	
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	End of season	Subtotal	Soil moisture carry-over	May-September	Inches	Feet		Delivered water, in feet	Rainfall, in feet
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1. Gross Rainfall	1.3	0.3	8.2	2.7	12.7	10.0	4.1		39.3		0.3	39.6	3.30			
2. Evaporation of Rainfall on Impervious Areas	0.5	0.3	1.1	0.9	0.8	1.3	1.2		6.1		0.3	6.4	0.53	0.05		0.03
3. Net Rainfall on Impervious Areas	0.8	0.0	7.1	1.8	11.9	8.7	2.9		33.2		0.0	33.2	2.77	0.05		0.14
4. Evaporation of Rain on Pervious Areas	0.9	0.3	1.1	0.9	1.1	2.0	2.5		8.8		0.3	9.1	0.76	0.95		0.72
5. Net Rainfall on Pervious Areas	0.4	0.0	7.1	1.8	11.6	8.0	1.6		30.5		0.0	30.5	2.54			
6. Total Irrigation Water	1.8	0.6	0.6	0.0	0.0	0.0	0.1		3.1		13.9	17.0	1.42			
7. Evaporation of Irrigation Water	0.3	0.1	0.1	0.0	0.0	0.0	0.0		0.5			0.5	0.04	0.95	0.04	
8. Net Irrigation Water	1.5	0.5	0.5	0.0	0.0	0.0	0.1		2.6							
9. Total Water Available on Pervious Area	1.9	0.5	7.6	1.8	11.6	8.0	1.7		33.1							
WATER DISPOSAL-PERVIOUS AREA																
10. Soil Moisture Deficiency, First of Month	4.0	4.0	4.0	0.0	0.0	0.0	0.0	0.5	3.5	R : DW 3.2 : 0.3						
11. Transpiration Rate	2.9	2.1	0.9	0.9	1.1	2.1	2.2									
12. Disposal of Net Water																
a. Transpiration	1.9	0.5	0.9	0.9	1.1	2.1	1.7	9.1	R : DW 8.4 : 0.7		R : DW 0.0 : 11.8	R : DW 8.4 : 12.5	R : DW 0.70 : 1.04	0.95	0.99	0.67
b. Soil Storage	0.0	0.0	4.0	0.0	0.0	0.0	0.0									
c. Deep Percolation	0.0	0.0	2.7	0.9	10.5	5.9	0.0	20.0	18.4 : 1.6		0.0 : 2.1	18.4 : 3.7	1.53 : 0.31	0.95	0.29	1.45
d. Subtotal	1.9	0.5	7.6	1.8	11.6	8.0	1.7									
13. Consumptive Use of Water in Soil Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.5 : 0.0		3.2 : 0.3	3.7 : 0.3	0.31 : 0.03	0.95	0.03	0.29

Weighted consumptive use = 1.06' from delivered water (sum of lines 7, 12a and 13).
= 1.71' from rain (sum of lines 2,4, 12a and 13).
Weighted deep percolation = 0.29 from delivered water and 1.45' from rain (line 12c).
Residual rain = 0.14' from rain (line 3).

Winter Season

Columns 1 through 9

- Line 1 - Monthly rainfall from October through April from Table E-6.
- Lines 2 and 4 - Monthly evaporation of rainfall from Table L-1.
- Line 3 - Monthly net rainfall on impervious areas (line 1 minus line 2).
- Line 5 - Monthly net rainfall on pervious areas (line 1 minus line 4).
- Line 6 - Monthly depth of delivered irrigation water in Table J-8 divided by percent pervious (95 percent for this crop).
- Line 7 - Evaporation of delivered irrigation water (15 percent of line 6).
- Line 8 - Net irrigation water (line 6 minus line 7).
- Line 9 - Total water available on pervious areas (line 5 plus line 8).
- Line 10 - Fall soil moisture deficiency as of October 1 is entered in column 1 (Table L-5).
- Line 11 - Monthly transpiration rate (Table L-2).

Line 12a
Line 12b
Line 12c -
Line 12d
Line 13

Monthly total water available on pervious areas is disposed of first by fulfilling the transpiration rate (line 11); second, soil moisture deficiency (line 10); and third, deep percolation. Each item must be met in the above order before the succeeding item is entered. The amount of transpiration (line 12a) cannot exceed the amounts in line 11. The amount of water transpired (12a) is equal to line 9 or line 11, whichever is the smaller. Any water remaining (line 9 minus line 12a) up to the amount of line 10 is placed in soil storage (12b) for use as transpiration (12a) in succeeding months whenever the water available (9) is less than the transpiration use requirement (11). The amount placed in soil storage (12b) during one month is subtracted from the amount of the soil moisture deficiency (10) for the following month. When water is withdrawn from soil storage to satisfy the transpiration rate, the amount is entered in line 13 and added to the soil moisture deficiency for the following months. The water remaining after transpiration and soil storage are satisfied is entered in line 12c as deep percolation. The amount of transpiration (line 12a), deep percolation (line 12c) and consumptive use of water in soil storage (line 13) are divided into their source of supply derived from precipitation and delivered water by the ratios of the subtotals for line 5 and line 8 to line 9 and entered in column 9. Line 12d is the sum of lines 12a, 12b and 12c and used as a check on the disposal of total water available on pervious areas (line 9).

Growing Season

Column 10

- Line 10 only - Soil moisture carry-over is equal to the amount in column 1, line 10, minus the amount in column 7, line 10, and is proportioned between precipitation and delivered water in the ratios of subtotals (column 9) for line 5 and line 6 to line 9.

Column 11

- Line 1 through 6 - Enter in column 11 as for winter season.
- Line 7 - Not used. Evaporation of irrigation included in irrigation efficiency.
- Line 12a - Consumptive use during the growing season is entered as the product of line 6 times the irrigation efficiency and proportioned according to the amounts of the source of supply derived from precipitation and delivered water (line 5 and line 6, column 11, (respectively).
- Line 12c - Same as line 12a except the values are multiplied by the reciprocal of irrigation efficiency.
- Line 13 - Soil moisture carry-over on line 10, column 10, becomes consumptive use during the growing season and is transferred to line 13, column 11.

Column 12

Sum of columns 9 and 11.

Column 13

Column 12 expressed in feet.

Column 14

Weighting factor for percent of impervious or pervious areas.

Columns 15 and 16

Final weighted values for the various items with total appearing at the bottom of the table.

Disposal of Water by Lawn Grass*

Culture in this classification consists of the irrigated lawn portion of installations such as golf courses, cemeteries, parks, and contains no impervious areas.

The depth of delivered water used for lawn grass was taken to be 3.2 feet based on irrigation records for this type of culture in the area. Total annual consumptive use of 3.67 feet was based on records from Raymond Basin Reference tanks. Consumptive use of rain and applied water was computed on the basis of the amount of each available.

Deep percolation was computed as the total available water less consumptive use. The deep percolation was proportioned into deep percolation of rain and delivered water on the basis of the amounts of each available.

Disposal of Water on Residential Areas

The disposal of water on the three portions of residential areas was made separately and the weighted values combined to give values for gross residential areas. A sample computation for the impervious and lawn area is shown on Figure L-2.

On the residential impervious area consumptive use consisted only of evaporation of rain. The remaining rain, less the portion of the lot (10 percent of the lot) which drains to the pervious area, was considered residual rain. On the pervious areas the method used during the winter is the same as that for irrigated crops. At the end of the winter season the disposal items were divided into quantities of rain and irrigation water based on the amount of each available during the season.

*Does not apply to residential lawn areas

FIGURE L-2

DISPOSAL OF WATER BY RESIDENTIAL IMPERVIOUS AND LAWN AREA

In Inches Except as Noted

Verdugo Hydrologic Subarea for 1940-41 — Percent of Residential Lot Lawn Grass: 25 — Percent Impervious: 35

	Winter season: Oct. (1)	Nov. (2)	Dec. (3)	Jan. (4)	Feb. (5)	Mar. (6)	Apr. (7)	End of season (8)	Subtotal (9)	Growing season: Soil moisture carry-over (10)	May-September (11)	Total to September 30: Inches (12)	Feet (13)	Weighting factor (14)	Weighted values: Delivered water, in feet (15)	Rainfall, in feet (16)
1. Gross Rainfall	1.7	0.7	6.6	3.2	17.2	11.7	6.5		47.6		0.3	47.9	3.99			
2. Evaporation of Rainfall on Impervious Areas	0.5	0.5	1.5	1.3	1.1	1.3	1.4		7.6		0.3	7.9	0.66	0.35		0.23
3. Net Rainfall on Impervious Areas	1.2	0.2	5.1	1.9	16.1	10.4	5.1		40.0		0.0	40.0	3.33			1.05
4. Drainage of Impervious to Pervious	0.1	0.0	0.7	0.3	2.2	1.5	0.7		5.5		0.0					
5. Irrigation Water	2.8	1.4	1.1	0.4	0.0	0.2	0.4		6.3		17.0	23.3	1.94			
6. Net Water Available on Pervious Area	4.6	2.1	8.4	3.9	19.4	13.4	7.6		59.4		17.3					
WATER DISPOSAL-PERVIOUS AREA																
7. Soil Moisture Deficiency, First of Month	1.0	0.2	0.4	0.0	0.0	0.0	0.0	0.0	1.0	R 0.9 : DW 0.1						
8. Consumptive Use Requirement	3.8	2.3	1.6	1.6	2.0	2.9	3.3				26.7					
9. Disposal of Net Water																
a. Consumptive Use	3.8	2.1	1.6	1.6	2.0	2.9	3.3	17.3	R 15.5 / DW 1.8		R 0.3 : DW 17.0	R 15.8 / DW 18.8	R 1.32 / DW 1.56	0.25	0.39	0.34
b. To Soil Storage	0.8	0.0	0.4	0.0	0.0	0.0	0.0									
c. Residual on Pervious Area	0.0	0.0	6.4	2.3	17.4	10.5	4.3	40.3	36.0 / 4.3		0.0 / 0.0	36.0 / 4.3	3.00 / 0.36	0.25	0.10	0.75
d. Subtotal	4.6	2.1	8.4	3.9	19.4	13.4	7.6									
10. Consumptive Use of Water in Soil Storage	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2 / 0.0		0.9 / 0.1	1.1 / 0.1	0.10 / 0.0	0.25	0.0	0.02

Weighted consumptive use = 0.39' delivered water and 0.59' rain.
Weighted deep percolation = 0.10' delivered water and 0.75' rain.
Weighted residual = 1.05' rain.

Line 4 = 10 percent of line 3 is distributed over the lawn area which equals to 25 percent of the lot, therefore, line 4 = $\frac{10\% \text{ of line 3} \times 35\%}{25\%}$

During the growing season it was considered that lawn grass consumed all available water up to the optimum amount* and excess water, if any, was considered to be deep percolation. It was assumed that the deciduous culture consumed all available water up to the average May-September consumptive use quantity of 28.4 inches and excess water, if any, was considered to be deep percolation. Native vegetation was considered to consume all available rain and soil moisture carry-over during the growing season.

The monthly depths of irrigation waters delivered to residential lawns and gardens for San Fernando, Sylmar and Verdugo Hydrologic Subareas are discussed and determined in Appendix J.

* See pages 20 through 25.

Disposal of Water in Industrial and Commercial Areas

There is a large variation in the amount of water used by different types of industries and commercial establishments in the area of investigation. For this reason it would have been desirable to separate the industrial and commercial water users into groups based on their relative consumptive uses. However, a review of available land use surveys indicates that this could not be satisfactorily accomplished, especially during the earlier portion of the base period. Commercial and industrial acreages have therefore been combined and treated as one group. Acreage of native vegetation in these land classes has been included in the overall acreage of native culture. Extensive lawn areas existing on the grounds of the various industrial and commercial establishments have also been considered separately and are included in the irrigated lawn grass category. Disposal of water applied to the pervious portion of the gross industrial and commercial areas has thus been separately accounted for.

Disposal of the water supply on the remaining impervious acreage in the industrial and commercial groups comprises evaporation of rainfall, industrial or commercial process consumption either by evaporation or incorporation into the product, sewage, evaporation from lined sumps, waste disposed through surface channels, and deep percolation. Deep percolation is a relatively small proportion of the industrial and commercial water utilized because it may only occur in the relatively few instances where waste is disposed to unlined sumps or channels and cesspools.

The 1958 land use survey indicates the following relationship existing between commercial and industrial acreage:

Water Service Area	1958 Culture Survey Commercial acreage	Industrial acreage
Owens River - City of Los Angeles		
San Fernando Subarea	4,173	3,311
Sylmar Subarea	123	8
Mission Wells - City of Los Angeles	145	78
Sunland and Tujunga - City of Los Angeles	194	2
Narrows - City of Los Angeles	336	939
City of Burbank	992	1,069
City of San Fernando	168	108
City of Glendale		
San Fernando Subarea	894	316
Verdugo Subarea	83	8
Crescenta Valley County Water District	133	14
TOTAL	7,241	5,853
PERCENT	55	45

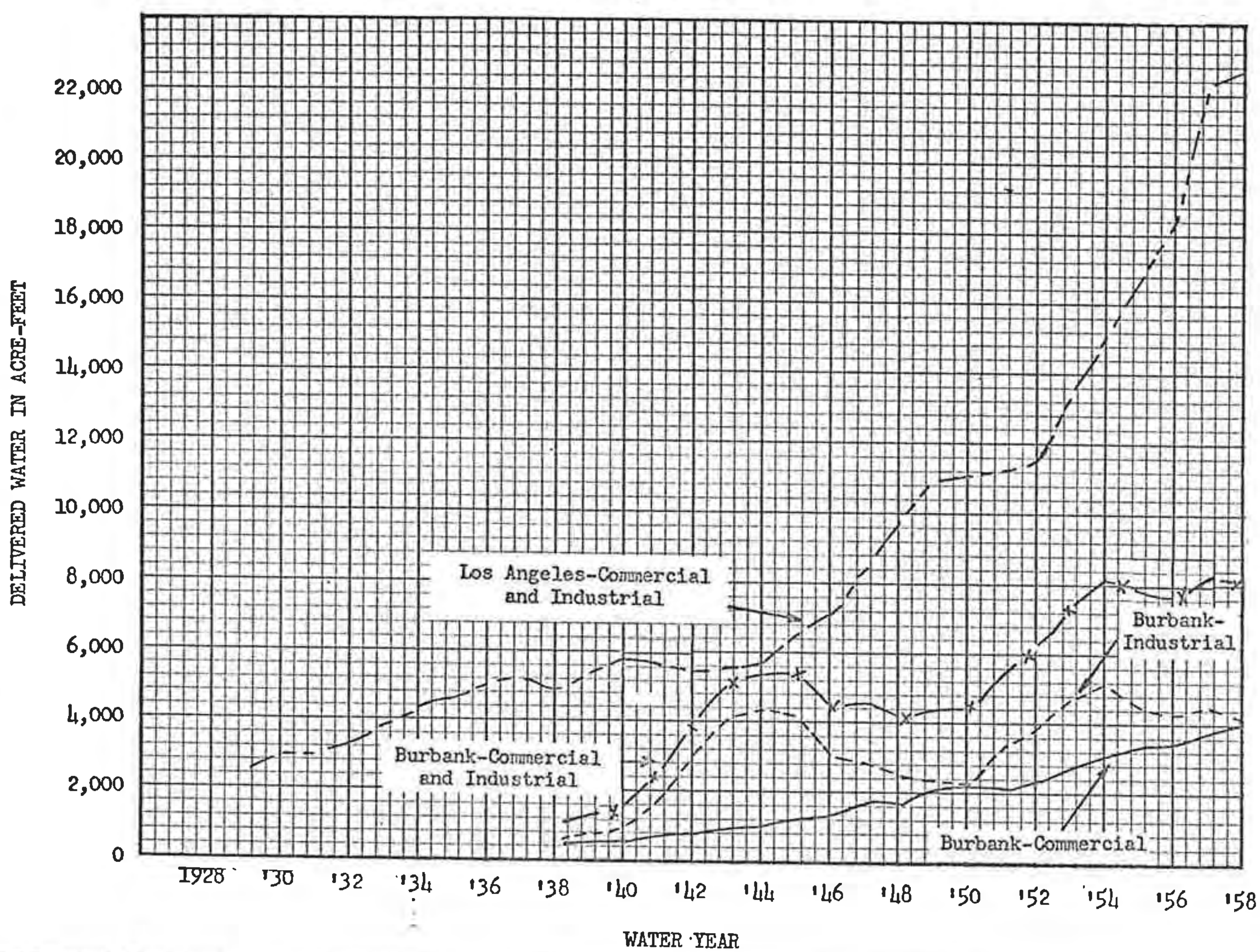
The amount of water delivered to commercial and industrial users is available for the City of Los Angeles service area west of Burbank for the period 1928-29 through 1957-58 and in the City of Burbank from 1936-37 through 1957-58. In the City of Los Angeles, annual industrial and commercial water deliveries are available as a combined amount, based on the type of electrical power account.

Electrical sales accounts include in one category all sales for commercial use, industrial use and some multiple dwellings where the water is served through one meter. The City of Burbank water sales records list commercial and industrial users separately based on actual type of water use.

The amount of industrial and commercial water sales in the two service areas is shown on Figure L-3, which indicates a sharp increase in the delivery of industrial water in Burbank during the periods of World War II and the Korean Police Action, while the deliveries of commercial water to this area show a more gradual increase during these periods.

The amount of water delivered to the Los Angeles-Owens area, depicted on Figure L-3, increased at a more or less uniform rate from 1928 through 1945. Commercial and industrial water sales increased rapidly during the periods of expanding population and industry following the war, as indicated by the uniform average annual increase in delivery of 1,300 acre-feet during the period 1947 through 1949 and 1,750 acre-feet during the period 1953 through 1956.

The computation of the disposal of water for industrial and commercial areas consists of the following; (1) evaporation of rain, (2) delivered water, (3) sewage, and (4) industrial wastes. The disposal of delivered water is based on data published in Table 11 of Bulletin 24, entitled "Los Angeles County Land and Water Use Survey, 1955", State Water Resources Board.



SAN FERNANDO VALLEY REFERENCE
DELIVERIES OF WATER TO COMMERCIAL AND INDUSTRIAL AREAS IN THE CITY OF LOS ANGELES WEST OF BURBANK AND IN THE CITY OF BURBANK

STATE WATER RIGHTS BOARD

FIGURE L-3

The unit values of delivered water less sewage as set forth in this bulletin are: 0.4 foot for strip commercial, 1.1 feet for downtown commercial and 1.4 feet for manufacturing industrial. These values were derived from acreages for each land use class excluding street rights of way. For use of these values with the land use survey made by the Board staff, the percentage of commercial and industrial lots occupied by streets was taken as 35 percent and 25 percent, respectively. The commercial acreages were equally divided into strip and downtown commercial to conform with the land use classification set forth in Bulletin 24.

A mean value for combined industrial and commercial areas was determined by weighting the aforementioned unit values with the area in each category existing as of 1958, resulting in a mean value of 0.85 foot. This value was applied to the combined industrial and commercial acreages for all years of the base period except 1940-41 through 1945-46 and 1951-52 through 1954-55 when the use was increased because of war activity.

Industries in Burbank, Glendale, and the Narrows service areas are considered to have been affected similarly by defense contracts resulting in an increased use of water. Since the City of Burbank is the only one of these service areas which measures industrial delivered water separately, the following adjustments were made based on delivered industrial water which occurred in the City of Burbank:

Year	Increased Industrial Deliveries in feet of depth
1940-41	0.85
1941-42 through 1944-45	1.70
1945-46	0.85
1951-52 through 1954-55	0.85

The mean value of 0.85 foot for delivered water less sewage was used for all years in the base period for San Fernando, Sylmar and Verdugo Subareas, except for the areas and years noted above as having higher deliveries. For the above years of increased deliveries a weighted value for the San Fernando Subarea was determined by using 1.70 feet and 2.55 feet for the industrial acreages in the Burbank, Glendale and the Narrows service areas. The proportion of commercial to industrial acreages for these service areas was based on the 1958 land use survey made by the Referee. The weighted value thus derived for the San Fernando Subarea was 1.00 foot and 1.15 feet for the increased use of 0.85 and 1.70 feet, respectively. The annual unit values of delivered water less sewage were then applied to the acreage classified as industrial and commercial in each of the subareas.

Industrial wastes discharged into the Los Angeles River, derived in Appendix N, were deducted from the computed commercial and industrial delivered water less sewage resulting in the annual consumptive use of commercial and industrial areas.

In the San Fernando Subarea an additional consumptive use of delivered water was added for the period 1954-55 through 1957-58. This additional consumptive use, as shown in Table L-11, was attributed to the breweries and the valley steam plant which were in operation at that time and was estimated as follows:

Plant: Anheuser Busch Brewery

Industrial area	26 acres
Delivered water	1,032 acre-feet (1955-56)
Gross depth per acre	39.7 feet
Sewage	421 acre-feet (March and April, 1955 spot measurements)
Consumptive use	611 acre-feet
Plant in operation	From March, 1955

Plant: Joseph Schlitz Brewery

Industrial area	17 acres
Delivered water	782 acre-feet (estimated by comparison to amount of sewage from Anheuser Busch)
Gross depth per acre	46.0 feet
Sewage	395 acre-feet (March and April, 1955 spot measurements)
Consumptive use	387 acre-feet
Plant in operation	From March, 1955

Plant: Valley Steam Plant (Los Angeles Department of Water and Power)

Industrial area 110 acres

Year	Delivered water, in acre-feet	Gross depth per acre, in feet	Sewage and waste, in acre-feet	Consumptive use,[a] in acre-feet	Consumptive use per acre, in feet	Deep percolation,[b] in acre-feet
1952-53	35	0.32		25	0.23	10
53-54	684	6.22		493	4.5	191
54-55	3,471	31.5		2,499	22.7	972
1955-56	6,056	55.2		4,360	39.6	1,700
56-57	6,976	63.5		5,023	45.7	1,952
57-58	7,000[c]	63.5	1,917[d]	5,083	46.3	1,920

a. Based on 1958 percentage of delivered water.
b. Delivered water minus consumptive use.
c. Estimated from calendar year measurements.
d. Estimated by the City of Los Angeles Department of Water and Power from operational records. The Valley Steam Plant was not connected to the sewers until October 15, 1958. Prior to this date, sewage and waste was discharged into the city's Gravel Pits or Tujunga Wash Channel.

TABLE L-11

ESTIMATED ADDITIONAL CONSUMPTIVE USE DUE TO BREWERIES AND VALLEY STEAM PLANT

In Acre-Feet

Year	Anheuser Busch Brewery	Joseph Schiltz Brewery	Los Angeles Valley Steam Plant (L.A.D.W.&P.)	Total	Based on unit values	Additional consumptive use
1952-53			25	25	110	0
53-54			493	493	110	383
54-55	305	194	2,499	2,998	131	2,867
1955-56	611	387	4,360	5,358	130	5,228
56-57	611	387	5,023	6,021	130	5,891
57-58	611	387	5,083	6,081	130	5,951

Table L-12 shows the computation for obtaining the consumptive use for commercial and industrial areas.

TABLE L-12

COMMERCIAL AND INDUSTRIAL
CONSUMPTIVE USE OF DELIVERED WATER

In Acre-Feet

Year	Delivered water less sewage (1)	Industrial wastes (2)	Additional consumptive use (3)	Total commercial and industrial consumptive use (1)-(2)+(3)=(4)
1928-29	2,550	0	0	2,550
29-30	2,950	0	0	2,950
1930-31	3,340	0	0	3,340
31-32	3,740	0	0	3,740
32-33	4,140	0	0	4,140
33-34	4,540	0	0	4,540
34-35	4,930	0	0	4,930
1935-36	5,330	0	0	5,330
36-37	5,730	0	0	5,730
37-38	6,130	0	0	6,130
38-39	6,520	0	0	6,520
39-40	6,930	0	0	6,930
1940-41	8,590	540	0	8,050
41-42	10,400	1,090	0	9,310
42-43	10,940	1,640	0	9,300
43-44	11,480	2,190	0	9,290
44-45	12,000	2,740	0	9,260
1945-46	10,920	3,290	0	7,630
46-47	9,700	3,840	0	5,860
47-48	10,100	4,090	0	6,010
48-49	10,500	4,660	0	5,840
49-50	10,670	4,740	0	5,930
1950-51	10,840	4,810	0	6,030
51-52	12,920	5,280	0	7,640
52-53	13,130	6,080	0	7,050
53-54	13,330	5,980	380	7,730
54-55	13,420	6,350	2,870	9,940
1955-56	11,540	5,880	5,230	10,890
56-57	11,620	5,580	5,890	11,930
57-58	11,700	5,750	5,950	11,900

Consumptive Use of Riparian Vegetation

Riparian vegetation as set forth in Appendix K consists of vegetation growing in swamps, meadowlands and stream channels. The annual transpiration use for riparian vegetation, as heretofore established, is equal to 3.68 feet. The total annual consumptive use is therefore equal to the sum of the evaporation of rain on pervious areas and the annual transpiration use. Since the annual depth of precipitation cannot satisfy the consumptive use requirements, the difference was assumed to have been withdrawn from ground water storage. The annual consumptive use of riparian vegetation was calculated by the following equation:

$$\text{Consumptive Use} = \text{Evaporation of rain on pervious areas} + 3.68 = \text{Annual depth of precipitation} + \text{withdrawal from ground water storage}$$

Unit Values of Consumptive Use and Deep Percolation for Culture Classes

The unit values of consumptive use, deep percolation and residual rain, contained in Table L-13, L-14 and L-15 for the San Fernando, Sylmar and Verdugo Hydrologic Subareas, respectively, have been weighted for the percent of impervious area and therefore are to be applied to gross acreage in each land use class. Unweighted unit values of consumptive use and deep percolation of portions of the residential land use class areas are shown in Table L-15A. As previously noted, the Eagle Rock Subarea is combined with the San Fernando Subarea and the units values of consumptive use and deep percolation reflect the combined areas.

TABLE L-13

FIRST TRIAL WEIGHTED UNIT CONSUMPTIVE USE AND DEEP PERCOLATION FOR
THE SAN FERNANDO AND EAGLE ROCK HYDROLOGIC SUBAREAS

In Acre-Feet per Gross Acre

Year	Deciduous						Citrus						Walnuts					
	Consumptive use			Deep percolation			Consumptive use			Deep percolation			Consumptive use			Deep percolation		
	Rain	Delivered water	Total	Rain	Delivered water	Total	Rain	Delivered water	Total	Rain	Delivered water	Total	Rain	Delivered water	Total	Rain	Delivered water	Total
1928-29	0.96	1.10	2.06	0	0.16	0.16	0.96	1.26	2.22	0	0.26	0.26	0.94	1.21	2.15	0	0.17	0.17
29-30	0.97	1.17	2.14	0	0.15	0.15	0.90	1.29	2.19	0.08	0.29	0.37	0.98	1.27	2.25	0	0.17	0.17
1930-31	1.19	1.14	2.33	0.03	0.14	0.17	1.04	1.23	2.27	0.19	0.31	0.50	1.17	1.24	2.41	0.05	0.17	0.22
31-32	1.38	0.93	2.31	0.22	0.17	0.39	1.18	1.05	2.23	0.41	0.31	0.72	1.38	1.03	2.41	0.22	0.19	0.41
32-33	0.99	1.01	2.00	0.03	0.13	0.16	0.73	1.08	1.81	0.30	0.34	0.64	1.00	1.13	2.13	0.04	0.16	0.20
33-34	1.06	1.04	2.10	0.07	0.15	0.22	0.83	1.14	1.97	0.29	0.32	0.61	1.06	1.12	2.18	0.07	0.17	0.24
34-35	1.57	0.94	2.51	0	0.13	0.13	1.47	1.06	2.53	0.10	0.24	0.34	1.56	1.03	2.59	0	0.15	0.15
1935-36	0.99	1.18	2.17	0	0.16	0.16	0.86	1.29	2.15	0.14	0.32	0.46	0.99	1.31	2.30	0	0.18	0.18
36-37	1.47	1.01	2.48	0.37	0.21	0.58	1.30	1.12	2.42	0.56	0.34	0.90	1.46	1.12	2.58	0.38	0.23	0.61
37-38	1.37	0.93	2.30	0.59	0.22	0.81	1.19	1.05	2.24	0.78	0.35	1.13	1.38	1.02	2.40	0.60	0.23	0.83
38-39	1.55	1.19	2.74	0.16	0.10	0.26	1.28	1.21	2.49	0.43	0.37	0.80	1.48	1.13	2.61	0.22	0.31	0.53
39-40	1.33	1.02	2.35	0	0.15	0.15	1.07	1.10	2.17	0.27	0.30	0.57	1.33	1.12	2.45	0	0.17	0.17
1940-41	1.70	0.81	2.51	1.46	0.23	1.69	1.54	0.93	2.47	1.61	0.35	1.96	1.70	0.91	2.61	1.46	0.26	1.72
41-42	1.06	1.11	2.17	0	0.14	0.14	1.06	1.31	2.37	0	0.24	0.24	1.07	1.25	2.32	0	0.16	0.16
42-43	1.34	1.12	2.46	0.60	0.28	0.88	1.15	1.27	2.42	0.82	0.46	1.28	1.31	1.21	2.52	0.65	0.30	0.95
43-44	1.32	1.11	2.43	0.66	0.32	0.98	1.19	1.26	2.45	0.77	0.46	1.23	1.29	1.17	2.46	0.68	0.32	1.00
44-45	1.12	1.33	2.45	0	0.18	0.18	1.11	1.51	2.62	0.03	0.31	0.34	1.12	1.32	2.44	0	0.19	0.19
1945-46	1.09	1.43	2.52	0	0.18	0.18	0.93	1.55	2.48	0.15	0.39	0.54	1.09	1.53	2.62	0	0.18	0.18
46-47	1.15	1.55	2.70	0.03	0.22	0.25	1.01	1.65	2.66	0.17	0.43	0.60	1.14	1.60	2.74	0.05	0.23	0.28
47-48	0.62	1.58	2.20	0	0.19	0.19	0.61	1.84	2.45	0	0.30	0.30	0.61	1.71	2.32	0	0.20	0.20
48-49	0.65	1.66	2.31	0	0.20	0.20	0.65	1.91	2.56	0	0.30	0.30	0.66	1.78	2.44	0	0.21	0.21
49-50	0.85	1.58	2.43	0	0.14	0.14	0.78	1.69	2.47	0.08	0.41	0.49	0.83	1.69	2.52	0.03	0.23	0.26
1950-51	0.69	1.70	2.39	0	0.21	0.21	0.70	1.90	2.60	0	0.30	0.30	0.69	1.77	2.46	0	0.21	0.21
51-52	1.56	1.13	2.69	0.85	0.31	1.16	1.44	1.25	2.69	0.97	0.48	1.45	1.55	1.16	2.71	0.87	0.34	1.21
52-53	0.93	1.55	2.48	0	0.16	0.16	0.92	1.69	2.61	0.02	0.30	0.32	0.93	1.56	2.49	0	0.18	0.18
53-54	1.05	1.29	2.34	0	0.15	0.15	0.91	1.40	2.31	0.14	0.33	0.47	0.99	1.11	2.10	0.08	0.43	0.51
54-55	1.13	1.30	2.43	0.01	0.15	0.16	1.12	1.46	2.58	0.02	0.24	0.26	1.14	1.33	2.47	0.01	0.15	0.16
1955-56	1.26	1.18	2.44	0.05	0.17	0.22	1.15	1.29	2.44	0.16	0.30	0.46	1.25	1.21	2.46	0.07	0.18	0.25
56-57	1.02	1.63	2.65	0.02	0.20	0.22	0.91	1.80	2.71	0.12	0.45	0.57	1.00	1.79	2.79	0.04	0.24	0.28
57-58	1.59	1.25	2.84	0.57	0.27	0.84	1.40	1.37	2.77	0.76	0.43	1.19	1.56	1.30	2.86	0.60	0.29	0.89
Mean 1929-57	1.15	1.23	2.38	0.18	0.18	0.36	1.03	1.37	2.40	0.34	0.30	0.63	1.14	1.30	2.45	0.19	0.22	0.41

TABLE L-13

FIRST TRIAL WEIGHTED UNIT CONSUMPTIVE USE AND DEEP PERCOLATION FOR
THE SAN FERNANDO AND EAGLE ROCK HYDROLOGIC SUBAREAS
(continued)

In Acre-Feet per Gross Acre

Year	Truck						Alfalfa and pasture						Vineyard					
	Consumptive use			Deep percolation			Consumptive use			Deep percolation			Consumptive use			Deep percolation		
	Rain	Delivered water	Total	Rain	Delivered water	Total	Rain	Delivered water	Total	Rain	Delivered water	Total	Rain	Delivered water	Total	Rain	Delivered water	Total
1928-29	0.95	1.29	2.24	0	0.44	0.44	0.95	1.47	2.42	0	0.21	0.21	0.95	0.79	1.74	0	0.16	0.16
29-30	0.94	1.38	2.32	0.04	0.43	0.47	0.97	1.61	2.58	0	0.14	0.14	0.96	0.80	1.76	0	0.15	0.15
1930-31	1.10	1.33	2.43	0.10	0.44	0.54	1.15	1.50	2.65	0.06	0.21	0.27	1.19	0.81	2.00	0.03	0.14	0.17
31-32	1.23	1.06	2.29	0.36	0.46	0.82	1.28	1.21	2.49	0.31	0.26	0.57	1.34	0.65	1.99	0.25	0.17	0.42
32-33	0.82	1.12	1.94	0.22	0.46	0.68	0.79	1.26	2.05	0.24	0.28	0.52	0.99	0.71	1.70	0.04	0.13	0.17
33-34	0.91	1.17	2.08	0.22	0.46	0.68	0.90	1.34	2.24	0.22	0.27	0.49	1.05	0.72	1.77	0.08	0.15	0.23
34-35	1.46	1.08	2.54	0.10	0.41	0.51	1.57	1.24	2.81	0	0.18	0.18	1.58	0.66	2.24	0	0.13	0.13
1935-36	0.90	1.36	2.26	0.09	0.50	0.59	0.93	1.56	2.49	0.05	0.24	0.29	0.98	0.84	1.82	0	0.16	0.16
36-37	1.34	1.16	2.50	0.50	0.53	1.03	1.43	1.34	2.77	0.42	0.28	0.70	1.45	0.74	2.19	0.40	0.19	0.59
37-38	1.23	1.08	2.31	0.74	0.52	1.26	1.33	1.23	2.56	0.64	0.30	0.94	1.35	0.66	2.01	0.61	0.21	0.82
38-39	1.31	1.27	2.58	0.40	0.54	0.94	1.34	1.42	2.76	0.36	0.32	0.68	1.51	0.79	2.30	0.20	0.16	0.36
39-40	1.15	1.14	2.29	0.20	0.47	0.67	1.17	1.30	2.47	0.18	0.25	0.43	1.33	0.73	2.06	0.01	0.15	0.16
1940-41	1.61	0.94	2.55	1.55	0.49	2.04	1.71	1.06	2.77	1.45	0.29	1.74	1.66	0.58	2.24	1.50	0.21	1.71
41-42	1.07	1.34	2.41	0	0.41	0.41	1.07	1.50	2.57	0	0.20	0.20	1.08	0.82	1.90	0	0.14	0.14
42-43	1.20	1.31	2.51	0.76	0.64	1.40	1.28	1.51	2.79	0.68	0.40	1.08	1.33	0.89	2.22	0.64	0.27	0.91
43-44	1.23	1.28	2.51	0.73	0.64	1.37	1.33	1.50	2.83	0.64	0.40	1.04	1.32	0.90	2.22	0.66	0.28	0.94
44-45	1.09	1.58	2.67	0.03	0.53	0.56	1.14	1.79	2.93	0	0.25	0.25	1.13	1.08	2.21	0	0.23	0.23
1945-46	0.98	1.56	2.54	0.12	0.63	0.75	1.02	1.85	2.87	0.07	0.29	0.36	1.08	1.08	2.16	0	0.21	0.21
46-47	1.08	1.78	2.86	0.12	0.62	0.74	1.10	2.06	3.16	0.09	0.33	0.42	1.15	1.25	2.40	0.02	0.23	0.25
47-48	0.61	1.95	2.56	0	0.52	0.52	0.62	2.16	2.78	0	0.25	0.25	0.61	1.16	1.77	0	0.22	0.22
48-49	0.66	2.02	2.60	0	0.53	0.53	0.65	2.24	2.89	0	0.26	0.26	0.66	1.37	2.03	0	0.24	0.24
49-50	0.80	1.87	2.67	0.05	0.53	0.58	0.85	2.12	2.97	0.01	0.20	0.21	0.86	1.07	1.93	0	0.24	0.24
1950-51	0.69	1.99	2.68	0	0.54	0.54	0.70	2.28	2.98	0	0.25	0.25	0.70	1.36	2.06	0	0.23	0.23
51-52	1.47	1.29	2.76	0.94	0.67	1.61	1.56	1.50	3.06	0.84	0.41	1.25	1.55	0.91	2.46	0.86	0.29	1.15
52-53	0.93	1.82	2.75	0.02	0.49	0.51	0.93	2.05	2.98	0	0.23	0.23	0.92	1.17	2.09	0	0.22	0.22
53-54	0.93	1.44	2.37	0.12	0.50	0.62	1.01	1.66	2.67	0.04	0.23	0.27	1.06	0.95	2.01	0	0.18	0.18
54-55	1.11	1.52	2.63	0.02	0.41	0.43	1.12	1.72	2.84	0.01	0.20	0.21	1.11	1.04	2.15	0.02	0.18	0.20
1955-56	1.23	1.37	2.60	0.08	0.43	0.51	1.22	1.53	2.75	0.09	0.24	0.33	1.30	0.99	2.29	0.02	0.18	0.20
56-57	0.94	1.88	2.82	0.09	0.62	0.71	1.00	2.12	3.12	0.04	0.31	0.35	1.03	1.27	2.30	0.02	0.24	0.26
57-58	1.54	1.41	2.95	0.63	0.63	1.26	1.57	1.62	3.19	0.60	0.37	0.97	1.58	1.02	2.60	0.59	0.28	0.87
Mean 1929-57	1.07	1.43	2.49	0.26	0.51	0.77	1.11	1.63	2.73	0.22	0.27	0.49	1.15	0.92	2.07	0.18	0.20	0.38

TABLE L-13

FIRST TRIAL WEIGHTED UNIT CONSUMPTIVE USE AND DEEP PERCOLATION FOR
THE SAN FERNANDO AND EAGLE ROCK HYDROLOGIC SUBAREAS
(continued)

In Acre-Feet per Gross Acre

Year	Lawn grass						Dry farm		Crop	Residential						
	Consumptive use			Deep percolation			Consumptive use	Deep percolation		Consumptive use			Deep percolation			Residual rain
	Rain	Delivered water	Total	Rain	Delivered water	Total	Rain	Rain	Residual rain	Rain	Delivered water	Total	Rain	Delivered water	Total	
1928-29	0.86	2.81	3.67	0.12	0.39	0.51	0.95	0	0.03	0.80	0.81	1.61	0.02	0.07	0.09	0.17
29-30	0.88	2.79	3.67	0.13	0.41	0.54	0.98	0	0.04	0.71	0.81	1.52	0.10	0.13	0.23	0.21
1930-31	1.03	2.64	3.67	0.22	0.56	0.78	1.22	0	0.05	0.64	0.71	1.55	0.15	0.13	0.28	0.28
31-32	1.25	2.42	3.67	0.40	0.78	1.18	1.46	0.14	0.06	0.95	0.41	1.36	0.32	0.10	0.42	0.38
32-33	0.92	2.75	3.67	0.15	0.45	0.60	1.00	0.04	0.04	0.64	0.39	1.03	0.18	0.07	0.25	0.27
33-34	0.98	2.69	3.67	0.19	0.51	0.70	1.11	0.01	0.05	0.69	0.44	1.13	0.18	0.08	0.26	0.30
34-35	1.23	2.44	3.67	0.39	0.76	1.15	1.57	0	0.05	1.17	0.33	1.50	0.11	0.04	0.15	0.34
1935-36	0.89	2.78	3.67	0.13	0.42	0.55	0.99	0	0.03	0.73	0.41	1.14	0.09	0.05	0.14	0.20
36-37	1.38	2.29	3.67	0.55	0.91	1.46	1.58	0.27	0.07	1.07	0.37	1.44	0.41	0.06	0.47	0.45
37-38	1.43	2.24	3.67	0.62	0.96	1.58	1.45	0.52	0.08	0.99	0.36	1.35	0.57	0.09	0.66	0.51
38-39	1.31	2.36	3.67	0.46	0.84	1.30	1.62	0.09	0.07	1.12	0.52	1.64	0.23	0.10	0.33	0.44
39-40	1.11	2.56	3.67	0.27	0.64	0.91	1.34	0	0.05	0.92	0.48	1.40	0.16	0.07	0.23	0.30
1940-41	1.86	1.81	3.67	1.44	1.39	2.83	1.82	1.35	0.14	1.24	0.35	1.59	1.19	0.10	1.29	0.87
41-42	0.93	2.74	3.67	0.16	0.46	0.62	1.06	0	0.03	0.86	0.53	1.39	0.04	0.05	0.09	0.19
42-43	1.43	2.24	3.67	0.61	0.96	1.57	1.41	0.55	0.08	0.97	0.60	1.57	0.57	0.13	0.70	0.51
43-44	1.43	2.24	3.67	0.62	0.96	1.58	1.40	0.57	0.08	0.97	0.60	1.57	0.57	0.16	0.73	0.52
44-45	0.98	2.69	3.67	0.19	0.51	0.70	1.12	0	0.04	0.82	0.73	1.55	0.09	0.08	0.17	0.25
1945-46	0.95	2.72	3.67	0.17	0.48	0.65	1.08	0	0.04	0.74	0.80	1.54	0.12	0.19	0.31	0.27
46-47	1.02	2.65	3.67	0.21	0.55	0.76	1.16	0	0.04	0.77	0.97	1.74	0.17	0.16	0.33	0.29
47-48	0.60	3.07	3.67	0.03	0.13	0.16	0.62	0	0.02	0.49	1.11	1.60	0.01	0.09	0.10	0.13
48-49	0.64	3.03	3.67	0.03	0.17	0.20	0.65	0	0.01	0.54	1.17	1.71	0.02	0.10	0.12	0.11
49-50	0.79	2.88	3.67	0.08	0.32	0.40	0.84	0	0.03	0.64	1.13	1.77	0.05	0.11	0.16	0.18
1950-51	0.67	3.00	3.67	0.04	0.20	0.24	0.69	0	0.02	0.58	1.20	1.78	0.02	0.08	0.10	0.13
51-52	1.61	2.06	3.67	0.90	1.14	2.04	1.68	0.73	0.10	1.02	1.01	2.03	0.70	0.22	0.92	0.78
52-53	0.85	2.82	3.67	0.11	0.38	0.49	0.94	0	0.03	0.67	1.25	1.92	0.09	0.15	0.24	0.21
53-54	0.93	2.74	3.67	0.16	0.46	0.62	1.06	0	0.04	0.64	1.19	1.83	0.16	0.21	0.37	0.31
54-55	0.98	2.69	3.67	0.18	0.51	0.69	1.14	0	0.03	0.84	1.16	2.00	0.08	0.12	0.20	0.24
1955-56	1.09	2.58	3.67	0.27	0.62	0.89	1.30	0	0.05	0.70	1.12	1.82	0.22	0.17	0.39	0.42
56-57	0.92	2.75	3.67	0.15	0.45	0.60	1.04	0	0.04	0.60	1.28	1.88	0.14	0.16	0.30	0.33
57-58	1.51	2.16	3.67	0.73	1.04	1.77	1.78	0.40	0.09	0.97	1.07	2.04	0.50	0.13	0.63	0.76
Mean 1929-57	1.07	2.60	3.67	0.31	0.60	0.91	1.18	0.15	0.05	0.82	0.78	1.60	0.23	0.11	0.35	0.33

TABLE L-13

FIRST TRIAL WEIGHTED UNIT CONSUMPTIVE USE AND DEEP PERCOLATION FOR
THE SAN FERNANDO AND EAGLE ROCK HYDROLOGIC SUBAREAS
(continued)

In Acre-Feet per Gross Acre

Year	Commercial and industrial			100 Percent impervious	Riparian			Miscellaneous		
	Consumptive use				Consumptive use			Consumptive use	Deep percolation	Residual rain
	Rain	Delivered water	Total	Residual rain	Rain	Ground water	Total	Rain	Rain	
1928-29	0.42			0.56	0.98	3.27	4.25	0.70	0	0.28
29-30	0.28			0.73	1.01	3.09	4.10	0.64	0	0.37
1930-31	0.34			0.91	1.25	2.90	4.15	0.79	0	0.46
31-32	0.43			1.22	1.65	2.60	4.25	0.97	0.08	0.61
32-33	0.21			0.66	1.07	2.89	3.96	0.62	0.02	0.43
33-34	0.20			0.97	1.17	2.82	3.99	0.68	0.01	0.49
34-35	0.53			1.09	1.63	2.77	4.40	1.08	0	0.55
1935-36	0.37			0.65	1.01	3.11	4.12	0.70	0	0.33
36-37	0.49			1.43	1.93	2.40	4.33	1.07	0.14	0.72
37-38	0.43			1.62	2.05	2.16	4.21	0.97	0.28	0.81
38-39	0.37			1.40	1.77	2.41	4.18	1.03	0.05	0.70
39-40	0.41			0.97	1.38	2.86	4.24	0.90	0	0.49
1940-41	0.53	See Table L-12		2.77	3.30	1.14	4.44	1.21	0.71	1.39
41-42	0.49			0.60	1.09	3.25	4.34	0.79	0	0.30
42-43	0.40			1.64	2.04	2.15	4.19	0.93	0.29	0.82
43-44	0.41			1.64	2.05	2.11	4.16	0.93	0.30	0.82
44-45	0.38			0.78	1.16	3.04	4.20	0.77	0	0.39
1945-46	0.37			0.75	1.12	3.02	4.14	0.75	0	0.35
46-47	0.42			0.81	1.23	2.97	4.20	0.82	0	0.41
47-48	0.28			0.35	0.64	3.41	4.05	0.45	0	0.18
48-49	0.38			0.29	0.67	3.48	4.15	0.52	0	0.15
49-50	0.37			0.50	0.87	3.36	4.23	0.62	0	0.25
1950-51	0.38			0.33	0.71	3.48	4.19	0.54	0	0.17
51-52	0.58			1.93	2.51	1.92	4.43	1.16	0.39	0.97
52-53	0.43			0.53	0.96	3.21	4.17	0.70	0	0.27
53-54	0.33			0.76	1.09	3.99	4.08	0.71	0	0.39
54-55	0.54			0.62	1.16	3.18	4.34	0.65	0	0.31
1955-56	0.40			0.96	1.36	2.85	4.21	0.88	0	0.48
56-57	0.32			0.75	1.07	3.07	4.14	0.69	0	0.38
57-58	0.54			1.70	2.24	2.14	4.38	1.18	0.21	0.85
Mean 1929-57	0.40			0.98	1.38	2.82	4.20	0.81	0.08	0.49

TABLE L-14

WEIGHTED UNIT CONSUMPTIVE USE AND DEEP PERCOLATION
FOR THE SYLMAR HYDROLOGIC SUBAREA

In Acre-Feet per Gross Acre

Year	Deciduous						Citrus						Walnuts					
	Consumptive use			Deep percolation			Consumptive use			Deep percolation			Consumptive use			Deep percolation		
	Rain	Delivered water	Total	Rain	Delivered water	Total	Rain	Delivered water	Total	Rain	Delivered water	Total	Rain	Delivered water	Total	Rain	Delivered water	Total
1928-29	1.03	1.11	2.14	0	0.15	0.15	1.06	1.28	2.34	0	0.25	0.25	1.04	1.21	2.25	0	0.17	0.17
29-30	1.17	1.12	2.29	0.01	0.14	0.15	0.97	1.17	2.14	0.20	0.32	0.52	1.13	1.20	2.33	0.04	0.16	0.20
1930-31	1.24	1.09	2.33	0.11	0.18	0.29	1.08	1.29	2.37	0.26	0.24	0.50	1.21	1.19	2.40	0.14	0.21	0.35
31-32	1.42	0.90	2.32	0.30	0.19	0.49	1.27	1.03	2.30	0.44	0.32	0.76	1.40	1.00	2.40	0.32	0.21	0.53
32-33	1.05	1.00	2.05	0.01	0.15	0.16	0.79	1.10	1.89	0.25	0.33	0.58	1.04	1.15	2.19	0.02	0.15	0.17
33-34	1.07	1.01	2.08	0.14	0.18	0.32	0.86	1.12	1.98	0.34	0.35	0.69	1.07	1.09	2.16	0.13	0.20	0.33
34-35	1.66	0.90	2.56	0.11	0.15	0.26	1.55	1.03	2.58	0.21	0.25	0.46	1.66	0.99	2.65	0.12	0.17	0.29
1935-36	1.19	1.11	2.30	0.08	0.17	0.25	0.94	1.17	2.11	0.34	0.38	0.72	1.19	1.22	2.41	0.10	0.21	0.31
36-37	1.58	0.94	2.52	0.49	0.21	0.70	1.41	1.05	2.46	0.67	0.34	1.01	1.58	1.06	2.64	0.50	0.23	0.73
37-38	1.44	0.87	2.31	0.70	0.24	0.94	1.25	1.01	2.26	0.88	0.36	1.24	1.44	0.99	2.43	0.70	0.24	0.94
38-39	1.44	1.06	2.50	0.27	0.21	0.48	1.21	1.15	2.36	0.50	0.39	0.89	1.42	1.17	2.59	0.30	0.23	0.53
39-40	1.36	0.96	2.32	0.02	0.14	0.16	1.10	1.06	2.16	0.28	0.29	0.57	1.35	1.08	2.43	0.03	0.16	0.19
1940-41	1.75	0.79	2.54	1.27	0.21	1.48	1.57	0.91	2.48	1.45	0.33	1.78	1.75	0.89	2.64	1.29	0.24	1.53
41-42	1.09	1.09	2.18	0	0.14	0.14	1.08	1.27	2.35	0	0.23	0.23	1.09	1.21	2.30	0	0.16	0.16
42-43	1.40	1.10	2.50	0.71	0.27	0.98	1.22	1.22	2.44	0.90	0.44	1.34	1.37	1.14	2.51	0.74	0.31	1.05
43-44	1.35	1.09	2.44	0.62	0.29	0.91	1.23	1.22	2.45	0.76	0.45	1.21	1.34	1.13	2.47	0.63	0.32	0.95
44-45	1.29	1.23	2.52	0	0.17	0.17	1.20	1.36	2.56	0.10	0.33	0.43	1.30	1.30	2.60	0	0.18	0.18
1945-46	1.16	1.31	2.47	0.07	0.20	0.27	0.98	1.41	2.39	0.24	0.40	0.64	1.12	1.36	2.48	0.11	0.24	0.35
46-47	1.28	1.45	2.73	0.12	0.25	0.37	1.17	1.56	2.73	0.24	0.44	0.68	1.27	1.49	2.76	0.14	0.27	0.41
47-48	0.68	1.52	2.20	0	0.18	0.18	0.69	1.79	2.48	0	0.29	0.29	0.69	1.66	2.35	0	0.19	0.19
48-49	0.86	1.62	2.48	0.01	0.18	0.19	0.86	1.83	2.69	0.01	0.31	0.32	0.86	1.72	2.58	0.01	0.21	0.22
49-50	0.95	1.46	2.41	0.13	0.32	0.45	0.86	1.60	2.46	0.20	0.32	0.52	0.92	1.56	2.48	0.16	0.41	0.57
1950-51	0.91	1.74	2.65	0	0.21	0.21	0.92	1.93	2.85	0	0.32	0.32	0.91	1.81	2.72	0	0.21	0.21
51-52	1.58	1.13	2.71	1.05	0.32	1.37	1.46	1.26	2.72	1.19	0.50	1.69	1.55	1.16	2.71	1.08	0.35	1.43
52-53	1.06	1.48	2.54	0.01	0.18	0.19	0.99	1.60	2.59	0.07	0.33	0.41	1.04	1.49	2.53	0.02	0.19	0.21
53-54	1.08	1.16	2.24	0.11	0.20	0.31	0.95	1.27	2.22	0.23	0.36	0.59	1.02	1.22	2.24	0.16	0.24	0.40
54-55	1.12	1.25	2.37	0.02	0.16	0.18	1.10	1.42	2.52	0.03	0.23	0.26	1.10	1.29	2.39	0.02	0.15	0.17
1955-56	1.32	1.08	2.40	0.19	0.20	0.39	1.22	1.19	2.41	0.26	0.33	0.59	1.30	1.11	2.41	0.20	0.21	0.41
56-57	1.15	1.52	2.67	0.01	0.19	0.20	1.06	1.70	2.76	0.11	0.40	0.51	1.13	1.66	2.79	0.04	0.23	0.27
57-58	1.62	1.17	2.79	0.76	0.27	1.03	1.47	1.27	2.74	0.90	0.44	1.34	1.59	1.21	2.80	0.76	0.31	1.07
Mean 1929-57	1.23	1.18	2.41	0.23	0.20	0.43	1.11	1.31	2.42	0.35	0.34	0.69	1.22	1.26	2.48	0.24	0.22	0.46

TABLE L-14

WEIGHTED UNIT CONSUMPTIVE USE AND DEEP PERCOLATION
FOR THE SYLMAR HYDROLOGIC SUBAREA
(continued)

In Acre-Feet per Gross Acre

Year	Truck						Alfalfa and pasture						Vineyard					
	Consumptive use			Deep percolation			Consumptive use			Deep percolation			Consumptive use			Deep percolation		
	Rain	Delivered water	Total	Rain	Delivered water	Total	Rain	Delivered water	Total	Rain	Delivered water	Total	Rain	Delivered water	Total	Rain	Delivered water	Total
1928-29	1.05	1.31	2.36	0	0.43	0.43	1.04	1.48	2.52	0	0.21	0.21	1.05	0.78	1.83	0	0.17	0.17
29-30	1.02	1.23	2.25	0.16	0.48	0.64	1.09	1.42	2.51	0.08	0.23	0.31	1.17	0.76	1.93	0.01	0.13	0.14
1930-31	1.17	1.28	2.45	0.18	0.48	0.66	1.26	1.46	2.72	0.09	0.24	0.33	1.23	0.77	2.00	0.12	0.17	0.29
31-32	1.30	1.05	2.35	0.41	0.46	0.87	1.38	1.20	2.58	0.34	0.26	0.60	1.41	0.65	2.06	0.31	0.16	0.47
32-33	0.87	1.14	2.01	0.17	0.45	0.62	0.86	1.29	2.15	0.19	0.28	0.47	1.06	0.73	1.79	0	0.13	0.13
33-34	0.91	1.15	2.06	0.29	0.48	0.77	0.92	1.31	2.23	0.27	0.30	0.57	1.04	0.71	1.75	0.15	0.16	0.31
34-35	1.60	1.05	2.65	0.18	0.41	0.59	1.68	1.21	2.89	0.07	0.20	0.27	1.65	0.64	2.29	0.12	0.14	0.26
1935-36	1.02	1.25	2.27	0.27	0.54	0.81	1.06	1.43	2.49	0.23	0.30	0.53	1.21	0.79	2.00	0.08	0.16	0.24
36-37	1.45	1.10	2.55	0.62	0.50	1.12	1.54	1.27	2.81	0.53	0.28	0.81	1.55	0.68	2.23	0.51	0.20	0.71
37-38	1.31	1.04	2.35	0.84	0.53	1.37	1.40	1.20	2.60	0.75	0.30	1.05	1.41	0.64	2.05	0.73	0.21	0.94
38-39	1.24	1.21	2.45	0.47	0.54	1.01	1.27	1.36	2.63	0.44	0.33	0.77	1.42	0.74	2.16	0.30	0.20	0.50
39-40	1.17	1.10	2.27	0.22	0.45	0.67	1.20	1.26	2.46	0.17	0.23	0.40	1.35	0.69	2.04	0.03	0.15	0.18
1940-41	1.70	0.92	2.62	1.31	0.47	1.78	1.80	1.07	2.87	1.22	0.28	1.50	1.72	0.56	2.28	1.31	0.19	1.50
41-42	1.09	1.30	2.39	0	0.40	0.40	1.09	1.45	2.54	0	0.20	0.20	1.08	0.79	1.87	0	0.14	0.14
42-43	1.29	1.24	2.53	0.82	0.64	1.46	1.36	1.41	2.77	0.76	0.39	1.15	1.39	0.87	2.26	0.73	0.25	0.98
43-44	1.31	1.25	2.56	0.69	0.61	1.30	1.40	1.45	2.85	0.59	0.40	0.99	1.36	0.88	2.24	0.62	0.27	0.89
44-45	1.19	1.43	2.62	0.10	0.52	0.62	1.30	1.65	2.95	0	0.24	0.24	1.29	1.01	2.30	0	0.21	0.21
1945-46	1.02	1.45	2.47	0.22	0.60	0.82	1.07	1.69	2.76	0.16	0.32	0.48	1.21	1.00	2.21	0.03	0.21	0.24
46-47	1.22	1.68	2.90	0.18	0.63	0.81	1.26	1.95	3.21	0.15	0.36	0.51	1.29	1.16	2.45	0.11	0.25	0.36
47-48	0.69	1.88	2.57	0	0.51	0.51	0.68	2.10	2.78	0	0.24	0.24	0.70	1.13	1.83	0	0.22	0.22
48-49	0.86	1.95	2.81	0.01	0.52	0.53	0.86	2.17	3.03	0.01	0.24	0.25	0.86	1.32	2.18	0.01	0.23	0.24
49-50	0.90	1.73	2.63	0.18	0.73	0.91	0.98	1.99	2.97	0.11	0.38	0.49	1.05	1.14	2.19	0.04	0.24	0.28
1950-51	0.93	1.03	1.96	0	0.55	0.55	0.92	2.32	3.24	0	0.27	0.27	0.92	1.37	2.29	0	0.25	0.25
51-52	1.48	1.29	2.77	1.14	0.70	1.84	1.64	1.50	3.14	0.99	0.43	1.42	1.55	0.91	2.46	1.08	0.30	1.38
52-53	1.01	1.72	2.73	0.04	0.53	0.57	1.07	2.00	3.07	0	0.22	0.22	1.07	1.14	2.21	0	0.21	0.21
53-54	0.97	1.31	2.28	0.21	0.52	0.73	1.06	1.52	2.58	0.13	0.27	0.40	1.12	0.89	2.01	0.05	0.19	0.24
54-55	1.10	1.47	2.57	0.03	0.40	0.43	1.11	1.65	2.76	0.02	0.19	0.21	1.11	0.98	2.09	0.03	0.17	0.20
1955-56	1.29	1.25	2.54	[illegible]	0.46	0.67	1.36	1.43	2.79	0.15	0.24	0.39	1.34	0.85	2.19	0.16	0.19	0.35
56-57	1.10	1.74	2.84	0.07	0.58	0.65	1.14	2.00	3.14	0.02	0.26	0.28	1.15	1.20	2.35	0.01	0.22	0.23
57-58	1.60	1.30	2.90	0.76	0.61	1.37	1.61	1.51	3.12	0.74	0.39	1.13	1.61	0.94	2.55	0.77	0.29	1.06
Mean 1929-57	1.15	1.33	2.48	0.31	0.52	0.83	1.20	1.56	2.76	0.26	0.28	0.54	1.23	0.89	2.12	0.23	0.20	0.42

TABLE L-14

FIRST TRIAL WEIGHTED UNIT CONSUMPTIVE USE AND DEEP PERCOLATION
FOR THE SYLMAR HYDROLOGIC SUBAREA
(continued)

In Acre-Feet per Gross Acre

Year	Lawn grass: Consumptive use: Rain	Lawn grass: Consumptive use: Delivered water	Lawn grass: Consumptive use: Total	Lawn grass: Deep percolation: Rain	Lawn grass: Deep percolation: Delivered water	Lawn grass: Deep percolation: Total	Dry farm: Consumptive use: Rain	Dry farm: Deep percolation: Rain	Crop: Residual rain	Residential: Consumptive use: Rain	Residential: Consumptive use: Delivered water	Residential: Consumptive use: Total	Residential: Deep percolation: Rain	Residential: Deep percolation: Delivered water	Residential: Deep percolation: Total	Residential: Residual rain
1928-29	0.95	2.72	3.67	0.17	0.48	0.65	1.04	0	0.07	0.84	0.78	1.62	0.08	0.08	0.16	0.21
29-30	1.06	2.61	3.67	0.23	0.58	0.81	1.18	0	0.10	0.84	0.76	1.60	0.12	0.17	0.29	0.30
1930-31	1.14	2.53	3.67	0.30	0.68	0.98	1.35	0	0.10	0.96	0.70	1.66	0.20	0.15	0.35	0.32
31-32	1.36	2.31	3.67	0.51	0.87	1.38	1.53	0.19	0.13	1.07	0.40	1.47	0.39	0.10	0.49	0.41
32-33	0.95	2.72	3.67	0.17	0.49	0.66	1.05	0	0.08	0.73	0.39	1.12	0.15	0.07	0.22	0.26
33-34	1.06	2.61	3.67	0.23	0.58	0.81	1.09	0.10	0.10	0.74	0.42	1.16	0.20	0.09	0.29	0.32
34-35	1.36	2.31	3.67	0.52*	0.89	1.41	1.79	0	0.12	1.31	0.32	1.63	0.20	0.04	0.24	0.38
1935-36	1.10	2.57	3.67	0.27	0.63	0.90	1.25	0.02	0.09	0.90	0.38	1.28	0.06	0.07	0.23	0.29
36-37	1.50	2.17	3.67	0.72	1.04	1.76	1.67	0.41	0.16	1.20	0.34	1.54	0.52	0.07	0.59	0.51
37-38	1.54	2.13	3.67	0.78	1.07	1.85	1.49	0.66	0.18	1.09	0.36	1.45	0.68	0.09	0.77	0.55
38-39	1.36	2.31	3.67	0.51	0.88	1.39	1.49	0.23	0.15	1.07	0.50	1.57	0.33	0.11	0.44	0.46
39-40	1.17	2.50	3.67	0.32	0.69	1.01	1.38	0	0.10	1.00	0.48	1.48	0.16	0.07	0.23	0.32
1940-41	1.87	1.80	3.67	1.44	1.38	2.82	1.86	1.13	0.27	1.32	0.35	1.67	1.04	0.09	1.13	0.84
41-42	0.95	2.72	3.67	0.17	0.50	0.67	1.09	0	0.05	0.91	0.52	1.43	0.04	0.05	0.09	0.16
42-43	1.54	2.13	3.67	0.76	1.06	1.82	1.46	0.66	0.18	1.04	0.59	1.63	0.63	0.13	0.76	0.57
43-44	1.47	2.20	3.67	0.67	1.01	1.68	1.46	0.52	0.17	1.06	0.60	1.66	0.52	0.15	0.67	0.52
44-45	1.10	2.57	3.67	0.27	0.64	0.91	1.30	0	0.09	0.96	0.71	1.67	0.13	0.10	0.23	0.28
1945-46	1.06	2.61	3.67	0.25	0.60	0.85	1.24	0	0.09	0.83	0.84	1.67	0.17	0.14	0.31	0.32
46-47	1.17	2.50	3.67	0.34	0.71	1.05	1.40	0	0.10	0.72	0.96	1.68	0.22	0.16	0.38	0.36
47-48	0.66	3.01	3.67	0.04	0.21	0.25	0.69	0	0.04	0.56	1.10	1.66	0.01	0.09	0.10	0.13
48-49	0.81	2.86	3.67	0.10	0.34	0.44	0.87	0	0.05	0.70	1.16	1.86	0.04	0.11	0.15	0.16
49-50	0.95	2.72	3.67	0.17	0.50	0.67	1.08	0	0.07	0.78	1.10	1.88	0.10	0.15	0.25	0.26
1950-51	0.84	2.83	3.67	0.11	0.38	0.49	0.92	0	0.05	0.74	1.18	1.92	0.05	0.10	0.15	0.18
51-52	1.72	1.95	3.67	1.12	1.27	2.39	1.74	0.90	0.23	1.07	0.99	2.06	0.88	0.23	1.11	0.93
52-53	0.95	2.72	3.67	0.17	0.48	0.65	1.06	0	0.07	0.73	1.22	1.95	0.13	0.18	0.31	0.27
53-54	1.03	2.64	3.67	0.22	0.57	0.79	1.18	0	0.09	0.70	1.18	1.88	0.23	0.24	0.47	0.36
54-55	0.99	2.68	3.67	0.19	0.53	0.72	1.12	0	0.06	0.69	1.18	2.07	0.06	0.12	0.18	0.25
1955-56	1.21	2.46	3.67	0.38	0.76	1.14	1.50	0	0.12	0.82	1.11	1.93	0.28	0.19	0.47	0.52
56-57	1.03	2.64	3.67	0.21	0.54	0.75	1.17	0	0.07	0.76	1.29	2.05	0.14	0.18	0.32	0.31
57-58	1.65	2.02	3.67	0.95	1.15	2.10	1.79	0.58	0.20	1.13	1.06	2.19	0.66	0.15	0.81	0.89
Mean 1929-57	1.17	2.50	3.67	0.39	0.70	1.09	1.29	0.17	0.11	0.91	0.75	1.66	0.27	0.12	0.39	0.37

TABLE L-14

FIRST TRIAL WEIGHTED UNIT CONSUMPTIVE USE AND DEEP PERCOLATION
FOR THE SYLMAR HYDROLOGIC SUBAREA
(continued)

In Acre-Feet per Gross Acre

Year	Commercial and industrial: Consumptive use: Rain	Commercial and industrial: Consumptive use: Delivered water	Commercial and industrial: Consumptive use: Total	100 Percent impervious: Residual rain	Miscellaneous: Consumptive use: Rain	Miscellaneous: Deep percolation: Rain	Miscellaneous: Residual rain
1928-29	0.44			0.67	0.78	0	0.34
29-30	0.32			0.96	0.80	0	0.48
1930-31	0.42			1.02	0.94	0	0.51
31-32	0.54			1.31	1.09	0.11	0.66
32-33	0.29			0.84	0.72	0	0.42
33-34	0.26			1.02	0.67	0.06	0.51
34-35	0.67			1.21	1.28	0	0.61
1935-36	0.45			0.92	0.90	0.01	0.46
36-37	0.62			1.62	1.20	0.23	0.81
37-38	0.55			1.76	1.08	0.37	0.88
38-39	0.38			1.48	1.00	0.13	0.74
39-40	0.43			1.02	0.98	0	0.51
1940-41	0.62	See Table L-12		2.68	1.33	0.63	1.34
41-42	0.63			0.51	0.89	0	0.26
42-43	0.47			1.82	1.03	0.37	0.91
43-44	0.50			1.65	1.04	0.29	0.83
44-45	0.48			0.90	0.93	0	0.45
1945-46	0.43			0.89	0.86	0	0.45
46-47	0.53			0.99	1.03	0	0.50
47-48	0.36			0.36	0.54	0	0.18
48-49	0.46			0.45	0.68	0	0.23
49-50	0.41			0.73	0.78	0	0.37
1950-51	0.50			0.46	0.73	0	0.23
51-52	0.58			2.30	1.21	0.50	1.15
52-53	0.45			0.68	0.79	0	0.34
53-54	0.37			0.90	0.82	0	0.45
54-55	0.57			0.62	0.89	0	0.31
1955-56	0.47			1.16	1.04	0	0.58
56-57	0.53			0.69	0.89	0	0.35
57-58	0.58			1.99	1.26	0.32	1.00
Mean 1929-57	0.47			1.09	0.93	0.09	0.55

TABLE L-15

FIRST TRIAL WEIGHTED UNIT CONSUMPTIVE USE AND DEEP PERCOLATION
FOR THE VERDUGO HYDROLOGIC SUBAREA

In Acre-Feet per Gross Acre

Year	Deciduous						Citrus						Truck					
	Consumptive use			Deep percolation			Consumptive use			Deep percolation			Consumptive use			Deep percolation		
	Rain	Delivered water	Total	Rain	Delivered water	Total	Rain	Delivered water	Total	Rain	Delivered water	Total	Rain	Delivered water	Total	Rain	Delivered water	Total
1928-29	1.37	1.10	2.47	0	0.16	0.16	1.27	1.24	2.51	0.10	0.29	0.39	1.32	1.28	2.60	0.05	0.46	0.51
29-30	1.18	1.10	2.28	0.03	0.14	0.17	1.04	1.19	2.23	0.16	0.30	0.46	1.06	1.26	2.32	0.14	0.45	0.59
1930-31	1.24	1.09	2.33	0.11	0.18	0.29	1.11	1.20	2.31	0.23	0.34	0.57	1.16	1.28	2.44	0.19	0.48	0.67
31-32	1.44	0.87	2.31	0.60	0.22	0.82	1.29	1.00	2.29	0.77	0.35	1.12	1.33	0.99	2.32	0.70	0.52	1.22
32-33	1.10	0.96	2.06	0.25	0.19	0.44	0.85	1.04	1.89	0.51	0.39	0.90	0.94	1.08	2.02	0.43	0.51	0.94
33-34	1.13	0.94	2.07	0.74	0.25	0.99	0.92	1.05	1.97	0.95	0.41	1.36	0.99	1.07	2.06	0.88	0.56	1.44
34-35	1.93	0.66	2.59	0.59	0.19	0.78	1.66	0.99	2.65	0.65	0.29	0.94	1.77	1.02	2.79	0.54	0.44	0.98
1935-36	1.24	1.07	2.31	0.23	0.21	0.44	0.99	1.16	2.15	0.48	0.39	0.87	1.07	1.22	2.29	0.40	0.57	0.97
36-37	1.60	0.93	2.53	0.96	0.23	1.19	1.49	1.03	2.52	1.07	0.36	1.43	1.53	1.07	2.60	1.03	0.53	1.56
37-38	1.47	0.87	2.34	1.58	0.26	1.84	1.30	0.99	2.29	1.75	0.38	2.13	1.33	1.01	2.34	1.72	0.56	2.28
38-39	1.66	1.05	2.71	0.34	0.21	0.55	1.49	1.17	2.66	0.52	0.37	0.89	1.44	1.21	2.65	0.56	0.54	1.10
39-40	1.38	0.94	2.32	0.22	0.18	0.40	1.15	1.04	2.19	0.45	0.31	0.76	1.20	1.07	2.27	0.39	0.48	0.87
1940-41	1.81	0.78	2.59	1.85	0.23	2.08	1.70	0.90	2.60	1.98	0.33	2.31	1.83	0.90	2.73	1.82	0.49	2.31
41-42	1.33	1.08	2.41	0.01	0.14	0.15	1.30	1.25	2.55	0.04	0.25	0.29	1.33	1.30	2.63	0.01	0.40	0.41
42-43	1.41	1.04	2.45	1.70	0.31	2.01	1.23	1.16	2.39	1.89	0.50	2.39	1.29	1.19	2.48	1.82	0.69	2.51
43-44	1.39	1.08	2.47	0.82	0.31	1.13	1.31	1.21	2.52	0.91	0.46	1.37	1.35	1.22	2.57	0.86	0.64	1.50
44-45	1.44	1.16	2.60	0.38	0.24	0.62	1.30	1.29	2.59	0.52	0.40	0.92	1.30	1.33	2.63	0.50	0.62	1.12
1945-46	1.21	1.25	2.46	0.30	0.26	0.56	1.02	1.36	2.38	0.48	0.45	0.93	1.05	1.40	2.45	0.45	0.65	1.10
46-47	1.43	1.37	2.80	0.41	0.33	0.74	1.35	1.51	2.86	0.49	0.49	0.98	1.41	1.60	3.01	0.42	0.71	1.13
47-48	0.82	1.53	2.35	0	0.18	0.18	0.77	1.73	2.50	0.05	0.35	0.40	0.76	1.82	2.58	0.04	0.57	0.61
48-49	1.13	1.62	2.75	0.01	0.18	0.19	1.10	1.81	2.91	0.03	0.33	0.36	1.12	1.94	3.06	0.01	0.53	0.54
49-50	1.09	1.37	2.46	0.30	0.41	0.71	1.02	1.51	2.53	0.37	0.65	1.02	1.05	1.67	2.72	0.33	0.79	1.12
1950-51	0.93	1.74	2.67	0	0.21	0.21	0.91	1.93	2.84	0.01	0.32	0.33	0.92	2.03	2.95	0	0.55	0.55
51-52	1.69	1.10	2.79	1.48	0.35	1.83	1.57	1.23	2.80	1.58	0.53	2.11	1.60	1.28	2.88	1.56	0.71	2.27
52-53	1.03	1.47	2.50	0.02	0.19	0.21	0.97	1.61	2.58	0.07	0.32	0.39	0.97	1.72	2.69	0.06	0.53	0.59
53-54	1.17	1.08	2.25	0.52	0.28	0.80	1.03	1.18	2.21	0.63	0.45	1.08	1.07	1.22	2.29	0.60	0.61	1.21
54-55	1.32	1.26	2.58	0.01	0.15	0.16	1.25	1.36	2.61	0.08	0.29	0.37	1.30	1.45	2.75	0.05	0.43	0.48
1955-56	1.34	1.05	2.39	0.34	0.23	0.57	1.24	1.16	2.40	0.42	0.36	0.78	1.32	1.21	2.53	0.34	0.50	0.84
56-57	1.28	1.48	2.76	0.08	0.23	0.31	1.13	1.63	2.76	0.22	0.47	0.69	1.18	1.69	2.87	0.17	0.63	0.80
57-58	1.64	1.15	2.79	1.09	0.29	1.38	1.51	1.28	2.79	1.19	0.43	1.62	1.64	1.30	2.94	1.06	0.62	1.68
Mean 1929-57	1.32	1.15	2.47	0.48	0.23	0.71	1.20	1.27	2.47	0.60	0.38	0.98	1.24	1.33	2.57	0.55	0.56	1.11

TABLE L-15

FIRST TRIAL WEIGHTED UNIT CONSUMPTIVE USE AND DEEP PERCOLATION
FOR THE VERDUGO HYDROLOGIC SUBAREA
(continued)

In Acre-Feet per Gross Acre

Year	Lawn grass						Dry farm		Crop	Residential						
	Consumptive use			Deep percolation			Consumptive use	Deep percolation		Consumptive use			Deep percolation			Residual rain
	Rain	Delivered water	Total	Rain	Delivered water	Total	Rain	Rain	Residual rain	Rain	Delivered water	Total	Rain	Delivered water	Total	
1928-29	1.14	2.53	3.67	0.31	0.68	0.99	1.38	0	0.10	1.03	0.60	1.63	0.14	0.08	0.22	0.31
29-30	1.06	2.61	3.67	0.24	0.59	0.83	1.20	0	0.10	0.91	0.66	1.57	0.11	0.12	0.23	0.31
1930-31	1.14	2.53	3.67	0.30	0.68	0.98	1.36	0	0.10	0.95	0.64	1.59	0.21	0.15	0.36	0.30
31-32	1.50	2.17	3.67	0.72	1.03	1.75	1.50	0.55	0.17	1.07	0.57	1.64	0.64	0.17	0.81	0.52
32-33	1.14	2.53	3.67	0.31	0.69	1.00	1.05	0.30	0.12	0.77	0.65	1.42	0.32	0.16	0.48	0.37
33-34	1.43	2.24	3.67	0.61	0.95	1.56	1.08	0.78	0.18	0.77	0.82	1.59	0.69	0.24	0.93	0.55
34-35	1.61	2.06	3.67	0.88	1.13	2.01	2.00	0.31	0.18	1.35	0.70	2.05	0.59	0.15	0.74	0.57
1935-36	1.21	2.46	3.67	0.37	0.74	1.11	1.30	0.17	0.12	0.94	0.70	1.64	0.31	0.14	0.45	0.34
36-37	1.69	1.98	3.67	1.06	1.25	2.31	1.72	0.84	0.22	1.20	0.76	1.96	0.91	0.18	1.09	0.69
37-38	1.87	1.80	3.67	1.46	1.40	2.86	1.49	1.57	0.28	1.12	0.72	1.84	1.35	0.24	1.59	0.88
38-39	1.47	2.20	3.67	0.68	1.02	1.70	1.83	0.18	0.18	1.29	0.82	2.11	0.34	0.19	0.53	0.55
39-40	1.28	2.39	3.67	0.44	0.81	1.25	1.45	0.15	0.13	1.00	0.89	1.89	0.33	0.19	0.52	0.40
1940-41	2.02	1.65	3.67	1.94	1.58	3.52	1.95	1.71	0.33	1.37	0.66	2.03	1.56	0.11	1.67	1.05
41-42	1.14	2.53	3.67	0.30	0.66	0.96	1.33	0	0.09	1.04	0.94	1.98	0.10	0.11	0.21	0.26
42-43	1.91	1.76	3.67	1.53	1.41	2.94	1.43	1.68	0.29	1.08	0.79	1.87	1.42	0.22	1.64	0.92
43-44	1.58	2.09	3.67	0.83	1.11	1.94	1.49	0.73	0.20	1.07	0.78	1.85	0.74	0.24	0.98	0.61
44-45	1.39	2.28	3.67	0.57	0.92	1.49	1.59	0.24	0.14	1.08	0.78	1.86	0.44	0.16	0.60	0.45
1945-46	1.25	2.42	3.67	0.39	0.76	1.15	1.35	0.16	0.13	0.85	0.88	1.73	0.36	0.18	0.54	0.42
46-47	1.39	2.28	3.67	0.57	0.93	1.50	1.56	0.27	0.14	1.05	0.89	1.94	0.42	0.18	0.60	0.50
47-48	0.77	2.90	3.67	0.08	0.32	0.40	0.82	0	0.05	0.61	1.05	1.66	0.05	0.12	0.17	0.20
48-49	0.99	2.68	3.67	0.19	0.52	0.71	1.13	0	0.06	0.90	0.92	1.82	0.08	0.10	0.18	0.22
49-50	1.17	2.50	3.67	0.32	0.69	1.01	1.38	0	0.10	0.92	0.87	1.79	0.20	0.15	0.35	0.37
1950-51	0.84	2.83	3.67	0.12	0.39	0.51	0.93	0	0.05	0.78	0.98	1.76	0.06	0.10	0.16	0.20
51-52	1.91	1.76	3.67	1.55	1.43	2.98	1.88	1.28	0.28	1.16	0.82	1.98	1.15	0.19	1.34	1.14
52-53	0.95	2.72	3.67	0.16	0.47	0.63	1.04	0	0.07	0.74	1.04	1.78	0.11	0.14	0.25	0.26
53-54	1.32	2.35	3.67	0.49	0.86	1.35	1.28	0.40	0.14	0.79	0.98	1.77	0.46	0.26	0.72	0.57
54-55	1.14	2.53	3.67	0.30	0.66	0.96	1.34	0	0.08	0.97	0.97	1.94	0.14	0.12	0.26	0.33
1955-56	1.32	2.35	3.67	0.48	0.85	1.33	1.61	0.06	0.14	0.88	1.04	1.92	0.37	0.19	0.56	0.62
56-57	1.14	2.53	3.67	0.31	0.68	0.99	1.35	0	0.10	0.88	1.04	1.92	0.28	0.19	0.47	0.46
57-58	1.76	1.91	3.67	1.18	1.28	2.46	1.83	0.87	0.24	1.04	1.14	2.18	0.73	0.17	0.90	1.06
Mean 1929-57	1.34	2.33	3.67	0.60	0.87	1.47	1.41	0.39	0.15	0.98	0.83	1.81	0.48	0.16	0.64	0.50

TABLE L-15

WEIGHTED UNIT CONSUMPTIVE USE AND DEEP PERCOLATION FOR THE VERDUGO HYDROLOGIC SUBAREA (continued)

In Acre-Feet per Gross Acre

Year	Commercial and industrial: Consumptive use: Rain	Commercial and industrial: Consumptive use: Delivered water	Commercial and industrial: Consumptive use: Total	100 percent impervious: Residual rain	Riparian: Consumptive use: Rain	Riparian: Consumptive use: Ground water	Riparian: Consumptive use: Total	Miscellaneous: Consumptive use: Rain	Miscellaneous: Deep percolation: Rain	Miscellaneous: Residual rain
1928-29	0.47			0.99	1.46	2.85	4.31	0.97	0	0.50
29-30	0.33			0.97	1.30	2.81	4.11	0.82	0	0.49
1930-31	0.43			1.02	1.45	2.76	4.21	0.95	0	0.51
31-32	0.54			1.67	2.21	2.09	4.30	1.08	0.31	0.84
32-33	0.30			1.17	1.47	2.59	4.06	0.72	0.17	0.59
33-34	0.27			1.77	2.02	1.96	4.00	0.72	0.44	0.89
34-35	0.66			1.82	2.48	2.05	4.53	1.40	0.17	0.91
1935-36	0.42			1.17	1.58	2.61	4.19	0.90	0.10	0.59
36-37	0.58			2.20	2.78	1.70	4.48	1.21	0.47	1.10
37-38	0.52			2.81	3.33	0.95	4.28	1.06	0.87	1.41
38-39	0.41			1.77	2.17	2.06	4.23	1.20	0.10	0.89
39-40	0.46			1.26	1.72	2.52	4.24	1.00	0.09	0.63
1940-41	0.66	See Table L-12		3.33	3.99	0.61	4.60	1.38	0.95	1.67
41-42	0.52			0.91	1.43	2.97	4.40	0.98	0	0.46
42-43	0.48			2.94	3.40	0.86	4.26	1.01	0.94	1.47
43-44	0.46			1.95	2.41	1.88	4.29	1.03	0.41	0.98
44-45	0.52			1.44	1.96	2.36	4.32	1.10	0.14	0.72
1945-46	0.37			1.25	1.62	2.55	4.17	0.91	0.09	0.63
46-47	0.59			1.38	1.97	2.43	4.40	1.14	0.15	0.69
47-48	0.33			0.54	0.87	3.23	4.10	0.61	0	0.27
48-49	0.57			0.62	1.18	3.20	4.38	0.88	0	0.31
49-50	0.45			1.03	1.48	2.80	4.28	0.97	0	0.52
1950-51	0.48			0.49	0.97	3.29	4.26	0.73	0	0.25
51-52	0.62			2.83	3.45	1.09	4.54	1.33	0.71	1.42
52-53	0.45			0.65	1.10	3.11	4.21	0.78	0	0.33
53-54	0.39			1.43	1.82	2.31	4.13	0.89	0.22	0.72
54-55	0.60			0.83	1.43	2.94	4.37	1.02	0	0.42
1955-56	0.42			1.38	1.80	2.43	4.23	1.07	0.04	0.69
56-57	0.43			1.03	1.46	2.86	4.32	0.95	0	0.52
57-58	0.58			1.94	2.94	1.50	4.44	1.27	0.49	0.97
Mean 1929-57	0.47			1.47	1.94	2.34	4.28	0.99	0.22	0.74

The unit values derived in this appendix are utilized for the purpose of determining recharge for each source of supply; i.e., native and delivered waters. The total consumptive use determined by the Integration Method as described herein and by the Inflow-Outflow Method, which is shown in Chapter V, are not equal. Adjustments which are made to the consumptive use as determined by the Integration Method are also discussed in Chapter VI.

TABLE L-15A

UNWEIGHTED UNIT DEPTHS OF CONSUMPTIVE USE AND
DEEP PERCOLATION ON RESIDENTIAL LAND USE AREAS

In Acre-Feet Per Acre

Year	San Fernando and Eagle Rock Subareas								Sylmar Subarea							
	Consumptive use						Deep percolation delivered water		Consumptive use						Deep percolation delivered water	
	Rain				Delivered water				Rain				Delivered water			
	Deciduous	Lawn grass	Native vegetation	Impervious	Deciduous	Lawn grass	Deciduous	Lawn grass	Deciduous	Lawn grass	Native vegetation	Impervious	Deciduous	Lawn grass	Deciduous	Lawn grass
1928-29	0.99	1.01	0.98	0.42	1.73	1.81	0.20	0.10	1.13	1.00	1.12	0.44	1.71	1.76	0.20	0.32
29-30	0.93	0.86	1.01	0.28	1.77	1.77	0.29	0.29	1.07	1.01	1.28	0.32	1.69	1.71	0.38	0.36
1930-31	1.08	0.99	1.25	0.34	1.58	1.60	0.31	0.29	1.18	1.10	1.45	0.42	1.54	1.59	0.35	0.31
31-32	1.37	0.89	1.50	0.43	0.93	0.90	0.19	0.22	1.48	1.01	1.64	0.54	0.92	0.90	0.20	0.22
32-33	1.04	0.59	1.03	0.21	0.90	0.82	0.12	0.20	1.13	0.66	1.14	0.29	0.91	0.83	0.10	0.19
33-34	1.07	0.69	1.16	0.20	0.99	0.94	0.16	0.21	1.11	0.76	1.08	0.26	0.97	0.94	0.18	0.21
34-35	1.62	1.34	1.62	0.53	0.71	0.73	0.09	0.07	1.75	1.41	1.90	0.67	0.70	0.73	0.12	0.08
1935-36	1.01	0.74	1.02	0.37	0.88	0.88	0.11	0.12	1.28	0.88	1.34	0.45	0.85	0.84	0.13	0.14
36-37	1.53	1.04	1.65	0.49	0.76	0.79	0.17	0.12	1.69	1.12	1.79	0.62	0.74	0.78	0.18	0.13
37-38	1.42	0.97	1.50	0.43	0.80	0.80	0.21	0.19	1.53	1.07	1.59	0.55	0.78	0.79	0.22	0.20
38-39	1.54	1.34	1.68	0.37	1.16	1.14	0.21	0.22	1.50	1.24	1.61	0.38	1.12	1.13	0.24	0.24
39-40	1.34	0.94	1.38	0.41	1.08	1.07	0.15	0.16	1.39	1.00	1.48	0.43	1.06	1.07	0.17	0.15
1940-41	1.75	1.31	1.88	0.53	0.74	0.81	0.24	0.18	1.86	1.29	2.03	0.62	0.75	0.82	0.24	0.17
41-42	1.09	1.00	1.09	0.49	1.12	1.18	0.14	0.08	1.14	0.98	1.14	0.63	1.12	1.18	0.14	0.07
42-43	1.36	1.06	1.46	0.40	1.28	1.38	0.33	0.23	1.48	1.10	1.57	0.47	1.27	1.38	0.34	0.22
43-44	1.30	1.08	1.45	0.41	1.28	1.35	0.39	0.33	1.41	1.11	1.57	0.50	1.28	1.35	0.37	0.32
44-45	1.17	0.94	1.17	0.38	1.59	1.62	0.20	0.17	1.31	0.98	1.39	0.48	1.57	1.60	0.23	0.19
1945-46	1.03	0.88	1.12	0.37	1.87	1.94	0.78	0.24	1.12	0.99	1.33	0.43	1.81	1.91	0.37	0.27
46-47	1.11	0.83	1.23	0.42	2.13	2.16	0.37	0.32	1.30	0.99	1.51	0.53	2.07	2.15	0.42	0.33
47-48	0.63	0.61	0.63	0.28	2.39	2.51	0.27	0.16	0.72	0.69	0.72	0.36	2.38	2.49	0.27	0.17
48-49	0.67	0.64	0.67	0.38	2.52	2.65	0.30	0.17	0.90	0.84	0.91	0.46	2.53	2.62	0.30	0.19
49-50	0.89	0.78	0.87	0.37	2.48	2.55	0.28	0.23	1.04	0.96	1.14	0.41	2.33	2.47	0.41	0.29
1950-51	0.71	0.74	0.71	0.38	2.65	2.75	0.31	0.09	0.96	0.89	0.96	0.50	2.55	2.66	0.31	0.17
51-52	1.53	1.22	1.74	0.58	2.12	2.30	0.63	0.43	1.59	1.28	1.86	0.58	2.06	2.28	0.65	0.43
52-53	0.88	0.80	0.96	0.43	2.67	2.84	0.45	0.28	1.00	0.90	1.12	0.45	2.57	2.80	0.50	0.32
53-54	0.87	0.78	1.09	0.33	2.55	2.71	0.61	0.43	0.95	0.85	1.26	0.37	2.50	2.67	0.66	0.47
54-55	1.12	1.05	1.16	0.54	2.53	2.63	0.36	0.23	1.15	1.10	1.19	0.57	2.50	2.67	0.35	0.22
1955-56	1.09	0.96	1.36	0.40	2.44	2.50	0.52	0.33	1.22	1.09	1.62	0.47	2.35	2.51	0.62	0.38
56-57	0.94	0.88	1.07	0.32	2.69	2.92	0.54	0.33	1.09	0.98	1.23	0.53	2.68	2.91	0.55	0.34
57-58	1.54	1.35	1.82	0.54	2.19	2.44	0.50	0.24	1.63	1.35	1.93	0.58	2.17	2.40	0.48	0.28

TABLE L-15A

UNWEIGHTED UNIT DEPTHS OF CONSUMPTIVE USE AND
DEEP PERCOLATION ON RESIDENTIAL LAND USE AREAS

In Acre-Feet Per Acre

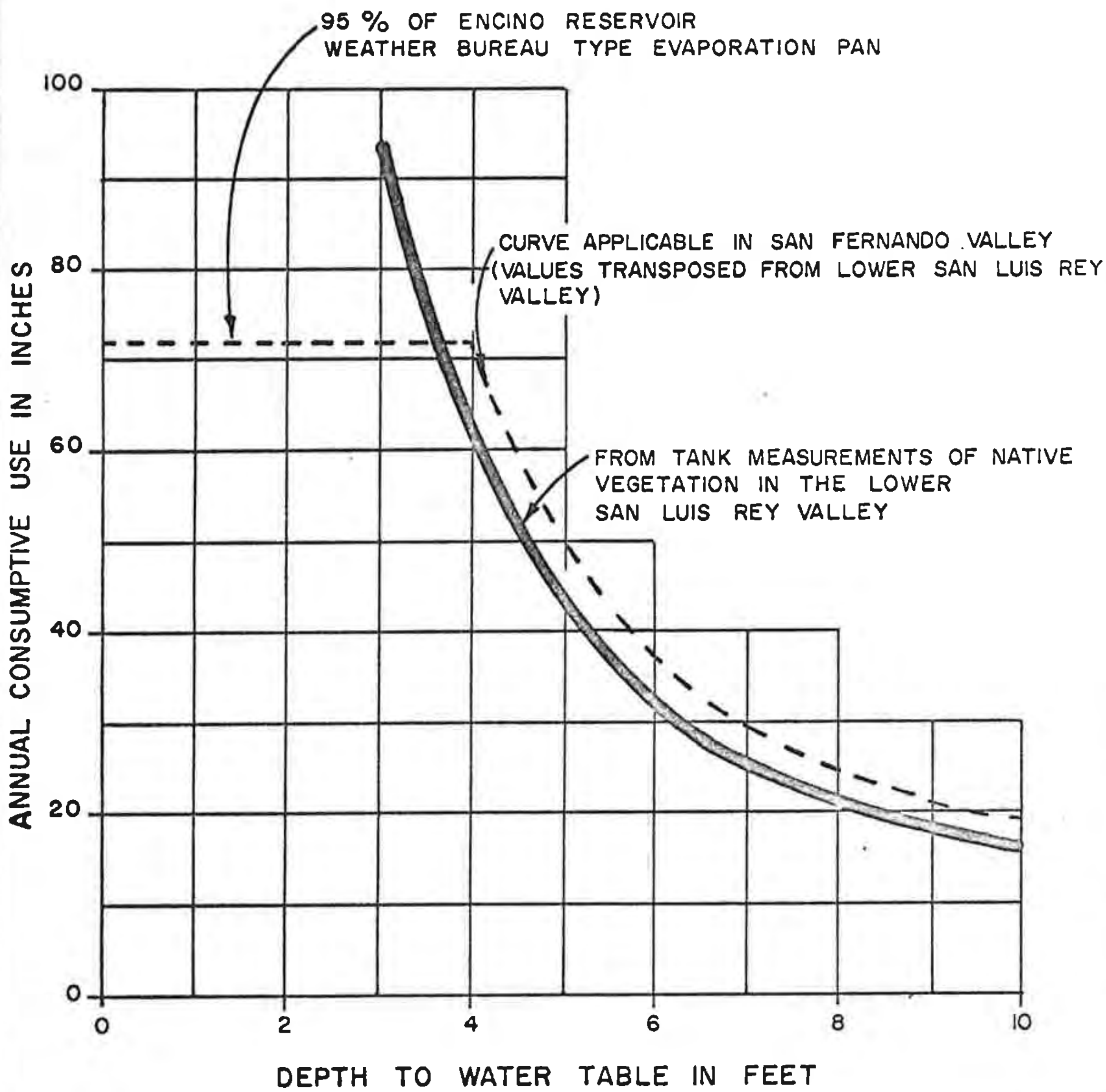
Year	Verdugo Subarea							
	Consumptive use						Deep percolation delivered water	
	Rain				Delivered water			
	Deciduous	Lawn grass	Native vegetation	Impervious	Deciduous	Lawn grass	Deciduous	Lawn grass
1928-29	1.37	1.19	1.46	0.47	1.32	1.35	0.21	0.17
29-30	1.17	1.15	1.30	0.33	1.51	1.45	0.24	0.28
1930-31	1.20	1.07	1.45	0.43	1.43	1.45	0.33	0.30
31-32	1.45	1.05	1.60	0.54	1.26	1.30	0.39	0.35
32-33	1.12	0.78	1.14	0.30	1.44	1.43	0.35	0.37
33-34	1.10	0.95	1.16	0.27	1.78	1.86	0.58	0.49
34-35	1.70	1.40	2.13	0.66	1.49	1.62	0.42	0.28
1935-36	1.26	1.02	1.39	0.42	1.52	1.59	0.34	0.27
36-37	1.66	1.20	1.85	0.58	1.60	1.75	0.48	0.33
37-38	1.48	1.27	1.59	0.52	1.55	1.68	0.61	0.47
38-39	1.66	1.73	1.97	0.41	1.80	1.87	0.45	0.38
39-40	1.28	1.10	1.55	0.46	1.93	2.05	0.48	0.34
1940-41	1.85	1.39	2.09	0.66	1.42	1.55	0.53	0.38
41-42	1.36	1.22	1.43	0.52	2.03	2.16	0.31	0.19
42-43	1.48	1.20	1.54	0.48	1.67	1.86	0.58	0.38
43-44	1.41	1.24	1.60	0.46	1.70	1.80	0.58	0.47
44-45	1.44	1.08	1.69	0.52	1.67	1.76	0.42	0.32
1945-46	1.17	1.02	1.44	0.37	1.88	2.00	0.49	0.38
46-47	1.46	1.14	1.67	0.59	1.89	2.02	0.49	0.37
47-48	0.83	0.77	0.87	0.33	2.23	2.30	0.32	0.24
48-49	1.18	1.01	1.18	0.57	2.01	2.05	0.24	0.20
49-50	1.23	1.11	1.48	0.45	1.84	1.96	0.41	0.29
1950-51	1.24	0.92	0.98	0.48	1.98	2.27	0.42	0.13
51-52	1.77	1.37	2.03	0.62	1.68	1.87	0.56	0.38
52-53	1.02	0.91	1.10	0.45	2.24	2.36	0.38	0.26
53-54	1.13	0.99	1.38	0.39	2.08	2.23	0.68	0.53
54-55	1.31	1.19	1.43	0.60	2.07	2.19	0.36	0.24
1955-56	1.30	1.29	1.73	0.42	2.18	2.36	0.58	0.38
56-57	1.25	1.34	1.46	0.43	2.26	2.35	0.48	0.39
57-58	1.64	1.36	1.96	0.58	2.28	2.59	0.63	0.33

Excess Consumptive Use in High Water Table Areas

Consumptive use in high water table areas is greater than in other areas of similar culture due to the evaporation of moisture brought to the land surface by capillary action and the increased transpiration rates brought about by greater available supply of water. Consumptive use of ground water in these areas (excess consumptive use) is considered to be the difference between normal consumptive use, as heretofore discussed, and that by vegetation in high water table areas.

Figure L-4 shows the relationship between consumptive use and depth to water table determined from tank measurements in the Lower San Luis Rey Valley.[13/] Although the curve indicates consumptive use by native vegetation under high water table conditions it was assumed that it would be approximately representative of use by other types of culture in areas of similar high water table elevation.

San Fernando Valley, in comparison with Lower San Luis Rey Valley, is less exposed to the coastal influence and more exposed to the dry easterly winds; therefore, the curve for Lower San Luis Rey Valley was adjusted to give consideration to these factors. The curve was adjusted by using the relationship of the k (consumptive use coefficient) values of alfalfa and citrus of the two areas. The k values in San Fernando Valley are about 15 percent greater than in Lower San Luis Rey Valley so that the curve values were increased by that amount.



SAN FERNANDO VALLEY REFERENCE

CONSUMPTIVE USE IN HIGH WATER TABLE AREAS

STATE WATER RIGHTS BOARD

When the depth to water table is between zero and three feet, swampy conditions tend to exist and tank experiments in Lower San Luis Rey Valley[13/] and near Victorville, California[12/] indicate that the consumptive use is 95 percent of the evaporation from a Weather Bureau type pan. In this instance 95 percent of the Encino Reservoir Weather Bureau type pan is 72.0 inches. This value, as shown on Figure L-4, has been extended to include the depth to water of from zero to four feet.

Average net consumptive use values were computed for three increments of depth to water table to facilitate computations and are as follows:

Depth to Water Table, in feet	Average Net Consumptive Use	
	Inches	Feet
0 - 4	72.0	6.0
4 - 8	40.9	3.4
8 - 10	22.0	1.8

<u>High Ground Water Areas in San Fernando Hydrologic Subarea</u>

Contour maps showing depth to ground water were drawn for high ground water areas in San Fernando Subarea from piezometer and well measurements for each year of available data. The contour maps for the years 1932, 1942, 1949, 1954 and 1958 were superimposed on culture maps constructed from land use surveys. For each of these years the acreage of each type of culture within each increment of depth to water table was determined and the total acreage of each increment of depth to ground water for the remaining years was determined. The acreage of each culture class for these years was computed on a straight line proportional basis of the percentage of each as found in the years in which land use surveys were available.

The average net values of consumptive use in high water table areas were weighted with respect to the percent of pervious area for each culture class. The difference between this value and the weighted normal consumptive use for each culture class was considered to be excess consumptive use supplied from ground water. In instances where normal consumptive use exceeded the high water table consumptive use no excess was taken. The excess depth of use multiplied by the acreage of the particular culture class gave the acre-feet of excess consumptive use.

The annual acreages of high water table areas are shown in Table L-16 and the annual excess consumptive use from 1928-29 through 1957-58 is shown in Table L-17. The areal extent of the high water table area during 1943-44 is shown on Plate 29.

TABLE L-16

TOTAL ACREAGE IN HIGH GROUND WATER AREAS
IN WEST SAN FERNANDO HYDROLOGIC SUBAREA

In Acre-Feet

Year	Depth to ground water			Total
	0-4 feet	4-8 feet	8-10 feet	
1928-29	250	1,500	1,000	2,750
29-30	165	1,109	1,144	2,418
1930-31	5	615	1,511	2,131
31-32	512	792	1,322	2,626
32-33	0	905	996	1,901
33-34	18	1,182	846	2,046
34-35	320	1,544	669	2,533
1935-36	548	1,235	939	2,722
36-37	323	1,547	1,517	3,387
37-38	804	1,382	1,010	3,196
38-39	702	1,749	1,341	3,792
39-40	613	1,503	1,697	3,813
1940-41	910	3,610	2,336	6,856
41-42	555	2,861	2,471	5,887
42-43	2,918	3,043	2,997	8,958
43-44	2,550	6,289	3,501	12,340
44-45	191	2,385	3,390	5,966
1945-46	177	2,550	2,036	4,763
46-47	0	1,747	2,378	4,125
47-48	72*	1,507*	1,836*	3,415*
48-49	145	1,267	1,294	2,706
49-50	145	1,267	1,296	2,708
1950-51	80	1,399	1,141	2,620
51-52	263	1,844	1,321	3,428
52-53	228	1,697	911	2,836
53-54	127	1,200	890	2,217
54-55	11	1,106	1,057	2,174
1955-56	20	1,061	1,185	2,266
56-57	0	997	1,046	2,043
57-58	0	1,242	797	2,039

Average for 29-year period 1928-29 through 1956-57 = 3,746.

* Average of 1946-47 and 1948-49.

TABLE L-17

EXCESS CONSUMPTIVE USE OF
GROUND WATER IN HIGH GROUND WATER AREAS
IN WEST SAN FERNANDO HYDROLOGIC SUBAREA[a]

In Acre-Feet

Year	Depth to ground water			Total[b]
	0-4 feet	4-8 feet	8-10 feet	
1928-29	851	409	21	1,280
29-30	540	311	24	880
1930-31	20	189	33	240
31-32	1,580	262	30	1,870
32-33	0	322	23	350
33-34	64	448	20	530
34-35	1,002	625	17	1,640
1935-36	1,685	529	24	2,240
36-37	980	701	40	1,720
37-38	2,413	661	27	3,100
38-39	2,087	879	37	3,000
39-40	1,825	793	49	2,670
1940-41	2,667	1,987	68	4,720
41-42	5,920	1,643	74	7,640
42-43	8,439	1,843	87	10,370
43-44	7,419	4,004	98	11,520
44-45	584	1,593	91	2,270
1945-46	532	1,686	53	2,270
46-47	7	1,206	59	1,270
47-48	250	1,082	44	1,380
48-49	445	945	30	1,420
49-50	431	1,137	72	1,640
1950-51	229	1,379	73	1,680
51-52	745	1,482	113	2,340
52-53	635	1,413	96	2,140
53-54	346	764	114	1,220
54-55	22	874	135	1,030
1955-56	60	632	127	820
56-57	0	517	110	630
57-58	0	649	84	730
29-year average 1929-57				2,550

a. Does not include excess consumptive use in San Fernando Cienaga area

b. Rounded off to nearest 10.

Estimated Reduction in Consumptive Use of Ground Water* in High Ground Water Areas of Sylmar Hydrologic Subarea

Abstract

Extent of the area affected by the high ground water conditions in the Sylmar Subarea was determined by studies set forth in Appendix C, "Characteristics of Soils and Their Relationship to Past Vegetative and Water Table Conditions in San Fernando Cienaga Area". Maximum consumptive use of ground water under predevelopment conditions was calculated by two methods. The first used the relative elevation of the maximum concentration of calcium carbonate to determine the maximum average predevelopment elevation of the water table. The second method estimated maximum water table conditions using historic records, surveys, court transcripts and other sources. Using these estimated water table elevations in conjunction with values for consumptive use of ground water under high water table conditions obtained from the curve set forth on Figure L-4, maximum evapotranspiration use was estimated to be about 1,600 acre-feet per year (see Tables L-18 and L-19). The closeness of these results indicates that the calcium carbonate content of the soil reflects the approximate predevelopment water table conditions. From this it was assumed that the relative magnitude of the maximum concentration of calcium carbonate in a given soil profile is proportional to the approximate period of time that water levels were at this elevation. Inasmuch as there is no development in the westerly portion of the Sylmar cienaga area and data are not available therein during the base period,

* Excess consumptive use of ground water caused by high water table conditions as defined in this appendix.

average predevelopment consumptive use was estimated in each area and is about 700 acre-feet per annum for the eastern portion of the area and 200 acre-feet per annum for the western portion (see Table L-25). This value, compared with estimated consumptive use of ground water during the base period determined from water level measurements modified to reflect soil types, indicates an estimated average reduction of consumptive use of ground water from predevelopment to developed conditions of about 600 acre-feet per annum (see Tables L-20 and L-21).

The areas affected by high water table conditions were considered to be those delineated by the outer boundary of the soils described in Appendix C and delineated as Types B-1, B-2, B-3, SB-1 and T-1 on Plate 7. The boundary between the East and West Cienaga areas has been taken as the topographic divide near Lakeside Street. The western portion of the West Cienaga is now inundated by San Fernando Reservoir.[17/] Some water level data are available in the East Cienaga area; however, no reliable water levels are available for the predevelopment period in either area, and therefore elevations of the predevelopment water table and resulting consumptive use of ground water under predevelopment conditions have been estimated by means of the chemical analysis of the soil as hereinafter described. Some water level data in the East Cienaga area are available during the base period and these have been utilized in conjunction with the soil chemistry information in estimating average consumptive use of ground water under conditions of pumpage and water supply development existing during this latter period. The results obtained are approximations but are believed to be indicative of the order of magnitude of use of ground water for the conditions set forth.

Estimated Consumptive Use of Ground Water

To determine the annual historic consumptive use of ground water prior to development and during the base period, an analysis was made of the data set forth in Appendix C "Characteristics of Soils and Their Relationship to Past Vegetative and Water Table Conditions in San Fernando Cienaga Area" in order to define water table conditions during periods when water level observations were not available. This information combined with available data concerning unit consumptive use contained in this appendix provided a means of estimating the limits of consumptive use of ground water in the area.

Soil samples and chemical analyses described in Appendix C show large quantities of calcium carbonate ($CaCO_3$) present in the soils. It was concluded that the $CaCO_3$ was precipitated from the ground water which was concentrated through transpiration and evaporation under high water table conditions. This deposition takes place in the root zone immediately above the water table where ground water is being consumed by vegetation[16/], or in the zone of aeration at or near the surface where water is lifted by capillary action. The first condition is thought to have occurred in this area. Although the zone of maximum transpiration is immediately above the water table, it has been assumed that the depth to the zone of maximum $CaCO_3$ deposition indicates the average depth to water during the period of high water table conditions in which the accumulation of salts occurred. It is further assumed that the relative quantities of $CaCO_3$ deposited indicate the relative period of time that the water table was at that elevation and the relative amount of water transpired. Thus it is possible to estimate depth to water under predevelopment high water table conditions and the proportion of time it was at that depth if it is assumed that during the subsequent period, when the water table had been lowered by development of the ground water supply, leaching of salts from the soils by deep percolation of rainfall and excess irrigation water had not been sufficient to remove or lower the zone of maximum $CaCO_3$ appreciably.

To determine depth to water in the area susceptible to high ground water losses, the depth to maximum $CaCO_3$ content at each boring in the area was superimposed on the soils map depicted on Plate 7. This depth was taken as indicating the average position of the predevelopment maximum water table and contours of equal depth to water table were drawn. Acreages with equal depth to water were measured and the unit values developed in this appendix concerning consumptive use under high ground water table conditions were applied to determine theoretical consumptive use of ground water, assuming that the water table was at maximum level at all times. It was further assumed, for purposes of this study, that the outer boundary of Hesperia fine sandy loam delineates the areal extent of the transition zone of soils affected by high water table conditions (see Plate 7) and thus denotes the northern extremity of the moist area. The acreages and amounts of consumptive use of ground water so determined are set forth in Table L-18.

To ascertain the validity of the foregoing approach, high water table conditions were determined after development of surface flows but prior to appreciable ground water development from historic records available in various publications, court transcripts and surveys. All references to springs, cienagas and seepages in these records have been taken as evidence that the water table was at or near the surface. The location of each was superimposed on Plate 7 and the use of ground water estimated on this basis. Assumptions made in this analysis are as follows:

1. The water table would be at ten feet at the outer limits of the Hesperia fine sandy loam which marks the northerly extremity of soils affected by high water table conditions and it would be less than ten feet at all other limits.

2. Where springs or other evidence indicate that water was at or near the surface, it was assumed that the depth to water increased uniformly to the ten-foot depth at the outer limit of the Hesperia fine sandy loam.

3. The water table between springs and other indications of high ground water would be relatively level and continuous.

4. Where no records were available in the western portion of the study area, the edge of the Chino fine sandy loam was assumed to coincide with water table depths of less than four feet, as indicated in the areas where records were available, and the water table sloped uniformly to the aforementioned ten-foot boundary.

The acreages and amounts of consumptive use of ground water estimated under the foregoing assumptions and conditions are set forth in Table L-19 for comparison with results in Table L-18, which were derived by fixing maximum levels as indicated by location of maximum concentrations of $CaCO_3$.

Values derived in Tables L-18 and L-19 reflect the maximum annual consumptive use of ground water realized with maximum water levels continuously maintained over a long-time period; however, the supply to the area, which is basically derived from precipitation, varies as indicated by recorded periods

TABLE L-18

ESTIMATED MAXIMUM ANNUAL CONSUMPTIVE USE OF GROUND WATER UTILIZING $CaCO_3$ FOR DETERMINATION OF HIGH WATER TABLE CONDITIONS PRIOR TO ANY DEVELOPMENT IN AREA

Soil type[a] (1)	Acreage, in acres (2)	Average depth to water, in feet (3)	Depth of consumptive use,[b] in feet (4)	Total, in acre-feet (5)=(2)x(4)	Consumptive use of precipitation,[c] in acre-feet (6)	Net consumptive use of ground water, in acre-feet (7)=(5)-(6)
B1	191.7	Less than 4	6.0	1,150	264	886
B2	2.3	Less than 4	6.0	14	3	11
B3	3.2	Less than 4	6.0	19	4	15
SB1	93.0	Less than 4	6.0	558	128	430
T1	37.7	Less than 4	6.0	226	52	174
T1	23.0	5	4.16	96	32	64
T1	25.0	6	3.16	79	35	44
T1	24.3	7	2.5	61	34	27
T1	27.7	8	2.0	55	38	17
T1	20.0	9	1.75	35	28	7
TOTALS	447.9			2,293	618	1,675

a. See Plate 7.
b. See Figure L-4.
c. Product of average annual consumptive use of precipitation (1.38 feet) and acreage in Column (2).

TABLE L-19

ESTIMATED MAXIMUM ANNUAL CONSUMPTIVE USE OF GROUND WATER IN THE VICINITY OF THE SYLMAR HYDROLOGIC SUBAREA UNDER HIGH GROUND WATER TABLE CONDITIONS

Soil type[a] (1)	Acreage, in acres (2)	Average depth to water, in feet (3)	Depth of consumptive use,[b] in feet (4)	Total, in acre-feet (5)=(2)x(4)	Consumptive use of precipitation,[c] in acre-feet (6)	Net consumptive use of ground water, in acre-feet (7)=(5)-(6)
B1	191.7	Less than 4	6.0	1,150	264	886
B2	2.3	Less than 4	6.0	14	3	11
B3	3.2	Less than 4	6.0	19	4	15
SB1	93.0	Less than 4	6.0	558	128	430
T1	22.9	Less than 4	6.0	137	32	105
T1	23.9	5	4.16	99	33	66
T1	24.8	6	3.16	78	34	44
T1	28.8	7	2.5	72	40	32
T1	28.8	8	2.0	58	40	18
T1	28.5	9	1.75	50	39	11
Totals	447.9			2,235	617	1,618

a, b and c. See Table L-18.

of drought and abnormal wetness. During a normal precipitation cycle, such as the 85-year period from 1872-73 through 1956-57, precipitation was above normal for about one-third of the time and subnormal the remaining two-thirds. It was assumed that predevelopment ground water levels varied during a long-time period in accordance with precipitation trends; therefore, the maximum quantities estimated for continuous high water table conditions, as shown in Table L-18, were modified in proportion to the decrease in amounts of $CaCO_3$ indicated at the zone of maximum accumulation in each boring sampled throughout the area.

To determine this modification, and hence the average annual consumptive use of ground water during conditions prior to development, it was assumed that continuous deposition of $CaCO_3$ occurred historically at rates varying in proportion to the wetness or dryness of the period and that these wet and dry cycles and the resultant water level changes caused by them are related directly to the percent of $CaCO_3$ deposited at the zone of maximum concentration within the top five feet of soil. These assumptions are supported by tree-ring studies of Schulman[14/] and Troxel[15/], which indicate that there has been no major change in climatic patterns in Southern California for over 560 years, and studies by Doneen[16/] and others indicating that in situations where ground water is available and is naturally transpired or evaporated, the less soluble mineral salts therein are deposited in the zone of use. Thus the procedures utilized are believed applicable for long-time conditions and the concentration of $CaCO_3$ deposited would be proportional to the average quantity of ground water consumed. Inasmuch as there are no records of water levels in the West Cienaga area during the base period, the average predevelopment consumptive use of ground water was calculated for each of the cienaga areas so that a comparison could be made with consumptive use during the base period.

Available records indicate that the areal extent of the zone containing 25 percent $CaCO_3$ within four feet of the surface coincides with reported existence of perennial springs, cienagas and damp areas during the dry portion of the 1870's; therefore this area was taken as having a predevelopment average water table within four feet of the surface 100 percent of the time. The average annual consumptive use of ground water throughout the remainder of the area was taken as proportional to the relative concentration of $CaCO_3$ at any place, compared to the aforementioned annual use of ground water determined for the area containing a 25 percent concentration of these salts. For example, an area containing soils with a maximum concentration of 25 percent $CaCO_3$ in the top four feet of the soil profile was presumed to have experienced average water levels within four feet of the surface for 100 percent of the time, whereas an area containing soils with 10 percent concentration of $CaCO_3$ within the top four feet of soil profile was assumed to have experienced maximum water levels during only 40 percent of the time, and areas containing soils with five percent concentration of $CaCO_3$ within seven feet of the surface were assumed to have experienced maximum water levels at seven feet for only 20 percent of the time.

Areas which historically were effluent during dry cycles were considered to have a water table within four feet of the surface 100 percent of the time regardless of $CaCO_3$ content. The conditions causing variations in $CaCO_3$ concentrations in these areas are set forth on pages C-24 and C-25 of Appendix C. The greatest influence on salt concentrations was considered to be from the flushing effect adjacent to continuously flowing springs.

In order to modify the maximum amounts set forth in Table L-18, values of the average percent $CaCO_3$ were superimposed on Plate 7 along with the contours of the maximum percent $CaCO_3$ utilized for high water table conditions. Lines of equal percentage were drawn for 100 percent, 40 percent, 20 percent and zero percent of time, based on $CaCO_3$ content of 25 percent, equaling an average water table four feet from the surface 100 percent of the time. Soil boundaries along with percent $CaCO_3$ were used to determine areas similarly affected by high water table conditions in the area. For example, the 13-acre area of Chino fine sandy loam located near Bradley Avenue and Hubbard Street and similar soils near the Mission well field, which were strongly affected by high water table conditions, were given more weight in the modification of the 100 percent contour than Grangeville fine sandy loam, which is somewhat less strongly affected by high water table conditions. The outer boundary of the Hesperia fine sandy loam, which marks the extremity of the soils affected by high water table conditions, was taken as the boundary where the water table was never high enough for consumptive use of ground water to take place. The enclosed areas were measured and average consumptive use of ground water was computed as set forth in Table L-20.

For the base period 1928-29 through 1956-57, water table measurements are available only in the areas near and to the east of East Cienaga. Records are available of water surface elevation at San Fernando Reservoir which now inundates a portion of the West Cienaga but there are no ground water level measurements in the moist area surrounding West Cienaga. It was not possible to estimate consumptive use of ground water for this area during the base period.

To determine the consumptive use of ground water from the moist area surrounding the East (Porter) Cienaga during the base period 1928-29 through 1956-57, depth to water was plotted from all available records in the area for

TABLE L-20

ESTIMATED AVERAGE ANNUAL CONSUMPTIVE USE OF GROUND WATER PRIOR TO ANY DEVELOPMENT IN AREA

Soil Types (Plate 7)	Relative percent $CaCO_3$[a] (1)	Maximum consumptive use of ground water, in acre-feet per annum (Table L-18) (2)	Area with percent $CaCO_3$ shown in Col. (1), in acres (3)	Ratio of area in Col. (3) to total area (4)		Net consumptive use of ground water, in acre-feet per annum (5)=(1)x(2)x(4) (5)
			West Cienaga Area			
B1, B2, B3, SB1	100		27.4	0.094		126.1
	70	1,342[b]	20.7	0.071		66.7
	30		13.2	0.046		18.5
T1	10	333[c]	24.2	0.153		5.1
					Total	216.4
			East Cienaga Area			
B1, B2, B3, SB1	100		67.7	0.234		314.0
	70	1,342[b]	77.7	0.268		251.8
	30		83.3	0.287		115.5
T1	10	333[c]	133.5	0.846		28.2
					Total	709.5
					Grand Total	925.9

a. Based on maximum concentration (i.e. 25 percent) equivalent to 100 percent.
b. On a total area of 290 acres (Plate 7).
c. On a total area of 158 acres (Plate 7).

each year. It was assumed that the upturned ends of the Saugus formation are in contact with the recent alluvium and that there is a free interchange of water (see Appendix D). Contours were drawn showing equal depth to water and consumptive use of ground water was determined as heretofore described. The amount of consumptive use so determined for each year under these conditions is set forth in Table L-21 and can be compared with average pre-development conditions in Table L-20.

TABLE L-21

ESTIMATED CONSUMPTIVE USE OF GROUND WATER FROM THE EAST CIENAGA IN SYLMAR SUBAREA 1928-29 THROUGH 1957-58

In Acre-Feet

Year	Consumptive use of ground water	Year	Consumptive use of ground water
1928-29	Less than 10	1945-46	172
29-30	Less than 10	46-47	139
		47-48	91
1930-31	60	48-49	51
31-32	63	49-50	46
32-33	255		
33-34	82	1950-51	46
34-35	136	51-52	Less than 10
		52-53	Less than 10
1935-36	Less than 10	53-54	Less than 10
36-37	58	54-55	Less than 10
37-38	36		
38-39	129	1955-56	Less than 10
39-40	121	56-57	Less than 10
		57-58	Less than 10
1940-41	159		
41-42	242		
42-43	242		Average about 85
43-44	242		
44-45	181		

Predevelopment Surface Water Supply

William Ham Hall in "Irrigation in Southern California", dated 1888, reported surface flow from the area as 10 miners inches (under four-inch pressure) at West Cienaga and 38 to 40 miners inches at East Cienaga. He also reported a flow of 50 miners inches in San Fernando Creek located to the west of the study area. It is noted in this respect that precipitation was above normal during the mid and late 1880's. Since little or none of the flow of San Fernando Creek is thought to have originated as rising water in the study area, it was disregarded and the predevelopment surface supply is thus computed as 50 miners inches or about 725 acre-feet per annum.

Summary and Conclusions

The estimated maximum theoretical consumptive use of ground water with water levels assumed at maximum elevation 100 percent of the time, as determined by maximum zone of accumulation of $CaCO_3$ and from maximum historic water elevations, was about 1,600 acre-feet per year (see Tables L-18 and L-19). An average annual consumptive use of ground water under predevelopment conditions was estimated to be about 900 acre-feet (see Table L-20).

During the base period the rate of consumptive use of ground water from the moist area surrounding East Cienaga averaged about 85 acre-feet per year and since about 1951 has been negligible (see Table L-21). Insufficient data are available for water-table conditions in the moist area surrounding West Cienaga and no estimates were made for consumptive use of ground water occurring there during the base period.

To evaluate the effect of lowering the water table and the resulting decrease in consumptive use of ground water, it has been assumed that the ground water divide between East and West Cienagas located near Lake Street, as shown on Plate 7, is coincidental with the topographic divide. As previously stated, there are little data available on the moist area in the vicinity of West Cienaga and it is not known what effect, if any, pumping has had upon this area. Proceeding on this basis, the average annual predevelopment consumptive use of ground water was estimated for each area as set forth in Table L-20. The consumptive use so estimated averages about 700 acre-feet per year in the moist area surrounding East Cienaga and 200 acre-feet per year in the area surrounding West Cienaga. During the base period, consumptive use of ground water in the eastern area was reduced to an average of about 85 acre-feet per year and an unknown amount for the western area, for a reduction in consumptive use of ground water of about 615 acre-feet per year in the East Cienaga area. This figure is tenuous, but from the data available it is a good indication as to the reduction of consumptive use of ground water in the East Cienaga area.

In addition to the reduction in consumptive use of ground water, the minimum surface flow from East Cienaga has been eliminated. Since West Cienaga is inundated by San Fernando Reservoir, it is not possible to determine the reduction in surface flow, if any, since development of the area. Thus, the total reduction in water leaving the East Cienaga area as consumptive use of ground water and surface outflow during the base period, as compared to predevelopment conditions, is equal to the 615 acre-feet reduced consumptive use plus the surface outflow reduction of 40 inches or 580 acre-feet, comprising a total average annual reduction of about 1,195 acre-feet.

Consumptive Use of Ground Water

The consumptive use of ground water by riparian vegetation and in high ground water areas has been hereinbefore discussed and is summarized in Table L-22.

Evaporation From Water Surfaces

Evaporation from water surfaces consists of evaporation from the City of Los Angeles terminal storage reservoirs and the flood control storage reservoir located at Hansen Dam. Various types of evaporation pans are installed at the three principal reservoirs of the City of Los Angeles. San Fernando Reservoir is equipped with a U. S. Weather Bureau type pan; Chatsworth Reservoir with a Los Angeles County Flood Control District ground pan; and Encino Reservoir with a U. S. Weather Bureau type pan and a Los Angeles County Flood Control District ground pan. Records of evaporation from these pans extend from 1932 to the present and are published in the State of California Bulletin No. 54-A and 54-B, entitled "Evaporation from Water Surfaces in California - Basic Data" and the Los Angeles County Flood Control District's Annual and Biennial Reports on Hydrologic Data.

TABLE L-22

SUMMARY OF CONSUMPTIVE USE OF GROUND WATER

In Acre-Feet

Year	High Ground Water Areas		Riparian Vegetation	Total
	San Fernando Cienaga	Other areas		
1928-29	*	1,280	4,570	5,850
29-30	*	880	4,310	5,190
1930-31	60	240	4,050	4,350
31-32	60	1,870	3,620	5,550
32-33	260	350	4,030	4,640
33-34	80	530	3,920	4,530
34-35	140	1,640	3,850	5,630
1935-36	*	2,240	4,350	6,590
36-37	60	1,720	3,340	5,120
37-38	40	3,100	2,990	6,130
38-39	130	3,000	1,410	4,540
39-40	120	2,670	1,140	3,930
1940-41	160	4,720	440	5,320
41-42	240	7,640	1,290	9,170
42-43	240	10,370	830	11,440
43-44	240	11,520	840	12,600
44-45	180	2,270	1,190	3,640
1945-46	170	2,270	1,200	3,640
46-47	140	1,270	1,170	2,580
47-48	90	1,380	1,260	2,730
48-49	50	1,420	1,140	2,610
49-50	50	1,640	1,090	2,780
1950-51	50	1,680	1,160	2,890
51-52	*	2,340	570	2,910
52-53	*	2,140	960	3,100
53-54	*	1,220	880	2,100
54-55	*	1,030	890	1,920
1955-56	*	820	790	1,610
56-57	*	630	770	1,400
57-58	*	730	460	1,190
29-Year Average 1929-57				4,640

* Less than 10 acre-feet.

The pan evaporation for the U. S. Weather Bureau pan was reduced to an equivalent reservoir evaporation by a coefficient of 0.77, which is applicable to coastal areas in Southern California. With the Los Angeles County Flood Control District ground pan a coefficient of 0.81 was used for data prior to October 1, 1946 and a coefficient of 1.0 subsequent to that date, in accordance with studies made by the U. S. Department of Agriculture. The evaporation from the city's reservoir was thus computed based on these coefficients. The evaporation prior to 1932 was extrapolated based on the period for which data are available. Evaporation from the U. S. Weather Bureau type pan at Encino Reservoir was considered to be representative of evaporation from the water surface in San Fernando Valley. The mean annual U. S. Weather Bureau pan evaporation at Encino Reservoir for the period extending from 1932 to 1954 was 75.79 inches and equivalent to an evaporation of 58.3 inches from a water surface.

Precipitation on and total evaporation from water supply reservoirs is shown in Table M-1. The annual water surface evaporation from the flood control reservoir at Hansen Dam is based on the annual depth of evaporation for the water supply reservoirs. For the water supply reservoirs and for Hansen Dam it is assumed that the rain on the water surfaces is evaporated first. The difference between total evaporation and the evaporation of precipitation is considered to be evaporation of delivered water in the case of the water supply reservoirs and evaporation of runoff in the case of Hansen Dam. The total evaporation on water surface areas and the portions assigned to precipitation, delivered water and runoff are shown in Table L-22A.

TABLE L-22A

CONSUMPTIVE USE ON WATER SURFACE AREAS

In Acre-Feet

Year	Total evaporation (1)	Consumptive use of delivered water (water supply reservoirs) (2)	Consumptive use of precipitation (3)	Consumptive use of runoff (Hansen Dam) (4)
1928-29	5,270	4,390	880	0
29-30	5,351	4,410	940	0
1930-31	5,991	4,880	1,110	0
31-32	4,597	3,240	1,360	0
32-33	5,389	4,550	840	0
33-34	5,237	4,270	970	0
34-35	4,293	2,880	1,410	0
1935-36	4,830	3,840	990	0
36-37	4,698	2,990	1,710	0
37-38	4,501	2,840	1,660	0
38-39	4,938	3,520	1,420	0
39-40	4,801	3,650	1,150	0
1940-41	4,770	1,500	3,060	210
41-42	5,420	3,870	1,010	540
42-43	5,390	3,070	1,900	420
43-44	5,180	2,860	1,940	380
44-45	5,080	3,440	1,150	490
1945-46	5,210	3,590	1,110	510
46-47	5,390	3,670	1,210	510
47-48	5,680	4,440	610	630
48-49	5,360	4,080	700	580
49-50	5,280	3,750	970	560
1950-51	5,220	3,840	810	570
51-52	5,200	2,390	2,450	360
52-53	5,440	3,870	1,000	570
53-54	4,890	3,300	1,100	490
54-55	5,350	3,720	1,100	530
1955-56	4,630	2,740	1,500	390
56-57	5,290	3,700	1,060	530
57-58	5,490	2,650	2,390	450
29-Year Average 1929-57	5,130	3,560	1,280	290

(1) Evaporation in water surface reservoirs x $\frac{\text{area of water surface}}{\text{area water surface reservoirs}}$

(2) Table 35, Column 10

(3) Table M-1, Column 6 plus rain on Hansen

(4) Column 1 - (Columns 2 and 3)

Consumptive Use of Distribution Losses

Water system loss is defined as being made up of leaks and breaks in water mains, meter slippage and unmetered water. In addition it includes a portion of the water used for fire protection and construction. Most of the water system loss occurs under roadways within the root zone of trees planted in the parkways.

From the data collected in the residential lot survey, it was determined that approximately 15 percent of the impervious area within the right of way of the street is covered by the spreading branches of trees. Since consumptive use is a function of the projected area of foliage, it was assumed that the water available beneath this foliage was consumed by trees. It was therefore assumed that 20 percent of the distribution loss was consumed and the remaining 80 percent available for deep percolation.

Disposition of Water Delivered to the Hills

The exact disposition of water delivered to the hill and mountain areas cannot be determined for the base period because of the lack of culture data. The only adequate culture data available were collected by the Board's staff in 1958. The acreages for the culture classifications determined in 1958 are shown in Table L-23.

TABLE L-23

1958 AREAL CULTURE IN THE HILL AND MOUNTAIN AREAS
AND 29-YEAR MEAN WEIGHTED UNIT VALUES FOR
CONSUMPTIVE USE OF DELIVERED WATER

Land use classification	Acreage, in acres	29-year mean unit values, Table L-13
Residential	8,710	0.78
Commercial and industrial	440	0.92
Citrus	723	1.36
Lawn grass (parks and cemetery)	1,628	2.50

The 29-year mean weighted unit value for the consumptive use of delivered water on the valley floor for San Fernando Subarea was used to determine the consumptive use of delivered water in the hill and mountain areas. The 29-year mean weighted unit values for the land use classifications are shown in Table L-23. Applying these unit values to the areas determined in 1958 and the sewage contributed from residential areas as shown in Table N-9, the disposition of delivered water can be itemized and is shown in Table L-24.

TABLE L-24

DISPOSITION OF DELIVERED WATER TO THE HILL AND MOUNTAIN AREAS BASED ON 1958 CULTURE

In Acre-Feet

Residential	8,710 (acres) x 0.78	= 6,790
Commercial and industrial	440 (acres) x 0.92	= 400
Citrus	720 (acres) x 1.36	= 980
Lawn grass	1,630 (acres) x 2.50	= 4,080
Sewage (Table N-9, 1957-58)		= 6,550
	TOTAL	18,800 acre-feet
Estimated deliveries in 1957-58 to hill and mountain areas (Table J-13)		17,920

The total amount of water delivered to the hill and mountain areas in 1957-58 was 17,920 acre-feet as shown in Table J-13. The amount delivered is less than the estimated amount necessary to supply the consumptive use and sewage average requirements of the area based on unit values determined from studies made on the valley floor. This difference was expected since the mean rain in the hill and mountain areas is higher than on the valley floor. Since the above difference exists, the amount of deep percolation from delivered water to the hill and mountain areas is in all probability insignificant and may be assumed to be nil during 1958 and also during the 29-year base period.

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APPENDIX M

TRANSFERS OF IMPORTED WATER AND GROUND WATER WITHIN AND OUT OF UPPER LOS ANGELES RIVER AREA

APPENDIX M

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TRANSFERS OF IMPORTED WATER AND GROUND WATER
WITHIN AND OUT OF UPPER LOS ANGELES RIVER AREA

The sources of waters imported to the area of investigation are primarily the Owens and Colorado Rivers. Owens River water first reached San Fernando Reservoir in 1913 through the Los Angeles Aqueduct and was exported to the City of Los Angeles for use. However, it was not until 1915 and after the major San Fernando Valley annexations to the City of Los Angeles had been completed that Owens River water was delivered to customers in the Owens water service area.

Beginning in 1940, water distributed by The Metropolitan Water District from the Colorado River was made available to its members in the Upper Los Angeles River area. At the present time those members are the Cities of Burbank, Glendale and Los Angeles and the Foothill Municipal Water District which redistributes Colorado River water to the Crescenta Valley County Water District and the La Canada Irrigation District.

Determination of quantities of imported water delivered to each service area from each of the two sources of imported water are discussed herein. The extent of each service area is shown on Plate 19.

Owens River Water

The quantities of Owens River water imported into the area are measured at a current meter-rated gaging station in the Los Angeles Aqueduct below Dry Canyon Reservoir for the years preceding 1933. From 1933, the discharge measurements consist of the sum of the discharges through the

Penstock meter at the San Fernando Power Plant, the Maclay Highline meter and the San Fernando bypass. The latter is a current meter-rated gaging station, except for the years prior to 1942 when the flow was estimated. The terminal storage reservoirs for imported Owens River water are the San Fernando and Chatsworth Reservoirs (see Plate 21).

From San Fernando Reservoir, a portion of the Owens River water is exported out of the Upper Los Angeles River area to Franklin, Hollywood, Stone Canyon and Silverlake Reservoirs. The latter reservoir did not receive Owens River water until the completion of the River Supply Conduit Extension in 1949. The quantity of exported Owens River water is metered at the inlet to Franklin and Stone Canyon Reservoirs and at the North Hollywood Pumping Plant which discharges into Hollywood and Silverlake Reservoirs (see Plate 21).

The major portion of the Owens River water remaining in the Upper Los Angeles River area is delivered to the Owens service area with small amounts to the Mission Wells and Sunland-Tujunga water service areas to supplement the ground water supply to these areas. During the base period the average amount of Owens River water remaining in the City of Los Angeles west of Burbank was approximately 125,000 acre-feet per year.

An inventory of the Owens River water was made for the area within the City of Los Angeles west of Burbank. Metered amounts of the water were utilized wherever possible. Items included in the inventory are the amounts of import to the area and transfers therefrom, sales to the consumers, water spread in spreading grounds, change in surface storage, estimated amounts of rain on reservoirs, runoff into the reservoirs, evaporation, spillage and water used for the generation of electricity in the River Power Plant.

Determination of precipitation and runoff are discussed in Appendixes E and F, respectively. Evaporation from the surface of reservoirs was determined by the use of the U. S. Weather Bureau pan and the Los Angeles County Flood Control District's 24-inch evaporation pan located at the City's terminal reservoirs, when records were available, or estimated by extending these records through the use of percent of daylight hours and mean temperature when no evaporation measurements were available.

Water used in the River Power Plant was estimated using the operational records of the plant and the quantity of water necessary to produce the power delivered by the plant. The operation of this plant was discontinued in 1940. The amounts of water used by the River Power Plant are included under operational spills as is water discharged from Chatsworth Reservoir for collection at the headworks and blowoffs from mains. Most of the spilled water was reclaimed at the headworks infiltration gallery and was exported out of the Upper Los Angeles River area as extracted ground water.

Table M-1 is an inventory of the Owens River water in the City of Los Angeles west of Burbank. The difference between the supply and disposal is termed unaccounted-for water.

TABLE M-1

**INVENTORY OF OWENS RIVER WATER,
CITY OF LOS ANGELES WEST OF BURBANK**

In Acre-Feet

Year	Supply: Import (1)	Supply: Export (2)	Supply: Residual[a] (1)-(2)=(3)	Supply: Change in reservoir storage (4)	Supply: Runoff to reservoirs (5)	Supply: Rain on reservoirs (6)	Supply: Total (3)+(4)+(5)+(6)=(7)	Disposal: Operational releases[b] (8)	Disposal: Spread (9)	Disposal: Sales (10)	Disposal: Evaporation from reservoirs (11)	Disposal: Total (8)+(9)+(10)+(11)=(12)	Unaccounted-for water (7)-(12)=(13)
1928-29	190,103	87,558	102,545	- 2,222	100	880	105,750	8,254	590	93,100	5,270	107,210	- 1,460
29-30	198,127	89,058	109,069	- 2,985	10	940	113,000	11,483	0	95,900	5,351	112,730	+ 270
1930-31	215,747	88,032	127,715	10,563	20	1,110	118,280	4,678	7,280	92,070	5,991	110,020	+ 8,260
31-32	238,195	112,182	126,013	5,100	2,550	1,360	124,820	3,291	31,743	70,390	4,597	110,020	+14,800
32-33	228,432	110,801	117,631	140	280	840	118,610	1,924	33,429	74,300	5,389	115,040	+ 3,570
33-34	185,579	85,556	100,023	- 3,230	730	970	104,950	2,008	20,855	79,220	5,237	107,320	- 2,370
34-35	194,924	94,528	100,396	- 1,590	250	1,410	103,650	486	30,804	71,130	4,293	106,710	- 3,060
1935-36	236,945	108,405	128,540	5,240	620	990	124,910	556	22,716	93,310	4,830	121,410	+ 3,500
36-37	206,673	113,876	92,797	- 1,330	3,430	1,710	99,270	1,922	9,307	83,710	4,698	99,640	- 370
37-38	209,081	124,536	84,545	- 1,970	5,070	1,660	93,240	1,761	7,315	73,110	4,501	86,690	+ 6,550
38-39	237,254	135,185	102,069	170	1,030	1,420	104,350	3,420	14,911	80,330	4,938	103,600	+ 750
39-40	217,158	130,302	86,856	2,580	500	1,150	85,930	762	3,407	71,260	4,801	80,230	+ 5,700
1940-41	200,976	126,998	73,978	5,270	6,470	2,670	77,850	0	3,446	66,220	4,172	73,840	+ 4,010
41-42	246,350	134,598	111,752	- 5,160	650	870	118,430	6,268	11,290	86,640	4,739	108,940	+ 9,490
42-43	264,396	143,918	120,478	- 5,750	2,320	1,650	130,200	8,702	12,130	96,320	4,718	121,870	+ 8,330
43-44	274,495	159,386	115,109	5,630	1,710	1,680	112,870	2,862	3,191	93,950	4,536	104,540	+ 8,330
44-45	267,238	156,446	110,792	- 5,640	510	1,000	117,940	1,305	0	99,920	4,441	105,670	+12,270
1945-46	283,968	158,069	125,899	- 1,920	170	970	128,960	7,869	0	108,220	4,560	120,650	+ 8,310
46-47	291,015	157,808	133,207	- 890	190	1,050	135,340	7,683	1,687	111,060	4,720	125,150	+10,190
47-48	306,458	160,875	145,583	3,030	40	530	143,120	2,935	0	121,330	4,970	129,240	+13,880
48-49	298,462	161,860	136,602	- 5,169	0	610	142,380	1,463	0	125,890	4,690	132,040	+10,340
49-50	305,398	158,241	147,157	7,611	70	870	140,490	1,337	762	121,110	4,624	127,830	+12,660
1950-51	317,374	163,481	153,893	- 7,114	50	730	161,790	3,942	2,354	135,960	4,571	146,830	+14,960
51-52	316,568	174,591	141,977	1,947	1,940	2,160	144,130	2,834	7,281	120,700	4,548	135,360	+ 8,770
52-53	320,924	162,664	158,260	- 2,121	180	890	161,450	5,408	0	137,740	4,758	147,910	+13,540
53-54	318,589	165,406	153,183	- 1,893	150	980	156,210	3,176	0	133,430	4,283	140,890	+15,320
54-55	316,319	161,081	155,238	860	130	960	155,470	7,863	0	129,780	4,680	142,320	+13,150
1955-56	321,256	164,449	156,807	6,010	240	1,310	152,350	4,003	1,610	131,640	4,047	141,300	+11,050
56-57	318,389	159,729	158,660	- 5,714	100	930	165,400	1,565	0	148,760	4,630	154,960	+10,450
57-58	325,387	165,911	159,476	3,225	1,430	2,150	159,830	90	0	143,090	4,800	147,980	+11,850
29-Year Average 1929-57	259,530	136,190	123,340	- 20	1,020	1,180	125,560	3,780	7,800	101,600	4,740	117,930	+ 7,630

a. Owens River water remaining in the City of Los Angeles west of Burbank.
b. Include water used in the River Power Plant.

Imported Waters in the Narrows Area

The completion of the River Supply Conduit Extension to Silverlake Reservoir in 1949 enabled the City of Los Angeles to transport Owens River water to Silverlake Reservoir. Thereafter, Owens River and well waters were commingled at the North Hollywood Pumping Plant and in the River Supply Conduit Extension (see Plate 21 for location).

The source of supply to the Narrows area is from Silverlake and Eagle Rock Reservoirs. Eagle Rock Reservoir is the distribution reservoir for Colorado River water received from The Metropolitan Water District. Eagle Rock Reservoir distributes water to the Narrows service area and the area to the east which is outside of the Upper Los Angeles River area. Through the Eagle Rock-Hollywood conduit, Colorado River water may be transferred to Hollywood Reservoir.

The annual amounts of water delivered to the Narrows service area from 1928-29 through 1957-1958 were estimated from the totals taken from field meter reading books or "Read Books" of the City of Los Angeles Department of Water and Power for each consumer and from trunk line metered consumption. When a book extended outside the area of investigation, the total amount of water recorded in the book was proportioned according to the area in and out of the area of investigation.

An estimate of the amount of water from each source was made by assuming that all the water commingled and the water was distributed uniformly over the area. The amount of water from each source was determined by summing up the amount of water supplied to various service zones served by Silverlake and Eagle Rock Reservoirs. The percent of Colorado River water was found by determining the percent of the total water which is supplied from Eagle Rock Reservoir.

The amount of Colorado River water delivered to the Narrows service area was obtained by applying the percent of Colorado River water calculated for the above area to the water delivered to the Narrows service area. The remaining amount of water is supplied from Silverlake Reservoir and consists of Owens River and ground water.

The amount of Owens River and ground water from Silverlake Reservoir delivered to the Narrows service area was proportioned according to the percentage of the inflow of each supplied to the reservoir.

The annual quantities of Owens River import delivered to each service area are shown in Table M-2.

TABLE M-2

IMPORTED OWENS RIVER WATER*

In Acre-Feet

Year	San Fernando Subarea: Owens Service Area	San Fernando Subarea: Sunland-Tujunga Service Area	San Fernando Subarea: Mission Wells Service Area	San Fernando Subarea: Narrows Service Area	San Fernando Subarea: Total	Sylmar Subarea: Owens Service Area	Verdugo Subarea: Sunland-Tujunga Service Area	Total Upper Los Angeles River Area
1928-29	98,790	0	0	0	98,790	3,760	0	102,550
29-30	105,860	0	0	0	105,860	3,210	0	109,070
1930-31	124,710	0	0	0	124,710	3,010	0	127,720
31-32	123,520	0	0	0	123,520	2,490	0	126,010
32-33	114,240	0	0	0	114,240	3,390	0	117,630
33-34	97,040	0	0	0	97,040	2,980	0	100,020
34-35	97,440	0	0	0	97,440	2,960	0	100,400
1935-36	124,460	0	0	0	124,460	4,080	0	128,540
36-37	89,410	0	0	0	89,410	3,390	0	92,800
37-38	81,980	0	0	0	81,980	2,570	0	84,550
38-39	98,990	0	0	0	98,990	3,080	0	102,070
39-40	84,180	0	0	0	84,180	2,680	0	86,860
1940-41	71,180	0	0	0	71,180	2,800	0	73,980
41-42	108,160	0	0	0	108,160	3,590	0	111,750
42-43	116,100	0	0	0	116,100	4,380	0	120,480
43-44	110,580	0	0	0	110,580	4,530	0	115,110
44-45	106,000	0	0	0	106,000	4,790	0	110,790
1945-46	120,610	0	0	0	120,610	5,290	0	125,900
46-47	127,050	0	0	0	127,050	6,160	0	133,210
47-48	139,080	0	0	0	139,080	6,500	0	145,580
48-49	130,190	0	0	0	130,190	6,410	0	136,600
49-50	141,410	0	0	1,300	142,710	5,750	0	148,460
1950-51	146,820	570	430	2,160	149,980	5,990	80	156,050
51-52	136,430	380	0	2,460	139,270	5,120	50	144,440
52-53	149,650	1,590	650	2,270	154,160	6,150	220	160,530
53-54	145,800	1,340	510	1,520	149,170	5,350	180	154,700
54-55	147,710	1,080	650	1,590	151,030	5,650	150	156,830
1955-56	149,010	1,020	1,160	1,770	152,960	5,480	140	158,580
56-57	149,670	1,080	1,230	2,250	154,230	6,530	150	160,910
57-58	151,260	630	1,880	2,540	156,310	5,620	90	162,020

* Gross amounts delivered to valley fill area and tributary hill and mountain areas.

Colorado River Water

Colorado River water was made available to the Cities of Burbank, Glendale and Los Angeles in 1940. The City of Burbank made immediate use of this water to supplement its primary water supply. The City of Los Angeles commenced using Colorado River water in the area south of Glendale in 1945 with the City of Glendale following in 1946. Upon formation of the Foothill Municipal Water District, Colorado River water was delivered to the Crescenta Valley County Water District and the La Canada Irrigation District in 1951.

The amount of Colorado River water delivered to each city or district, with the exception of the Narrows service area, Crescenta Valley County Water District and the La Canada Irrigation District, was compiled from the records of The Metropolitan Water District of Southern California. For Crescenta Valley County Water District and the La Canada Irrigation District, the amounts of Colorado River water purchased by them from the Foothill Municipal Water District were utilized. The locations where these cities and districts connect into The Metropolitan Water District and the Foothill Municipal Water District distribution lines are shown on Plate 21. Annual amounts of Colorado River import delivered to each service area are shown on Table M-3. The method used to determine the amount delivered to the Narrows service area has been previously discussed.

TABLE M-3

IMPORTED COLORADO RIVER WATER*

In Acre-Feet

Year	Los Angeles Narrows Service Area (1)	City of Burbank Service Area (2)	City of Glendale Service Area: San Fernando Subarea (3)	City of Glendale Service Area: Verdugo Sub-area (4)	City of Glendale Service Area: Total (3)+(4)=(5)	La Canada Service Area (6)	Crescenta Valley County Water District Service Area (7)	Total: San Fernando Subarea (1)+(2)+(3)=(8)	Total: Verdugo Subarea (4)+(6)+(7)=(9)	Total: Upper Los Angeles River Area (8)+(9)=(10)
1939-40	0	70	0	0	0	0	0	70	0	70
1940-41	0	250	0	0	0	0	0	250	0	250
41-42	0	420	0	0	0	0	0	420	0	420
42-43	0	1,200	0	0	0	0	0	1,200	0	1,200
43-44	0	710	0	0	0	0	0	710	0	710
44-45	150	610	0	0	0	0	0	760	0	760
1945-46	870	1,070	270	0	270	0	0	2,210	0	2,210
46-47	1,270	2,200	1,000	0	1,000	0	0	4,470	0	4,470
47-48	1,330	700	510	0	510	0	0	2,540	0	2,540
48-49	1,340	330	60	0	60	0	0	1,730	0	1,730
49-50	480	210	270	0	270	0	0	960	0	960
1950-51	660	840	920	70	990	0	0	2,420	70	2,490
51-52	890	1,660	1,230	80	1,310	30	0	3,780	110	3,890
52-53	1,180	2,570	1,080	80	1,160	110	0	4,830	190	5,020
53-54	4,500	2,430	1,550	150	1,700	120	0	8,480	270	8,750
54-55	6,530	1,430	780	60	840	280	490	8,740	830	9,570
1955-56	5,190	1,700	1,960	310	2,270	510	890	8,850	1,710	10,560
56-57	6,370	3,070	2,050	350	2,400	400	1,010	11,490	1,760	13,250
57-58	7,050	3,320	1,260	350	1,610	450	620	11,630	1,420	13,050

* Gross delivered to valley fill and tributary hill and mountain areas within the service area.

Water Transfers Between Hydrologic Subareas and Tributary Areas

The various water service areas in the Upper Los Angeles River area do not correspond with the boundaries of the three hydrologic subareas. The amount of water transferred from one subarea to another for each service area, with the exception of the Mission Wells service area, was estimated as discussed hereafter. Water transfers involving only ground water extracted in one subarea and transferred to another subarea are shown on Table M-4. Imported Owens River and Colorado River water were assumed to be delivered to the subarea regardless of the actual location of the point of delivery of these waters. This assumption was made to facilitate the calculations in determining the transfer of imported waters between subareas. It is reasonable to assume that when imported waters are supplied at a point in the system that this mixture is uniform over the entire service area.

City of San Fernando Service Area

A major portion of the water extracted from the Sylmar Hydrologic Subarea is exported to the San Fernando Hydrologic Subarea. The City of San Fernando's wells are located in Sylmar Hydrologic Subarea, while 91 percent of the service area of that city is in San Fernando Subarea. No measurements are available of the amount of water delivered to each subarea. Accordingly, an estimate was made of the amount of water delivered to each subarea, based on the percentage of the areal extent of the City of San Fernando service area within each subarea.

TABLE M-4

TRANSFERS OF GROUND WATER EXTRACTIONS BETWEEN HYDROLOGIC SUBAREAS[a]

In Acre-Feet

Year	Transfers from Sylmar Subarea to San Fernando Subarea			Transfers from Verdugo Subarea to San Fernando Subarea	Transfers from San Fernando Subarea to Verdugo Subarea		
	Mission Wells[b]	City of San Fernando	Total	City of Glendale	Sunland-Tujunga[b]	City of Glendale	Total
1928-29	2,460	1,150	3,610	1,800[c]	100		100
29-30	2,080	1,150	3,230	1,800[c]	100		100
1930-31	1,500	1,150	2,650	1,840	100		100
31-32	1,170	1,170	2,340	1,520	100		100
32-33	560	1,160	1,720	1,050	100		100
33-34	1,270	1,200	2,470	780	110		110
34-35	2,040	1,090	3,130	920	90		90
1935-36	2,260	1,300	3,560	1,030	100		100
36-37	2,010	1,310	3,320	920	110		110
37-38	2,380	1,280	3,660	1,320	110		110
38-39	2,270	1,400	3,670	2,590	120		120
39-40	2,220	1,380	3,600	2,370	120		120
1940-41	2,700	1,380	4,080	3,090	120		120
41-42	2,430	1,580	4,010	3,110	140		140
42-43	2,230	1,700	3,930	2,990	170		170
43-44	2,500	1,630	4,130	3,250	170		170
44-45	2,540	1,700	4,240	2,940	180		180
1945-46	2,900	1,800	4,700	2,570	220		220
46-47	2,990	1,890	4,880	3,310	220		220
47-48	2,900	2,160	5,060	1,420	270		270
48-49	2,540	2,290	4,830	760	280		280
49-50	2,460	2,240	4,700	0	280	10	290
1950-51	2,170	2,420	4,590	0	210	1,280	1,490
51-52	2,320	2,020	4,340	0	100	940	1,040
52-53	2,440	2,010	4,450	0	100	1,260	1,360
53-54	2,160	2,430	4,590	0	90	1,630	1,720
54-55	2,190	2,260	4,450	0	100	1,290	1,390
1955-56	1,930	2,120	4,050	0	30	2,740	2,770
56-57	2,430	2,160	4,590	0	200	3,150	3,350
57-58	1,690	2,530	4,220	0	200	3,670	3,870

a. Includes hill and mountain areas within the service area.
b. Water service areas of City of Los Angeles
c. Estimated.

Mission Wells Service Area

The Mission Wells service area receives a major portion of its supply from the Mission Wells in Sylmar Hydrologic Subarea. The total amount extracted from this field is exported from Sylmar Subarea to the Mission Wells service area in San Fernando Hydrologic Subarea.

Sunland-Tujunga Service Area

The Sunland-Tujunga service area in Verdugo Hydrologic Subarea was treated similarly to the City of San Fernando service area. All of the water extracted or diverted by the City of Los Angeles is in the San Fernando Hydrologic Subarea. A small portion of the service area, representing 12 percent of the areal extent of the service area, is in the Verdugo Hydrologic Subarea. The quantity of water transferred from San Fernando Subarea to supply the demands of the portion of San Fernando service area in Verdugo Subarea was proportioned according to the percentage of the service area in Verdugo Subarea.

City of Glendale Service Area

The amounts of water transferred into and out of the Verdugo Hydrologic Subarea were estimated by assuming that all of the water originating in Verdugo Subarea first supplied the demands of that subarea based on the meter readings of various booster pumps in the system necessary to supply the area. Any surplus water was exported from that subarea to San Fernando Subarea to serve the remainder of the City of Glendale. Also when the demand for water exceeded the supply originating in Verdugo Subarea, water was transferred from San Fernando Subarea to supplement the Verdugo supply.

Transfers into and from the Verdugo Subarea, estimated on the above assumptions, are listed in Table M-5. The amount of Colorado River water imported into the Verdugo Hydrologic Subarea was proportioned according to the percent of water from this source to the total Glendale supply. The percentage of Colorado River water in the water transferred to Verdugo Subarea was assumed the same as in deliveries to the San Fernando Subarea, since the transfer is through the Glendale system wherein the two waters are commingled in that proportion.

Export of Ground Water

In addition to transfers of Owens River water by the City of Los Angeles, the ground water extracted from the River System wells of the City of Los Angeles is also exported to reservoirs outside of the Upper Los Angeles River area from which a portion returns to the Los Angeles Narrows area. The River System wells of the City of Los Angeles is comprised of the North Hollywood, Erwin, Whitnall, Verdugo, Deep Gallery, Headworks, Crystal Springs and the Pollock wells or well fields. The quantity of water extracted from this system is metered individually or as a well field and is shown in column 1 of Table M-6 as water transferred from the Upper Los Angeles River area.

The amount of the ground water thus transferred, which is returned for use in the City of Los Angeles Narrows water service area, has been estimated as discussed under Imported Waters in the Narrows Area, and the estimated amount is shown in column 2 of Table M-6.

Net export of ground water from the Upper Los Angeles River area has been computed as the difference between columns 1 and 2 of Table M-6 and is shown in column 3 of that table.

TABLE M-5

ESTIMATED TRANSFERS OF GROSS DELIVERED WATER BY THE CITY OF GLENDALE BETWEEN VERDUGO AND SAN FERNANDO SUBAREAS AND TRIBUTARY AREAS

In Acre-Feet

Year	Water demand in Verdugo	Supply originating in Verdugo	Amounts transferred		Colorado River water	
			Verdugo to San Fernando	San Fernando to Verdugo	Percent in transferred supply*	Transferred to Verdugo
1928-29		1,987	1,800			
29-30		2,134	1,800			
1930-31	639	2,480	1,841			
31-32	639	2,154	1,515			
32-33	730	1,781	1,051			
33-34	1,009	1,790	781			
34-35	900	1,824	924			
1935-36	1,025	2,059	1,034			
36-37	1,168	2,083	915			
37-38	1,186	2,507	1,321			
38-39	1,271	3,863	2,592			
39-40	1,481	3,850	2,369			
1940-41	1,306	4,399	3,093			
41-42	1,640	4,750	3,110			
42-43	1,721	4,712	2,991			
43-44	1,686	4,937	3,251			
44-45	1,836	4,778	2,942			
1945-46	2,152	4,723	2,571			
46-47	2,191	5,497	3,306			
47-48	2,151	3,575	1,424			
48-49	2,203	2,960	757			
49-50	2,338	2,333		5	1.7	1
1950-51	2,665	1,384		1,281	5.8	74
51-52	2,364	1,422		942	8.5	80
52-53	3,212	1,954		1,258	6.5	82
53-54	3,732	2,105		1,627	9.2	150
54-55	3,621	2,327		1,294	4.4	57
1955-56	4,669	1,930		2,739	11.2	307
56-57	4,814	1,667		3,147	11.1	349
57-58	5,596	1,929		3,667	9.4	345

* Percent of Colorado River water is the proportion of Colorado River water in transferred supply.

TABLE M-6

EXPORT OF GROUND WATER FROM UPPER LOS ANGELES RIVER AREA BY CITY OF LOS ANGELES[a]

In Acre-Feet

Year	Transfer of ground water from Upper Los Angeles River area	Ground water returned to Upper Los Angeles River area[b]	Net export of ground water from Upper Los Angeles River area
1928-29	61,220	6,410	54,810
29-30	63,680	6,490	57,190
1930-31	66,480	7,090	59,390
31-32	40,730	6,510	34,220
32-33	38,330	6,420	31,910
33-34	60,780	6,720	54,060
34-35	48,860	6,040	42,820
1935-36	55,660	6,150	49,510
36-37	50,700	6,430	44,270
37-38	45,420	6,870	38,550
38-39	43,800	7,540	36,260
39-40	45,070	7,210	37,860
1940-41	47,560	6,860	40,700
41-42	41,680	8,350	33,330
42-43	52,500	8,570	43,930
43-44	56,030	8,730	47,300
44-45	70,740	8,840	61,900
1945-46	77,070	9,040	68,030
46-47	82,210	9,040	73,170
47-48	76,990	9,180	67,810
48-49	76,160	9,270	66,890
49-50	81,610	8,870	72,740
1950-51	74,600	8,220	66,380
51-52	70,720	7,680	63,040
52-53	90,400	8,420	81,980
53-54	89,160	5,650	83,510
54-55	83,140	2,970	80,170
1955-56	87,910	3,910	84,000
56-57	93,630	2,880	90,750
57-58	84,320	1,040	83,280

a. Gross amounts.
b. To Narrows service area.

Export and Import of Water by La Canada Irrigation District

The La Canada Irrigation District transferred water out of and into the Upper Los Angeles River area due to the location of their water service area (see Plate 19). A portion of their water supply is obtained from surface diversions and a well in Verdugo Subarea. Their remaining supply is obtained from sources outside the area of investigation from ground water and the Foothill Municipal Water District.

An estimate of the amounts of water exported and imported from the Upper Los Angeles River area was determined by estimating the amount of water necessary to supply the portion of the service area in the Upper Los Angeles River area. Of their total service area, 42 percent of the areal extent of the district is in the Upper Los Angeles River area. This percentage was applied to the total water supply of the district and was assumed to be the demand of the service area in the Upper Los Angeles River area.

The portion of the district's water supply obtained in Verdugo Subarea was assumed to first supply the demand of the area and any amount in excess was exported out of the area of investigation. Conversely, water was imported when the demand was greater than the supply.

Table M-7 is an estimate of the amount of water exported and imported by the La Canada Irrigation District based on the above assumptions.

TABLE M-7

ESTIMATE OF GROSS DELIVERED WATER EXPORTED AND IMPORTED FROM THE UPPER LOS ANGELES RIVER AREA BY LA CANADA IRRIGATION DISTRICT

In Acre-Feet

Year	Total supply of District	Water requirements in Upper Los Angeles River area	Water supplied from Upper Los Angeles River area	Export	Import
1928-29	339	142	160	18	
29-30	361	152	227	75	
1930-31	353	148	217	69	
31-32	353	148	245	97	
32-33	350	147	246	99	
33-34	349	147	223	76	
34-35	277	116	199	83	
1935-36	389	163	256	93	
36-37	373	157	320	163	
37-38	421	177	391	214	
38-39	498	209	437	228	
39-40	473	199	424	225	
1940-41	499	210	476	266	
41-42	577	242	540	298	
42-43	661	278	619	341	
43-44	701	294	636	342	
44-45	647	272	567	295	
1945-46	844	354	559	205	
46-47	897	377	655	278	
47-48	1,023	430	712	282	
48-49	1,118	470	661	191	
49-50	1,191	500	554	54	
1950-51	1,310	550	469		81
51-52	1,362	572	545		27*
52-53	1,714	720	614		106*
53-54	1,802	757	633		124*
54-55	1,739	730	449		281*
1955-56	1,881	790	279		511*
56-57	1,997	839	435		404*
57-58	1,898	797	352		445*

* Imported Colorado River water purchased from Foothill Municipal Water District.

APPENDIX N

SEWAGE EXPORT, CESSPOOL RECHARGE AND WASTE DISCHARGE

APPENDIX N

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SEWAGE EXPORT, CESSPOOL RECHARGE AND WASTE DISCHARGE

History of Sewerage Systems

All of the sewage exported out of the area of investigation is conveyed through the City of Los Angeles sewerage system. Sewage treatment and disposal for the Cities of Burbank, Glendale and San Fernando is furnished by the City of Los Angeles through a contractual agreements. The North Outfall Sewer was the first trunk sewer constructed to convey sewage out of the Upper Los Angeles River area and was placed in operation in 1926. Its general alignment is shown on Plate 26. Areas sewered prior to the base period include portions of the Cities of Los Angeles south of Glendale, Burbank, Glendale and San Fernando.

The City of San Fernando, prior to 1952, maintained its own sewage treatment plant and discharged the effluent into Pacoima Wash. Since 1952, that city's sewage has been transported through the City of Los Angeles sewerage system and exported out of the area of investigation.

The City of Los Angeles west of Burbank did not have sewers installed until 1929. The rapid growth of this area soon caused the capacity of the North Outfall Sewer to be exceeded. Spot measurements made by the State Department of Public Health indicate that the North Outfall Sewer was overflowing into the Los Angeles River at various locations in 1952 and 1953. In 1954 the Valley Settling Basin was installed on the south bank of the Los Angeles River south of the City of Burbank. Its purpose was to store the peak flow until such time as it could be discharged back into the trunk sewer without exceeding the capacity of the sewer. On brief occasions when the capacity of the trunk sewer and the Valley Settling Basin were both exceeded, stored sewage was chlorinated and discharged into the Los Angeles River. The estimated amounts of sewage overflowing into the Los Angeles River during 1952-53 and 1953-54 and the measured amounts of sewage discharged from the Valley Settling Basin from 1954-55 through 1957-58 are listed in Table N-7.

In 1956, the San Fernando Valley Relief Sewer (see Plate 26) was constructed through the Santa Monica Mountains to intercept sewage originating west of the City of Burbank. No provision has been made for measurement of sewage through this sewer.

Source of Sewage Records

Sewage gaging stations, the locations of which are shown on Plate 26, are installed at strategic points for the purpose of determining the amount of sewage contributed to the City of Los Angeles sewerage system by the Cities of Burbank, Glendale and San Fernando. Whenever possible, the Referee determined the amount of sewage contributed by each city from measurements made at these gaging stations. The measurements at these gaging stations are from continuous recording devices which are in operation for a period of one week during the middle part of each month. By mutual agreement between the cities these measurements are accepted as being the average weekly flow for the month and billings for the cost of treating this sewage are based on these measurements. The period of record and source of data on sewage contributed to the City of Los Angeles sewerage system are shown in Table N-1.

TABLE N-1

RECORDS ON SEWAGE CONTRIBUTED
BY MUNICIPALITIES TO CITY OF LOS ANGELES
SEWERAGE SYSTEM

City	Period of record	Source
Burbank	October 1928-September 1958	Gaging charts and billings
Glendale	October 1928-September 1958	Billings
Los Angeles		
Upper Burbank gage	July 1930-March 1956	Gaging charts and billings
4th and Hubbard Streets gage	October 1930-September 1958	Billings
San Fernando Road and 4th Street gage	July 1958-September 1958	Billings
San Fernando	October 1930-September 1958	Billings
Valley Settling Basin (inflow)	September 1954-September 1958	Daily operational records
Discharges to Los Angeles River	September 1954-September 1958	Daily operational records

The amount of sewage exported from the City of Los Angeles west of Burbank prior to June 1956 was obtained from the records of the Upper Burbank sewage gaging station located west of the westerly city boundary of Burbank. After completion of the San Fernando Valley Relief Sewer Tunnel in June 1956, the sewage contributed by the City of Los Angeles west of Burbank was estimated as the number of sewer house connections multiplied by the expected sewage discharge per house connection. The number of sewer house connections was tabulated from sewer permits issued by the City of Los Angeles Valley District office. The mean sewage discharge per house connection (Table N-2) for each year of record, 1930-31 through 1954-55, was calculated by dividing the annual measured sewage originating in the area by the number of sewer house connections in service. The average sewage per sewer house connection computed for the period during which records were considered accurate, 1935-36 through 1954-55, was 0.30 acre-foot. This mean value, which appears reasonable when compared with the trend of values during the 1950's, was utilized as the expected sewage per house connection in the City of Los Angeles west of Burbank for the period after June 1956.

There are no records of sewage flow originating from the City of Los Angeles south of Glendale. Sewage from this area, which has been almost completely sewered since 1926, was estimated from a count of the number of sewer house connections shown on the City of Los Angeles "Y" maps for the area. The number of sewer house connections was enumerated for every five years within the base period and a straight line variation was used for the intervening years. The annual unit sewage flows per sewer house connection derived from the area west of the City of Burbank, discussed below, were utilized to estimate the sewage from this area.

The annual amounts of sewage exported from the Upper Los Angeles River area, based on measured and estimated values thus determined, are shown in Table N-7.

Annual Unit Sewage Flows

The City of Los Angeles west of Burbank was used as a study area to determine annual unit sewage discharge per house connection. This area contains a major portion of the area of investigation and receives a large amount of delivered water. The percentage of commercial development is relatively low in the area; thus, the unit values derived are believed applicable to sewage contributions from residential areas in all portions of the area of investigation.

Flow in a sewerage system originates generally from two main sources: (1) sanitary and industrial waste and (2) infiltration into the sewers from surface and ground waters. To separate the sewage flows as to each source, the amount of sewage discharged per house connection for each year was calculated for the study area by dividing the annual measured sewage discharge by the number of sewer house connections in service during the year. These annual values are shown in Table N-2 and plotted on Figure N-1. The wide range in values for the measured sewage per house connection occurred in the study area ranging from 0.17 acre-foot in 1933-34 to 0.47 acre-foot in 1943-44. The amount of water delivered per meter for domestic, combination and commercial and industrial meters was

TABLE N-2

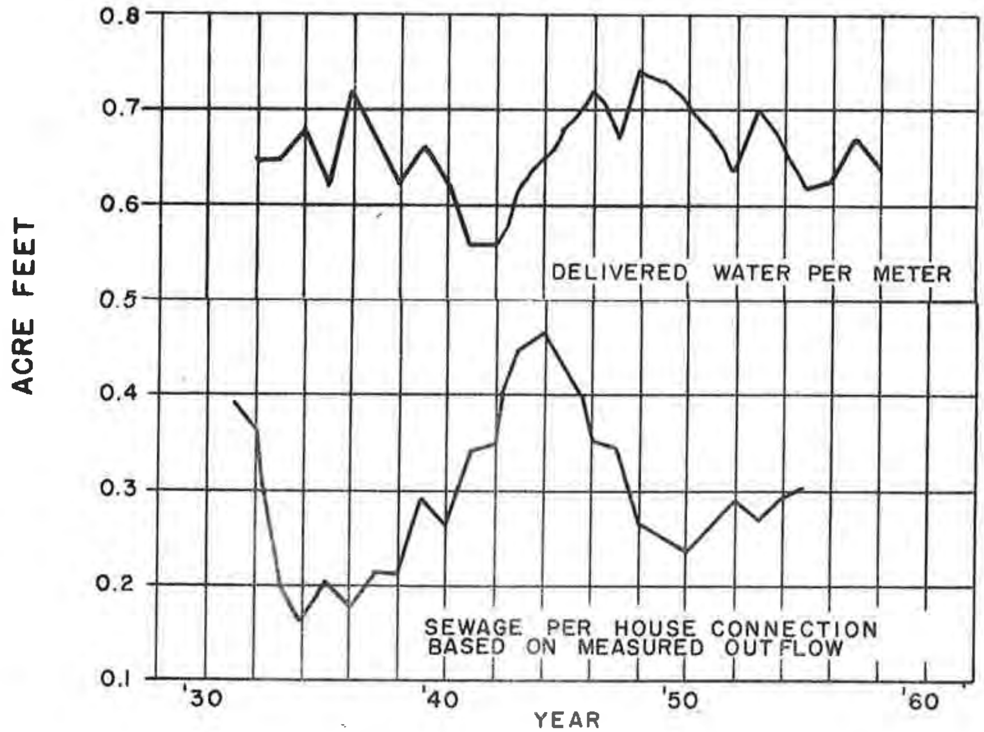
COMPARISON OF UNIT SEWAGE AND WATER DELIVERIES,
CITY OF LOS ANGELES WEST OF BURBANK

Year	Measured sewage per house connection, in acre-feet	Per capita delivered water, in gallons per capita day	Estimated sewage per house connection, in acre-feet
1928-29		94	0.17
29-30		93	0.17
1930-31	0.33	83	0.17
31-32	0.35	77	0.17
32-33	0.20	72	0.17
33-34	0.17	69	0.17
34-35	0.20	61	0.17
1935-36	0.18	68	0.17
36-37	0.21	70	0.18
37-38	0.21	79	0.18
38-39	0.29	90	0.18
39-40	0.27	93	0.18
1940-41	0.35	96	0.18
41-42	0.36	109	0.18
42-43	0.46	121	0.18
43-44	0.47	117	0.19
44-45	0.43	117	0.20
1945-46	0.35	125	0.20
46-47	0.34	125	0.21
47-48	0.26	127	0.21
48-49	0.24	131	0.21
49-50	0.23	126	0.22
1950-51	0.25	133	0.23
51-52	0.27	134	0.24
52-53	0.25	143	0.24
53-54	0.27	145	0.25
54-55	0.28	139	0.26
1955-56		139	0.27
56-57		150	0.27
57-58		142	0.28
29-year average 1929-57		108	0.20

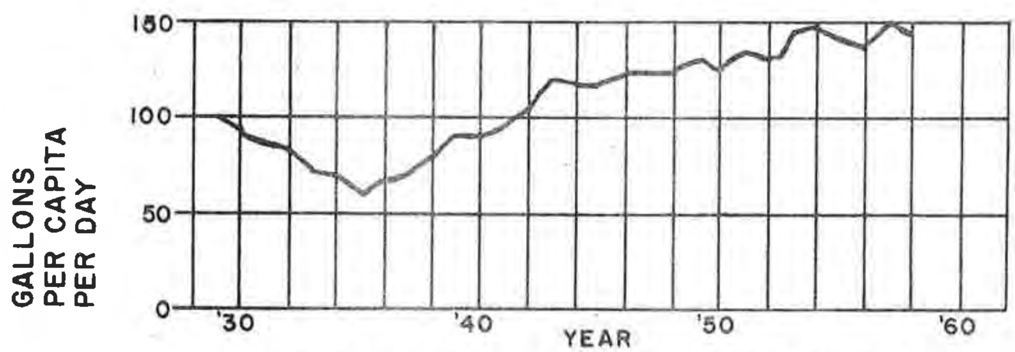
also computed for the study area. The trends of the annual sewage discharge per house connection and delivered water per meter did not correspond with each other. Analysis of the data indicated that a large amount of water from combination meters was used for irrigation purposes. To adjust for this difference, only water delivered to domestic meters was utilized in computing the per capita delivered water.

The population in the study area, as discussed in Appendix L, was utilized in determining the per capita delivery of water. It was assumed that the number of persons per meter was the same for both domestic and combination services. The annual population for the study area was derived from census values and was proportioned according to the percentage of domestic and combination meters in service for each year. The estimated annual population using domestic meters was divided into the amounts of water delivered to these meters to determine the per capita delivered water. The annual per capita delivered water thus computed is shown in Table N-2 and shown graphically on Figure N-1.

Comparison of the delivered water per meter curve (Figure N-1) with sewage flow per house connection curve (Figure N-1) for the City of Los Angeles west of Burbank shows that these two curves do not have the same long-time trend as expected, since an increase in water consumption should have a direct effect on sewage discharges. During the period of higher water levels the two curves have dissimilar short-time trends. Since infiltration is a source of flow in a sewer main, the water levels in the sewered area were compared with the annual sewage flow per house connection (Figure N-2). The records of water levels in well No. 3770



DELIVERED WATER AND SEWAGE



ESTIMATED DELIVERED WATER PER CAPITA

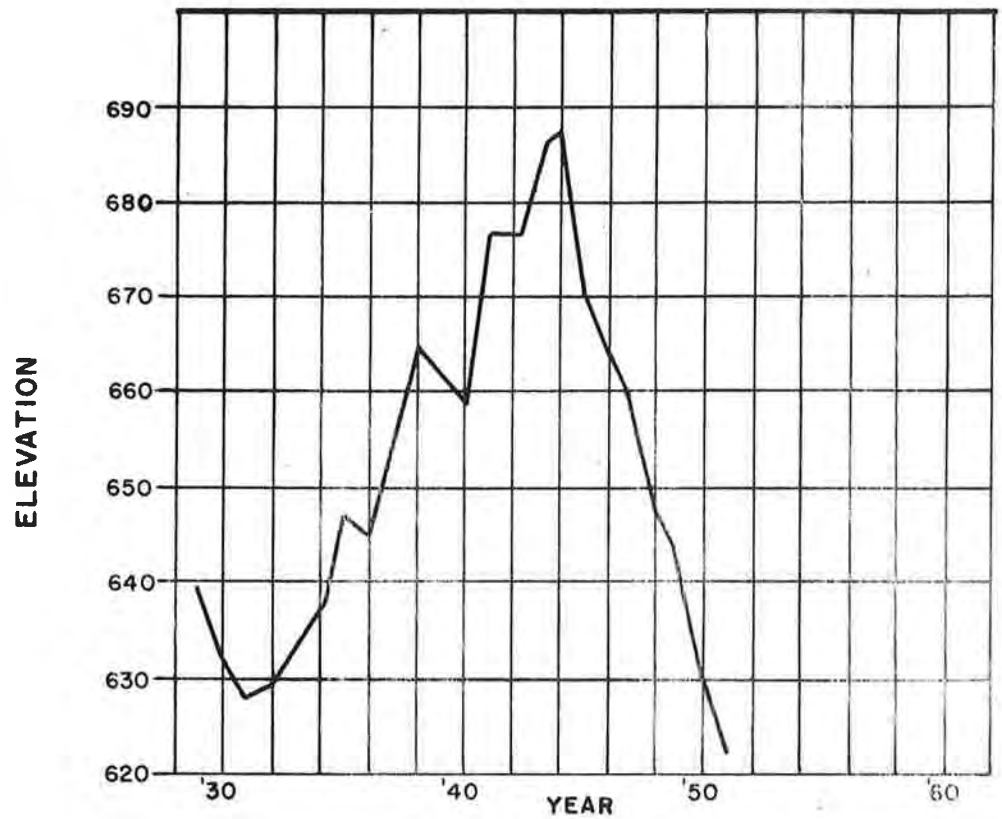
SAN FERNANDO VALLEY REFERENCE

TRENDS OF DELIVERED WATER AND SEWAGE, CITY OF LOS ANGELES WEST OF BURBANK

STATE WATER RIGHTS BOARD

(Figure N-2) in the vicinity of Van Nuys were utilized for this purpose. Comparing the water level measurements and the annual sewage flow per house connection, it is apparent that the variation in unit sewage flows from 1933-34 to 1949-50 corresponds to the fluctuations of water levels. A sharp increase in the annual unit sewage discharge from 1937 to 1944 occurred concurrently with increasing ground water levels, and the recession of water levels was accompanied by a similar reduction in unit sewage discharges. This relationship, combined with the fact that certain reaches of the sewer trunk invert were below the water table during the period of high ground water elevations, leads to the conclusion that the higher unit values were caused by the infiltration of ground water into the sewerage system.

The contribution of ground water to sewage by infiltration was estimated by using the per capita delivered water as an indication of the increase in both the residential use within the home and the resulting increase in the annual unit sewage per house connection during the base period. On this basis, the annual unit value for sewage per house connection was a minimum in 1935 and gradually increased thereafter to the end of the base period. The amount that the measured unit value of sewage discharge exceeded the estimated value was assumed to be the amount contributed by infiltration. The portion of the sewage which is derived from delivered water was estimated by multiplying the estimated sewage flow per house connection in acre-feet by the number of existing sewer house connections. The difference between the calculated and the measured sewage export was assumed to have originated from ground water infiltrated



SAN FERNANDO VALLEY REFERENCE

WATER LEVEL WELL 3770

STATE WATER RIGHTS BOARD

into the sewers. Table N-2 summarizes the annual measured and estimated sewage per house connection and the adjusted per capita delivered water for the City of Los Angeles west of Burbank.

The annual measured unit sewage flow per sewer house connection for the Cities of Burbank and Glendale is somewhat higher than that found in the City of Los Angeles west of Burbank. The data shown in Table N-3 and on Figure N-3 illustrate this relationship. The measured unit sewage value prior to 1944-45 for the City of Burbank is high as a result of industrial wastes being discharged into the sanitary sewers. This problem was recognized by the City of Burbank when the total annual amount of sewage being discharged was exceeding the contracted amount for sewage treatment with the City of Los Angeles. An industrial waste program was initiated to remove a large amount of industrial waste from the sanitary sewers into the storm drain after proper treatment. This effect was evaluated by comparing the City of Burbank's delivered water with the resulting sewage. Since 1937 residential, commercial and industrial meters in the Burbank system have been billed separately. Water delivered to industrial meters constitutes, on the average, approximately 20 percent of the total delivered water in the City of Burbank. An estimate of industrial sewage was made by deducting the consumptive use for industrial (see Appendix L) from the amount of industrial delivered water. The total sewage discharge was then adjusted for the above amount and the annual unit sewage discharge per house connection recalculated. The adjusted unit values for residential sewage thus computed were found to be

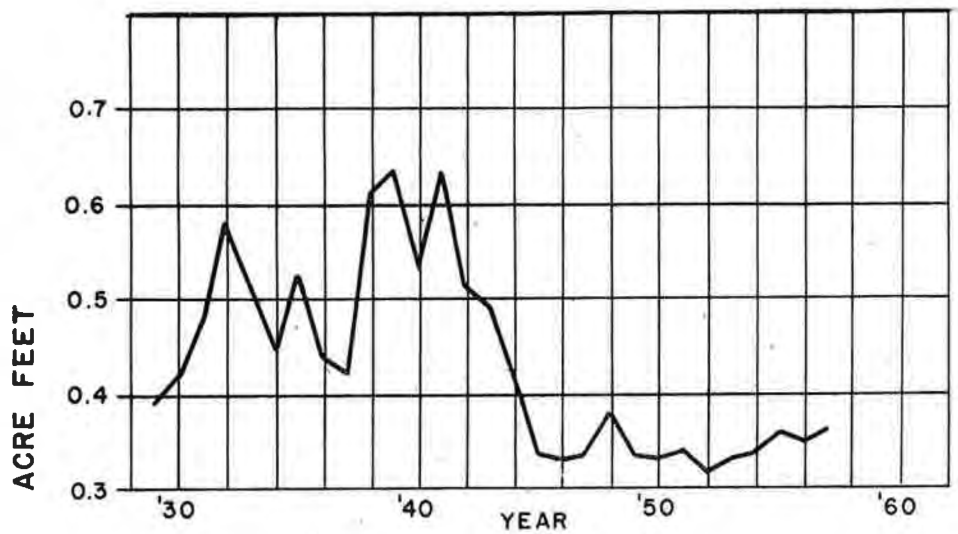
TABLE N-3

SUMMARY OF ANNUAL SEWAGE DISCHARGE
PER HOUSE CONNECTION

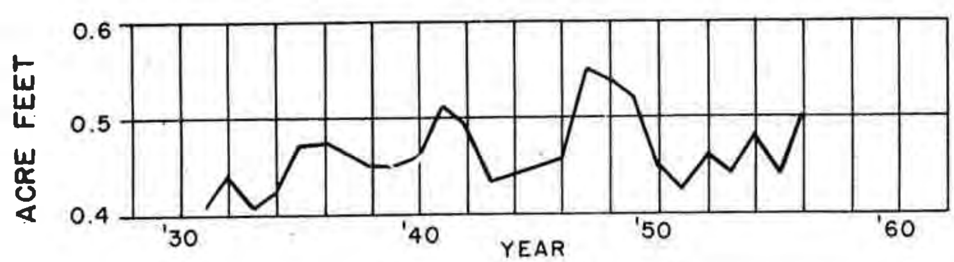
In Acre-Feet

Year	City of Los Angeles west of Burbank	City of Glendale		City of Burbank	
	Measured[a]	Measured[a]	Adjusted	Measured[a]	Adjusted
1928-29				0.39	
29-30				0.42	
1930-31	0.33	0.41		0.48	
31-32	0.35	0.44		0.58	
32-33	0.20	0.41		0.51	
33-34	0.17	0.42		0.45	
34-35	0.20	0.48		0.53	
1935-36	0.18	0.48		0.49	
36-37	0.21	0.46		0.47	
37-38	0.21	0.45	0.36	0.62	0.57
38-39	0.29	0.45	0.38	0.64	0.58
39-40	0.27	0.46	0.39	0.53	0.47
1940-41	0.35	0.51	0.44	0.64	0.55
41-42	0.36	0.49	0.42	0.51	0.39
42-43	0.46	0.43	0.36	0.49	0.35
43-44	0.47	0.44	0.38	0.42	0.30
44-45	0.43	0.45	0.36	0.35	0.25
1945-46	0.35	0.46	0.34	0.33	0.27
46-47	0.34	0.54	0.40	0.34	0.29
47-48	0.26	0.53	0.41	0.38	0.34
48-49	0.24	0.51	0.37	0.34	0.30
49-50	0.23	0.45	0.35	0.33	0.29
1950-51	0.25	0.42	0.30	0.34	0.29
51-52	0.27	0.46	0.36	0.32	0.27
52-53	0.25	0.44	0.32	0.33	0.27
53-54	0.27	0.48	0.33	0.35	0.29
54-55	0.28	0.44	0.30	0.36	0.31
1955-56		0.50		0.35	
56-57		0.48		0.36	
57-58		0.55		0.36	
18-year average 1938-55	0.31	0.47	0.36	0.42	0.35

a. Based on gaged sewage outflows.



CITY OF BURBANK



CITY OF GLENDALE

SAN FERNANDO VALLEY REFERENCE

SEWAGE FLOW PER HOUSE CONNECTION

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comparable to the values for the City of Los Angeles west of Burbank for the same period from 1937-38 through 1954-55.

In addition to the large amount of industrial waste being discharged into the sewers, ground and surface water contribute to the measured sewage from the City of Burbank. Sewer gaging stations are located along the north side of the Los Angeles River at the westerly and easterly boundaries of the city (see Plate 26). The period when the annual measured unit sewage values were high corresponds with the period when the water table was at an elevation equal to or above the invert of the trunk sewer line, making it possible for ground water to enter the sewer.

Annual measured unit sewage values for the City of Glendale were also larger than those of the study area. It was found that a large number of sewer flushing manholes had been installed in the city's sewerage system. These manholes were connected to the water mains with no means of measuring the amount of water used for flushing the sewers. Due to the lack of proper maintainence, flushing devices were soon flowing continuously thus increasing the amount of sewage discharged by the city. In 1957, the City of Glendale commenced removing the water connections from their flushing manholes. A rapid decrease in the water system losses became apparent. In 1954-55, the City of Glendale's water system loss was 25.3 percent. By 1958-59, the water system loss had been reduced to 7.2 percent. The reduction in percent of water system loss between 1955-56 and 1958-59, if considered as being caused entirely by faulty flushing devices, amounted to approximately 0.1 acre-foot per sewer house connection. An evaluation of the amount of flushing water entering the sewers is contained in the section on infiltration.

Unit sewage discharge values for the Cities of Burbank and Glendale, as measured and adjusted by removing industrial waste and flushing water amounts, are listed in Table N-3 for comparison purposes. For the 18-year period, 1937-38 through 1954-55, the average adjusted sewage discharge per house connection for the Cities of Burbank and Glendale agreed fairly well with the average value for the City of Los Angeles west of Burbank for the same period. This indicates that the values of unit domestic sewage contribution derived for the City of Los Angeles west of Burbank are comparable and may be utilized in determining the sewage contribution from residential areas.

Delivered Water and Sewage

The amount of sewage originating from delivered water may be estimated by assuming that none of the water delivered during months of prolonged rainfall is used outside for irrigation on lawns and gardens; thus, except for a small amount of water consumed by use within the household, the remaining water becomes sewage during these months.

Listed in Table N-4 are the amounts of water delivered to residential and commercial meters in the City of Los Angeles west of Burbank during months in which large amounts of precipitation have occurred over prolonged periods. Assuming that all of the water delivered during these months becomes sewage, the extension of this amount over a 12-month period (see line 6, Table N-4) results in the annual amount of sewage contributed. A comparison of actual total annual deliveries shown in line 7 of Table N-4

TABLE N-4

ESTIMATED PERCENT SEWAGE RESULTING FROM
USE OF WATER BY RESIDENTIAL AND COMMERCIAL AREAS
IN CITY OF LOS ANGELES WEST OF BURBANK

Item	Month						Mean
	February 1938	February 1941	March 1941	March 1943	February 1944	January 1952	
1. Precipitation (Rainfall Station No. 15) inches	8.95	11.25	11.41	4.10	10.94	12.97	
2. Number of water meters in thousands	24.71	34.13	34.13	39.82	40.96	110.65	
3. Water delivered, million cubic feet	20.82	28.42	30.61	37.67	40.22	122.92	
4. Water delivered, gallons per day per meter[a]	226	223	217	229	253	269	236
5. Water delivered, gallons per day per capita[b] equals estimated sewage, per day per capita	61	60	59	62	68	73	63
6. Estimated annual sewage,[c] acre-feet	5,735	7,828	8,432	10,376	11,079	33,861	
7. Total annual delivered water,[d] acre-feet	13,416	17,798	17,798	22,828	25,428	68,880	
8. Estimated sewage as percent of annual delivery = $\frac{(6)}{(7)} \times 100$	43	44	47	44	44	49	45

a. Gallons per day per meter equals (3) x 7.48 ÷ (2) x days in month.
b. Based on 3.7 persons per meter from population census and number of meters.
c. Estimated annual sewage is based on estimated sewage per day during wet months extended to 12-month period.
d. Annual metered amount.

and the estimated sewage for the year indicates that an average of 45 percent of the annual delivered water becomes sewage.

For comparison, during this period there was an average of 3.7 persons per residential water meter, as determined from data supplied by the United States Bureau of the Census. Based on the above criteria, the amount of sewage contributed from each person was 63 gallons per capita per day, or 0.26 acre-foot per year per meter. Increased sewage during the warmer summer months is believed countered by a decrease resulting from other factors such as vacancies during the summer period; thus, the 45 percent value was taken as representative of the average annual proportion of sewage to water delivered for an average residential lot.

Where the number of meters or consumers is unknown, an estimate of the amount of sewage originating from such an area was computed by multiplying the annual net residential and commercial delivered water to the area by 45 percent.

Cesspool Recharge

Individual sewage disposal units are scattered throughout the area of investigation. The number of these units in operation for any year must be estimated. The existence of a sewer line in an area does not necessarily imply that all the homes are connected to the sewer, since under present city and county ordinances the property owner is not required to connect to a sewer line to which he has access until his sewage disposal unit fails to function properly. Depending on the type of soil and the amount of sewage discharged, the sewage disposal unit may function properly indefinitely.

The number of individual sewage disposal units was estimated by calculating the difference between the number of consumer's water meters and the number of sewer house connections. These data were obtained from the various cities and agencies involved in this investigation. It was assumed that for every water meter there would be a connection draining the waste products into a sewer or an individual sewage disposal unit. With the number of individual sewage disposal units thus determined, an estimate of the amount of sewage was determined by multiplying the estimated annual unit sewage per house connection for each year, shown in Table N-2, by the number of individual sewage disposal units estimated to be in operation during the year.

When an area is partly sewered or contains individual sewage disposal units, the total amount of sewage is computed as 45 percent of the net residential and commercial delivered water. The amount of cesspool recharge from a partially sewered area was determined by proportioning the total sewage in the area according to the percentage of the areal extent sewered and unsewered. This method was utilized to determine the sewage originating in the Sylmar and Verdugo Hydrologic Subareas and the Mission Wells and Sunland-Tujunga water service areas. If measurements of the sewage discharge into a sewerage system were available, the amount measured was subtracted from the total amount of sewage originating in the area and the remainder was assumed to be cesspool recharge.

Effluent from sewage disposal units is usually discharged into a cesspool or leaching field. The effluent from cesspools is usually discharged at a depth that is below the root zone of most vegetation and becomes recharge to the ground water. Leaching fields are usually shallow and the effluent may be available for consumptive use by the vegetation on the surface. The number of disposal units using leaching fields in the area of investigation cannot be determined, but it is believed that due to the limited size of the residential lots in the area of investigation only a small number of leaching fields exist.

The annual amounts of cesspool recharge determined for each water service area and for each hydrologic subarea are listed in Table N-7, as hereinbefore discussed.

Infiltration and Sewer Flushing Water

Infiltration is water entering the sewer either through its joints, abandoned house connections, or manholes. Sewer flushing water is unmetered delivered water entering sewer lines of the City of Glendale through faulty flushing devices. Due to the limitations in construction, sewers are seldom laid with a watertight joint. If the sewers are laid below the ground water level a certain amount of ground water will enter through the joints or from poorly made and abandoned house connections. No attempt by the Referee or other agencies has been made to measure the amount of infiltration entering the sewers in the area of investigation. An estimate of the amount of sewer infiltration in the Burbank sewerage system and the amounts of infiltration and sewer flushing water in the Glendale system were determined in the same manner as for the City of Los Angeles west of Burbank, which has been discussed heretofore. The average unit sewage value per house connection thus determined for the Cities of Burbank and Glendale was 0.35 and 0.36 acre-foot per house connection, respectively. The difference between these average unit sewage values and the measured annual unit sewage values was assumed to be infiltration and sewer flushing water.

The amount of unmetered delivered water discharged into the City of Glendale's sewers constitutes a portion of the city's water system loss. The amounts of these discharges were required in the disposition of water system losses in the area of investigation. A comparison of the water distribution systems of the Cities of Burbank and Glendale indicates that the two systems are comparable and that the water system losses should be approximately the same for the two systems. This was demonstrated when the City of Glendale commenced removing the faulty flushing devices and the water system loss decreased to 7.2 percent in 1958-59. It was therefore assumed that an average water system loss over the base period of seven percent, which is equivalent to the City of Burbank loss, would have resulted if the flushing manhole mechanism had been properly maintained.

The annual amount of water discharged into the sewers was estimated as the difference between the actual water system loss and the average water system loss of seven percent of the gross delivered. If this difference was greater than the calculated amount of infiltration plus flushing water, the latter amount was taken and assumed to consist of sewer flushing water. Conversely, when the estimated amount of sewer flushing water was less than the calculated infiltration plus flushing water, it was assumed that the difference was contributed from the ground water infiltrating the sewers. Table N-5 shows the estimated amounts of infiltration entering the sewers, based on the preceding discussion.

The occurrence of ground water entering the sewers is dependent on the elevation water table. After 1952, the possibility of ground water entering the sewers east of the westerly boundary of the City of Burbank diminished due to the lowering of the ground water table below the invert of the sewers. However, infiltration from storm runoff can enter during the winter season through poorly constructed house connections or manholes.

The annual estimated amounts of infiltration shown in Table N-5 are reasonable if compared with the allowable infiltration in accordance to specifications under which sewers are constructed. The maximum allowable infiltration for newly laid sewers, according to the City of Los Angeles Standard Specification No. 151 for public improvements, is six-tenths of a gallon per minute per inch of diameter for sewer per 1,000 feet of sewer laid. For a new 8-inch sewer the maximum allowable infiltration for 1,000 feet amounts to 41 acre-feet per year. To obtain the maximum infiltration of 6,290 acre-feet per year as shown in Table N-5, it would require 153 miles of 8-inch sewers. In the area of investigation there are approximately 2,200 miles of sewers as of July, 1959. This consists of sewers whose diameter varies from 8 inches to over 48 inches. During the period prior to 1952, it appears that 153 miles of sewers could have been at or below the ground water table and infiltration into the sewers could have occurred.

TABLE N-5

ESTIMATED SEWER INFILTRATION AND FLUSHING WATER

In Acre-Feet

Year	Sewer Infiltration				Sewer Flushing
	Burbank	Glendale	Los Angeles[a]	Total	Glendale
1928-29	70	270	0	340	0
29-30	120	0	50	170	320
1930-31	230	0	200	430	490
31-32	400	120	360	880	810
32-33	320	0	110	430	610
33-34	220	70	20	310	700
34-35	390	1,170	140	1,700	450
1935-36	340	1,180	50	1,570	560
36-37	340	1,370	150	1,860	200
37-38	830	1,150	190	2,170	350
38-39	1,110	1,330	840	3,280	300
39-40	920	1,650	680	3,250	250
1940-41	1,790	2,840	1,660	6,290	150
41-42	1,360	2,500	1,870	5,730	170
42-43	1,360	1,280	3,150	5,790	0
43-44	930	1,680	3,500	6,110	0
44-45	220	1,800	3,290	5,310	90
1945-46	0	1,670	2,330	4,000	500
46-47	130	2,780	2,350	5,260	1,230
47-48	800	1,990	1,250	4,040	1,900
48-49	180	1,280	860	2,320	2,290
49-50	0	910	330	1,240	1,320
1950-51	200	0	970	1,170	1,520
51-52	0	0	2,090	2,090	2,530
52-53	0	0	950	950	2,090
53-54	0	0	1,840	1,840	2,620
54-55	0	0	1,950	1,950	2,240
1955-56	0	0	2,970	2,970	3,660
56-57	0	0	3,290	3,290	3,270
57-58	0	0	2,330	2,330	1,650

a. City of Los Angeles west of Burbank. Infiltration in Los Angeles South of Glendale assumed to be nil.

Sewage Exported from Sylmar Hydrologic Subarea

Part of the sewage originating in the Sylmar Hydrologic Subarea is exported to the San Fernando Subarea. From 1928 through August 1951, sewage originating in portions of Los Angeles and in San Fernando was treated in the City of San Fernando sewage treatment plant and discharged into Pacoima Wash. From September 1951 to the present, sewage discharged into sewers is exported from the Upper Los Angeles River area. Sewage from the City of Los Angeles is measured by a gage located at Fourth and Hubbard Streets in the City of San Fernando. An estimate of the sewage exported from the Sylmar Hydrologic Subarea, originating in the City of Los Angeles, was obtained by using the Fourth and Hubbard Streets gage, and commencing in July 1958, the San Fernando Road and Fourth Street gage. These gages are located in close proximity to the boundary of the Sylmar Subarea. With the exception of a few house connections located along the northeasterly boundary of the City of San Fernando and on San Fernando Road, these gages measure all the sewage exported from the City of Los Angeles in the Sylmar Subarea.

Sewage exported from the portion of the City of San Fernando in the Sylmar Subarea was estimated based on the percent of the areal extent of the city within each subarea.

Sewage Exported from Verdugo Hydrologic Subarea

The only area that is sewered in the Verdugo Subarea is within the City of Glendale (see Plate 26). The northerly boundary of the sewered area is approximately at the southerly boundary of the Crescenta Valley County

Water District service area. This area has had sewers available since 1926 and was assumed to have no individual sewage disposal units. Due to the lack of measurements of the amount of sewage from this area, an estimate was made by using 45 percent of the net delivered water to residential and commercial classifications as sewage exported from the Verdugo Hydrologic Subarea.

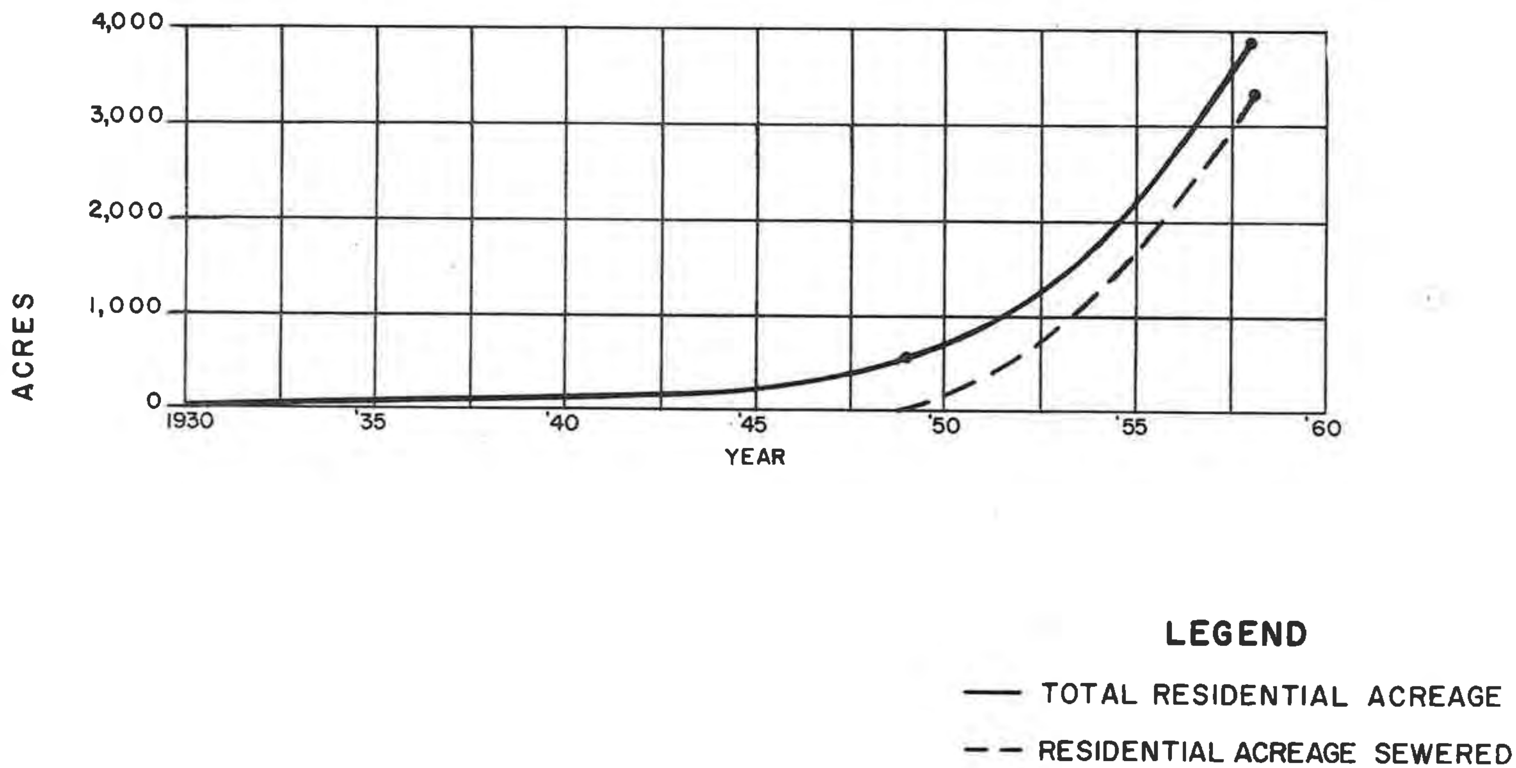
Imported Waters in Cesspool Recharge

To account for the disposition of imported water in the area of investigation, an estimate of the amount of imported Colorado River water in sewage was determined by utilizing the percentage of imported water in each water service area. It was assumed that the imported water supplied to the service areas commingled with the native ground water used to supply the area and the amount of imported water in the sewage was proportional to the amount of imported water in the net delivered water.

Prior to the introduction of Colorado River water into their water supply, the Cities of Burbank and Glendale utilized extracted ground water for their supply and therefore cesspool recharge and sewage exported by these cities consisted entirely of ground water. The annual percent of Colorado River water in each city's supply was applied to their respective amounts of sewage export and cesspool recharge to determine the amounts supplied from Colorado River water. In the City of Los Angeles west of Burbank, Owens River water is used almost exclusively in the area and has been discussed previously.

Sewage from the Hill and Mountain Areas

The sewage measured at the various sewage gaging stations includes sewage originating in the hill areas. To obtain values for the valley floor areas, sewage originating from the hill areas had to be determined. Most of the residential acreage in the hill areas is in the Narrows water service area and in the Santa Monica Mountains. The acreage of residential in the hill areas is found in Appendix K. To utilize the annual unit sewage flow per house connection, the number of sewer house connections in the Narrows water service area was enumerated from the City of Los Angeles Engineer's sewer maps, as discussed previously. On the basis of this enumeration, it was found that over the base period there was an average of 3.4 sewer connections per acre in the hill area. The sewered areas in the Santa Monica Mountains were planimetered for 1955 and 1958 from Plate 26. The acreages thus determined were plotted on a graph showing the acreage of residential in the Santa Monica Mountains. A curve representing the acreage sewered was extrapolated using these two points and the total acreage curve for this area, as shown on Figure N-4. The sewage from the Santa Monica Mountains was estimated by utilizing the number of lots per acre found in the Narrows hill area and the annual unit sewage flow per house connection. Sewage from hillside residential areas in the other water service areas did not constitute any significant amount of sewage being exported. It was, therefore, assumed to all be on individual sewage disposal units.



SAN FERNANDO VALLEY REFERENCE

RESIDENTIAL ACRES, SANTA MONICA MOUNTAINS

STATE WATER RIGHTS BOARD

Sewage Export and Cesspool Recharge

The methods of determining and evaluating sewage export and cesspool recharge for each service area and hydrologic subarea, as previously described, are presented in Table N-6. Summaries of sewage export and cesspool recharge for the area of investigation have been prepared for valley floor and hill and mountain areas. For convenience, these values are presented by water service areas and by hydrologic subareas. The summaries are presented in the following tables:

- N-7 Cesspool Recharge by Water Service Area
- N-8 Contribution of Sewage to Sewerage System by Water Service Area
- N-9 Sewage Exported from Hill and Mountain Areas

A summary of cesspool recharge in hill and mountain areas is not presented since it is believed that this recharge is not a contribution to the hydrologic subareas.

TABLE N-6

METHODS OF DETERMINING SEWAGE EXPORT AND CESSPOOL RECHARGE

Area	Cesspool recharge	Sewage export
CITY OF LOS ANGELES		
West of Burbank	Unit sewage discharge per cesspool.	Measured.
Owens Service Area in Sylmar Subarea	Total sewage based on 45 percent of delivered water* minus measured sewage export.	Measured.
Sunland-Tujunga Service Area	Total sewage based on 45 percent of delivered water* minus estimated sewage export.	Total measured sewage export for the City of Los Angeles west of Burbank minus measured sewage export from the Owens Service Area in Sylmar. The remaining sewage is split by the areal extent of sewered areas within each service area.
Mission Wells Service Area	Total sewage based on 45 percent of delivered water* minus estimated sewage export.	
Owens Service Area in San Fernando Subarea	Total cesspool recharge in Los Angeles west of Burbank minus the sum of the three areas above.	
Narrows Service Area	None.	Estimated, based on unit sewage discharge per house connection.
CITY OF SAN FERNANDO	Unit sewage discharge per cesspool.	Measured.
In San Fernando Subarea	Split by areal extent of the City in each subarea.	Split by areal extent of sewered area.
In Sylmar Subarea	Split by areal extent of the City in each subarea.	Split by areal extent of sewered area.
CITY OF GLENDALE	Unit sewage discharge per cesspool.	Measured.
In Verdugo Subarea	Total sewage based on 45 percent of delivered water* minus estimated sewage export.	Split by areal extent of sewered area.
In San Fernando Subarea	Total cesspool recharge for the City less recharge in Verdugo Subarea.	Split by areal extent of sewered area.
CITY OF BURBANK	Unit sewage discharge per cesspool.	Measured.
LA CANADA IRRIGATION DISTRICT	Total sewage based on 45 percent of delivered water.*	None.
CRESCENTA VALLEY COUNTY WATER DISTRICT	Total sewage based on 45 percent of delivered water.*	None.

* Residential and commercial delivered water only.

TABLE N-7

CESSPOOL RECHARGE BY WATER SERVICE AREA

In Acre-Feet

Year	City of Burbank, San Fernando Subarea: Ground water	City of Burbank, San Fernando Subarea: Metropolitan Water District	City of Burbank, San Fernando Subarea: Total	City of San Fernando: Sylmar Subarea[a]: Ground water	City of San Fernando: San Fernando Subarea: Ground water	City of San Fernando: Sub-total[b]	City of San Fernando: Sylmar Subarea: Ground water	City of San Fernando: San Fernando Subarea: Ground water	City of San Fernando: Sub-total[c]	City of San Fernando: Total	Crescenta Valley County Water District[d], Verdugo Subarea: Ground water	Crescenta Valley County Water District[d], Verdugo Subarea: Metropolitan Water District	Crescenta Valley County Water District[d], Verdugo Subarea: Total	La Canada Irrigation District, Verdugo Subarea: Ground water	La Canada Irrigation District, Verdugo Subarea: Metropolitan Water District	La Canada Irrigation District, Verdugo Subarea: Total
1928-29	550		550	40	380	420	10	100	110	530	190		190	30		30
29-30	560		560	40	420	460	10	90	100	560	210		210	40		40
1930-31	550		550	50	500	550	10	90	100	650	230		230	40		40
31-32	550		550	40	420	460	10	80	90	550	210		210	50		50
32-33	540		540	40	350	390	10	70	80	470	230		230	50		50
33-34	540		540	30	230	260	10	60	70	330	300		300	50		50
34-35	560		560	40	350	390	10	60	70	460	210		210	40		40
1935-36	560		560	40	380	420	10	50	60	480	190		190	50		50
36-37	640		640	40	420	460	10	60	70	530	220		220	50		50
37-38	790		790	50	440	490	10	50	60	550	250		250	60		60
38-39	1,020		1,020	60	560	620	10	50	60	680	290		290	70		70
39-40	1,090	0	1,090	60	570	630	0	50	50	680	310		310	70		70
1940-41	1,440	50	1,490	50	530	580	0	50	50	630	290		290	60		60
41-42	1,310	60	1,370	50	500	550	0	50	50	600	360		360	90		90
42-43	1,160	130	1,290	50	470	520	10	50	60	580	330		330	100		100
43-44	1,020	60	1,080	40	360	400	10	50	60	460	410		410	110		110
44-45	910	40	950	50	440	490	0	50	50	540	370		370	100		100
1945-46	800	70	870	50	500	550	10	100	110	660	490		490	130		130
46-47	960	170	1,130	60	530	590	10	110	120	710	580		580	140		140
47-48	860	40	900	60	620	680	10	90	100	780	790		790	140		140
48-49	530	10	540	60	620	680	10	90	100	780	670		670	150		150
49-50	480	10	490	80	600	680	10	140	150	830	740		740	170		170
1950-51	390	20	410	100	980	1,080	10	150	160	1,240	830		830	190		190
51-52	340	30	370				20	190	210	210	900		900	160	40	200
52-53	200	30	230				20	200	220	220	1,040		1,040	190	60	250
53-54	180	20	200				20	230	250	250	1,130		1,130	180	60	240
54-55	190	10	200				30	250	280	280	890	190	1,080	190	70	260
1955-56	130	10	140				30	260	290	290	840	340	1,180	90	180	270
56-57	50	10	60				20	240	260	260	860	380	1,240	80	220	300
57-58	30	10	40				30	240	270	270	970	230	1,200	80	200	280

CESSPOOL RECHARGE BY WATER SERVICE AREA
(continued)

In Acre-Feet

Year	City of Glendale, Verdugo Subarea: Ground water	City of Glendale, Verdugo Subarea: Metropolitan Water District	City of Glendale, San Fernando Subarea: Ground water	City of Glendale, San Fernando Subarea: Metropolitan Water District	City of Glendale: Total	City of Los Angeles West of Burbank: Sylmar Subarea: Owens River	City of Los Angeles West of Burbank, San Fernando Subarea: Owens River[e]	San Fernando Subarea, Mission Wells: Ground water	San Fernando Subarea, Mission Wells: Owens River	San Fernando Subarea, Sunland-Tujunga Service Area: Ground water	San Fernando Subarea, Sunland-Tujunga Service Area: Owens River	San Fernando Subarea, Owens Service Area: Owens River	San Fernando Subarea: Total	Verdugo Subarea, Sunland-Tujunga Service Area: Ground water	Verdugo Subarea, Sunland-Tujunga Service Area: Owens River	Verdugo Subarea: Total
1928-29	10		1,330		1,340	0	130	160		370		1,630	2,290	10		10
29-30	10		1,200		1,210	0	140	220		480		1,490	2,330	10		10
1930-31	10		1,080		1,090	0	150	170		380		1,660	2,360	10		10
31-32	10		940		950	0	150	110		240		1,740	2,240	10		10
32-33	10		800		810	0	170	120		240		1,520	2,050	10		10
33-34	10		690		700	0	160	120		250		1,570	2,100	10		10
34-35	10		600		610	0	160	110		210		1,580	2,060	10		10
1935-36	10		550		560	0	150	140		270		1,620	2,180	10		10
36-37	10		510		520	0	160	150		280		2,010	2,600	10		10
37-38	10		450		460	0	160	160		310		2,310	2,940	10		10
38-39	20		400		420	0	190	190		350		2,570	3,300	10		10
39-40	20		370		390	0	200	200		360		3,170	3,930	10		10
1940-41	20		350		370	0	190	210		370		3,670	4,440	10		10
41-42	30		420		450	70	180	250		440		4,100	4,970	10		10
42-43	40		350		390	170	160	300		510		4,250	5,220	20		20
43-44	40		280		320	160	220	390		580		4,200	5,390	20		20
44-45	50		300		350	240	190	400		560		4,680	5,830	20		20
1945-46	60		300	10	370	320	230	460		630		4,860	6,180	20		20
46-47	80		280	20	380	410	240	450		680		6,050	7,420	30		30
47-48	120		280	10	410	470	260	580		800		6,050	7,690	40		40
48-49	140		220	0	360	510	300	790		880		6,130	8,100	50		50
49-50	120	0	140	0	260	560	300	900		960		6,240	8,400	60		60
1950-51	130	10	60	10	200	680	290	880	180	800	280	7,450	9,880	50	20	70
51-52	120	10	60	10	190	670		1,200	0	720	350	9,720	11,990	50	20	70
52-53	160	0	90	10	260	830		1,090	290	430	890	9,780	12,480	30	60	90
53-54	160	10	80	10	260	1,070		1,150	270	470	840	11,180	13,910	30	60	90
54-55	190	0	100	10	300	1,220		1,140	350	530	780	12,390	15,190	40	60	100
1955-56	140	10	60	10	220	1,330		970	590	640	680	13,450	16,330	50	40	90
56-57	140	20	60	10	230	1,610		570	660	820	610	14,090	16,750	50	50	100
57-58	320	30	160	10	520	1,310		390	320	1,140	230	14,330	16,410	100	20	120

a. Measured sewage exported out of Sylmar Subarea.
b. Measured sewage treated at City of San Fernando Sewage Treatment Plant in San Fernando Subarea.
c. Estimated sewage discharged into private sewage disposal unit.
d. Including Mountain Water Company.
e. Exported to San Fernando Hydrologic Subarea from Sylmar Subarea.

TABLE N-8

CONTRIBUTION OF SEWAGE TO SEWERAGE SYSTEM BY WATER SERVICE AREA[a]

In Acre-Feet

Year	City of San Fernando: Sylmar Subarea[b] Ground water	City of San Fernando: San Fernando Subarea[b] Ground water	City of San Fernando: Total	City of Burbank, San Fernando Subarea[b]: Metropolitan Water District	City of Burbank, San Fernando Subarea[b]: Ground water	City of Burbank, San Fernando Subarea[b]: Total	City of Glendale, Verdugo Subarea[b]: Metropolitan Water District	City of Glendale, Verdugo Subarea[b]: Ground water	City of Glendale, San Fernando Subarea[b]: Metropolitan Water District	City of Glendale, San Fernando Subarea[b]: Ground water	City of Glendale: Total
1928-29					470	470		80		2,590	2,670
29-30					580	580		100		3,090	3,190
1930-31					720	720		120		3,960	4,080
31-32					930	930		110		4,800	4,910
32-33					890	890		140		4,830	4,970
33-34					830	830		230		5,160	5,390
34-35					1,020	1,020		240		6,220	6,460
1935-36					1,040	1,040		260		6,680	6,940
36-37					1,150	1,150		330		6,910	7,240
37-38					1,780	1,780		350		7,150	7,500
38-39					2,290	2,290		380		7,780	8,160
39-40					2,420	2,420		450		8,310	8,760
1940-41				130	3,780	3,910		410		9,750	10.160
41-42				160	3,680	3,840		500		9,570	10,070
42-43				400	3,750	4,150		570		8.390	8,960
43-44				240	4,120	4,360		580		8,630	9,210
44-45				180	3,980	4,160		600		8,830	9.430
1945-46				330	4,070	4,400		700	160	9.100	9,960
46-47				700	3,990	4,690		710	660	10,680	12,050
47-48				280	5,740	6.020		670	330	11,100	12,100
48-49				130	5,960	6,090		670	0	11,470	12,140
49-50				80	6,190	6,270		750	180	10,210	11,140
1950-51				330	6,710	7.040	20	830	560	9,170	10,580
51-52	120	1,150	1,270	610	6,370	6,980	30	760	920	9,940	11,650
52-53	180	1,700	1,880	920	6,580	7,500	20	930	760	9,770	11,480
53-54	140	1,360	1,500	900	7,490	8,390	40	1,120	1,050	10,320	12,530
54-55	130	1,260	1,390	560	8,050	8,610	20	1,050	470	10,240	11,780
1955-56	120	1,110	1,230	750	8,120	8,870	90	1,270	1,310	10,400	13,070
56-57	120	1,130	1,250	1,240	8,150	9,390	100	1,340	1,290	10,370	13,100
57-58	120	1,200	1,320	1,350	7.460	8,810	180	1,710	1.280	12,320	15,490

CONTRIBUTION OF SEWAGE TO SEWERAGE SYSTEM BY WATER SERVICE AREA[a]
(continued)

In Acre-Feet

Year	City of Los Angeles West of Burbank: Sylmar Subarea[b] Owens River	City of Los Angeles West of Burbank, San Fernando Subarea[b]: Owens River	City of Los Angeles West of Burbank, San Fernando Subarea[b]: Ground water	City of Los Angeles West of Burbank: Total	City of Los Angeles Narrows, San Fernando Subarea[b]: Metropolitan Water District	City of Los Angeles Narrows, San Fernando Subarea[b]: Owens River	City of Los Angeles Narrows, San Fernando Subarea[b]: Ground water	City of Los Angeles Narrows: Total	Lees Valley Settling Basin[c]	Total sewage export out of Upper Los Angeles River Area[e]
1928-29		0	0	0			3,180	3,180		6,320
29-30		50	50	100			3,230	3,230		7,100
1930-31		200	200	400			3,290	3,290		8,490
31-32		350	360	710			3,350	3,350		9,900
32-33		590	110	700			3,410	3,410		9,970
33-34		640	20	660			3,460	3,460		10,340
34-35		720	140	860			3,510	3,510		11,850
1935-36		830	50	880			3,590	3,590		12.450
36-37		1,020	150	1,170			3,670	3,670		13,230
37-38		1,140	190	1,330			3,750	3,750		14,360
38-39		1,350	840	2,190			3,830	3,830		16,470
39-40		1,660	680	2.340			3,920	3,920		17,440
1940-41		1,950	1,660	3,610			3,950	3,950		21,630
41-42		2,150	1,870	4,020			3,980	3,980		21,910
42-43		2,200	3,150	5,350			4,010	4,010		22,470
43-44		2,360	3,500	5,860			4,040	4,040		23.470
44-45		2,830	3,290	6,120	70		4,000	4,070		23,780
1945-46		3,200	2,330	5,530	360		3.780	4,140		24,030
46-47		3,780	2,350	6,130	520		3,690	4,210		27,080
47-48		5,240	1,250	6,480	540		3,740	4,280		28,880
48-49		6,900	860	7,760	550		3,800	4,350		30,340
49-50		9,790	330	10,120	200	540	3,680	4,420		31,950
1950-51		12,580	970	13,550	270	880	3,340	4,490		35,660
51-52	310	13,100	2,090	15,500	360	1,020	3,170	4,550		39,950
52-53	360	14,810	950	16,120	460	880	3,280	4,620	10[d]	41,590
53-54	270	18,230	1,840	20,340	1,810	610	2,270	4,690	190[d]	47,260
54-55	260	21,770	1,950	23,980	2,800	450	1,500	4,750	4,840	45,670
1955-56	260	25,220	2,970	28,450	2,280	440	2,060	4,780	4,540	51,860
56-57	280	28,010	3,290	31,580	2,660	570	1,570	4,800	60	60,060
57-58	340	31,040	2,330	33,710	3,230	680	960	4.870	240	63,960

a. Including infiltration.
b. Include tributary drainage area.
c. Discharged into Los Angeles River.
d. Overflow of North Outfall Sewer.
e. Does not include sewage flowing in Los Angeles River.

TABLE N-9

SEWAGE EXPORTED FROM HILL AND MOUNTAIN AREAS

In Acre-Feet

Year	Water Service Area				Total
	Owens	Burbank	Glendale	Narrows	
1928-29	0	0	0	870	870
29-30	0	0	0	880	880
1930-31	0	0	0	900	900
31-32	0	0	0	910	910
32-33	0	0	0	920	920
33-34	0	0	0	940	940
34-35	0	0	0	960	960
1935-36	0	0	0	970	970
36-37	0	0	0	990	990
37-38	0	0	0	1,060	1,060
38-39	0	0	0	1,080	1,080
39-40	0	0	0	1,090	1,090
1940-41	0	0	0	1,170	1,170
41-42	0	0	0	1,190	1,190
42-43	0	0	0	1,200	1,200
43-44	0	0	0	1,220	1,220
44-45	0	0	10	1,310	1,320
1945-46	0	0	20	1,320	1,340
46-47	0	0	40	1,410	1,450
47-48	0	10	70	1,420	1,500
48-49	10	10	110	1,440	1,570
49-50	140	10	160	1,530	1,840
1950-51	300	10	230	1,620	2,160
51-52	490	20	320	1,710	2,540
52-53	730	30	400	1,730	2,890
53-54	1,090	30	520	1,830	3,470
54-55	1,490	40	640	1,930	4,100
1955-56	2,000	50	790	2,020	4,860
56-57	2,510	60	920	2,050	5,540
57-58	3,240	70	1,100	2,140	6,550

Waste Discharge

An estimate of the amount of industrial wastes being discharged into the Los Angeles River was made by using the quantity of industrial wastes permitted to enter into storm drains which discharge into the river. These amounts were in accordance with industrial waste permits issued by the City of Los Angeles, Bureau of Sanitation, Industrial Waste Division. The quantities being discharged under each permit were assumed to begin with the date of issuance of the permit during the period 1946-47 through 1957-58. For the prior years, a straight line extrapolation was used to extend these data back to 1939-40, at which time the amount of waste being discharged was assumed to be negligible.

Industrial waste discharges are also present in the flow from Burbank-Western Storm Drain. The low flow measurements of this storm drain were utilized to obtain an estimate of the amount of industrial waste tributary to Burbank-Western Storm Drain. Prior to 1951-52, no measurements were available and a straight line extrapolation was used assuming that waste discharges were negligible in 1939-40. The estimated amount of waste discharged into the Los Angeles River is shown in Table N-10.

TABLE N-10

ESTIMATED DISCHARGE OF INDUSTRIAL WASTE AND SEWAGE INTO RIVER SYSTEM

In Acre-Feet

Year	Low flow of Burbank-Western Storm Drain (1)	City of Los Angeles industrial waste permits (2)	Total waste (1)+(2)=(3)	Sewage* (4)	Total waste and sewage (3)+(4)=(5)
1939-40	0	0	0	0	0
1940-41	240	300	540	0	540
41-42	490	600	1,090	0	1,090
42-43	740	900	1,640	0	1,640
43-44	990	1,200	2,190	0	2,190
44-45	1,240	1,500	2,740	0	2,740
1945-46	1,490	1,800	3,290	0	3,290
46-47	1,740	2,100	3,840	0	3,840
47-48	1,990	2,100	4,090	0	4,090
48-49	2,240	2,420	4,660	0	4,660
49-50	2,320	2,420	4,740	0	4,740
1950-51	2,390	2,420	4,810	0	4,810
51-52	2,460	2,820	5,280	0	5,280
52-53	2,530	3,550	6,080	10	6,090
53-54	2,430	3,550	5,980	190	6,170
54-55	2,800	3,550	6,350	4,840	11,190
1955-56	2,330	3,550	5,880	4,540	10,420
56-57	2,030	3,550	5,580	60	5,640
57-58	2,200	3,550	5,750	240	5,990

* Overflow of North Outfall Sewer 1952-53 and 1953-54 and discharge from Valley Settling Basin 1954-55 through 1957-58.

APPENDIX O

SEPARATION OF SURFACE FLOW OF THE LOS ANGELES RIVER AT GAGE F-57

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SEPARATION OF SURFACE FLOW OF THE LOS ANGELES RIVER AT GAGE F-57

Gage F-57 measures the surface outflow of the Upper Los Angeles River area and is located approximately 0.2 mile above the confluence of the Arroyo Seco and the Los Angeles River.

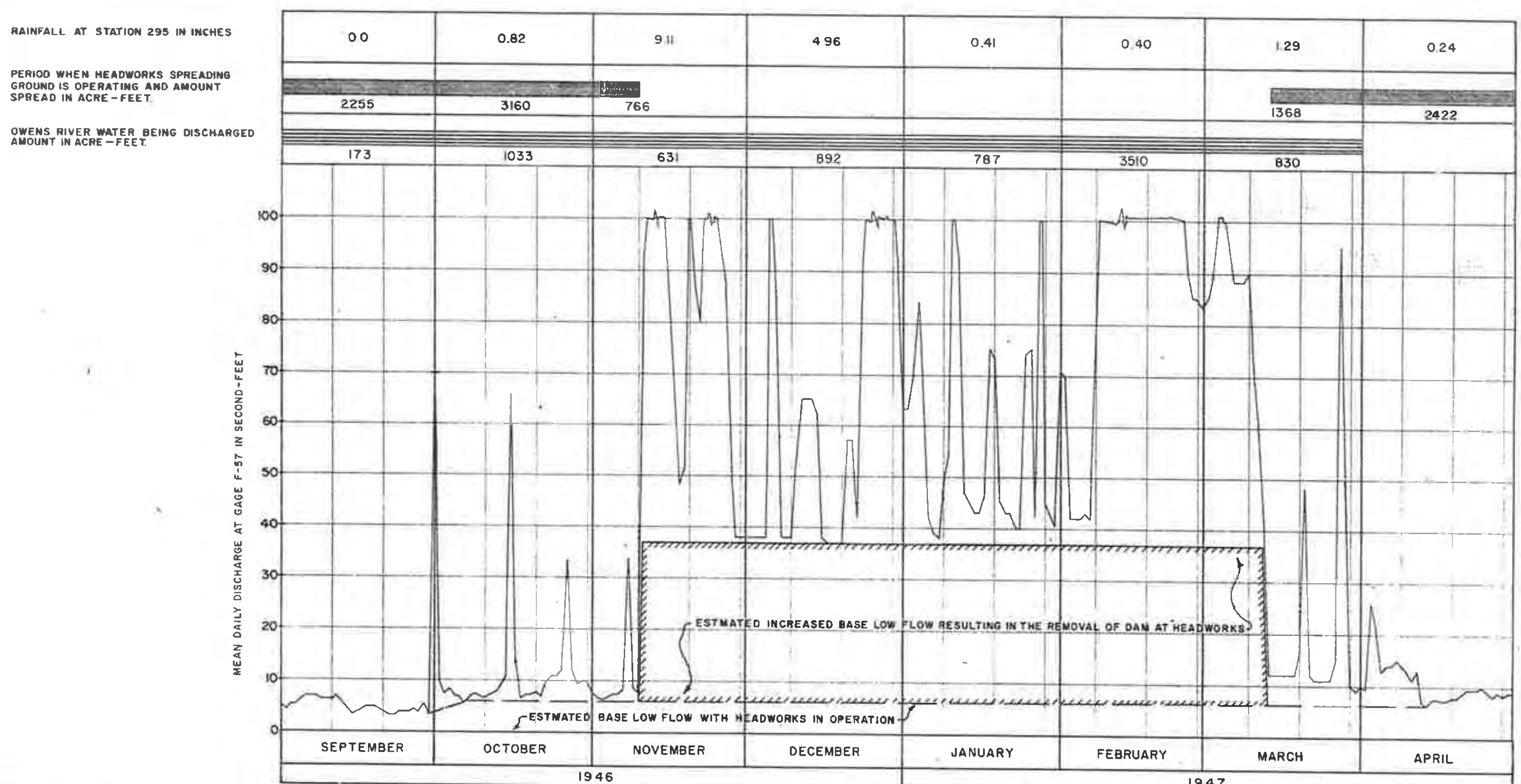
The surface flow of the river originates from four sources:

1. Storm runoff from precipitation.
2. Owens River water.
3. Rising water.
4. Industrial waste and sewage discharges.

Available Data

Surface outflow measurements at Gage F-57 are available from January 1929 through September 1958. Records for Gage F-57 from January 1929 through August 1929 were weekly measurements made at the approximate location of the present gage. Subsequent records for Gage F-57 were compiled from the charts of a continuous type recorder maintained by the Los Angeles County Flood Control District. This agency also rates the station with periodic current meter measurements. The mean daily flows computed from these records were utilized to construct a hydrograph of the surface flow passing the gage (see Figure O-1).

The occurrence of the surface flow passing the gage is influenced by the operation of the Headworks Infiltration Gallery and the amounts of Owens River water discharged into the Los Angeles River.



NOTE: DISCHARGES GREATER THAN 100 SECOND-FEET NOT SHOWN

SAN FERNANDO VALLEY REFERENCE

ILLUSTRATED EXAMPLE FOR SEPARATION OF FLOW AT GAGE F-57

STATE WATER RIGHTS BOARD

FIGURE O-1

The location of the Headworks Infiltration Gallery is shown on Plate 12. The monthly amount of water diverted from the Los Angeles River into the headworks was compiled by the Los Angeles Department of Water and Power from October 1938 through September 1958. Diversion into the headworks inlet structure is made by the installation of a temporary dam across the river. Due to regulations established by the Corps of Engineers, this dam is required to be removed when the flow in the river increases due to storm runoff. Beginning in 1958-59, a permanent Imbertson collapsible rubber dam has been used. This dam remains in place and automatically collapses when there is sufficient flow in the river.

The discharge of Owens River water into the Los Angeles River from the River Power Plant, Chatsworth Reservoir and from blowoffs is discussed in Appendix M. The monthly amounts of water discharged from these sources from October 1928 through September 1958 have been recorded by the Los Angeles Department of Water and Power. Annual amounts of these discharges are shown in column 8, Table M-1.

Separation of the Surface Outflow

The total surface outflow of the Los Angeles River measured at Gage F-57 was divided into two basic parts, the base low flow and surface runoff. Base low flow is the discharge of the river when runoff from precipitation has ceased and includes rising ground water, industrial waste and sewage discharge. Surface runoff is the discharge derived from storm runoff and any Owens River water which may be discharged to the river during periods of high flow.

In order to determine the amount of each component derived from the four aforementioned sources, the monthly amount of Owens River water discharged into the river, the periods when the Headworks Infiltration Gallery was in operation and the monthly amount of rain occurring at Gage 295 in the City of Glendale were noted on hydrographs of the mean daily flow measured at Gage F-57. These various items were utilized to separate the base low flow and the storm runoff into their separate components.

Surface Runoff and Base Low Flow

It is assumed that during months of no rainfall the base low flow makes up the entire flow of the river measured at Gage F-57. In order to separate surface runoff due to precipitation from the total, a straight line was drawn on the hydrograph from the end of one dry period to the beginning of the following dry period. Allowance was made for a period of recession after a wet season as indicated by the rate of change in value of runoff subsequent to precipitation, as illustrated on Figure O-1.

From 1938-39 through 1957-58 when the headworks was in operation, this line was adjusted during periods of storm runoff to compensate for the increased amount of base low flow which would be measured at the gage when the headworks was not diverting. It was assumed that a major portion of the water diverted into the headworks would be measured at the gage when the headworks diversion was shut down. However, the amount of this increase in the base low flow was limited by the maximum monthly rate of diversion into the headworks for each year, less an estimated amount of Owens River water diverted by the headworks plus rate of flow measured at the gage when the headworks was in operation.

The base low flow for each month was then computed from the hydrograph and deducted from the total gaged amount, the remainder being the surface runoff.

Owens River Water

The discharge passing Gage F-57 is at times composed partly of Owens River water which has been discharged from the City of Los Angeles River Power Plant, spillage from Chatsworth Reservoir and blowoffs from Los Angeles City mains. It should be noted that the quantities of Owens River water from blowoff discharges are estimated and that the exact time and location where they occurred are not all known. An inspection of the record of the daily flows at F-57 indicates that portions of the aforementioned Owens River water discharges do not reach F-57 as surface flow.

Available data indicate that the disposition of Owens River water discharged into the river may be estimated under the following sets of conditions:

1. That all Owens River water discharged through the City of Los Angeles River Power Plant during periods of high river flow passed Gage F-57.

2. That all Owens River water released from Chatsworth Reservoir, when the headworks spreading grounds were in operation, was

diverted into the headworks and when the headworks was not in operation (i.e. during high flow periods) all such water would pass Gage F-57.

3. That all other Owens River water discharged into the Los Angeles River flowed past Gage F-57 except during periods of diversion to the headworks. At times of these diversions it was assumed that all available Owens River water up to the amount of the diversion was diverted to the spreading grounds and did not reach Gage F-57.

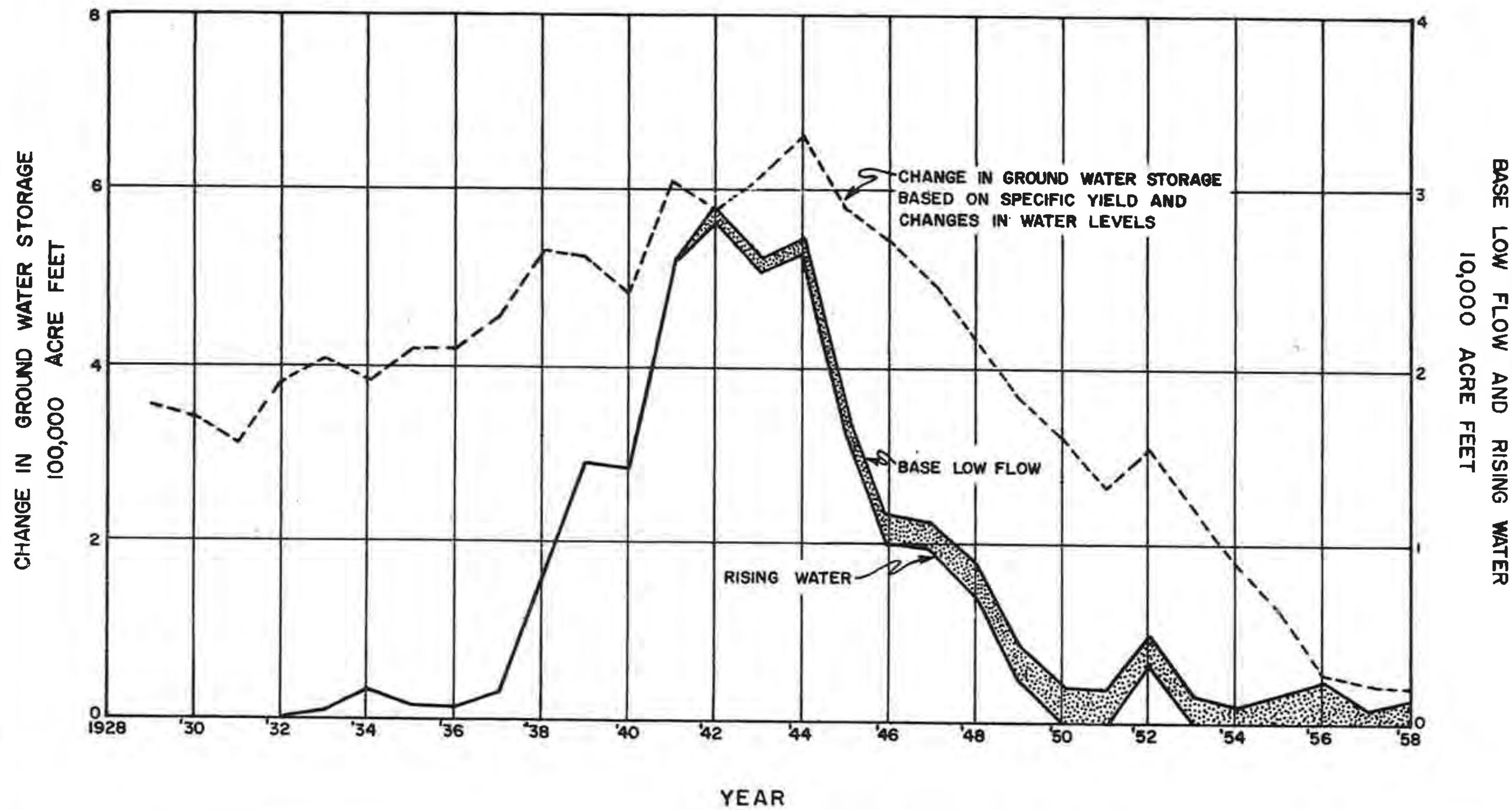
Prior to October 1938, available information indicates that Owens water releases were made predominantly during periods of high flow. These releases include discharges from the River Power Plant and blowoffs.

Base Low Flow

As mentioned previously, the base low flow at Gage F-57 originates from rising water and industrial waste and sewage discharges into the Los Angeles River. The relationship which exists between the water in storage in the valley fill and the amount of the base low flow is illustrated on Figure O-2.

Water in storage in the valley fill was plotted by taking an arbitrary value of 400,000 acre-feet in storage in 1927-28. The annual changes in storage, as computed from specific yield and water levels, were accumulated and plotted on Figure O-2. The base low flow was also plotted on Figure O-2 to illustrate the relationship with the change in storage.

FIGURE O-2



SAN FERNANDO VALLEY REFERENCE

RELATIONSHIP OF RISING WATER AND CHANGE IN GROUND WATER STORAGE

STATE WATER RIGHTS BOARD

Inspection of the hydrographs of the mean daily flow at Gage F-57 indicates a rapid increase in the base low flow after the March 1938 flood coincident with the deepening of the river invert for its improvement by the Corps of Engineers.

The base low flow from 1949-50 through 1957-58, with the exception of 1951-52, appears to have little or no rising water. It was therefore assumed that no rising water could appear at Gage F-57 when storage in the valley fill was below the amount of water in storage in 1949-50, and that the amount of the base low flow measured at Gage F-57 during this period originated from industrial waste and sewage discharged into the river. Sewage discharge from the Valley Settling Basin began in 1954-55; however, the North Outfall Sewer is known to have been overloaded and discharging sewage to the Los Angeles River in 1952-53 and 1953-54.

There are no actual measurements of industrial waste discharged directly into the river. Waste water discharged into the Los Angeles River in any appreciable amount began during World War II with the expansion of industrial development in the San Fernando Valley. There are no records of significant amounts of industrial waste discharge prior to 1940 and it has therefore been assumed that the annual base flow was equal to the rising water at Gage F-57 prior to that date. The amount of industrial waste and sewage passing Gage F-57 was estimated by using a straight line relationship to extrapolate the amount of these waste discharges from 1940 through 1949. From 1950 through 1958 the amount of the base low flow is equal to the waste discharges, with the exception of 1951-52 when the amount of water in storage was greater than the amount of 1949-50. The amount of wastes for 1951-52 was estimated by utilizing the average amount of wastes estimated for 1950-51 and 1952-53.

The separation of the surface outflow measured at Gage F-57 into its four sources is shown in Table O-1.

TABLE O-1

SEPARATION OF SURFACE FLOW AT GAGE F-57

In Acre-Feet

Year	Base low flow: Rising water	Base low flow: Waste discharge[a]	Surface runoff: Owens River water	Surface runoff: Net storm runoff	Measured Outflow
1928-29	0	0	650	2,950	3,600[b]
29-30	0	0	330	1,330	1,660
1930-31	0	0	260	3,710	3,970
31-32	60	0	1,550	13,630	15,240
32-33	440	0	0	10,200	10,640
33-34	1,670	0	1,750	26,400	29,820
34-35	760	0	440	11,350	12,550
1935-36	720	0	560	4,490	5,770
36-37	1,430	0	1,770	21,270	24,470
37-38	7,740	0	1,690	123,210	132,640
38-39	14,490	0	2,940	24,930	42,360
39-40	14,050	0	760	24,780	39,590
1940-41	25,770	200	0	138,990	164,960
41-42	28,600	410	5,160	20,630	54,800
42-43	25,490	620	8,680	89,600	124,390
43-44	26,500	830	2,850	79,650	109,830
44-45	16,610	1,040	1,210	18,130	36,990
1945-46	10,500	1,250	4,100	20,040	35,890
46-47	9,700	1,460	5,960	14,210	31,330
47-48	7,270	1,670	0	5,950	14,890
48-49	2,440	1,880	710	12,580	17,610
49-50	0	2,090	0	8,670	10,760
1950-51	0	1,890	1,080	4,870	7,840
51-52	3,110	1,750	1,430	101,750	108,040
52-53	0	1,400	1,650	15,430	18,480
53-54	0	960	290	19,750	21,000
54-55	0	1,550	0	16,720	18,270
1955-56	0	2,390	0	33,500	35,890
56-57	0	830	0	24,060	24,890
57-58	0	1,270	0	89,750	91,020
29-Year Average 1929-57	6,810	770	1,580	30,790	39,940

a. Includes industrial waste and sewage discharged into Los Angeles River.
b. Partially estimated.

APPENDIX P

METHODS OF DETERMINING UNDERFLOW
AT HYDROLOGIC BOUNDARIES

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METHODS OF DETERMINING UNDERFLOW AT HYDROLOGIC BOUNDARIES

Subsurface Flow

Purpose of this appendix is to set forth methods and procedures utilized in evaluating the subsurface flow out of the Upper Los Angeles River area which has occurred historically in the vicinity of Gage F-57 through a section at the lower end of the Los Angeles Narrows and also in the vicinity of Pickens Canyon in the easterly side of La Crescenta Valley. Evaluation of subsurface flow which has occurred between Sylmar and San Fernando Hydrologic Subareas in two locations and between the Verdugo and San Fernando Hydrologic Subareas at one location, is also included. There is little or no subsurface flow from the Eagle Rock Subarea to the Los Angeles Narrows.

Methods

The quantity of subsurface flow was computed by the slope area method through use of Darcy's Law which states that the rate of discharge through a given cross section of saturated material, under laminar flow conditions, is proportional to the hydraulic gradient and may be expressed as follows:

$$Q = PIA \text{ in which}$$

Q = amount of flow in gallons per day

P = Meinzer's coefficient of permeability expressed in gallons per day per square foot under a hydraulic gradient of unity and existing ground water temperatures

I = hydraulic gradient in feet per foot at the section in a direction normal to the section

A = saturated area of the section in square feet

Subsurface flow may also be computed by the rising water method where rising water (effluent seepage) occurs perennially and where the cross-sectional area of saturated materials is unknown. The method has been noted by Tolman in Ground Water, pages 490-91, 1937. This method is also based on Darcy's Law and is dependent on the variation at different times in the amount of perennial rising water with variation in the ground water slope above the first appearance of rising water in a restricted filled channel. The formula is

$$Qu = \frac{I_1 (Qr_2) - I_2 (Qr_1)}{I_2 - I_1}$$

where Qu = subsurface flow (constant as long as rising water occurs) I_1 and I_2 the ground water slopes and Qr_1 and Qr_2 the amounts of rising water at times t_1 and t_2, respectively.

The rising water method was applied to the problem of solving for the underflow at F-57; however, the results were found to be unreliable due to the localized effects of pumping and waste discharges by the Southern Pacific Company.

Subsurface Outflow through Los Angeles Narrows at Gage F-57

Subsurface flow can take place out of the San Fernando Hydrologic Subarea in the vicinity of Gage F-57. Flow passes through a relatively thin section of water-bearing material as shown in Section L-L' on Plate 5D.

The underflow characteristics at this section are complicated by two factors. First the water table slopes away from Arroyo Seco at the eastern end of Section L-L', in the vicinity of Cypress Avenue and Huron Street, with a drop 15 feet indicating that there may be some influence on underflow at this section caused by the coalescence of Arroyo Seco detritus and flows with those of the Los Angeles River. Data with which to completely evaluate this effect are not available. Secondly, an interlocking sheet pile cutoff wall located at the beginning of the lined section (approximately 1,000 feet upstream from Gage F-57) was placed to a depth of 15 feet for the width of the lined channel in 1938 and presumably is still in place. The presence of this cutoff wall, approximately 3,900 square feet in area, may cause an unnatural rising water condition at this point. The underflow at Gage F-57 has previously been estimated by Homer Hamlin in U.S.G.S. Water Supply and Irrigation Paper No. 112 (1905). His estimate of 2.27 cfs was based on a total cross-sectional area of 107,700 square feet (1896) and an elaborate electrical velocity measuring device invented by C. S. Slichter. Review of this estimate indicates that the value determined is high because the results were based on permeability measurements in the more porous portions of the channel.

The data necessary to apply the slope area method were determined to be:

1. The weighted average permeability for the total cross-sectional area was calculated to be 1,132 gallons per day per square foot under 100 percent hydraulic gradient. This determination was made by constructing a geologic section from well and test hole logs and assigning the following permeability values to the materials designated in the logs.

Gravel	2,000 gpd	Silt	100 gpd
Sand and gravel	1,500 gpd	Clay	50 gpd
Sand	1,000 gpd	Cemented gravel	100 gpd

These values have been established in Southern California by means of pump tests performed by State and Federal agencies. These are generalized values; however, it should be noted that the weighted mean permeability determined by the panel method with the assigned values compared favorably with the results obtained at the Pollock well field (Los Angeles Department of Water and Power) by time-recovery methods.

The pump test performed by the Referee on May 5 to 11, 1959, in the Pollock well field utilized Pollock No. 3 (3949B) as the pumping well and Pollock Nos. 1 and 2 (3949 and 3949A) as observation wells. The discharge of the pumping well was metered at 3.7 cfs or 1,661 gpm.

Drawdown and recovery measurements were made on all three wells. Inasmuch as boundary conditions (bedrock outcrops about 1,000 feet from the pumping well) probably caused the erratic variation in the drawdown curves, the recovery curves which were more uniform were used to calculate an approximate permeability.

Due to the 6-day period of pumping and the relatively long interval of time before start of the drawdown test, time was plotted directly against recovery in feet on semilog paper rather than time divided by total elapsed time against recovery. The values thus obtained were used in Wenzel's nonequilibrium equation:*

$$T = \frac{2.303\,Q}{4\pi\,\Delta s}$$ where T = transmissibility, Q = discharge of well prior to shut down in cfs

Δs = the distance in feet as measured from the tangent to the straightest part of the recovery curve. This measurement is expressed as the difference in feet per log cycle of time

A time recovery method was utilized in that it provides an easy check on pumping tests and also implies a constant Q which is difficult to control accurately in the field. A sample computation for Pollock well No. 3 (3949B) follows:

$Q = 3.7$, $\Delta s = 1.39$

$$T = \frac{2.303 \times 3.7}{4 \times 3.14 \times 1.39} = 0.488 \text{ cfs or } = 315{,}000 \text{ gpd}$$

The well was perforated from 40 to 205 feet. The static water level prior to turning on pump was 44.05 feet. This would give 160.95 feet of saturated alluvium:

$$P = \frac{T}{\text{Saturated thickness}} = \frac{315{,}000}{160.95} = 1{,}956 \text{ gpd/square foot}$$

The log of well 3949B indicates that the majority of materials penetrated are gravels. The pump test results and the assigned value of 2,000 gallons per day per square foot for gravel are in substantial agreement.

* U. S. G. S. Water Supply Paper 887.

Each log in the section was assumed to be characteristic of the area halfway to the next log. The section is shown on Plate 5D as Section L-L'.

2. The maximum hydraulic gradient above the section is limited by the slope of the bottom of the channel ($s = 0.0034$). Annual gradient values were obtained from water level measurements of wells between the section and a point 4,900 feet upstream. All large amounts of pumpage and discharge are made above the reach of channel used in the computations.

3. The section has a total cross-sectional area of 312,600 square feet; 105,080 square feet of saturated cross-sectional area under high water surface conditions; and 76,590 square feet of saturated cross-sectional area under low water surface conditions. The saturated area was determined year by year by using water level measurements along the line of section.

Annual values of subsurface flow at Gage F-57 are shown in Table P-1. The average variations during each year amount to 0.015 to 0.030 cfs above or below the tabulated November values.

Subsurface Outflow at Pickens Canyon

From geologic studies it appears that a bedrock ridge, the westerly bank of an ancestral Pickens Wash cut into bedrock, exists within the area defined as the Verdugo Hydrologic Subarea. This bedrock ridge begins at the mouth of the first canyon westerly of Pickens Canyon and extends southerly to the granitic outcrop located near the intersection of Foothill Boulevard and Pickens Canyon Wash. The location is shown on Figure Q-1, Appendix Q, as the western boundary of storage unit V-2, while a portion of its profile is shown in Section P-P on Plate 5F.

TABLE P-1

SUBSURFACE OUTFLOW AT GAGE F-57

(Based on Measurements in November of Each Water Year)

Year	Gradient	Saturated area, in square feet	Underflow[b] Cubic feet per second	Underflow[b] Acre-feet per year
1928-29	0.0026	102,550	0.47	340
29-30	0.0020	102,550	0.36	260
1930-31	0.0016	102,550	0.29	210
31-32	0.0026	102,550	0.47	340
32-33	0.0034[a]	104,420	0.62	450
33-34	0.0034[a]	104,200	0.62	450
34-35	0.0034[a]	105,080	0.69	500
1935-36	0.0034[a]	102,440	0.61	440
36-37	0.0034[a]	100,570	0.60	430
37-38	0.0032	100,570	0.56	410
38-39	0.0034[a]	100,570	0.60	430
39-40	0.0034[a]	91,990	0.55	400
1940-41	0.0034[a]	80,880	0.48	350
41-42	0.0034[a]	84,510	0.50	360
42-43	0.0034	76,590	0.46	330
43-44	0.0034[a]	80,330	0.47	340
44-45	0.0034[a]	81,210	0.48	350
1945-46	0.0034[a]	77,690	0.46	330
46-47	0.0034[a]	76,630	0.46	330
47-48	0.0033	78,130	0.45	330
48-49	0.0030	77,250	0.41	300
49-50	0.0029	77,030	0.39	280
1950-51	0.0032	78,240	0.44	320
51-52	0.0028	78,570	0.38	280
52-53	0.0027	85,500	0.40	290
53-54	0.0025	82,090	0.36	260
54-55	0.0029	81,980	0.42	300
1955-56	0.0032	81,320	0.46	330
56-57	0.0018	82,970	0.26	190
57-58	0.0011	86,160	0.21	160
29-Year Average 1929-1957				340

a. Gradient adjusted downwards to grade of Los Angeles River channel = 0.0034.

b. Based on weighted average permeability = 1,132 gallons per day (100% hydraulic gradient) and rounded off to nearest 10 acre-feet.

A series of cross sections and bedrock contours (Plate 6) drawn through the subarea indicate that the bedrock is lower in the La Canada-Pickens Canyon area and that the area east of the bedrock ridge slopes to the Monk Hill Basin. Available ground water levels indicate that the ridge obstructs the flow of ground water and acts as a ground water barrier under low water table conditions such as in the fall of 1958, but not in high water table years such as 1944 when the water is above the ridge.

The amount of underflow from the Verdugo Subarea to Monk Hill Basin and the amount leaving the area of investigation were calculated at the narrowest section of the valley fill east of the boundary between Verdugo and Monk Hill. This section crosses Foothill Boulevard approximately halfway between the boundary of the area of investigation and Pickens Canyon Wash. These calculations indicate that the amount of underflow was approximately 250 acre-feet during 1928-29 and 400 acre-feet for 1943-44. Values for individual years were estimated by correlation to water levels in the area and are listed in Table P-2.

Subsurface Flow Between Sylmar and San Fernando Hydrologic Subareas

Subsurface flow can take place between the Sylmar and San Fernando Hydrologic Subareas at the Pacoima Notch in the Pacoima Wash, and at the Sylmar Notch near the intersection of San Fernando Road and Bleeker Street in San Fernando (see Plate 5 for location). In both cases flow is in a southerly direction out of the Sylmar Hydrologic Subarea.

TABLE P-2

ESTIMATED UNDERFLOW FROM
VERDUGO HYDROLOGIC SUBAREA TO MONK HILL BASIN[a]

In Acre-Feet

Year	Underflow[b]	Year	Underflow[b]
1928-29	250	1945-46	400
29-30	250	46-47	400
		47-48	300
1930-31	250	48-49	300
31-32	250	49-50	300
32-33	250		
33-34	250	1950-51	250
34-35	250	51-52	250
		52-53	300
1935-36	300	53-54	250
36-37	300	54-55	250
37-38	300		
38-39	400	1955-56	250
39-40	400	56-57	250
		57-58	250
1940-41	400		
41-42	400	29-Year Average	
42-43	400	1928-29 to	
43-44	400	1956-57	300
44-45	400		

a. Based on hydrographs of wells 5077B and 5078.
b. Values rounded off to nearest 50 acre-feet.

A third possibility for subsurface underflow out of Sylmar Subarea exists in the vicinity of and through a gap immediately northwest of the West Cienega. No data as to the depth of alluvial fill or character of materials are available in this locale. Study of aerial photographs of the area and subsequent field investigation indicates the possible existence of a north northwesterly trending fault which crosses the West Cienega. If this fault acts as a barrier or partial barrier to the subsurface outflow a marshy condition would exist. The West Cienega was in existence before the construction of Lower San Fernando Reservoir; however, the surface water levels and ground water levels now vary with the levels in the reservoir which is located to the west of the West Cienega.

On the basis of the aforementioned, subsurface outflow in the vicinity of the West Cienega and the gap immediately northwest thereof is of small magnitude and therefore not significant.

Pacoima Notch

The Pacoima Notch is located in the Pacoima Wash where the ancestral stream has eroded a notch to a maximum depth of 55 feet in the nonwater-bearing Repetto formation (see Plate 5H). The Pacoima Notch has an area of approximately 35,000 square feet as interpreted from the drawing in Reservoirs for Irrigation, Eighteenth Annual Report of U.S.G.S., Part IV, d, by James Dix Schuyler, dated 1897. The calculation of underflow at this point is somewhat complicated by the fact that the lower portion of an old submerged dam is still in place and its effect on flow through the porous Pacoima Wash deposits is not known.

The submerged dam was built by the Maclay Rancho Water Company in 1888 and was reported to be the only submerged dam in the world at that time. It was constructed of rubble masonry using Portland cement and sand mortar. It was three feet thick at the base and two feet thick at the surface. The maximum height of the structure was 52 feet with a crest length of 550 feet. Two gathering wells were provided in the line of the dam, each four feet in diameter. The structure was founded on the relatively impervious sandstone of the Repetto formation. Schuyler states:

> "The dimensions and capacity of this novel reservoir have not been definitely determined, but in round numbers it covers an area of 300 acres and has a mean depth of 15 to 20 feet, and, although it lies on a slope of 100 feet per mile, the water passes down through the gravel so slowly that it is believed the yield is equivalent to the volume of the voids in this area to the depth mentioned. As the gravel appears to be loose and rather coarse, the voids may be considered as about one-fourth of the volume and the resultant capacity about 1,300 acre-feet of water."

This storage was in the voids of the porous channel deposits upstream from the dam. Due to leakage problems in the structure the dam was abandoned as a gravity source of water in 1915 by the Maclay Rancho Water Company. In 1917 the San Fernando Water Company installed a pump in one of the masonry gathering wells of the dam and pumped water for use in their system until 1927.

A study of the water level measurements at the submerged dam in one of the old gathering wells (5989A) indicates that during the base period 1928-57 the water levels have fluctuated between the elevation of 1,199.08 feet (January 27, 1931) and 1,224.17 feet (March 19, 1938).

The annual underflow through the Pacoima Notch as shown in Table P-3 has been calculated on the basis that the old submerged dam is still intact below 1,200 feet and that subsurface flow would occur only between the 1,200 foot elevation and the static water level above that elevation. The permeability was assumed to be 1,000 gallons per day per square foot, which compares favorably with permeabilities of similar materials below Hansen Dam which were determined by pumped well methods.

An estimate of the underflow through the Pacoima Notch under unimpaired flow conditions, i.e., without the submerged dam acting as a partial barrier was made. Utilizing an assumed permeability, as interpreted from well log 5989A, of 1,000 Meinzer Units, which does not discount for the effect of the portion of the submerged dam which is still in place, the following computations of the underflow for the high and low water surface conditions were made using the formula Q = PIA:

High water surface condition (March 18, 1938)

P = 1,000, I = 0.0125, A = 34,500 square feet wetted area

Q = 431,250 gallons per day

= 1.32 acre-feet per day or 482 acre-feet per year

Low water surface condition (January 27, 1931)

P = 1,000, I = 0.0107, A = 20,200 square feet wetted area

Q = 216,140 gallons per day

= 0.66 acre-feet per day or 241 acre-feet per year

These calculations indicate that for unimpaired flow conditions the annual flow through the Pacoima Notch varies between 241 and 482 acre-feet per year and that a mean flow for the base period would be approximately 350 acre-feet per year.

Sylmar Notch

The results of the exploratory drilling performed by the City of San Fernando, the City of Los Angeles and the Referee indicate that a notch, hereinafter called the Sylmar Notch, exists from which subsurface flow can escape the subarea, (see Plate 5H). This notch has been incised in the Saugus formation to a depth of approximately 45 feet and back-filled with Upper Pleistocene and Recent alluvial detritus. It is located between the Mission well field and the intersection of Fourth and Hubbard Streets, (see Plate 5).

The total cross-sectional area, as determined by the interpretation of the test hole logs, is on the order of 96,000 square feet. The wetted cross-sectional area, as of May 26, 1959, was planimetered to be 22,300 square feet. The gradient computed between test holes SF-1 and SF-4 (Figure A-1), is 18 feet in 600 feet or 0.030 feet per foot. Based on the average permeability values listed on page P-6 and an interpretation of the logs of test holes SF-4, SF-5 and WR-6, an average permeability of 400 Meinzer Units was selected for use in the formula Q = PIA:

TABLE P-3

ESTIMATED ANNUAL UNDERFLOW THROUGH PACOIMA NOTCH[a]

Year	Gradient	Saturated area, in square feet	Underflow[c] in acre-feet per year
1928-29	b	b	(160)[d]
29-30	b	b	(160 [d]
1930-31	b	b	(160)[d]
31-32	b	10,394	(160)[d]
32-33	0.021	6,429	150
33-34	0.020	6,311	140
34-35	0.020	8,854	200
1935-36	0.021	5,270	120
36-37	0.022	12,908	320
37-38	0.024	9,234	250
38-39	0.022	7,039	180
39-40	0.021	6,524	150
1940-41	0.024	11,122	300
41-42	0.023	8,176	210
42-43	0.023	11,060	290
43-44	0.023	9,464	250
44-45	0.023	7,599	200
1945-46	0.025	7,123	200
46-47	0.025	6,149	170
47-48	0.025	4,104	110
48-49	0.027	1,865	60
49-50	0.027	1,198	40
1950-51	0.028	62	20
51-52	0.026	6,692	190
52-53	0.030	2,666	90
53-54	0.028	1,921	60
54-55	0.028	2,498	80
1955-56	0.025	3,002	80
56-57	0.024	2,005	60
57-58	0.025	5,309	150
25-Year Average 1933-1957			160

a. Assuming submerged dam impervious below elevation 1,200 feet.

b. No water level measurements available.

c. Based on assumed permeability of 1,000 gallons per square foot per day (100% hydraulic gradient).

d. 25-year average utilized for hydrologic inventory.

P = 400 Meinzer Units, I = 0.030, A = 22,300 square feet

then Q = 267,600 gallons per day

= 0.82 acre-foot per day or 300 acre-feet per year

The 300 acre-feet computed as underflow in the Sylmar Notch is based on low ground water surface conditions in 1959. Underflow for high ground water surface conditions is estimated to be approximately 500 acre-feet per year. An average value for the base period 1928-29 through 1956-57 is thus estimated to be about 400 acre-feet per year and was utilized for purposes of hydrologic inventories.

Pumping of the Mission well field of the City of Los Angeles in June and July of 1960 has apparently resulted in the lowering of water levels (0.5, 0.39 and 0.19 feet in test holes SF-1, SF-3 and SF-4, respectively). This lowering of water levels effects a reduction in ground water slope at the section thus reducing the subsurface flow from the Sylmar Subarea through Sylmar Notch.

Subsurface Flow Between Verdugo and San Fernando Hydrologic Subareas

In 1894 the damming of the underflow of Verdugo Creek was first initiated by the Verdugo Canyon Water Company. The first dam extended only 6 feet below the surface, was 50 feet long and extended across the west branch of Verdugo Creek. In the summer of 1895, work was begun on a submerged dam that was founded on bedrock and connected to the western rock wall of the canyon. This structure extended 245 feet to the northeast.

Beyond the dam, 260 feet of cribs extended which reached a maximum depth of 29.4 feet. A 225-foot tunnel was driven in the east bank of the channel and connected to the crib by a 50-foot long cut. The total yield of these works was approximately 26 miners inches (234 gpm).

The present day submerged dam, situated approximately in the same location, was built by the City of Glendale in 1935. This structure intercepts a substantial amount of the underflow of Verdugo Canyon; however, it extends only part way across the canyon. Approximately 23,000 square feet of water-bearing material in the most easterly portion of the section (see Plate 5H) east of the east manhole of the dam is not cut off by the structure. A profile which accompanied the report of James D. Schuyler and Samuel Starrow, dated March 31, 1903, entitled "Report of Verdugo Canyon Water Company", indicated an inferred deep on the east side of the canyon which is not traversed by the present dam. A shaft 48 feet deep sunk near the portal of the 1899 Verdugo Canyon Water Company tunnel in this vicinity did not intercept bedrock.

Bedrock in the Verdugo well, which is also located 300 feet easterly of the submerged dam, is 54 feet from the ground surface. The submerged dam has approximately 3,400 square feet of cross-sectional area which is nearly normal to the course of the channel. The wing wall which extends southerly from the east manhole is not included in the above figure because it more or less parallels the general direction of ground water movement.

There is very little information available concerning the character of the materials which lie easterly of the east manhole of the submerged dam. There is no log of the materials penetrated by the Verdugo Well (3963A). With no data available from which to estimate the permeability a method devised by the U.S.G.S. for this type of situation was utilized. The method of determining permeability utilizes the specific capacity, yield factor and total saturated thickness and is based on complete penetration of the aquifer. This method was applied to the Verdugo Well (3963A) in the vicinity of the submerged dam.

The factors are expressed as follows:

$$\frac{\text{yield (gpm)}}{\text{drawdown (feet)}} = \text{specific capacity}$$

$$\frac{\text{specific capacity}}{\text{thickness of saturated material}} \times 100 = \text{yield factor}$$

$$\text{yield factor} \times 20 = \text{permeability (gpd)}$$

The number 20 is an empirical constant based on many pump tests performed by the U.S.G.S. in various points of the country and includes the average effect of well losses encountered in the tests. It should be understood that this method is to be used only when there is no other alternative.

Utilizing this method, a permeability coefficient of 350 gallons per day (Meinzers units) was obtained and applied to the saturated cross-sectional area of approximately 6,900 square feet which is not effected by the submerged dam with the slope at the section determined between Verdugo Well (3963A) and test hole No. 12 (39720) of the City of Glendale.

The underflow during 1957-58 was thus computed, by the Darcy formula, to be 78 acre-feet. Subtraction of the extractions by the Verdugo well, which amounted to 68 acre-feet during 1957-58, from the computed underflow would leave practically nothing available for subsurface flow around the submerged dam and the underflow passing the dam was considered to be nil during 1957-58. Since the diversion from the Verdugo submerged dam has fluctuated with the available supply it is deduced that the annual amounts of underflow through the base period have also been nil.

Summary of Underflow

The quantity of underflow leaving the Upper Los Angeles River area and the quantity of underflow between hydrologic subareas are summarized in Tables 31 and 32.

APPENDIX Q

CHANGE IN STORAGE

APPENDIX Q

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APPENDIX Q

CHANGE IN STORAGE

In evaluating changes in ground water storage, only changes occurring in the zone of saturation within the boundary of the valley fill area have been considered. Changes in moisture content also occur in the zone of aeration; however, such changes cannot be feasibly measured for historic periods or over large areas. The times of year when water levels are determined should be after the end of heavy pumping and before appreciable precipitation occurs in order to minimize the amount of water in transit within the zone of aeration.

Change in storage has been computed by first multiplying the area of material which was saturated or drained by the difference in water level occurring therein, thereby to evaluate the volume of fill material dewatered or saturated. This product was then multiplied by the average specific yield of this fill material as computed from the available well logs in the area. Determination of specific yield utilized is described in Appendix D.

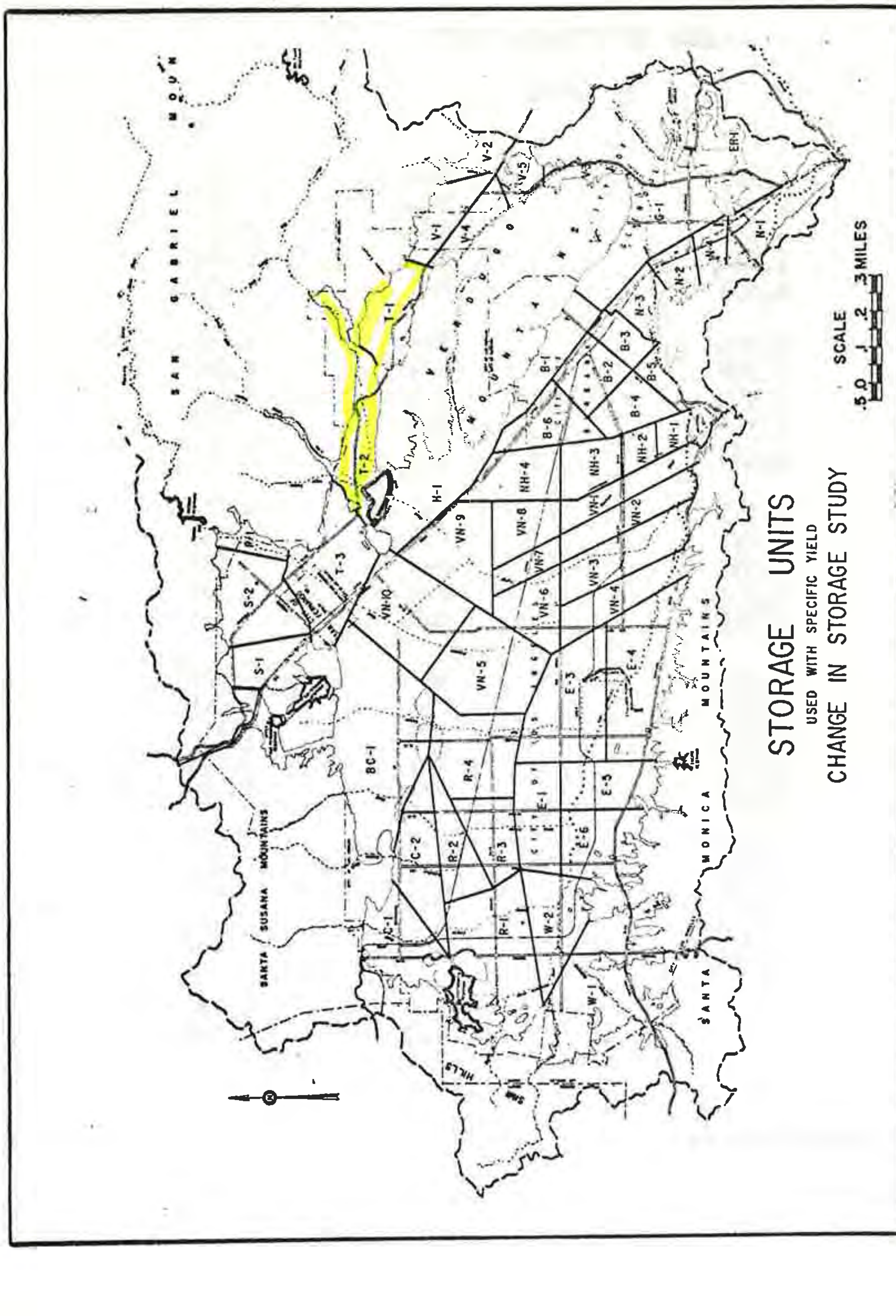
Free ground water conditions are generally found to exist in the major portion of the valley fill including the San Fernando and Verdugo Hydrologic Subareas. Confined conditions, however, are indicated in the Eagle Rock and Sylmar Hydrologic Subareas. Change in storage in the Eagle Rock Subarea was considered to have occurred only in the free water table or forebay portion thereof. This forebay comprises 535 acres or 69 percent of that small hydrologic subarea. Specific yields for this area were obtained by correlation of existing geologic information with specific yield data determined for the neighboring valley fill in the vicinity of the City of Glendale. A paucity of well data precluded a determination of the forebay extent in the Sylmar area and change in storage in this area was determined from water level changes and specific yields occurring throughout that subarea. It is believed that this approximation gives results which will not grossly affect the accuracy of the overall determination of change in storage in the combined subareas because of the relatively small specific yields used and the relatively moderate cyclic variation of water levels which has occurred in the Sylmar Subarea during the base period.

Storage Units

Water-bearing materials contained under the valley floor area vary greatly from place to place. The accuracy and quantity of water level and specific yield data also vary between areas. Because of these factors, the change in storage was not determined for the valley floor or hydrologic subareas as a whole but was determined for 52 separate storage units. The summation of the change in storage for a group of storage units was then equal to the change in storage of any desired larger area.

The storage units selected are shown on Figure Q-1. These units were delineated on the basis of containing similar lithologic properties throughout and having annual water level fluctuations of the same range and magnitude throughout. The area contained within each of the storage units is shown in Table Q-1.

FIGURE Q-1



SAN FERNANDO VALLEY REFERENCE

STORAGE UNITS

USED WITH SPECIFIC YIELD CHANGE IN STORAGE STUDY

STATE WATER RIGHTS BOARD

TABLE Q-1

AREAS OF STORAGE UNITS

In Acres

C-1	2,487	NH-1	617
C-2	2,741	NH-2	681
R-1	5,436	NH-3	1,537
R-2	1,824	NH-4	2,046
R-3	1,869	B-1	1,935
R-4	3,338	B-2	1,599
W-1	5,208	B-3	1,020
W-2	2,541	B-4	1,541
E-1 + E-2	2,278	B-5	787
E-3	4,458	B-6	1,841
E-4	4,895	G-1	4,310
E-5	2,287	N-1	2,376
E-6	2,593	N-2	957
BC-1	8,391	N-3	1,189
VN-1	1,861	N-4	792
VN-2	1,802	ER-1	536*
VN-3	2,905	T-1	2,097
VN-4	2,419	T-2	3,220
VN-5	4,110	T-3	3,994
VN-6	1,937	S-1	1,938
VN-7	837	S-2	3,320
VN-8	1,579	P-1	621
VN-9	3,166	V-1	1,553
VN-10	4,138	V-2	982
H-1	3,740	V-3	655
		V-4	1,151
		V-5	753

* Estimated forebay area.

Specific Yield

Selection of specific yield values is described in Appendix D. From a review of the variation of specific yield with thickness of fill material it was determined that the greatest depth interval that could be utilized and still maintain accuracy with a reasonable amount of computation was 25 feet. The depth interval utilized in the Bulletin 45[1] study was 50 feet. It is believed that the 25-foot interval gives a more accurate relationship between the specific yield of the materials and the zone of fluctation of the water surface.

Well logs made by drillers are subject to the interpretation of the materials penetrated and the diligence of the driller. Poor logs which had obvious errors in descriptions were not used in the change in storage study. Approximately 560 well logs were utilized in the determination of the change in storage.

1/ California State Department of Public Works, Division of Water Resources. "South Coastal Basin Investigation, Geology and Ground Water Storage Capacity of Valley Fill." Bulletin 45. 1934.

Water Levels

Ground water levels utilized in the computations are generally based on measurements as of October of each year. The beginning of the water year is considered as the best annual reference point because at this time the water surface has generally recovered from localized effects of heavy summer pumping and it is usually prior to any normal rainfall which might cause abnormalities in the ground water surface. In many instances where measurements in October were not available, measurements in November were utilized. Many of the wells in the San Fernando Valley are only measured twice a year. Prior to 1942 there were numerous monthly readings made from which ground water contour maps were constructed. Subsequent to 1942 semiannual readings were made, partly by the City of Los Angeles Department of Water and Power and partly by the Los Angeles County Flood Control District. In years when precipitation occurred prior to making ground water level measurements, and where water levels were measured subsequent to September 30, the computed change in storage may be in error for that hydrologic year and for the following hydrologic year. The error, however, will compensate during the two-year period involved. Table Q-2 lists the years in which precipitation occurred prior to measurement of ground water levels and the amount of precipitation occurring between the first of October and the date of water level measurement. In evaluating the change in ground water levels within a storage unit the change was determined at the center of the storage unit.

TABLE Q-2

PRECIPITATION DURING PERIODS OF FALL
WATER LEVEL MEASUREMENT, UPPER LOS ANGELES RIVER AREA

Year	Start of fall measurements	Precipitation*, in inches			
		October	November	December	Total
1942	November 10	0.96	0.08	-	1.04
1943	November 2	0.22	0	-	0.22
1944	November 22	0.11	4.66	-	4.77
1945	November 29	0.81	0.14	-	0.95
1946	October 30	0.80	-	-	0.80
1947	December 10	0.04	0.04	1.44	1.52
1948	November 8	0.13	0	-	0.13
1949	November 14	0.01	1.05	0	1.06
1950	November 1	0.36	0	-	0.36
1951	November 6	1.15	0	-	1.15
1952	November 26	0.01	3.82	-	3.83
1953	November 5	T	0	-	T
1954	November 19	T	1.37	-	1.37
1955	November 5	0.01	0	-	0.01
1956	November 23	0.51	0	-	0.51
1957	November 13	2.42	0.27	-	2.69
1958	November 12	0.02	T	-	0.02
1959	December 2	T	0.01	0	0.01

* Precipitation measured at Lockheed Airport Weather Bureau Station between the first of October and the date when the fall well measurements were started.

Sample Computation

The procedures used in the computations are a simplification of methods used in previous determinations in other areas. They were devised to permit a mechanical system and to eliminate, as far as possible, variations in interpretation.

Each of the storage units utilized specific yield values from logs of several wells. For simplicity, the sample computation for the first three years in the 1929-58 period has been made for a hypothetical storage unit containing only two wells with logs.

These logs, which were selected as being representative of those involved in the calculations, are shown in Table Q-3.

Specific Yield

The mean specific yield for each storage unit was computed on the form entitled "Well Group Computations" shown in the upper left portion of Figure Q-2, which is based on Form 136 utilized in Bulletin 45. The computations were broken into 25-foot depth intervals. Within each 25-foot interval the footage of each of the calls of the logs was entered in the appropriate square opposite the assigned specific yield value. The footages for each specific yield value from the separate logs were totaled and entered under total footage. These values were then multiplied by the specific yield and entered under product. The products in each 25-foot interval were added together and divided by the total footage of all the wells in the depth interval and the result entered under total yield in percent. The right-hand column, total yield in percent, represents

TABLE Q-3

LOGS FOR SAMPLE COMPUTATION

STORAGE UNIT X

Sample Log A (3814G)

0 - 15	Sandy loam
15 - 28	Gravel
28 - 39	Clay
39 - 51	Gravel
51 - 112	Clay
112 - 119	Sand and gravel
119 - 150	Blue clay

Sample Log B (3947E)

0 - 27	Brown sandy clay
27 - 30	Dry sandy clay
30 - 53	Dry sandy clay
53 - 64	Blue sand and gravel
64 - 68	Brown clay
68 - 72	Cemented sand and gravel
72 - 74	Blue clay
74 - 110	Hard yellow clay
110 - 114	Hard brown clay
114 - 121	Hard yellow clay
121 - 122	Black clay and gravel
122 - 123	Sandstone
123 - 133	Black clay and sand
133 - 134	White sand cemented
134 - 142	Black clay
142 - 148	Decomposed granite
148 - 150	Hard granite

weighted averages for a composite log and is considered to be located in the center of the storage unit.

Water Levels

Form CS-1, shown in the upper right portion of Figure Q-2, lists the average water surface elevation existing at approximately the beginning of each water year. The elevation of the water surface was obtained from hydrographs of well measurements and ground water contour maps.

Form CS-2, shown in the lower left portion of Figure Q-2, lists the average ground surface elevation of the storage unit as well as elevations for 25-foot intervals below ground surface. The average specific yield for each 25-foot interval is repeated opposite the proper interval.

Change in Storage

The steps in computing change in storage are shown on Form CS-3, shown in the lower right portion of Figure Q-2. Column 2 is the difference in water levels between water years. Column 3 is column 2 multiplied by the number of acres within the storage unit, the number of acres in the storage unit being shown at the top of the form. Column 5 is column 3 multiplied by average specific yield for the 25-foot interval (column 4). When the change in water surface occurs in more than one of the 25-foot intervals, as in 1930-31, a separate computation is made for the change in each different 25-foot interval. Column 6 is a summation of the change in the various 25-foot intervals shown in column 5.

SAMPLE FORMS USED IN CHANGE IN STORAGE COMPUTATIONS

Form 138 — STATE OF CALIFORNIA

INVESTIGATION **WELL GROUP COMPUTATIONS** SHEET 1 of 1

SAN FERNANDO VALLEY — BASIN San Fernando

REFERENCE — GROUP DESIGNATION X

WELL NUMBER		TOTAL FOOTAGE "A"	"B"		
LOCATION IN COORDINATE	EAST				
	SOUTH				
SURFACE ELEVATION					
ELEVATION USED FOR WELL GROUP					
DEPTH OF WELL IN FEET					
UNLOGGED THICKNESS IN FEET					
DEPTH TO BEDROCK IN FEET					
WATER BEARING FORMATION FEET LOGGED					

DEPTHS	YIELD VALUE	"A"	"B"	GROUP TOTAL FOOTAGE	GROUP PRODUCT		TOTAL YIELD PER CENT
0-25	3-5		25	25	125		
	10-14	15		15	150	405/50	9.70
	16-19						
	21-26	10		10	210		
25-50	3-5	11	25	11	33 / 125		
	10-14					452/50	9.04
	16-19						
	21-26	14		14	[illegible]		
50-75	3-5	24	7 / 4 / 3	[illegible] / 4	15 / 60		
	10-14					370/50	7.56
	16-19		11	11	209		
	21-26	1		1	21		
75-100	3-5	25	25	50	150		
	10-14					150/50	3.00
	16-19						
	21-26						
100-125	3-5	10	21 / 4	39 / 4	117 / 20		
	10-14					270/50	5.40
	16-19	7		7	133		
	21-26						
125-150	3-5	25	0 / 15	33 / 15	99 / 75		
	10-14					174/48	3.63
	16-19						
	21-26						

89.-148 feet

Form CS-1

Sheet 1 of

Entered By RHB
Date 7/15/59
Checked By GAB
Date 7/15/59

E X A M P L E

Storage Unit X

October of year	Water surface elevation of composite well in feet
1928	498.3
29	500.6
1930	501.7
31	496.2
32	
33	
34	
1935	
36	
37	
38	
39	
1940	
41	
42	
43	
44	
1945	
46	
47	
48	
49	
1950	
51	
52	
53	
54	
1955	
56	
57	
58	

Form CS-2

E X A M P L E

Computed By RHB
Date 7/15/59
Checked By GAB
Date 7/15/59

Storage Unit X

Ground surface elevation of composite well: in feet	Depths of interval below ground surface in feet	Elevations of interval in feet	Average specific yield of interval
573	0-25	573-548	9.7
	25-50	548-523	9.0
	50-75	523-498	7.6
	75-100	498-473	3.0
	100-125	473-448	5.4
	125-150	448-423	3.6

Form CS-3

Sheet 1 of

E X A M P L E

Computed By RHB
Date 7/15/59
Checked By GAB
Date 7/15/59

Storage Unit X - 10,000 Acres

October of year	(1)* Water surface elevation in feet	(2) Difference in elevation (+ or -) in feet	(3)=(2)x10,000 acres Volume of increment (+ or -) in acre-feet	(4)** Average specific yield of respective interval in: per cent	(5)=(3)x(4) Change in storage within increment (+ or -) in acre-feet	(6)= sum of column (5) Total change in storage (+ or -) in acre-feet
1928	498.3					
1929	500.6	+ 2.3	+ 23,000	7.6	+ 1,748	+ 1,748
1929	500.6					
1930	501.7	+ 1.1	+ 11,000	7.6	+ 836	+ 836
1930	501.7					
	498.0	- 3.7	- 37,000	7.6	- 2,812	- 3,352
1931	496.2	- 1.8	- 18,000	3.0	- 540	

* From Form CS-1
** From Form CS-2

The change in storage for each of the storage units shown on Figure Q-1 is listed in Table Q-4. These results, summarized by hydrologic subareas in the area of investigation, are also shown in Table Q-4.

The data indicates that heavy pumping continued in the eastern portion of the San Fernando Subarea through the fall of 1956 until the end of January 1957, whereas the heavy pumping stopped by the end of November in other years. Computations showed that cones of depression resulted in an apparent excess of water removed from storage and is reflected by the large change in storage for the year 1955-56 as shown in Table Q-4. Adjustment of change in storage for 1955-56 is difficult due to a lack of water level measurements for January through February 1957. A straight line correction for the years 1955-56 and 1956-57 may be applied to obtain an estimate of change in storage for the year 1955-56 and would result in a modified cumulative change in storage for 1955-56 of minus 308,870 acre-feet.

TABLE Q-4

CHANGE IN STORAGE, BASED ON SPECIFIC YIELD AND WATER LEVELS

In Acre-Feet

Year	San Fernando plus Eagle Rock Hydrologic Subareas														
	C-1	C-2	R-1	R-2	R-3	R-4	W-1	W-2	E-1+E-2	E-3	E-4	E-5	E-6	BC-1	VN-1
1928-29	-373	-1,579	-587	-89	+179	-371	-318	-264	-91	-571	-925	+190	0	-2,389	-856
29-30	0	+592	0	-89	-90	-742	0	0	+182	-1,427	-1,542	+380	+1,411	-2,389	-642
1930-31	+746	-197	+587	+89	-90	+371	-318	-264	-182	-571	0	-1,139	-882	-2,389	-661
31-32	+746	-789	+587	0	+179	-1,112	+318	+264	+91	-3,134	0	+1,329	0	+1,593	+875
32-33	0	+1,184	-1,174	+89	0	+2,225	+318	0	-91	-379	-308	+380	+176	+2,389	+1,070
33-34	-373	-395	0	-89	0	0	0	0	+91	-379	-308	-1,708	-176	0	-428
34-35	-373	+197	-549	0	0	-371	0	+132	-91	-758	-4,420	+1,139	+882	+1,593	+856
1935-36	0	-1,184	-549	-268	-179	-1,112	-635	-132	+273	+2,653	+4,420	+190	+353	+796	-214
36-37	+2,427	+197	+1,098	+179	+179	-2,225	+635	0	-273	+1,712	+617	-190	-1,234	+1,593	+1,498
37-38	+420	+987	+1,761	+89	-90	+5,192	0	0	+91	+1,997	+1,234	+380	+1,411	+3,604	+1,926
38-39	-841	+1,184	+587	+536	-90	-744	-318	+132	0	-1,427	-1,234	-380	-1,411	+608	+214
39-40	-841	-592	-587	-89	+179	+1,112	-318	-132	+182	+285	-308	+380	0	-608	-642
1940-41	+2,942	+1,184	+3,523	+358	+449	+371	+1,906	+529	+91	+1,427	+2,467	+1,329	+1,587	+5,468	+1,848
41-42	-1,681	+592	+587	+89	-359	+371	0	-132	+91	-285	+2,467	-380	-1,763	+1,215	-452
42-43	+1,261	0	+1,761	+89	+179	+742	+318	+132	-182	+1,427	+617	-1,329	+176	+3,645	+452
43-44	+420	+789	+1,761	+830	+269	+742	+500	+132	+182	+856	-5,243	+3,705	+2,292	+3,645	+301
44-45	-841	+197	+1,761	-383	-269	+371	-818	-529	-182	-285	+2,159	-3,895	-2,469	+1,108	-904
1945-46	0	+1,423	-1,174	+383	+179	+742	0	0	+364	0	-617	0	-529	-4,753	-817
46-47	-420	-685	0	-383	0	-742	-635	0	-182	-856	+617	-380	+529	-1,822	-1,284
47-48	-841	+343	-587	+383	+359	-742	-318	-132	0	-1,141	0	+190	+882	-3,038	-2,140
48-49	+420	+343	-587	0	-179	-371	-635	0	-364	+571	+308	+759	-882	-3,645	-2,605
49-50	-420	-343	+1,174	+115	-628	0	-318	-132	+91	-2,853	-1,542	-380	+353	-1,822	-447
1950-51	+420	+1,028	0	+689	+449	+371	-318	-132	0	+1,141	+1,234	+569	+353	-2,808	-2,233
51-52	+841	+2,056	+1,761	+230	+269	-4,079	+635	+132	-182	-1,141	-308	-2,088	+705	+1,593	-1,117
52-53	-841	-343	-1,174	0	-449	0	0	0	+182	-3,322	+1,234	+3,417	-529	-1,593	-1,224
53-54	-420	0	-587	-919	+359	+371	0	0	-638	-4,547	-617	-3,037	-705	-3,185	-1,656
54-55	-420	-1,028	-587	+575	-538	-1,483	+318	-132	0	+758	-2,159	+380	-705	-4,778	-1,325
1955-56	-420	-343	-2,935	-804	-179	-371	+953	0	-456	-5,002	+3,392	+380	+1,234	-3,185	-1,202
56-57	0	-685	+1,761	+345	+90	-1,483	+635	-396	+1,002	+303	-617	+2,639	+529	-3,185	+125
57-58	+420	+1,028	-587	+689	0	+742	+1,250	+132	-638	-3,031	-925	-1,310	0	+796	-1,247

CHANGE IN STORAGE, BASED ON SPECIFIC YIELD AND WATER LEVELS
(continued)

In Acre-Feet

Year	San Fernando plus Eagle Rock Hydrologic Subareas														
	VN-2	VN-3	VN-4	VN-5	VN-6	VN-7	VN-8	VN-9	VN-10	H-1	NH-1	NH-2	NH-3	NH-4	B-1
1928-29	-476	0	+215	-2,137	-2,708	-733	-1,003	-2,508	-8,714	-1,819	-89	-188	-1,314	-2,488	-387
29-30	-634	-241	0	-164	+225	-105	-549	-2,280	-8,566	-910	-74	-188	-262	+622	-194
1930-31	-159	-723	-431	-1,972	-1,123	-523	-742	-1,140	-3,186	-910	-74	-376	-1,314	-1,244	-97
31-32	+793	+964	+646	+1,315	+2,247	+1,464	+2,495	+6,839	+11,752	+4,995	+74	+282	+1,840	+3,732	+290
32-33	+476	+723	+431	+822	+1,130	+523	+1,003	+3,191	+571	+1,788	+341	+470	+1,840	+2,205	+290
33-34	0	+282	+968	0	-1,130	-523	-1,404	-912	-6,281	-1,788	-267	-376	-1,840	-2,828	+290
34-35	+317	+1,127	0	-493	+1,360	+837	+2,005	+3,191	+16,213	+4,469	+133	+94	+2,103	+3,847	0
1935-36	-476	+282	+358	+493	+461	-209	-602	-912	+2,383	-2,682	-44	+188	-262	-1,981	+677
36-37	+1,427	+1,972	+1,432	+493	+461	+523	+1,805	+3,191	-2,383	+3,575	+89	+460	+1,314	+4,018	-290
37-38	+1,768	+564	+716	+2,030	+3,227	+1,435	+3,144	+6,595	+13,300	+5,363	+89	+634	+3,578	+4,076	+509
38-39	+196	0	+1,969	-193	-231	-201	-1,017	-1,608	-3,766	-4,022	-44	+91	-286	-2,038	+488
39-40	-982	-564	-1,611	0	-1,153	-711	-1,926	-5,443	-2,383	-1,788	0	-272	-2,766	-3,736	-244
1940-41	+2,750	+3,100	+1,790	+2,125	+2,914	+2,117	+5,740	+12,348	+10,667	+10,581	+133	+634	+5,625	+8,491	+488
41-42	-982	-1,409	0	-580	-227	-703	-2,288	-472	-4,519	-6,558	-133	0	-1,715	-3,057	0
42-43	+589	+1,691	-358	+1,932	+680	+1,004	+2,796	+1,415	+3,766	+5,498	-89	-181	-1,715	+3,736	+366
43-44	+393	+282	0	+773	+302	+301	+508	+1,887	+17,851	+3,180	+222	+543	+572	+340	+731
44-45	-589	-1,409	-537	-773	-755	-1,205	-3,559	-4,106	-24,630	-9,570	-44	-272	-3,431	-5,434	-1,219
1945-46	-1,375	-564	-537	-773	-1,070	-904	-2,796	-4,021	-3,136	+1,341	-89	-543	-2,241	-1,359	-610
46-47	-1,375	-1,127	0	0	-231	-100	-201	-1,608	-5,959	-4,022	-89	-453	-1,051	-2,717	-993
47-48	+196	-1,409	-716	-1,545	-1,614	-1,033	-2,807	-4,987	+1,192	-3,128	-281	-829	-4,205	-3,253	-1,355
48-49	-2,175	-2,536	-1,074	-386	-2,536	-1,465	-2,302	-5,471	-7,746	-3,137	-444	-1,034	-2,731	-5,598	+387
49-50	-634	-1,488	-1,183	-1,788	-1,815	-628	-742	-4,103	-2,284	-2,274	-666	-940	-1,214	-1,232	-2,322
1950-51	-1,427	-1,447	-1,722	-822	-1,348	-1,151	-1,781	-5,015	-10,279	-2,274	-913	-746	-2,914	-4,268	-677
51-52	0	-723	0	-329	-899	-105	+594	+3,419	+2,284	+13,048	-481	-373	0	+2,439	-342
52-53	-503	-964	-1,292	-986	-1,123	-314	-1,484	-4,559	-8,574	-6,257	-1,427	-840	-1,992	-5,183	-799
53-54	-2,042	-2,394	-1,722	-1,644	-1,326	-1,262	-2,136	-4,559	-5,230	-3,152	-896	-1,294	-2,988	-319	-913
54-55	+742	-2,118	-718	-329	-746	-1,169	-2,136	-4,511	-7,248	-3,638	-299	-754	-4,158	-2,873	-963
1955-56	-3,930	-3,530	-3,592	-1,644	-678	-1,164	-3,223	-5,224	-6,368	-1,364	-1,066	-462	-1,214	+5,504	-3,290
56-57	+6,366	-1,177	-958	-164	-1,075	-203	+1,200	-4,702	-4,246	-1,819	+168	-129	+729	-1,074	+658
57-58	-7,141	-706	-999	+493	-1,612	-1,215	-2,400	+522	+5,661	+11,314	-898	-386	-2,186	+358	+1,809

TABLE Q-4

CHANGE IN STORAGE, BASED ON SPECIFIC YIELD AND WATER LEVELS
(continued)

In Acre-Feet

Year	San Fernando plus Eagle Rock Hydrologic Subareas														
	B-2	B-3	B-4	B-5	B-6	G-1	N-1	N-2	N-3	N-4	ER-1	T-1	T-2	T-3	Total
1928-29	- 812	-1,357	- 456	- 634	-1,245	-1,043	- 542	- 352	- 352	- 266	- 93	0	-1,555	- 503	- 41,603
29-30	- 812	0	- 456	+ 91	- 583	- 862	+1,083	+1,409	+2,611	+ 521	- 93	0	-1,020	0	- 15,787
1930-31	0	0	- 912	+ 181	-1,635	-2,155	- 271	- 176	- 499	- 122	- 93	+ 214	-1,530	- 503	- 26,415
31-32	+1,015	+ 228	+ 456	+ 272	+2,218	+3,017	+1,896	+2,770	+1,498	+1,220	+278	+ 428	+7,314	+4,026	+ 67,311
32-33	+1,218	+ 528	+ 912	0	+1,556	+2,086	+ 813	+ 388	+ 125	+ 122	- 93	- 214	-1,070	-1,510	+ 26,544
33-34	0	- 150	- 684	- 362	-1,556	-1,043	- 542	-1,045	-1,498	0	- 93	0	-1,601	- 503	- 28,651
34-35	- 203	+ 300	+ 228	+ 272	+2,178	+ 522	0	- 352	- 301	- 122	0	0	+1,070	+1,006	+ 38,038
1935-36	+ 812	- 300	0	0	- 622	+ 522	0	+ 528	+ 925	+ 122	- 93	- 428	-2,649	0	+ 903
36-37	- 203	- 150	+ 912	- 91	+1,867	0	+ 271	- 528	+ 125	- 244	+185	+ 214	+3,184	+1,006	+ 30,848
37-38	+1,285	- 343	+2,053	0	+3,111	0	-3,521	-1,057	-2,282	- 610	+185	+ 642	+ 535	+2,013	+ 66,609
38-39	- 473	+ 643	- 684	0	- 311	+ 522	+ 271	+1,409	+1,783	+ 122	-185	0	+ 535	-2,516	- 12,730
39-40	+ 237	0	0	- 91	-2,489	- 522	0	- 528	-1,255	- 122	-185	- 214	-1,605	- 503	- 32,835
1940-41	+1,420	+ 600	+ 912	+ 181	+4,986	+1,043	0	+ 704	+1,629	+ 122	+ 93	+2,567	+2,674	+5,032	+116,945
41-42	- 473	- 300	+ 684	+ 181	-1,563	+ 522	0	- 352	0	- 122	+ 93	- 856	-2,139	-4,529	- 31,137
42-43	+ 473	+ 300	-1,140	+ 181	+ 937	- 522	- 542	0	- 499	0	+ 93	+ 856	+1,070	- 503	+ 31,122
43-44	+ 237	-1,014	+ 684	- 181	+ 940	- 522	+ 271	-1,233	-1,306	0	+ 93	+1,560	+1,070	+7,633	+ 47,298
44-45	- 947	+ 264	- 456	- 91	-3,434	-1,043	+ 271	- 528	- 352	0	0	-1,774	+ 535	-4,110	- 74,177
1945-46	-1,556	- 150	- 684	0	-2,489	-1,996	0	-1,409	- 880	- 122	-185	-1,069	+ 535	0	- 33,481
46-47	-1,218	- 685	-1,596	- 453	-1,556	-1,293	0	- 352	- 528	- 122	+ 93	-1,497	-2,674	-3,019	- 41,069
47-48	-1,856	- 914	-1,368	-1,177	-4,318	-1,724	- 542	- 344	- 880	- 244	-185	-2,661	-2,674	-1,510	- 52,953
48-49	-2,000	- 228	-1,825	+ 362	-2,995	- 862	+ 271	- 168	-1,182	0	-464	-1,566	-1,555	+ 503	- 56,824
49-50	-1,298	- 343	-2,053	- 930	-1,688	-1,293	- 271	- 337	-1,753	- 399	0	-1,044	- 510	-1,006	- 43,390
1950-51	-1,113	-2,798	-2,743	-1,546	-3,908	-1,724	0	-1,347	-2,074	0	+185	0	-1,020	+1,006	- 53,103
51-52	-1,917	+ 755	0	+ 412	0	- 431	+ 271	- 168	+ 480	- 133	+278	+4,630	+8,968	+3,019	+ 34,003
52-53	- 496	-2,264	-4,592	-1,941	-3,257	0	- 594	-2,672	-3,048	- 665	- 93	+2,139	-6,928	-3,019	- 68,369
53-54	-2,478	+1,057	- 902	- 938	-2,124	-3,017	- 323	-1,139	-1,602	- 532	+185	+2,617	+1,580	-1,510	- 56,584
54-55	-1,487	- 453	-1,848	-1,055	-2,942	-1,332	+ 646	0	+ 319	+ 399	- 93	0	-1,070	- 503	- 51,461
1955-56	-4,213	-4,623	-1,939	- 806	-4,177	- 888	- 323	- 325	-1,434	0	- 93	-1,975	0	+ 503	- 71,484
56-57	+ 496	+ 645	- 129	- 95	-1,235	-1,332	+ 323	- 163	- 159	- 399	+ 93	+ 642	-1,020	+1,510	- 6,186
57-58	-1,735	-1,877	-2,201	-1,333	+1,852	-1,332	0	-1,139	-4,580	- 133	+ 93	-1,283	+3,159	+1,510	- 9,066

CHANGE IN STORAGE, BASED ON SPECIFIC YIELD AND WATER LEVELS
(continued)

In Acre-Feet

Year	Sylmar Hydrologic Subarea				Verdugo Hydrologic Subarea*						Total Valley Fill Area	
	S-1	S-2	P-1	Total	V-1	V-2	V-3	V-4	V-5	Total	Total	Cumulative total
1928-29	0	0	- 65	- 65	- 511	-344	- 101	- 147	- 267	-1,370	- 43,038	- 43,038
29-30	+ 169	+ 315	-190	+ 294	- 511	-344	- 101	- 147	- 267	-1,370	- 16,863	- 59,901
1930-31	0	+1,262	-243	+1,019	- 292	-196	- 101	- 442	- 400	-1,431	- 26,827	- 86,728
31-32	+1,195	+ 830	+433	+2,458	+ 73	+ 49	- 202	+ 147	0	+ 67	+ 69,836	- 16,892
32-33	+ 180	- 514	-190	- 524	+ 292	+196	- 202	- 147	- 400	- 261	+ 25,759	+ 6,867
33-34	- 529	+ 514	- 61	- 76	+ 584	+393	+ 101	0	+ 533	+1,611	- 27,116	- 18,249
34-35	- 169	-1,145	+187	-1,127	+ 219	+147	+ 504	0	+ 800	+1,670	+ 38,581	+ 20,332
1935-36	- 169	- 315	-248	- 732	+ 146	+ 98	+ 511	- 147	- 267	+ 341	+ 512	+ 20,844
36-37	+ 169	+ 315	+893	+1,377	+ 469	+246	+ 817	+1,284	+1,200	+4,016	+ 36,241	+ 57,085
37-38	+ 518	+1,544	-194	+1,868	+ 969	+687	+1,877	+2,279	+2,132	+7,944	+ 76,421	+133,506
38-39	0	+ 598	-452	+ 146	+1,025	- 49	- 186	+1,241	+ 449	+2,480	- 10,104	+123,402
39-40	-1,703	-1,826	-126	-3,655	- 75	- 49	- 93	-1,114	- 785	-2,116	- 38,606	+ 84,796
1940-41	+2,782	+2,424	+836	+6,042	+ 820	+737	+ 372	+1,721	+1,380	+5,030	+128,017	+212,813
41-42	- 360	- 797	-452	-1,609	0	+ 98	- 372	- 203	- 931	-1,408	- 34,154	+178,659
42-43	- 901	+ 598	+323	+ 20	+ 224	0	+ 558	+ 608	0	+1,390	+ 32,532	+211,191
43-44	+1,622	0	-129	+1,493	+ 149	- 49	+ 186	- 405	+ 449	+ 330	+ 49,121	+260,312
44-45	+ 360	- 398	-258	- 296	- 373	-393	- 186	-1,721	0	-2,673	- 77,146	+183,166
1945-46	+ 901	0	+ 65	+ 966	- 373	-344	-2,361	-1,139	-1,459	-5,676	- 38,191	+144,975
46-47	-1,262	- 199	- 65	-1,526	- 224	-295	-1,427	-1,814	-1,501	-5,261	- 47,856	+ 97,119
47-48	-1,622	- 598	-258	-2,478	- 298	-344	0	-3,241	-2,799	-6,682	- 62,113	+ 35,006
48-49	-1,353	-2,921	0	-4,274	- 230	-295	-1,009	-2,319	-4,367	-8,220	- 69,318	- 34,312
49-50	- 169	+ 315	-122	+ 24	+ 81	- 98	- 605	- 511	-1,118	-2,251	- 45,617	- 79,929
1950-51	- 338	- 315	- 61	- 714	- 646	- 98	+1,412	- 632	- 373	- 337	- 54,154	-134,083
51-52	+2,041	+1,262	+635	+3,938	+ 81	-196	+2,650	+2,165	+4,721	+9,421	+ 47,362	- 86,721
52-53	- 857	-1,577	-129	-2,563	+ 81	+638	- 307	- 767	-1,242	-1,597	- 72,529	-159,250
53-54	- 330	- 315	-129	- 782	- 81	-196	- 613	-1,761	- 497	-3,148	- 60,514	-219,764
54-55	- 846	+ 315	- 65	- 596	- 81	-196	- 920	+2,527	- 745	+ 585	- 51,472	-271,236
1955-56	- 508	-1,577	-190	-2,275	+ 323	- 49	+ 204	0	+1,864	+2,342	- 71,417	-342,653
56-57	0	-1,262	-243	-1,505	0	+442	+ 409	+1,592	+1,491	+3,934	- 3,757	-346,410
57-58	+ 677	- 946	+498	+ 229	- 162	- 49	+1,226	+ 884	+2,666	+4,565	- 4,272	-350,682

* Includes the portion of the Monk Hill Basin within the Upper Los Angeles River area.

APPENDIX R

GROUND WATER RECHARGE AND SAFE YIELD

APPENDIX R

TABLE OF CONTENTS

TABLES

APPENDIX R

GROUND WATER RECHARGE AND SAFE YIELD

Contained herein are tables and computations which support and elaborate on determinations made in Chapters VI and VII.

Ground Water Recharge

The ground water recharge is determined in this report as supply less the consumptive use and outflows of that supply. The consumptive use adopted by the Referee is based on the unit consumptive use values listed in Tables L-13, L-14 and L-15, the land use shown in Table K-6, and the adjustments to consumptive use determined in Chapter VI. The annual adjustment to the consumptive use of rain is expressed as 30 percent of the difference between annual precipitation on the pervious valley fill area in acre-feet and the 29-year average precipitation thereon. In years when precipitation is above normal, the adjusted consumptive use of rain is greater than the unadjusted value and in years of below normal precipitation the adjusted value is less than the unadjusted value. The consumptive use of delivered water is adjusted by reducing its annual amount by an amount equal to five percent of the sum of consumptive use and deep percolation for residential land use areas. For convenience, the adjustment of the consumptive use of delivered water may be made by adjusting the unit value of consumptive use for residential land use areas. The adjusted unit values for consumptive use of delivered water on residential land use areas are shown in Table R-1.

TABLE R-1

FINAL ADJUSTED UNIT DEPTHS OF CONSUMPTIVE USE OF RESIDENTIAL DELIVERED WATER

In Acre-Feet Per Gross Acre

Year	Consumptive use		
	San Fernando and Eagle Rock Subareas	Sylmar Subarea	Verdugo Subarea
1928-29	0.77	0.74	0.57
29-30	0.76	0.71	0.62
1930-31	0.67	0.66	0.60
31-32	0.39	0.38	0.53
32-33	0.37	0.37	0.61
33-34	0.41	0.40	0.77
34-35	0.31	0.30	0.66
1935-36	0.39	0.36	0.66
36-37	0.35	0.32	0.72
37-38	0.34	0.34	0.67
38-39	0.49	0.47	0.77
39-40	0.45	0.45	0.84
1940-41	0.33	0.33	0.62
41-42	0.50	0.49	0.89
42-43	0.56	0.55	0.74
43-44	0.56	0.56	0.73
44-45	0.69	0.67	0.73
1945-46	0.75	0.79	0.83
46-47	0.91	0.90	0.84
47-48	1.05	1.04	0.99
48-49	1.11	1.10	0.87
49-50	1.07	1.04	0.82
1950-51	1.14	1.12	0.93
51-52	0.95	0.93	0.77
52-53	1.18	1.15	0.98
53-54	1.12	1.11	0.92
54-55	1.10	1.10	0.92
1955-56	1.06	1.05	0.98
56-57	1.21	1.22	0.98
57-58	1.01	1.00	0.97
29-Year Average 1929-57	0.72	0.71	0.78

Safe Yield

The method for determining safe yield is discussed in Chapter VII. The safe yield for any year is computed by superimposing the land use in existence during the safe yield year over a normal period of precipitation. The magnitude and regimen of occurrence of annual precipitation during the 29-year base period, 1928-29 through 1956-57, have been taken as equivalent to a long-time mean or normal precipitation. The varying land use trends and economic conditions occurring during the 29-year base period have been considered in the determination of safe yield. The variation in the composition of residential land use areas has been compensated for by adjusting the weighted unit values for residential areas to reflect the composition existing during each of the safe yield years (see Appendix L). The change between economic conditions existing during the earlier years of the base period and those existing in the latter years was significant; therefore, the mean for the 29-year base period could not be used to determine averages for items influenced by economics. The 9-year subperiod of normal precipitation on the valley floor was utilized as being representative of economic conditions extant during the safe yield years.

Adjustment of Weighted Unit Values Under Safe Yield Conditions

The weighted unit values for consumptive use and deep percolation shown in Tables L-13, L-14 and L-15 are weighted according to the percent impervious and types of land use within each classification. Under safe yield culture conditions, all of the land use classes with the exception of residential have a constant percent of the area impervious during the base period. As discussed in Appendix L, percentages of residential lot areas containing deciduous trees, lawns, gardens, native vegetation and impervious areas have varied during the 29-year base period. The adjusted unit values for residential land use classes were therefore reweighted to correspond to the percentages which existed in each safe yield year. The mean weighted unit depths of consumptive use and deep percolation for the 9-year subperiod for each land use class and hydrologic subarea are shown in Table R-2.

Average Consumptive Use and Deep Percolation of Delivered Water and Average Consumptive Use of Precipitation for Safe Yield Computation

The average amounts of consumptive use and deep percolation of delivered water for the various land use classes within each subarea for the three safe yield years are shown in Table R-3. With the exception of water surface and commercial and industrial land use, which are discussed and derived in Chapter VII of this report, these average amounts are the product of the 9-year average weighted depths of consumptive use and deep percolation (Table R-2) and the acreage of each type of land use (Table K-6) in each subarea.

Table R-4 itemizes the average consumptive use of precipitation under safe yield culture. These amounts were computed utilizing the 9-year average weighted depths of consumptive use of precipitation (Table R-2) and the acreage of each land use class (Table K-6).

TABLE R-2

MEAN WEIGHTED DEPTHS OF CONSUMPTIVE USE AND DEEP PERCOLATION, 9-YEAR SUBPERIOD 1949-50 THROUGH 1957-58

In Acre-Feet Per Gross Acre

Culture class	Consumptive use			Deep percolation		
	Rain	Delivered: water	Total	Rain	Delivered: water	Total
San Fernando Subarea						
Deciduous	1.12	1.40	2.52	0.17	0.20	0.37
Citrus	1.04	1.54	2.58	0.25	0.36	0.61
Walnuts	1.10	1.44	2.54	0.19	0.25	0.44
Truck	1.07	1.62	2.69	0.22	0.54	0.76
Alfalfa and pasture	1.11	1.84	2.95	0.18	0.27	0.45
Vineyard	1.12	1.09	2.21	0.17	0.23	0.40
Lawn grass	1.04	2.63	3.67	0.29	0.57	0.86
Dry farm and native vegetation	1.16	--	1.16	0.13	--	0.13
Miscellaneous	0.81	--	0.81	0.07	--	0.07
Commercial and industrial	0.43	--	--	--	--	--
Residential[a]						
1949-50	0.72	1.09	1.81	0.22	0.23	0.45
1954-55	0.68	1.09	1.77	0.21	0.23	0.44
1957-58	0.66	1.09	1.76	0.21	0.22	0.43
Sylmar Subarea						
Deciduous	1.20	1.33	2.53	0.25	0.23	0.48
Citrus	1.11	1.47	2.58	0.33	0.36	0.69
Walnuts	1.17	1.39	2.56	0.27	0.26	0.53
Truck	1.15	1.43	2.58	0.29	0.56	0.85
Alfalfa and pasture	1.21	1.77	2.98	0.24	0.29	0.53
Vineyard	1.21	1.05	2.26	0.24	0.23	0.47
Lawn grass	1.15	2.52	3.67	0.39	0.69	1.08
Dry farm and native vegetation	1.28	--	1.28	0.16	--	0.16
Miscellaneous	0.93	--	0.93	0.09	--	0.09
Commercial and industrial	0.50	--	--	--	--	--
Residential[a]						
1949-50	0.89	1.07	1.96	0.27	0.24	0.51
1954-55	0.86	1.07	1.93	0.27	0.24	0.51
1957-58	0.82	1.08	1.90	0.28	0.23	0.51

TABLE R-2

MEAN WEIGHTED DEPTHS OF CONSUMPTIVE USE AND DEEP PERCOLATION, 9-YEAR SUBPERIOD 1949-50 THROUGH 1957-58 (continued)

In Acre-Feet Per Gross Acre

Culture class	Consumptive use			Deep percolation		
	Rain	Delivered: water	Total	Rain	Delivered: water	Total
Verdugo Subarea						
Deciduous	1.28	1.30	2.58	0.43	0.26	0.69
Citrus	1.18	1.43	2.61	0.51	0.42	0.93
Truck	1.23	1.51	2.74	0.46	0.60	1.06
Lawn grass	1.28	2.39	3.67	0.55	0.81	1.36
Dry farm and native vegetation	1.40	--	1.40	0.29	--	0.29
Miscellaneous	1.00	--	1.00	0.16	--	0.16
Commercial and industrial	0.49	--	--	--	--	--
Residential[a]						
1949-50	0.95	0.92	1.87	0.44	0.23	0.67
1954-55	0.95	0.92	1.87	0.44	0.23	0.67
1957-58	0.87	0.93	1.80	0.45	0.22	0.67

a. Adjusted to percentages of residential lot impervious for each safe yield year.

TABLE R-3

CONSUMPTIVE USE AND DEEP PERCOLATION OF DELIVERED WATER UNDER SAFE YIELD CULTURE

Land use class	1949-50 Acreage: In acres	1949-50 Consumptive use: In acre-feet	1949-50 Deep percolation: In acre-feet	1954-55 Acreage: In acres	1954-55 Consumptive use: In acre-feet	1954-55 Deep percolation: In acre-feet	1957-58 Acreage: In acres	1957-58 Consumptive use: In acre-feet	1957-58 Deep percolation: In acre-feet
San Fernando and Eagle Rock Subareas									
Deciduous	420	590	80	510	710	100	380	530	80
Citrus	10,480	16,140	3,770	7,780	11,980	2,800	4,440	6,840	1,600
Walnuts	4,230	6,090	1,060	2,910	4,190	730	1,160	1,670	290
Truck	4,870	7,890	2,630	4,350	7,050	2,350	3,730	6,040	2,010
Alfalfa	8,770	16,140	2,370	4,320	7,950	1,170	2,720	5,000	730
Vineyard	190	210	40	100	110	20	60	70	10
Lawn grass	1,780	4,680	1,010	1,860	4,890	1,060	2,090	5,500	1,190
Residential	42,060	45,850	9,670	49,840	54,330	11,460	56,900	62,590	12,520
Water surface*		3,560	0		3,560	0		3,560	0
Commercial and industrial*		5,750	0		9,660	970		12,100	2,000
Subtotal		106,900	20,630		104,430	20,660		103,900	20,430
Sylmar Subarea									
Deciduous	570	760	130	780	1,040	180	590	780	140
Citrus	590	870	210	580	850	210	430	630	150
Walnuts	20	30	10	10	10	0	0	0	0
Truck	1,060	1,520	590	260	370	150	240	340	130
Alfalfa	30	50	10	80	140	20	40	70	10
Vineyard	20	20	0	30	30	10	20	20	0
Lawn grass	40	100	30	40	100	30	40	100	30
Residential	900	960	220	1,310	1,400	310	1,560	1,680	360
Commercial and industrial*		40	0		90	0		140	0
Subtotal		4,350	1,200		4,030	910		3,760	820
Verdugo Subarea**									
Deciduous	30	40	10	10	10	0	10	10	0
Citrus	10	10	0	10	10	0	10	10	0
Truck	10	20	10	20	30	10	60	90	40
Lawn grass	110	260	90	120	290	100	150	360	120
Residential	2,030	1,870	470	2,750	2,530	630	3,200	2,980	700
Commercial and industrial*		140	0		190	0		210	0
Subtotal		2,340	580		3,060	740		3,660	860
Total for three subareas		113,590	22,410		111,520	22,310		111,320	22,110
Delivered water retention (Sum of consumptive use and deep percolation) in acre-feet.		136,000			133,830			133,430	

* See Chapter VII for source and derivation of the values for this land use class.

** Includes portion of Monk Hill Basin within Upper Los Angeles River area.

TABLE R-4

CONSUMPTIVE USE OF PRECIPITATION UNDER SAFE YIELD CULTURE

Land use class	Safe yield year 1949-50 Acreage In acres	1949-50 Consumptive use In acre-feet	1954-55 Acreage In acres	1954-55 Consumptive use In acre-feet	1957-58 Acreage In acres	1957-58 Consumptive use In acre-feet
			San Fernando Subarea			
Deciduous	420	470	510	570	380	430
Citrus	10,480	10,900	7,780	8,090	4,440	4,620
Walnuts	4,230	4,650	2,910	3,210	1,160	1,280
Truck	4,870	5,210	4,350	4,650	3,730	3,990
Alfalfa	8,770	9,730	4,320	4,800	2,720	3,020
Vineyard	190	210	100	110	60	70
Lawn grass	1,780	1,850	1,860	1,930	2,090	2,170
Dry farm and native	24,630	28,570	24,870	28,850	24,090	27,940
Miscellaneous	1,770	1,430	1,900	1,540	2,720	2,200
Water surface	960	1,320	960	1,320	960	1,320
Riparian	300	410	260	360	200	280
Commercial and industrial	12,340	5,310	13,140	5,650	13,350	5,740
Residential	42,060	30,280	49,840	33,890	56,900	37,550
Subtotal		100,340		94,970		90,610
			Sylmar Subarea			
Deciduous	570	680	780	940	590	710
Citrus	590	650	580	640	430	470
Walnuts	20	20	10	10	0	0
Truck	1,060	1,220	260	300	240	280
Alfalfa	30	40	80	100	40	50
Vineyard	20	20	30	40	20	20
Lawn grass	40	50	40	50	40	50
Dry farm and native	2,170	2,780	2,270	2,910	2,430	3,110
Miscellaneous	150	140	130	120	80	70
Commercial and industrial	50	30	110	60	170	90
Residential	900	800	1,310	1,130	1,560	1,280
Subtotal		6,430		6,300		6,130
			Verdugo Subarea			
Deciduous	30	40	10	10	10	10
Citrus	10	10	10	10	10	10
Truck	10	10	20	20	60	70
Lawn grass	110	140	120	150	150	190
Dry farm	2,300	3,220	1,590	2,230	1,220	1,710
Miscellaneous	320	320	260	260	80	80
Riparian	30	60	20	40	20	40
Commercial and industrial	160	80	220	110	250	120
Residential	2,030	1,930	2,750	2,610	3,200	2,780
Subtotal		5,810		5,440		5,010
Total for three subareas		112,580		106,710		101,750

Modifications of Runoff Items to Suit Safe Yield Conditions

Items of runoff, which are modified to reflect safe yield conditions in the stream system, consist of residual rain, additional hill and mountain runoff due to residential development, runoff to reservoirs and native spread water. Native spread water has been discussed and derived in Chapter VII and the estimated amounts apread under safe yield conditions are shown in Table 49.

The calculations for residual rain and additional hill and mountain runoff due to residential development are shown in Tables R-5 and R-6 respectively. The source and derivations of the tables are described therein.

Ground Water Reservoir Operations Under Safe Yield Conditions

The theoretical operation of the ground water reservoir under safe yield conditions was made for the safe yield years 1949-50 and 1957-58. The safe yield years for which the study was made represented the maximum and minimum safe yield pumpage for which safe yield was determined under the Order of Reference.

By definition, the safe yield of the ground water reservoir of the Upper Los Angeles River area is the maximum average annual pumping draft which can be continually withdrawn for useful purposes under a given set of conditions without causing an undesired result. The conditions imposed upon the ground water reservoir are:

1. A period of normal precipitation was taken as the 29-year base period from 1928-29 through 1956-57.

TABLE R-5

RESIDUAL RAIN FOR SAFE YIELD COMPUTATION

Year	San Fernando and Eagle Rock Subareas: Depth of residual rain, in feet (1)	Residual rain in acre-feet, Safe yield year 1949-50 (2)	1954-55 (3)	1957-58 (4)	Sylmar Subarea: Depth of residual rain, in feet (5)	Residual rain in acre-feet, Safe yield year 1949-50 (6)	1954-55 (7)	1957-58 (8)	Verdugo Subarea: Depth of residual rain, in feet (9)	Residual rain in acre-feet, Safe yield year 1949-50 (10)	1954-55 (11)	1957-58 (12)	Total residual rain, in acre-feet, Safe yield year 1949-50 (13)	1954-55 (14)	1957-58 (15)
1928-29	0.56	15,970	18,920	22,010	0.67	570	700	800	0.99	1,160	1,470	1,680	17,700	21,090	24,490
29-30	0.73	20,810	24,660	28,700	0.96	820	1,000	1,150	0.97	1,130	1,440	1,650	22,760	27,100	31,500
1930-31	0.91	25,940	30,740	35,770	1.02	870	1,060	1,220	1.02	1,190	1,510	1,730	28,000	33,310	38,720
31-32	1.22	34,780	41,210	47,960	1.31	1,110	1,360	1,570	1.67	1,950	2,470	2,840	37,840	45,040	52,370
32-33	0.86	24,520	29,050	33,810	0.84	710	870	1,010	1.17	1,370	1,730	1,990	26,600	31,650	36,810
33-34	0.97	27,650	32,770	38,130	1.02	870	1,060	1,220	1.77	2,070	2,620	3,010	30,590	36,450	42,360
34-35	1.09	31,080	36,820	42,850	1.21	1,030	1,260	1,450	1.82	2,130	2,690	3,090	34,240	40,770	47,400
1935-36	0.65	18,530	21,960	25,550	0.92	780	960	1,100	1.17	1,370	1,730	1,990	20,680	24,650	28,640
36-37	1.43	40,770	48,310	56,210	1.62	1,380	1,680	1,940	2.20	2,570	3,260	3,740	44,720	53,250	61,890
37-38	1.62	46,190	54,720	63,680	1.76	1,500	1,830	2,110	2.81	3,290	4,160	4,780	50,980	60,710	70,570
38-39	1.40	39,910	47,290	55,030	1.48	1,260	1,540	1,780	1.77	2,070	2,620	3,010	43,240	51,450	59,820
39-40	0.97	27,650	32,770	38,130	1.02	870	1,060	1,220	1.26	1,470	1,860	2,140	29,990	35,690	41,490
1940-41	2.77	78,970	93,570	108,890	2.68	2,280	2,790	3,220	3.33	3,900	4,930	5,660	85,150	101,290	117,770
41-42	0.60	17,110	20,270	23,590	0.51	430	530	610	0.91	1,060	1,350	1,550	18,600	22,150	25,750
42-43	1.64	46,760	55,400	64,470	1.82	1,550	1,890	2,180	2.94	3,440	4,350	5,000	51,750	61,640	71,650
43-44	1.64	46,760	55,400	64,470	1.65	1,400	1,720	1,980	1.95	2,280	2,890	3,320	50,440	60,010	69,770
44-45	0.78	22,240	26,350	30,660	0.90	770	940	1,080	1.44	1,680	2,130	2,450	24,690	29,420	34,190
1945-46	0.75	21,380	25,340	29,480	0.89	760	930	1,070	1.25	1,460	1,850	2,130	23,600	28,120	32,680
46-47	0.81	23,090	27,360	31,840	0.99	840	1,030	1,190	1.38	1,610	2,040	2,350	25,540	30,430	35,380
47-48	0.35	9,980	11,820	13,760	0.36	310	370	430	0.54	630	800	920	10,920	12,990	15,110
48-49	0.29	8,270	9,800	11,400	0.45	380	470	540	0.62	730	920	1,050	9,380	11,190	12,990
49-50	0.50	14,260	16,890	19,660	0.73	620	760	880	1.03	1,210	1,520	1,750	16,090	19,170	22,290
1950-51	0.33	9,410	11,150	12,970	0.46	390	480	550	0.49	570	730	830	10,370	12,360	14,350
51-52	1.93	55,020	65,200	75,870	2.30	1,960	2,390	2,760	2.83	3,310	4,190	4,810	60,290	71,780	83,440
52-53	0.53	15,110	17,900	20,830	0.68	580	710	820	0.65	760	960	1,110	16,450	19,570	22,760
53-54	0.76	21,670	25,670	29,880	0.90	770	940	1,080	1.43	1,670	2,120	2,430	24,110	28,730	33,390
54-55	0.62	17,680	20,940	24,370	0.62	530	640	740	0.83	970	1,230	1,410	19,180	22,810	26,520
1955-56	0.96	27,370	32,430	37,740	1.16	990	1,210	1,390	1.38	1,610	2,040	2,350	29,970	35,680	41,480
56-57	0.75	21,380	25,340	29,480	0.69	590	720	830	1.03	1,210	1,520	1,750	23,180	27,580	32,060
29-Year Average 1929-57													30,590	36,420	42,330

Source and derivation of values by column number:

Column number

1, 5 and 9. Depth of residual rain on 100 percent impervious areas, Table L-13 through L-15, Appendix L.

2, 3 and 4. Column 1 multiplied by the acreage of impervious areas in San Fernando and Eagle Rock Subareas for each safe yield year: 1949-50 = 28,510 acres; 1954-55 = 33,780 acres; and 1957-58 = 39,310 acres.

6, 7 and 8. Column 5 multiplied by the acreage of impervious areas in Sylmar Subarea for each safe yield year: 1949-50 = 850 acres; 1954-55 = 1,040 acres; and 1957-58 = 1,200 acres.

10, 11 and 12. Column 9 multiplied by the acreage of impervious area in Verdugo Subarea for each safe yield year: 1949-50 = 1,170 acres; 1954-55 = 1,480 acres; and 1957-58 = 1,700 acres.

13. Sum of Columns 2, 6 and 10.

14. Sum of Columns 3, 7 and 11.

15. Sum of Columns 4, 8 and 12.

TABLE R-6

ADDITIONAL RUNOFF TRIBUTARY TO THE VALLEY FILL FROM
HILL AREAS DUE TO RESIDENTIAL DEVELOPMENT FOR SAFE YIELD CONDITIONS

Year	Additional runoff in inches		Additional runoff in acre-feet								
			Safe yield year								
			1949-50			1954-55			1957-58		
	San Fernando Subarea[a] (1)	Verdugo Subarea (2)	San Fernando Subarea[a] (3)	Verdugo Subarea (4)	Valley fill (5)	San Fernando Subarea[a] (6)	Verdugo Subarea (7)	Valley fill (8)	San Fernando Subarea[a] (9)	Verdugo Subarea (10)	Valley fill (11)
1928-29	9.5	11.9	1,000	30	1,030	2,040	110	2,150	3,300	190	3,490
29-30	8.7	11.8	910	30	940	1,870	110	1,980	3,020	190	3,210
1930-31	11.3	12.3	1,190	30	1,220	2,430	110	2,540	3,920	190	4,110
31-32	13.1	17.0	1,380	40	1,420	2,820	160	2,980	4,550	270	4,820
32-33	10.7	13.9	1,120	30	1,150	2,300	130	2,430	3,710	220	3,930
33-34	16.1	20.3	1,690	50	1,740	3,460	190	3,650	5,590	320	5,910
34-35	14.4	22.4	1,510	60	1,570	3,100	210	3,310	5,000	350	5,350
1935-36	9.6	13.5	1,010	30	1,040	2,060	120	2,180	3,330	210	3,540
36-37	15.0	22.0	1,580	60	1,640	3,230	200	3,430	5,210	350	5,560
37-38	15.5	26.0	1,630	70	1,700	3,330	240	3,570	5,380	410	5,790
38-39	14.9	20.3	1,560	50	1,610	3,200	190	3,390	5,170	320	5,490
39-40	9.5	14.8	1,000	40	1,040	2,040	140	2,180	3,300	230	3,530
1940-41	25.3	29.5	2,660	70	2,730	5,440	270	5,710	8,780	470	9,250
41-42	6.0	10.3	630	30	660	1,290	90	1,380	2,080	160	2,240
42-43	14.2	26.9	1,490	70	1,560	3,050	250	3,300	4,930	430	5,360
43-44	13.8	18.3	1,450	50	1,500	2,970	170	3,140	4,790	290	5,080
44-45	9.4	16.3	990	40	1,030	2,020	150	2,170	3,260	260	3,520
1945-46	10.0	14.7	1,050	40	1,090	2,150	140	2,290	3,470	230	3,700
46-47	16.5	16.1	1,730	40	1,770	3,550	150	3,700	5,730	250	5,980
47-48	5.0	6.5	530	20	550	1,080	60	1,140	1,740	100	1,840
48-49	4.9	7.6	510	20	530	1,050	70	1,120	1,700	120	1,820
49-50	7.4	12.7	780	30	810	1,590	120	1,710	2,570	200	2,770
1950-51	3.9	5.8	410	10	420	840	50	890	1,350	90	1,440
51-52	20.7	26.1	2,170	70	2,240	4,450	240	4,690	7,180	410	7,590
52-53	5.5	7.8	580	20	600	1,180	70	1,250	1,910	120	2,030
53-54	9.8	17.2	1,030	40	1,070	2,110	160	2,270	3,400	270	3,670
54-55	7.3	9.7	770	20	790	1,570	90	1,660	2,530	150	2,680
1955-56	11.8	16.7	1,240	40	1,280	2,540	150	2,690	4,090	260	4,350
56-57	9.7	12.0	1,020	30	1,050	2,090	110	2,200	3,370	190	3,560
29-Year Average 1929-57					1,230			2,590			4,180

a. Includes Eagle Rock and Sylmar Subareas.

Source and derivation of values by column number:

Column Number

1. Table F-8, Column 5, tributary to San Fernando and Sylmar Hydrologic Subareas.
2. Extension of value shown in Table F-8, Column 5, tributary to Verdugo Hydrologic Subarea.

3,4,6,7, 9 and 10. Column 1 or 2 converted to feet multiplied by the residential acreages and percent impervious (Table F-8, Columns 6 and 7) for the respective safe yield year and subarea.

5,8 and 11. Sum of the additional runoff for the subareas for the safe yield year.

2. Cyclic trends of precipitation correspond to the 29-year base period; i.e., beginning and ending in a dry cycle.

3. The average amounts of import, export, safe yield pumpage and natural depletion prevailed during each year of the 29-year base period of normal precipitation.

4. Ground water levels for purpose of these studies were assumed to be equal to the ground water levels as they existed in 1957-58 and the available storage in the ground water reservoir above the 1957-58 ground water levels is equal to that which has existed historically; maximum ground water levels occurred in 1943-44. The difference between the amount dewatered from the high in 1943-44 to the low in 1957-58 is equal to 611,000 acre-feet.

The theoretical operation of the ground water reservoir with safe yield culture imposed over the 29-year base period utilized the basic hydrologic equation: supply minus disposal equals change in storage. Computations for the gross recharge of native water for the safe yield year 1949-50, shown in Table R-7, include the recharge from land use areas, stream system and the spreading grounds. A small difference (five percent) occurred between the 29-year average gross recharge computed for the ground water reservoir operational study and the 9-year average gross recharge determined for safe yield. The annual amounts of the gross recharge of native water were adjusted so that the 29-year average would be equal to the computed safe yield gross recharge of native water (Table 55). The values thus derived for the purpose of this study are called the adjusted gross recharge of native water.

TABLE R-7

COMPUTATION OF GROSS RECHARGE OF NATIVE WATER FOR THEORETICAL GROUND WATER RESERVOIR OPERATION STUDY BASED ON 1949-50 SAFE YIELD CULTURE CONDITIONS ON THE VALLEY FILL AREA

In 1,000 Acre-Feet

Year	Precipitation (1)	Integrated consumptive use of rain (2)	Consumptive use of rain adjustment (3)	Residual rain (4)	Recharge: Land use areas (5)	Recharge: Stream system (6)	Recharge: Native spread water (7)	Gross recharge (8)	Adjustment factor (9)	Adjusted gross recharge (10)
1928-29	122.4	103.5	-11.4	17.7	12.6	13.9	1.1	27.6	0.96	26.6
29-30	125.7	97.2	-10.7	22.8	16.4	15.6	1.2	33.2	0.96	32.0
1930-31	155.8	116.2	- 3.9	28.0	15.5	17.4	1.1	34.0	0.96	32.7
31-32	207.4	132.5	7.7	37.8	29.4	39.6	10.2	79.2	0.96	76.3
32-33	133.5	87.3	- 8.9	26.6	28.5	21.4	0	49.9	0.96	48.0
33-34	150.0	99.2	- 5.2	30.6	25.4	25.7	0.7	51.8	0.96	49.9
34-35	207.1	157.1	7.6	34.2	8.2	27.6	3.7	39.5	0.96	38.0
1935-36	131.0	96.7	- 9.5	20.7	23.1	18.3	6.2	47.6	0.96	45.8
36-37	242.2	148.1	15.5	44.7	33.9	53.1	14.5	101.5	0.96	97.7
37-38	258.6	135.4	19.2	51.0	53.0	84.5	11.9	149.4	0.96	143.8
38-39	219.1	147.8	10.4	43.2	17.7	34.0	1.1	52.8	0.96	50.8
39-40	172.0	124.5	- 0.2	30.0	17.7	24.4	2.8	44.9	0.96	43.2
1940-41	409.8	173.7	53.3	85.2	97.6	94.5	30.2	222.3	0.96	214.0
41-42	137.7	113.7	- 8.0	18.6	13.4	21.3	0.1	34.8	0.96	33.5
42-43	259.0	132.7	19.3	51.8	55.2	81.5	11.6	148.3	0.96	142.7
43-44	254.3	134.5	18.3	50.4	51.1	63.5	22.2	136.8	0.96	131.7
44-45	148.5	115.3	- 5.5	24.7	14.0	26.7	9.1	49.8	0.96	47.9
1945-46	141.3	107.6	- 7.2	23.6	17.3	23.9	2.8	44.0	0.96	42.4
46-47	156.0	115.8	- 3.8	25.5	18.5	23.6	12.5	54.6	0.96	52.6
47-48	80.1	67.8	-20.9	10.9	22.3	10.4	0	32.7	0.96	31.5
48-49	86.6	75.2	-19.5	9.4	21.5	8.1	0	29.6	0.96	28.9
49-50	111.2	87.3	-13.9	16.1	21.7	12.5	0.3	34.5	0.96	33.2
1950-51	89.9	76.1	-18.7	10.4	22.1	8.3	0	30.4	0.96	29.3
51-52	315.0	157.6	31.9	60.3	65.2	63.5	22.9	151.6	0.96	146.0
52-53	118.9	95.3	-12.2	16.5	19.3	16.1	2.9	38.3	0.96	36.9
53-54	138.4	98.9	- 7.8	24.1	23.2	20.0	2.9	46.1	0.96	44.4
54-55	142.9	116.3	- 6.8	19.2	14.2	15.6	0.2	30.0	0.96	28.9
1955-56	171.2	123.0	- 0.4	30.0	18.6	21.6	0.6	40.8	0.96	39.3
56-57	134.0	99.6	- 8.8	23.2	20.0	16.7	0.5	37.2	0.96	35.8
57-58	278.6	161.2	23.7	52.9	40.8	60.5	29.6	130.9	0.96	126.0
29-Year Average 1929-57	173.1	115.0	0	30.6	27.5	31.2	6.0	64.5		62.2

Source and derivation of values by column number:

Column No.

1. Table 1.
2. Weighted unit consumptive use of rain, Tables L-13, 14 and 15, times the acreage for 1949-50, Table K-6.
3. Consumptive use of rain adjustment = 30 percent times percent pervious times (annual rain minus 29-year average rain).
4. Table R-5, Column 13.
5. Column 1 minus Columns 2, 3 and 4.
6. Table 51, Column 9, for safe yield year 1949-50.
7. Table 51, Column 6, for safe yield year 1949-50.
8. Sum of Columns 5, 6 and 7.
9. Adjustment to make the 29-year average gross recharge equal to average gross recharge under safe yield conditions (Table 53). Adjustment factor is equal to the average gross recharge of native water, Table 53, divided by the 29-year average gross recharge, Column 8.
10. Column 8 multiplied by Column 9.

Under the conditions heretofore set forth, the average import, safe yield pumpage and export are assumed to be constant during each year of the operational study. Since the annual import is a constant, the gross recharge of import would also be a constant. With a constant safe yield pumpage and export, the pumpage available for delivered water on the valley fill area would also be a constant as would the recharge of delivered water.

The theoretical annual changes in storage in the ground water reservoir study for the 1949-50 safe yield year are shown in Table R-8. Using the ground water levels as they existed in 1957-58 as the levels at the start of the period of operation, 150,000 acre-feet of storage below and 210,000 acre-feet of storage above the beginning ground water levels would be required to operate the ground water reservoir through the base period.

TABLE R-8

THEORETICAL OPERATION OF GROUND WATER RESERVOIR UNDER CONDITIONS OF
SAFE YIELD CULTURE, AVERAGE IMPORT AND EXPORT AND SAFE YIELD PUMPAGE*

In 1,000 Acre-Feet

Year	Adjusted gross recharge (1)	Gross recharge of average import (2)	Average natural depletion (3)	Return of pumped water on valley fill area (4)	Net recharge (5)	Safe yield pumpage (6)	Theoretical net annual change in storage (7)	Theoretical amount of water in ground water reservoir, Safe yield year 1949-50 (8)	Theoretical amount of water in ground water reservoir, Safe yield year 1957-58 (9)
1928-29	26.6	38.0	4.5	5.5	65.5	100.8	- 35.3	- 35.3	- 30.8
29-30	32.0	38.0	4.6	5.5	70.9	100.8	- 29.9	- 65.2	- 55.4
1930-31	32.7	38.0	4.6	5.5	71.6	100.8	- 29.2	- 94.4	- 78.2
31-32	76.3	38.0	4.6	5.5	115.2	100.8	14.4	- 80.0	- 63.8
32-33	48.0	38.0	4.6	5.5	86.9	100.8	- 13.9	- 93.9	- 74.5
33-34	49.9	38.0	4.6	5.5	88.8	100.8	- 12.0	-105.9	- 80.7
34-35	38.0	38.0	4.6	5.5	76.9	100.8	- 23.9	-129.8	- 98.0
1935-36	45.8	38.0	4.6	5.5	84.7	100.8	- 16.1	-145.9	-112.1
36-37	97.7	38.0	4.6	5.5	136.6	100.8	35.8	-110.1	- 80.4
37-38	143.8	38.0	4.6	5.5	182.7	100.8	81.9	- 28.2	- 18.5
38-39	50.8	38.0	4.5	5.5	89.7	100.8	- 11.1	- 39.2	- 28.0
39-40	43.2	38.0	4.6	5.5	82.1	100.8	- 18.7	- 57.9	- 42.5
1940-41	214.0	38.0	4.6	5.5	252.9	100.8	152.1	94.2	84.2
41-42	33.5	38.0	4.6	5.5	72.4	100.8	- 28.4	55.8	58.6
42-43	142.7	38.0	4.6	5.5	181.6	100.8	80.8	136.6	119.0
43-44	131.7	38.0	4.6	5.5	170.6	100.8	69.8	206.4	176.8
44-45	47.9	38.0	4.6	5.5	86.8	100.8	- 14.0	192.4	166.0
1945-46	42.4	38.0	4.6	5.5	81.3	100.8	- 19.5	172.9	149.5
46-47	52.6	38.0	4.6	5.5	91.5	100.8	- 9.3	163.6	144.7
47-48	31.5	38.0	4.6	5.5	70.4	100.8	- 30.4	133.2	117.9
48-49	28.9	38.0	4.6	5.5	67.8	100.8	- 33.0	100.2	87.1
49-50	33.2	38.0	4.6	5.5	72.1	100.8	- 28.7	71.5	61.6
1950-51	29.3	38.0	4.6	5.5	68.2	100.8	- 32.6	38.9	30.9
51-52	146.0	38.0	4.6	5.5	184.9	100.8	84.1	123.0	102.8
52-53	36.9	38.0	4.6	5.5	75.8	100.8	- 25.0	98.0	80.7
53-54	44.4	38.0	4.6	5.5	83.3	100.8	- 17.5	80.5	67.1
54-55	28.9	38.0	4.6	5.5	67.8	100.8	- 33.0	47.5	37.8
1955-56	39.3	38.0	4.6	5.5	78.2	100.8	- 22.6	24.9	21.1
56-57	35.8	38.0	4.6	5.5	74.7	100.8	- 26.1	- 1.2	- 1.4
57-58	126.0	38.0	4.6	5.5	164.9	100.8	64.1	62.9	43.6

* Calculations for the theoretical operation of ground water reservoir are shown for only 1949-50. The results of the operational studies for 1957-58 are shown in Column 9.

Source and derivation of values by column number:

Column No.

1. Table R-7, Column 10.
2. Table 55, Item 1.
3. Table 52, Item 7.
4. Table 56, Item 2, minus Table 55, Item 10, times (100 minus Table 56, Item 11).
5. Sum of Columns 1, 2 and 4, minus Column 3.
6. Table 55, Item 10.
7. Column 5 minus Column 6.
8. Cumulation of Column 7.

APPENDIX S

ORDERS OF REFERENCE

APPENDIX S

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IN THE SUPERIOR COURT OF THE STATE OF CALIFORNIA

IN AND FOR THE COUNTY OF LOS ANGELES

THE CITY OF LOS ANGELES, a Municipal Corporation, Plaintiff, vs. CITY OF SAN FERNANDO, a Municipal Corporation, CITY OF GLENDALE, a Municipal Corporation, CITY OF BURBANK, a Municipal Corporation, et al, Defendants.	No. 650079 INTERIM ORDER OF REFERENCE To STATE WATER RIGHTS BOARD (To Investigate And Report Upon The Physical Facts Under Section 2001, Water Code)

The Motion of certain defendants for an Order of Reference to the State Water Rights Board to investigate and report upon the physical facts herein involved having come on regularly for hearing on Tuesday, March 18, 1958, after having been previously continued from time to time to said date, before the above-entitled Court, the Honorable Virgil M. Airola, Judge (assigned), Presiding, the Court having heard argument, written and oral, and considered the same, and good cause appearing therefor;

NOW, THEREFORE, IT IS HEREBY ORDERED, pursuant to Section 2001 of the Water Code of California:

I

That the State Water Rights Board of the State of California be and it is hereby appointed in the above-entitled action to study the availability and extent of any and all public and private records, documents, reports and data relating to the matters and things contained and set forth in Appendix B (Proposed Order of Reference) attached to the Order to Show Cause of the above-entitled Court, dated March 10, 1958, and to approximate the time required for, and to estimate the cost of obtaining, correlating and reporting upon, such records, documents, reports and data, and to report the results of its investigation and study to this Court on June 9, 1958.

II

The cost of this interim investigation and report shall be apportioned, and shall be paid by, the parties hereto at such time and in such proportions as shall hereafter be determined by the Court.

III

This interim investigation and report shall be made without prejudice to the right of any party hereto to hereafter object to any further Order of Reference herein and/or to object to the method and manner of the allocation of any costs of reference herein.

IV

It is recommended: (1) to the parties to this action that they co-operate with the Board by and through engineers appointed jointly or severally by them; and (2) to the Board that it seek the advice and counsel of such engineers in its investigation and in the preparation of its report.

DONE IN OPEN COURT THIS 19th day of March, 1958.

Virgil M. Airola
Virgil M. Airola
Judge (assigned) of the Superior Court

IN THE SUPERIOR COURT OF THE STATE OF CALIFORNIA

IN AND FOR THE COUNTY OF LOS ANGELES

THE CITY OF LOS ANGELES, A Municipal Corporation, Plaintiff vs. CITY OF SAN FERNANDO, a Municipal Corporation, CITY OF GLENDALE, a Municipal Corporation, CITY OF BURBANK, a Municipal Corporation, et al., Defendants.	No. 650079 ORDER OF REFERENCE To STATE WATER RIGHTS BOARD To Investigate And Report Upon The Physical Facts. (Section 2001, Water Code)

The Motions of certain defendants for an Order of Reference to the State Water Rights Board to investigate and report upon the physical facts herein involved, and the Order of the Court to the parties herein to show cause why such Order of Reference should not be made, having come on regularly for hearing on Wednesday, June 11th, 1958 (after having been previously continued from time to time to said date), before the above entitled Court, the Honorable Virgil M. Airola, Judge Presiding, the Court having heard argument, written and oral, and considered the same, and good cause appearing therefor;

NOW, THEREFORE, IT IS HEREBY ORDERED, pursuant to Section 2001 of the Water Code of the State of California, that the State Water Rights Board of said State shall be, and it is hereby, appointed in the above entitled action to investigate the following physical facts which are involved in the above entitled action and report thereon to the above entitled Court on or before two (2) years from and after the date of this Order, or within such additional time as shall be reasonably required and as shall hereafter be fixed and allowed by the Court, namely:

I

The Board is requested to investigate, find, provide data and report upon the following physical facts in accordance with the authorization of Section 2001 Water Code:

1. The geographic and hydrologic (surface and ground water) boundaries of the watershed of the Los Angeles River and its tributaries above the junction of the surface channels of the Los Angeles River and the Arroyo Seco at a point now designated as Los Angeles County Flood Control District Gauging Station No. F57. (Note: If said boundary differs from that depicted on and described in Appendixes "A" and "B" attached to plaintiff's Amended Complaint, then the areas included within both boundaries shall be studied and shall be included in the term "said area" as hereinafter used.)

2. The complete geology, insofar as it affects the occurrence and movement of ground water, and the surface and ground water hydrology of said area, including basins and sub-basins therein, including but not limited to:

A. The topography and soils.

B. The surface location of the bed and banks of the channels of the Los Angeles River and its tributaries.

C. The areas, limits and direction of flow of all ground water in said area, including, but not limited to, any and all waters percolating therein.

D. The area, location, nature, characteristics and limits of any and all basins and sub-basins and the interconnection or interdependence thereof, within said area.

E. The quality of all waters within said area, and the effect thereon of the importation of Owens Valley water.

F. The source and quantity of all waters, and the places of application and use of foreign waters, entering said area each water year for the period covered by available records and information.

G. The nature and quantity of all water loss and diminution within and from said area, each water year for the period covered by available records and information.

H. The safe yield, and the effect thereon of the importation of foreign waters, shall be determined for the water year immediately preceding the filing of the report for which data is available, and for the water years ending 1950 and 1955.

3. The geographic and hydrologic (surface and ground water) boundaries of all watersheds supplying the Los Angeles River below Los Angeles County Flood Control District Gauging Station No. F57 and above the southern boundary of the original pueblo.

4. As to each party to the within action for the period of available records and information:

(a) The location and capacity of his or its diversion works;

(b) The character of his or its use or uses of water; and

(c) The amount of his or its taking and use of water.

5. The use of water by The City of Los Angeles and its inhabitants:

(a) Since 1948 within the territory of the original pueblo; and

(b) For the period of available records within the expanded boundaries of said city as the same existed from time to time up to the date of the Report herein.

6. The amount of water distributed by plaintiff, for the period of available records and information to and including the date of the report, for use outside its boundaries as such boundaries have existed from time to time.

7. All sources of water supply of plaintiff and defendants, and the quantity thereof for the period of available records and information to and including the date of the report:

(a) Diverted and used; and

(b) Available for diversion and use.

II

The Board shall investigate, and, on the 17th day of November, 1958, or as soon thereafter as is reasonably practicable and convenient to Court and counsel, shall report to the Court and counsel upon, the following:

1. With respect to water years from and including that ending 1900 to and including that ending immediately preceding the filing of the Board's report hereunder (other than the water years specified in Paragraphs I, 2H hereof), the nature, extent and availability of any and all records and data reasonably necessary for the study by the Board of

the safe yield of the area referred to in Paragraphs I, 1 hereof and the approximate time required for, and the estimated cost of, obtaining, correlating, supplying, producing, supplementing and reporting upon such records; and

2. With respect to the water years from and including that ending 1900 to and including that ending immediately preceding the filing of the Board's report, the nature, extent, and availability of any and all of the records and data specified in Paragraphs I, 4, 5, 6 and 7 hereof, and the approximate time required for, and the estimated cost of, obtaining, correlating, supplying, producing, supplementing, and reporting upon such records and data;

3. The necessity or desirability of the Board's obtaining, correlating and reporting upon physical facts other than, and in addition to, those specified in this Order.

III

The Board is requested to retain in its Los Angeles office and have available to the parties the basic data upon which the Board bases its findings with respect to the foregoing items until thirty (30) days after the date of mailing of notice of filing its Final Report and thereupon to file a copy thereof with the Court.

IV

The parties are directed to make available to the Board such records and data as they may have which are pertinent to the subject matter of this reference.

V

It is recommended: (1) to the parties to this action that they co-operate with the Board by and through engineers appointed jointly or severally by them; and (2) to the Board that it seek the advice and counsel of such engineers in its investigation and in the preparation of its report.

DATED this 11th day of June, 1958.

s/ VIRGIL M. AIROLA
Judge of the Superior Court

IN THE SUPERIOR COURT OF THE STATE OF CALIFORNIA

IN AND FOR THE COUNTY OF LOS ANGELES

THE CITY OF LOS ANGELES, a Municipal Corporation, Plaintiff, vs. CITY OF SAN FERNANDO, a Municipal Corporation et al., Defendants.	No. 650,079 INTERIM ORDER RECEIVING AND FILING "FIRST REPORT OF STATE WATER RIGHTS BOARD PURSUANT TO PARAGRAPH II OF REFERENCE ORDER DATED JUNE 11, 1958" AND DIRECTING NO FURTHER STUDIES OR PROCEEDINGS OR REPORTS UNDER SAID PARAGRAPH II OF SAID REFERENCE ORDER UNTIL AND UNLESS FURTHER ORDERED AND DIRECTED ON MOTION AND AFTER NOTICE PREVIOUSLY GIVEN TO ALL PARTIES, AND REQUIRING PROGRESS REPORTS FROM STATE WATER RIGHTS BOARD AT FUTURE PRE-TRIAL SESSIONS.

The State Water Rights Board having rendered and presented herein a report entitled "First Report of State Water Rights Board Pursuant to Paragraph II of Reference Order dated June 11, 1958", and good cause appearing therefor;

IT IS ORDERED:

1. That said First Report be accepted and filed herein as the report required by Paragraph II of the Reference Order of June 11, 1958;

2. That, with respect to the matters required to be investigated and reported upon as directed and outlined in paragraphs 1, 2 and 3 of said paragraph numbered II of said Order of Reference dated June 11, 1958, no further investigations, studies, proceedings or reports be made thereunder by said State Water Rights Board until and unless further ordered and directed hereafter on motion made and after notice has been previously given to all parties; and

3. That said State Water Rights Board, however, continue to be and appear by and through its attorneys and/or representatives at all future sessions of the pre-trial conference herein to make and render progress reports, oral or written, to the Court on the matters required to be reported under said Order of Reference dated June 11, 1958, except as hereinabove otherwise provided.

Dated on November 19, 1958.

VIRGIL M. AIROLA
Judge (assigned) of the Above-Entitled Court

APPENDIX T

AVAILABLE INFORMATION ON HYDROLOGIC SUBAREAS

APPENDIX T

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TABLES

APPENDIX T

AVAILABLE INFORMATION ON HYDROLOGIC SUBAREAS

The chapters in this report dealing with historic water supply and ground water recharge treat the entire valley fill area of the Upper Los Angeles River area as a unit. In view of the objections by various parties this appendix has been prepared to summarize the data available throughout the report with respect to each of the four hydrologic subareas. Particular information concerning the consumptive use of delivered water and amounts of import served to the service areas of the Crescenta Valley County Water District and La Canada Irrigation District within the Upper Los Angeles River area is also included.

The data collected in the course of this investigation were not always conducive to dividing the values into the four hydrologic subareas. Various studies were made in an attempt to separate these items into their respective subareas. The values thus determined should be considered solely as estimates of the amounts occurring in the subareas where there are no actual measurements corresponding to the exact hydrologic boundaries of the subareas.

Values presented for Verdugo Hydrologic Subarea in Tables T-2 through T-11 of this appendix exclude the amounts of water supply and disposal derived from the portion of Monk Hill Basin within the Upper Los Angeles River area.

Summary of Available Hydrologic Information

A summary of the hydrologic information available by subareas is shown in Table T-1. This table lists items of the hydrologic inventory for each subarea. Where a certain item of the inventory is not pertinent to the particular subarea, it is designated as "none". Data needed to complete items of the inventory are the surface runoff between subareas, and areal culture and gross delivered water of Eagle Rock Subarea.

Numerous items can be determined for the combined areas of San Fernando and Eagle Rock Subareas but difficulties arise in an attempt to separate the quantities derived from within the respective subareas. These quantities were therefore combined as shown in Table T-1.

Surface Runoff Between Subareas

Surface runoff occurs between Eagle Rock, Sylmar and Verdugo Subareas and San Fernando Subarea. The only stream gage measurement available in proximity to a subarea boundary is the Los Angeles County Flood Control District Stream Gaging Station No. 252. This gage, located approximately 2.8 miles below the boundary of Verdugo Subarea on Verdugo Wash, has a period of record from 1936 through 1958 (Table 27). Tributary areas between this gage and the boundary of Verdugo Subarea are areas of residential and commercial acreages and portions of the Verdugo Mountains and San Rafael Hills.

Areal Culture and Gross Delivered Water for Eagle Rock Subarea

The major difficulty encountered in a separate evaluation of the items of hydrologic information for the Eagle Rock Subarea is the determination of the areal culture and gross delivered water. There are land use data

TABLE T-1

SUMMARY OF HYDROLOGIC INFORMATION AVAILABLE ON SUBAREAS

Item	Hydrologic Subareas			
	San Fernando	Eagle Rock	Sylmar	Verdugo
1. Precipitation on subareas	Table T-2	Table T-2	Table T-2	Table T-2
2. Residual rain in subareas	Table T-3[a]	Table T-3[a]	Table T-3	Table T-3
3. Surface inflow to subareas				
a. From hill and mountain areas under conditions of native culture	Table T-4	Table T-4	Table T-4	Table T-4
b. Additional runoff from hill and mountain areas due to residential development	b	b	c	b
c. From tributary subareas	b	None	None	b
4. Runoff into reservoirs	Table F-7[d]	None	None	None
5. Native water spread in subareas	Table 30[d]	None	None	None
6. Surface outflow from subareas	Table 28	e	e	e
7. Subsurface inflow to subareas	Table 32	None	None	None
8. Subsurface outflow from subareas	Table 31	Table 32	Table 32	Table 32
9. Import to subareas				
a. Ground water originating in Upper Los Angeles River area	Table M-4[f]	Table M-4[f]	None	Table T-5
b. Water originating in Colorado and/or Mono-Owens Basin areas	Table 21[f]	Table 21[f]	Table 21	Table T-5
c. Total	f	f		

TABLE T-1

SUMMARY OF HYDROLOGIC INFORMATION AVAILABLE ON SUBAREAS (continued)

Item	Hydrologic Subareas			
	San Fernando	Eagle Rock	Sylmar	Verdugo
10. Import spread in subareas	Table 23[d]	None	None	None
11. Ground water extractions				
a. Extracted in subareas	Table T-6	Table T-6	Table T-6	Table T-6
b. Exported from subareas	Table T-7[a]	Table T-7[a]	Table T-7	Table T-7
12. Surface water diversions				
a. Diverted in subareas	Table 21	None	Table 21	Table T-8
b. Exported from subareas	None	None	None	Table T-8
13. Gross delivered water	Table 21[f]	Table 21[f]	Table 21	Table T-5
14. Water system loss	Table J-3[f]	Table J-3[f]	Table J-4	Table J-5
15. Sewage export	Table T-9[g]	Table T-9[g]	Table T-9	Table T-9
16. Sewer infiltration	h	h	h	h
17. Sewage import	g	None	None	None
18. Areal culture	Table K-6[a]	Table K-6[a]	Table K-6	Table T-10
19. Adjusted consumptive use	Table T-11[a]	Table T-11[a]	Table T-11	Table T-11
20. Cesspool Recharge	Table N-4[a]	c	Table N-4	Table N-4

TABLE T-1

SUMMARY OF HYDROLOGIC INFORMATION AVAILABLE
ON SUBAREAS
(continued)

Footnotes

a. Information available for combined subareas. Split cannot be made until breakdown of culture for each subarea is determined.
b. Data incomplete.
c. Data incomplete; however, the amount can be assumed to be equal to zero for practical purposes.
d. Occurs only in this subarea.
e. Amounts for Verdugo can be estimated based on short period of record from a gage 2.8 miles downstream from subarea boundary. No data are available for Sylmar and Eagle Rock.
f. Information available for combined subareas. Data incomplete for separate evaluation.
g. An estimate of this item would require additional separate information concerning Eagle Rock Subarea.
h. Estimate available for Upper Los Angeles River area but data incomplete for breakdown by subareas.

Note: Values for Verdugo Subarea are exclusive of amounts occurring or derived from the portion of Monk Hill Basin within the Upper Los Angeles River area.

available for 1949, 1955 and 1958. However, prior to these years the lack of data would necessitate the extrapolation of the land use acreages back 20 years to 1928-29.

Eagle Rock Subarea is located within the Narrows Service area of the City of Los Angeles. The determination of the gross delivered water would necessitate a study of the city's "Read Book" for the subarea, as discussed in Appendix M. Due to the continuous changing of the Read Books, the cost of determining the amount of gross delivered water from 1928-29 through 1957-58 would be prohibitive.

TABLE T-2

ANNUAL PRECIPITATION ON VALLEY FILL AREA

In Acre-Feet

Year	Hydrologic Subareas			
	San Fernando (1)	Eagle Rock (2)	Verdugo (3)	Sylmar (4)
1928-29	108,070	900	6,370	6,190
29-30	111,390	740	5,690	7,090
1930-31	139,460	950	6,380	8,070
31-32	184,740	1,290	9,690	10,350
32-33	118,910	840	6,460	6,360
33-34	131,470	1,210	8,920	7,170
34-35	182,980	1,280	10,850	10,430
1935-36	114,540	920	6,960	7,580
36-37	214,230	1,480	12,220	12,470
37-38	227,360	1,630	14,580	12,870
38-39	196,650	1,260	9,510	10,350
39-40	154,310	920	7,470	8,230
1940-41	369,020	2,560	17,510	18,250
41-42	123,420	780	6,280	6,360
42-43	227,710	1,510	14,920	12,710
43-44	228,870	1,380	10,520	11,980
44-45	130,070	950	8,560	7,660
1945-46	125,090	900	7,050	7,250
46-47	136,610	1,080	8,660	8,390
47-48	71,210	520	3,820	3,990
48-49	75,100	580	5,180	4,970
49-50	96,740	740	6,450	6,360
1950-51	79,170	530	4,250	5,300
51-52	279,750	2,050	15,130	15,890
52-53	106,530	670	4,840	6,190
53-54	121,390	870	7,970	7,010
54-55	128,310	870	6,190	6,600
1955-56	152,220	1,050	7,890	8,960
56-57	119,150	850	6,370	6,760
57-58	248,140	1,560	12,810	14,260
29-Year Average 1929-57	153,600	1,080	8,510	8,680

TABLE T-3

RESIDUAL RAIN BY SUBAREAS

In Acre-Feet

Year	Hydrologic Subareas: San Fernando plus Eagle Rock (1)	Sylmar (2)	Verdugo (3)
1928-29	5,950	420	340
29-30	7,670	580	510
1930-31	11,830	650	550
31-32	18,760	880	980
32-33	12,190	580	710
33-34	17,720	630	1,140
34-35	21,330	680	1,070
1935-36	12,410	580	690
36-37	26,150	1,130	2,510
37-38	30,400	1,260	2,080
38-39	27,040	1,040	1,140
39-40	20,170	680	740
1940-41	62,410	1,950	2,560
41-42	15,230	380	660
42-43	38,220	1,320	2,370
43-44	39,990	1,270	1,530
44-45	19,910	620	1,120
1945-46	20,270	590	1,760
46-47	22,670	970	1,370
47-48	11,170	230	480
48-49	9,420	220	500
49-50	14,520	690	1,010
1950-51	9,650	340	330
51-52	65,090	2,140	3,640
52-53	17,010	550	730
53-54	25,380	840	1,910
54-55	20,080	610	990
1955-56	38,660	1,300	1,900
56-57	29,580	730	1,110
57-58	68,030	2,250	4,070
29-Year Average 1929-57	23,130	820	1,260

Source and derivation by column number:

Column No.

1, 2 and 3. Annual precipitation (Table T-2) minus the summation of the weighted unit values of consumptive use and deep percolation of rain for each land use classification and respective subarea (Tables L-13, L-14 and L-15) multiplied by the respective acreage (Table K-6 and Table T-10).

TABLE T-4

HILL AND MOUNTAIN RUNOFF TO VALLEY FILL
UNDER CONDITIONS OF NATIVE CULTURE

In Acre-Feet

Year	Tributary to: San Fernando Subarea (1)	Eagle Rock Subarea (2)	Verdugo Subarea (3)	Sylmar Subarea (4)
1928-29	5,120	420	100	930
29-30	4,350	0	0	960
1930-31	3,070	0	0	860
31-32	40,490	5,040	1,790	10,350
32-33	9,720	1,050	250	1,990
33-34	12,210	3,570	610	2,970
34-35	17,710	0	260	5,530
1935-36	13,040	1,470	460	3,530
36-37	64,430	5,880	2,420	17,320
37-38	128,180	11,130	4,310	31,600
38-39	21,570	1,890	640	3,890
39-40	15,040	1,050	210	3,470
1940-41	133,980	19,530	5,640	28,960
41-42	16,870	1,680	530	2,520
42-43	124,470	10,080	4,690	24,790
43-44	94,900	6,510	2,740	18,620
44-45	27,670	2,520	870	5,740
1945-46	20,030	840	250	3,090
46-47	22,890	1,260	490	6,410
47-48	5,320	210	50	390
48-49	2,460	0	0	740
49-50	3,810	210	40	1,120
1950-51	2,470	210	50	170
51-52	77,150	12,390	4,420	18,220
52-53	10,110	840	220	3,750
53-54	11,060	840	210	3,140
54-55	6,250	840	200	940
1955-56	8,260	1,050	180	1,540
56-57	4,750	840	210	970
57-58	66,920	630	1,200	17,540
29-Year Average 1929-57	31,290	3,150	1,100	7,050

TABLE T-5

IMPORT AND GROSS DELIVERED WATER
TO VERDUGO SUBAREA

In Acre-Feet

Year	Import: Ground water[a] (1)	Import: Colorado and/or Mono-Owens Basin water[b] (2)	Gross delivered water (3)
1928-29	100	0	1,280
29-30	100	0	1,360
1930-31	100	0	1,430
31-32	100	0	1,450
32-33	100	0	1,540
33-34	100	0	1,940
34-35	90	0	1,680
1935-36	100	0	1,790
36-37	110	0	1,930
37-38	110	0	2,060
38-39	110	0	2,190
39-40	120	0	2,420
1940-41	120	0	2,260
41-42	140	0	2,660
42-43	170	0	2,850
43-44	170	0	3,030
44-45	180	0	3,060
1945-46	220	0	3,710
46-47	220	0	4,080
47-48	270	0	4,660
48-49	280	0	4,390
49-50	290	0	4,560
1950-51	1,490	150	4,940
51-52	1,040	130	4,700
52-53	1,360	300	6,110
53-54	1,720	330	6,810
54-55	1,390	700	6,640
1955-56	2,770	1,340	7,670
56-57	3,350	1,510	8,180
57-58	3,870	1,060	8,690
29-Year Average 1929-57	570	150	3,500

a. Ground water originating in Upper Los Angeles River area outside of Verdugo.

b. Water originating in Colorado and/or Mono-Owens Basin areas.

Source and derivation by column number:

Column No. 1- Table M-4.

Column No. 2- Sum of Columns 4 and 7, Table M-3 plus Column 7, Table M-2.

Column No. 3- Table 21, total for Verdugo Subarea minus gross delivered for La Canada Irrigation District from Tables J-5 and J-13.

TABLE T-6

GROUND WATER EXTRACTIONS AND SURFACE DIVERSIONS
FROM VALLEY FILL AREA BY HYDROLOGIC SUBAREAS

In Acre-Feet

Year	San Fernando Subarea (1)	Eagle Rock Subarea (2)	Sylmar Subarea (3)	Verdugo Subarea (4)
1928-29	82,100	24	4,830	2,890
29-30	85,680	24	4,560	3,100
1930-31	89,020	24	4,020	3,440
31-32	62,720	24	3,700	3,100
32-33	61,600	24	3,050	2,740
33-34	85,090	24	4,010	2,900
34-35	71,870	24	4,410	2,670
1935-36	80,680	24	4,730	2,980
36-37	76,240	24	4,670	3,030
37-38	73,430	24	5,540	3,580
38-39	74,000	24	5,540	5,030
39-40	76,200	25	5,420	5,040
1940-41	76,820	25	5,980	5,580
41-42	74,660	25	6,020	6,150
42-43	87,760	25	5,890	6,190
43-44	92,480	35	6,070	6,590
44-45	110,080	35	6,160	6,310
1945-46	120,220	35	6,640	6,600
46-47	122,880	45	6,770	7,750
47-48	124,560	45	6,980	6,490
48-49	125,770	50	6,810	5,530
49-50	129,700	50	6,570	4,900
1950-51	124,880	50	6,240	3,850
51-52	119,950	110	5,960	4,280
52-53	144,510	120	5,490	5,250
53-54	144,610	120	5,160	5,600
54-55	140,250	120	5,630	5,280
1955-56	143,560	130	5,980	4,480
56-57	151,960	140	6,020	4,400
57-58	136,120	150	5,470	4,910
29-Year Average 1929-57	101,840	50	5,480	4,680

TABLE T-7

EXPORT OF GROUND WATER BY SUBAREAS AND TRIBUTARY AREAS

In Acre-Feet

Year	San Fernando plus Eagle Rock (1)	Sylmar (2)	Verdugo[a] (3)
1928-29	54,910	3,610	1,960
29-30	57,290	3,230	2,030
1930-31	59,490	2,650	2,060
31-32	34,320	2,340	1,760
32-33	32,010	1,720	1,300
33-34	54,170	2,470	1,000
34-35	42,910	3,130	1,120
1935-36	49,610	3,560	1,290
36-37	44,380	3,320	1,240
37-38	38,660	3,660	1,710
38-39	36,380	3,670	3,030
39-40	37,980	3,600	2,790
1940-41	40,820	4,080	3,570
41-42	33,470	4,010	3,650
42-43	44,100	3,930	3,610
43-44	47,470	4,130	3,890
44-45	62,080	4,240	3,510
1945-46	68,250	4,700	3,130
46-47	73,390	4,880	3,970
47-48	68,080	5,060	2,130
48-49	67,170	4,830	1,420
49-50	73,030	4,700	550
1950-51	67,870	4,590	470
51-52	64,080	4,340	540
52-53	83,340	4,450	610
53-54	85,230	4,590	630
54-55	81,560	4,450	450
1955-56	86,770	4,050	280
56-57	94,100	4,590	440
57-58	87,150	4,220	350
29-Year Average 1929-57	58,030	3,880	1,870

a. Includes surface diversions exported out of subarea (Table T-8).

Source and derivation by column number:

Column No. 1 - Column 3, Table M-6 plus Column 7, Table M-4.
Column No. 2 - Column 3, Table M-4.
Column No. 3 - Column 4, Table M-4 plus Column 3, Table M-7.

TABLE T-8

DIVERSIONS AND EXPORT OF SURFACE WATER
FROM TRIBUTARY HILL AREAS TO VERDUGO SUBAREA

In Acre-Feet

Year	Diverted (1)	Exported (2)
1928-29	130	70
29-30	120	70
1930-31	100	80
31-32	130	130
32-33	100	110
33-34	80	70
34-35	130	140
1935-36	170	150
36-37	310	280
37-38	400	360
38-39	390	340
39-40	360	280
1940-41	480	390
41-42	450	360
42-43	620	440
43-44	740	500
44-45	490	340
1945-46	370	270
46-47	420	240
47-48	400	120
48-49	320	120
49-50	300	110
1950-51	260	90
51-52	360	170
52-53	390	90
53-54	360	120
54-55	190	100
1955-56	150	70
56-57	140	60
57-58	190	90
29-Year Average 1929-57	300	190

Source and derivation by column number:

Column No. 1 - Table 21, surface diversion for Verdugo Subarea minus surface water diverted from Snover Canyon by La Canada Irrigation District.

Column No. 2 - Surface diversion for Pickens Canyon by La Canada Irrigation District.

TABLE T-9

SEWAGE EXPORTED BY SUBAREAS[a]

In Acre-Feet

Year	San Fernando[b] (1)	Sylmar (2)	Verdugo (3)
1928-29	6,320	170	80
29-30	7,100	180	100
1930-31	8,490	200	120
31-32	9,900	190	110
32-33	9,970	210	140
33-34	10,340	190	230
34-35	11,850	200	240
1935-36	12,450	190	260
36-37	13,230	200	330
37-38	14,360	210	350
38-39	16,470	250	380
39-40	17,440	260	450
1940-41	21,630	240	410
41-42	21,910	230	500
42-43	22,470	210	570
43-44	23,470	260	580
44-45	23,780	240	600
1945-46	24,030	280	700
46-47	27,080	300	710
47-48	28,880	320	670
48-49	30,340	360	670
49-50	31,950	380	750
1950-51	35,660	390	850
51-52	39,950	430	790
52-53	41,590	540	950
53-54	47,670	410	1,160
54-55	45,670	390	1,070
1955-56	51,860	380	1,360
56-57	60,060	400	1,440
57-58	63,960	460	1,890
29-Year Average 1929-57	24,670	280	570

a. Includes tributary drainage area and sewer infiltration.
b. Includes Sylmar, Verdugo and Eagle Rock Subareas.

Source and derivation by column number:

Column No.

1. Column 1, Table 26.
2. Sum of Columns 4 and 23, Table N-7, and sum of Columns 1 and 12, Table N-8.
3. Sum of Columns 7 and 8, Table N-8.

TABLE T-10

AREAL CULTURE WITHIN BOUNDARY OF THE
VALLEY FILL IN VERDUGO HYDROLOGIC SUBAREA

In Acres

Year	Irrigated crops				Residential	Commercial and industrial	Miscellaneous	Riparian vegetation	Dry farm and native vegetation
	Deciduous	Truck	Lawn grass	Total					
1928-29	110	0	100	210	450	30	320	20	3,360
29-30	90	0	100	190	470	30	320	20	3,360
1930-31	60	0	100	160	500	40	320	20	3,350
31-32	70	0	100	170	520	40	320	20	3,320
32-33	60	0	100	160	540	40	320	20	3,310
33-34	60	0	100	160	570	40	320	20	3,280
34-35	60	0	100	160	590	40	320	20	3,260
1935-36	60	0	100	160	610	50	320	20	3,230
36-37	60	0	100	160	660	50	320	20	3,180
37-38	50	0	100	150	710	60	320	20	3,130
38-39	40	0	100	140	750	60	320	20	3,100
39-40	30	0	100	130	800	70	320	20	3,050
1940-41	60	0	110	170	900	70	320	20	2,910
41-42	40	0	110	150	940	80	320	20	2,880
42-43	30	0	110	140	1,040	90	320	20	2,780
43-44	30	0	110	140	1,140	90	320	20	2,680
44-45	30	0	110	140	1,220	100	320	20	2,590
1945-46	40	0	110	150	1,320	110	320	20	2,470
46-47	30	0	110	140	1,440	120	320	20	2,350
47-48	30	0	110	140	1,560	130	320	20	2,220
48-49	30	0	110	140	1,650	140	320	20	2,120
49-50	20	0	110	130	1,780	150	320	20	1,990
1950-51	20	0	110	130	1,890	160	320	20	1,870
51-52	30	0	120	150	2,030	170	320	20	1,700
52-53	30	0	120	150	2,130	180	320	20	1,590
53-54	30	0	120	150	2,270	200	320	20	1,430
54-55	10	10	120	140	2,410	210	260	10	1,360
1955-56	10	20	120	150	2,500	220	200	10	1,310
56-57	10	30	150	190	2,640	230	140	10	1,180
57-58	10	50	150	210	2,800	240	80	10	1,050

TABLE T-11

ADJUSTED INTEGRATED CONSUMPTIVE USE ON LAND USE AREAS BY SUBAREAS

In Acre-Feet

Year	San Fernando plus Eagle Rock Subareas				Sylmar Subarea			Verdugo Subarea			
	Rain (1)	Delivered water (2)	Other sources (3)	Total (4)	Rain (5)	Delivered water (6)	Total (7)	Rain (8)	Delivered water (9)	Other sources (10)	Total (11)
1928-29	90,330	92,790	5,860	188,980	5,100	4,190	9,290	5,300	640	60	6,000
29-30	89,420	95,560	5,110	190,090	5,770	3,630	9,400	4,290	670	50	5,010
1930-31	116,390	90,880	4,280	211,550	6,730	3,470	10,200	5,050	650	50	5,750
31-32	147,600	67,350	5,490	220,440	8,300	2,850	11,150	6,680	590	40	7,310
32-33	82,550	72,060	4,560	159,170	4,750	3,550	8,300	4,900	670	50	5,620
33-34	95,060	77,900	4,470	177,430	5,150	3,350	8,500	4,730	740	40	5,510
34-35	164,000	70,120	5,570	239,690	9,630	3,210	12,840	8,940	570	40	9,550
1935-36	86,840	89,520	6,510	182,870	5,960	3,920	9,880	5,000	770	50	5,820
36-37	162,750	76,500	5,070	244,320	9,490	3,370	12,860	7,210	760	30	8,000
37-38	154,010	69,590	6,100	229,700	8,740	3,040	11,780	7,920	740	20	8,680
38-39	156,260	78,320	4,480	239,060	7,920	3,470	11,390	7,750	900	40	8,690
39-40	122,810	73,380	3,850	200,040	6,850	3,200	10,050	5,620	1,000	50	6,670
1940-41	221,840	59,340	5,510	286,690	11,860	3,140	15,000	10,520	830	10	11,360
41-42	100,000	90,100	9,620	199,720	5,360	4,260	9,620	4,860	1,220	60	6,140
42-43	144,610	88,270	11,830	244,710	8,330	4,210	12,540	7,730	1,050	20	8,800
43-44	145,090	86,100	12,920	244,110	8,150	4,220	12,370	6,540	1,160	40	7,740
44-45	101,040	100,850	4,060	205,950	6,480	4,760	11,240	6,210	1,260	50	7,520
1945-46	90,700	104,810	4,070	199,580	5,650	4,940	10,590	3,950	1,600	50	5,600
46-47	100,370	106,830	3,020	210,220	6,660	5,520	12,180	5,990	1,580	50	7,620
47-48	41,400	122,080	3,260	166,740	2,590	6,070	8,660	2,010	2,040	70	4,120
48-49	47,690	122,800	3,090	173,580	3,750	5,830	9,580	3,660	1,870	70	5,600
49-50	66,670	112,550	3,260	182,480	4,730	4,790	9,520	4,520	1,890	50	6,460
1950-51	52,940	124,990	3,310	181,240	4,090	4,480	8,570	2,670	2,210	70	4,950
51-52	113,880	93,790	3,240	210,910	10,110	3,730	13,840	8,230	1,920	20	10,170
52-53	75,450	119,220	3,580	198,250	4,820	4,590	9,410	2,950	2,610	60	5,620
53-54	79,740	106,710	2,520	188,970	5,190	3,750	8,940	4,200	2,550	50	6,800
54-55	99,150	103,010	2,390	204,550	5,340	4,000	9,340	4,280	2,700	30	7,010
1955-56	100,390	96,310	1,950	198,650	6,980	3,520	10,500	4,770	2,930	30	7,730
56-57	74,560	110,980	1,870	187,410	5,190	4,160	9,350	3,980	3,180	30	7,190
57-58	151,660	93,950	1,610	247,220	8,880	3,400	12,280	6,530	3,560	10	10,100
29-Year Average 1929-57	107,710	93,200	4,860	205,760	6,540	4,040	10,580	5,530	1,420	40	7,000

Source and derivation by column number:

Column Nos.

1, 5 and 8. Summation of the weighted unit values for precipitation for each land use classification and respective subarea (Tables L-13, L-14 and L-15) multiplied by the respective acreage (Table K-6 for San Fernando plus Eagle Rock and Sylmar Subareas and Table T-10 for Verdugo Subarea) except for water surface evaporation (water surface evaporation computed as per Appendix L) plus 30 percent of annual precipitation above and below 29-year average falling on pervious areas for each subarea.

2, 6 and 9. Summation of the weighted unit values for delivered water for each land use classification and respective subarea (Tables L-13, L-14 and L-15) multiplied by the respective acreage (Table K-6 for San Fernando plus Eagle Rock and Sylmar Subareas and Table T-10 for Verdugo Subarea) plus 5 percent of residential delivered water applied to land use areas (excluding sewage) for each subarea.

3. Column 17, Table 35, minus consumptive use, weighted unit value for riparian (ground water) vegetation (Table L-15), multiplied by the riparian acreage in Verdugo and Monk Hill (Table K-6).

4. Sum of Columns 1, 2 and 3.

7. Sum of Columns 5 and 6.

10. Weighted unit value for riparian (ground water) vegetation (Table L-15) multiplied by the riparian acreage for Verdugo Subarea (Table T-10).

11. Sum of Columns 8, 9 and 10.

Supplemental Information for Crescenta
Valley County Water District and La Canada
Irrigation District Service Areas

Gross delivered water to Crescenta Valley County Water District and La Canada Irrigation District Service areas is derived from ground water extractions and import. Disposal of gross delivered water is through consumptive use on land use areas and water system losses. The residual amounts of gross delivered water become recharge to the ground water reservoir as deep percolation on land use areas and cesspool recharge due to the lack of sewers within these service areas.

The consumptive use of delivered water from land use areas, including consumption of water system losses for these service areas, is shown in Table T-12. The values computed in Table T-12 are derived from average unit values for the consumptive use of delivered water (Table L-15, Appendix L, excepting residential classifications from Table R-1, Appendix R) for Verdugo Subarea. As heretofore discussed in Chapter VI, the integrated consumptive use computed from unit values is the average unit value representative of the subarea. Variations may occur in the amount of water delivered to each land use classification for different water service areas. Since the combined service areas of Crescenta Valley County Water District and La Canada Irrigation District are equal to approximately 50 percent of the total valley fill area of Verdugo Subarea and Monk Hill Basin within the Upper Los Angeles River area, it is believed that the average unit values for consumptive use of delivered water are applicable.

Since the average unit values of consumptive use of delivered water are dependent on the gross water delivered to Verdugo Subarea, the gross amounts imported from the Colorado River and delivered to the valley fill area by Crescenta Valley County Water District and La Canada Irrigation District are also shown in Table T-12.

TABLE T-12

ESTIMATED CONSUMPTIVE USE OF DELIVERED WATER AND AMOUNTS OF IMPORTED WATER FOR CRESCENTA VALLEY COUNTY WATER DISTRICT AND LA CANADA IRRIGATION DISTRICT SERVICE AREAS, VALLEY FILL AREA

In Acre-Feet

Year	Consumptive use of delivered water[a]		Import	
	Service Areas		Service Areas	
	Crescenta Valley (1)	La Canada (2)	Crescenta Valley (3)	La Canada (4)
1928-29	380	150	0	0
29-30	360	140	0	0
1930-31	340	140	0	0
31-32	310	130	0	0
32-33	340	140	0	0
33-34	430	130	0	0
34-35	380	130	0	0
1935-36	400	150	0	0
36-37	440	150	0	0
37-38	420	140	0	0
38-39	490	150	0	0
39-40	550	170	0	0
1940-41	470	140	0	0
41-42	690	210	0	0
42-43	620	210	0	0
43-44	660	200	0	0
44-45	720	220	0	0
1945-46	890	260	0	0
46-47	960	280	0	0
47-48	1,260	330	0	0
48-49	1,170	290	0	0
49-50	1,140	280	0	0
1950-51	1,380	340	0	0
51-52	1,250	300	0	30[c]
52-53	1,630	380	0	110
53-54	1,630	390	0	120
54-55	1,670	380	480[b]	260
1955-56	1,880	420	880	480
56-57	2,010	450	1,000	380
57-58	2,130	450	600	420
29-Year Average 1929-57	860	230		

a. Based on acreages for the water service areas (Table K-7, Appendix K) and the average unit values for consumptive use of delivered water in Verdugo Subarea (Table L-15, Appendix L, excepting residential which are from Table R-1, Appendix R) plus consumptive use of water system losses computed in the same manner as in Table 36.

b. Purchase of Colorado River water commenced June 1955 (Table M-3, Appendix M, Column 7) minus import delivered to hill areas (Table J-13, Appendix J).

c. Purchase of Colorado River water commenced February 1952 (Table M-3, Appendix M, Column 6) minus import delivered to hill areas (Table J-3, Appendix J).