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FINAL REPORT

ADEQUACY OF THE SANTA MARIA GROUNDWATER BASIN

November 1977

SANTA BARBARA COUNTY WATER AGENCY

by

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ADEQUACY OF THE SANTA MARIA
GROUNDWATER BASIN

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SUMMARY

Cultural Development and Historical Groundwater Use

1. In 1975, irrigated agriculture accounted for 86 percent of the net consumption of groundwater in the basin, and urban use accounted for 14 percent. Agricultural irrigation accounted for over 113,000 AFY of applied water, based on the 1975 GRSU crop survey, of which it is estimated that about 27 percent (say 30,500 AFY) returned to the groundwater basin, the remaining 82,500 AFY being lost to comsumptive use (evapotranspiration).

2. Also for 1975 conditions, the municipal and industrial extractions, consumptive use losses and returns to the groundwater basin were estimated as follows:

Values in Acre-Feet Per Year (AFY)

Extractor	Extractions	Consumptive Use*	Returns to GWB**
City of Santa Maria***	10,350	4,600	5,750
City of Guadalupe	800	800	0
California Cities Water Company	4,000	3,050	950
Private Industry	5,100	4,800	300
Totals	20,250	13,250	7,000

*This includes domestic and municipal irrigation losses, evapotranspiration, wastewater treatment plant effluent applied to crop irrigation, industrial cooling tower losses, and the like.

**This includes domestic and municipal irrigation return water as well as returns from disposal of wastewater treatment plant effluent and some industrial return water.

***This includes 2,350 AFY of private pumpage by Western Refrigeration Company which disposes of its effluent to the City of Santa Maria wastewater treatment plant.

3. The sum total urban or municipal and industrial (M & I) and agricultural (Ag) uses of water from the Santa Maria Groundwater Basin are estimated to have been as follows:

Type of Use	Extractions AFY	Consumptive Use AFY	Consumptive Use % of Total	Returns to GWB AFY	Returns to GWB % of Total
M & I	20,250	13,250	65	7,000	35
Ag	113,300	82,700	73	30,600	27
Totals	133,550	95,950	72	37,600	28
Round Off*	133,500	96,000	72	37,500	28

*Lack of metering of agricultural pumpage and other data limitations warrant the use of rounded numbers only in these various estimates.

Basin Geohydrology

1. Santa Maria Groundwater Basin overlies and is bounded by consolidated, impermeable rock formations. These are, for the most part, non-water-bearing.

2. Within the basin formed by the consolidated basement rock and its boundary outcropping lies a large mass of unconsolidated water-bearing deposits extending to an average depth of about 1,000 feet within an area of approximately 107,000 acres. Actual depths range from a few hundred feet to 2,800 feet.

3. The gross volume of unconsolidated sediments in the basin is estimated as slightly over 100 million acre-feet; however, the specific yield of these deposits (the portion which represents water that can be extracted by pumping) is about 10 percent. Accordingly, the total volume of groundwater in storage is currently estimated at about 10 million acre-feet. Of this, about 8 million acre-feet are below sea level and about 2 million acre-feet are above sea level. Some 59 years ago, it is estimated that there was an additional one million acre-feet in storage above sea level.

4. The unconsolidated sediments from oldest to youngest (upward succession) include the Careaga sand, Paso Robles formation, Orcutt formation, Terrace deposits, Alluvium, River-channel deposits, and Dune sands. All of these are water-bearing.

5. As is the case in a typical coastal basin, the upper alluvial deposits nearest the coast are sufficiently impervious to form a confining layer over the main water body. Also, the deeper deposits extend seaward and intersect the ocean floor below sea level some distance from the coastline. It is suspected that the deep aquifer (Careaga sand) may outcrop as much as ten miles offshore.

6. No geologic faults protect the basin against possible sea-water intrusion, nor are there any significant geologic faults impeding the movement of groundwater in the basin except for the area between the City of Santa Maria and the Town of Sisquoc. In this location, two or three faults exist and cut the Careaga sand and Paso Robles formation, but apparently not the recent sediments. The water table gradient steepens as it crosses the fault area.

7. The most important water-bearing formations in the basin are the alluvium and the Paso Robles formation; the Orcutt formation is of considerable local importance in the Orcutt Uplands area. The Careaga sand (the deepest water-bearing formation) has poor permeability and is not tapped by water supply wells.

Basin Hydrology

1. Recharge to the groundwater basin occurs by streambed seepage, deep percolation of rainfall, and subsurface inflow from the surrounding foothills. Return waters from irrigation and from disposal of wastewaters represent a recycling of previously extracted groundwater and hence is not really a recharge.

2. Removal of water from the groundwater basin is largely by pumped extractions for irrigated agriculture but also includes pumpage for municipal and industrial (M & I) purposes and also subsurface outflow through the ocean floor.

3. Recharge to the groundwater basin varies from year to year, being most significant during wet years and least significant during dry ones. These aspects include both streambed percolation and deep penetration of rainfall.

4. The long-range average stream seepage for recharge of the Santa Maria Groundwater Basin is estimated to be nearly 70,000 acre-feet per year (AFY), including the effects of Twitchell Dam. This combination flood control and water conservation facility has been in operation since 1959 and is estimated by Toups Corporation to contribute about 20,000 AFY to the recharge by capture and subsequent regulated release of Cuyama River runoff that would otherwise have been lost to the Pacific Ocean. The estimates of stream seepage are based upon a comparison of stream gaging upstream of Santa Maria Valley and at the lower end of the Valley in addition to the approximations made by Toups Corporation for ungaged stream inflow to the Valley.

5. Rainfall recharge of the groundwater basin generally occurs only in years of above average rainfall. In general, deep

penetration of rainfall is believed to be experienced whenever the annual rainfall is within a range of 11 to 30 inches in the case of irrigated lands and within a range of 17 to 30 inches for native vegetation. Anything smaller than the lower limit will be insufficient to overcome field moisture deficiency (the absorptive capacity of the soil to the lower limits of the root zone); anything larger is assumed to result in soil saturation and runoff. The long-term average recharge from deep penetration of rainfall, assuming current cultural conditions, is estimated at 10,700 AFY.

6. Subsurface inflow to the groundwater basin is assumed to be 1,500 AFY, of which 1,000 AFY was estimated by Toups Corporation for that portion which is contributed from the southeastern portion of the periphery.

7. The total average annual recharge of the Santa Maria Groundwater Basin under current cultural conditions is estimated as 69,600 AFY by stream seepage, 10,700 AFY by deep penetration of rainfall, and 1,500 AFY by subsurface inflow, for a total of approximately 82,000 AFY. The net recharge of the basin is the total average annual recharge less the subsurface outflow to the ocean, this latter being estimated at 6,000 AFY currently. Therefore, the net recharge is estimated as 76,000 AFY.

8. Removal of groundwater from the basin is accomplished by net extractions plus subsurface outflow. Net extractions are the differences between total extractions by pumping and returns from irrigation and wastewater percolation. In general, such net extractions represent consumptive use by evapotranspiration. Subsurface outflow requires separate estimation.

9. Consumptive use by M & I water users was estimated at about 13,000 AFY for 1975 conditions out of a total extraction of about 20,000 AFY. Most of the M & I extracted water is measured by metering, but estimates of consumptive use are necessary in many cases.

10. Agricultural irrigation water is not metered, and its magnitude is estimated on the basis of cropping patterns and cultivated acreages. Extractions for agricultural irrigation were estimated for 1975 conditions as slightly over 113,000 AFY of which about 73 percent (82,500 AFY) is consumptively used and 27 percent (30,500 AFY) returns to the groundwater basin. A large portion of the consumptive use occurs over the confined layer of alluvium in the Guadalupe area.

11. Subsurface outflow was estimated by calculating probable subsurface discharge rates across a known geological cross-sectional area near the coastline and deducting from this annual flow rate the portion of groundwater extracted for irrigation and other uses on the seaward side of this cross-section. For

1975 conditions, the computed subsurface outflow was 6,000 AFY, while for the 1935-72 base period, it was similarly estimated at 9,000 AFY. The USGS has estimated subsurface outflow at 7,000 AFY under 1975 conditions.

12. The total estimated removals from the groundwater basin for 1975 was 13,250 AFY M & I consumptive use, plus 82,700 AFY agricultural consumptive use, plus 6,000 AFY subsurface outflow, for a total of about 102,000 AFY.

13. A comparison of the annual recharge, believed representative of long-range conditions, with current (1975) removals from the groundwater basin shows a difference between 82,000 AFY recharge and 102,000 AFY removal or 20,000 AFY current annual deficit. It is necessary to consider storage changes before proper interpretations can be made as to safe yield of the groundwater basin.

Changes in Storage

1. The amounts of water in storage above sea level in seven of the eight storage units and above 10 foot elevation, Mean Sea Level for the (coastal) Guadalupe Storage Unit of the Santa Maria Groundwater Basin were previously estimated by the USGS for conditions prevailing in 1918, 1950, and 1959 respectively. The Water Agency prepared a corresponding estimate for Spring, 1975 conditions, using about 250 standing water elevations in various wells scattered throughout the basin.

2. The 1918 condition represented an historic high for groundwater in storage. Since that time, it has been apparent that an annual dewatering of about 18,000 AFY has occurred (somewhat over 1 million acre feet less storage in 1975 than in 1918), with the rate of dewatering being greatest in the period prior to 1959 and averaging only about 10,000 AFY since 1959. Similar storage changes were cited by the USGS in a recent publication. The most significant storage changes have occurred in Orcutt, Bradley Canyon and Santa Maria storage units; for 1959-75, the dewatering of these storage units has been 50,000 AF, 45,000 AF, and 40,000 AF, respectively. The Orcutt and Bradley Canyon storage units are those farthest removed from the basin's primary source of recharge, the Santa Maria River.

3. The dewatering of groundwater storage noted above is due, at least in part, to climatological conditions. For example, water supply, as represented by rainfall at Santa Maria, was only 3 percent below normal, on the average during 1918-75. However, for 1959-75, the rainfall was 16 percent below normal.

4. During the base period used in the Toups study (1935-72), Toups estimated an average basin-wide dewatering of 6,700 AFY and an average excess of water disposal over supply of up to 9,000 AFY under existing conditions. As previously noted, the Water Agency estimated a deficit between water supply and disposal of 20,000 AFY under 1975 cultural conditions. However, if

the current rate of subsurface outflow is actually 6,000 AFY as compared to the Toups estimate of 2,000 AFY, an additional 4,000 AFY of disposal brings the current water supply deficit estimated by Toups to 13,000 AFY. This value is of the same magnitude as the 20,000 AFY deficit estimated by the Water Agency.

Perennial Yield

1. The Water Agency determined the current perennial yield of the Santa Maria Basin for consumptive use to be about 76,000 AFY. This was determined by subtracting subsurface outflow from the sum of stream seepage, subsurface inflow, and deep penetration from rainfall. This figure is close to previous estimates made by the USGS. However, recent cultural development by decreasing the subsurface outflow, may increase the yield of the onshore aquifer system at the extense of mining the offshore aquifer. Continued reduction in the quantity of subsurface outflow could eventually cause seawater instrusion of the onshore basin, however.

2. The safe yield for consumptive use is identical to the net recharge or perennial yield, that is, 76,000 AFY.

3. The safe yield for extractions presumes a certain portion of such extractions returns to the groundwater basin via percolation of applied water. It is assumed that this return portion of applied water (mostly irrigation and/or disposal of urban wastewater) amounts to 27 percent of the total agricultural application and 35 percent of the total urban application (both "inside" and "outside" water). Under these assumptions, which are believed representative for the Santa Maria Valley cultural mix of the present, at least 37,600 AFY of the total extractions return to the aquifer by percolation. This corresponds to an estimated 133,500 AFY agricultural and urban extractions. The safe yield for extractions is determined by dividing the safe yield for consumptive use (76,000 AFY) by the percentage of extracted water that is lost by consumptive use (72 percent), giving 105,500 AFY as the estimated safe yield for extractions.

Current Overdraft

1. The overdraft for consumptive use currently (1975 condition estimate) is taken as 13,250 AFY urban consumptive use plus 82,700 AFY agricultural consumptive use which is about 96,000 AFY total consumptive use less 76,000 AFY perennial yield or 20,000 AFY overdraft for consumptive use. Consumptive use denotes complete removal of the water from the system without further possibility of recovery.

2. The overdraft for extractions (1975 conditions), is taken as 113,300 AFY agricultural extractions plus 20,250 AFY urban extractions equals 133,500 AFY total extractions less 105,500 safe yield for extractions or about 28,000 AFY overdraft for extractions.

3. The current overdraft for consumptive use is estimated as being about 86 percent attributable to agricultural pumpage and about 14 percent attributable to urban pumpage.

4. For planning purposes, it is considered that the water in storage in the basin in 1975 was approximately at an historic low, and thus the accumulated overdraft is taken as zero at that time. This approximation recognizes an apparent shift in water levels so that not all areas currently witness historic low water level conditions. Cultural changes are reflected in the redistribution of water levels.

Projected Supply and Demand

1. By 2000, it is estimated that the extractions by the various M & I purveyors within Santa Maria Valley as well as by private industry may be approximately as follows:

Extractor	Extractions/AFY
City of Santa Maria	15,350
City of Guadalupe	1,250
California Cities Water Co.	4,850
Lake Marie	400
Private Industry	5,100
Total, M & I	26,950

The foregoing presumes a moderate amount of consumer conservation.

2. By 2000, in addition to projected agricultural water needs of 125,000 AFY, the total extractions for both M & I and Ag needs are projected as approximately 152,000 AFY (rounded number).

Projected Overdrafts for 2000

1. By 2000, the projected extractions of 152,000 AFY would result in an annual overdraft for extractions of 42,000 AFY, assuming overall groundwater returns of 29 percent, and also assuming no supplemental water supply, imported and/or locally developed. If supplemental water supply were available, the overdrafts could be correspondingly reduced.

2. Similarly, the projected annual overdraft for consumptive use in 2000 is projected as approximately 29,500 AFY.

3. The estimated 2000 overdraft for consumptive use is projected to be about 84 percent attributable to agricultural pumpage and aboug 16 percent attributable to urban pumpage.

4. The accumulated overdraft (basin depletion) since 1975, as projected, would be approximately 600,000 AFY, assuming some slowdown in the subsurface outflow to the Pacific Ocean and, hence, some modest increase in the net recharge. This figure does not include the effects of supplemental water supply which appear feasible, such as spreading grounds, weather modification, watershed management, and imported State project water. Any of these effects would tend to mitigate the overdraft as they would, in effect, represent "new water." State project water, if imported to the area and used for "surface" (pipeline) deliveries to urban consumers would represent a double benefit in that the water would substitute for groundwater extractions, yet a portion of the water so delivered would percolate to the groundwater basin as new recharge water.

5. The accumulated overdraft as indicated (and qualified) above, would represent approximately 29 percent of the usable storage in the basin, depleted over a span of 25 years. This appears significant enough to deserve serious attention but may not, of itself, warrant prohibition of reasonable growth in the area, provided that adequate mitigation measures are taken on a timely basis.

Water Level Changes and Impacts

1. An estimated 1975 basin depletion rate of about 20,000 AFY corresponds to a gross basin average lowering of the water table by about 1.3 foot/year. This assumes a basinwide specific yield of about 14 percent, and a basin area of 107,000 acres. Local effects may, of course, differ from gross basin average effects.

2. As examples of water purveyor well standing levels which have declined in recent years, California Cities Water Company (Southern California Water Company) wells in the Oructt System have apparently averaged about one foot per year decline over the past several years, while the City of Santa Maria's Airport wells have shown a slightly greater decline average, also over a period of nearly two decades. In both instances, pumping depressions or "holes" have been created in the underlying water table. Both purveyors have been extracting fairly heavily from their wells, particularly in recent years. A certain portion of the water table lowering is attributable to the generally dry period during which these measurements have been made (the past one or two decades), but a major effect has probably been due to the extractions themselves.

3. Standing water levels in the two Lake Marie Water Company wells to the east of Orcutt have shown an average of less than one foot per year decline over the past 16 years, according to Company furnished records. The historic extractions from these

deep wells have been relatively low, and there is no known local depressions of the groundwater table. On the other hand, the extractions from the two water wells of the neighboring Southdown Land Company have apparently been greater than those of Lake Marie Water Company, and the decline in standing level has been over four feet per year since the time of initial drilling in the mid-1960's. No information is available as to possible local effects upon the water table, if any.

4. Water levels in agricultural wells in the Santa Maria Valley vary according to seasonal pumping demands and climatic cycles. In addition, a geographic variability in agricultural water well levels is related to the influence of recharge from the Santa Maria and Sisquoc Rivers. Those wells which are farthest from the source of river recharge will experience the greatest water level declines. Hydrographs from representative wells in the basin are used to approximate the following historical water level declines in the various storage units:

Storage Unit	Water Level Decline ft/yr
Fugler Point	0.5
Sisquoc	0.75
Santa Maria	1.0
Guadalupe	0.75
Orcutt	n/a
Bradley Canyon	1.5
Betteravia	n/a

5. If the projected 2000 basin groundwater depletion rate of 29,500 AFY were to be realized (projected consumption but no mitigation measures), the water table decline rate would then correspond to about 2.0 feet per year on a gross basin average. Since some of this might represent fairly concentrated areas of extractions, local effects could be significant.

6. The prediction of local area water level decline rates is complex. Because of this factor and various uncertainties, it was not included in the scope of this report. However, it might be surmised that increased pumping could result in somewhat increased rate of decline of well standing levels, perhaps even in proportion to such increase. Thus, a local water table decline rate of two feet per year in such ares as the Santa Maria Public Airport and Orcutt areas is not at all inconceivable within the next decade or so, assuming that even heavier extractions are experienced in these areas.

Water Quality

1. Areally, groundwater quality deteriorates from east to west, laterally from the Santa Maria River, and northward from the southern edge of the basin. This distribution is related to sources of recharge and is a function of groundwater flow patterns.

2. The respective values of total dissolved solids (TDS) concentrations typically appearing in the water supply and subsequently in the corresponding wastewater emanating from the service area are currently about as follows:

City of Santa Maria	770/1,480 mg/l
City of Guadalupe	1,200/2,000 mg/l
Santa Maria Public Airport Dist.	770/1,090 mg/l
Calif. Cities Water Co. (Orcutt area, tributary to Laguna Co. Sanitation Dist. Plant)	620/1,245 mg/l

3. The use and reuse of groundwater, coupled with introduction of certain additives as a consequence of both M & I and Ag use and evaporation of much of the applied water result in an increased mineralization of the groundwater. The greatest effects of these actions are noticed in the westerly portion of the Valley, particularly around the area of the confined water table. This area is characterized by relatively heavy irrigation pumpage, and is generally farthest from the areas of greatest recharge by riverbed seepage and rainfall percolation, which are in the easterly areas of the basin. Mineralization is characterized by increased concentrations of TDS, sulfate, hardness constituents (calcium and magnesium), and nitrogen in the groundwater.

4. Seawater intrusion of the onshore aquifer system has not occurred to date. Continued lowering of water levels near the coast, however, could result in future seawater contamination of the groundwater basin.

5. The U.S. Environmental Protection Agency recommends a limit of 10 mg/l NO_3-N (nitrate as nitrogen) for drinking water. Concentrations in excess of 40 mg/l were found in water from a few wells and concentrations in excess of 10 mg/l in water from a large number of wells encompassing a significant part of the Valley. High nitrate concentrations are the result of the leaching of chemical fertilizers applied to agricultural lands.

Water Quality Trends

1. Specific water quality trends have not been addressed in this report, because the subject has been dealt with recently by other investigators, such as USGS, Brown & Caldwell and Toups Corporation.

2. Local water quality conditions in the supply wells of California Cities Water Company's Orcutt System have been reported by the Company in their June 20, 1966, report to the Santa Barbara County Board of Supervisors. The mineral quality of all eight wells so reported is considered to be good, based upon TDS concentrations ranging from about 572 to 656 mg/l (1975 conditions) and 623 to 698 mg/l (1960-66 conditions). The fact that the TDS levels in these several wells were apparently lower in 1975 than in early or mid-1960 may be due, at least in part, to the intervening year of heavy recharge (1969). The dual samples for each well at the beginning and end of the cited samples periods, respectively, consistently show an average reduction in mineral concentration (TDS) ranging between 53 and 96 mg/l.

3. The California Cities Water Company's Orcutt wells are within the Orcutt Storage Unit of the Santa Maria Groundwater Basin, whose recharge is considered to be mainly from deep penetration of rainfall and local streambed percolation, as contrasted with the relatively mineralized inflows to the storage units adjacent to the Sisquoc and Santa Maria Rivers. Thus under current conditions, the water quality distributed in the Orcutt System (and also in the City of Santa Maria's Airport system, Lake Marie and Southdown systems) would be expected to remain at relatively favorable levels, assuming little agricultural development.

4. It is expected that the existence of pumping depressions underlying the Orcutt System wells (and Airport wells, also) may tend to cause some groundwater movement in an easterly direction towards these depressions, in reversal of the normal westerly movement of the water. Neither the Orcutt System's wells nor the City's Airport wells would be expected to experience significant effect from any of the municipal wastewater operations, due to their remoteness and the extent of consumptive use. Over a period of many years, however, it is conceivable that very gradual effects from agricultural return waters might be felt in the form of increased mineral concentrations.

5. Due to the heavy pumping, surface transfers, and the general movement of groundwater, the greatest impacts of water quality degradation will probably be experienced in the Guadalupe area, involving the confined portion of the groundwater basin. The perched water above the clay layers which overly the deep aquifer in the westerly part of the basin already contain fairly heavily mineralized groundwater, but only limited communication between these perched waters and the better quality, deep aquifer water exists. This communication is in the form of agricultural wells whose casings are perforated in both zones and also via discontinuities in the clay lenses.

6. As increased pumping takes place within the basin, gradual water table lowering is expected within the basin. Within the confined area, this could make for increased movement of the relatively mineralized perched water into the deeper aquifers.

below. In fact, the existing pumping depression at the easterly edge of the confined area may already be drawing perched water "backwards" into the depression, causing increased mineralization of this better quality deeper water which, in turn, may be eventually drawn westerly beneath the "clay cap" under the influence of the local irrigation pumpage.

7. A <u>theoretical</u> mineralization trend of the groundwater based upon salt accumulation from various mechanisms would indicate a gross rate of mineralization for the entire groundwater basin of roughly 4 mg/l per year, ignoring the effects of soil precipitation. However, as previously indicated, some areas would experience more mineralization and other areas relatively little mineral increase. Shallower wells would probably be greater affected than deeper wells.

8. The point sources of waste discharge, such as municipal wastewater disposal operations, do not currently present a major source of groundwater pollution. Agricultural operations, although apparently not contributing salts to the area significantly more than M & I operations, do subtract much more water from the area than the latter, thereby tending to redistribute and concentrate the minerals in certain groundwater areas. Also, the contribution of nitrogen (usually in the form of nitrate) is a fairly significant effect of agricultural operations. (Long-range studies involving the agricultural community are currently underway to attempt to mitigate these problems).

<u>Salt Balance</u>

1. Sources of salt inflow to the Santa Maria Groundwater Basin include surface runoff, precipitation, M & I accretions and agricultural return flows. Salt disposal from the basin occurs through the processes of surface outflow and subsurface outflow.

2. Agricultural water use has a significant impact on basin water quality by concentrating dissolved solids through evapotranspiration of groundwater and through the leaching of applied fertilizers below the root zone. However, only the latter mechanism represents new solutes added to the basin.

3. M & I effluent discharge accounts for about 10 percent of the total 84,000 tons/year salt inflow to the Valley. Subtracting the estimated salt outflow from the basin of about 35,900 tons/year (T/yr), indicates a net salt addition of about 48,500 T/yr under 1975 conditions. These results are limited by the accuracy of the assumptions and data employed in the calculations.

4. Water quality in the Santa Maria Basin is projected to deteriorate slightly as the rate of salt buildup increases. A rising population, along with increases in agricultural acreage and water use, will tend to compound the currently adverse salt balance. Water Agency projections indicate that net salt additions to the groundwater basin will increase slightly by the year 2000 to about 56,600 T/yr, assuming no supplemental water supply has been made available. A sample calculation assuming that as much as 10,000 AFY of State project water were to be imported to the area by the year 2000 (thereby causing a reduction in groundwater extractions) indicated that the net salt additions would be about 53,100 T/yr under such conditions.

5. There is a need for better data on the mineral quality of surface outflow leaving the basin, and all estimates of salt balance are sensitive to the assumptions made on this item. The Water Agency assumptions and salt balance results, in this regards, are much closer to those of Brown and Caldwell than to those of Toups Corporation.

SANTA MARIA GROUNDWATER BASIN

Location and General Features

The Santa Maria Groundwater Basin underlies a large coastal valley in northern Santa Barbara and southern San Luis Obispo counties. The Santa Maria Valley trends in a northwesterly direction for approximately 28 miles and attains a maximum width of 15 miles.

Total surface area of the Santa Maria Plain, Nipomo Uplands, Sisquoc Plain and tributary watershed of the Santa Maria Valley is estimated at 164,000 acres.

The limits of the groundwater basin encompass 107,000 acres, with about 30,000 acres of this total lying north of the Santa Maria River in San Luis Obispo County. Of the total basin area, about 30,000 acres of the western portion are covered by a semi-permeable alluvial cap.

The basin is bounded on the northwest by the San Rafael mountains and on the north coastal area by a topographic groundwater divide in the vicinity of Nipomo Mesa. The groundwater basin continues eastward under the Sisquoc River Plain to a point two miles east of Foxen Canyon where the main water body pinches out, giving way to river gravel deposits which directly overlie the consolidated basement rocks. The southern groundwater basin boundary east of Highway 101 extends well into the Solomon Hills and is in hydraulic continuity with the San Antonio Basin to the south. Over this area, the basin boundary is assumed to be the topographic divide between the two basin-valley watershed areas. West of Highway 101, however, the southern boundary generally runs along the northern flanks of the Solomon and Casmalia Hills to the Pacific Ocean. The western basin boundary lies at the contact between the water-bearing formations and the ocean floor approximately two to four miles from the coastline.

Cultural Development and Historical Groundwater Use

Virtually all of the water consumed in the Santa Maria Basin for irrigation, livestock, and municipal and industrial uses is derived from the underground water supply. Since the early 1900's, agricultural acreage has steadily increased to the point where, in 1975, irrigated agriculture accounted for 86% of the net consumption of groundwater in the basin. The principal communities in the basin include the City of Santa Maria, the City of Guadalupe and the unincorporated Orcutt area. Important water consuming industries include oil extraction and processing activities in the Santa Maria, Nipomo Mesa, and Cat Canyon areas, a sugar beet refinery and livestock fodder producing plant near Betteravia, various ranches devoted to livestock raising, and a vegetable packing plant in Santa Maria. Total municipal and industrial groundwater extractions totaled approximately 20,000 AF in 1975. Of this total, approximately 13,000 AF were consumptively used, which represents about 14 percent of the basin-wide net pumpage in 1975.

Climate

The climate of the Santa Maria Valley is characterized by a dry summer and a wet winter season with the bulk of the precipitation occuring between October and April. Prevailing storm patterns generally originate in the Pacific Northwest, moving inland from the Pacific Ocean. During the summer, moist marine air layers bring heavy fog into the coastal valleys, thereby reducing potential evapotranspiration.

Average annual rainfall values vary considerably over the basin with the lowland areas generally receiving less rainfall than the surrounding foothills and mountains. The annual precipitation values at the City of Santa Maria for which records are available since 1886 are assumed to represent average rainfall over the entire basin. Mean annual precipitation over the period 1868-1976 was calculated as 13.44 inches. For years before actual records are available for the City of Santa Maria, the rainfall data are based on the application of average rainfall indices to the average rainfall at Santa Maria during the period of record. (See Fig's. 1 and 2).

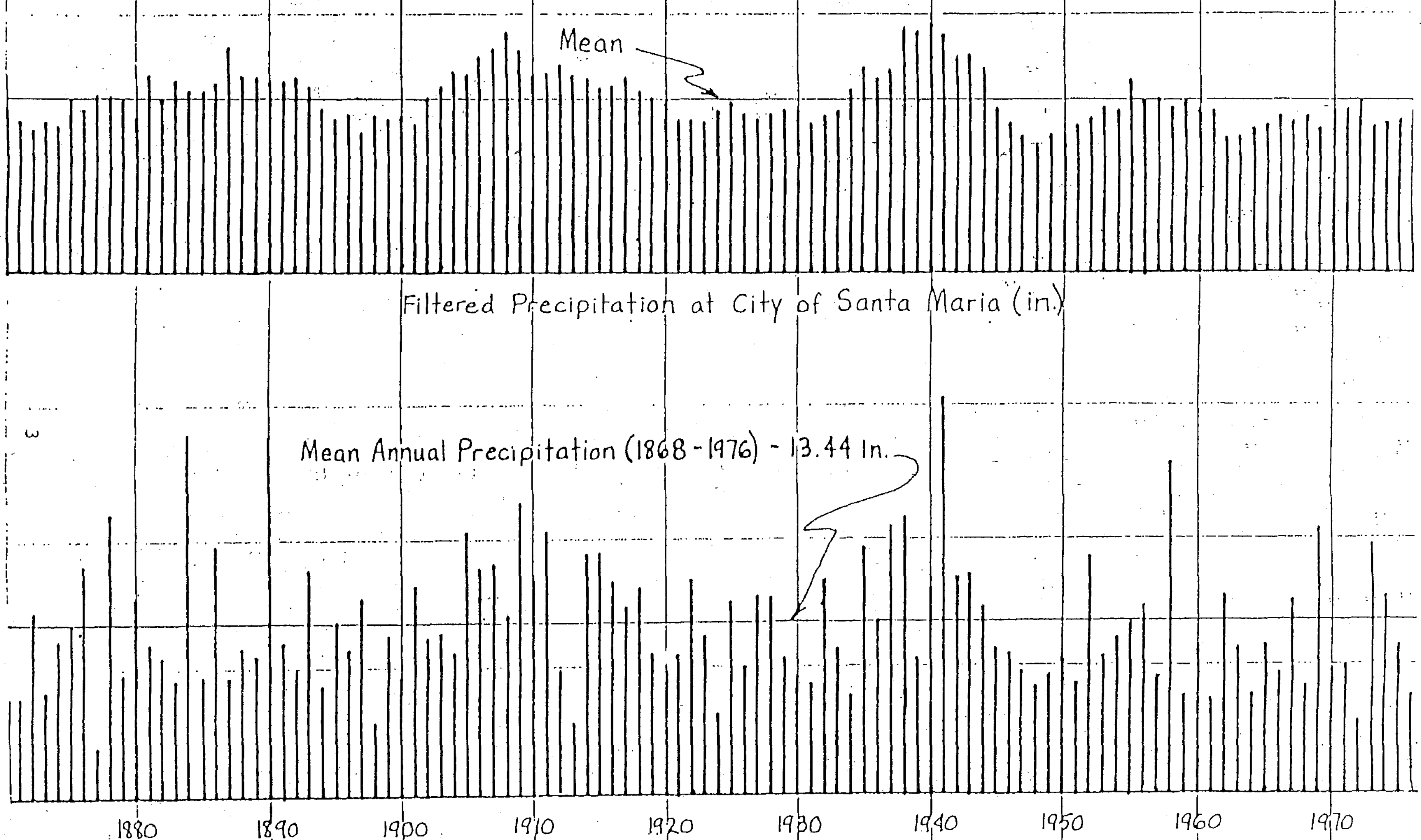
Temperatures vary considerably between winter and summer, but the mean annual temperature is near 60° F. During the winter, freezing temperatures are infrequent near the coast with the probability of below freezing temperatures increasing as a function of distance from the coast. Summer temperatures are mild averaging near 70° F. Only on rare occasions during Santa Ana conditions do temperatures approach 100° F.

Previous Investigations

The most comprehensive analysis of the geology, surface-water and groundwater resources of the Santa Maria Basin was accomplished by G. F. Worts, Jr. of the USGS in 1951 (1). The present study has largely relied upon the description of the basin geology as reported in Worts' investigation. The U.S. Geological Survey published another report in 1966 (2) in an attempt to evaluate previous investigations and to determine the effect of Twitchell Reservoir releases on the safe yield of the basin. The above report summarizes hydrologic data for the period 1919-1959. Brown and Caldwell (1975) analyzed the hydrologic budget for the basin in a study on local sources of pollution (3). Toups

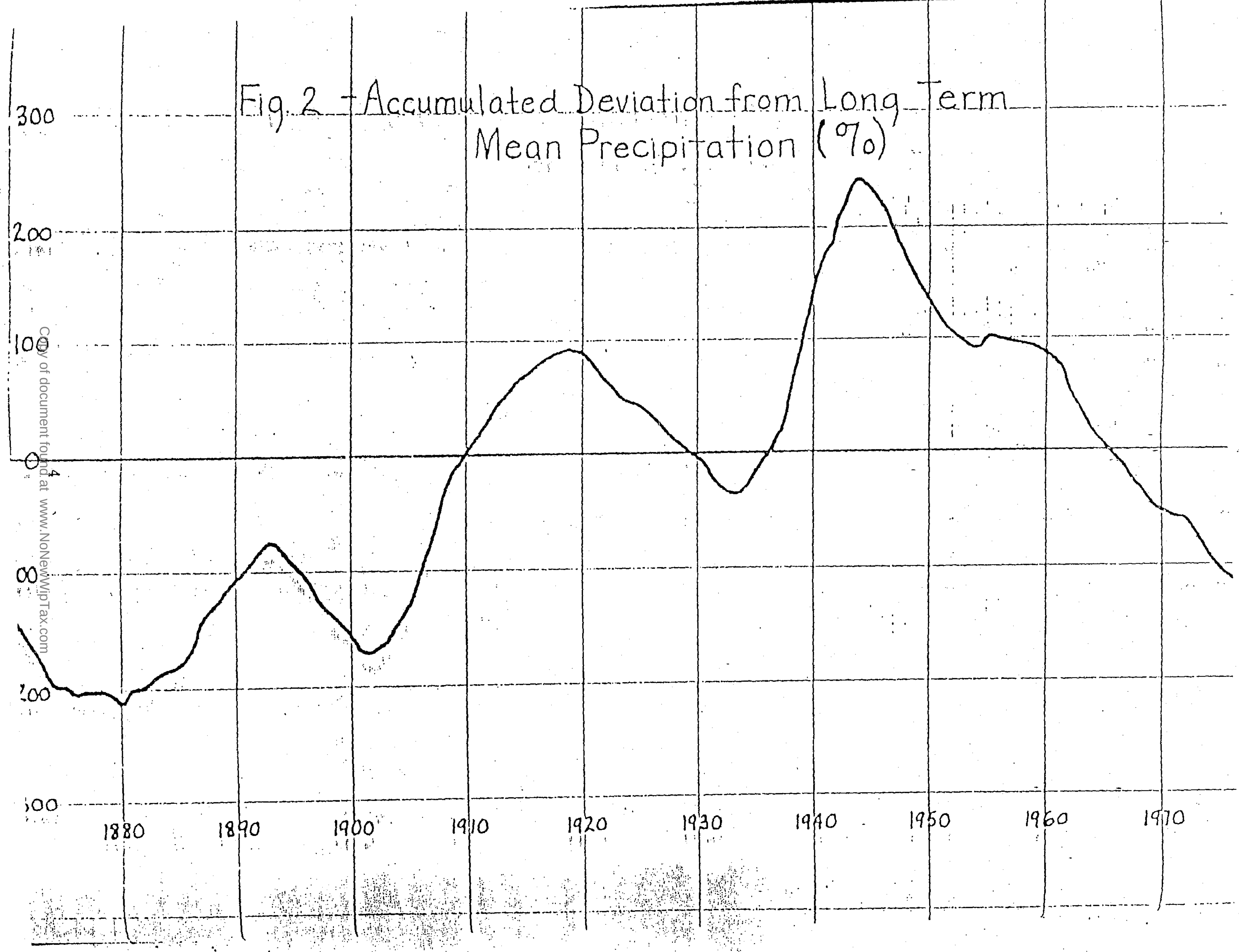
Fig. 1 - Rainfall Records - City of Santa Maria

Fig. 1 - Rainfall Records - City of Santa Maria



Seasonal Precipitation - City of Santa Maria (in.)
Period of Record - 1876 - 1976

Fig. 2 - Accumulated Deviation from Long Term Mean Precipitation (%)



Corporation published an extensive study of Santa Maria Valley water resources in 1976 (4). The USGS has also recently completed a water quality study of the Santa Maria Basin which was published in July 1977 (16).

Purpose and Scope of the Report

This study was undertaken to evaluate the current overdrafting situation in the Santa Maria Basin in terms of the long-term safe yield. Data from previous investigations were reviewed and amended where appropriate. Hydrologic data for the period 1959-1975 were developed in terms of the elements of recharge and discharge, and changes in groundwater storage over this period. This 17 year period, when combined with previous information from USGS reports, extends the available data base over the period 1919-1975.

In addition, data from the 1976 Toups report (4) were analyzed and the elements of recharge and discharge over the 1935-72 base period were independently developed by the SBCWA.

Basin Geology

General

The groundwater basin overlies and is bounded by consolidated, impermeable, Tertiary and Jurassic rock formations which outcrop along most of the basin periphery. These rocks are essentially non-water-bearing, except for fracture systems and springs which locally yield small quantities of water. The unconsolidated water-bearing deposits are of uppermost Tertiary and Quaternary age and outcrop over an area of approximately 107,000 acres. From oldest to youngest (upward succession) these deposits include the Careaga sand, Paso Robles formation, Orcutt formation, Terrace deposits, Alluvium, River-channel deposits, and Dune sands. Over the western extent of the basin, the upper alluvium acts as a confining layer over the main water body.

Structure

The Santa Maria Valley lies between the San Rafael Mountains on the north and the Solomon-Casmalia Hills on the south. The basin is thus a structural depression between the two ranges with the basement rocks forming a broad syncline. The axis of the syncline runs beneath the Sisquoc River channel in the eastern part of the basin where the flanks of the syncline rise steeply to the north and gently to the south. The basin thickness and lowest elevation in the Sisquoc Plain are 1,600 feet and 1,200 feet below MSL, respectively. West of the town of Sisquoc, the synclinal axis turns southward away from the river channel and trends toward the Orcutt area. Just west of the town of Garey, the basin thickness remains near 1,600 feet, but bedrock elevation rises to 1,000 feet, indicating a slight structural closure (approximately 200 feet) under the Sisquoc Plain. In the vicinity of

Orcutt and continuing westward to the coast, the synclinal axis trends parallel to and slightly north of the Casmalia Hills. From the Orcutt area to the coast, the basin asymmetry is reversed from the Sisquoc and eastern basin structure. The middle and western portions of the basin have synclinal flanks which slope steeply upward to the south and gently upward to the north. The thickest section through the basin is found in the Orcutt area, where the basin thickness is about 2,800 feet, and the bedrock elevation is about 2,600 below MSL.

Further west near the town of Guadalupe, the maximum basin thickness (over the synclinal axis about a mile southwest of Guadalupe) is approximately 2,000 feet, with bedrock elevation at 1,900 feet below MSL. The main basin, therefore, has a probable structural closure of at least 700 feet, since the bedrock appears to slope upward from Guadalupe to the coast.

For the main groundwater body of 107,000 acres, the average depth is approximately 1,000 feet. Therefore, the basin volume is roughly 100 million AF while the portion above sea level is about 20 million AF.

Geologic Faults

There are several minor faults along the southern boundary of the basin paralleling the Solomon and Casmalia Hills which do not have any effect on groundwater movement because of their peripheral location. However, there are two, or possibly three, major faults between the town of Sisquoc and the City of Santa Maria which displace basin sediments. These faults are roughly parallel, striking in a direction slightly west of north.

The faults cut the Careaga sand and Paso Robles formation but do not appear to offset the Pleistocene or recent sediments. Movement along the faults is thought to be predominantly vertical, with maximum displacement on the Santa Maria fault measured at near 150 feet. Because of the lenticular nature of the stratigraphic units which comprise the Paso Robles formation, groundwater movement across the fault plane is impeded to some extent as evidenced by the steepening hydraulic gradient near the fault trace.

Water-Bearing Properties of the Stratigraphic Units

The consolidated Tertiary and Jurrasic rocks are essentially non-water-bearing because of their density, compaction and degree of cementation. However, small quantities of water may be conveyed through fissures, joints and fracture systems to the adjacent unconsolidated water-bearing rocks. Small springs which issue from the south flank of the San Rafael Mountains and a limited number of wells which tap the basement rocks for water for domestic uses indicate that a relatively small quantity of subsurface inflow enters the basin in this manner. (1)

Over most of the basin, the unconsolidated water-bearing sediments essentially behave as a single aquifer system except in the western portion of the basin, where 30,000 acres are confined under a clay cap in the upper alluvium. In general, permeability of the aquifer decreases from east to west as the sediments become more fine-grained. In the eastern portion of the basin, coarse-grained surficial deposits readily transmit substantial amounts of seepage from the Sisquoc and Santa Maria Rivers to the underlying groundwater body.

The most important water-bearing formations in the basin are the Alluvium and the Paso Robles formation which constitute the bulk of the water-bearing deposits. Locally, the Orcutt formation is also an important aquifer system. In the Orcutt Uplands area, this formation is the principal source of supply, and yields some of the best quality water available in the Santa Maria Valley. While the Careaga sand lies at the base of the water-bearing formations, its permeability is quite low and it is not tapped by wells.

The Alluvium (thickness 0-230 ft.) of recent age occupies the river-channel area in the eastern part of the basin and spreads over a broad portion of the central and western valley. In the eastern part of the basin, the Alluvium is more coarse-grained and highly permeable than in the coastal portion, where two distinct members become evident. The upper member near the coast contains clay layers which form a confining cap over the groundwater body. The lower member near the coast is fairly coarse-grained with good permeability and is the primary source of water for wells in the coastal region.

Beneath the Alluvium and the Orcutt formation, the Paso Robles formation ranges in thickness from 0-2,000 ft. This formation is filled with lenticular bodies of gravel, sand, silt, and clay of continental origin. The coarse-grained deposits within the Paso Robles formation provide most of the water that is tapped by wells in the basin.

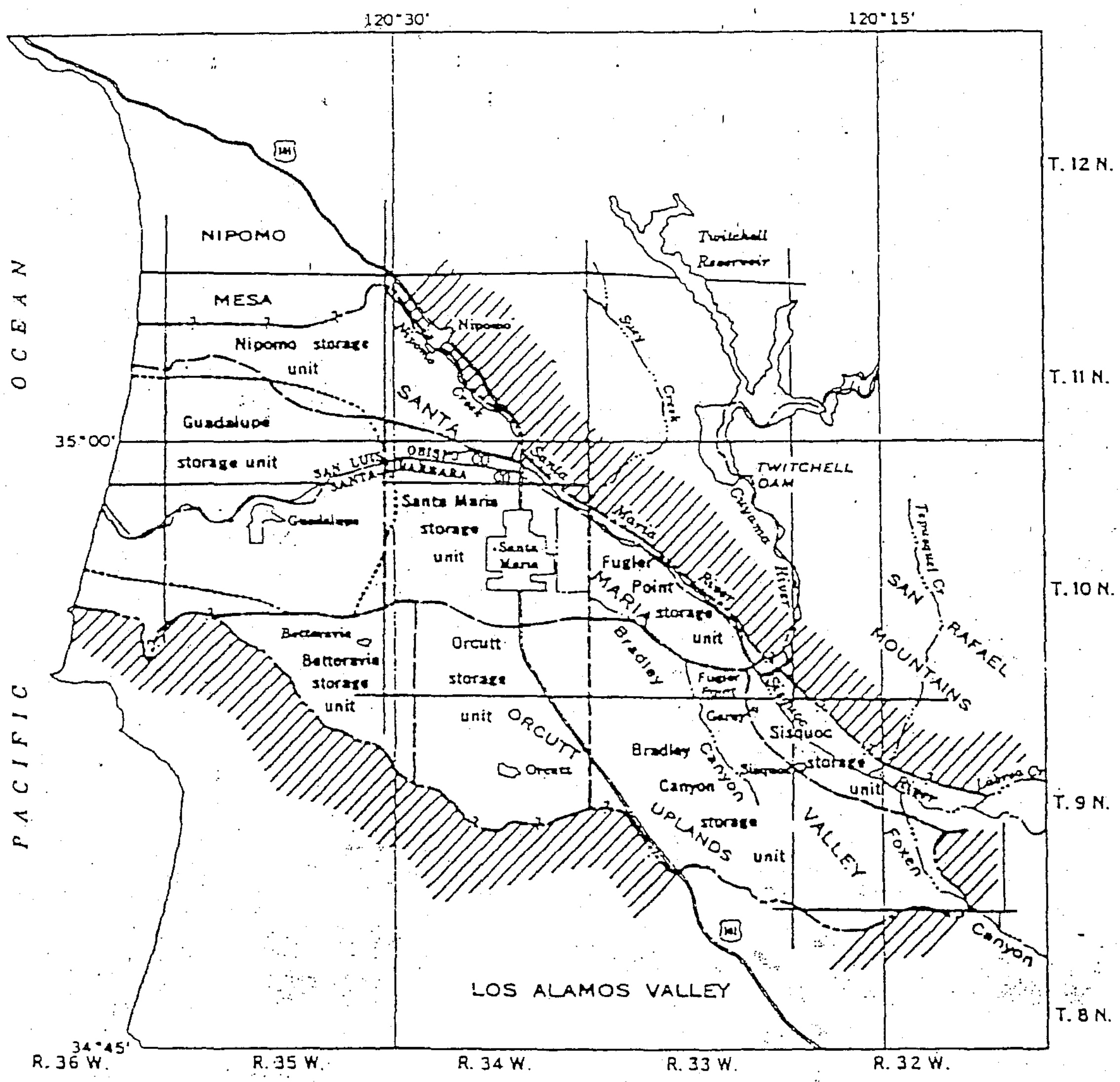
Storage Capacity

Total groundwater storage within the saturated deposits of the groundwater basin has been previously estimated at 10 million AF. However, the usable storage capacity of a coastal groundwater basin is limited by the threat of seawater encroachment if lowered water levels near the coast produce a landward hydraulic gradient.

Figure 3

PREPARED IN COOPERATION WITH

THE SANTA BARBARA COUNTY WATER AGENCY



B. STORAGE UNITS

Source: Miller & Evenson, Utilization of Groundwater in the Santa Maria Valley Area, CA USGS Water Supply Paper #1819 A, 1966.

Table 1

SANTA MARIA BASIN

ESTIMATED GROUNDWATER IN STORAGE[a]

CHANGE IN GROUNDWATER STORAGE (AF X 1,000)

Storage Unit	Surface Area (AC)	1,000 AF in Storage 1918	1950	1959	1975
Guadalupe[b]	25,000	235	171	145	145
* Nipomo	10,500	250	160	140	140
Betteravia	6,100	82	65	47	43
Santa Maria	17,400	540	292	265	223
Fugler Point	5,500	230	153	170	170
Orcutt	16,200	460	277	290	238
Bradley Canyon	22,000	1,020	992	900	855
Sisquoc	4,280	255	252	250	240
Total	107,000	3,070	2,360	2,210	2,054

Dewatered Storage (AF)

	1950-59	1959-75	1918-75
Net	150,000	160,000	1,020,000
Average Annual	17,000	10,000	18,000

* Nipomo storage unit is outside of Santa Barbara County.

[a] 1918, 1950, 1959 estimates from USGS (Miller & Evenson, 1966) showing groundwater in storage above sea level. 1975 figure developed by SBCWA.

[b] Groundwater in storage from 10 ft. above sea level to top of saturated zone.

Dewatered storage numbers are rounded.

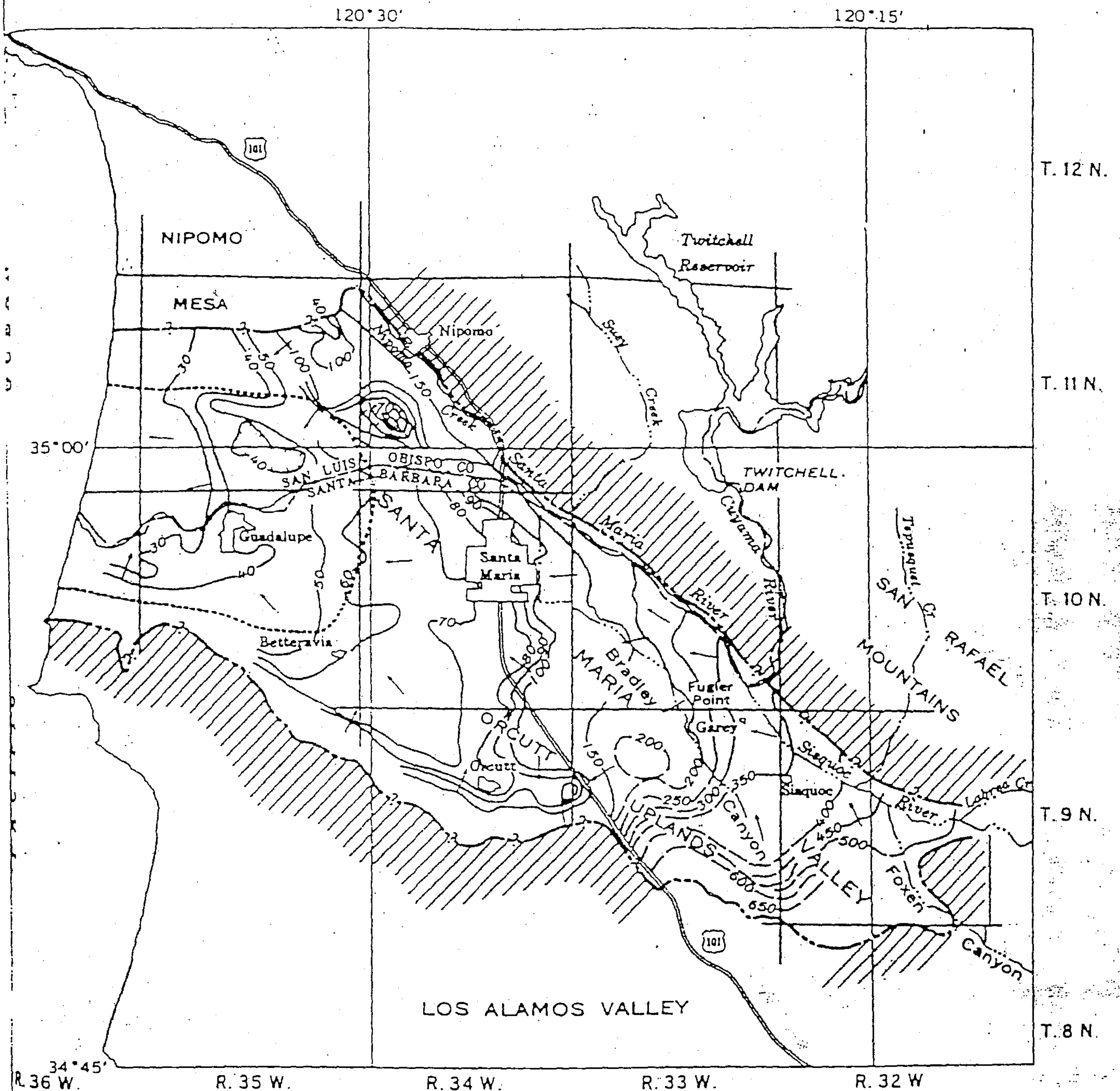
Estimates of groundwater in storage for the years 1918, 1950, 1959, and 1975 are shown in Table 1 for each of eight storage units delineated in Figure 3. These figures represent groundwater in storage above sea level for all of the storage units except Guadalupe for which the USGS arbitrarily chose the depth between 10 feet above MSL and the top of the saturated zone as providing an adequate natural barrier against sea-water intrusion (2). The previously compiled data from the USGS showed a total decrease in storage of 860,000 AF for the period 1918-59 which represents an average annual dewatering of 21,000 AF.

Estimated groundwater in storage for 1975 was indirectly calculated by the Water Agency in the process of determining storage changes between 1959 and 1975. Due to the abundance of conflicting reports as to historical water level changes in the Santa Maria Basin, the Water Agency sought to independently evaluate these trends. Approximately 250 static water levels in various wells throughout the basin were plotted on a base map and spring 1975 water level contours were interpolated between these data points. (See Fig. 5). Data for these wells were derived from USGS measurements (5) and from data supplied by the City of Santa Maria, Southern California Water Company (California Cities Water Company), Lake Marie Water Company, and Union Sugar. The water level contours reveal significant depressions in the water table west of the City of Santa Maria, south of the city near the airport, and east of the town of Orcutt. While the area of closure west of the city represents an area of intense agricultural water demand, the depressions south of the city are the result of municipal and industrial extractions by the City of Santa Maria and the unincorporated Orcutt area. In addition, comparison of 1975 water level contours prepared by the Water Agency and a contour map from a recent USGS report revealed a very good correlation.

In conjunction with water level contours for the spring of 1959 previously developed by the USGS (see Fig. 4) water level contours for spring 1975 prepared by the Water Agency were used to determine changes in groundwater storage over this 16 year period. By superimposing 1975 water level contours on the 1959 contour map, changes in water levels for each of the township sections in the basin were determined. Using specific capacity values summarized in Toups 1975 [App. D(4)] and a known area of each township section, actual decrease in groundwater volume was determined. Because water level declines in the Guadalupe Storage Unit actually represent a loss of head over the confined area rather than an actual dewatering of sediments, specific yield values as summarized by Toups were not employed over the confined area. Instead, it was assumed that there was no decrease in groundwater storage in the Guadalupe Storage Unit.

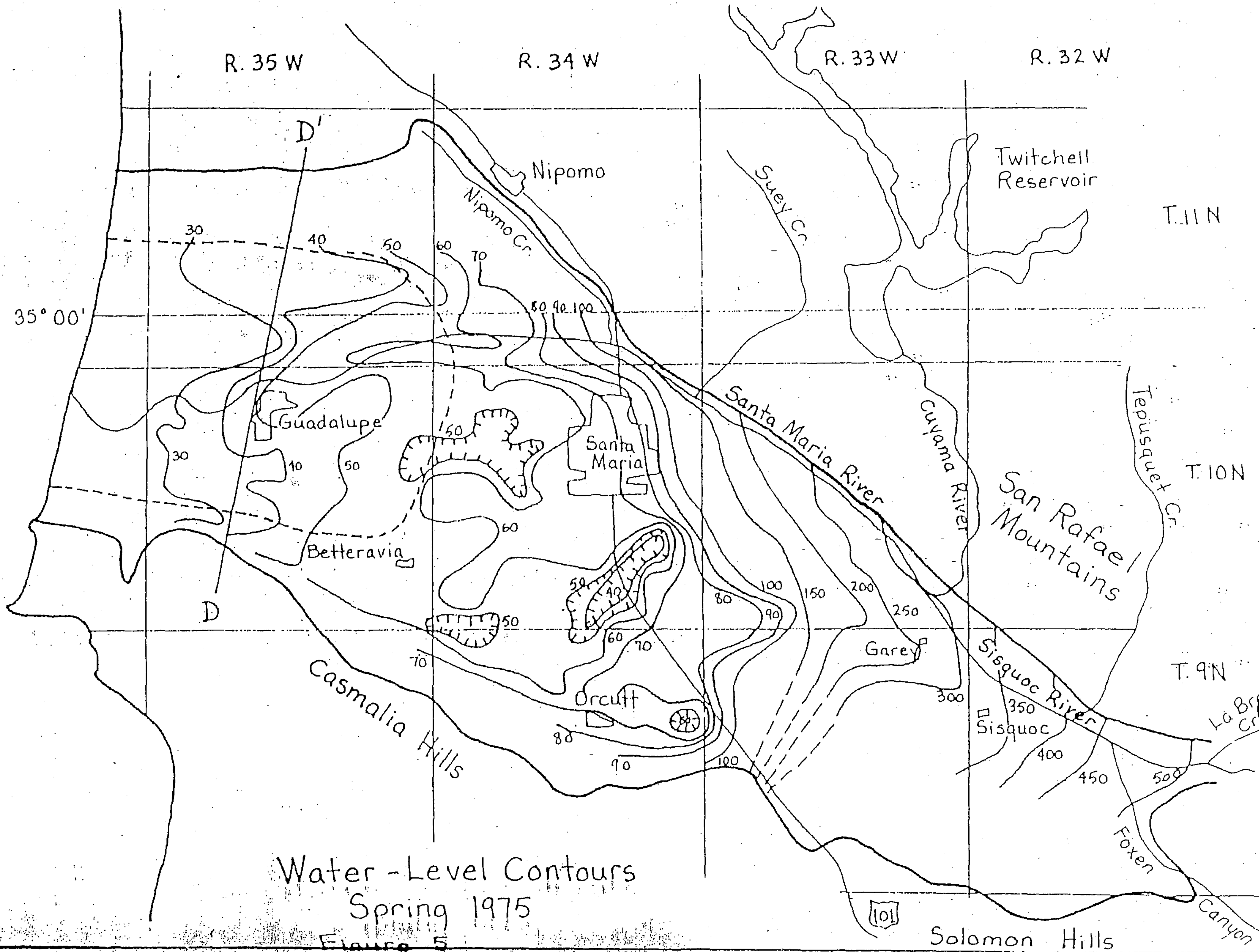
Between 1959 and 1975, net loss of groundwater in storage amounts to 160,000 AF, or approximately 10,000 AFY. The most

Fig. 4

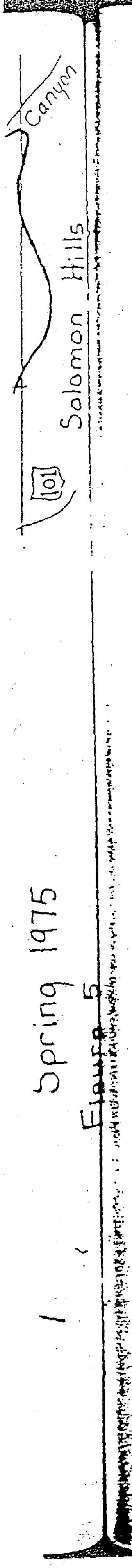


C. WATER-LEVEL CONTOURS, SPRING 1959

Source: Miller & Evenson, Utilization of Groundwater in the Santa Maria Valley Area, CA USGS Water Supply Paper #1819 A, 1966.



Water - Level Contours
Spring 1975
Figure 5



significant storage changes occurred in the Orcutt, Bradley Canyon and Santa Maria storage units. The net loss in groundwater volume for each of these storage units was found to be 50,000 AF, 45,000 AF, and 40,000 AF, respectively. For those areas in which insufficient control over the water level contours existed, no storage change calculations were made. Furthermore, there was probably some lowering of water levels along the southern margins of the basin in response to declining water levels in the central part of the basin. For the reasons outlined above, these storage change figures are believed to be conservative. Since 1918, when basin water levels were at an historic high, well over one million AF have been removed from storage.

Selected hydrographs for each of the storage units in Santa Barbara County are assembled in Appendix A. Hydrographs for the Sisquoc and Fugler Point storage units show the dramatic fluctuations in static water levels as the result of recharge during wet years and drawdown during dry periods. The pronounced peaks can be attributed to the direct influence of recharge through the highly permeable channel deposits of the Sisquoc and Santa Maria Rivers. These peaks display a good correlation with periods of high streamflow.

Hydrographs of wells which are farther removed from the influence of river recharge show a progressive flattening. Wells 10/34-2R1, 10/34-22R1, and 9N/34-8H roughly lie in a plane of cross-section through the basin at a distance of ¼ mile, 3½ miles, and 7½ miles, respectively.

Beyond a decrease in the magnitude of the recharge peaks of wells some distance from the river, a considerable lag time is evident in the response of these water levels to river recharge. In well 10N/34W-2R1, the peak water level after the relatively wet year in 1969, occurred in 1970, whereas the corresponding peak for well 10N/34W-22R1 occurred in 1971. This indicates that the wave of river recharge took approximately one year to travel a distance of three miles from the river channel to the edge of the Santa Maria Plain.

Similar observations by Worts [USGS 1951 (1)] also revealed progressively smaller rises in water levels at some distance from the river as well as a slower response to river recharge. He associated water level rises with the movement of a recharge mound away from the river water channel. To some extent, this mound was interrupted or partially masked in areas where water level rises coincided with peak demand periods. Worts concluded that in the unconfined area "during years of average recharge from streams, the mound probably does not extend far beyond the southern edge of the plain, and during years of below-average recharge it probably does not move even that far south "(1). In the confined area, the recharge mound was not considered to affect the hydraulic head until it had produced a general rise in water level along the greater part of the inland boundary of confinement.

Because of the relative isolation of the southern portion of the basin from river recharge, natural recharge to Betteravia, Orcutt, and Bradley Canyon storage units is primarily dependent on deep percolation of rainfall and subsurface inflow. Therefore, these areas are probably recharged only during periods of above average rainfall. Groundwater storage depletion in the Orcutt Storage Unit has amounted to approximately 50,000 AF during the 1959-75 period. Based on a weighted percentage of the surface area of the Orcutt Uplands as compared to total area of the basin, deep percolation of rainfall and subsurface inflow in the Orcutt area averages about 2,000 AFY. Given an average of M & I consumptive extractions totally 6,000 AFY for the Orcutt Storage Unit, an average annual overdraft of 4,000 AFY would be expected. This value is comparable with a conservatively estimated storage loss value of 3,200 AFY, calculated for the Orcutt Storage Unit.

Hydrologic Balance

To evaluate the magnitude of the overdraft in the Santa Maria Basin, the elements of recharge and discharge are examined in order to determine the perennial yield of the basin. Overdraft occurs when the quantity of water withdrawn from the basin exceeds the perennial yield. The elements of discharge are subtracted from the elements of recharge and the difference is balanced against the observed changes in storage for several time periods.

The selection of a representative base period is essential to the development of a hydrologic equation which will evaluate long-term conditions within the basin. For a base period to be representative climatically, it should include a typical wet and dry period. A curve depicting the accumulated departure from long-term mean rainfall is a useful tool in choosing a representative base period (see Fig. 3). For a base period to have mean rainfall near the long-term average, a line joining the beginning and end of the period should be close to horizontal. In addition to these considerations, for change of storage purposes, it is important to start the base period at a time such that the immediately preceding year was not extremely wet, and not have the base period end in a year that was extremely wet (6). This is done in order to avoid underestimation of groundwater storage that may not reflect "water in transit" that has not been reflected in basin water levels.

Hydrologic equations and change in groundwater storage calculations were developed for the periods 1959-75, and 1935-72. The 1959-75 period, although somewhat drier than the long-term average, shows the effects of Twitchell Reservoir releases on natural recharge. The 1935-72 period, as employed in the Toups study (4), meets the necessary conditions of a base period, and is considered to best represent long-term hydrologic conditions in the Santa Maria Basin. Data for this period were independently developed by the Water Agency and compared to data generated in the Toups study.

Elements of Recharge

Recharge to the groundwater basin occurs through the process of stream seepage, deep percolation of rainfall, and subsurface inflow from the surrounding foothill-mountain watershed. Groundwater recharge by irrigation return flows and from M & I uses are indirectly included in the equation by calculating net consumption by agricultural and M & I water purveyors.

Preliminary estimates of groundwater recharge by the Water Agency were based on the assumption of extremely limited deep percolation over the confined area. However, because this methodology consistently led to overestimations of net disposal from the basin, an allowance for deep percolation within the confined area has been included in subsequent evaluations. A recent publication by the USGS (16) has also tended to substantiate these conclusions pertaining to recharge over the confined area. Figure 6 shows a diagrammatic section through the area of confinement. It is apparent from this cross-section that the clay layers are areally and vertically discontinuous, with the volume of clay in the section decreasing in proportion to the distance inland from the ocean. Therefore, the potential for groundwater recharge also increases by a similar function. Thus, the series of confining layers act as an aquitard rather than an aquiclude to groundwater movement. Estimates of rainfall infiltration and irrigation return waters in this report include an allowance of one-half the potential groundwater recharge by deep percolation over the confined area.

Stream Seepage

Recharge to the groundwater body occurs by the downward and lateral percolation of water from flowing streams. Due to the depth of the water table below the streamcourses and the high permeability of the river channel deposits, large seepage losses are experienced by the Sisquoc and Santa Maria Rivers. In addition, several other tributary streams contribute significant amounts of seepage to the groundwater basin. Estimates of the total stream seepage in the Santa Maria Basin are calculated as the total inflow minus total outflow from the basin. Because there are few phreatophytes along the major streamcourses, evapotranspiration of streamflow is considered negligible (1).

Estimates of seepage losses for the period 1919-59 were made by the USGS [1966 (2)]. Seepage losses for the period 1959-75

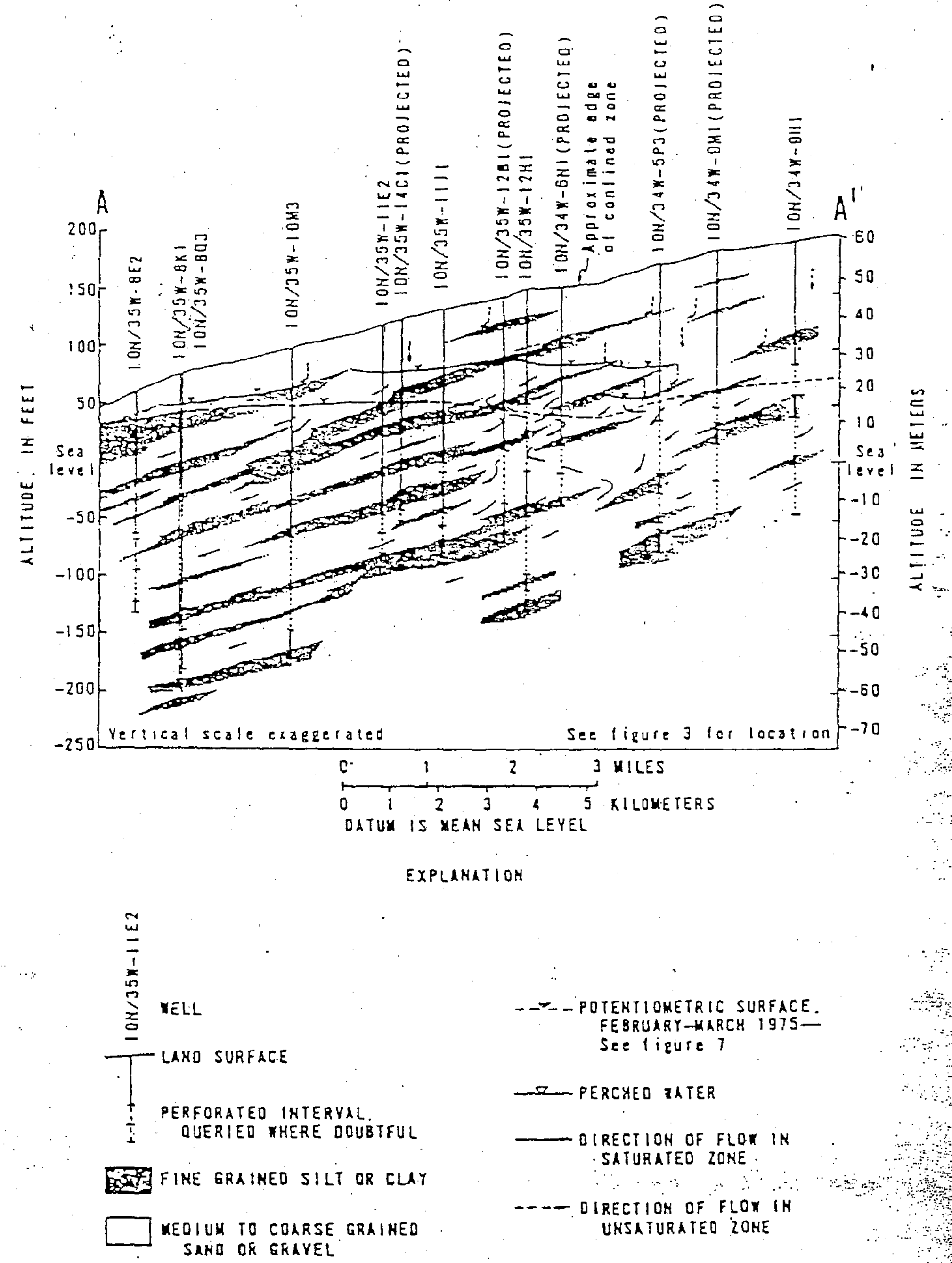


FIGURE 6.--Diagrammatic section through the area of confined ground water showing lithology and ground-water flow system.

Source: Hughes, J.L., Evaluation of Groundwater Quality in the Santa Maria Valley, California. USGS Water Resources Investigation, pp. 76-128, July 1977.

since Twitchell Reservoir has been in operation were determined from gaging station records of inflow from streams tributary to the Santa Maria Valley area plus an estimate of ungaged runoff minus the measured outflow to the ocean. Gaging station records of inflow include those of the Sisquoc River near Sisquoc, La Brea Creek, Tepusquet Creek, Foxen Creek and the Cuyama River below Twitchell Dam. Streamflow records of the Santa Maria River at Guadalupe gaging station are assumed to equal outflow from the basin.

Estimates of runoff from ungaged streams tributary to the basin are derived from Toups [1976 (4)] use of the "recoverable water" concept developed by the USGS [1965 (7)]. The isohyetal method was employed to determine the volume of precipitation over the 57,000 acre foothill-mountain watershed. By subtracting the estimated evapotraspirative losses over this area from the derived rainfall volume, the amount of residual water available for direct groundwater recharge and surface water runoff was estimated. For the purposes of this report, a figure of 1,500 AFY of "recoverable water" is used to represent the long-term runoff from ungaged streams in the Santa Maria Valley.

Gaging station records and estimates of seepage losses in the Santa Maria Valley are presented in Table 2, which reflect losses over the entire basin. While Toups 1976 Santa Maria Valley Water Resources study derives separate hydrologic budgets for the Sisquoc Plain and Santa Maria Valley, the two areas are in reality hydraulically connected and, consequently, have been considered as a single aquifer system in this report.

Underflow from streams tributary to the basin has been considered negligible. Surface inflow into the basin is measured at the Sisquoc River near Sisquoc gaging-station 2.6 miles above La Brea Creek. The relatively small magnitude of underflow is related to a low concrete dam about 1,000 feet above the gaging station which reportedly extends to bedrock, thus intercepting most of the underflow. Records of the gaging station below Twitchell Reservoir do not measure underflow nor small-scale diversions along the 3.5 mile section of the Cuyama River upstream to the dam. However, the magnitudes of these values are probably negligible in relation to the total stream seepage for the basin. In the remaining tributary streams, quantities of underflow are extremely small.

Average annual stream seepage in the Santa Maria Basin for the period 1959-75 since Twitchell Reservoir has been in operation, is estimated at 62,000 AFY. For the base period 1935-72, the average annual stream seepage, modified to show the effects of Twitchell Reservoir for years in which it was not in operation, results in a long-term groundwater recharge by stream seepage that may be expected in the future of approximately 70,000 AFY.

Table 2

SANTA MARIA GROUNDWATER BASIN
STREAM SEEPAGE* (AF)

Water Year	Inflow	Outflow	Net Seepage Loss
1935	43,200	3,600	39,600
36	55,500	19,300	36,200
37	190,000	880,000	102,000
38	262,000	135,000	127,000
39	24,600	0	24,600
1940	27,7000	0	27,700
41	333,000	183,000	150,000
42	52,600	1,090	51,500
43	178,000	71,900	106,000
44	83,000	13,560	69,400
1945	49,250	4,950	44,300
46	29,500	4,880	24,600
47	15,800	2,540	13,300
48	4,000	0	4,000
49	7,000	0	7,000
1950	13,100	2,460	10,600
51	6,300	0	6,300
52	210,800	104,700	106,000
53	27,200	360	26,800
54	29,900	1,270	28,600
1955	11,100	0	11,100
56	36,500	4,200	32,300
57	6,200	0	6,200
58	270,300	133,500	137,000
59	14,500	0	14,500

Water Year	Inflow	Outflow	Net Seepage Loss
1960	4,110	0	4,110
61	890	0	890
62	118,220	24,270	93,950
63	8,260	0	8,260
64	4,300	0	4,300
1965	16,680	0	16,680
66	31,050	910	30,140
67	214,000	32,090	181,910
68	56,420	100	56,320
69	469,100	179,670	289,430
1970	130,680	130	130,550
71	22,390	0	22,390
72	7,430	0	7,430
73	97,210	10,000	87,210
74	57,930	210	57,720
1975	27,340	300	27,040
Total			2,281,630

Average Annual Stream Seepage

1935-72 = 55,500 AFY
1959-75 = 60,750 AFY

* Stream seepage data for the 1935-58 period from previous USGS estimates (2). Seepage estimates for the period 1959-75 derived by the Water Agency from USGS gaging station records.

Twitchell Reservoir

Twitchell Dam was completed in 1959 and first began capturing runoff from the Cuyama River and its tributaries in 1962. The reservoir has a capacity of 240,000 AF of which 151,000 AF are devoted to a conservation pool, and 89,000 AF are reserved for flood control storage. Operation of the reservoir involves controlled releases of stored water for groundwater replenishment to the groundwater body along the Santa Maria River channel. Optimum flow in the Santa Maria River for maximum groundwater recharge is considered as 300 cfs. Thus, if flow in the Sisquoc River equals or surpasses 300 cfs, no releases are made. If flow in the Sisquoc River is less than 300 cfs, releases from the reservoir are made to make up the difference.

The USBR [1959 (8)] originally estimated the incremental yield from Twitchell Reservoir at 21,200 AFY. This value was derived from theoretical data developed before the reservoir was actually put into operation. A computer analysis developed by Toups [1976 (4)] determined the long-term yield of Twitchell Reservoir over the 1935-72 base period to be 19,750 AFY. In the present determination of the perennial yield of the basin, an additional 20,000 AFY of recharge from stream seepage as the result of controlled Twitchell releases was included in the estimates of recharge for those years before the reservoir existed.

Rainfall Infiltration

Rainfall over the entire basin is assumed to approach the measured rainfall at the City of Santa Maria (see Fig. 1). For the purposes of determining deep percolation of rainfall, the basin has been divided into irrigated and non-irrigated acreage. Historical irrigated acreage data for the 1959-75 period are displayed in Table 3.

Groundwater recharge may occur through the downward percolation of rainfall through the soil profile to the water table. The major proportion of rainfall is disposed of by surface runoff, evaporation, and transpiration. However, a small quantity of rainfall may percolate to the groundwater body under proper conditions. This quantity is dependent on such factors as soil type, depth to the water table, slope, vegetative cover, field capacity, and storm characteristics. Most of the rainfall on a given area during periods of average precipitation is held within the soil profile or is returned to the atmosphere through evapotransipration of plants. Only during years of above average rainfall does any significant quantity of water pass below the root zone of plants under the force of gravity to become deep percolation. In areas of deeply rooted native vegetation, very little water is able to penetrate below the

Table 3

SANTA MARIA GROUNDWATER BASIN
AGRICULTURAL ACREAGE[a/]

	Truck Crops	Field Crops	Pasture-Alfalfa	Citrus-Avocados	Vineyards	Ornamentals	Deciduous	Irrigated Total	Dry Grain	% Irrigated Ag[b/] in Confined Area
1959	15,653	7,376	3,989	0	0		20	27,038	7,397	47
1960	15,655	7,702	4,462	7	10		19	27,855	7,191	47
61	15,654	8,028	4,935	14	20		19	28,670	6,987	47
62	15,650	8,354	5,408	21	30		18	29,481	6,783	47
63	15,646	8,680	5,881	28	40		18	30,293	6,579	47
64	15,642	9,006	6,354	35	50		17	31,104	6,375	48
1965	15,638	9,332	6,827	42	60		17	31,916	6,171	48
66	15,635	9,658	7,300	49	70		16	32,728	5,967	48
67	15,632	9,983	7,773	56	80		16	33,540	5,763	48
68	15,628	10,313	8,243	60	90		15	34,349	5,556	48
69	17,268	10,118	7,922	51	809	89	13	36,270	5,312	46
1970	18,908	9,922	7,600	42	1,528	178	11	38,189	5,068	44
71	20,548	9,726	7,278	33	2,247	261	9	40,102	4,824	42
72	22,188	9,530	6,956	24	2,966	356	7	42,027	4,580	40
73	23,828	9,334	6,634	15	3,685	445	5	43,946	4,336	38
74	25,468	9,138	6,312	6	4,404	534	3	45,865	4,097	37
1975	27,110	8,942	5,991	0	5,121	626	0	47,790	3,846	36
Avg. Annual Condition (1959-74)	17,991	9,138	6,492	30	1,006	116	14	34,586	5,812	15,420

a/ 1975 acreage figures include 8,807 acres of irrigated land and 22 acres of dry-farmed grain outside of Santa Barbara County in the Nipomo area. Acreage data from DWR land use studies [1959 (13) and 1968 (14)] and the GRSU, UCSB, "1975 Agricultural Land Use Survey" (15). Intermediate values were interpolated between years of existing data.

b/ Agricultural acreage in confined area in 1959 and 1968 from Toups, 1976, Appendix D (4). 1975 acreage in confined area planimetered by SBCWA from 1975 agricultural land use maps.

root zone. However, more rainfall is available for deep percolation on irrigated farmland since applied irrigation water maintains the soil moisture at or near field capacity.

The chronological distribution of rainfall also has a significant effect on deep percolation of rainfall. Precipitation which occurs during the early part of the rainy season will be readily taken up by vegetation or used to satisfy soil moisture deficiencies. Subsequent rainfall will have a much greater chance of percolating below the root zone if the field capacity has been satisfied by earlier storms. Thus, high-intensity storms of long duration will result in much more deep percolation than rainfall which is evenly spread out over the year.

Since information on storm intensity and duration is generally lacking, previous studies have attempted to relate rainfall infiltration to vegetative cover. Little improvement has been made on the method of estimating rainfall infiltration developed by Blaney in Ventury County 1934 (9). The results of this study were graphically summarized in infiltration curves relating rainfall to deep percolation on irrigated and non-irrigated land. A subsequent study by Blaney et. al. 1963 (10) in the Lompoc area essentially confirmed earlier conclusions that deep penetration of rainfall occurs only in years of above average rainfall. These curves are considered to provide a reasonable estimate of rainfall infiltration in the semi-arid Southern California basins.

Rainfall infiltration curves used in this report were patterned after those developed by Blaney in the Ventura County investigation (9). These curves were modified by the Water Agency to show increased deep penetration of rainfall predicted by Blaney's Lompoc study. It is assumed here that no deep percolation occurs if rainfall is less than 11 inches on irrigated land, or if rainfall is less than 17 inches on areas of native vegetation. Furthermore, it is assumed that annual rainfall over 30 inches does not contribute any additional deep percolation. Similar observations in the Carpinteria Basin also indicate an upper limit on rainfall which effectively increases the quantity of deep percolation (11). In addition, one-half of the potential recharge by deep penetration of rainfall over the confined area is included in the calculations.

Rainfall infiltration data for the Santa Maria Basin are presented in Table 4. These values were determined to average 8,700 AFY over the 1935-72 base period, and 4,800 AFY during the 1959-75 period. The difference in these values is basically attributable to the lower than average rainfall between 1959 and 1975. Rainfall infiltration under 1975 conditions was similarly calculated as 10,700 AFY, while by the year 2000, average yearly deep penetration of rainfall is expected to increase slightly to 11,000 AFY. The increases in the long-

Table 4

SANTA MARIA GROUNDWATER BASIN

RAINFALL INFILTRATION[a/]

(AF)

Water Year	Rainfall (in)	Historical Condition	Current (1975) Condition
1935	19.55	22,314	27,820
36	13.48	3,387	5,309
37	20.82	29,323	35,241
38	22.18	36,828	43,189
39	11.51	1,148	1,799
1940	14.61	4,671	7,322
41	30.75	79,985	88,886
42	16.95	8,146	12,768
43	17.22	9,455	14,204
44	14.56	4,614	7,233
1945	11.31	1,105	1,443
46	11.08	791	1,033
47	9.42	Ø	Ø
48	8,20	Ø	Ø
49	9.17	Ø	Ø
1950	10.47	Ø	Ø
51	8.66	Ø	Ø
52	18.57	18,734	22,093
53	10.87	505	659
54	12.12	2,209	2,886
1955	13.17	3,035	4,757
56	14.56	4,614	7,233
57	9.01	Ø	Ø
58	25.86	55,007	64,693
59	7.62	Ø	Ø
1960	11.33	804	1,479
61	7.11	Ø	Ø
62	16.39	6,556	11,086
63	11.30	843	1,425
64	7.81	Ø	Ø
1965	11.62	1,267	1,995
66	9.13	Ø	Ø
67	14.96	5,044	7,946
68	8.25	Ø	Ø
69	20.84	30,656	35,358

Table 4 (cont'd)

Water Year	Rainfall (in)	Historical Condition	Current (1975) Condition
1970	9.59	∅	∅
71	9.82	∅	∅
72	5.45	∅	∅
73	19.63	26,117	28,287
74	15.21	8,391	8,391
1975	11.59	1,942	1,942
Total		367,491	446,480
Annual Average			
1935-72		8,712	10,733
1960-75		4,801	-

a/ Based on rainfall infiltration curves developed by the Water Agency, current condition represents 1975 irrigated/ non-irrigated acreage applied to base period rainfall. Infiltration values assume that one half of the irrigated and non-irrigated acreage in the confined area effectively transmit deep percolation of rainfall.

term averages of rainfall infiltration under current and projected conditions are associated with increases in irrigated agricultural acreage.

Subsurface Inflow

The Santa Maria Groundwater Basin is in hydraulic continuity with the San Antonio Basin to the south, as shown by water level contours depicting the base of fresh water (4). A topographic divide following the crest of the Solomon Hills separates the basin along the southeastern boundary of the Santa Maria Basin. Toups estimated inflow from this source at 1,000 AFY. Along with an arbitrarily chosen estimate of 500 AFY subsurface underflow from the remaining consolidated rocks surrounding the basin, total annual subsurface inflow to the basin is estimated at 1,500 AFY.

Estimates of Total Recharge

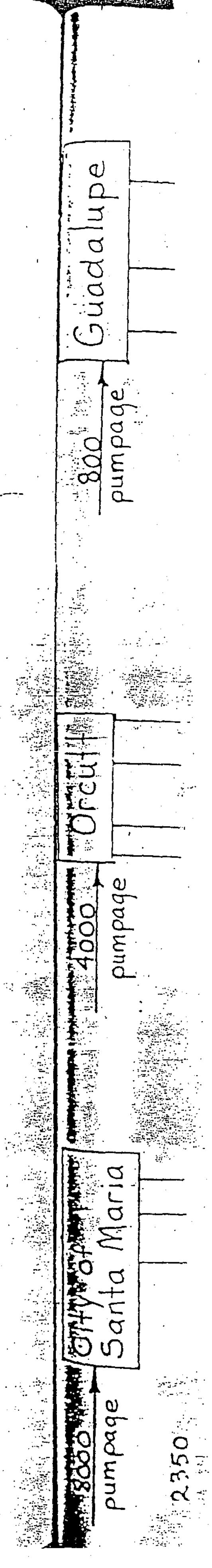
Average annual recharge from stream seepage, subsurface inflow, and rainfall infiltration totaled 68,150 AFY during the 1959-75 period. Over the base period 1935-72, average annual recharge amounted to 67,200 AFY. Base period recharge, modified to show the effects of Twitchell Reservoir, indicates a long-term annual recharge of approximately 82,000 AFY under 1975 basin conditions.

Elements of Discharge

Discharge from the basin represents the sum of surface outflow, subsurface outflow, and the evapotranspirative losses from agricultural, municipal, and industrial uses of groundwater. Surface outflow from the basin has already been accounted for in the calculation of net seepage losses from streams. Subsurface outflow from a coastal basin such as Santa Maria results in water irrecoverably lost to the ocean. Gross pumpage by M & I and agricultural water users, less return flows from excess irrigation water and effluent percolation ponds, represents net water losses from evapotranspiration.

M & I Water Use

The cities of Santa Maria, Guadalupe, and the unincorporated Orcutt area (served by the Southern California Water Company) are the largest M & I water purveyors in the Santa Maria Valley. Part of the water extracted by these municipalities ends up as effluent that is conveyed to the various wastewater treatment plants serving the area (see Fig. 7). All of the effluent produced within the basin is disposed of either through percol-



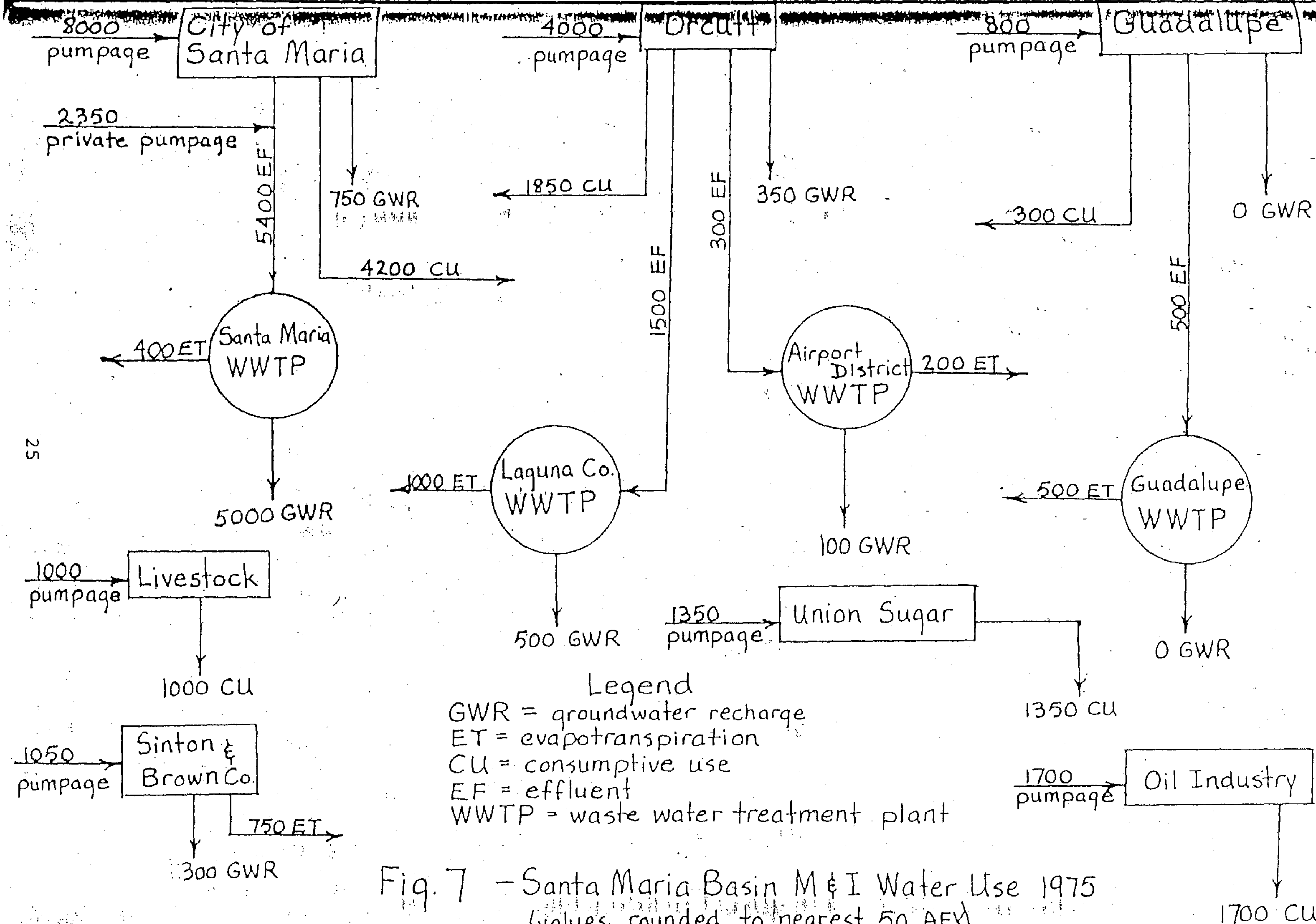


Fig. 7 – Santa Maria Basin M & I Water Use 1975
(values rounded to nearest 50 AFY)

ation ponds or is reclaimed for irrigation of pasture crops. While part of the effluent is lost through evapotranspiration, significant portions are returned to the main groundwater body. Pumpage that is not accounted for as sewage outflow represents outside water use. This is essentially lawn watering and garden uses. Most of this applied water is lost through evapotranspiration, but a small percentage probably does recharge the groundwater body. A small amount of domestic water use in the Nipomo, Garey, Sisquoc and surrounding rural areas has been considered negligible in the development of the hydrologic equation for the basin.

Current (1975) M & I water use for the Santa Maria Basin is depicted in Figure 7. Pumpage estimates were supplied by the various entities. The amount of deep percolation and evapotranspiration of effluent was derived from Water Agency estimates of the proportions of inside and outside water use for purveyors throughout the basin. Groundwater recharge as the result of outside water use was assumed to equal 15 percent of the total outside use. Because the City of Guadalupe is within the confined area, groundwater recharge from percolation ponds and from outside water use is considered to be negligible.

Industrial water use in the Santa Maria Valley is largely related to the requirements of the food processing and oil-related industries. Water use by the vegetable processing plant in the City of Santa Maria is basically nonconsumptive in nature, since virtually all of the fresh water used appears as effluent in the cities wastewater treatment plant. The production and refining of oil is a major water consuming industry in the Santa Maria Valley. Most of the fresh water used in oil producing and refining activities is removed from the basin through evaporation from cooling systems and deep injection of oil field brines as a means of wastewater disposal and secondary recovery. Other important water consuming industries include the Union Sugar refining plant at Betteravia, which pumps from its own wells and discharges wastewater to nearby holding ponds. While much of this water is lost through evaporation, some of the water is later recycled through the plant for cooling and for beet transportation purposes. The Sinton and Brown Company produces livestock feed by dehydrating sugar beet pulp generated at the Union Sugar Refinery. Wastewater from this process is used to irrigate pasture. In addition, it is estimated that the livestock raising industry consumes approximately 1,000 AFY. Figures for industrial water consumption are those from Toups 1976 "Santa Maria Valley Water Resources Study (4).

Thus computed, gross pumpage for M & I uses totaled 20,250 AF in 1975. Net consumption amounted to 13,200 AF in 1975 while the base period average (1959-75) is estimated at 9,300 AFY. For the period 1919 - 1959, M & I water consumption has been summarized by the USGS [1966 (2)].

Agricultural Water Use

The Santa Maria Valley is the most productive agricultural area in the County. Much of the land area is intensively cultivated, especially around the Guadalupe area, where vegetable fields are often triple-cropped. Approximately 50 percent of the irrigated agricultural acreage within the basin is devoted to truck crops, 20 percent is planted in field crops, and the remaining acreage is distributed among pasture and alfalfa, vineyards, and ornamental crops. The continued viability of agriculture in the Santa Maria Valley is evident from the increases in truck-cropped acreage on the Santa Maria Plain and in the increasing importance of vineyard production on the Sisquoc Plain over the 1959-75 period (see Table 4). The increases in acreage devoted to water-intensive truck crops will tend to place additional demands on the groundwater basin. Agriculture accounted for 86 percent of the total basin net water consumption in 1975 and was about 83,000 AFY. This was estimated on the basis of the 1975 GRSU crop survey and appropriate factors for consumptive use of applied waters.

The amount of irrigation return flow is subtracted from the gross fresh water pumpage to determine the net water consumption by agriculture over a given period. The figure thus derived indicates the amount of water irrecoverably lost through ET. Irrigation return flow is that amount of water which is available for deep percolation after the evapotranspirative needs of crops have been satisfied and the field capacity of the soil has been exceeded. Typical irrigation practices result in applied water in excess of the ET needs in order to facilitate leaching of accumulated salts below the root zone. Depending on the effectiveness of previous irrigations and rainfall in satisfying the field capacity of the soil, some or all of the excess applied water may reach the water table.

Irrigated acreage during the base period 1959-75 was determined from land-use studies by the DWR in 1959 and 1968, and from the GRSU 1975 land-use study (see Table 4). Using a linear extrapolation of data between these study years, an average base period irrigated acreage of 35,000 acres was computed of which 15,000 acres were within the confined area. Using modified long-term average applied water duty factors supplied by the Santa Barbara County Farm Advisors for the various crop types in the Santa Maria Valley, total average annual applied water during the 1959-75 period was approximately 81,600 AFY.

These applied water factors were modified to reflect the reduced water needs of crops near the coast. This is a result of the fine-grained soils within the confined area as well as climatic influences along the coastal fog belt. Data compiled by the DWR (20) indicate that annual pan evaporation near Guadalupe is approximately 80 percent of that found at a test site approximately 15 miles inland. If this same relationship is applied to gross agricultural water needs, then 80 percent of the overall average basin agricultural water duty of 2.58 AF/ac/yr indicates that water needs of crops grown within the confined area average 2.0 AF/ac/yr. This value is similar to the base period average water duty within the confined area of 1.93 AF/ac/yr determined by Toups (4).

Worts [USGS 1951 (1)] originally estimated irrigation return flows on the order of 30 percent of the applied water in the unconfined area, and acreage over the confined area amounting to approximately one-third of the total basin irrigated acreage, he concluded the irrigation return flows were about 20 percent of gross pumpage over the entire basin (1). Miller and Evenson [USGS 1966 (2)] also applied this methodology in the calculation of net irrigation pumpage in a subsequent study. However, due to the availability of subsequent land-use studies which delineate geographic distribution of agricultural acreage in more detail, Water Agency calculations of net water consumption over the confined and unconfined areas were derived separately.

Studies by Blaney, Nixon, Lawless and Wiedmann [1963 (10)] in the Lompoc area demonstrated that 44 percent of the applied water from rainfall and irrigation was realized as deep percolation. These findings indicate that a figure of 30 percent irrigation return flow under unconfined conditions previously developed by the USGS is probably a reasonable one. Gross pumpage for irrigation in the unconfined area under these conditions for the 1939-75 base period amounts to 51,600 AFY, of which 30 percent or 15,500 AFY returns to the groundwater basin.

Worts suggested that essentially all applied water over the confined area was lost through ET, or was eventually discharged to the ocean from the shallow water body [USGS 1951 (1)]. Toups 1976 study developed two hydrologic equations; one assuming no recharge through the confining layer and the other assuming 100 percent recharge of excess applied irrigation water, percolating effluent from the Guadalupe disposal site, and from urban outdoor water use (1). The Toups study tended to place more credence in their scenario assuming negligible recharge through the clay cap. As was previously discussed the confining layers are not totally impervious and probably transmit by leakage through the confining layer under a reduced pressure head. Furthermore, an additional quantity of perched water may be shed off the edges of the confining layer and percolate to the main water body. To account for these potential mechanisms of groundwater recharge over the confined area, 15 percent of the applied irrigation water in the confined area is assumed to be realized as deep percolation.

Overall groundwater returns of applied agricultural water in both the confined and unconfined areas averaged approximately

25 percent over the 1959-75 period. Net consumption of applied water thus amounted to 61,700 AFY during this period. As compared to average base period conditions, recent increases in agricultural acreage have occurred primarily in the unconfined portion of the groundwater basin. This has resulted in an increase in the weighted average irrigation returns in the basin. Thus, under current (1975) conditions, 27 percent returns accounted for a net agricultural water consumption of 82,700 AFY. Projected demands for the year 2000 similarly assume an increase in irrigation returns to 28 percent of the total applied water.

Subsurface Outflow

Groundwater moving downgradient beneath the confining beds is eventually discharged to the ocean, where the unconsolidated deposits are exposed on the ocean floor about two to four miles offshore (1). Because of the lack of well logs in the offshore area, the precise configuration of the submarine extension of the groundwater basin is unknown.

The method used to estimate groundwater discharge by outflow is based on Darcy's law of saturated flow, patterned after the methodology used by the USGS [1951 (1)]. Geologic cross-section D-D' (see Fig. 5) which cuts the basin just west of Guadalupe, defines an area through which water being discharged at the coast must move. The water-bearing deposits cut by this section include the Careaga sand, Paso Robles formation, the lower part of the Orcutt formation and the lower member of the Alluvium. The actual cross-sectional area and the permeabilities of the various formations were previously determined by the USGS [1951 (1)] from well-logs and laboratory tests. These data are presented in Table 5. As thus defined, the total saturated cross-sectional area is about 43 million square feet. Water level changes in the confined area do not significantly affect the cross-sectional area since the top of the saturated zone remains within the confining layer.

Given the information on the cross-sectional area and permeabilities of the affected formations, the hydraulic gradient across this section will determine the seaward flow potential. The calculated flow across this section less any demands west of this line of section will equal the subsurface outflow.

The hydraulic gradient was computed from a 1975 water level map prepared by the Water Agency. A gradient of 11 feet per mile, corresponding to a flow of approximately 18,000 AFY was found to coincide with the gradient derived from a 1975 water level map independently prepared by the USGS. Because of consumptive extractions seaward of this section, the actual subsurface outflow must be somewhat less than 18,000 AFY. Agricultural acreage

Table 8

SUBSURFACE OUTFLOW

SANTA MARIA GROUNDWATER BASIN[a/]

Formation	Permeability ($gpd/ft.^2$)	Saturated Cross-Section (ft.-miles)
Alluvium (lower member)	450	2,000
Paso Robles & Orcutt	5,500	65
Careaga Sand	2,200	75

Hydraulic Gradient (ft./mile)	Wedge Length (ft.)	Discharge (AFY)
1	79,200	1,600
2	39,600	3,200
3	26,400	4,800
4	19,800	6,400
5	15,800	8,000
6	13,200	9,600
7	11,300	11,200
8	9,900	12,800
9	8,800	14,400
10	7,920	16,000
11	7,200	17,600
12	6,600	19,200

[a/] Cross-sectional area and permeability from Worts, Geology and Groundwater Resources of the Santa Maria Valley, CA. USGS Water Supply Paper #1000, 1951.

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west of D-D' was planimetered from the GRSU 1975 agricultural land-use maps and found to total approximately 6,000 acres. Most of this land is intensively farmed truck crops. Due to the relatively low evaporation potential and fine-grained soils along the coastal fog belt, ET of these crops is somewhat less than the overall basin average. Applying a water duty of 2.0 AF/ac/yr Toups 1976, Table D-6 (4) to this acreage and accounting for five percent return flow yields a consumptive use figure of 11,000 AFY. Combined with an estimated 1,000 AFY of water use by Union Oil's Oso Flaco Refinery [Toups 1976 (4)], total consumptive extractions west of D-D' are approximately 12,000 AFY. Therefore, subsurface outflow from the basin under 1975 conditions was about 6,000 AF. Since subsurface outflow in 1959 as estimated by the USGS [1966 (2)] was 8,000 AF, average annual outflow during the period 1959-75 is considered to be 7,000 AFY. A recent study by the USGS (16) has concluded that subsurface outflow presently totals 7,000 AFY.

Miller and Evenson [USGS (2)] suggested that with continuing overdraft, underflow to the ocean would decrease from 8,000 AFY to 3,000 AFY as the hydraulic gradient decreased from five feet to two feet per mile. Toups [1976 (4)] estimated that on the basin of their 1975 water level contours that the hydraulic gradient had been reduced to two feet per mile, and consequently concluded that this would result in subsurface outflow totaling 2,000 AFY. The substantial difference in hydraulic gradients determined by the Water Agency and the Toups Corporation study [1976 (4)] is related to the respective areas over which the gradient was calculated. Toups calculated the gradient over the entire basin while the present study determined the gradient between the 30 and 50 foot water level contours which roughly straddle section D-D' (11). Because concentrated areas of demand within the unconfined area can produce significant water level fluctuations, use of the basin-wide hydraulic gradient does not necessarily reflect groundwater conditions at the coast. The piezometric level within the confined area is less subject to variations induced by pumping stresses, and therefore calculation of the hydraulic gradient near the coast is more likely to reflect actual conditions of discharge.

The prediction by the USGS that continuing overdraft conditions would bring about a 5,000 AFY reduction in subsurface outflow appears not to have been substantiated by recent data (2). While some lowering of head in the confined area has undoubtedly occurred, this does not necessarily imply a reduction in gradient. A more or less uniform lowering of water levels near the coast could tend to establish the same gradient at a new equilibrium level.

A subsurface outflow to the ocean has decreased under continuing overdraft, some mining of the offshore extension of the groundwater basin has occurred. The magnitude of this loss of fresh water storage is indeterminable because of the unknown volume of the offshore aquifer. If the subsurface outflow from the basin has declined from 8,000 AFY in 1959 to 6,000 AFY in 1975, this would imply that the salt-water wedge within the main aquifer has moved about one mile landward from its former position. Subsurface outflow at the rate of 6,000 AFY would mean that the salt-water wedge would have intruded the offshore aquifer system by a total of approximately four miles from the point where fresh water is discharged on the ocean floor. Water quality analyses of wells to date have not shown any abnormally high chloride levels which would indicate that seawater intrusion of the onshore portion of the basin had occurred. However, progressive lowering of water levels along the eastern margins of the confined area will tend to reduce the seaward hydraulic gradient, thereby causing a landward movement of seawater. The potential for brackish water contamination of near shore wells is currently being assessed in a coastal well monitoring program by the USGS in cooperation with the SBWCA.

Early detection of seawater contamination of the onshore aquifer system is essential to the timely implementation of mitigation measures.

The Hydrologic Equation

The previously quantified elements of recharge and discharge are applied in the hydrologic equation for the period 1959-75 shown in Table 6. The equation displays relatively good agreement between estimates of recharge and discharge and calculations of net depletion of storage. These figures indicate an annual overdraft of about 10,000 AFY in the Santa Maria Groundwater Basin. Because this is an average depletion over the base period, increases in M & I and agricultural water extractions have probably resulted in an increasing rate of storage loss in recent years.

Also presented in Table 6 are the elements of supply and disposal for the 1935-72 base period. In particular, the computed values for the various sources of recharge during this period, plus the average incremental yield from Twitchell Reservoir operations, are equated to the long-term source of supply to the basin. Under 1975 basin cultural conditions, average annual groundwater recharge is estimated at nearly 82,000 AFY.

All the estimates for the various elements of the hydrologic equation are subject to a range of error. This is apparent from the change in storage calculations as compared to the difference between total recharge and total discharge over the same time period. Errors in the estimated recharge may be due to underestimation of rainfall infiltration and additional unknown sources of recharge. Errors in estimated net pumpage may be due to inaccurate estimates of return irrigation water.

SANTA MARIA GROUNDWATER BASIN
HYDROLOGIC EQUATION
Avg. Annual Supply (AF) 1935-72 1959-75 1975 b/ Condition 2000 b/ Condi...

SANTA MARIA GROUNDWATER BASIN
HYDROLOGIC EQUATION

Avg. Annual Supply (AF)	1935-72	1959-75	1975 b/ Condition	2000 b/ Condition
Stream Seepage				
Gaged	55,500	60,750	68,100	68,100
Ungaged	1,500	1,300	1,500	1,500
Subsurface Inflow	1,500	1,300	1,500	1,500
Rainfall Infiltration	8,700	4,800	10,700	11,000
Total	67,200	68,150	81,800	82,100
Avg. Annual Disposal (AF)				
Subsurface Outflow	9,000	7,000	6,000	4,000
Net Pumpage				
M&I	8,000	9,300	13,250	17,500
Agriculture	61,200	61,700	82,700	90,000
Total	78,200	78,000	101,950	111,500
Supply minus Disposal	-11,000	-9,850	-20,150	-29,400
Avg. Annual Change in Storage	-6,700 a/	-10,000		

Footnotes:

a/ Storage change estimated by Toups (4).

b/ 1975 and 2000 water budgets include long-term stream seepage values adjusted to reflect an additional 20,000 AFY of yield augmentation from Twitchell Reservoir operations. Rainfall infiltration values reflect current and projected irrigated/non-irrigated acreage. Subsurface outflow is projected to decline slightly in response to increased groundwater pumpage.

The effectiveness of the confining layer near the coast in preventing deep percolation of rainfall and irrigation return flow also requires additional field study. The estimates of subsurface outflow are an additional source of error in the hydrologic equation.

Perennial Yield and Overdraft

The perennial yield of a groundwater basin is that amount of water that can be withdrawn on an annual basis and still maintain the basin as a renewable resource (2). Any quantity of withdrawal in excess of the perennial yield is overdraft. In a coastal groundwater basin the additional factor of potential seawater intrusion of fresh water aquifers must also be con- ered. While increased extractions can actually increase perennial yield in that it may reduce outflow to the ocean, rate of withdrawal must be less than that which would pro- e a deterioration in water quality.

Table 7 shows estimates of perennial yield based on the various base periods employed in this study. The perennial yield is here derived as the average annual recharge minus the unrecoverable water. These figures are in terms of the perennial yield for consumptive uses or net extractions. In addition, values for perennial yield are also calculated for gross extractions. Since some portion of the groundwater pumped for M & I and agricultural uses eventually returns to the aquifer system, the perennial yield for extractions will be somewhat greater than the yield for consumptive uses. Thus, the perennial yield for extractions is derived separately under assumed cultural conditions for the respective periods.

The perennial yield for consumptive use under 1935-72 base period conditions was computed as 71,000 AFY, compared to a figure of 70,000 AFY previously derived by the USGS (2). During the relatively dry 1959-75 period the perennial yield for consumptive use was found to equal 61,000 AFY. However, since the elements of supply and disposal are sensitive to changing cultural conditions, the perennial yield may vary with time. Thus, under 1975 and 2000 basin conditions, the perennial yield for consumptive use is found to increase to 76,000 AFY and 78,000 AFY, respectively. These increases in net recharge to the basin are the result of increases in rainfall infiltration on irrigated lands, as well as a decline in subsurface outflow to the ocean.

However, this analysis considers only the effects on the onshore portion of the groundwater basin. A reduction is subsurface outflow from the system in effect results in mining of

Table 7

SANTA MARIA GROUNDWATER BASIN
PERENNIAL YIELD*

Base Period	Perennial Yield (AF)		Consumptive Use
	Consumptive Use	Extractions	% of Extractions
1935-72	71,000	96,000	74%
1959-75	61,00	82,400	74%
1975 Basin Condition	76,000	105,500	72%
2000 Basin Condition	78,000	110,000	71%

* Perennial yield calculated as average annual recharge minus unrecoverable water (subsurface outflow).

the offshore extension of the aquifer. The ultimate limit upon the incremental yield derived from the increasing groundwater extractions will be the threat of seawater intrusion of the onshore groundwater body.

Current Hydrologic Balance

As compared to the average base period conditions, current cultural development in the Santa Maria Valley indicates an increasing rate of overdraft. While the long-term elements of supply remain fixed, additional consumptive uses of groundwater by a growing population and an expanding agricultural industry will tend to compound the current overdraft situation.

Average annual groundwater storage depletion over the 1959-75 period was previously estimated by the Water Agency at 10,000 AFY. A recent publication by the USGS has also indicated that the overdraft has been approximately 10,000 AFY (16). This period was chosen in order to assess the incremental yield from Twitchell Reservoir as well as to provide recent information on groundwater storage depletion. Because of the growing consumptive extractions of groundwater during this period, the current annual storage loss must be somewhat greater than this average. As previously discussed, mean annual recharge to the basin has been estimated at 82,000 AFY. Under 1975 cultural conditions, total disposal from the basin was approximately 102,000 AFY, resulting in a total deficit in the hydrologic budget of about 20,000 AFY.

Groundwater Levels

In general, the Santa Maria Groundwater Basin occasionally receives heavy recharge during very wet years, such as 1969, both from river percolation and from deep penetration of rainfall. This type of recharge causes significant rising of the water table, but it is mostly of a cyclic nature. On the other hand, cultural activities, especially those involving increasing consumptive use of extracted water, cause both local and fairly widespread declines in the water table. (In certain cases, extractions from one area and disposal by percolation in another area may result in a depression of the water table in the area of extractions and a rise in the area of disposal).

For example, assuming a basinwide specific yield of 14 percent, a basin area of 107,000 acres, and an estimated 1975 depletion rate of about 20,000 AFY, the average decline would be expected to be about 1.3 feet per year. However, within the basin, certain areas would experience greater declines than this "average" value, while other areas would have smaller declines, perhaps even stable water levels.

As an example, the June 20, 1977 letter report of the Southern California Water Company (SoCalWCo) regarding its Orcutt System cited historical changes in water levels for the eight water supply wells serving this system, these being located generally about Clark Avenue westerly of Highway 101 and easterly of the Santa Maria Public Airport. Four of the five Mira Flores Wells, which are near Clark Avenue and Highway 101, have shown a decline ranging from 0.3 ft/yr to 1.8 ft/yr, with an average of slightly greater than 1 ft/yr. It might be noted that in Figure 5, the "pumping hole" located approximately in 9N/34W-Sections 12 and 13, appears to coincide with the location of the Mira Flores Wells. On the other hand, the standing water levels in the two Evergreen Wells have reportedly dropped about 1 ft/yr for the past 17 years. These wells are located generally about the Township Line (9N/10N) within R34W, and they appear to be located near the southeasterly edge of a pumping depression easterly of the airport. Data were not included in the SoCalWCo report as to extractions from these several wells in the Orcutt System. In general, the period of time represented by the water level data embraces 1958 (at the earliest) to the present. Referring to Figure 2, it appears that this was a relatively dry period, in which Santa Maria precipitation was generally below average, resulting in a drop of up to perhaps 200 percent in the accumulated deviation from the long-term mean precipitation. During this period, the extractions from these wells grew substantially as the area developed. Thus, it appears that the moderate decline in storage that has taken place within the 19-year period may be at least partially attributable to climatic conditions.

As another example, the standing level in the City of Santa Maria's Well No. 5A-S, located near the southeast corner of the airport, appears to have declined about 26 feet in the past 19 years, or about 1.4 ft/yr. Similarly, Well No. 2A-S's standing level declined about 22 feet in the past 18 years or about 1.2 ft/yr decline. This well is about 1.1 mile northerly of Well No. 5A-S and is located within a pumping trough (Fig. 5). The airport wells of the City of Santa Maria are the most widely used of the City's supply wells, and the declines cited are probably representative of most of these wells.

Another example of well water trends is that of Lake Marie Water Company, located in 9N/33W-Section 8. Water Well No. 3 (1,000 feet deep) has shown no water level decline since its construction in 1961, although the well has been in regular production for 16 years. On the other hand, Water Well No. 4A (1,051 feet deep) has shown a very slight decline of standing water levels (seven feet drop in 16 years or less than 0.5 ft/yr). It might be noted that the pumping levels (which reflect the drawdown during extractions) were stable for Well No. 3 and actually rose for Well No. 4A. However, two Southdown Land Company water wells, used for vineyard irrigation, have shown significant water level declines. These wells are located in the northwest quarter of 9N/33W-Section 9. The standing level in Southdown Well No. 6 (1,406 feet deep) has declined 24 feet in the first five years since its construction, for an average of 4.8 feet per year up to 1971. Southdown Well No. 7 (1,508 feet deep) has experienced a standing water level decline of 56 feet during the 13 years since its construction, for an average decline rate of 4.3 feet per year. The extractions from the Southdown Wells are thought to be on the order of 800 AFY.

The bulk of the recharge to the aquifer in this area is believed to result from deep penetration of precipitation and limited streambed percolation from intermittent streams. Any effects of Sisquoc River recharge to this Lake Marie-Southdown area are believed minimal because of the apparent influence of agricultural pumping in the Sisquoc Plain which tends to intercept such river recharge. Current extractions by Lake Marie Water Company are estimated at slightly over 300 AFY and appear to have had negligible effect on the water table. The more substantial extractions by the Southdown Land Company wells appear to be lowering the water table in the vicinity by a significant rate.

<u>Projected Groundwater Supply and Demand</u>

Continued agricultural, residential, and industrial development in the Santa Maria Valley will tend to intensify the current rate of overdraft. The cumulative groundwater storage depletion may ultimately adversely affect the integrity of the basin water supply:

1. Lowered water levels may substantially increase pumping lift and incremental energy costs may strain the payment capacity of certain pumpers;

2. The salt load on the basin will increase as additional quantities of water are extracted, portions of which are realized as returns to the groundwater basin. Gradual mineralization will continue;

3. Lowering of water levels along the eastern edge of the confined area may reduce the rate of subsurface outflow from the basin, allowing seawater intrustion of the coastal aquifer system (unless a barrier project were developed); and

4. If water levels in the Guadalupe area were lowered sufficiently, a dewatering of the clay confining beds could produce land subsidence.

Water Agency projections of water demand in the Santa Maria Valley indicate a significant water supply deficit by 2000, assuming reliance upon existing resources. Assuming that industrial water consumption remains at 1975 levels, increases in domestic water use will result in a total M & I water demand of approximately 27,000 AFY. Combined with projected agricultural water needs of 125,000 AFY, total demand on the groundwater basin is projected to reach 152,000 AFY by the year 2000. This represents an overdraft for extractions of about 42,000 AFY under 1975 cultural conditions. Since a portion of the groundwater extractions return to the groundwater basin, the amount of water removed from storage is somewhat less, or about 29,000 AFY.

Water Quality

General

Groundwater quality has deteriorated significantly in some areas of the Santa Maria Valley over the past two decades. Along with the natural sources of salts added to the basin by surface runoff and rainfall, man's activities have tended to concentrate these salts through continued use and reuse of groundwater. Discharge of wastewater from point sources has created localized water quality problems. Agricultural water use tends to concentrate existing solutes in a smaller volume of water as well as add new salts to the groundwater basin. The following summary of water quality in the Santa Maria Valley is based on a recent published report (1977) by the USGS, "Evaluation of Groundwater Quality in the Santa Maria Valley, California"(16).

Surface Water

The Cuyama River has historically exhibited an inverse relationship between runoff and dissolved solids. Completion of Twitchell Reservoir has resulted in the detainment of good quality water during periods of high flow for later controlled releases. Retention of high quality runoff has resulted in a dilution of poor quality base flow and an improvement in the average quality of river recharge to the groundwater basin. Water quality in the Cuyama River averages 1,000 mg/l TDS.

The Sisquoc River, Nipomo Creek, and Orcutt Creek all exhibit TDS values near 600 mg/l. Infrequent sampling of water from La Brea, Foxen, and Tepusquet Creeks indicate that their TDS concentrations are somewhat greater.

Orcutt Creek significantly influences water quality in the Orcutt area. Upstream from the Laguna wastewater treatment plant, Orcutt Creek recharges the groundwater basin through exposures of the Orcutt sand. Downstream from this point, TDS values increase as the result of wastewater discharge from the Laguna wastewater treatment plant (WWTP), Santa Maria Airport WWTP, industry at Betteravia, and irrigation return water.

A system of drainage ditches in the Santa Maria area receives agricultural tail water and discharges to Orcutt Creek, Green Canyon and the Santa Maria River. Several water quality samples from these sources indicate specific conductance of 2-3,000 micromhos per centimeter (approximately 1,280-1,920 mg/l TDS).

Groundwater Quality

Most of the groundwater in the study area is classified as a calcium magnesium sulfate type. This classification is compatible with the quality of runoff in the Cuyama and Sisquoc Rivers, the principal sources of recharge to the basin. Higher chloride levels are found along the southern margins of the basin, especially along Orcutt Creek. Areally, groundwater quality deteriorates from east to west, laterally from the Santa Maria River , and northward from the southern edge of the groundwater basin. This distribution is related to sources of recharge and is a function of groundwater flow patterns. Available data on present groundwater quality and historical water quality trends are presented in Appendix B.

Water from wells in the Orcutt area has a different character from water sampled from other wells in the basin. Most wells in the valley have a calcium-to-sodium ratio of 2:1 which is similar to surface flow recharging the groundwater basin through the Santa Maria River system. The calcium-to-sodium ratio of water from wells in the Orcutt Storage unit is 1:1. The same ratio was found in groundwater sampled downgradient from the City of Santa Maria wastewater treatment facilities, suggesting that the identity of the supply is retained despite use by city residents.

While the areal distribution of groundwater quality is fairly well documented, vertical variations in groundwater quality are relatively unknown. This is because wells in the Santa Maria Valley are perforated throughout long intervals in order to give maximum yield. This allows for mixing of groundwater from separate aquifers with distinct water quality types, thus preventing identification of changes in water quality with depth.

Water quality degradation has been most significant in the area of confined groundwater. This is due to the recycling of groundwater for application on irrigated fields, creating a body of poor quality water perched on top of the confining beds. The large depression in the water table at the eastern edge of the confined area has caused a localized reversal of the seaward hydraulic gradient. This allows poor quality water from the confined area to mix with water from the deeper aquifers of the confined area. It is also thought that vertical mixing of distinct water types under fluctuating pressure head may occur through well casings which are perforated in both the shallow, poor quality zone, and the deeper, good quality zone. Both these mechanisms will contribute to the degradation of the deeper aquifers in the confined area over an extended period of time.

Recent water quality analyses by the USGS demonstrate that seawater intrusion of the onshore aquifer system has not occurred (16). As expected, the existence of a seaward hydraulic gradient has maintained the intrusion offshore. If it had reached the Coast, seawater intrusion would have resulted in above-normal concentrations of sodium, chloride, boron, and other chemical constituents of seawater. Groundwater in the coastal area is a calcium sulfate type with only moderate concentrations of boron and chloride. Specific conductance values for well water near the coast were less than 2,000 micromhos (approximately 1,280 mg/l TDS) which is far less than expected if seawater encroachment had occurred.

Salt Balance

Point Sources of Solutes

Percolating effluent from point sources of wastewater discharge is contributing to the degradation of groundwater quality within the valley. The effect of the wastewater on local water quality is related to the compatibility of the two water types. In some cases, the quality of the discharge source is better than the receiving groundwater. The effect of a point source of solutes on local water quality is difficult to determine unless: (1) a recharge mound is created, or (2) an ion unique to the source of readily identifiable. A point source of wastewater discharge represents in part the addition of new solutes, but also a part of the solutes already in the system which have been concentrated by the process of evapotranspiration. Important point sources of waste discharge in the Santa Maria area include sugar and oil refineries, wastewater treatment facilities, solid waste landfill sites, golf courses, stockyards, poultry farms, and feed lots.

Wastewater from the Union Sugar Company is discharged to several evaporation-percolation ponds. The recharge mound beneath the plant is relatively small in comparison with the amount of effluent discharged to these ponds, suggesting that little water is deep percolating to the main water body. Water quality analyses from these ponds exhibit high counts of suspended solids and microorganisms which may clog the bottom and reduce the infiltration capacity. Tests for DOC (dissolved organic carbon) show concentrations of up to 44 mg/l in pond water samples. However, wells adjacent to and downgradient from the ponds exhibited DOC concentrations of 2.0 mg/l or less, again indicating the imperviousness of the pond bottoms.

Wastewater for oil extractions and refining activities is either discharged to the ocean or injected into saline aquifers through abondoned or non-producing wells. Sump disposal is no longer permitted in the Santa Maria Valley. Oil fields may contribute to water quality degradation through casing leaks, spills, well blowouts, percolation of water used in drilling and repair, and from runoff through oil fields. However, no specific instances of localized groundwater pollution by oil field activities were cited in the USGS report (15).

Wastewater from the Valley's four treatment facilities is discharged to streams and to evaporation-percolation ponds or is sold to nearby farmers for application on feed crops. The quality of effluent produced from each of the wastewater treatment plants is proportional to the quality of the source water. The TDS content of effluent from the Guadalupe wastewater treatment plant averages about 2,000 mg/l compared to 1,380, 1,090 and 1,245 mg/l for the other wastewater treatment facilities. The dissolved solids concentration of water pumped for use by the City of Guadalupe, City of Santa Maria, Santa Maria Airport District, and the Laguna County Sanitation District averages 1,200, 770, 770 and 620 mg/l, respectively. Water delivered for use in the Orcutt community is of superior quality in comparison to other water supplies in the valley. This has prompted the City of Santa Maria to concentrate its pumping from the Oructt storage unit.

With the exception of chloride, the quality of water discharged from the City of Santa Maria wastewater treatment facility is about the same or better than the receiving groundwater. The percolating wastewater from this facility has resulted in both a pronounced recharge mound and an area with noticeably different groundwater quality.

Wastewater discharge from the Guadalupe facility has also produced a small recharge mound. Chemical constituents of groundwater in this area exhibit an area of degradation related to this point source. The cyclic use and reuse of water in the area of confined groundwater has caused a concentration of dissolved solids in Guadalupe's water supply.

The effect of wastewater discharged from the Laguna and Airport facilties appears to have a minimal effect on groundwater quality. The volume of wastewater discharged from the Airport facility is relatively minor and is probably recharged to the groundwater basin due to favorable surface drainage. Discharge from the Laguna plant is used to irrigate pasture crops. The high consumptive use of pasture crops is likely to be responsible for the lack of a pronounced recharge mound. Because the water supply source is fairly near the point of effluent discharge, the two water types are fairly compatible.

Average TDS values of effluent from the valley's four wastewater treatment facilities are expected to rise with population increases and deterioration of the water supply source.

Stockyards, poultry farms, and golf courses appear to have little impact on groundwater quality. A slight increase in chloride is evident near the golf course east of Orcutt. In addition, active and inactive solid-waste disposal sites to not have a significant impact on groundwater quality. However, one inactive site northwest of the City of Santa Maria may have an influence on chloride and calcium plus magnesium concentrations.

Analyses of groundwater for synthetic detergents (as MBAS - methylene-blue active substances) showed very low concentrations with no direct relation, either to point or non-point sources. All observed values were less than or equal to the U.S. Environmental Protection Agency recommended limit for detergents of 0.5 mg/l. Trace elements also were not found in any alarming quantities.

The distribution of boron in groundwater showed a definite pattern in areas downgradient from the City of Santa Maria and Guadalupe wastewater treatment facilities. The distribution near these facilities was similar to that of chloride concentrations, ranging from 0.45 - 0.62 mg/l. Sensitive crops, such as artichokes and grapes (both of which are grown in the study area) can tolerate no more than 0.5 to 1.0 mg/l boron.

Non-Point Sources of Solutes

The use of groundwater for irrigation tends to concentrate solutes in the water supply through evaporation and transpiration. The addition of chemical fertilizers also contributes to the solute load. The most conclusive evidence of groundwater contamination by fertilizer is the buildup of nitrogen compounds in the water supply. The U.S. Environmental Protection Agency recommends a limit of 10 mg/l NO_3-N (nitrate as nitrogen) for drinking water. Concentrations in excess of 40 mg/l were found in water from a few wells and concentrations in excess of 10 mg/l in water from a large number of wells encompassing a significant part of the valley.

Salt Balance Model

A comparison of the magnitudes of salts entering the Santa Maria Groundwater Basin and those which are disposed of in outflow from the basin can lead to an approximation of the net salt accumulation. Sources of natural salt inflow to the basin include surface runoff and precipitation. Disposal of salts from the basin occurs through surface outflow from the Santa Maria River and by subsurface outflow.

Man's activities have also significantly influenced the adverse salt balance in the valley. Agricultural production tends to concentrate existing salts in the basin through the natural process of evapotranspiration. However, this does not represent an addition of salts but merely a concentration of these salts in a smaller volume of water. The leaching of fertilizers applied to agricultural lands represents a true addition of salts. Municipal and industrial uses of groundwater also contribute to the salt load on the basin. In recent years, wastes from home regenerating water softeners have become an increasingly large component of M & I effluent.

The Water Agency has attempted to derive a salt balance model for the Santa Maria Basin under present conditions (1975) and for projected conditions in the year 2000. Because only salts new to the basin are considered, redistribution such as would be expected for agricultural and municipal acitivies, are not accounted for. The limitation inherent in this study is the result of considering the basin as a whole and ignoring internal conditions of various localities. An approximation was included for salt outflow by agricultural tailwater, under the assumption that about 5 cfs for 8 months per year (corresponding to the heavy irrigation season) would escape to the ocean and would contain about 4 tons per acre-foot (corresponding to at least one reuse of tailwater, such as for pasture).

Current (1975) salt balance conditions in the Santa Maria Basin are depicted in Tables 8 and 9. Of the total M & I salt accretions to the basin, amounting to about 8,700 tons/year, approximately 4,650 tons/year are contributed by the City of Santa Maria. However, salt inflow from M & I water uses is only about 10 percent of the total salt additions to the basin (about 84,400 tons/year).

The most significant means of salt movement into and from the basin is via the surface flows of Cuyama, Sisquoc and Santa Maria Rivers, and La Brea, Foxen Canyon and Tepusquet Creeks. These salt loads were determined using the average annual flows, calculated from USGS records for the period of study between water years 1959 and 1975, and estimates of water quality levels, derived from data presented by Toups Corporation (4) and the USGS (1).

Salt inflow attributed to precipitation on the drainage area (260 sq. miles) was computed using an annual rainfall rate of 13.2" per year (base period 1935-72) and a TDS level in rainwater of 20 mg/l, assumed applicable for a coastal basin.

Table 8

Table 8

SALT BALANCE STUDY - M&I ACCRETIONS IN SANTA MARIA BASIN

Source of Salt Inflow	Wastewater Flow (AFY)	TDS Increment mg/l	TDS Increment Tons/AF	Annual Salt Load Tons/Year
Santa Maria, City of[b/]	5,600	610	0.83	4,650
Guadalupe, City of	500	255	0.347	170
Laguna County Sanitation District	1,300	700	0.95	1,240
Santa Maria Public Airport District	390	350	0.476	190
Sinton & Brown Co.	770	690	0.938	1,530
Union Sugar Co.	1,070	480	0.653	700
Rural Areas	NA	NA	NA	240
				8,720

M&I Salt Load = 8,720 Tons/Year

Table 9

SALT BALANCE STUDY - SANTA MARIA BASIN
(1975 conditions)

Source of Salt Inflow	Annual Flow (acre-feet)	TDS Increment mg/l	TDS Increment Tons/AF	Annual Salt Load Tons/Year
Surface flow				
Cuyama River	31,960	650	0.884	28,250
Sisquoc River	36,070	550	0.748	26,980
Tributaries	6,870	525	0.714	4,910
Precipitation	183,040	20	0.027	4,940
M&I (see Table 11)				8,720
Agriculture	(38,980 irrig. acres)		(0.23 tons/acre/year)	8,970
Dairies	(3,685 animals)		(0.84 lbs/head/day)	560
Feedlots	(30,000 animals)		(0.20 lbs/head/day)	1,100
				84,430
Source of Salt Outflow				
Santa Maria River				
Surface flow at Guadalupe	14,570	800*	1.088	15,850
Subsurface flow	6,000	1,280	1.741	10,450
Agricultural Tailwater	2,410*	2,940	4.000*	9,640
				35,940

Net Salt Addition = 48,490 tons/year

ROUND OFF: 48,500

*Assumed

The introduction of new salts by agricultural operations was calculated using a factor of 0.23 tons/acre/year (to account for leaching of fertilizers) and a value for irrigated acreage (34,800 acres) derived by GRSU 1975 Land Use Survey(15). The salt load factor was obtained by direct communication between the Water Agency and Water Resources engineers, SWRCB, U.S. Salinity Lab, Riverside, and U.S. Cooperative Extension on 5/13/77. The amount of salts added by dairies and feedlots was determined by Brown and Caldwell (3).

Two approaches were taken in projecting the net salt addition in the Santa Maria Valley for the year 2000. In Tables 10 and 11, salt inflow and outflow were determined assuming the only change from 1975 was the growth of agricultural and municipal activities, as computed by SBCWA.

Conditions for Table 12 include importation of State project water, as well as the growth incorporated in Tables 10 and 11. For both of these cases, salt loads which were computed as a long-term average (precipitation, surface and subsurface flows) and point sources for which data for future dates are not available (oil refineries, Sinton and Brown, Union Sugar Co., and rural areas) were assumed to remain constant.

The net salt addition for both these circumstances is slightly higher than for the present. Lowering water tables assumed for the Guadalupe area by 2000 resulted in a reduced seaward gradient and a corresponding reduction in subsurface outflow, thereby reducing the salt export by this mechanism. It was assumed that a mineralization rate of groundwater of about 12 mg/l per year would accompany this trend. This mineralization rate was approximated on a gross basis for the Guadalupe and Santa Maria storage units of the basin.

Santa Maria Basin With State Project Water

Supplemental water needs in the Santa Maria Valley are projected for the year 2000 based on entity supplied information presented by SBCWA "Comparison of Estimated Supplemental Water Needs of Water Entities," August 1975, Table II. The bulk of this indicated demand is in the City of Santa Maria (10,000 AFY).

Any State project water to be used for domestic purposes would first require filtration. For the City of Santa Maria, this could be accomplished on the high ground east of the City, where gravity service could be used to operate the distribution system. Depending on the extent to which the groundwater supply is to be used by the City, introduction into the distribution system at various locations along its path could provide the desired blend.

Table 10

SALT BALANCE - M & I ACCRETIONS IN SANTA MARIA BASIN IN YEAR 2000

Source of Salt Inflow	Wastewater Flow (AFY)	TDS Increment mg/1	TDS Increment Tons/AF	Annual Salt Load Tons/Year
City of Santa Maria[a/]	6,910	610	0.83	5,740
City of Guadalupe[a/]	500	255	0.347	170
Laguna Co. Sanitation Dist.[a/]	2,200	700	0.95	2,090
Sinton & Brown Co.[b/]	770	690	0.938	1,530
Union Sugar Co.[b/]	1,070	480	0.653	700
Rural Areas[b/]	na	na	na	240
				10,470

M & I Salt Load = 10,470 tons/year

Table 11

SALT BALANCE FOR SANTA MARIA BASIN IN YEAR 2000

Table 11

SALT BALANCE FOR SANTA MARIA BASIN IN YEAR 2000

Source of Salt Inflow	Annual Flow (acre-feet)	TDS Increment mg/1	TDS Increment Tons/AF	Annual Salt Load Tons/Year
Surface flow				
Cuyama River	31,960	650	0.884	28,250
Sisquoc River	36,070	550	0.748	26,980
Tributaries	6,870	525	0.714	4,910
Precipitation	183,040	20	0.027	4,940
M&I (see Table 13)				10,470
Agriculture	(49,800 Irrig. Acres)	(0.23 tons/acre/year)		11,450
Dairies	3,685	(0.84 lbs./head/day)		560
Feedlots	30,000	(0.20 lbs./head/day)		1,100
				88,660
Source of Salt Outflow				
Santa Maria River				
Surface flow at Guadalupe	14,570	800*	1.088	15,850
Subsurface flow	3,000	1,600	2.176	6,530
Agricultural Tailwater	2,410*	2,940	4.000*	9,640
				32,020

Net Salt Addition of 56,640 tons/year

ROUND OFF: 56,600 tons/year

*Assumed

Table 12

SALT BALANCE FOR SANTA MARIA BASIN IN YEAR 2000

Source of Salt Inflow	Annual Flow (acre-feet)	TDS Increment mg/l	TDS Increment Tons/AF	Annual Salt Load Tons/Year
Surface flow				
Cuyama River	31,960	650	0.884	28,250
Sisquoc River	36,070	550	0.748	26,980
Tributaries	6,870	525	0.714	4,910
Precipitation	183,040	20	0.027	4,940
M&I (See Table 13)				10,470
Agriculture	(49,800 irrig. acres)		(0.23 tons/acre/year)	11,450
Dairies	3,685		(0.84 lbs./head/day)	560
Feedlots	30,000		(0.20 lbs./head/day)	1,100
State Project Imports	10,000	220	0.299	2,990
				91,650
Source of Salt Outflow				
Santa Maria River				
Surface flow at Guadalupe	14,570	800	1.088	15,850
Subsurface flow	6,000	1,600	2.176	13,060
Agricultural Tailwater	2,410	2,940	4.000	9,640
				38,550

Net Salt Addition of 53,100 tons/year

ROUND OFF: 53,100 tons/year

The Orcutt area currently derives water from Santa Maria Valley Groundwater Basin and is expected to continue this practice.

The anticipated costs of importing State water and constructing a distribution system to agricultural customers makes it doubtful whether the agricultural community would desire a direct surface delivery system. It is therefore projected that they continue to pump from present sources.

In terms of the salt balance, the only change anticipated resulting from the importation of State project water is the salt contained therein. Because wastewater effluent is currently applied in the basin, proposed reclamation projects involving agricultural irrigation would not represent an additional load.

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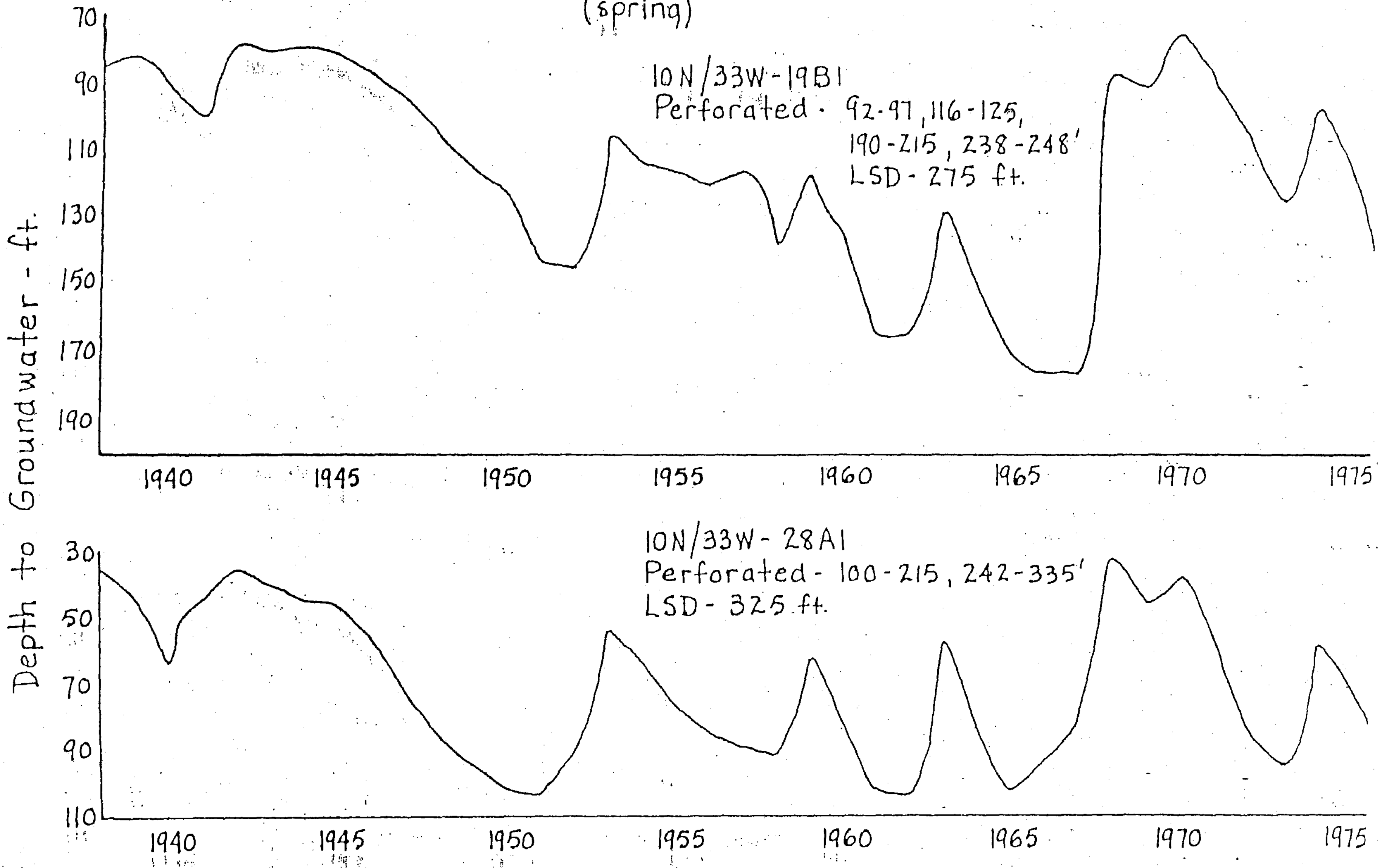
APPENDIX A

HYDROGRAPHS

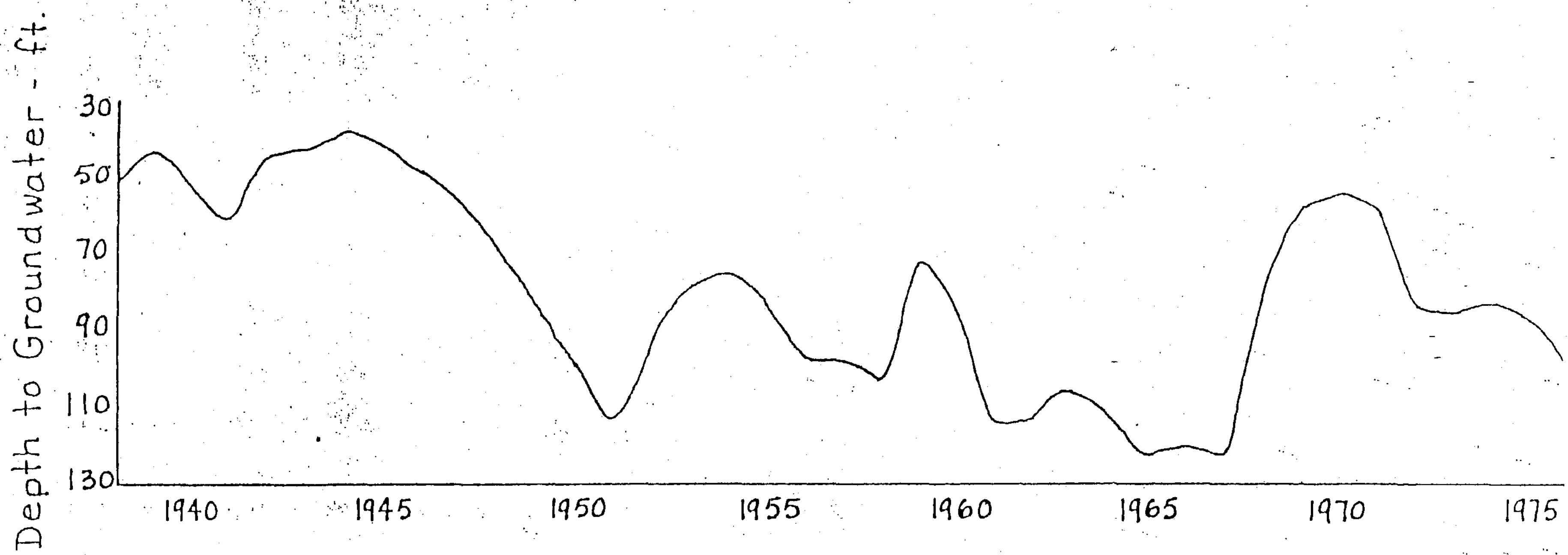
Fugler Point Storage Unit
Static Water Levels
(spring)

70

Fugler Point Storage Unit
Static Water Levels
(spring)



Sisquoc Storage Unit
Static Water Levels
(spring)

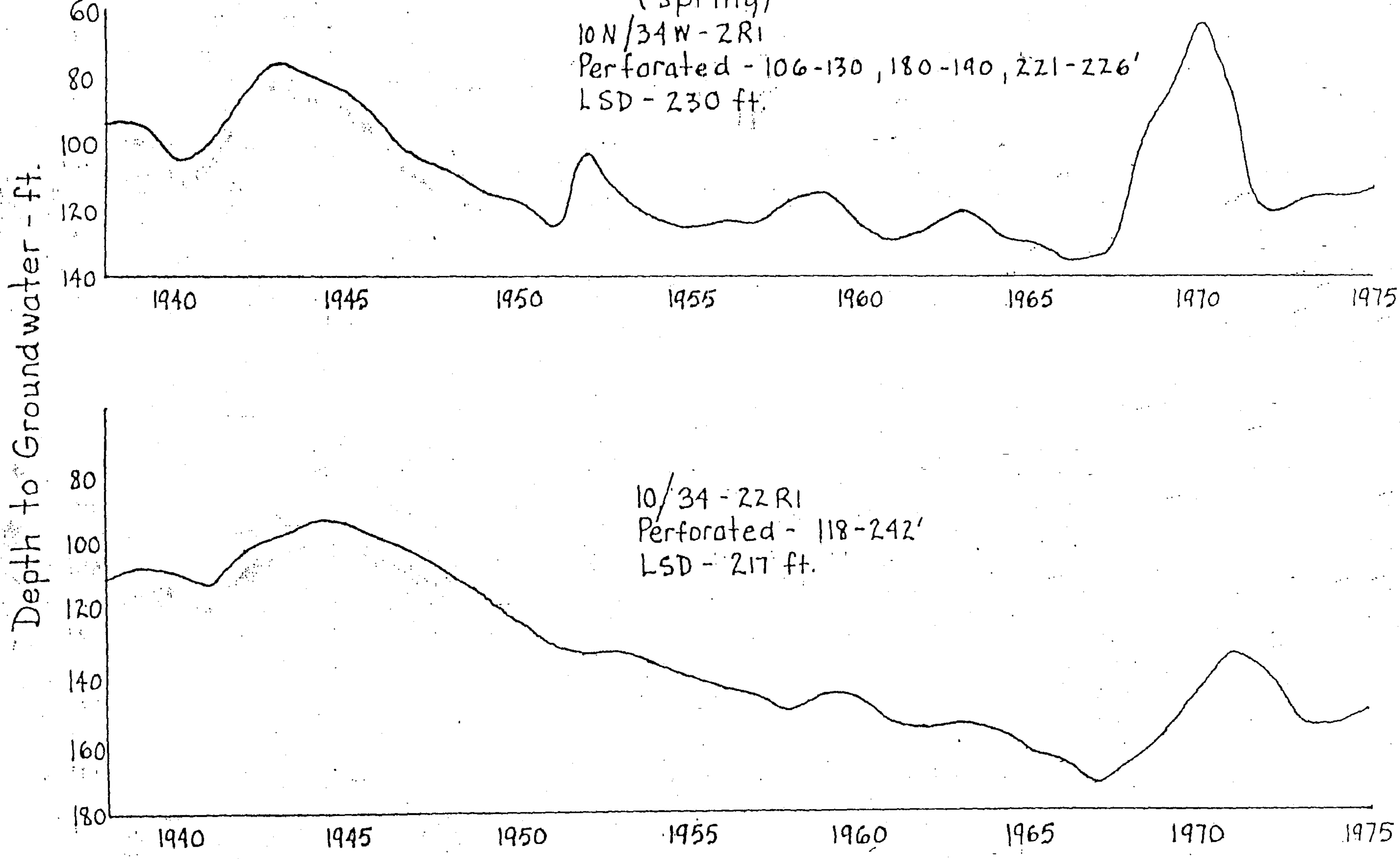


A-2

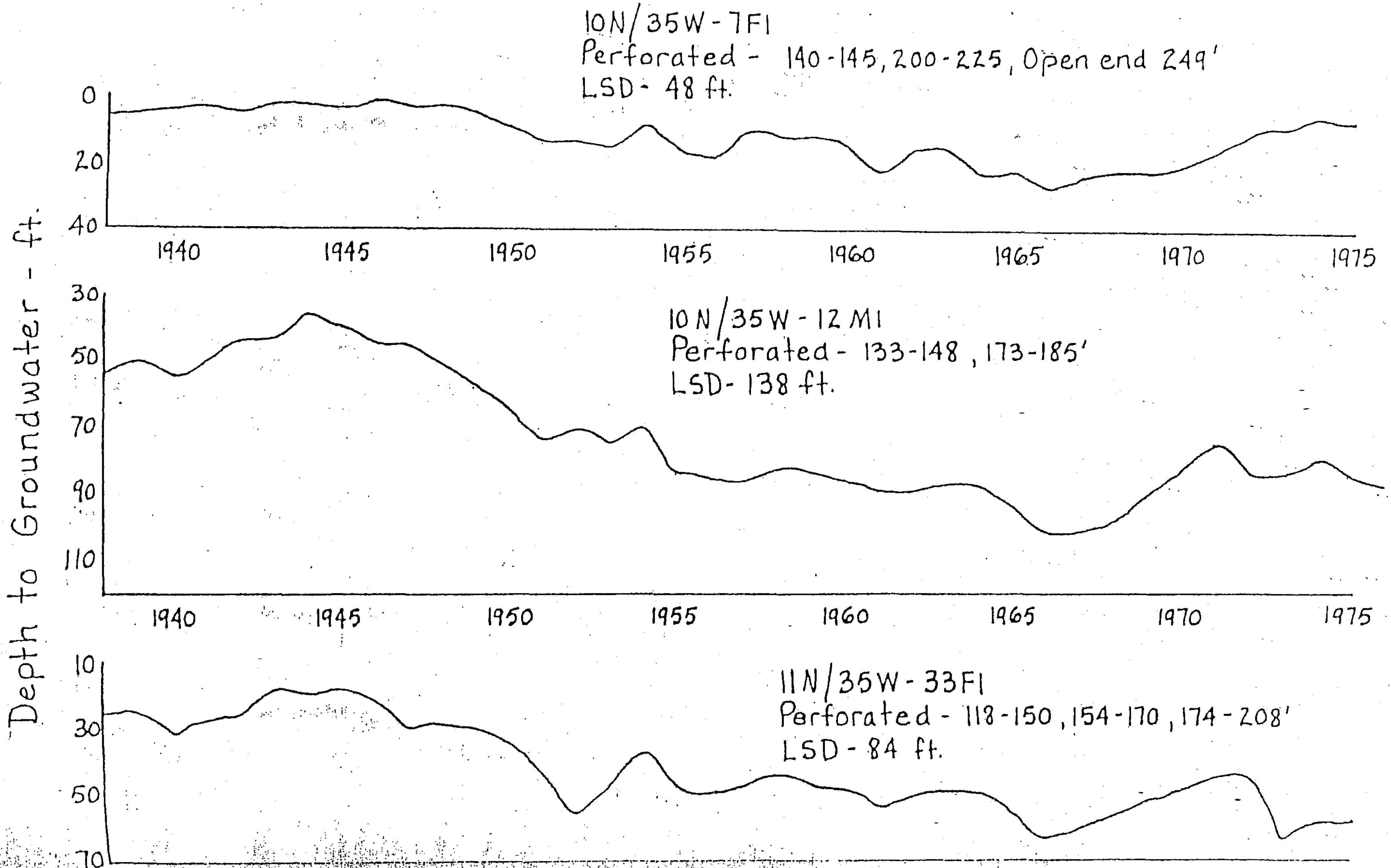
9N/32W-7N1
Perforated - 82-97, 105-145, 162-185'
LSD - 422 ft.

Santa Maria Storage Unit
Static Water Levels
(spring)

Santa Maria Storage Unit
Static Water Levels
(spring)



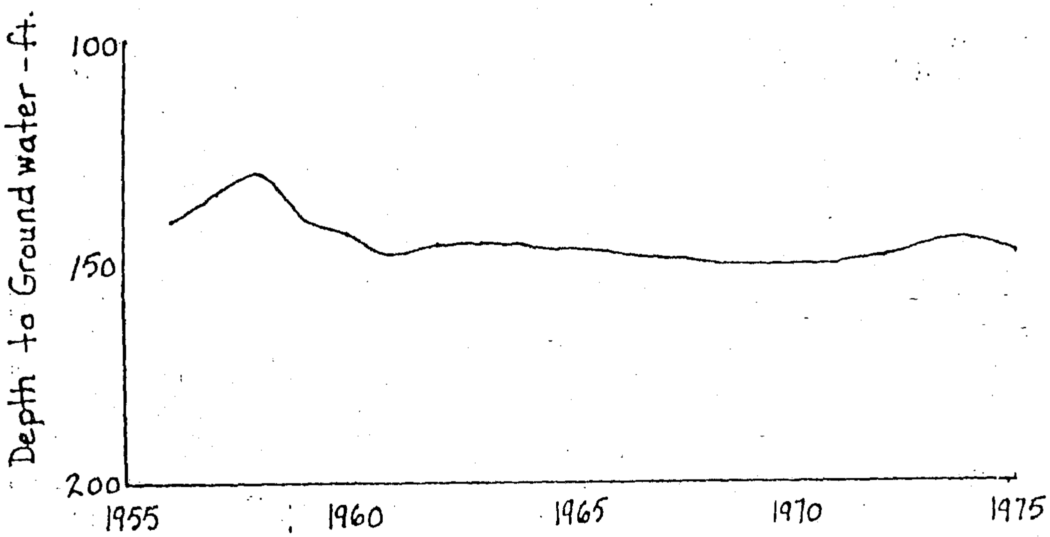
Guadalupe Storage Unit
Static Water Levels
(spring)



Orcutt Storage Unit
Static Water Levels
(spring)

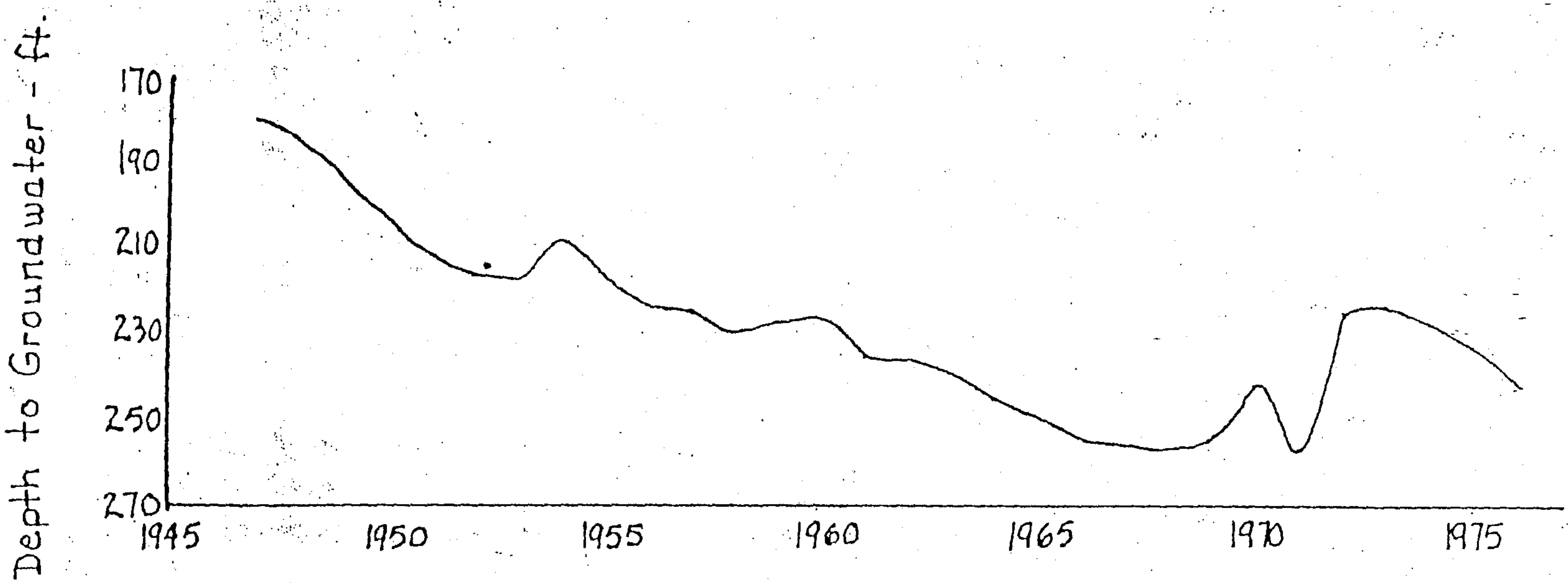
70

Orcutt Storage Unit
Static Water Levels
(spring)



9N/34W - 8H1
Depth - 200 ft.
LSD - 222 ft.

Bradley Canyon Storage Unit
Static Water Levels
(spring)



10N/33W-33H1
Perforated - 204-232, 245-250, 270-280'
LSD - 402 ft.

APPENDIX B

WATER QUALITY DATA

PRESENT GROUNDWATER QUALITY

Storage Unit and Well Number	Depth msl (ft): Top of Sample Interval	Depth msl (ft): Bottom of Sample Interval	Date of Sample	Selected Water Qlty Constituents (mg/l): SO_4	Cl	NO_3	TDS	TH	EC
Bradley Canyon									
9N33W 6G1	+ 21	-555	73-05-16	290	28	4.6	698	430	977
9N33W10C1	-	-	75-09-22	320	31	-	-	520	1,175
9N33W18R1	- 20	- 44	75-05-15	61	110	20.0	488	240	900
10N33W29N1	-	-	75-09-27	230	57	-	-	410	950
10N33W30K1	+122	- 38	75-09-27	600	66	-	-	690	1,600
10N33W32F1	-	-	75-09-27	270	22	-	-	410	950
Sisquoc									
9N32W 6P1	-	-	75-09-22	310	21	-	707	490	1,090
9N33W 2H9	+270	- 80	75-09-22	350	48	-	821	520	1,210
9N33W12R1	+200	+115	75-05-15	400	35	30.0	972	600	1,400
Fugler Point									
10N33W 7R2	-	-	75-09-28	270	41	-	-	420	950
10N33W18H1	+135	-145	75-09-28	330	95	-	-	460	1,200
10N33W20F1	+210	+ 35	73-05-15	430	42	18.0	954	540	1,290
10N33W20N3	+140	-300	75-09-27	660	68	-	-	830	2,000
10N33W21F6	-	-	75-09-27	370	52	-	-	460	1,125
10N33W27G1	+200	+ 80	75-09-22	460	50	-	-	600	1,350
10N33W28F1	-	-	75-09-22	430	49	-	-	600	1,450
Betteravia									
9N34W 6C1	-	-	75-09-19	230	49	-	-	400	950
9N34W 8C1	+ 40	+ 30	75-09-20	85	120	-	-	150	710
9N34W 8H1	-	-	75-05-15	70	120	16.0	451	140	750
10N34W29A1	-	-	75-09-23	410	68	-	-	630	1,350
10N34W29N1	-	-	75-09-20	250	36	-	-	380	950
10N34W31D1	+60	+40	75-09-19	100	100	-	-	230	950

PRESENT GROUNDWATER QUALITY (cont'd)

B-2

PRESENT GROUNDWATER QUALITY (cont'd)

Storage Unit and Well Number	Depth msl (ft) Top of Sample Interval	Bottom of Sample Interval	Date of Sample	Selected Water Qlty Constituents (mg/l) SO4	Cl	NO3	TDS	TH	EC
Orcutt									
9N34W 3F1	- 56	-184	75-09-27	240	32	-	-	380	900
9N34W10D2	-	-	75-09-27	40	69	-	-	100	455
10N34W26A3	-	-	75-09-22	420	60	-	-	590	1,300
10N34W27H4	-	-	75-09-27	470	54	-	-	620	1,500
10N34W28L1	-	-	75-09-23	320	52	-	-	440	1,125
10N34W34E2	+ 40	-1,165	75-09-23	250	32	-	-	420	960
Santa Maria									
10N34W 3H3	-	-	75-09-28	310	68	-	-	530	1,200
10N34W 4L1	+ 60	- 30	75-09-26	370	42	-	-	550	1,150
10N34W 5P3	-	-	75-09-23	410	62	-	-	680	1,550
10N34W 7B1	-	-	75-09-24	750	87	-	-	1,000	2,400
10N34W 8E1	-	-	75-09-24	610	67	-	-	850	1,950
10N34W 9H1	+ 80	- 50	75-09-26	310	37	-	-	530	1,150
10N34W12H1	+105	+ 50	75-09-28	330	40	-	-	500	1,200
10N34W13C1	+124	+ 45	75-09-27	340	43	-	-	480	1,200
10N34W14E5	+ 71	-	75-09-26	420	43	-	-	570	1,275
10N34W16J2	-	-	75-09-26	510	68	-	-	1,210	1,700
10N34W17D1	-	-	75-09-20	520	230	-	-	870	2,400
10N34W17F1	+ 85	-	75-12-05	820	90	-	-	1,000	2,130
10N34W18L1	+ 46	-102	75-09-20	400	280	-	-	630	2,200
10N34W18P1	+ 59	- 80	75-05-15	700	270	41.0	1,800	890	2,800
10N34W19R2	-	-	75-09-23	310	79	-	-	540	1,800
10N34W20H3	+ 46	- 54	75-09-23	510	99	-	-	810	1,800
10N34W22C1	-	-	75-09-23	450	57	-	-	650	1,500
10N34W23R2	+125	-	75-09-22	560	70	-	-	730	1,645
10N34W24H2	+140	-	75-09-22	690	67	-	-	820	1,850
11N34W29P2	+ 36	- 30	75-05-15	330	54	76.0	-	530	1,200
11N34W31C1	-	-	75-09-25	400	51	-	-	650	1,500
11N34W33J1	-	-	75-09-26	340	160	-	-	720	1,600

PRESENT GROUNDWATER QUALITY (cont'd)

Storage Unit and Well Number	Depth msl (ft) Top of Sample Interval	Bottom of Sample Interval	Date of Sample	Selected Water Qlty Constituents (mg/l) SO_4	Cl	NO_3	TDS	TH	EC
Guadalupe									
10N35W 3N1	-	-	75-09-25	1,900	210	-	-	1,900	4,000
10N35W 4C1	- 60	-	75-05-15	660	91	20.0	1,350	740	2,100
10N35W 5J1	-	-	75-09-25	480	65	-	-	660	2,150
10N35W 7F1	- 92	-	74-10-24	1,100	140	6.5	2,240	1,400	2,600
10N35W11E2	-	-	75-09-25	1,300	200	-	-	1,500	3,400
10N35W11J1	-	-	75-09-25	990	230	-	-	1,400	3,050
10N35W13H1	-	-	75-09-19	440	290	-	-	720	2,300
10N35W13N1	+ 58	-	75-09-26	900	150	-	-	1,200	2,500
10N35W14D1	+ 22	-184	74-10-24	580	120	52.0	1,430	790	1,880
10N35W16M1	- 69	-	75-09-18	300	160	-	-	1,400	3,200
10N35W21C1	-	-	75-05-15	670	190	73.0	1,660	800	2,600
10N35W22G3	-	-	75-09-26	1,100	160	-	-	1,400	3,000
11N35W34E2	-	-	75-09-25	410	52	-	1,040	710	1,550

HISTORIC ANNUAL GROUNDWATER TRENDS

HISTORIC ANNUAL GROUNDWATER TRENDS

Storage Unit and Well Number	Depth msl (ft) Top of Sample Interval	Bottom of Sample Interval	Period of Record	Annual Trends of Selected Water Qlty Constituents (mg/l) SO4	Cl	NO3	TDS	TH	EC
Bradley Canyon									
9N33W 6G1	+ 21	-555	'64-'73	1	- 1	1	3	4	7
9N33W 9A1	-	-	'54-'64	0	1	1	- 3*	1	9
9N33W18R1	- 20	- 44	'61-'76	1	- 1	0	- 5*	2	3
Sisquoc									
9N33W12R1	+200	+115	'53-'76	3	0	1	9*	4	9
Fugler Point									
10N33W20F1	+210	+ 35	'65-'73	-32	- 4	- 2	-52*	-38	-70
10N33W20N3	+140	-300	'54-'75	2	0	-	-	8	22
Betteravia									
9N34W 8H4	-210	-340	'65-'72	-	-	-	- 5	- 1	- 2
10N34W29N1	-	-	'60-'75	0	0	0	0	0	3
Orcutt									
9N34W10D2	-	-	'58-'75	- 1	1	-	-	- 1	- 4
10N34W26H2	-	-	'54-'64	- 9	8	2	15	3	22
10N34W34E2	+ 40	-1,165	'62-'76	-18	9	-	- 4	- 2	- 3
Santa Maria									
10N34W 3P2	-	-	'58-'74	-15	- 2	- 3	-36	-21	-36
10N34W 6N1	-	-	'57-'69	- 3	0	+ 6	- 1	0	- 3
10N34W14E5	+ 71	-	'64-'75	-16	- 3	-	-	-19	-28
10N34W17D1	-	-	'60-'75	-19	9	-	-	- 8	20
10N34W17F1	+ 85	-	'66-'75	12	0	3	20*	13	24
10N34W18L1	+ 46	-102	'60-'75	- 7	5	-	-11*	-18	- 3
10N34W18P1	+ 59	- 80	'67-'76	-12	23	- 1*	37*	-23	91

HISTORIC ANNUAL GROUNDWATER TRENDS (cont'd)

Storage Unit and Well Number	Depth msl (ft): Top of Sample Interval	Depth msl (ft): Bottom of Sample Interval	Period of Record	Annual Trends of Selected Water Qlty Constituents (mg/1): SO_4	Cl	NO_3	TDS	TH	EC
Santa Maria (cont'd)									
10N34W19H1	-	-	'53-'63	1	4	1	23*	7	18
10N34W23R2	+125	-	'54-'75	1	1	-	-	6	13
11N34W29P2	+ 36	- 30	'42-'75	- 1	0	2	1*	0	0
Guadalupe									
10N35W 3N1	-	-	'27-'75	30	2	-	27	26	42
10N35W 4C1	- 60	-	'52-'75	0	1	-	11	- 4	17
10N35W 5J1	-	-	'27-'75	1	0	-	8	3	11
10N35W 7F1	- 92	-	'41-'74	21	3	0	41	26	37
10N35W 9N2	+ 60	-377	'52-'71	1	1	-	5	3	6
10N35W11C1	-	-	'55-'69	10	1	5	15	11	18
10N35W11E2	-	-	'27-'75	18	3	-	-	12	-
10N35W11J1	-	-	'27-'75	11	2	-	-	16	-
10N35W13H1	-	-	'60-'75	- 3	13	-	24	6	33
10N35W13N1	+ 58	-	'38-'75	14	1	-	-	-	-
10N35W14D1	+ 22	-184	'61-'74	1	1	4	9	1	8
10N35W16M1	- 69	-	'53-'75	-	2	-	-	17	45
10N35W21C1	-	-	'63-'75	21	4	3	38	10	77
10N35W22G3	-	-	'60-'75	- 2	2	-	12	9	14
10N35W24B2	+ 32	-	'41-'71	4	1	1	10	6	-
11N35W19E2	-	-	'52-'68	1	0	-	-	- 1	2
11N35W33F1	- 34	-	'58-'71	- 4	0	0	15	9	10

Santa Maria

All-America City ®

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STATE OF CALIFORNIA)
COUNTY OF SANTA BARBARA) ss.
CITY OF SANTA MARIA)

I, PATRICIA A. PEREZ, Chief Deputy City Clerk and ex-officio Clerk of the City Council of the City of Santa Maria, County of Santa Barbara, State of California, do hereby certify that the attached are true and correct copies of official City documents:

1. Final Report Adequacy of the Santa Maria Groundwater Basin, November 1977.

2. Santa Barbara County Growth Inducement Potential of State Water Importation Final, March 1991.

3. Santa Maria Valley Water Resources Report, 1994.

IN WITNESS WHEREOF, I have hereunto set my hand and caused the Seal of said City to be affixed this 14th day of October, 2003.

Patricia A. Perez

Chief Deputy City Clerk