

**Monterey County
Flood Control and
Water Conservation
District**

**MONTEREY COUNTY FLOOD CONTROL
& WATER CONSERVATION DISTRICT
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FINAL REPORT

El Toro Area Groundwater Study

OCTOBER 1981

Anderson - Nichols & Co., Inc.

Palo Alto, CA

Richmond, CA

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
I Introduction	1
II Summary Of Findings	6
III Conclusions And Recommended Actions	11
IV Hydrogeology	15
V Surface Hydrology	43
VI Groundwater Storage	51
VII Current Groundwater Demands	54
VIII Projected Groundwater Demands	57
IX Evaluation Of Groundwater Quantity	61
X Groundwater Quality	76
XI Groundwater Supply Adequacy	103
References	110

LIST OF TABLES

	<u>Page</u>
Table 1	Average Monthly Rainfall For Each Subarea 46
Table 2	Mean Annual Recharge Evaluation In The El Toro Study Area 50
Table 3	Groundwater Storage 53
Table 4	Current Groundwater Inflows And Demands For Each Subarea Of The El Toro Study Area In An Average Year 56
Table 5	Projected Groundwater Inflows And Demands At Year 2000 For Each Subarea Of The El Toro Study Area In An Average Year. 59
Table 6	Projected Groundwater Inflows And Demands At Saturated Development For Each Subarea Of The El Toro Study Area In An Average Year. 60
Table 7	Current Groundwater Storage, Inflows And Demands 62
Table 8	Groundwater Storage, Inflows And Demands At Saturated Development. 63
Table 9	Summary Of Water Quality Exceedences, By Subarea, Based On Monterey County Flood Control And Health Department Data 77
Table 10	Results Of Supplemental Groundwater Quality Analyses In The El Toro Area 81-82
Table 11	Summary Of Electroconductivity, Chloride, And Nitrate Values For Wells Which Perforate Only one Formation 84
Table 12	Summary Of Water Quality Exceedences For Water Bearing Formations In The El Toro Area 86
Table 13	Equilibrium Concentrations Of $\text{NO}_3\text{-N}$ Based On Current Development Conditions 93

Page

Table 14	Equilibrium $\text{NO}_3\text{-N}$ Concentrations At Saturated Development	94
Table 15	Horizontal Protective Distances	98
Table 16	Characteristics Of Water Supply Zones	105-106

LIST OF FIGURES

	<u>Page</u>
Figure 1 Vicinity Map	2
Figure 2 Study Area and Moratorium Area Boundaries	3
Figure 3 Geologic Map	16
Figure 4 Geologic Cross Section A - A'	22
Figure 5 Geologic Cross Section B - B'	23
Figure 6 Geologic Cross Section C - C'	24
Figure 7 Geologic Cross Section D - D'	25
Figure 8 Geologic Cross Section E - E'	26
Figure 9 Isopach Map for the Alluvium	27
Figure 10 Isopach Map for the Aromas-Paso Robles	28
Figure 11 Isopach Map for the Santa Margarita Sandstone	29
Figure 12 Hydrologic Subareas, Directions of Groundwater Movement	36
Figure 13 Water Table Elevations	37
Figure 14 Total Saturated Thickness of the Alluvium, Aromas-Paso Robles, and Santa Margarita Sandstone Formations	40
Figure 15 Isohyetal Map, Rainfall Stations	44
Figure 16 Water Level Changes in Wells	65
Figure 17 Water Level Changes in Wells	66
Figure 18 Groundwater Quantity Evaluation at Saturated Development	69
Figure 19 Assessment of Water Availability	72
Figure 20 Prime Recharge Map	74
Figure 21 Definition of Water Supply Zones	104

I. INTRODUCTION

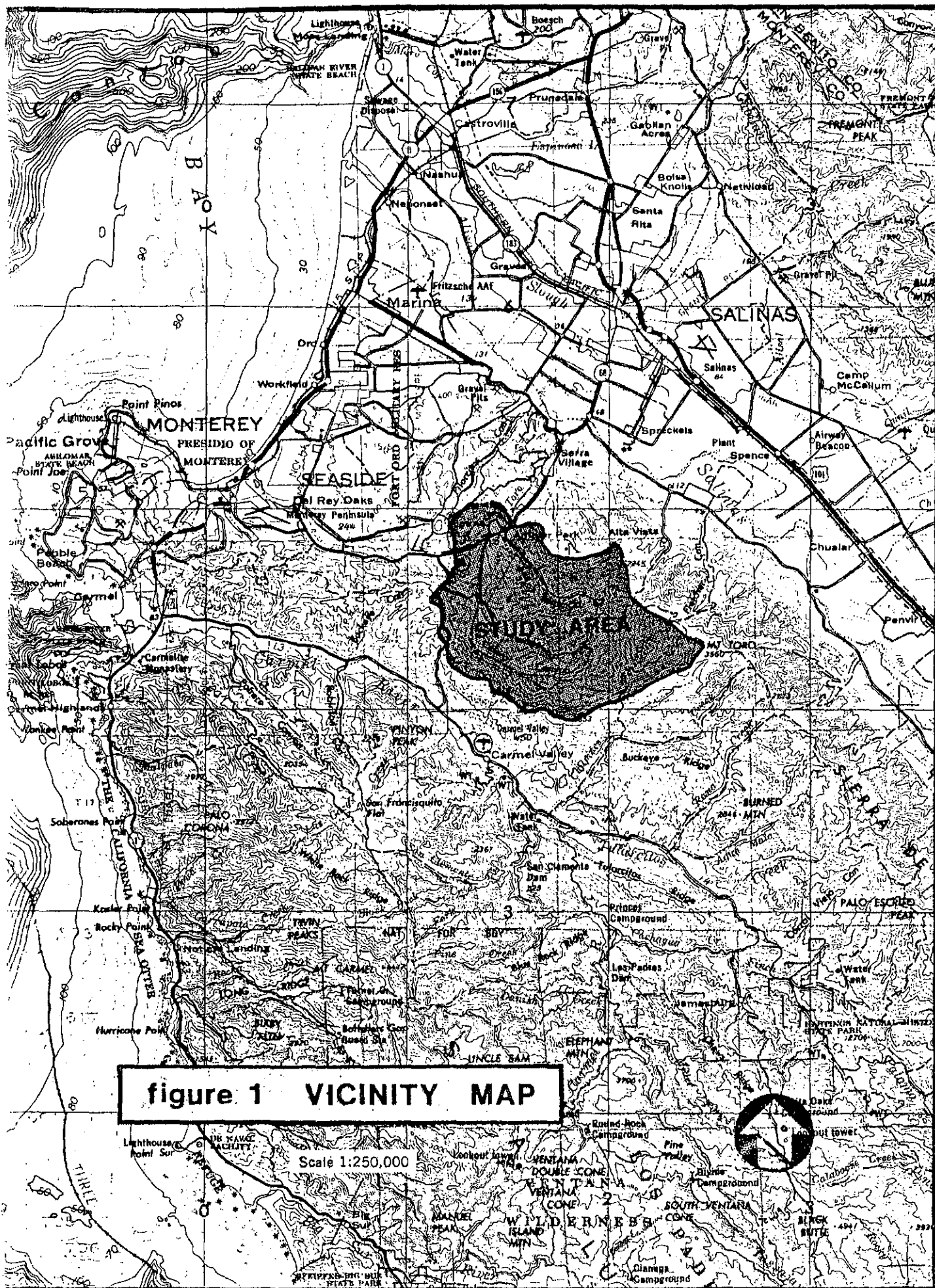
A. Background and Purpose of Study

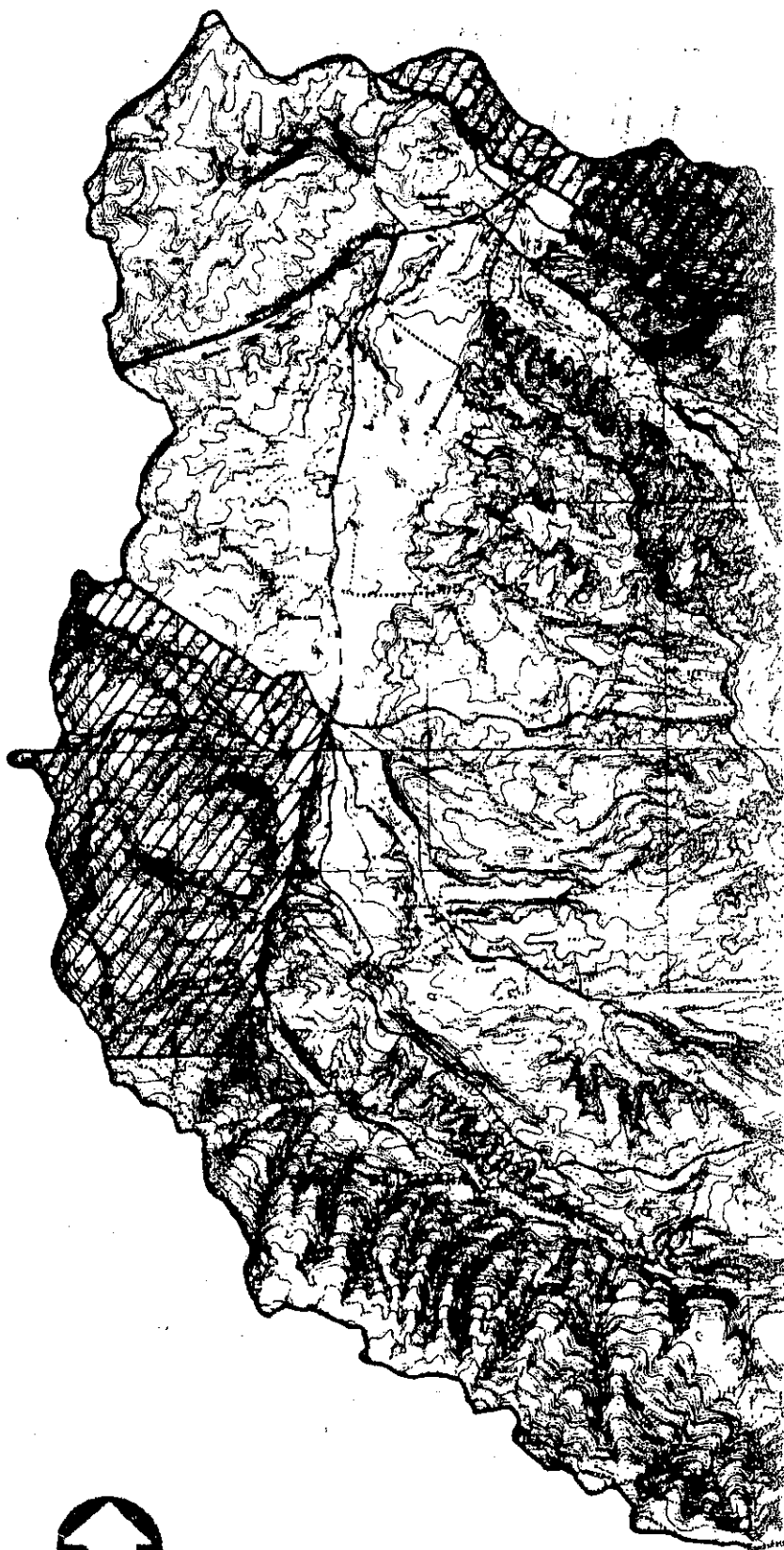
The El Toro area of Monterey County is currently earmarked for residential developments that would increase its population from 2775 to 5675 in the immediate future. Since the area is ideally situated near Route 68, between Salinas and the Monterey Peninsula (see Figure 1), more residential subdivisions will certainly be proposed. The County of Monterey requested that a thorough assessment of the groundwater resources of this area be made to evaluate the viability of the water supply to support major increases in population. Until this groundwater resource evaluation is completed, a subdivision moratorium has been declared over most of the El Toro Study Area (see Figure 2).

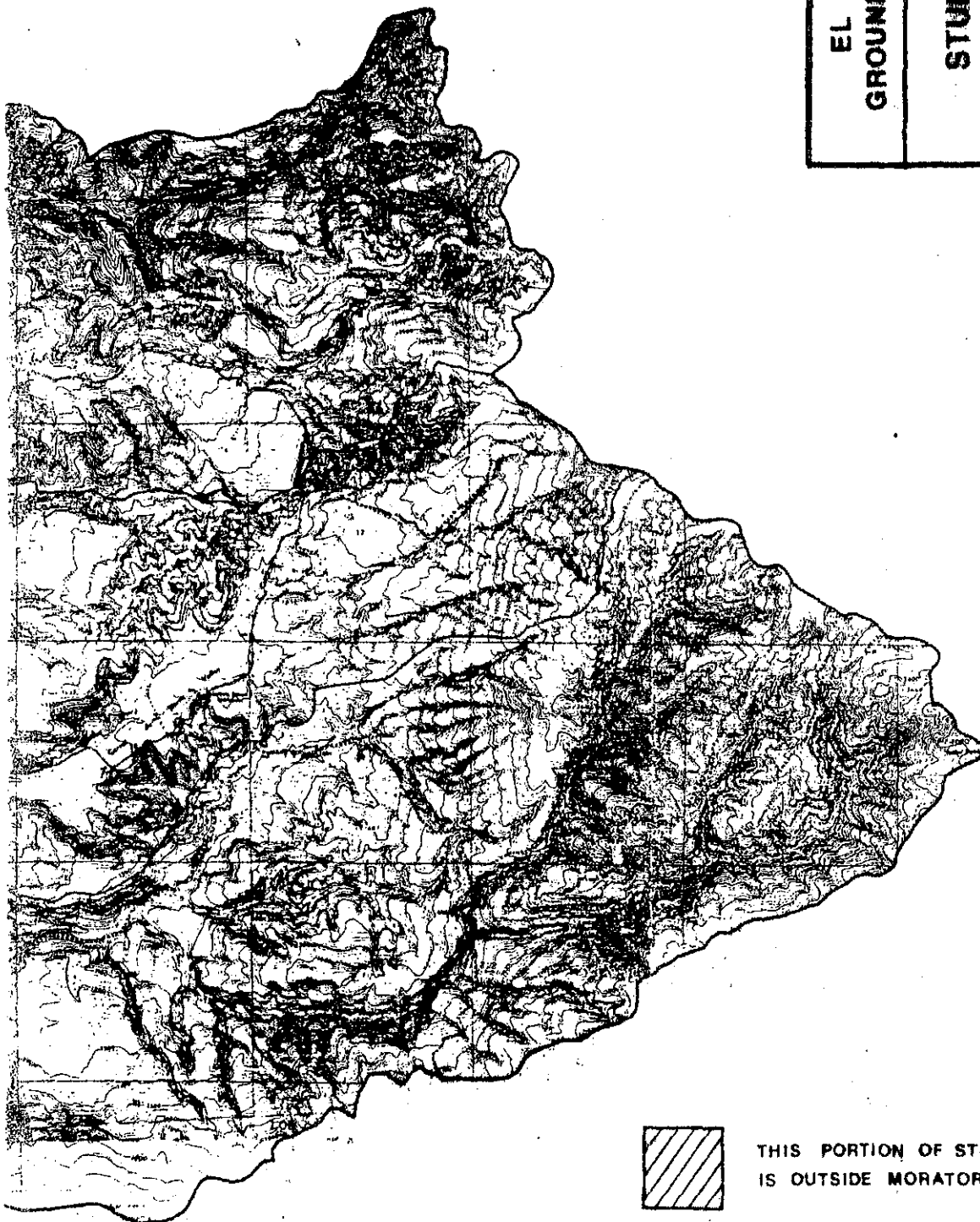
In March 1981, the Monterey County Flood Control and Water Conservation District contracted with Anderson-Nichols & Co., Inc. to study the El Toro area. The objectives of this study were fourfold:

1. Perform a thorough hydrogeologic investigation of the El Toro area, concentrating on an analysis of the quantity and quality of available groundwater resources within its boundaries.
2. Based on demographic, water use, recharge, and storage analyses, assess the safe yield and adequacy of the groundwater supply.
3. Identify present and potential problems related to the use of groundwater within the area, and suggest mitigating solutions for dealing with these problems.
4. Prepare a comprehensive Final Report which includes an "action plan" for future management of the area's groundwater resources.

This report presents the findings of the El Toro groundwater investigation.







THIS PORTION OF STUDY AREA
IS OUTSIDE MORATORIUM AREA

EL TORO AREA
GROUNDWATER STUDY

STUDY AREA AND
MORATORIUM AREA
BOUNDARIES

ANDERSON - NICHOLS & CO., INC.

Scale 1 in. = 4000 ft.

Figure 2

B. General Study Area Description

The study area (Figure 2) consists of 20,416 acres of hilly terrain covered by grasslands and clumps of trees, situated in the northwestern part of Monterey County between the Cities of Salinas and Monterey. The area is drained by El Toro Creek and its tributaries, and exhibits elevations ranging from 400 to 3500 feet (NGVD)* with a significant portion of the land surface sloping at greater than 30%. Sparsely settled rangeland is currently the predominant land use, but in recent years there has been considerable pressure for expanded residential development. The water supply for the area is derived solely from small wells tapping multiple local groundwater aquifers.

The area of study in this report is somewhat larger than the moratorium area, as is shown in Figure 2. All determinations in this report refer to the study area.

The marine-mediterranean climate of Monterey County is characterized by mild wet winters, cool summers, and occasional fog. The mean daily temperature at Salinas near the study area is 56.4°F⁽¹⁾. Mean annual precipitation in the study area is 17.3 inches (as determined in this study) with about 90% of this annual rainfall occurring from November through April.

* National Geodetic Vertical Datum

(1) Numbered references cited at end of report.

C. Well Numbering System

The locations of wells referenced in this report are indicated by the well number used. The numbering system is based upon designation by township (i.e., T. 15S), range (i.e., R. 1E), section (1-36), and 40-acre subsection (A - R (as shown below)). Wells may be additionally designated by a serial number following the subsection letter. Range and section numbers are shown most clearly on Figure 12, while these designations together with roads and stream channels, appear on Figures 12, 14, 15, 19, 20, and 21.

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

II. SUMMARY OF FINDINGS

The groundwater resource of the El Toro study area is composed of five dissimilar water-bearing units that each exhibit spatial variations in their water quality, storage, and hydraulic properties. The units are briefly described below in order of their geologic age, beginning with the youngest.

- 1) Alluvium - This aquifer is found in the stream valleys of the area where it attains thicknesses of nearly 200 feet. Well yields in the range of .8 to 500 gpm and specific yields of about 10 to 20% characterize the mixture of sand, gravel, and clay that make up the alluvium.
- 2) Aromas - Paso Robles - The total thickness of these two formations ranges to over 800 feet in the northern portion of the study area where they are found. Interlaced with extensive deposits of clay, the sand and decomposed granite of this aquifer have low specific yields (1-10%) and widely varying well yields (3-400 gpm). At present, the Aromas - Paso Robles is the most frequently used water source in El Toro.
- 3) Santa Margarita Sandstone - Through occasionally marked by streaks of clay or shale, the Santa Margarita is most often composed of well sorted, fine to coarse grained sand. Deposits over 250 feet thick are found in the northwest corner of the study area, but are seen to thin out in moving to the east and south. With a specific yield of 15 to 25%, this aquifer produces from 2 to 750 gpm in those few wells presently tapping it.
- 4) Monterey Shale - Data on the hydrogeologic properties of the Monterey Shale are lacking due to the minor use it receives as a water source. The formation is made up of two shale layers which together range from 600 to 2600 feet in thickness and are found at substantial depth in most of the

study area. Tectonic uplift in the southern portion of El Toro has made drilling to the aquifer practical, but poor water quality generally prevents the tapping of the formation for domestic use.

- 5) Basal Sand Formation - The oldest significant water-bearing layer in the study area is a largely unexplored sand formation. Brought up to or near the surface by the Chupines and Corral de Tierra Faults, the Basal Sands are tapped by a handful of wells in the southern half of El Toro. One of these wells is artesian and yields up to 300 gpm. We have recommended that this artesian flow be controlled to conserve storage in the Basal Sand aquifer. The Basal Sands may be an unreliable source of water in areas where its recharge is hampered by the overlying Monterey Shale and by tectonic faults. Upgradient of the faults, near its surface outcrops, is the most likely location for tapping this formation.

Within each water-bearing unit, low hydraulic conductivities in localized areas may necessitate lower water withdrawal rates to prevent significant reductions in the yields and water levels of wells.

The groundwater aquifers of El Toro are recharged by rain falling within the basin. Runoff from the area is very low, reflecting the existence of highly permeable soils in the low slope stream valleys. The trees and grassland of El Toro combine to transpire substantial amounts of water that are lost to the groundwater system.

The movement of groundwater generally follows the direction of surface water flow, moving down basin through the El Toro Creek watershed. There does appear to be approximately 2000 acre-feet of groundwater that leaves the study area

each year, crosses the surface drainage divide to the west, and enters Laguna Seca.

Net annual groundwater inflows to the El Toro groundwater system exceed existing demands by a factor of 6 to 1, and exceed projected demands at saturation population by a factor of 2 to 1. Moreover, utilizable storage is 50 times greater than the demands of a saturated population for all sub-areas except Calera Canyon, where storage is 3 times larger than demand. These large surpluses provide assurance that the demands in each subarea can be met in the long-term and that drought conditions will not cause failure of the water supply. Part of the El Toro Creek basin, not directly studied in the report, lies downgradient from the study area. Local recharge makes this area self-sufficient in terms of groundwater supply and no constraints on development in our study area are necessary to guarantee an adequate groundwater supply in areas downgradient.

Measurements of wells in the study area for the past two decades show some reductions in water levels. These lower levels appear to be caused by the severe drought of the mid-1970's, locally poor aquifer characteristics, and inadequate well maintenance. There is no indication that the dropping water levels observed are caused by an overdraft condition.

Groundwater quality in the study area is generally fair to poor. While water quality in the upper aquifers (alluvium, Aromas - Paso Robles) appears somewhat better than in the lower aquifers (Santa Margarita Sandstone, Monterey Shale, Basal Sand), recommended levels for numerous quality constituents have been exceeded in all aquifers at selected wells. In particular, problems with total dissolved solids, sulfates, chlorides, metals, color,

and turbidity have been identified and appear to be caused by aquifer mineralogy, not land use. Our equilibrium calculations indicate that at a saturated level of development, human activity will not result in degradation of the general water quality to unacceptable levels.

Since the overall quantity of groundwater in the study area is sufficient to meet demands at saturated development and the general water quality will not be unacceptably degraded by this peak population, the continuation of the present moratorium on subdivision within the study area is not warranted. However, development of the area should account for the various suitabilities of different parts of El Toro for supplying water and assimilating septic effluent. Section XI of this report delineates six zones within El Toro and provides descriptions of the quantity (storage and recharge) and quality (natural quality and risk of degradation by septic systems) of groundwater in each zone. A summary table of the water supply zones is presented below (Section XI should be consulted for location map and detailed descriptions):

<u>zone</u>	<u>description</u>	<u>water availability</u>	<u>natural water quality</u>	<u>assimilative capacity for septic effluent</u>
	Granite outcrops	poor	----	poor
	Monterey Shale outcrops	poor to moderate	poor to fair	poor
	Areas of unproven storage	poor	----	good
	Basal Sand outcrops	moderate	fair	fair
	Saturated thickness 0-600 ft.	moderate	fair	fair to good
	Saturated thickness greater than 600 ft.	high	fair	fair to good

In using this table for planning development of the area, it is important to remember that these zonal designations are based on generalized characteristics that may not conform to data gathered in localized areas. Before consulting this assessment of water supply adequacy, it is necessary to ascertain whether on-site septic systems and well water supplies are required. If sewage is to be disposed of at other locations or water will be piped to the area being studied, then some of the findings of this analysis will not be applicable.

III CONCLUSIONS AND RECOMMENDED ACTIONS

A. Conclusions

1. The overall quantity and quality of the existing groundwater supply in the El Toro area are sufficient to meet the demands of both the current population and the population projected for saturated development. There is, however, significant potential for localized groundwater quality or quantity problems due to variable aquifer characteristics (see Section XI).
2. The continuation of the existing moratorium on subdivision within the El Toro area is not warranted by existing or projected groundwater conditions. There are no existing problems with the overall groundwater supply which would justify such an area-wide restriction.
3. The availability of groundwater varies within the study area based upon recharge capabilities, storage volumes, and local hydraulic conductivities. Groundwater is most available in the northwestern portion of the study area where the saturated thicknesses of the alluvium, Aromas-Paso Robles, and Santa Margarita Sandstone total to over 600 feet. In general, water availability is poor in areas of granite outcrops, Monterey Shale outcrops not near Basal Sand recharge areas, and in areas of unsaturated deposits of Santa Margarita Sandstone and Aromas-Paso Robles (see Figure 19 and Section XI for details).
4. An estimated annual transfer of 2000 acre-feet of groundwater leaves the El Toro area and enters the Laguna Seca region (see page 38).
5. In the El Toro basin downstream of our study area, local recharge is sufficient to meet projected demands of a saturation population. No

constraints on development in the study area are therefore warranted to guarantee an adequate groundwater supply in areas downstream (see page 58).

6. The prime recharge areas include low slope stream valleys where future development is most likely to occur (see Figure 20). Development of prime recharge sites is possible if construction practices are designed to protect recharge capabilities.
7. Drops in water levels in wells in El Toro can be attributed to the drought of the mid-1970's and to localized conditions and cannot be linked to a generalized overdraft condition (see pages 64-68).
8. The artesian well (16S/2E/24J) is depleting storage in the Basal Sands and alluvium above the Corral de Tierra Fault (see pages 41-42).
9. Overall water quality in the El Toro area is fair to poor. Localized exceedences of state water quality criteria have been found in all aquifers, involving a multitude of constituents. Nonetheless, potable water has been found in each aquifer except the Monterey Shale (see pages 76-90).
10. Current quality problems result from natural aquifer mineralogy and are not a result of chemical loadings from land use activities (see pages 76-78).
11. The major potential for future groundwater contamination is related to nitrate loadings from domestic wastewater. Equilibrium calculations indicate that nitrate loadings from saturated development will not degrade the general groundwater quality to unacceptable levels (see pages 90-94).

12. The extreme variability of aquifer characteristics, recharge rates, and percolation rates within the study area will result in large variations in the effects of domestic effluent on aquifer water quality. Although overall water quality issues do not prevent full development, localized water quality problems will result if development does not take local hydrogeologic conditions into account. These localized problems with the assimilation of septic effluent are most likely in the alluvium, and in outcrops of Monterey Shale, granite, and Basal Sands. The most immediate concern is in the alluvium where current and projected future development will be concentrated (see pages 95-102 and Section XI).
13. Adherence to existing regulations (county ordinance and Regional Water Quality Control Board regulations), which limit septic discharge into the groundwater to 300 gallons per day for each acre of land, will provide a reasonable level of protection against localized groundwater quality problems (see pages 100-101).

B. Recommended Actions

1. Allow the existing moratorium on subdivision within the study area to expire.
2. Control the artesian well (16S/2E/24J) as soon as possible.
3. Monitor water levels in additional wells tapping the Basal Sand Formation to provide more data on conditions in this aquifer.
4. In the prime recharge areas, require that planned developments submit designs and calculations establishing that their planned construction will

not reduce recharge.

5. Due to indications of locally low hydraulic conductivities in all aquifers, minimum 72-hour pump tests should be performed and analyzed by a hydrogeologist on all wells proposed as water supplies for subdivisions within the study area. These tests will indicate if the water demands of the subdivision can be met without adversely affecting the local groundwater supply. Once adequate data for characterizing the aquifers has been obtained through such tests, this requirement may be relaxed.
6. Require complete water quality analyses before approving any new domestic wells (including single household wells).
7. To more carefully monitor possible degradation of groundwater by septic systems, increase water quality sampling by the Monterey County Flood Control and Water Conservation District in areas with surface deposits of alluvium or Basal Sands.
8. The findings of this study regarding the distribution of adequate groundwater supplies (see Section XI) should be considered in long range planning for growth within the El Toro area.

IV. HYDROGEOLOGY

A. Geology

1. Stratigraphy and Lithology

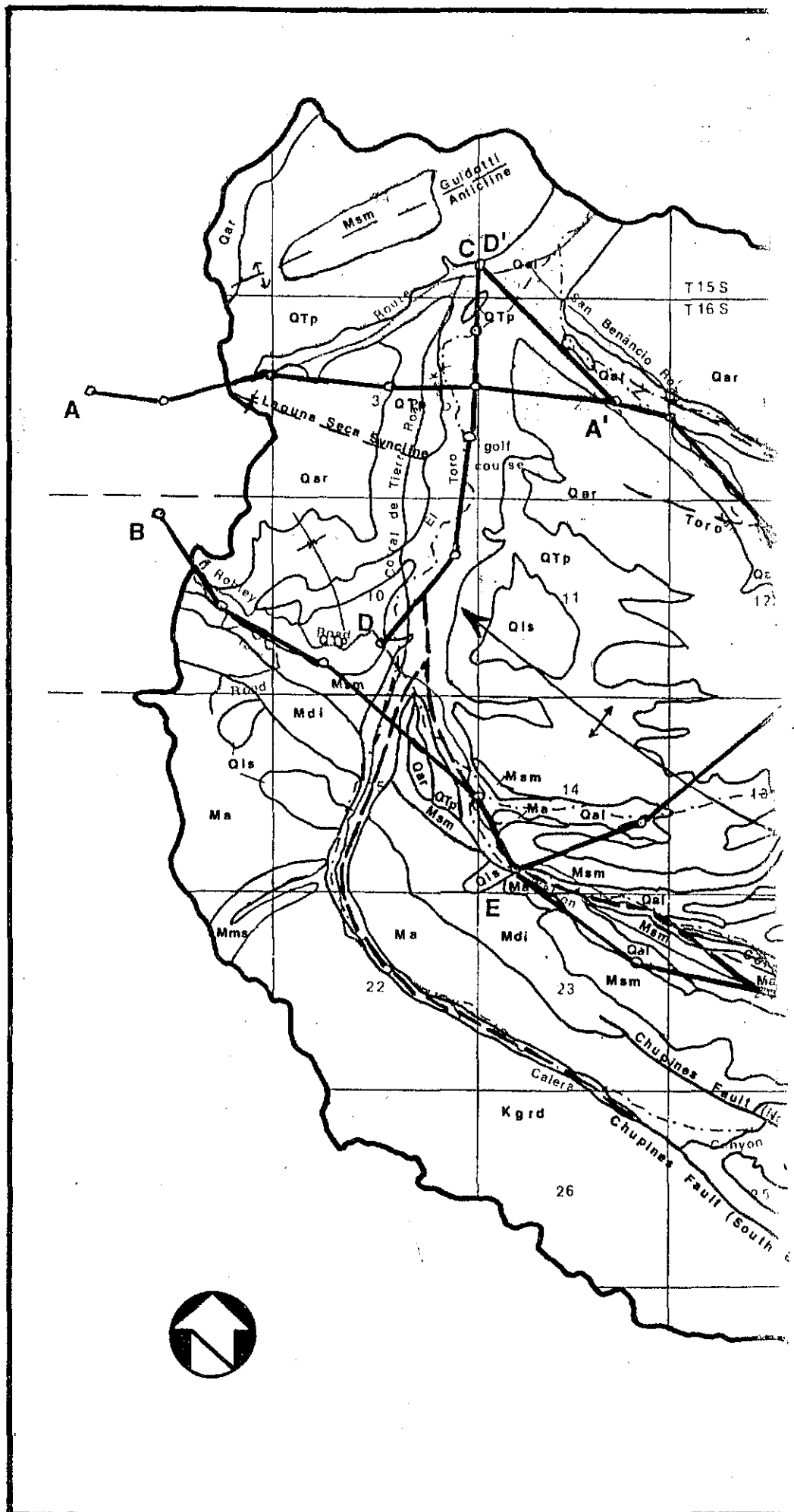
The major geologic units in the study area, from oldest to youngest, are:

- a) Granite Basement (Mesozoic Era)
- b) Basal Sand Formation (Tertiary Period, Miocene Epoch)
- c) Monterey Shale Formation (Tertiary Period, Miocene Epoch)
- d) Santa Margarita Sandstone Formation (Tertiary Period, Pliocene Epoch)
- e) Paso Robles Formation (Quaternary Period, Pliocene-Pleistocene Epoch)
- f) Aromas Sand Formation (Quaternary Period, Pliocene-Pleistocene Epoch)
- g) Alluvium (Late Quaternary Period)

All units except the Granite Basement have been tapped as aquifers in the study area. A brief description of the lithology of these stratigraphic units follows, with Figure 3 (Geologic Map) presenting their surface distribution.

Granite Basement

The Granite Basement is composed of hard crystalline, igneous rock (largely quartz monzonite, mica-quartz plagioclase schist and granodiorite) (2) from the Mesozoic Era. This formation, which underlies all other geologic layers in the area, is generally found only at considerable depths except along the higher regions of the eastern and southwestern borders of the study area where the granite has been faulted upward and exposed.



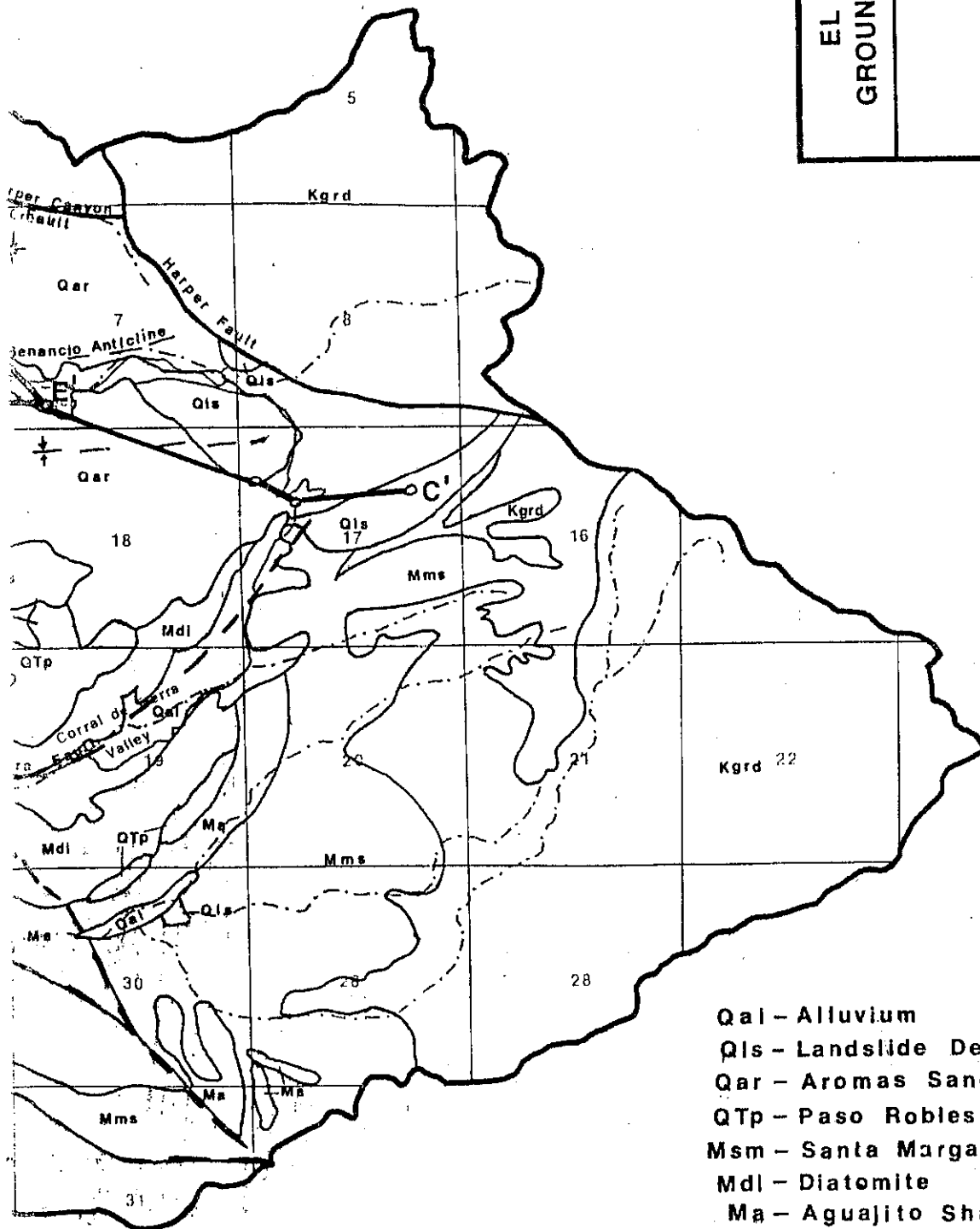
EL TORO AREA
GROUNDWATER STUDY

GEOLOGIC
MAP

(after Dibblee and Thorup)

ANDERSON - NICHOLS & CO., INC.

Scale 1 in. = 4000 ft. figure 3



- Qal - Alluvium
 - Qls - Landslide Debris
 - Qar - Aromas Sand
 - QTP - Paso Robles
 - Msm - Santa Margarita Sandstone
 - Mdi - Diatomite
 - Ma - Agujito Shale
 - Mms - Basal Sands
 - Kgrd - Granite Basement
- } Monterey
Shale

Basal Sands

This aquifer is a marine formation composed of two sand types (Los Laureles sand and Tularcitos sandstone) separated by a fifty foot layer of clay shale⁽³⁾. Lying just above the granite basement, this formation is generally found far below the ground surface. As with the granite, however, tectonic faults have shifted the Basal Sands close to the surface in the southern portion of the study area, causing outcrops in sections of upper Calera and Corral de Tierra Canyons.

The Basal Sands are a viable water source in the southern region of the study area, where a few wells are producing significant quantities of potable water.

Monterey Formation

This is also a marine formation with two distinct members. The lower member, Aquajito shale, is a hard, brittle siliceous shale whose thickness ranges from 200 - 2000 feet⁽³⁾. The upper member is Canyon Del Rey Diatomite which, when exposed in outcrops, is a white diatomaceous shale with streaks of siliceous shale, and when below the ground is a green clay or shale. Total thickness of the diatomite is 400 - 600 feet⁽³⁾.

Some water can be found in fractures within the shale, however, wells drilled into this formation have high concentrations of dissolved solids, (lead,) and manganese, making the water generally unsuitable for

domestic use. Since vertical movement of water through the shale is very slow, this formation effectively isolates the basal sands from the upper aquifers.

Santa Margarita Formation

Overlying the Monterey Shale is a marine sandstone known as the Santa Margarita Formation. Although it may include streaks of clay and/or shale, it is often composed entirely of well sorted, fine to course grained sand. Its thickness varies substantially within the study area, being very thin in the southern and eastern portions, and gradually thickening to over 250 feet in the northwest corner. Outcrops in the study area occur in the central region and at the northwest corner (near Guidotti Ranch). The limited water quality data available suggest that its future exploitation may be hindered by naturally occurring problems with color and turbidity.

Paso Robles and Aromas Sand Formations

These two formations, deposited in the Quaternary Period, together comprise the major water source of the region. They occur mainly in the northern half of the study area, attaining total thicknesses of over 800 feet. Due to a high clay content and difficulties with the sand and granitic debris clogging well perforations, permeabilities and production will vary considerably within the two formations.

The Aromas and Paso Robles Formations are often difficult to separately identify since both consist largely of unsorted granitic debris. Delineation of the two layers as separate occurrences may be possible,

based upon the presence of 1) shale pebbles and/or 2) a significant amount of interbedded clay beds in the lower Paso Robles layer (with a distinct absence of the two in the upper Aromas sand layer)⁽³⁾.

Alluvium

The alluvium is the youngest, least consolidated geologic member in the study area. It is the uppermost geologic deposit and is found in the stream valleys of lower Calera Canyon, the lower and middle Corral de Tierra Canyon, San Benancio Gulch, and the Harper Canyon. In some locations where it is present, this major aquifer attains thicknesses of nearly 200 feet. Well production varies widely within the alluvium, being largely dependent upon whether and to what extent the sand and gravel zones of old buried stream channels are encountered.

2. Faults and Tectonic Activity

Much of the hydrology in the study area is controlled by northwest-southeast trending folds and faults, as can be seen from Figure 3. The major faults in the area are the Harper Canyon, the Harper, the Chupines and the Corral de Tierra Faults.

The Harper and the Harper Canyon Faults both lie in the northeast corner of the study area. As the name implies, the Harper Canyon Fault lies along the floor of Harper Canyon. At the head of the canyon, the Harper Fault joins the Harper Canyon Fault and extends in a north-northwest direction as shown on the geologic map (Figure 3). The Harper Canyon Fault offsets the Aromas Sand Formation against Monterey Shale, while

the Harper Fault offsets it against the granite basement. This against the granite by the Harper Fault has caused almost total erosion of the Santa Margarita Sandstone to the immediate west of the fault.

Beginning in the Carmel Valley mountains, the Chupines Fault cuts through Hidden Hills a short distance south of Highway 68 and follows Canyon del Rey Boulevard into Monterey Bay⁽⁴⁾. It is eleven miles⁽⁴⁾ long and offsets Pleistocene layers (Aromas-Paso Robles) against Monterey Shale.

The Corral de Tierra Fault is actually a branch of the Chupines Fault. It lies in the Corral de Tierra Canyon following along the western side of Corral de Tierra Road and offsets Santa Margarita Sandstone against Monterey Shale⁽⁴⁾.

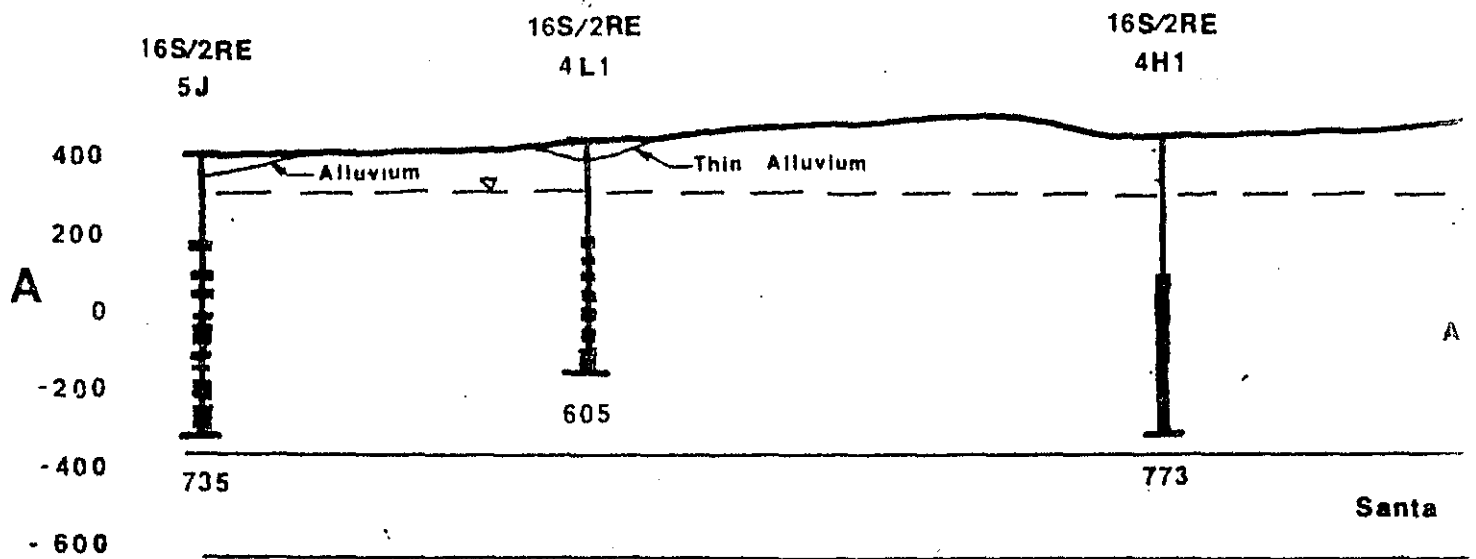
The Corral de Tierra Fault and its southward trending branch have uplifted the Basal Sands and granite basement formations south of the fault system, causing surface exposure of these formations. This fault system isolates water which recharges through the Basal Sands outcroppings and results in artesian aquifer conditions up-slope from the fault. The Chupines Fault (south branch) similarly uplifts and isolates Monterey Shale and Basal Sand aquifers on its south side. The exposure of large expanses of granite in the southwest, southeast, and northeast parts of the study area is due to these faults.

3. Geologic Cross Sections and Isopach Maps

Figures 4 - 8 provide five cross sections through the study area (as located on Figure 3) showing depths and thicknesses of various geologic formations, well depths, water table elevations, and the perforated intervals of wells (indicated as widened bands along the well). All elevations are based on the National Geodetic Vertical Datum. The data for the five cross sections were taken from well logs (numbers of wells indicated) and the geologic map (Figure 3). The Aromas Sand and Paso Robles Formations are combined into a single layer on the cross sections because the descriptions provided in the well logs did not allow a reliable differentiation of the two formations. Data on the extent of the Granite Basement and the Basal Sand Formation is scarce and the information provided on the cross sections concerning these two layers is therefore limited.

The water table elevations shown on the cross sections are based largely upon data gathered in the fall of 1980 (a complete water table map is presented later in this report section). The water table elevations shown reflect conditions at the end of the dry season when water levels are relatively low.

Using the well log data, isopach maps (Figures 9 - 11) were completed presenting the generalized contours of the thicknesses (saturated and unsaturated) of the upper three geologic members. Only these three units were delineated due to the lack of well log data



M

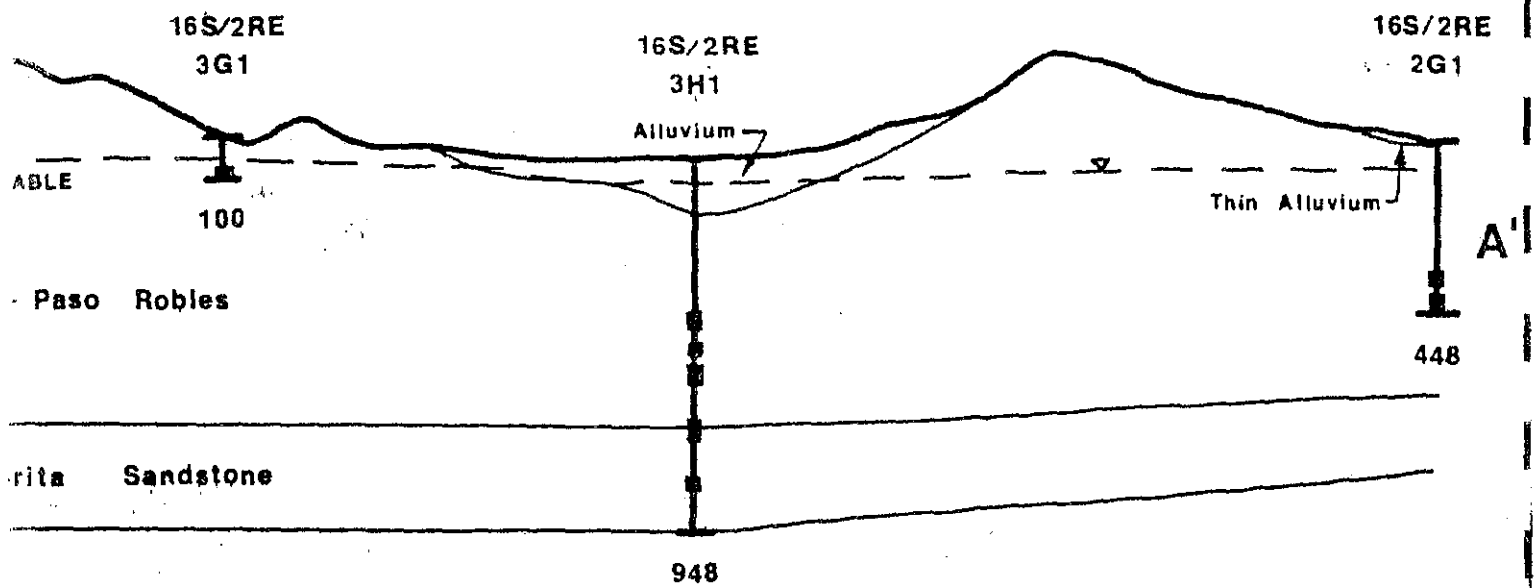
SE

EL TORO AREA
GROUNDWATER STUDY

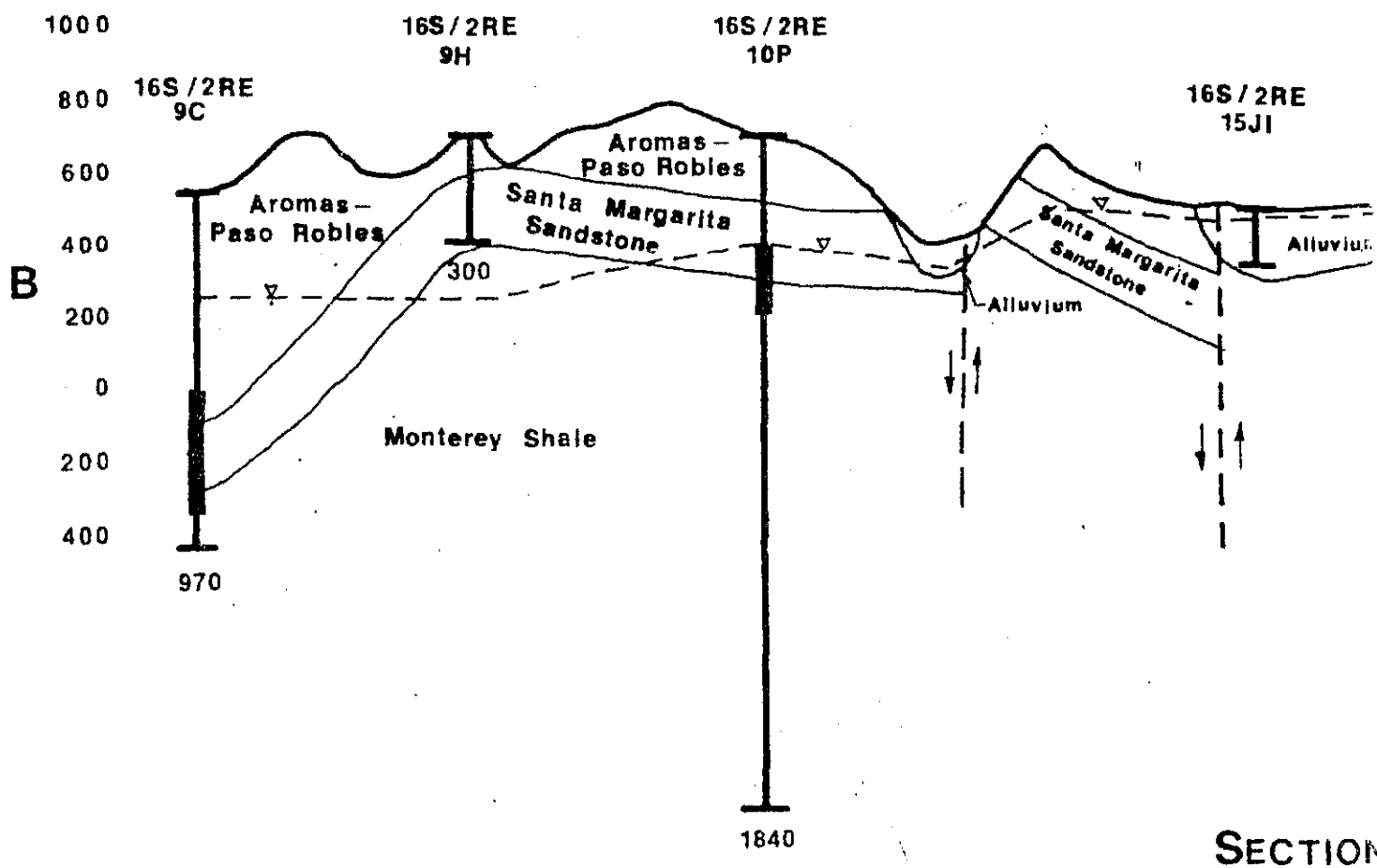
GEOLOGIC
CROSS-SECTION

Horizontal Scale 1 in. = 1000 ft.
Vertical Scale 1 in. = 500 ft.

figure 4



A - A'

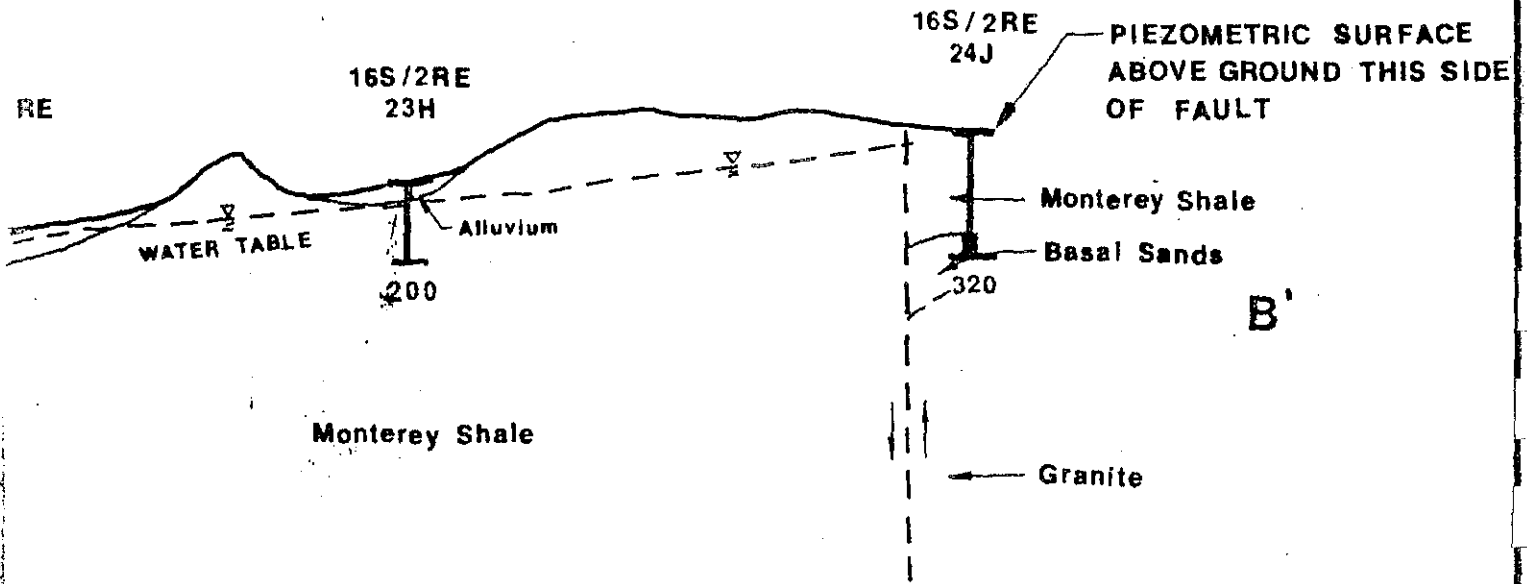


EL TORO AREA
GROUNDWATER STUDY

GEOLOGIC
CROSS-SECTION

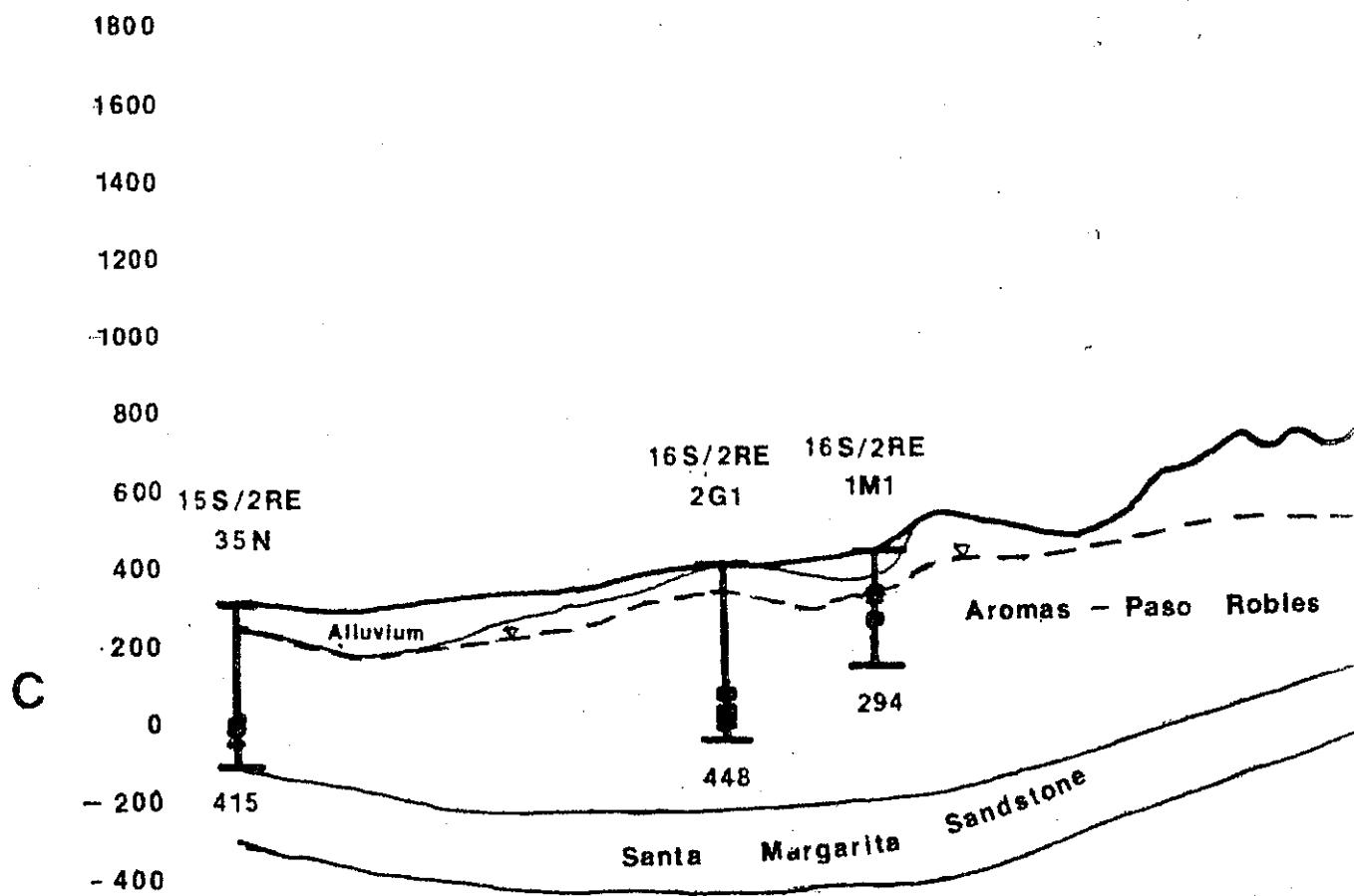
Horizontal Scale 1 in. = 2000
Vertical Scale 1 in. = 500

figure 5



103

B - B'



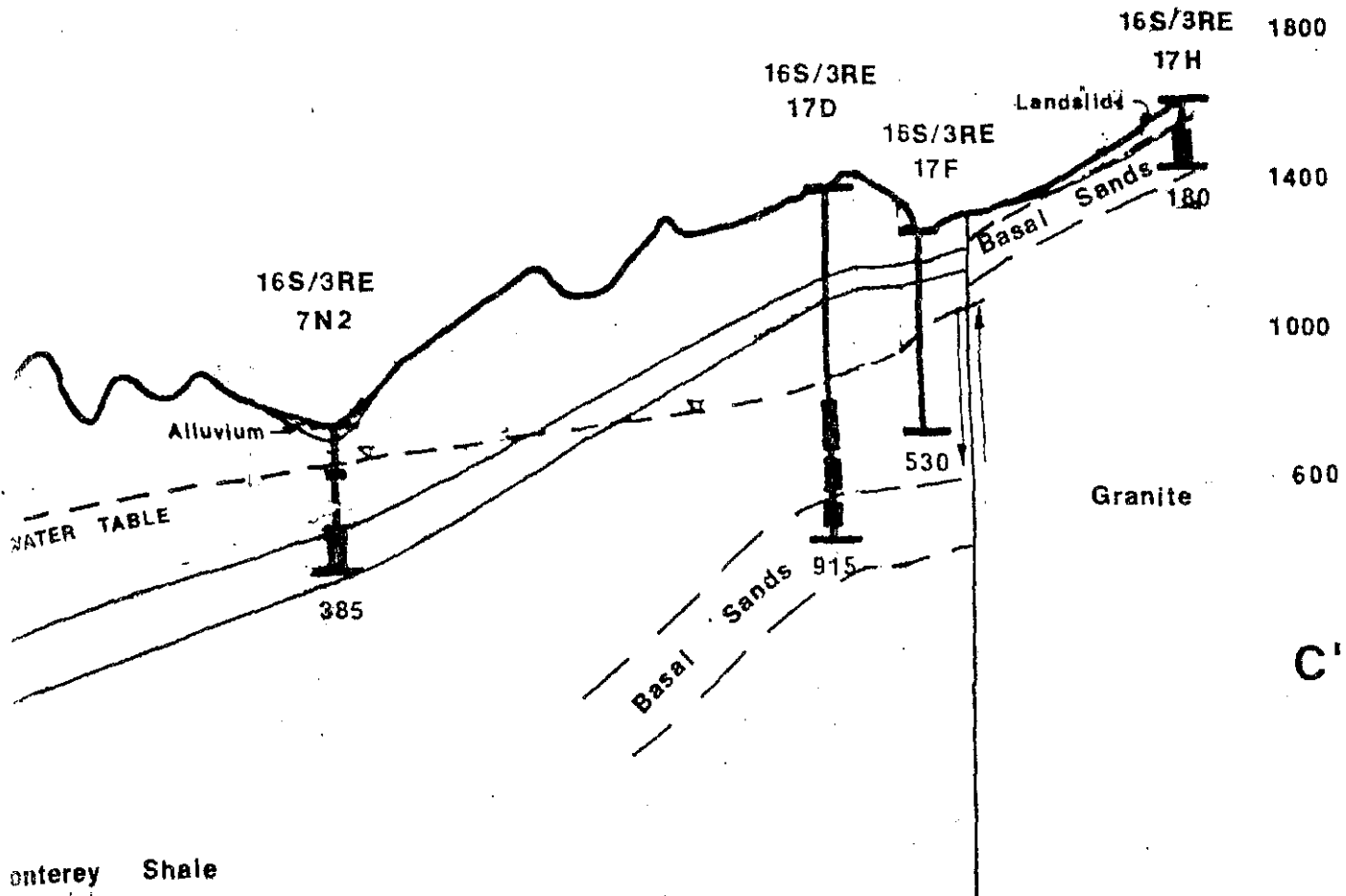
SECT

EL TORO AREA
GROUNDWATER STUDY

GEOLOGIC
CROSS-SECTION

Horizontal Scale 1 in. = 2000 ft.
Vertical Scale 1 in. = 500 ft.

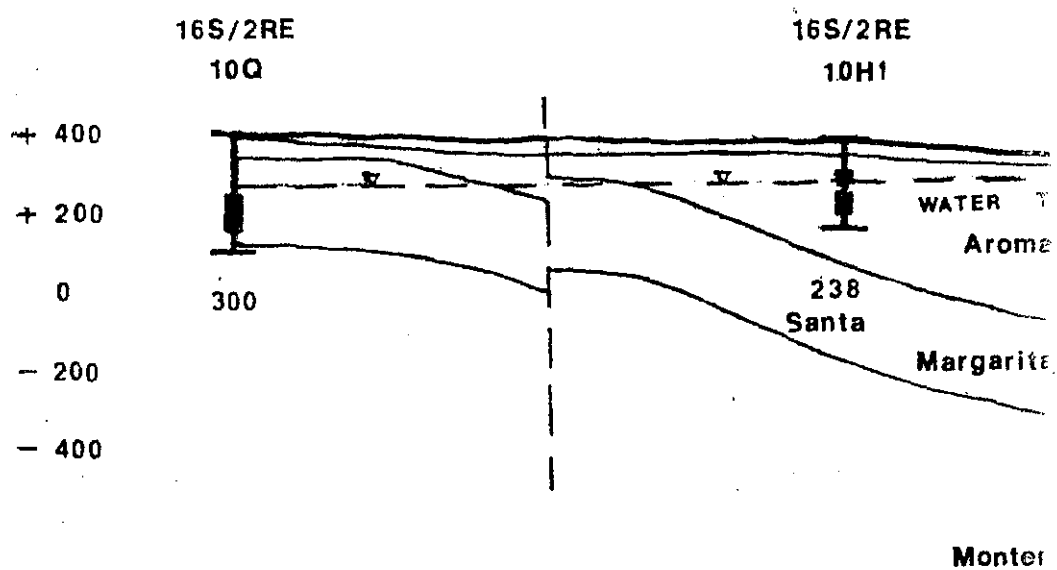
figure 6



C - C'

onterey Shale

D

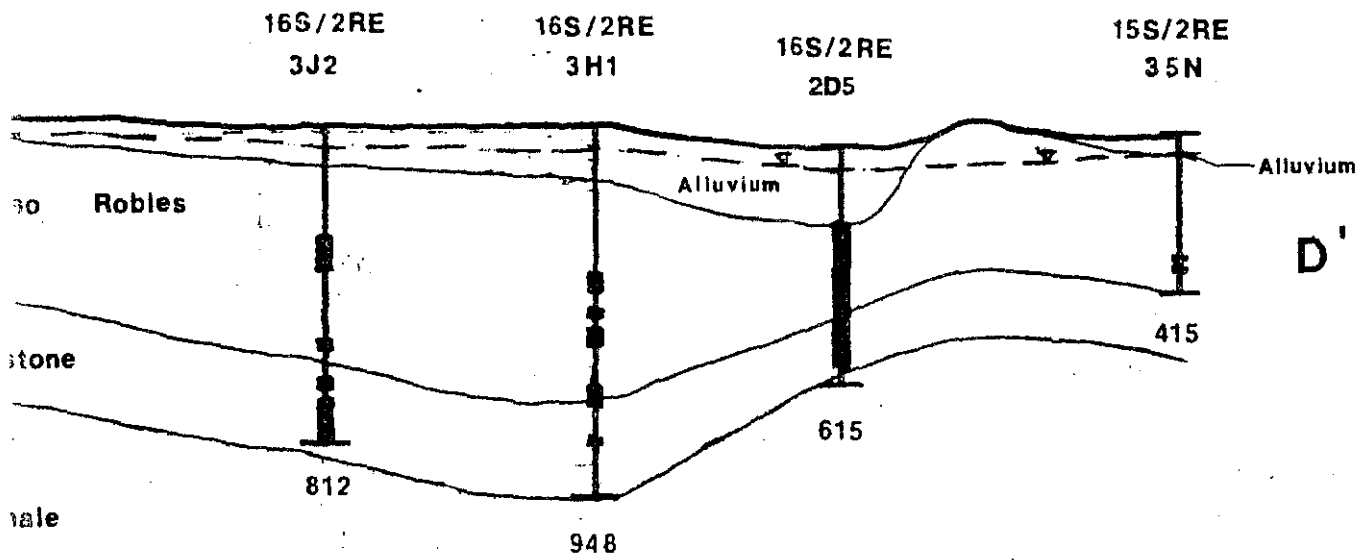


SECTION

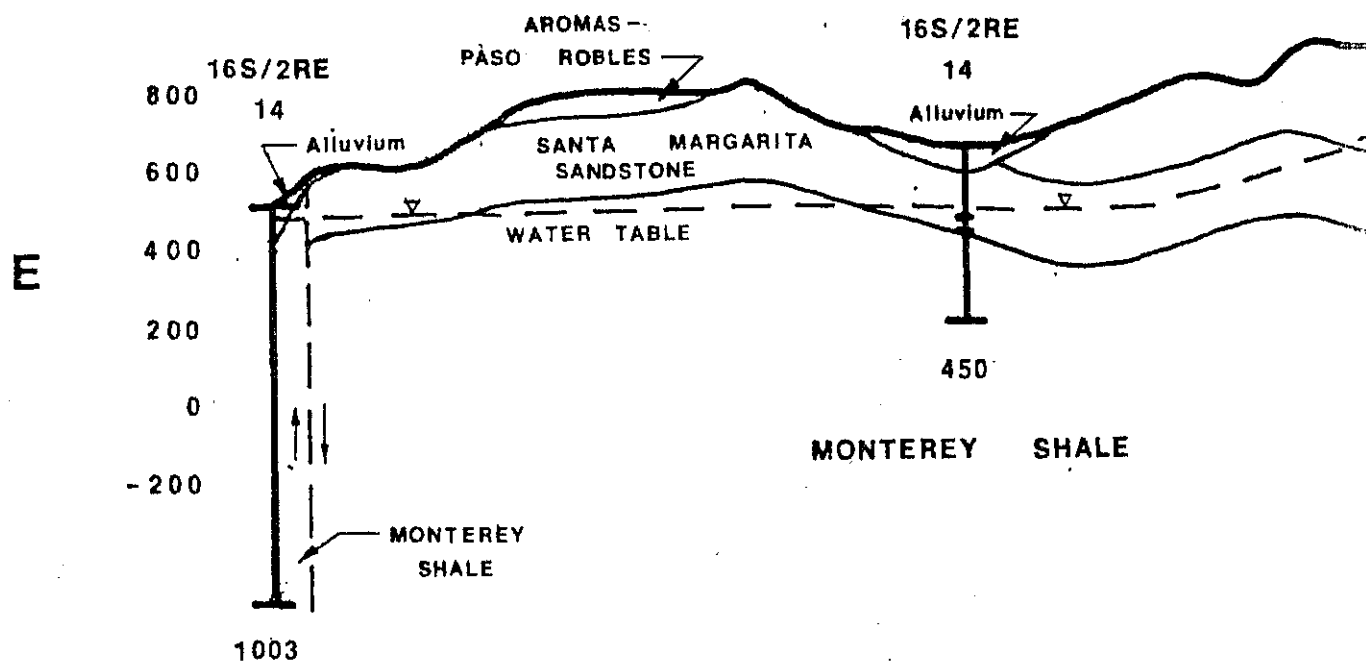
EL TORO AREA
GROUNDWATER STUDY

GEOLOGIC
CROSS-SECTION

Horizontal Scale 1 in. = 1000 ft.
Vertical Scale 1 in. = 500 ft.
figure 7



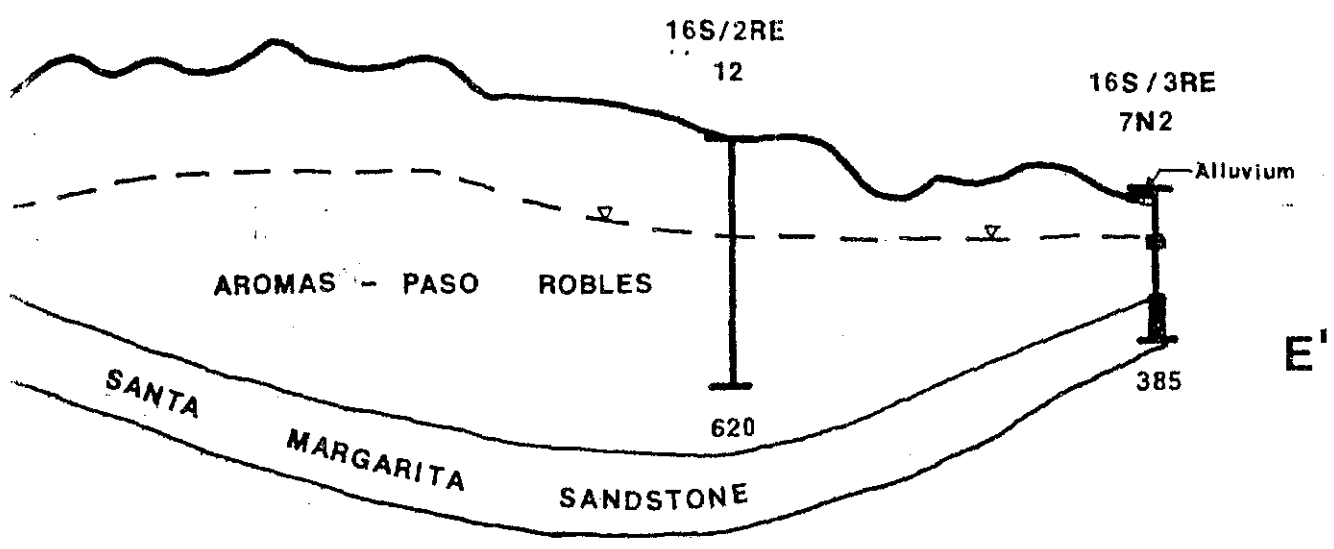
D' - D'



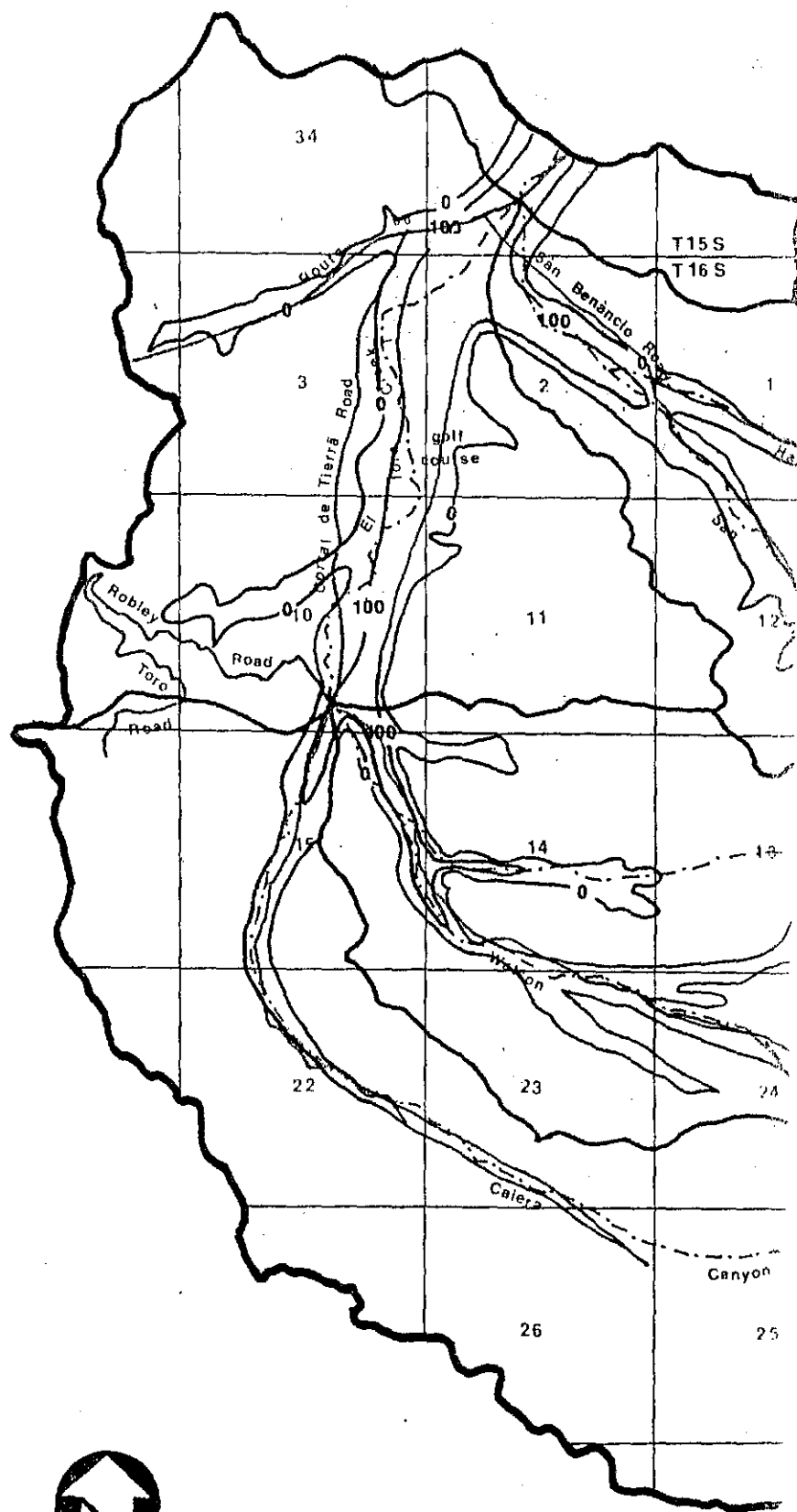
EL TORO AREA
GROUNDWATER STUDY

GEOLOGIC
CROSS-SECTION

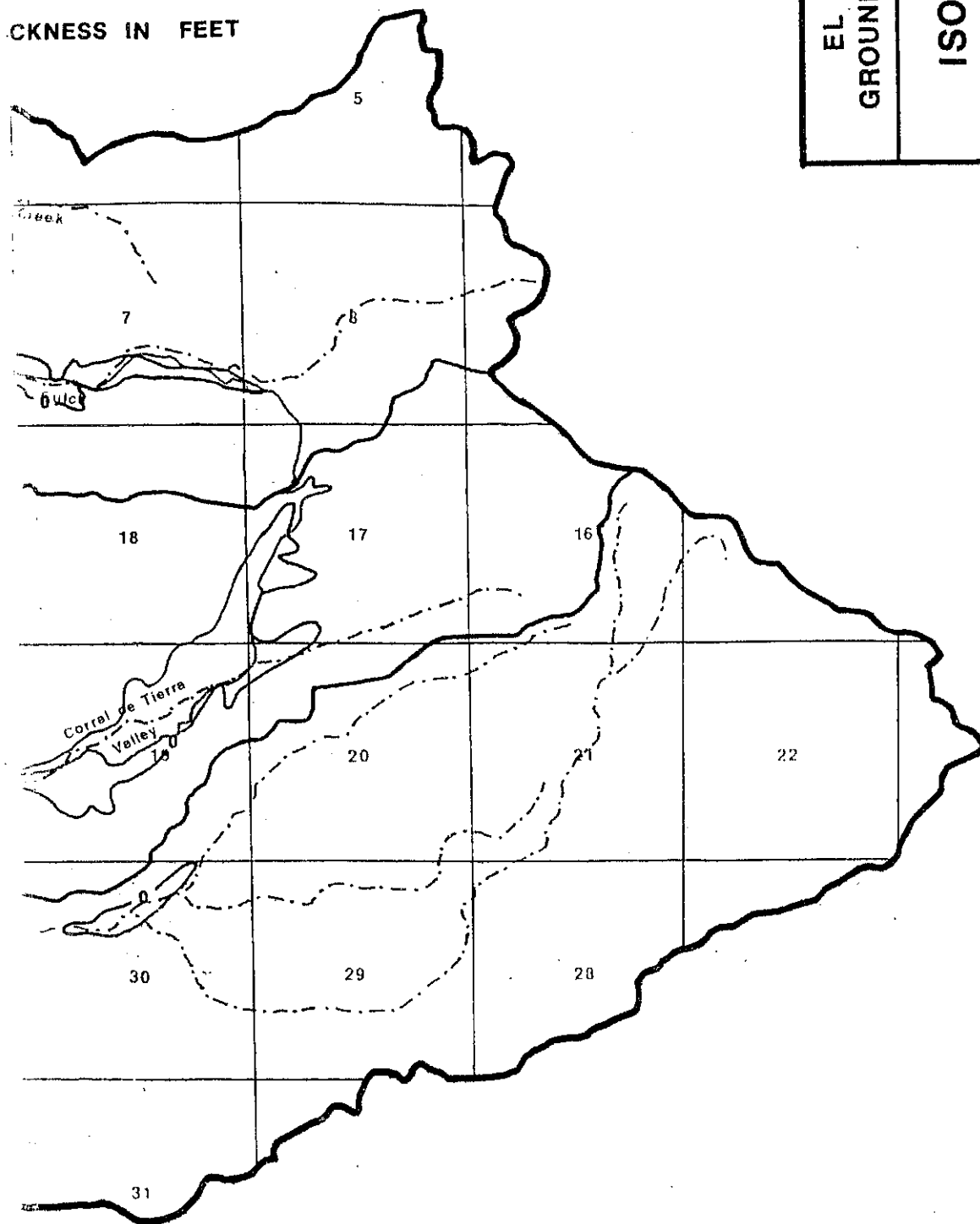
Horizontal Scale 1 in. = 1000 ft.
Vertical Scale 1 in. = 500 ft.
figure 8



- E'



CKNESS IN FEET

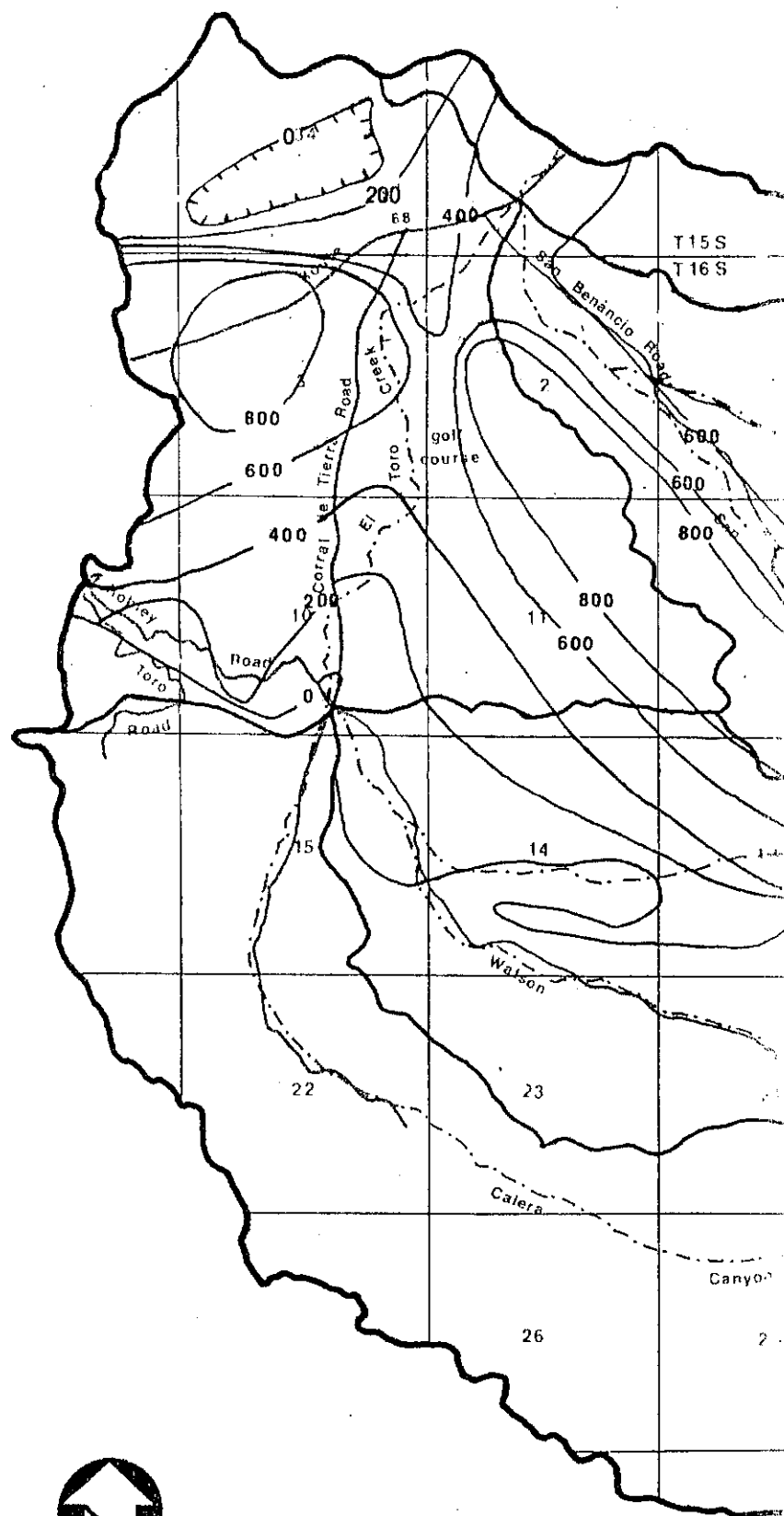


EL TORO AREA
GROUNDWATER STUDY

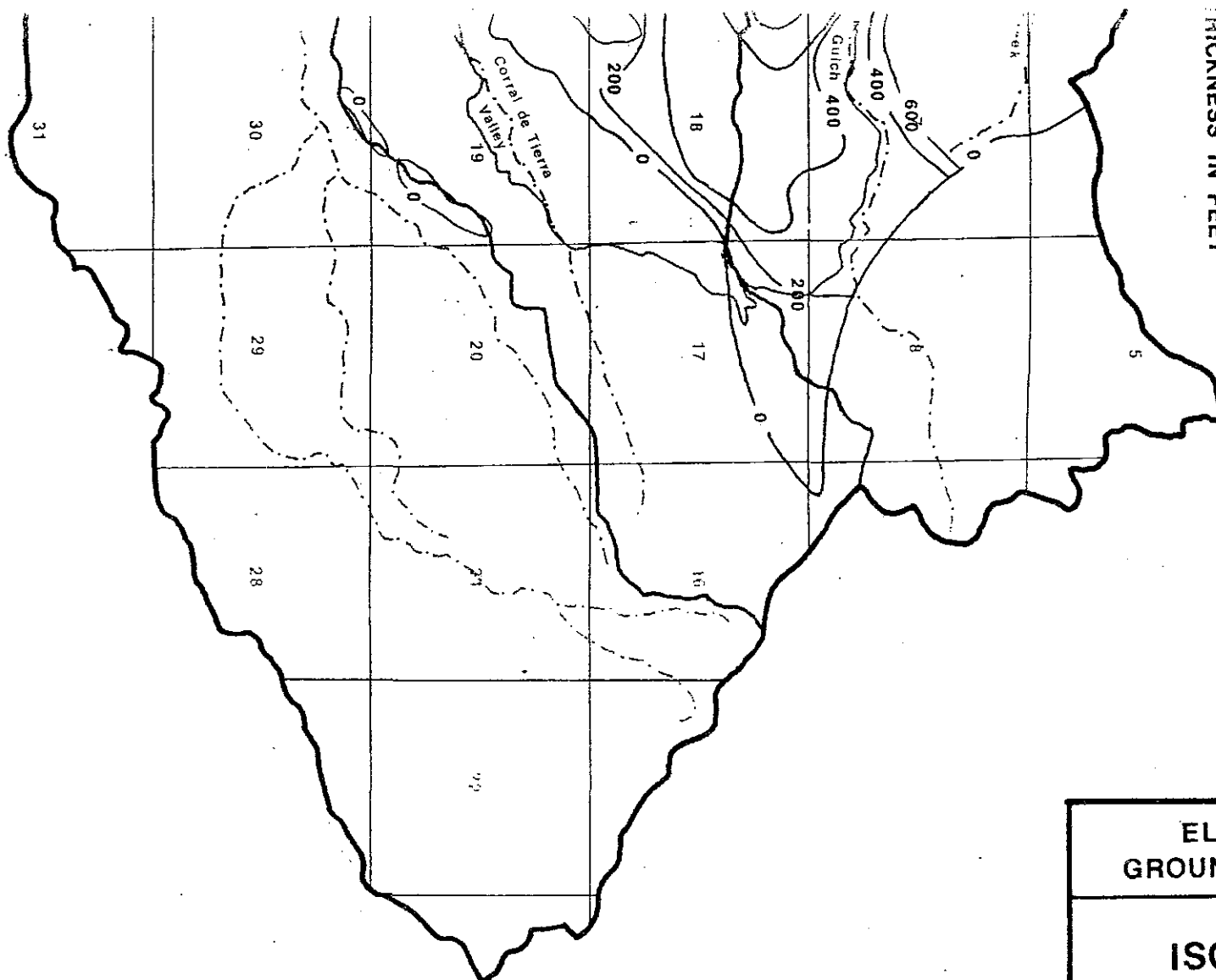
ISOPACH MAP
FOR THE
ALLUVIUM

ANDERSON - NICHOLS & CO., INC.

Scale 1 in. = 4000 ft. figure 9



THICKNESS IN FEET

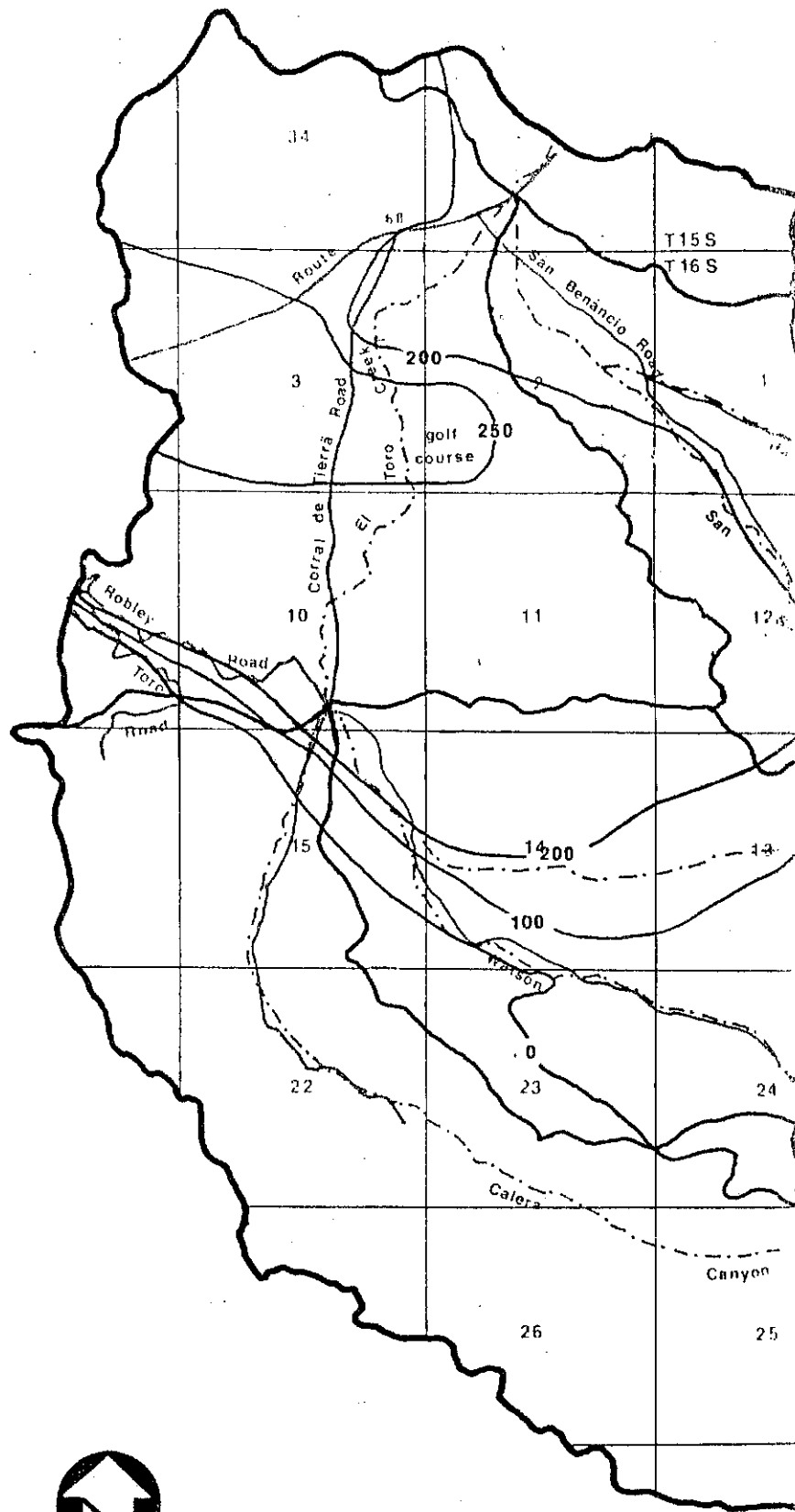


EL TORO AREA
GROUNDWATER STUDY

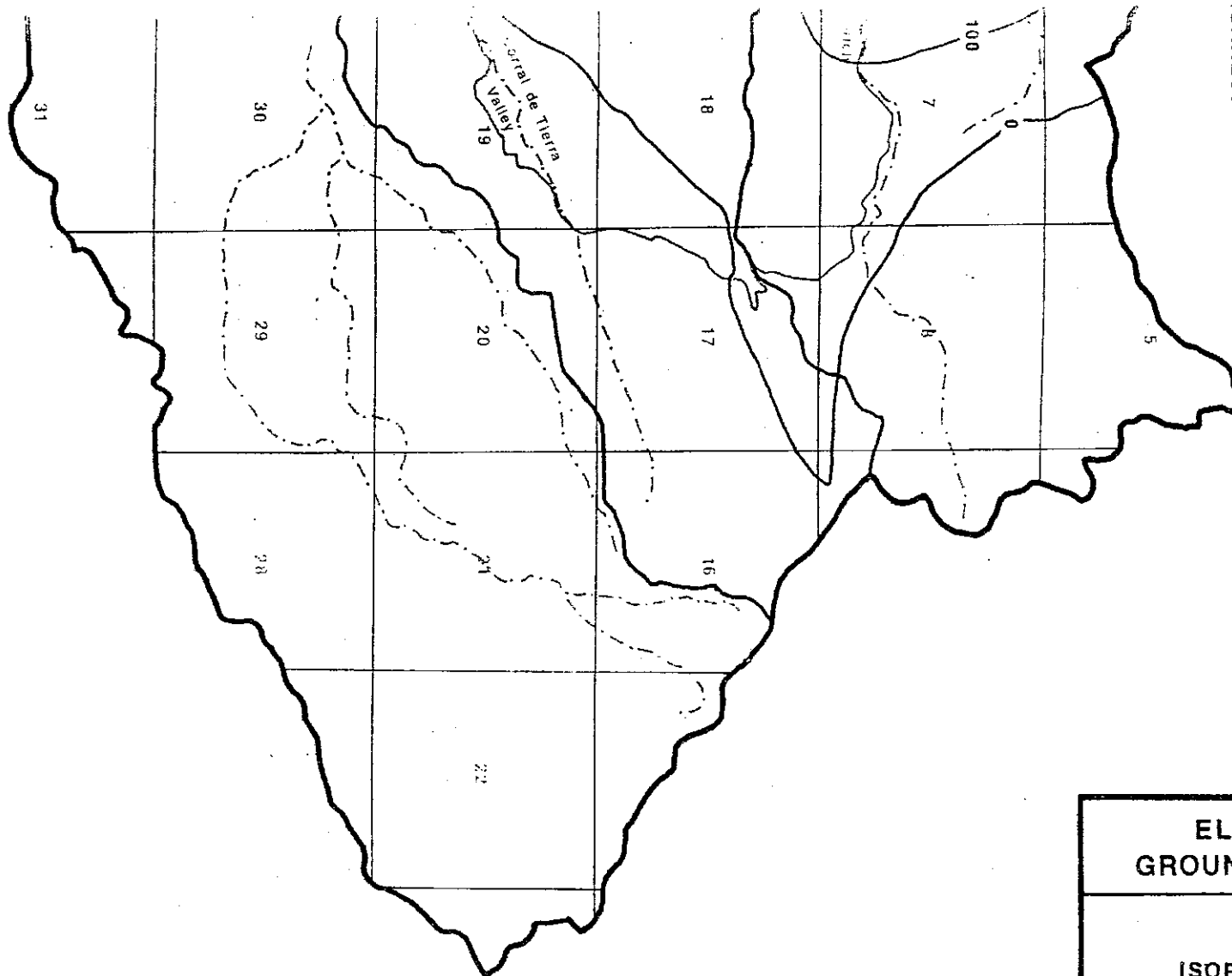
ISOPACH MAP
FOR THE
AROMAS-PASO ROBLES

ANDERSON-NICHOLS & CO., INC.

Scale 1 in. = 4000 ft. figure 10



THICKNESS IN FEET



**EL TORO AREA
GROUNDWATER STUDY**

**ISOPACH MAP FOR THE
SANTA MARGARITA SANDSTONE**

ANDERSON-NICHOLS & CO., INC.

Scale 1 in. = 4000 ft.

figure 11

in the lower formations. The absence of isopach maps for the Monterey Shale and Basal Sand Formations does not in any way indicate that these formations may not be viable aquifers in certain areas.

Figure 9 shows that the alluvium is found only in the stream valleys with thicknesses in excess of 100 feet in places. The Aromas-Paso Robles (Figure 10) is found only in the northwest corner of the area, attaining thicknesses of over 800 feet along ridges, but decreasing in thickness along stream channels. The northwest portion of the study area is underlain by a Santa Margarita Sandstone layer (Figure 11) over 200 feet in thickness. The sandstone formation thins out towards the east and south and is not found in the upper watershed of El Toro.

4. Soils

The description of soil types in the study area that follows is based upon a soil survey performed by the Soil Conservation Service (5).

Gorgonio Series

The lower flatter valley areas are generally overlain by soils of the Gorgonio Series. These soils, which are mainly composed of sandy loam, are excessively drained and exhibit low runoff rates and erosion hazards.

Santa Ynez Series

The slightly higher region on the western edge of the study area with slopes of 15 - 30% is covered with the moderately well drained,

fine sandy loam soil of the Santa Ynez Series. Runoff from these soils is generally rapid and the erosion hazard is high.

Arnold Series

The Arnold Series overlays much of the north-central region of the study area. This somewhat excessively drained soil is moderate in terms of both runoff and erosion hazard. It is composed of loamy sand, and lies on slopes of 9 - 75%.

Santa Lucia Series

In the southern areas, the shale outcrops are covered by the soil of the Santa Lucia Series. With slopes of 28 - 75%, runoff from these well-drained soils of shaly clay loam is rapid and the erosion hazard is high.

Sheridan, Vista, and Xeorthents Series

These three series, composed of well-drained, sandy loam, overlay the granite basement in the steepest regions of the study area. The eastern portion of the study area is covered by the Sheridan Series, with the Vista Series in the northwest and the Xeorthents Series in the high central areas. Due to the steep grades in these areas, all three series have very rapid runoff rates and high erosion hazard ratings.

B. Groundwater and Aquifer Characteristics

1. Material Properties

Specific hydrogeologic characteristics are difficult to determine for the five aquifers in the study area due to lack of adequate pumping tests and to a high degree of spatial variability. However, by examining the

general material composition of these layers it is possible to generally estimate the character of the layers. These estimates are provided in the following discussions.

Hydraulic Conductivity

Hydraulic conductivity (coefficient of permeability) measures the ability of the aquifer material to transmit fluids under the influence of a natural hydraulic gradient (slope) or pumping-induced stress. Generally, the larger the value of hydraulic conductivity, the greater the well yield for a given drawdown at the well.

The following table presents a range of hydraulic conductivities associated with consolidated and semi-consolidated sediments of varying grain sizes⁽⁶⁾. These values are based on laboratory measurements and assume flow cross-sectional areas measured in square feet and hydraulic gradients measured in feet of drop per foot of distance.

<u>Material</u>	<u>Typical Range of Hydraulic Conductivity (gal/day/ft²)</u>
Gravel	$10^4 - 10^6$
Clean Sand	$10 - 10^4$
Silty Sand	$1 - 10^3$
Silt	$10^{-2} - 10^2$
Sandstone	$10^{-3} - 10$
Shale	$10^{-6} - 10^{-3}$
Unweathered Marine Clay	$10^{-5} - 10^{-2}$

Based upon these values of hydraulic conductivity for various materials, the hydraulic conductivities of the five water sources of the study area have been estimated as follows:

<u>Water Source</u>	<u>Hydraulic Conductivity (gal/day/ft²)</u>
Alluvium	1 -10 ⁴
Aromas-Paso Robles	10 ⁻² -10
Santa Margarita Sandstone	10 ⁻² -10
Monterey Shale	10 ⁻⁶ -10 ⁻³
Basal Sands	10 ⁻¹ -10 ³

The coefficient of permeability varies widely within each water bearing member in the area due to the non-homogeneous composition of the formations. Due to the presence of clay and/or shale in all aquifers, localized areas of any aquifer may exhibit poor transmissivities and therefore low yields per unit of drawdown. Overpumping at these locations can result in a significant lowering of the water table immediately adjacent to the well.

Pump tests performed in the area provide insufficient data to allow an accurate determination of hydraulic conductivity for any aquifer. In order to characterize the groundwater system from pump tests, all five aquifers should be tested at a multiple number of sites within the area of study. Such an extensive program of testing was beyond the scope of this investigation and more cursory pump testing would be unlikely to aid in our formulation of a groundwater management plan.

Specific Yield

Specific Yield is a measure of the freely-available water contained within the pore spaces of the material, expressed as a fraction or percentage of the total value. Generally it is somewhat less than the porosity (percentage of open space) of the material, since it

represents only the amount of water which can actually be removed when the water table declines. The following table presents values of both porosity and specific yields for uniform sizes of aquifer materials:

Porosity and Specific Yield

<u>Material</u>	<u>Porosity (%)</u>	<u>Specific Yield (%)</u>
Medium Gravel	30	25
Medium Sand	40	30
Fine Sand	40	20
Sand and Clay	45	10
Clay	50	1

As can be seen from this table, although material containing clay has a high porosity (indicating a large volume of stored water) the water is bound to the particles and held by small capillaries and cannot be easily extracted. Therefore, the specific yield is dramatically less than the total porosity.

For unconfined aquifers, the specific yield represents a measure of the total storage which can be pumped from an aquifer. In Section VI of this report, we will estimate the total available storage in the alluvium, Aromas-Paso Robles, and Santa Margarita Sandstone Formations based on our estimations of the specific yields of these aquifers. By considering the material composition of the water-bearing strata, we have estimated the following likely ranges of specific yields:

Specific Yield (%)

<u>Water Source</u>	<u>Low</u>	<u>High</u>
Alluvium	10	20
Aromas-Paso Robles	1	10
Santa Margarita Sandstone	15	25

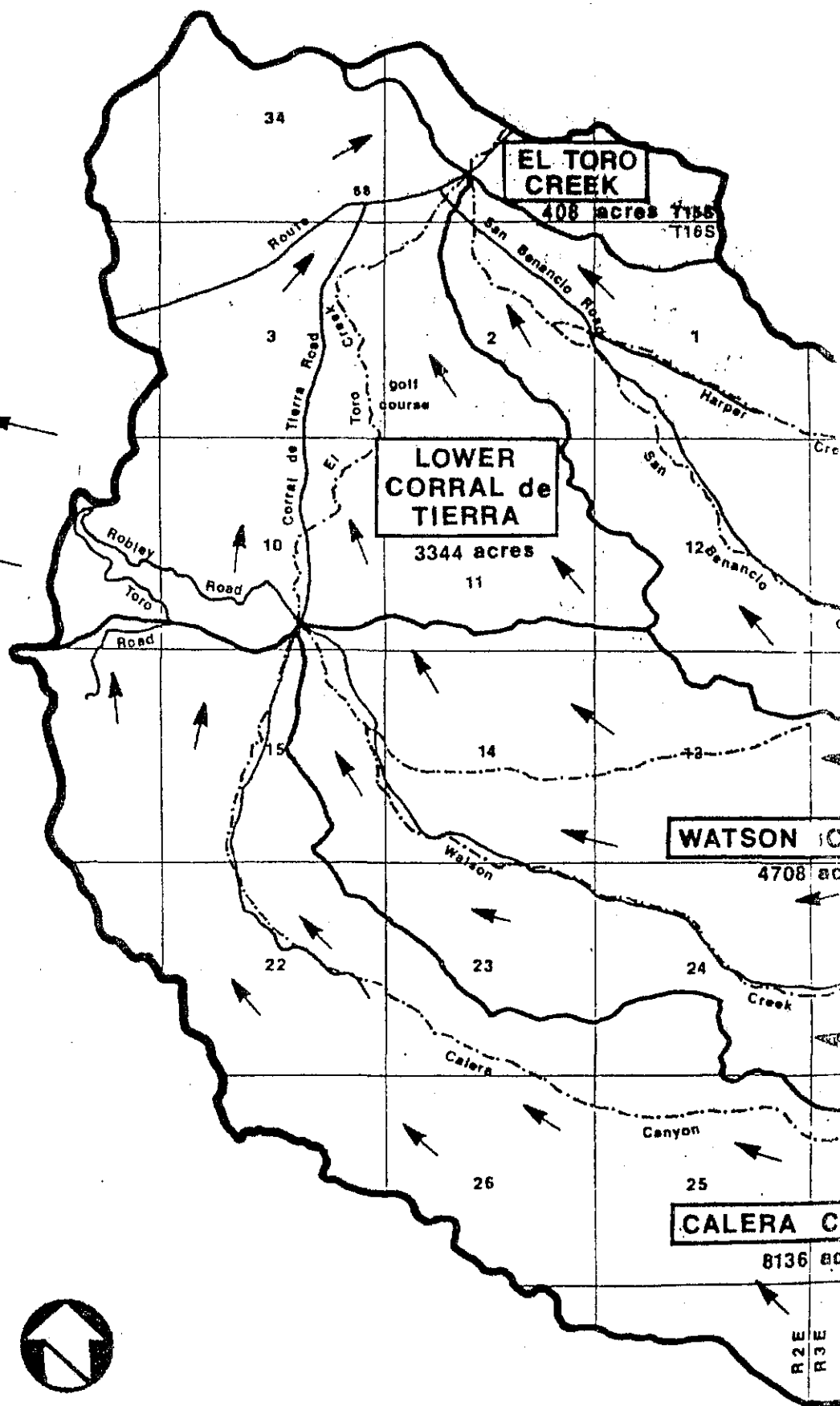
Due to the non-homogeneity of the aquifers, specific yield varies significantly within each geologic member.

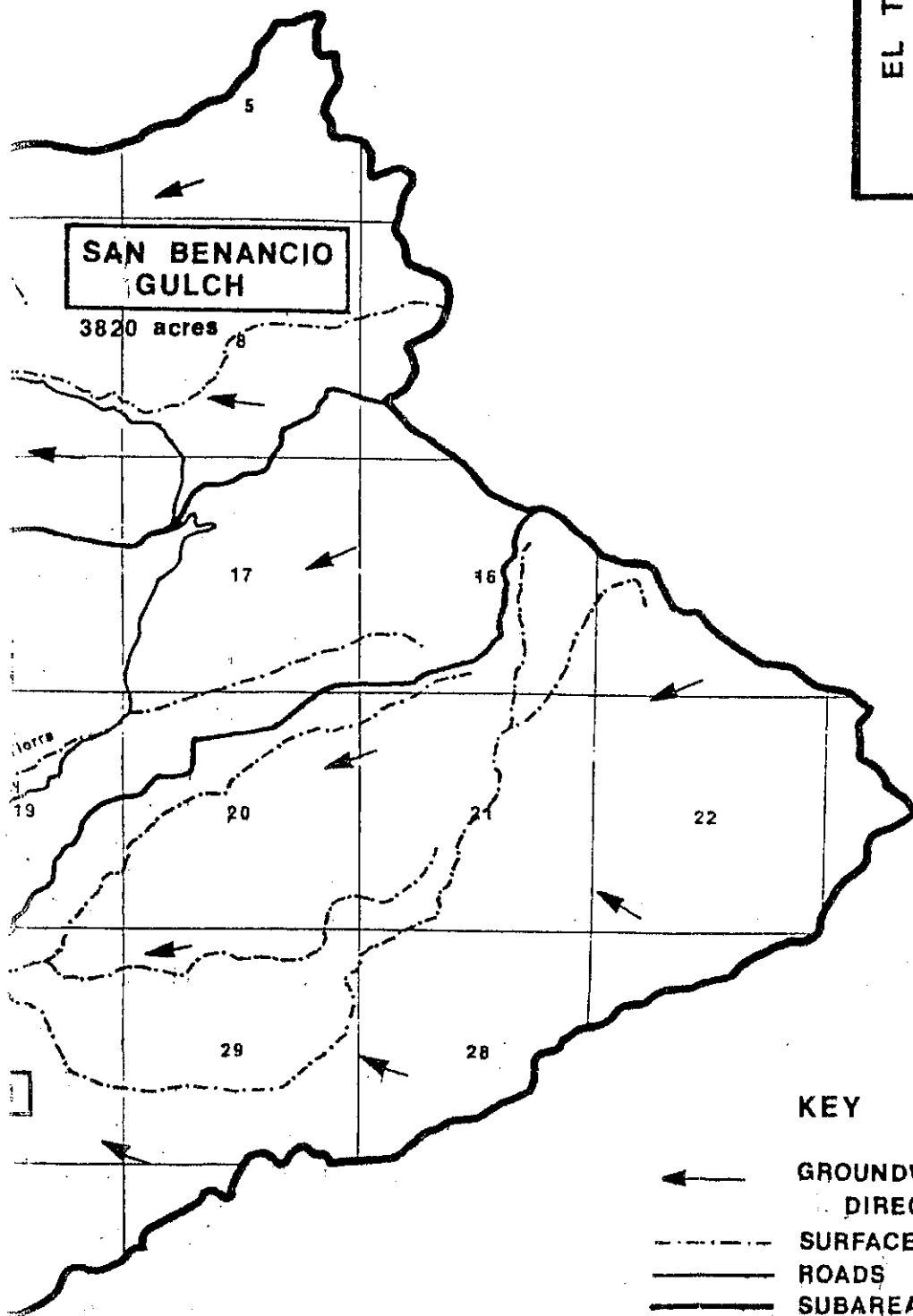
2. Occurrence and Movement of Groundwater

As depicted in Figure 12, the study area has been divided into five subareas based on surface drainage divides. The flow of groundwater in the area, as shown by the arrows on the figure, generally follows the pattern of surface drainage. Although the majority of the groundwater flow moves from the upper subareas (San Benancio Gulch, Watson Creek, and Calera Canyon) to the lower subareas (Lower Corral de Tierra and El Toro Creek), there is evidence of a significant movement of groundwater from Lower Corral de Tierra into the adjoining Laguna Seca basin.

This pattern of groundwater movement was inferred from a water table map (Figure 13) based largely upon data gathered in the fall of 1980. Much of the available water level data (shown on Figure 13) were in the north central portion of the study area where wells are concentrated. Contours drawn in areas where data were sparse were estimated from knowledge of geologic structure and are less reliable than contours based

Potential
Groundwater
Flow Into
Laguna Seca





KEY

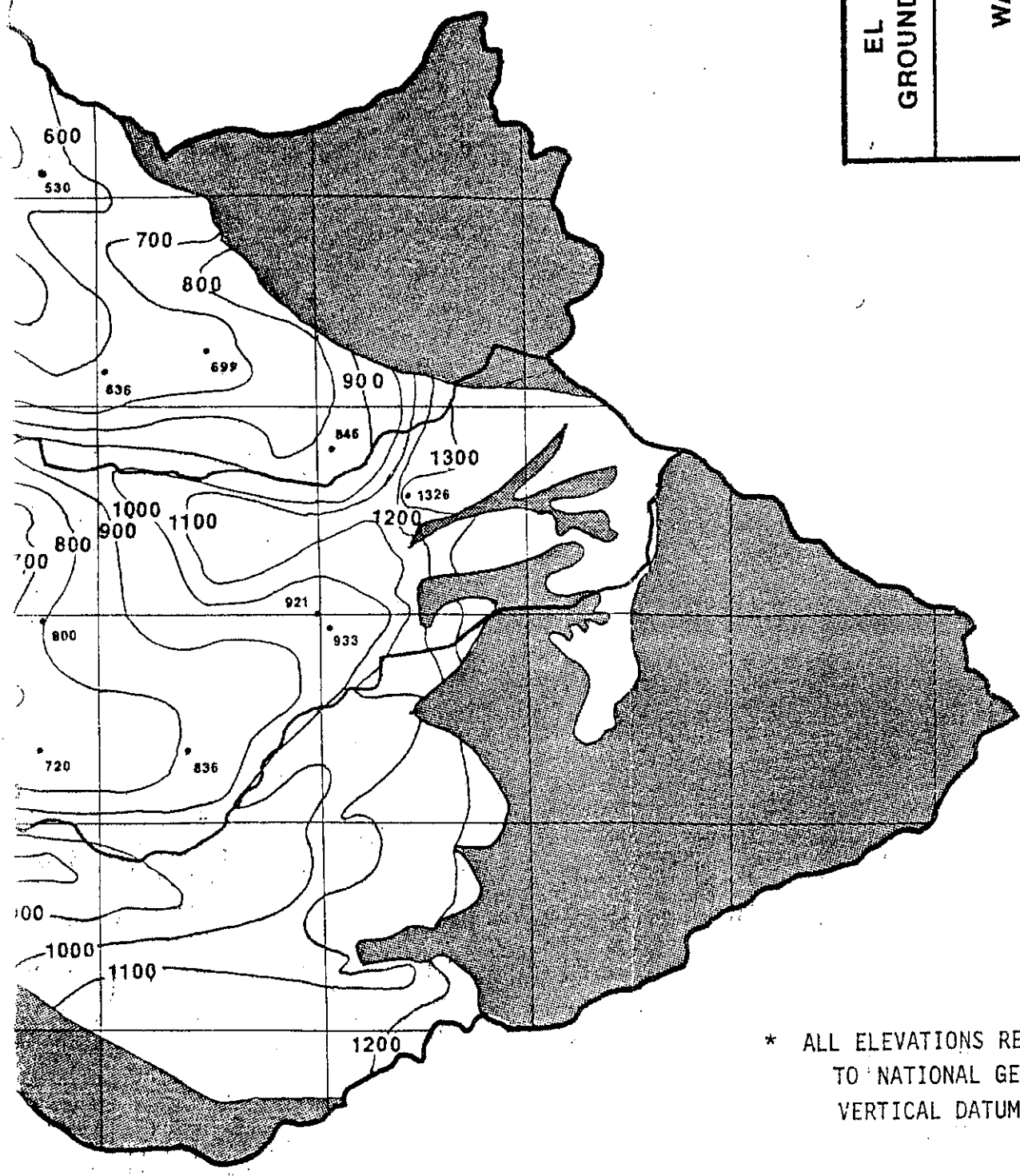
- ← GROUNDWATER FLOW DIRECTION
- SURFACE STREAMS
- ===== ROADS
- ===== SUBAREA BOUNDARIES
- 8 TOWNSHIP NUMBERS

EL TORO AREA
GROUNDWATER STUDY

HYDROLOGIC SUBAREAS
DIRECTIONS OF GROUNDWATER
MOVEMENT

ANDERSON - NICHOLS & CO., INC.

Scale 1 in. = 4000 ft. figure 12



EL TORO AREA
GROUNDWATER STUDY

WATER TABLE
ELEVATIONS

ANDERSON - NICHOLS & CO., INC.

Scale 1 in. = 4000 ft. Figure 13

* ALL ELEVATIONS REFERENCED
TO NATIONAL GEODETIC
VERTICAL DATUM

on nearby well measurements. Areas of granite outcrops (indicated on Figure 13) do not contain significant groundwater and are therefore not contoured on the water table map.

The transfer of groundwater out of the study area toward Laguna Seca is of particular interest. Based on a sample application of Darcy's Law and the directions of flow and estimations of hydraulic gradient from the groundwater table map, the rate of groundwater transfer appears to be about 2300 acre-feet/year. This figure agrees well with Thorup's (3,7) estimated outflow of 2000 acre-feet/year based on the geology of the area. The level of accuracy in our calculation does not warrant the use of more than one significant figure in the result; therefore all calculations in this report will be based on an assumed outflow of groundwater of 2000 acre-feet/year, leaving the upper end of the Lower Corral de Tierra subarea.

Well yields are wide ranging in each formation in the El Toro area. An indication of this range in yields can be seen in the following table:

<u>Formation</u>	<u>Well Yield (gpm)</u>
Alluvium	8 - 500
Aromas-Paso Robles	3 - 400
Santa Margarita Sandstone	2 - 758
Monterey Shale	2 - 25
Basal Sands	15 - 300

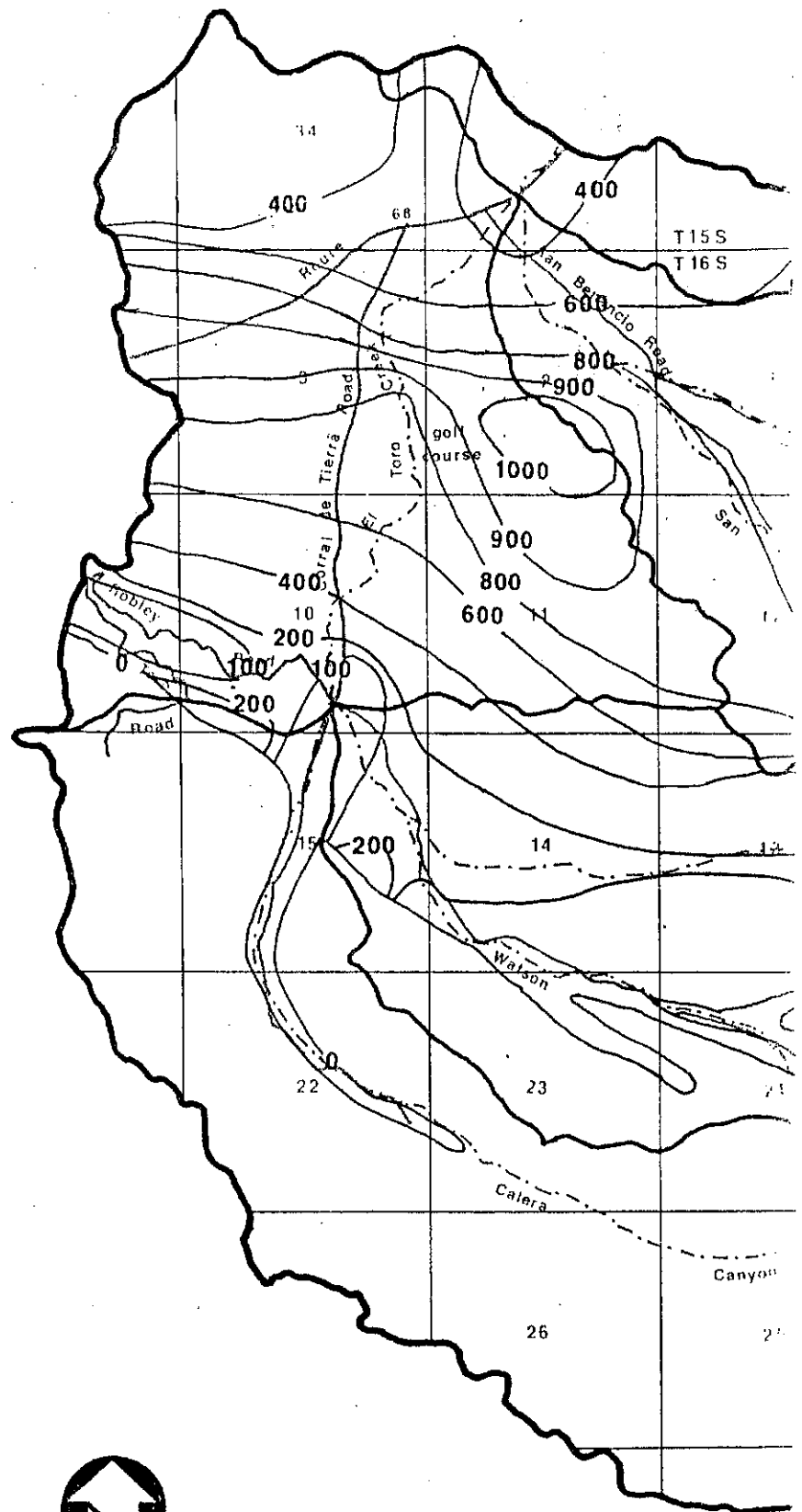
The yield ranges tabulated here are not intended as a precise listing of all well yields, but are presented to provide evidence of the variable nature of well production within single aquifers at different locations.

3. Suitability of Aquifers for Water Supply

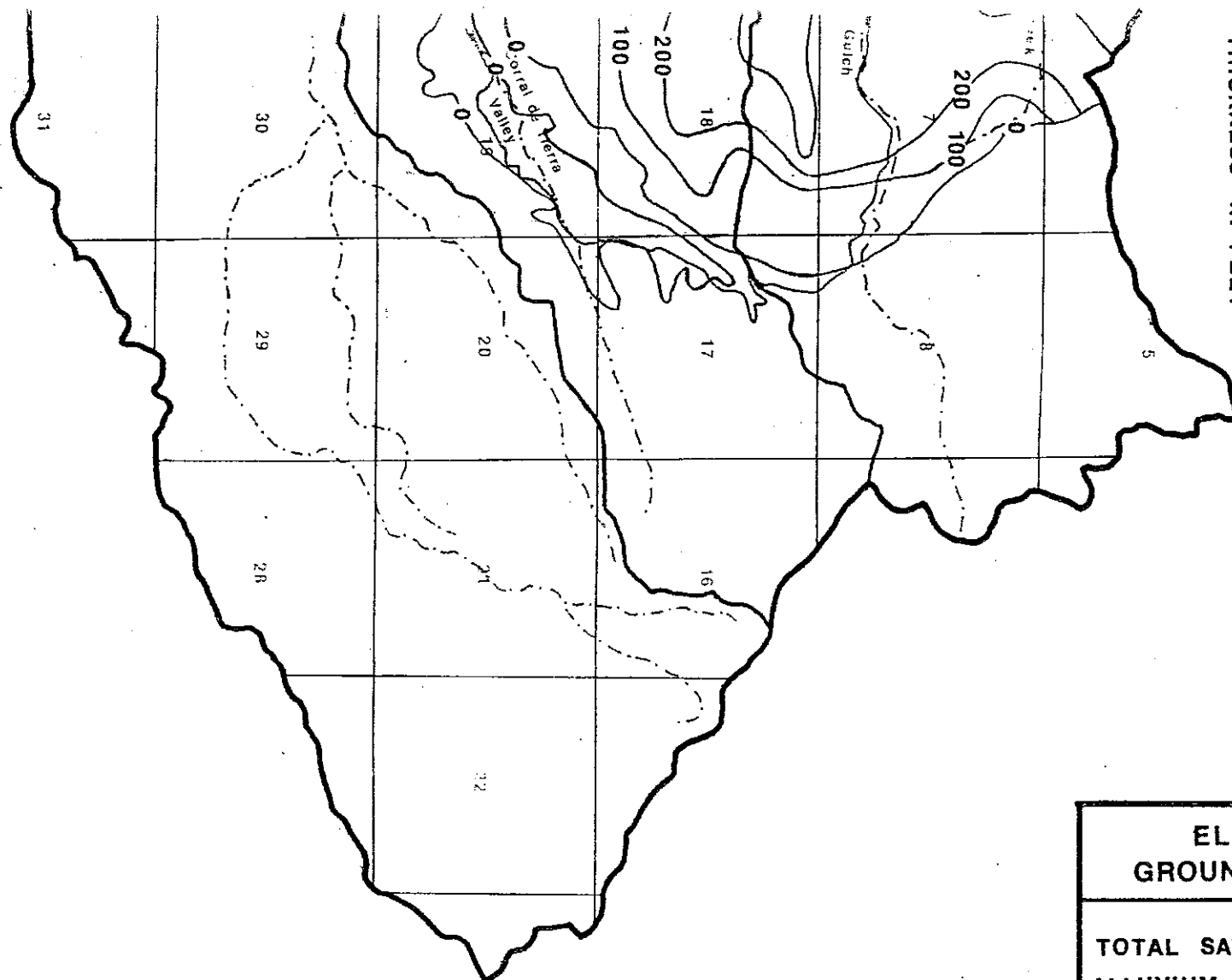
The alluvium, Aromas-Paso Robles, and Santa Margarita Formations have been shown to be viable aquifers in a significant part of the area of study. Figure 14 depicts the saturated thickness of these three aquifers as determined from well log data, the geologic cross sections, and the water table map. In constructing Figure 14, the elevation of the top of the Monterey Shale Formation was compared with the water table map to determine the depth of groundwater in the upper three units. The contours of saturated thickness thus determined were checked against actual data from available well logs.

Figure 14 indicates that stored groundwater in the upper three geologic members is most abundant in the Lower Corral de Tierra, El Toro Creek, and San Benancio Creek subareas. Groundwater in these three aquifers is least ample in the upper parts of the study area watershed (in the eastern and southern parts of the basin). Storage estimates will be determined in Section VI of this report based upon the information shown on Figure 14.

Monterey Shale in the northwest section of the study area is generally quite deep and has a low conductivity. To the south, however, the Corral de Tierra Fault and the Chupines Fault have shifted the



THICKNESS IN FEET



**EL TORO AREA
GROUNDWATER STUDY**

**TOTAL SATURATED THICKNESS OF
ALLUVIUM, AROMAS - PASO ROBLES
AND SANTA MARGARITA
SANDSTONE FORMATIONS**

ANDERSON - NICHOLS & CO., INC.

Scale 1 in. = 4000 ft.

figure 14

Monterey Shale to the surface. Although low yields are encountered, it may be practical to drill to this aquifer in the southern part of the study area. However, as will be discussed in a later section, due to quality problems, it is often not feasible to use this formation as a domestic water source.

Along with the Monterey Shale, the Chupines Fault and its branch, the Corral de Tierra Fault, have also uplifted the Basal Sand layer toward the land surface. A product of this tectonic activity is an artesian well (16S/2E/24J) producing up to 300 gpm from the Basal Sands in the Watson Creek watershed south of the Corral de Tierra Fault. The pressure that is inducing the flow from this well is partially caused by the "damming" of the aquifer by two branches of the Corral de Tierra Fault (as shown on Figure 3). The Monterey Shale layer above, the Granite layer below and the "V" formed by the two branches of the fault result in the confinement of water in the aquifer both horizontally and vertically. Water from the well drilled into this area flows readily on the surface due to the pressurized state of the aquifer. The artesian well has been allowed to flow freely since 1974, resulting in a steady decrease in water levels at two wells directly upgradient. Knowledge of the magnitude of the storage in and the avenue of the recharge of the Basal Sands is incomplete, making judgments concerning this artesian well difficult. A continuous flow rate of 300 gpm (480 acre-feet per year) represents roughly 50 per cent of the total mean annual recharge occurring in the Watson Creek basin upstream of the artesian well. Since the Monterey Shale, Basal Sand, and alluvium aquifers are all supplied by the total recharge, the water flow

from the artesian well represents a very high proportion of the probable mean annual recharge to the Basal Sand Formation. To prevent possible storage depletion of the potentially important Basal Sand aquifer, the flow from the artesian well should be controlled as soon as possible.

The long-term potential of the Basal Sands as a reliable aquifer is dependent upon the accessibility of recharge into this deep formation. In areas where the Basal Sands Formation occurs at depth, but not near its surface outcrops, the vertical recharge to the aquifer is inhibited by the low permeability of the overlying Monterey Shale. The Corral de Tierra Fault and the North Branch of the Chupines Fault are additional blockages to the recharge of the Basal Sands. Geologic structure therefore indicates that recharge of the Basal Sands in areas not adjacent to surface outcrops is hindered vertically (Monterey Shale) and horizontally (tectonic faults). Until further well development takes place, only areas adjacent to Basal Sand outcrops can be considered likely locations for finding reliable water supplies from the Basal Sand Formation.

V. SURFACE HYDROLOGY

Since rainfall/runoff relationships determine the quantity of groundwater in the study area, an estimation of safe yield requires the determination of mean annual recharge. We investigated surface hydrology in El Toro by organizing data on a monthly accounting system under current conditions. Rainfall, evapotranspiration, runoff, and subsequently recharge were determined for five separate watersheds and for the entire study area according to the methodologies outlined below.

A. Precipitation

Numerous rainfall gages are situated in and around the El Toro area, but the length of operation of each gage is quite short and variable. Therefore, we first determined mean annual precipitation at Salinas where rainfall has been measured for the past 108 years. The short term rainfall records at 8 locations in the immediate vicinity of the study area were then adjusted with the longer period of observation at Salinas based on the following relationship:

$$M_a = M_s (m_t / m_s)$$

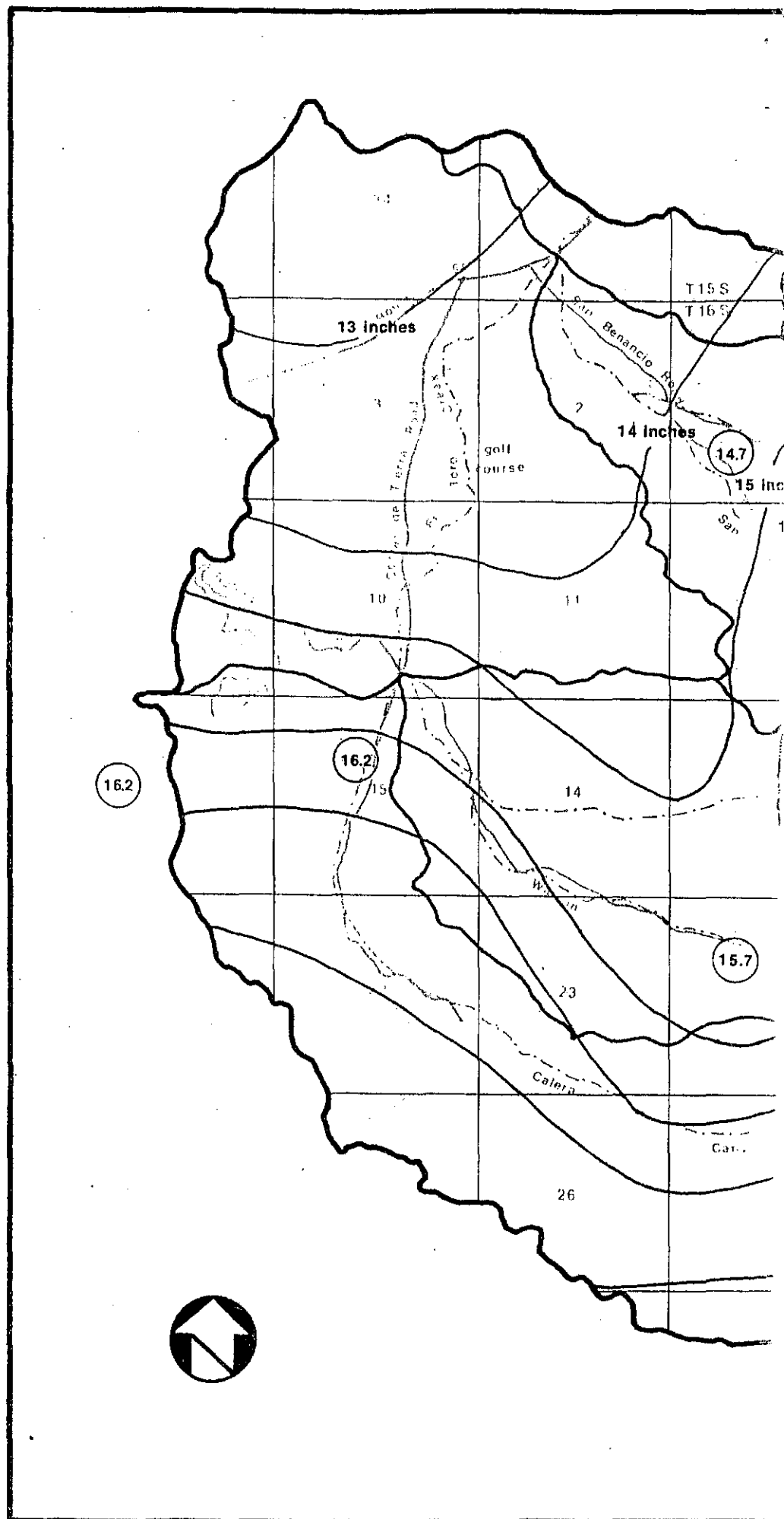
Where M_a = adjusted mean annual precipitation at given El Toro station

M_s = mean annual precipitation at Salinas for 108 years (13.6")

m_t = mean annual precipitation at given El Toro station

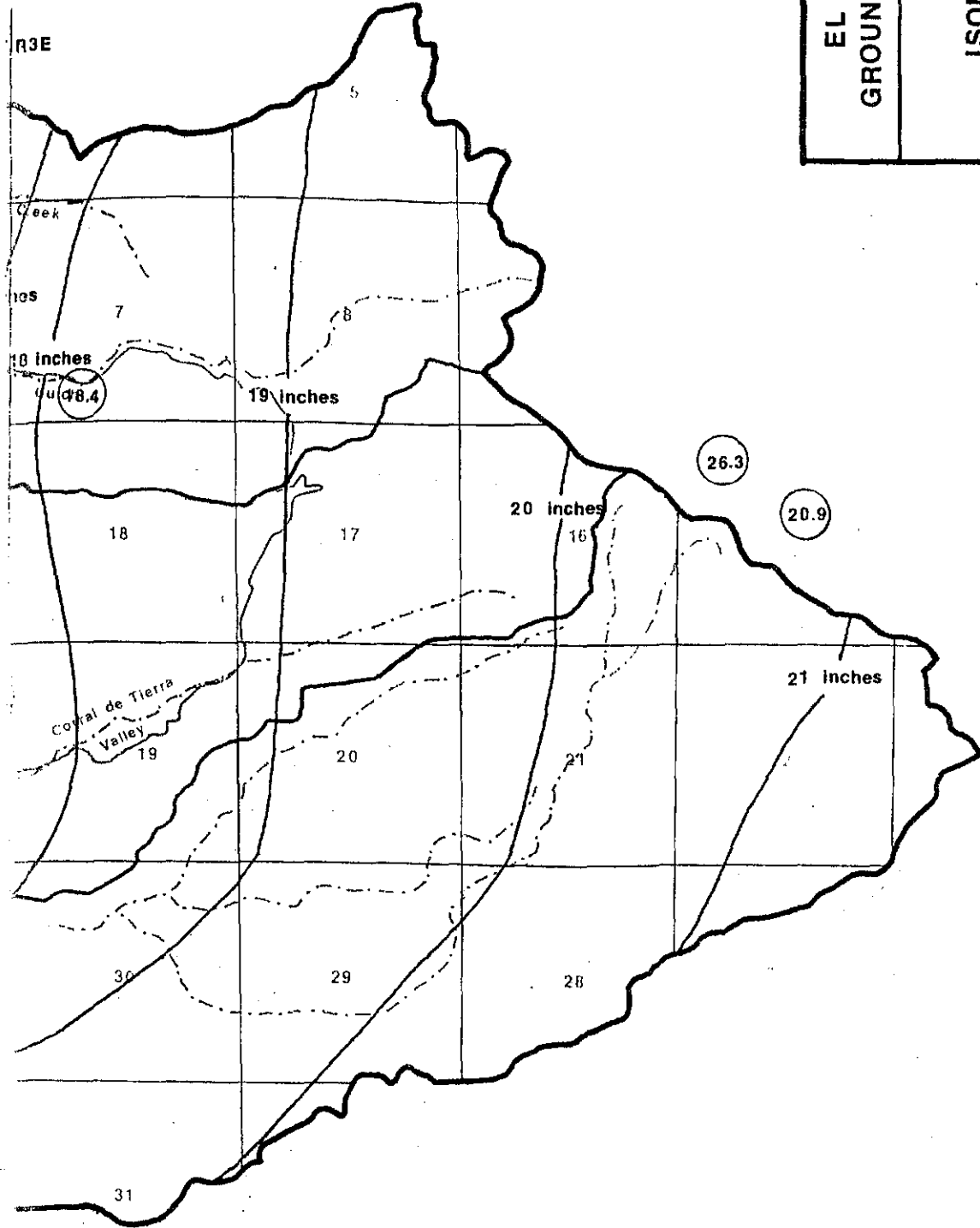
m_s = mean annual precipitation at Salinas for same period of record as given El Toro station

Through this adjustment procedure we obtained mean annual precipitation at 8 sites in the area of study that reflected long term climatic patterns (108 years). The adjusted rainfall figures and the isohyets drawn from these data points are depicted in Figure 15. Two stations located in the vicinity of Mt. Toro showed considerable differences in measured rainfall for the two



13.1

RO REGIONAL PARK
LOCATED OUTSIDE
MAP COVERAGE



EL TORO AREA
GROUNDWATER STUDY

ISOHYETAL MAP
RAINFALL STATIONS

ANDERSON-NICHOLS & CO., INC.

Scale 1 in. = 4000 ft.

figure 15

years they operated concurrently (1969 - 1971) and in the adjusted mean value shown on Figure 15. Since the records at the Mt. Toro station operated by the Monterey County Flood Control and Water Conservation District were considered to be more reliable than those available at the Dorrance Ranch, they served as the basis for the isohyets drawn in this area of Figure 15.

Mean annual precipitation for the study area and the five subareas was determined from the isohyetal map and was distributed on a monthly basis (Table 1). The distribution used represented an average of the distributions seen at Salinas and the 8 study area rain gages. All 9 locations showed roughly the same pattern of rainfall from month-to-month in an average year.

B. Evapotranspiration

Mean monthly potential evapotranspiration values for the grassland of the study area were developed based on local evaporation records. In the immediate vicinity of El Toro, the evaporation station has been positioned at three different locations in the past ten years: Salinas 3E, Salinas 4NE, and Santa Rita. The records from these three locations were combined and compared to the three long-term NOAA records in the central coast drainage: Burlingame, Nacimiento Dam, and Newark. Of the three long-term records, only the Burlingame record exhibited a similar mean annual evaporation to that calculated for the combined Salinas/Santa Rita record. The other two stations recorded considerably higher evaporation values since they are located farther inland from the coast. Given the fact that there was less variability in annual evaporation totals in the combined Salinas/Santa Rita record than in the homogeneous Burlingame record, the combined records from the three local stations (Salinas 3E, Salinas 4NE, Santa Rita) were considered as one record (i.e., differences introduced by moving the stations within a small area

TABLE 1

AVERAGE MONTHLY RAINFALL FOR EACH SUBAREA

	RAINFALL (INCHES)												
SUBAREA	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	YEAR
CALERA CANYON	3.83	3.39	3.18	1.74	0.34	0.13	0.04	0.13	0.30	0.73	2.05	3.24	19.1
WATSON CREEK	3.45	3.05	2.86	1.57	0.31	0.12	0.03	0.12	0.27	0.66	1.85	2.91	17.2
SAN BENANCIO GULCH	3.46	3.06	2.87	1.58	0.32	0.12	0.03	0.12	0.28	0.67	1.87	2.92	17.3
LOWER CORRAL DE TIERRA	2.74	2.43	2.28	1.25	0.25	0.10	0.03	0.10	0.21	0.52	1.47	2.32	13.7
EL TORO CREEK	2.73	2.42	2.27	1.24	0.24	0.09	0.03	0.09	0.21	0.51	1.46	2.31	13.6
TOTAL AREA	3.46	3.06	2.87	1.58	0.32	0.12	0.03	0.12	0.28	0.67	1.87	2.92	17.3

were considered insignificant). Monthly averages for evaporation were calculated and adjusted to estimate potential evapotranspiration (PET) using data from Table 5 of California Department of Water Resources Bulletin 113-3, entitled "Vegetative Water Use in California". Based on this analysis, the mean annual PET for the El Toro study area is 37.7 inches. Mean monthly values are provided below:

Potential Evapotranspiration (inches)

	<u>JAN</u>	<u>FEB</u>	<u>MAR</u>	<u>APR</u>	<u>MAY</u>	<u>JUN</u>	<u>JUL</u>	<u>AUG</u>	<u>SEP</u>	<u>OCT</u>	<u>NOV</u>	<u>DEC</u>	<u>YEAR</u>
Evaporation (E)	1.88	2.70	3.36	4.48	5.70	5.95	6.63	5.59	4.52	3.93	2.71	1.91	49.36
PET/E*	.71	.74	.76	.77	.78	.78	.78	.78	.77	.75	.73	.70	
PET (PET/E x E)	1.33	2.00	2.55	3.45	4.47	4.64	5.17	4.36	3.48	2.95	1.98	1.34	37.72

These potential evapotranspiration figures are based on grassland environments (the predominant ecosystem in El Toro). The additional water use by the forested parts of El Toro is accounted for by further adjustments of the water balance and is discussed later in this report section.

C. Rainfall Excess

Rainfall excess was calculated by comparing mean rainfall and evapotranspiration for each month to determine if a surplus of rain was generated. The separate monthly excesses were summed to provide a mean annual value of rainfall excess.

D. Runoff

Some of the rainfall in excess of evapotranspiration runs off the land as surface flow and does not enter the groundwater aquifers. At the downstream limit of our study area, a U.S. Geological Survey gaging station has measured runoff since October 1961 (El Toro Creek near Spreckels, station number 1152540)

* PET/E is the ratio between actual PET and measured pan evaporation.

and has recorded a mean value of 0.7"/year. After determining that rainfall for the period of record at the gage was in close agreement with long term rainfall patterns, the value of 0.7 inches was applied in our analysis of the entire area of study. In order to account for variations in the runoff characteristics between subareas, the Master Drainage Study⁽⁸⁾ for El Toro Creek was consulted for localized runoff data. As part of this 1974 study, watershed correction factors were generated based on the runoff characteristics of each of the watersheds analyzed. We estimated mean annual runoff values for each of the five subareas by comparing their correction factors with the correction factor for the entire study area. As a result of this analysis four of the five subareas were given runoff values of 0.7 inches with Calera Canyon receiving a value of 1.4 inches. Since runoff is transferred between some of the subareas the net effect of runoff on the water budget of a subarea was determined by subtracting the outflowing runoff from that which was inflowing.

E. Water Use By Trees

Potential mean annual recharge for each subarea was determined by subtracting mean annual runoff from mean annual rainfall excess. Actual recharge values were estimated by adjusting potential recharge values to account for increased evapotranspiration losses by woodland areas. Results of research performed by Burgy⁽⁹⁾ indicate that oak woodland areas experience approximately 3.2 inches more evapotranspiration than grassland areas do in an average year. This increased water loss is attributed to the deep roots of the oak which can tap water from areas up to 100 feet below the surface. In accounting for the water use by oaks and other trees in the study area, we estimated the areal coverage of trees in each subarea from topographic

mapping⁽¹⁰⁾ and assumed that all these woodland areas withdrew an additional 3.2 inches of water each year. This woodland use of water was subtracted from potential evaporation to yield actual evapotranspiration.

F. Recharge

Final estimates of actual recharge in inches and in acre-feet are presented in Table 2 for each subarea and for the total study area. These calculations have not attempted to distribute total recharge into the individual aquifers present in El Toro nor have they considered spatial variability in recharge within a subarea. At a specific location, one cannot predict the availability of groundwater by consulting Table 2 since only the overall recharging of subareas is shown without regard to more localized factors which affect water availability.

TABLE 2

MEAN ANNUAL RECHARGE EVALUATION IN THE EL TORO STUDY AREA

SUBAREA	ANNUAL RAINFALL (IN)	RAINFALL EXCESS (IN)	NET RUNOFF EFFECT* (IN)	POTENTIAL RECHARGE (IN)	WOODLAND WATER USE (IN)	ACTUAL RECHARGE	
						(IN)	(ACRE-FEET)
CALERA CANYON	19.1	¹⁶⁶ 6.49	- 0.70	5.79	1.18	4.6	3126
WATSON CREEK	17.2	¹⁷ 5.05	- 1.40	3.65	0.78	2.9	1126
SAN BENANCIO GULCH	17.3	⁷ 5.09	- 0.70	4.39	1.05	3.3	1063
LOWER CORRAL DE TIERRA	13.7	⁷⁹ 2.82	+ 0.29	3.11	0.69	2.4	674
EL TORO CREEK	13.6	⁷⁹ 2.79	- 0.70	2.09	1.53	0.6	19
TOTAL AREA	17.3	⁶⁸⁸ ⁷ 5.22	- 0.70	4.52	0.99	3.5	6008

* EQUALS RUNOFF INTO SUBAREA LESS RUNOFF OUT OF SUBAREA

VI. GROUNDWATER STORAGE

Storage in the alluvium, Aromas-Paso Robles, and Santa Margarita Sandstone Formations was estimated by first determining the saturated volumes in each subarea using Figure 14. An overall specific yield range of 5 to 20 percent was assumed for these three formations based on our estimates of specific yields in each formation (Section IV). The storage values presented in Table (5) were determined by multiplying specific yield (low and high values in range) by total saturated volume.

No storage estimates have been provided for the Basal Sand or Monterey Shale Formations for the following reasons.

- 1) Few wells have been drilled that tap these formations and therefore data on the saturated thicknesses and the magnitude and reliability of well yields are sparse.
- 2) Water quality in the Monterey Shale Formation is poor, making the aquifer unsuitable as a domestic water supply in many areas.
- 3) Recharge of the Basal Sands appears to be hindered by the overlying Monterey Shale Formation and by faults in many areas, leading to uncertainties with regard to the maintenance of the long term well yields.

Overall, we feel that questions regarding the magnitude, stability, and quality of stored water in the Basal Sand and Monterey Shale Formations are too numerous to warrant inclusion of these aquifers in our storage determinations. In acknowledgment of the fact that some wells are effectively utilizing the

Basal Sands in the southeast portion of the study area, we have delineated an area of moderate water availability in this region in our evaluation of water quantity (Section IX).

TABLE 3

Groundwater Storage (1000 acre-feet)

<u>Area</u>	<u>Alluvium, Aromas-Paso Robles, and Santa Margarita Sandstone</u>	
	<u>low</u>	<u>high</u>
Calera Canyon	0.7	2.8
Watson Creek	21.7	86.8
San Benancio Gulch	60.2	241.0
Lower Corral de Tierra	89.4	357.8
El Toro Creek	10.1	40.3
Total Study Area	182.1	728.7

VII. CURRENT GROUNDWATER DEMANDS

Current gross and net groundwater withdrawals (demands) were estimated for each subarea based on residential development and on water use by the golf course in the El Toro area. Commercial and agricultural use of water in El Toro is insignificant for the purposes of this study.

A. Residential Demand

The populations of the subareas were estimated by counting the number of dwellings in each subarea⁽¹¹⁾ and multiplying by the estimated average number of persons per dwelling unit. Population and housing data collected in 1976⁽¹²⁾ in the El Toro area yielded the occupancy rate used (3.34 persons per household). Gross residential water demands for each subarea were calculated based on an average daily per capita domestic use of 150 gallons. This rate of use is the average value measured by the Toro Water Service over the past five years as shown below:

<u>Per Capita Use Per Day (gallons)</u>	<u>Year</u>
160	1976
156	1977
149	1978
137	1979
138	1980

The Toro Water Service figures were used in these analyses because the present and planned future development of the study area generally conforms with the type of settlement serviced by the company (large homes with lots greater than or equal to one acre).

Net residential water demand was equated to 50% of gross demand based upon the following assumptions⁽¹³⁾:

- 1) 50% of domestic water is used for landscape watering with a 20% return flow to the aquifer.
- 2) 50% of domestic water passes through septic systems with an 80% return flow to the aquifer.

B. Golf Course Water Demand

Gross water use by the golf course located in Lower Corral de Tierra was calculated by applying a use rate of 3.9 acre-feet/acre⁽¹⁴⁾ to the area of the course estimated from the county land use map⁽¹¹⁾. The net use of water was assumed to be 80% of gross based on figures for domestic watering of lawns⁽¹³⁾.

A summary of the net demands for each subarea is presented in Table 4. This table presents total net demand and net inflow and the difference between the two. Groundwater outflows from upstream subareas are assumed to flow into downstream subareas and are included in the net inflow figures in Table 4. It is assumed that 2000 acre-feet per year of groundwater flows to Laguna Seca from the upper end of Lower Corral de Tierra. The total quantity of groundwater from recharge in each subarea greatly exceeds the net demand, but safe yield will be less than recharge in those areas with inadequate groundwater storage. This concept will be more fully evaluated in Section IX of the report.

TABLE 4

CURRENT GROUNDWATER INFLOWS AND DEMANDS FOR EACH SUBAREA
OF THE EL TORO STUDY AREA IN AN AVERAGE YEAR

SUBAREA	POPULATION	NET RESIDENTIAL DEMAND (Ac-Ft)	NET GOLF COURSE DEMAND (Ac-Ft)	TOTAL NET DEMAND (Ac-Ft)	NET INFLOW * (Ac-Ft)	DIFFERENCE ** (Ac-Ft)
CALERA CANYON	267	22		22	3126	3104
WATSON CREEK	444	38		38	1126	1088
SAN BENANCIO GULCH	1112	94		94	1063	969
LOWER CORRAL DE TIERRA	939	79	443	522	2866	2344
EL TORO CREEK	13	1		1	3332	3331
TOTAL AREA	2775	234	443	677	² / ₄₀₀₈	3331

* NET INFLOW INCLUDES LOCAL RECHARGE AND GROUNDWATER INFLOWS FROM UPSTREAM SUBAREAS.

** DIFFERENCE EQUALS NET INFLOW LESS NET DEMAND

VIII. PROJECTED GROUNDWATER DEMANDS

Groundwater use was projected for each study area for the year 2000 and for a population at saturated development based upon the following significant assumptions:

*COULD
BE
REMOVED*

- 1) Water use by the golf course remained unchanged from the current level.

- 2) No significant commercial, industrial, or agricultural demands for water were projected.

- 3) Residential populations at saturated development were supplied to us by the Monterey County Planning Department. The current gross per capita demand of 150 gallons per day and a housing occupancy rate of 3.34 persons per unit were applied in all projections.

*PER
CAPITA
DEMAND
MAY HAVE
GONE DOWN*

- 4) In projecting population for the year 2000 it was assumed that in 1985 all currently proposed subdivisions in the study area would be completed. Projections from 1985 to 2000 utilized an annual rate of growth of 2.11%⁽¹⁵⁾ for the entire area of study although the populations developed for each of the five subareas do not individually conform to this 2.11% yearly increase. The relative contribution of each subarea to the overall growth in population for the year 2000 equals the proportion of growth seen in projecting the subarea populations to saturated development.

Tables 5 and 6 show the net demands and inflows, together with the differences between each in the subareas at projected growth conditions. As before,

the unused groundwater resources of upstream watersheds are included as a groundwater inflow downstream. A 2000 acre-foot annual transfer of groundwater to Laguna Seca is assumed to occur at the upper end of Lower Corral de Tierra.

The groundwater leaving the downstream end of the study area flows beneath El Toro Creek and enters the Salinas River basin. Since significant current and projected development exists in this downstream area, its water supply balance was analyzed to determine if the area's water needs required the maintenance of a minimum groundwater outflow from our study area. Rainfall, evapotranspiration, runoff, and water use by trees were all estimated to quantify the annual groundwater recharge. A saturation population of 4603 people was projected and compared to the net recharge available locally. These calculations revealed that the area in the El Toro Creek watershed downstream of our area of study was self-sufficient in terms of groundwater supply at saturated development and did not require any inflow of groundwater from the area upstream to meet its demands. No constraints on development in the study area are therefore warranted to guarantee an adequate groundwater supply in areas downstream.

TABLE 5

PROJECTED GROUNDWATER INFLOWS AND DEMANDS AT YEAR 2000 FOR
EACH SUBAREA OF THE EL-TORO STUDY AREA IN AN AVERAGE YEAR

SUBAREA	POPULATION	NET RESIDENTIAL DEMAND (Ac-Ft)	NET GOLF COURSE DEMAND (Ac-Ft)	TOTAL NET DEMAND (Ac-Ft)	NET INFLOW * (Ac-Ft)	DIFFERENCE ** (Ac-Ft)
CALERA CANYON	822	69		69	3126	3057
WATSON CREEK	1896	159		159	1126	967
SAN BENANCIO GULCH	1821	153		153	1063	910
LOWER CORRAL DE TIERRA	2637	222	443	665	2698	2033
EL TORO CREEK	586	49		49	2962	2913
TOTAL AREA	7762	652	443	1095	4008	2913

* NET INFLOW INCLUDES LOCAL RECHARGE AND GROUNDWATER INFLOWS FROM UPSTREAM SUBAREAS.

** DIFFERENCE EQUALS NET INFLOW LESS NET DEMAND

TABLE 6

PROJECTED GROUNDWATER INFLOWS AND DEMANDS AT SATURATED DEVELOPMENT
FOR EACH SUBAREA OF THE EL TORO STUDY AREA IN AN AVERAGE YEAR

SUBAREA	POPULATION	NET RESIDENTIAL DEMAND (Ac-Ft)	NET GOLF COURSE DEMAND (Ac-Ft)	TOTAL NET DEMAND (Ac-Ft)	NET INFLOW * (Ac-Ft)	DIFFERENCE ** (Ac-Ft)
CALERA CANYON	2605	219		219	3126	2907
WATSON CREEK	4576	384		384	1126	742
SAN BENANCIO GULCH	3908	328		328	1063	735
LOWER CORRAL DE TIERRA	3507	295	443	738	2323	1585
EL TORO CREEK	785	66		66	2339	2273
TOTAL AREA	15,381	1292	443	1735	4008	2273

* NET INFLOW INCLUDES LOCAL RECHARGE AND GROUNDWATER INFLOWS FROM UPSTREAM SUBAREAS.

** DIFFERENCE EQUALS NET INFLOW LESS NET DEMAND

IX. EVALUATION OF GROUNDWATER QUANTITY

Earlier sections of this report have presented the available data on the geologic, hydrologic, hydraulic, and water usage characteristics of the study area without attempting to draw any conclusions. In this section, the safe yield of the groundwater resource will be discussed so as to provide guidance for the wise development of the El Toro area.

Definition of Safe Yield

The safe yield of an aquifer is usually defined in terms of a long-term average withdrawal rate, which, if exceeded, would result in such undesirable effects as storage depletion through overdraft. In many aquifers, safe yield is equal to mean annual recharge, but when only moderate volumes of stored water are present, safe yield can actually be less than mean annual recharge, since insufficient storage will result in dry wells during or following periods of drought. Usually, as long as groundwater in storage exceeds several times the mean annual recharge rate, the effects of dry years are smoothed sufficiently to rely on mean annual recharge as the best estimate of safe yield.

Combining data from Tables 3 and 6 of this report, Table 7 has been prepared to allow a direct comparison between groundwater storage, inflows, and current water demands. A similar comparison for projected demands at saturated development is presented in Table 8. The storages shown in Tables 7 and 8 are calculated from three aquifers (Alluvium, Arpmas-Paso Robles, and Santa Margarita Sandstone) without considering the Monterey Shale or Basal Sand Formations due to a lack of data on these two aquifers. A groundwater outflow of 2000 acre-feet per year to Laguna Seca has been accounted for in the tables.

TABLE 7

CURRENT GROUNDWATER STORAGE, INFLOWS, AND DEMANDS

AREA	TOTAL KNOWN STORAGE (ACRE-FEET)		NET INFLOWS* (ACRE-FEET/YR)	DEMAND (ACRE-FEET/YR)
	LOW	HIGH		
CALERA CANYON	700	2,800	3,126	22
WATSON CREEK	21,700	86,800	1,126	38
SAN BENANCIO GULCH	60,200	241,000	1,063	94
LOWER CORRAL DE TIERRA	89,400	357,800	2,866	522
EL TORO CREEK	10,100	40,300	3,332	1
TOTAL STUDY AREA	182,100	728,700	4,008	677

* NET INFLOWS EQUAL LOCAL RECHARGE PLUS UNUSED GROUNDWATER ENTERING FROM UPSTREAM AREAS.

TABLE 8

GROUNDWATER STORAGE, INFLOWS, AND PROJECTED
DEMANDS AT SATURATED DEVELOPMENT

AREA	TOTAL KNOWN STORAGE (ACRE-FEET)		NET INFLOWS* (ACRE-FEET/YR)	DEMAND (ACRE-FEET/YR)
	LOW	HIGH		
CALERA CANYON	700	2,800	3,126	219
WATSON CREEK	21,700	86,800	1,126	384
SAN BENANCIO GULCH	60,200	241,000	1,063	328
LOWER CORRAL DE TIERRA	89,400	357,800	2,323	738
EL TORO CREEK	10,100	40,300	2,339	66
TOTAL STUDY AREA	182,100	728,700	4,008	1,735

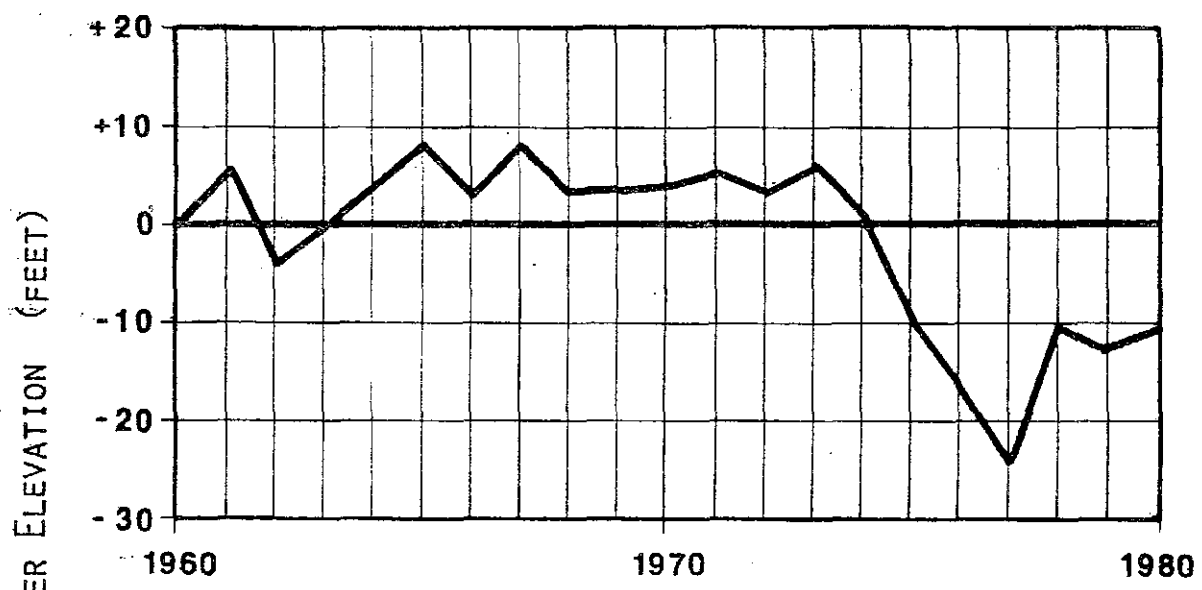
* NET INFLOWS EQUAL LOCAL RECHARGE PLUS UNUSED GROUNDWATER ENTERING FROM UPSTREAM AREAS.

B. Current Supply Condition

In evaluating groundwater quantity in an area, one should verify that mean annual groundwater inflows are equal to or greater than annual demand and that available storage is several times annual demand. These criteria are easily met in all subareas of El Toro under the current rates of usage, indicating that the safe yield exceeds the current demand by a substantial margin. This assessment of groundwater supply pertains to the overall situation in each subarea and does not mean that at every location in a subarea ample groundwater will be found. In granite outcrop areas groundwater will probably be scarce and at other localized sites transmissivities in water bearing aquifers may be so low that extraction of groundwater is severely hindered. As part of our prediction of future supply conditions later in this report we will address the problem of the uneven availability of groundwater within subareas.

In order to verify the analysis of the groundwater supply developed in this study, well water elevation data collected by the Monterey County Flood Control and Water Conservation District were studied. Figures 16 and 17 present water elevation changes at four selected wells over the past two decades (please note the various vertical scales used). The monitoring program carried out by the District provided good records at 33 different wells. Nearly all wells showed a drop in water level during the drought of the mid-1970's, as can be seen at wells 16S/2E/2D3 (Figure 16), 16S/3E 17F2 (Figure 17), and 16S/2E 15P1 (Figure 17). The wells have shown increased water levels since the drought, but some have not yet fully recovered. (See well 16S/2E 2D3, Figure 16). The following rainfall records at Salinas

LOWER CORRAL DE
TIERRA
(ALLUVIUM & PASO ROBLES)
16S/2E 2D3



SAN BENANCIO
GULCH
(PASO ROBLES)
16S/2E 2G1

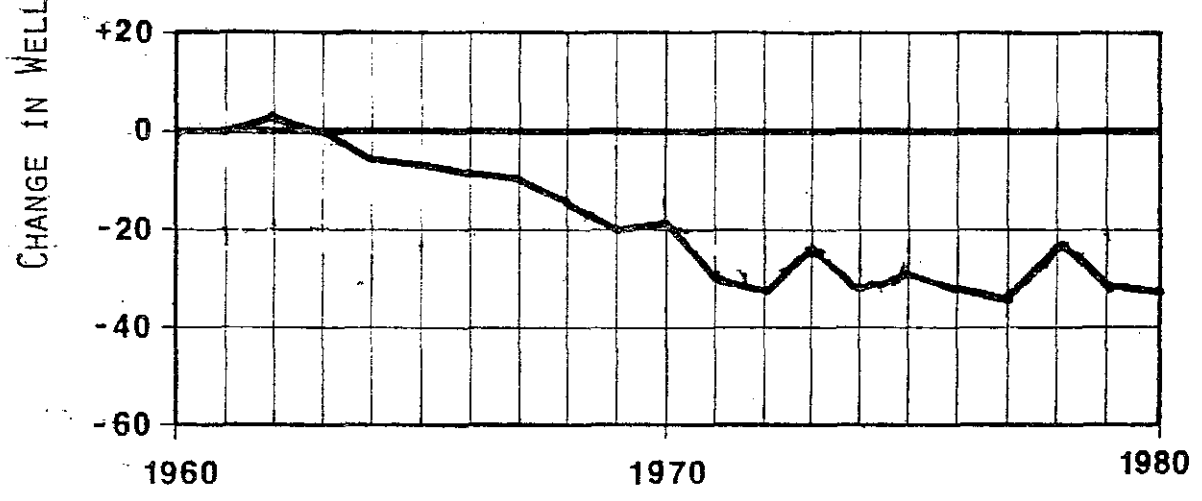
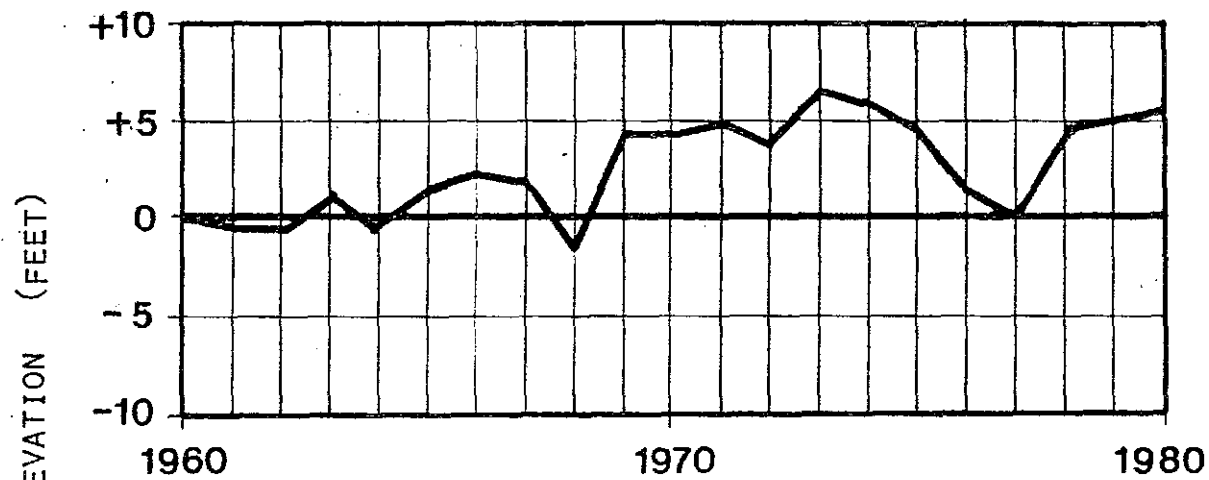


FIGURE 16

WATSON CREEK (ALLUVIUM)

16S/3E 17F2



CALERA CANYON (ALLUVIUM)

16S/2E 15P1

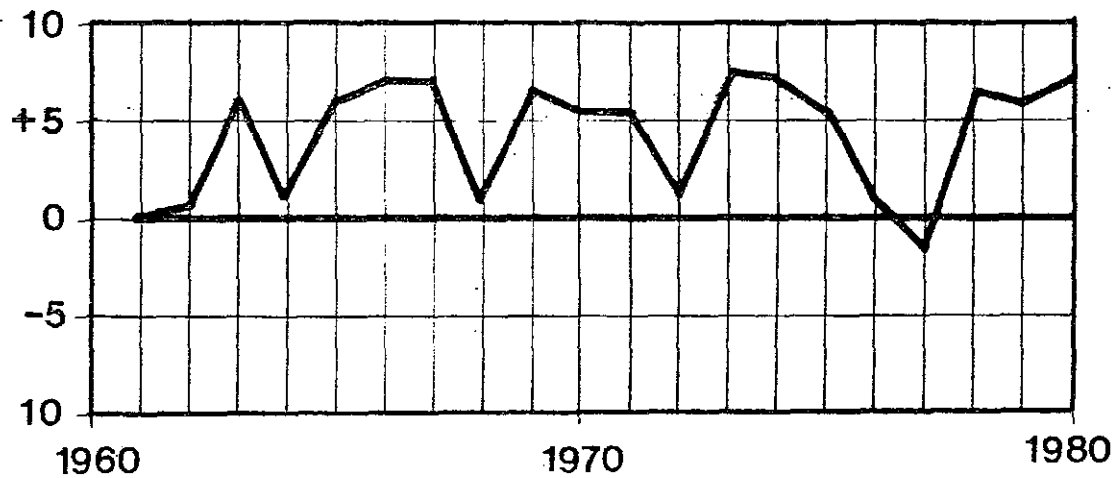


FIGURE 17

are instructive in explaining the drought and post-drought periods.

	<u>Period (Water Years)</u>	<u>Average Rainfall @ Salinas (inches)</u>
	1872/73 - 1979/80	13.6
Drought	1974/75 - 1976/77	9.3
	1977/78 - 1979/80	14.2
	1974/75 - 1979/80	11.9

These records show that in the six years since 1974, the average rainfall is below normal, indicating that the drought-induced rainfall deficit has not been equalled by the rainfall surplus since the drought's end. Wells tapping deep aquifers with large volumes of storage will require more surplus rainfall in order to attain their pre-drought water levels.

Any analysis of well water levels should account for the effects of the drought before concluding that dropping water levels are caused by an overdraft condition. The water level records gathered at 33 wells were studied for the period prior to the drought to assess recent trends in the water supply condition not induced by the drought. Of these 33 well records, 13 showed dropping water levels and 20 exhibited steady or increasing levels. The wells with dropping water levels are not concentrated in any particular portion of the area of study. A drop in water level (for example well 16S/2E 2G1 on Figure 16) can be caused by localized effects not connected with overall groundwater overdraft such as clogged well perforations, blocked well piping, and ^{low} transmissivity or poor recharge in the immediate area of the well. Some wells that have been cleaned, back flushed, or repaired have shown immediate increases in water levels.

only well pumping

✓
pumping

Water levels in monitored wells in El Toro have been lowered by the drought of the mid-1970's and have remained depressed due to insufficient rainfall since that time. Forty percent of the monitored wells showed drops in water levels before the drought but they are located near wells that have shown reliable water levels. Therefore, the trends in well water levels provide no conclusive evidence that an overdraft condition exists and, hence, support a determination that ample groundwater supplies are available in the El Toro area.

C. Future Supply Condition

Demands projected for saturated development (Section VIII) have been tabulated with groundwater storage and inflows (Table 8) to provide data for the following discussion of future groundwater quantity conditions. Figure 18 depicts the data in Table 8 in graphical form. Storage should be several times mean annual demand and mean annual inflows should equal or exceed mean annual demand to insure that a stable groundwater supply is available. At saturated development, mean annual inflows are at least two times greater than demands in each of the five subareas. The volume of storage is 50 times greater than demand at saturated development for all subareas except Calera Canyon where storage is three times demand. Therefore, the overall supply situation in each subarea at saturated development is adequate in terms of both groundwater inflows and storage.

Due to an uneven distribution of storage within each subarea, some locations may not possess a reliable on-site supply of groundwater. The bulk of the storage in the alluvium, Aromas-Paso Robles, and Santa Margarita

LOWER CORRAL DE TIERRA

STORAGE*	89,400 AC-FT
INFLOWS	2,323 AC-FT/YR
DEMAND	738 AC-FT/YR

WATSON C

STORAGE*
INFLOWS
DEMAND

CALERA

STORAGE
INFLOWS
DEMAND



EL TORO CREEK

AGE* 10,100 AC-FT
 FLOWS 2,339 AC-FT/YR
 AND 66 AC-FT/YR

GUANANCIO GULCH

AGE* 60,200 AC-FT
 FLOWS 1,063 AC-FT/YR
 AND 328 AC-FT/YR

K

700 AC-FT
 126 AC-FT/YR
 384 AC-FT/YR

ION

700 AC-FT
 126 AC-FT/YR
 219 AC-FT/YR

EL TORO AREA
 GROUNDWATER STUDY

GROUNDWATER QUANTITY
 EVALUATION AT
 SATURATED DEVELOPMENT

ANDERSON - NICHOLS & CO., INC.

Scale 1 in. = 4000 ft. figure 18

* STORAGE BASED ON THREE AQUIFERS ONLY
 (ALLUVIUM, PASO ROBLES AND SANTA
 MARGARITA SANDSTONE)

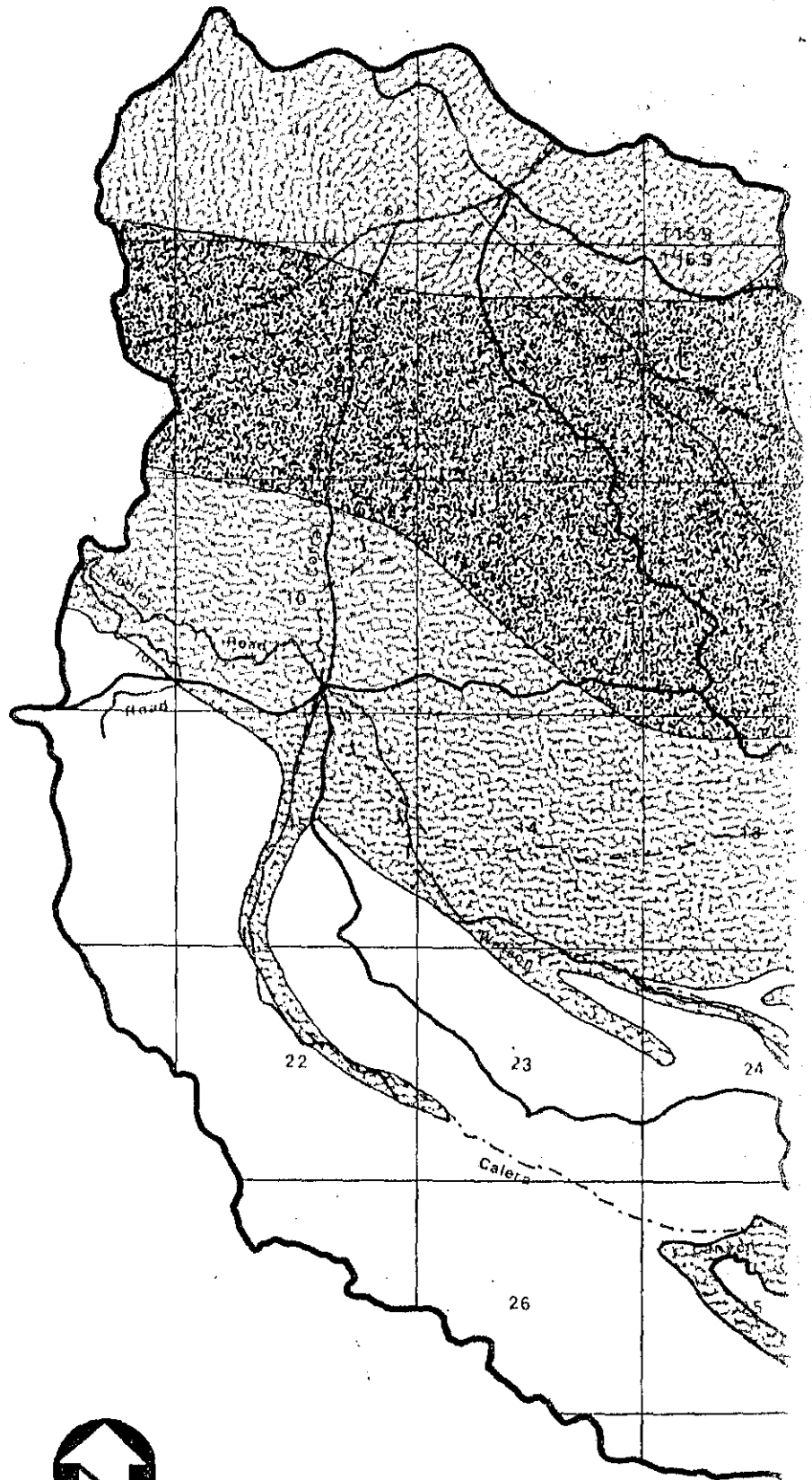
Sandstone aquifers ¹¹⁶ is located in the northwestern portion of the study area. Reference to the map of saturated thickness (Figure 14) will confirm that these three water sources thin out and disappear in the upper watershed of the El Toro Creek basin. In general, hydraulic conductivities in these water bearing units are sufficient to provide reasonable yields to wells, but yields may be inadequate due to locally low hydraulic conductivities or where the saturated thickness is thin. Wells that consistently pump the water source faster than it can be resupplied by inflowing groundwater will show localized reductions in the water table. Recharge of the alluvium, Aromas-Paso Robles, and Santa Margarita Sandstone is generally good where alluvium lies at the surface due to its high permeability and low slopes. The Paso Robles and Santa Margarita Sandstone outcrop in areas of higher slope with less ability to recharge, but since permeabilities are relatively good, moderate recharge is anticipated. The well logs indicate substantial amounts of clay in the Aromas-Paso Robles Formations which may hinder the recharge of the underlying Santa Margarita Sandstone in some locations.

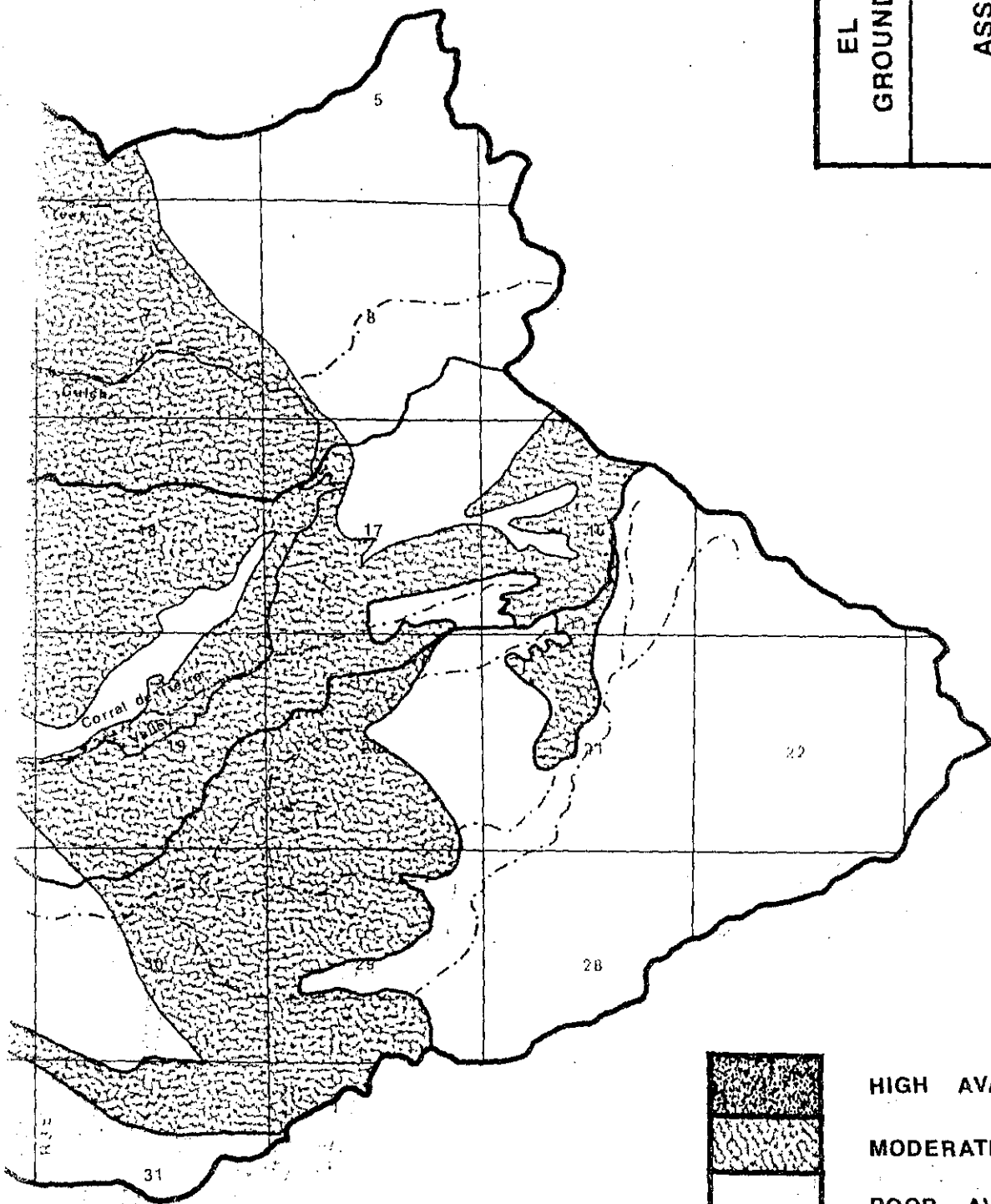
Dependable storage in substantial amounts appears likely in the Basal Sand Formation in areas in or near surface outcrops of this aquifer. Recharge of the Basal Sands appears uncertain in other areas due to the hindering of groundwater flow by the Monterey Shale Formation and/or by faults. Without adequate recharge, wells cannot depend on long term yields from the aquifers they are tapping. The region around the Basal Sand outcrops has provided significant quantities of water to the few wells presently located there. The artesian well (16S/2E 24J) is tapping the Basal Sands at a location between the Corral de Tierra fault and the Basal Sand outcrops and has flowed at close to 300 gpm for several years. Well yields in the Basal Sand

aquifer indicate that the movement of groundwater through the formation is sufficiently fast to provide adequate quantities of water.

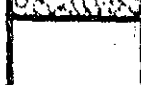
The availability of groundwater is generally poor at granite outcrops and at Monterey Shale outcrop areas not near Basal Sand outcrops. Water may be found in cracks in the granite, but the volume of this stored water is often limited. Recharge of the water found in the granite is not good, because water can readily enter the granite outcrop only through surface fissures which are often isolated from other cracks in the granite. Except for those areas near Basal Sand outcrops (discussed previously), outcrop areas of Monterey Shale are unlikely to provide usable quality water in sufficient quantities. These areas depend upon the Monterey Shale as their sole reliable source of groundwater since the underlying Basal Sand aquifer may not be sufficiently recharged to serve as a stable supply of water. Since in the Monterey Shale aquifer water quality is poor, recharge is poor, and extraction rates from the aquifer are usually low, the Monterey Shale is not a reliable domestic water source.

In summary, at a saturated level of development, overall groundwater inflows and storage are adequate to meet demands in each subarea. However, in certain areas, groundwater resources may not provide reliable water supplies. Figure 19 depicts our analysis of water availability within the study area based on the amount of good quality stored water that is readily recharged and extractable. The three separate designations used on Figure 19 to indicate our assessment of groundwater availability are as follows:





EL TORO AREA GROUNDWATER STUDY	
ASSESSMENT OF WATER AVAILABILITY	
ANDERSON - NICHOLS & CO., INC.	
Scale 1 in. = 4000 ft.	figure 19

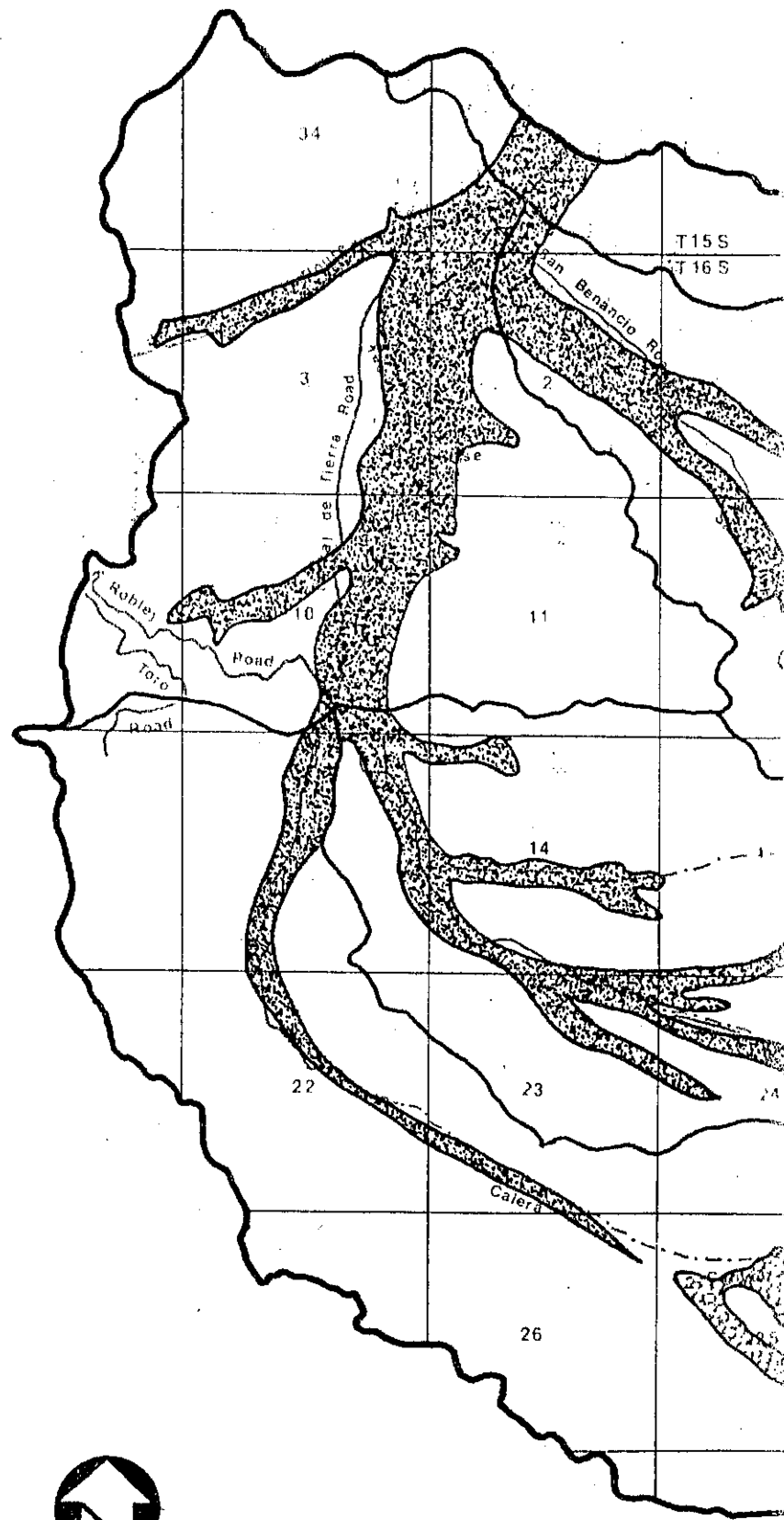
	HIGH AVAILABILITY
	MODERATE AVAILABILITY
	POOR AVAILABILITY

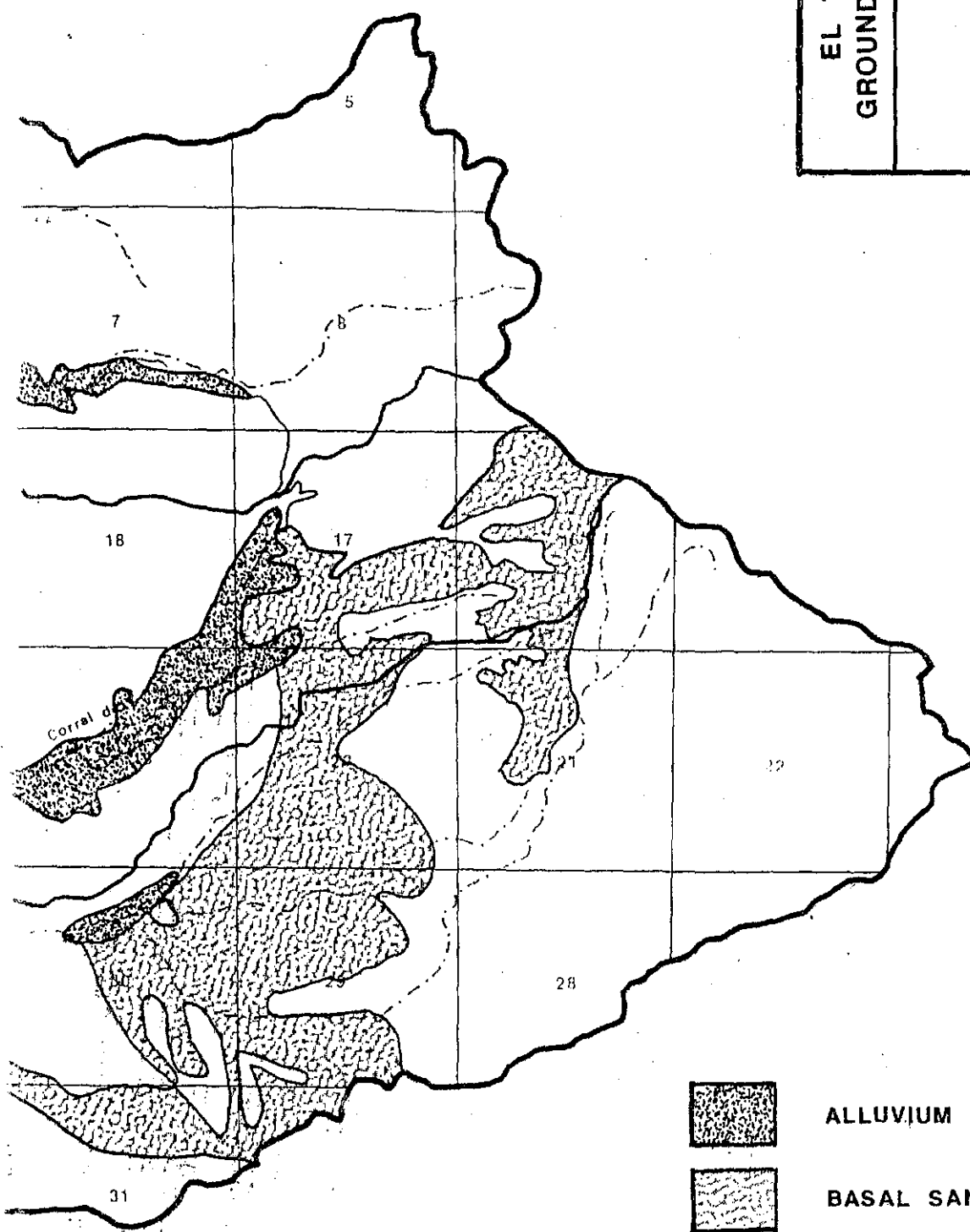
- 1) high availability - thickness of 600 - 1000 feet in the alluvium, Aromas-Paso Robles, and Santa Margarita Sandstone aquifers.
- 2) moderate availability - saturated thickness of 0 - 600 feet in the alluvium, Aromas-Paso Robles, and Santa Margarita Sandstone aquifers or areas where the Basal Sand aquifer appears to receive adequate recharge.
- 3) poor availability - all other parts of the study area including granite outcrops, Monterey Shale outcrops, and areas without proven sources of reliable groundwater supply.

The water availability zones shown on Figure 19 should be used as a general guide to the relative ability of various areas to supply sufficient quantities of water. Within our poor availability zone, a particular well site may find a reliable supply of water, but this occurrence is much less likely than in the zone of high availability.

D. Prime Recharge Areas

Protection of recharge zones is important to the maintenance of the current groundwater supply. Figure 20 indicates the prime recharge areas (designated as alluvium deposits or Basal Sand outcrops). The alluvium areas represent locations with permeable surface material at low slopes and therefore good areas for recharge. The Basal Sand areas shown in Figure 20 are the best sites for recharge of the Basal Sand aquifer. The Monterey Shale layer and tectonic faults appear to hinder the resupply of the Basal Sands in many areas, making recharge through surface outcrops crucial. The Basal Sand aquifer appears to be a potentially significant source of water in the upper portions of the El Toro watershed where other viable water sources are lacking.





EL TORO AREA
GROUNDWATER STUDY

PRIME RECHARGE MAP

ANDERSON - NICHOLS & CO., INC.

Scale 1 in. = 4000 ft. figure 20

Much of the prime recharge area shown on Figure 20 lies along stream valleys in some of the most suitable locations for development. Development of the prime recharge areas can be accomplished without reducing recharge by employing careful building practices. A sample list of some measures for protecting recharge follows⁽¹⁶⁾:

- 1) grading practices to maximize on-site retention of overland flow.
- 2) use of pervious pavement.
- 3) dutch drains, seepage basins, stormwater leachfields, and other systems that collect runoff from impervious areas and promote infiltration of water into the ground.

By employing these and other recharge protection measures, the prime recharge areas can be developed without reducing the groundwater supply.

X. GROUNDWATER QUALITY

A. Assessment of Current Water Quality

In general, the overall quality of groundwater within the study area is fair to poor. Total dissolved solids (TDS) range from 300 to 1500 milligrams per liter (mg/l), making some well water unusable for domestic purposes. Concentrations of sulfate, chloride, and nitrate vary from moderate to high, with a number of samples exceeding maximum recommended concentrations for domestic water supplies. Some wells in the area yield water with iron, manganese, and magnesium levels in excess of California state drinking water standards or criteria, and thus require treatment. In addition, high levels of lead, bicarbonate, hardness, color, odor, and turbidity have been identified in individual wells.

Table 9 provides a summary of the existing groundwater quality data for each subarea of the El Toro Basin. For each water quality parameter the total number of samples and the number of values which exceed the recommended level or standard for the parameter are tabulated. The data indicate quality problems in all areas of the El Toro Basin, although the problems appear more frequent in the Calera Canyon and Watson Creek subareas than in the San Benancio and Lower Corral de Tierra subareas.

The predominant influence on the existing chemical composition of groundwater in the El Toro area is the aquifer mineralogy, since the current low levels of development in the area preclude significant chemical loadings to groundwater from land use activities. Hence, the quality of groundwater extracted at a

Table 9. Summary of Water Quality Exceedences, By Subarea, Based on
Monterey County Flood Control and Health Department Data

Subarea

Constituent

	TDS, specific conductance		sulfate		chloride		nitrate		iron, manganese		magnesium		lead		bicarbonate		total hardness		color		turbidity	
	# of samples	# of samples > 1000 mg/l TDS > 1600 umhos/cm	# of samples	# of samples > 250 mg/l	# of samples	# of samples > 250 mg/l	# of samples	# of samples > 10 mg/l NO ₃ -N	# of samples	# of samples > 0.3 mg/l Fe 0.05 mg/l Mn	# of samples	# of samples > 50 mg/l	# of samples	# of samples > .05 mg/l	# of samples	# of samples > 150 mg/l CaCO ₃	# of samples	# of samples > 500 mg/l CaCO ₃	# of samples	# of samples > 15 color units	# of samples	# of samples > 5 t.u.
Calera Canyon	13	7	8	2	14	5	7	1	6	2	7	2	2	2	9	8	6	3	2	2	1	1
Watson Creek	42	17	22	4	40	2	28	0	17	15	18	0	9	1	18	17	13	4	8	2	9	4
San Benancio	63	0	18	0	61	0	35	0	11	7	17	0	10	1	21	9	8	1	9	2	9	3
Lower Corral de Tierra	73	6	20	0	73	18	38	2	7	2	17	0	6	1	22	16	6	0	2	1	2	0

particular point in the basin is largely determined by the mineral characteristics of the aquifer or aquifers through which the water has travelled. Isolated high chloride concentrations, for example, can be attributed to mineral leaching from marine deposits prevalent in the El Toro area.

As previously noted, wells have tapped five different aquifers in the study area - Alluvium, Paso Robles, Santa Margarita Sandstone, Monterey Shale, and Basal Sand. Considerable data are available from the Flood Control and Health Departments of Monterey County which can be used to characterize the water quality of the aquifers nearest to the surface (i.e. Alluvium and Paso Robles). However, characterization of the lower formations is difficult, because most wells deeper than 250 feet are perforated in more than one aquifer and therefore commingle the groundwater. In order to more clearly define the groundwater quality characteristics of the various aquifers, a supplemental program of water quality analysis was performed as part of this study. The primary goals of the program were twofold:

- (1) Characterize water quality in the lower aquifers (i.e. Santa Margarita Sandstone, Monterey Shale, Basal Sand).
- (2) Supplement already existing data on the general mineral characteristics of the upper aquifers with selected analyses of additional inorganic chemicals, general physical data, and organics.

The following procedures were used in selecting sample wells and determining the analyses to be performed on each well:

- (1) Well-driller's logs for wells in the study area were examined, and wells which were perforated in only one aquifer were identified.
- (2) Given the scarcity of quality data on the lower aquifers, all wells which solely perforated the Santa Margarita Sandstone, Monterey Shale,

or Basal Sand aquifers were selected for full analysis (general mineral, inorganic chemical, organic chemical, and general physical data).

- (3) In addition, on a subarea basis one well was selected which perforated each of the upper two aquifers. Whenever possible, wells were selected which had previously been analyzed for general mineral characteristics so that sampling costs could be held to a minimum.

Based on this selection process, 18 wells were chosen for sampling with the following breakdown by formation:

<u>Formation</u>	<u>Number of Sample Wells</u>
Alluvium	5
Paso Robles	2
Santa Margarita Sandstone	5
Monterey Shale	4
Basal Sand	<u>2</u>
total	18

Samples were collected from 12 of the 18 wells on July 23-24, 1981. Six of the original wells selected for analysis could not be sampled, because they had been capped, well pumps had been removed, or the wells could not be located. Unfortunately, 3 of the 4 wells which perforated Monterey Shale were no longer in operation, and consequently only one sample was taken from the shale aquifer. Likewise, it was only possible to take samples from 2 of the 5 wells which perforated Santa Margarita Sandstone.

The results of the supplemental groundwater analyses are presented in Table 10. Recommended maximum levels for parameters are provided in the last column of the table, and all measured values which exceed these levels are flagged with double asterisks (**). The following groundwater quality problems were identified in the well samples:

Inorganic chemicals - The values reported for concentrations of inorganic chemicals in Table 10 are generally below recommended levels. In some wells the values for lead are slightly above the recommended level (0.05 mg/l), and nitrate-nitrogen values for some alluvium wells are high, but nonetheless within the acceptable range.

General mineral - All wells in our sampling program which perforate one of the three lower aquifers (Basal Sand, Monterey Shale, Santa Margarita Sandstone) exceeded recommended levels for at least two, and up to five, different minerals. Generally speaking, high levels of bicarbonate, iron, manganese, and specific conductance were found. In addition, isolated problems with chloride and total hardness were identified. Mineral concentrations for the two Alluvium wells sampled were generally in the acceptable range.

General physical - Color and turbidity measurements for the lower three aquifers were generally higher than recommended levels, while odor was only a problem in one well. Color, odor, and turbidity measurements for Alluvium wells did not exceed recommended levels.

Organic chemicals - There was no indication of domestic/industrial organic pollution (gasoline, acetone, MEK, ethyl acetate, toluene, xylene) in the well samples. Analysis by gas chromatography yielded values of less than 1 part per million for all samples.

Table 10 Results of Supplemental Groundwater Quality Analyses in the El Toro Area¹

WELL ID	16S/3E 17M	16S/2E 24J1	16S/2E 8	16S/3E 7	16S/2E 10	15S/2E 34	RECOMMENDED
SUBAREA	WATSON CREEK	WATSON CREEK	near CALERA CANYON	SAN BENANCIO	WATSON CREEK	CORRAL DE TIERRA	MAXIMUM LEVEL
FORMATION	BASAL SAND	BASAL SAND	MONTEREY SHALE	SANTA MARGARITA SANDSTONE	SANTA MARGARITA SANDSTONE	PASO ROBLES	FOR DOMESTIC USE
INORGANIC CHEMICALS							
Arsenic	<0.004	<0.004	<0.04	<0.004	<0.004	<0.004	.05 *
Barium	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	1.0
Cadmium	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	.01
Chromium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	.05
Lead	0.07 **	0.04	0.06 **	0.04	0.05	0.05	.05 *
Mercury ²	<0.5	<0.5	0.75	0.58	0.57	0.74	5
Nitrate-N	0.13	<0.1	0.25	0.55	1.7	<0.1	10 *
Selenium	<0.05	<0.005	<0.005	<0.005	<0.005	<0.005	.01 *
Silver	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	.05
Fluoride	0.31	0.06	0.14	0.16	0.41	0.23	1.0 *
GENERAL MINERAL							
Bicarbonate ³	340 **	270 **	140	240 **	190 **		150
Carbonate ³	0	0	0	0	0		20
Hydroxide ³	0	0	0	0	0		
Calcium	160	120	180	100	75		200
Chloride	170	120	260 **	110	110		250 *
Copper	<0.02	<0.02	<0.02	<0.02	<0.02		1.0
Foamy agents	<0.2	<0.2	<0.2	<0.2	<0.2		
Iron	18 **	0.31 **	0.05	6.0 **	0.74 **		0.3 *
Magnesium	36	29	65 **	18	22		50
Manganese	1.2 **	0.25 **	0.03	0.41 **	<0.01		.05 *
pH	6.8	5.2	6.7	6.1	4.8		
Sodium	110	100	170	99	100		270
Sulfate	170	190	470 **	79	97		250 *
Specific Conduct ⁴	1700 **	1400	2100 **	1200	900		1600 *
TDS	1000	870	1400 **	720	570		1000 *
Total hardness ³	570 **	410	650 **	320	280		500
Zinc	1.8	0.02	0.12	1.2	0.05		5.0 *
GENERAL PHYSICAL							
Color ⁵	600 **	15	20 **	200 **	40 **		15
Odor ⁶	1.4	no odor	19 **	no odor	1.4		3
Turbidity ⁷	180 **	5.5 **	3.3	72 **	10 **		5
ORGANICS							
Contaminants	<1	<1	<1	<1	<1	<1	

1. Units are mg/l unless otherwise noted.

2. Units are µg/l.

3. Units are mg CaCO₃/l.

4. Units are µmhos/cm.

5. Units are color units.

6. Units are T.O.N.

7. Units are turbidity units.

* denotes California Health and Safety Code Primary and Secondary Drinking Water Standard. All values in this column which are not followed by an asterisk are recommended levels from California State Water Quality Criteria (18).

** denotes violation of standard or recommended level.

Table 10 Results of Supplemental Groundwater Quality Analyses in the El Toro Area (continued)¹

WELL ID	16S/2E 1M1	16S/2E 1	16S/3E 17	16S/3E 17F2	16S/2E 15P1	16S/2E 10Q2	RECOMMENDED
SUBAREA	SAN BENANCIO	SAN BENANCIO	WATSON CREEK	WATSON CREEK	CALERA CANYON	CORRAL DE TIERRA	MAXIMUM LEVEL
FORMATION	PASO ROBLES	ALLUVIUM	ALLUVIUM	ALLUVIUM	ALLUVIUM	ALLUVIUM	FOR DOMESTIC USE
INORGANIC CHEMICALS							
Arsenic	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	.05 *
Barium	< 0.1	0.1	< 0.1	< 0.1	0.17	< 0.1	1.0
Cadmium	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	.01
Chromium	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	.05
Lead	< 0.03	< 0.03	< 0.03	< 0.03	0.06 **	0.06 **	.05 *
Mercury ²	< 0.5	1.8	< 0.5	0.91	1.5	< 0.5	5
Nitrate-N	2.4	7.2	5.4	5.0	0.33	0.33	10 *
Selenium	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	.01 *
Silver	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	.05
Fluoride	0.37	0.36	0.63	0.80	0.41	0.50	1.0 *
GENERAL MINERAL							
Bicarbonate ³		110	180 **				150
Carbonate ³		0	0				20
Hydroxide ³		0	0				
Calcium		42	48				200
Chloride		120	35				250 *
Copper		< 0.02	< 0.02				1.0
Foamy agents		< 0.2	0.2				0.3 *
Iron		0.18	< 0.02				50
Magnesium		20	11				.05 *
Manganese		0.03	< 0.01				
pH		6.4	7.4				
Sodium		99	44				270
Sulfate		94	6.1				250 *
Specific Conduct ⁴		840	510				1600 *
TDS		540	310				1000 *
Total hardness ³		180	160				500
Zinc		0.08	0.05				5.0 *
GENERAL PHYSICAL							
Color ⁵		15	0 .				15
Odor ⁶		1.4	no odor				3
Turbidity ⁷		2.5	2				5
ORGANICS							
Contaminants	<1	<1	<1	<1	<1	<1	

1. Units are mg/l unless otherwise noted.

2. Units are µg/l.

3. Units are mg CaCO₃/l.

4. Units are µmhos/cm.

5. Units are color units.

6. Units are T.O.N.

7. Units are turbidity units.

* denotes California Health and Safety Code Primary and Secondary Drinking Water Standard. All values in this column which are not followed by an asterisk are recommended levels from California Water Quality Criteria (18).

** denotes violation of standard or recommended level.

Data for selected water quality parameters (specific conductance, chloride, and nitrate-nitrogen) were extracted from Table 10 and combined with data from the Flood Control District to produce Table 11. Table 11 summarizes the range of values for electroconductivity, chloride, and nitrate-nitrogen recorded for groundwater taken from wells which are perforated in only one of the five aquifers. It should be noted that some inaccuracies may result from commingling of waters from several aquifers in the zone of gravel packing of individual wells; nonetheless this well data provides the best information available for characterizing the individual aquifers. Several conclusions can be drawn from Table 11:

- (1) Groundwater from the Alluvium and Paso Robles aquifers exhibits a good deal of variability in electroconductivity, chloride, and nitrate-nitrogen concentrations. Both the highest and the lowest values for all three parameters were recorded in the Alluvium and Paso Robles. While a number of wells tapping these aquifers exceed recommended levels for electroconductivity and chloride, violations of the nitrate-nitrogen standard are not frequent.
- (2) Based on the limited data for the Santa Margarita Sandstone aquifer, chloride and nitrate-nitrogen concentrations are currently not a problem in this formation. Values for specific conductance (electroconductivity) for the two wells sampled are high, but do not exceed recommended limits.
- (3) The scarcity of wells currently tapping the Monterey Shale formation and the widespread capping and abandonment of wells previously drilled into the formation testify to the poor quality of water in the shale aquifer. Tables 10 and 11 indicate excessive values for specific conductance, chloride, hardness, sulfate, magnesium, lead, color, and

Table 11. Summary of Electroconductivity, Chloride, and Nitrate
Values for Wells Which Perforate Only One Formation *

FORMATION / WELL ID	subarea**	Electroconductivity (EC)		Chloride (Cl)		Nitrate (NO ₃ -N)	
		# samples	range (ppm)	# samples	range (ppm)	# samples	range (ppm)
<u>Alluvium</u>							
16S/2E - 15P1	CC	6	1260 - 2250	6	206 - 306	4	0.3 - 5.0
16S/2E - 10Q2	WC	5	1530 - 1950	5	230 - 274	3	0.3 - 1.7
16S/2E - 15J1	WC	6	1280 - 1845	6	194 - 210	3	2.2 - 2.8
16S/3E - 17F	WC	1	510	1	35	1	5.4
16S/3E - 17F2	WC	6	430 - 660	6	34 - 50	1	5.0
16S/2E - 10Q1	CT	7	660 - 1105	7	90 - 40	3	1.6 - 3.2
16S/2E - 2P1	CT	4	780 - 1035	4	148 - 154	2	0.5 - 0.6
16S/2E - 1	SB	1	840	1	120	1	7.2
Total		36	430 - 2250	36	34 - 306	18	0.3 - 7.2
<u>Paso Robles</u>							
16S/2E - 1L1	SB	5	440 - 750	5	94 - 140	2	2.5 - 2.8
16S/2E - 1M1	SB	6	500 - 750	6	126 - 156	4	1.5 - 4.7
16S/2E - 2G1	SB	7	500 - 730	7	130 - 142	3	0.7 - 1.2
16S/3E - 7N1	SB	4	610 - 670	4	78 - 98	2	8.1 - 9.1
16S/2E - 3G1	CT	7	940 - 1300	7	310 - 326	3	1.4 - 1.6
16S/2E - 3K1	CT	2	1090 - 1140	2	272 - 232	2	1.8 - 1.9
16S/2E - 4H1	CT	7	1240 - 1700	7	398 - 432	3	2.5 - 2.8
16S/2E - 10B1	CT	4	620 - 920	4	24 - 110	2	1.0 - 1.1
16S/2E - 10H1	CT	6	890 - 1570	6	170 - 258	2	11.2 - 16.9
16S/2E - 34	CT					1	0.1
Total		48	440 - 1700	48	24 - 432	24	0.1 - 16.9
<u>Santa Margarita Sandstone</u>							
16S/2E - 10	WC	1	1200	1	110	1	1.7
16S/3E - 7	SB	1	900	1	110	1	0.6
Total		2	900 - 1200	2	110	2	0.6 - 1.7
<u>Monterey Shale</u>							
16S/2E - 8	CC	1	2100	1	260	1	0.3
<u>Basal Sand</u>							
16S/2E - 24J1	WC	4	1120 - 1400	4	120 - 144	4	0.1 - 1.0
16S/3E - 17M	WC	1	1700	1	170	1	0.1
Total		5	1120 - 1700	5	120 - 170	5	0.1 - 1.0

* This table is a summary of data compiled by County Flood Control, County Health Department, and Anderson-Nichols.

** CT = Lower Corral de Tierra; SB = San Benancio; WC = Watson Creek; CC = Calera Canyon.

odor. Water from this formation does not appear suitable for domestic water supply.

- (4) Table 11 suggests that the quality characteristics of Basal Sand groundwater are somewhat similar to those of the Santa Margarita Sandstone. While chloride and nitrate-nitrogen concentrations are currently not a problem, specific conductance values are high. Of the two wells tapping Basal Sand, one well exceeds recommended limits for specific conductance, and one does not. Data for other quality parameters (Table 10) suggest that groundwater from at least one well (16S/2E-24J1) tapping the Basal Sand aquifer is suited for use as a domestic water supply; however, treatment to reduce concentrations of iron and manganese may be required.

Summary information concerning the quality of groundwater in the five aquifers of the El Toro area is contained in Table 12. The table integrates the data gathered by the Health Department and Flood Control District of Monterey County with the supplemental data from Anderson-Nichols' sampling program. The data is presented in the form of a matrix which identifies the occurrence of exceedences of recommended levels for each of 12 parameters within each of the five aquifers.

As an aid to understanding the significance of the exceedences indicated in Table 12, a brief description of the possible impacts of each of the parameters included in the table was extracted from the California State Water Resources Control Board Water Quality Criteria and included below.

Table 12. Summary of Water Quality Exceedences for Water Bearing Formations in the El Toro Area*

<u>Formation</u>	<u>Constituent</u>											
	<u>TDS, speci- fic conduc- tance</u>	<u>sulfate</u>	<u>chloride</u>	<u>nitrate</u>	<u>iron, manganese</u>	<u>magnesium</u>	<u>lead</u>	<u>bicar- bonate</u>	<u>total hardness</u>	<u>color</u>	<u>odor</u>	<u>turbidity</u>
Alluvium	X	X	X		X		X	X				
Paso Robles	X	X	X	X								
Santa Margarita	X	X	X		X			X		X		X
Monterey Shale	X	X	X			X	X		X	X	X	
Basal Sand	X				X		X	X	X	X		X

* X denotes one or more recorded exceedences of California Health and Safety Code Primary and Secondary Drinking Water Standards (for sulfate, chloride, nitrate, iron, manganese, and lead) or recommended levels from California State Water Quality Criteria (for TDS, magnesium, bicarbonate, hardness, color, odor, and turbidity). Maximum acceptable levels are indicated in the last column of Table 9.

Total Dissolved Solids

The TDS standard was set primarily on the basis of taste. Many communities in the United States and in other countries use water containing from 2000 to 4000 mg/l of dissolved salts when no better water is available. Such waters are not palatable, may not quench thirst, and may have laxative action on new users. However, no harmful physiological effects of a permanent nature have been identified.

Sulfate

Public and private water supplies with sulfate concentrations above the 250 mg/l standard are commonly and constantly used without adverse effects. A dose of 1.0 to 2.0 grams, or a liter of water containing 1000 to 2000 mg/l of sulfates, acts as a laxative.

Chlorides

Restrictions on chloride concentrations in drinking water are generally based on palatability requirements rather than on health. The tolerance of chlorides by human beings varies with climate and exertion, and chlorides lost through perspiration may be replaced by chlorides in drinking water. Concentrations up to almost 900 mg/l have not been harmful in hot dry areas.

Nitrate

The recommended limit for nitrate-nitrogen in domestic water supplies was established to lessen the risk of developing methhemoglobinemia in infants. This disease is caused by nitrate reacting with hemoglobin and reducing

the associated oxygen carrying capacity of the blood. Many well waters containing over 500 mg/l of nitrate-nitrogen have never been linked with the disease. Most cases, however, have been associated with the use of water containing 50 mg/l or more of nitrate-nitrogen. While it is still impossible to state precise concentration limits, it has been widely recommended that water containing more than 10 mg/l of nitrate-nitrogen should not be used for infants.

Manganese

Limits for manganese have been established on the basis of aesthetic and economic considerations rather than physiological hazards. Manganese is undesirable in domestic water supplies because it causes unpleasant tastes, deposits on food during cooking, stains and discolors laundry and plumbing fixtures, and fosters the growth of microorganisms.

Iron

The limit for iron is also based on aesthetic and taste considerations. Iron and manganese tend to precipitate as hydroxides and stain laundry and porcelain fixtures.

Magnesium

Magnesium is considered relatively non-toxic to man and not a public health hazard because, before toxic concentrations are reached in water, the taste becomes quite unpleasant. At high concentrations, magnesium salts have a laxative effect. While several groundwater samples in the El Toro area exceed the 1958 WHO International Standards "permissible limit" of 50 mg/l,

the magnesium concentrations in the area should not cause adverse health effects.

Lead

Lead may enter the body through food, air, and tobacco smoke as well as from water and other beverages. The intake that can be regarded as safe for everyone cannot be stated definitely, because the sensitivity of individuals to lead differs considerably. Lead poisoning among human beings is reported to have been caused by drinking water containing lead in concentrations varying from 0.042 to 1.0 mg/l or more. On the other hand, other data suggest that concentrations of up to 0.16 mg/l have been non-poisonous over long periods of time.

Bicarbonate

Other than the fact that excessive bicarbonates add to the salinity and total solids content of water, and tend to form carbonates and scale, bicarbonates in water are seldom considered to be detrimental.

Hardness

Hard waters have had no demonstrable harmful effects upon the health of consumers. The recommended limit for hardness is intended to eliminate problems with waste of soap and encrustations of utensils and plumbing.

Color

Color problems are most likely attributable to iron and manganese compounds. Color, of course, does not cause health problems per se.

Odor

Odor problems in El Toro groundwater are most likely attributable to high concentrations of sulfur compounds. While odor may be an indicator of the presence of potentially harmful substances, it is not apparent that this is the case in the study area.

Turbidity

Turbidity in itself is not harmful to humans, but may be an indicator of harmful substances. In the case of groundwater, high turbidity is most likely attributable to high concentrations of mineral compounds. Iron, manganese, and magnesium compounds are most likely responsible for high levels of turbidity in some El Toro well water.

In summary, the majority of groundwater quality problems in the El Toro area do not seriously affect health in the chemical concentrations currently experienced. At most, chronic problems with diarrhea, nausea, or inability to quench thirst could result from water from some of the inferior wells. As indicated by the descriptions of individual parameter impacts, issues of taste, aesthetics, and economics (as well as compliance with state law) are of greater concern given the characteristics of groundwater in the El Toro area.

B. Potential for Future Groundwater Quality Problems

The purpose of this section is to assess the potential for groundwater contamination by chemical loadings from land use activities in the El Toro basin. Given that current and projected land use for the basin include very little agricultural or commercial activity, the major potential for groundwater

contamination is related to domestic activity. The groundwater characteristics most affected by domestic activity are the concentrations of potassium, sulfate, and nitrate. High concentrations of potassium and sulfate have a laxative effect on users, while nitrate in drinking water can cause methemoglobinemia in infants. As a screening technique to identify potential contamination from these chemicals in the El Toro aquifer, the equilibrium (long-term) groundwater concentration of each chemical which would result from domestic loadings from saturated development of the entire basin was calculated based on an estimated saturation population of 15,381 people and a total annual recharge (gross recharge + return flows) of 7411 acre-feet. We have assumed that the equilibrium pollutant concentration in groundwater can be estimated by dividing the annual pollutant loading from all significant sources by the annual recharge and returned water. The results are tabulated below:

<u>chemical</u>	<u>per capita loading rate (lbs/year)</u>	<u>resultant equilibrium conc. (mg/l)</u>	<u>maximum acceptable conc. (mg/l)</u>
potassium	1.2	0.9	1000
sulfate	4.6	3.5	250
nitrate (as N)	8.1	6.2	10

Comparison of the last two columns of the above table indicates that only nitrate loadings present a possible contamination threat to the El Toro aquifer on a basin-wide scale.

Naturally occurring concentrations of potassium (1.8 - 10.0 mg/l) and sulfate (9.0 - 470 mg/l) within El Toro groundwater range from comparable to significantly higher values than those which would result from chemical loadings from domestic activities under saturated development conditions. Likewise, naturally occurring

levels of total dissolved solids are quite high and should remain relatively unaffected by domestic loadings. Preliminary calculations suggest, however, that domestic loadings of nitrate-nitrogen could result in groundwater nitrate concentrations of the same order of magnitude as the U.S. EPA standard of 10 mg/l.

In order to further assess the potential for groundwater contamination by nitrogen, we have calculated the equilibrium concentration for nitrate-nitrogen under current development conditions in each subarea of the El Toro basin, and the results are presented in Table 13. For the upstream areas of the El Toro basin (Calera Canyon, Watson Creek, San Benancio) the net equilibrium concentration is the same as the equilibrium concentration for local recharge. However, the downstream areas (Corral de Tierra and El Toro Creek) receive groundwater inflows from up-gradient areas, and consequently net equilibrium concentrations for these areas are calculated as a weighted average of local recharge concentrations and groundwater inflow concentrations. The analysis was performed based on the following assumptions:

- a. Total recharge is derived from local percolation, groundwater inflows, and return flows from domestic irrigation and wastewater.
- b. Domestic water usage (nonirrigation) is estimated as 75 gallons per person per day, 80% of which results in recharge (i.e. 20% consumptive use).
- c. Domestic irrigation water use is estimated as 75 gallons per person per day, 20% of which results in recharge (i.e. 80% consumptive use).
- d. An estimate of 40 mg/l $\text{NO}_3\text{-N}$ was assumed for the nitrogen content of septic tank effluents. This estimate is based on the typical

nitrogen content of domestic sewage⁽¹⁷⁾.

- e. Nitrogen content of nondomestic recharge is estimated as 1.5 mg/l based on general data provided by Loehr⁽¹⁸⁾. Thus, return flows from the irrigation of the golf course and from domestic irrigation are assumed to contain 1.5 mg/l nitrogen.
- f. Net equilibrium concentrations are estimated assuming a 2000 acre-foot/year outflow from Lower Corral de Tierra to Laguna Seca.

Table 13: Equilibrium Concentrations of $\text{NO}_3\text{-N}$ Based on Current Development Conditions

<u>Area</u>	<u>Equilibrium Concentration of Local Recharge (mg/l)</u>	<u>Net Equilibrium Concentration (mg/l)</u>
Calera Canyon	1.7	1.7
Watson Creek	2.5	2.5
San Benancio	4.0	4.0
Corral de Tierra	4.3	2.7
El Toro Creek	3.2	3.1
Total	2.6	-

The results reported in Table 13 indicate that nitrogen loadings from current land use in the El Toro area do not pose a serious threat to groundwater contamination on an area-wide basis. At present, naturally high concentrations of total dissolved solids, sulfates, iron, and manganese are more detrimental to groundwater quality than are loadings from land use activities.

Using the same methodology developed for the calculation of current equilibrium concentrations, it is possible to estimate the equilibrium nitrate-nitrogen concentration at saturation population for each subarea (Table 14). As before, the net equilibrium concentrations in the Corral de Tierra and El Toro Creek subareas are calculated as weighted averages of local recharge concentrations and groundwater inflow concentrations from up-gradient areas.

Table 14. Equilibrium $\text{NO}_3\text{-N}$ Concentrations at Saturated Development

Subarea	Saturation Population	Equilibrium $\text{NO}_3\text{-N}$ Concentration (mg/l)
Calera Canyon	2605	3.5
Watson Creek	4576	9.4
San Benancio Gulch	3908	8.8
Lower Corral de Tierra	3507	7.3
El Toro Creek	785	7.8

Note: Federal and California State Drinking Water Standard for $\text{NO}_3\text{-N}$ is 10 mg/l.

Calculated equilibrium concentrations range from 3.5 mg/l $\text{NO}_3\text{-N}$ in Calera Canyon to 9.4 mg/l in the Watson Creek subarea. While calculated values for all subareas are below the EPA $\text{NO}_3\text{-N}$ standard, the values are close to unacceptable levels and should not be misinterpreted as an indication that full development can occur without water quality problems. Equilibrium calculations can only be used to determine a rough estimate of maximum acceptable density of development. If calculated equilibrium concentrations for an area exceed acceptable levels, the population density is too large for unsewered development. On the other hand, the fact that calculated equilibrium concentrations are less than acceptable levels does not indicate that projected development can occur without localized water

quality problems. It must be remembered that the equilibrium calculations are based on complete mixing of recharge and pollutant loadings. While such a calculation is a reasonable approximation of long term trends, the localized chemical concentrations near the source of pollution (i.e., septic leach fields) will always be higher than those farther away. Areas where pollutants are concentrated due to dense development and areas where pollutant dilution is hindered by flow through materials with low hydraulic conductivity will be prone to higher pollutant concentrations. In order to assess the potential for localized water quality problems, consideration must be given to the nature of septic leachates, the vertical and horizontal movement of leachates which dilutes and disperses the pollutants, and degradation and removal processes which further reduce potential concentrations.

Leachate characterization - Onsite wastewater treatment in the El Toro area begins with primary treatment in the septic tank. Within the septic tank, scum and settleable solids are removed and partial decomposition of organics is performed. Septic tank effluent is then discharged to an absorption field. Generally speaking, the modified wastewater, or septage, applied to the absorption field contains concentrations of organic and inorganic chemicals and microorganisms which could potentially cause serious contamination of groundwater. When the tank effluent reaches the absorption field it is characterized by a variable load of bacteria and viruses and the following average pollutant concentrations (17):

BOD ₅	150 mg/l
Suspended Solids	50-100 mg/l
Total Nitrogen	40 mg/l
Total Phosphorus	20 mg/l

Movement of leachate - Wastewater leaching from the absorption field moves essentially downward after entering unsaturated soil. Horizontal movement in the unsaturated zone is negligible⁽¹⁹⁾. Once the wastewater reaches the zone of groundwater saturation, it takes the form of a ribbon-like plume and moves with the prevailing groundwater flow. In its travel, the waste plume is vertically depressed by rainwater recharge. The movement, dispersion, and dilution of the waste plume is dependent on the groundwater flow characteristics of the aquifer into which the wastewater migrates. Consequently, the areal extent of groundwater pollution from one or more leach fields is determined by the characteristics of both the unsaturated zone, which is responsible for significant cleansing of the leachate, and the saturated zone, which determines the ultimate dispersal of chemicals.

Removal/degradation of pollutants - Whether or not pollutants moving from an absorption field through the soil reach the groundwater and subsequently a water supply depends to a large extent on the type of subsurface material present and the thickness. The geology of the El Toro area is generally well-suited for protection of the groundwater supply. The types of rock (fractured, fissured, cavernous, or coarse) which transmit pollutants great distances are not common. Instead, large portions of the watershed are characterized by sands, sandy-clay, and consolidated sandstones which provide a suitable environment for the three major processes necessary to retard or control the movement of pollutants - filtration, adsorption, and microbial degradation. Research has shown that most of the known contaminants in septic tank effluent can be removed by movement through a few feet of soil under proper conditions⁽²⁰⁾. The amount of soil required is dependent on the particular contaminant; the pH, moisture, temperature, and oxidation-reduction potential of the soil; the size, shape, and interstitial voids of the soil; and the velocity of flow through the voids. Most physical and

bio-degradable impurities have usually disappeared after a vertical infiltration of 8 to 12 feet, while chemical pollutants and viruses are more persistent and can be detected down to 25 to 30 feet of depth⁽²⁰⁾.

Some chemicals, such as chlorides and nitrates, are essentially unaffected by movement through most soils. Most nitrogen from septic tank effluents occurs in the organic and ammonia forms which are readily adsorbed to soil particles within short distances. However, under favorable moisture, temperature, and oxygen conditions such as generally occur in well-drained soils, soil bacteria oxidize the nitrogen compounds to highly mobile nitrates which have penetrated hundreds of feet in some aquifers in other areas of the United States. Thus, the potential zone of nitrate contamination surrounding a leach field is considerably larger than that for other contaminants.

Protection of well water - The two factors which are most important in preventing pollution of a well in the vicinity of a seepage absorption field are the depth of the well and the type of soil. Fine grained and fine pored soils (silt and clay) offer much superior elimination of pollutants as compared to sand and gravel. In the U.S. Commission on Rural Water publication Wastewater Treatment Systems for Rural Communities, Bernhart⁽²¹⁾ calculated horizontal protective distances between seepage beds and neighboring wells based on depth and soils type. His results, which are contained in Table 15, illustrate the fact that the largest horizontal protective distances are required for shallow wells in coarse grained sandy soils, while much shorter protective distances are necessary for deep wells and/or fine grained soils. For example, Bernhart recommends a distance of 480 feet between a 40-foot deep well and the nearest seepage bed in sandy soil; however, according to his calculations, only one fourth as much separation (120 feet) is necessary if the well is 100 feet deep instead of 40 feet deep. Likewise, if the

Table 15. Horizontal protective distances. Recommended distance, in feet, measured from water supply well to nearest limit of seepage bed.*

Type Of Soil	Percolation Time (t in min.)	Seepage Rate anaerobic (g/sq. ft)	Depth Of Well (feet)					
			40	60	80	100	120	140
Sand	5	0.45	480	260	170	120	90	75
Fine Sand	10	0.37	430	235	150	110	85	66
Fine Sand	15	0.29	380	210	135	100	75	60
Silt	20	0.24	350	190	125	90	65	55
Silt	30	0.17	295	160	105	75	55	45
Loam	45	0.10	225	120	80	60	45	35
Loam	60	0.06	175	95	60	45	35	30
Clay	90	0.04	140	80	50	35	30	20

*from "A Rational Approach to Determining Sizes Of Building Lots According to Their Capabilities For On-site Wastewater Treatment And Disposal," Wastewater Treatment Systems For Rural Communities, 1973.

soils are clay rather than sand, the required horizontal distance for the 40-foot deep well reduces by a factor of more than three (140 ft. versus 480 ft).

While Bernhart's guidelines offer reasonable assurance that well waters will not be polluted by most contaminants associated with septage, they are to a large extent inappropriate for consideration of nitrate. Given the fact that nitrate is largely unaffected by most biological/chemical processes which occur in soil, significant removal of nitrate does not occur below the root zone, where a small amount of plant uptake takes place. Hence, ultimate contamination by nitrate can occur regardless of well depth or soil type. At best, development of guidelines for lot sizes based on wastewater disposal requirements is a difficult and inexact science, and at present there are no guidelines that are widely accepted. In the Environmental Protection Agency report Environmental Effects of Septic Tank Systems⁽²⁰⁾, the reason for the current lack of guidelines is summarized as follows:

Satisfactory resolution of most of the questions regarding the effects of septic tank systems on ground-water quality is ultimately dependent on the development of a better understanding of the movement and fate in the subsurface of leachates generated by such systems. For example, definitive information concerning the movement and fate of pollutants in both unsaturated and saturated subsurface environments, were information available, would comprise the firm scientific basis needed for resolution of most of the disagreements which underlie the wide variation in existing codes and regulations presently governing the utilization and construction of septic tank systems. Considerable research, therefore, has been and continues to be directed toward the development of such information.

One aspect of current research on movement and fate of pollutants is concerned with the development of guidelines for allowable densities of septic tank systems for various geological and climatic conditions. Guidelines are urgently needed in order that utilization of septic systems can be logically controlled in situations where local or regional ground-water pollution problems may result from their intensive use. Such work was instigated at the request of and partially funded by the Office of Water and Hazardous Materials. It mainly entails the development of definitive, quantitative information concerning the movement in various soil types of chemicals and microorganisms, including various nitrogen forms, phosphate, sulfate, chloride, coliform organisms, viruses, and organics known to be constituents of septic tank leachate. Although considerable information concerning the movement and fate of most of these pollutants has been provided by many previous studies of septic tank systems, this information has not been sufficiently definitive nor quantitative to provide a basis for density criteria. This reflects inherent difficulties in conducting studies of the movement and fate of pollutants in subsurface environments. Field investigations have suffered because of sampling problems and difficulty in controlling experimental conditions, while laboratory studies have usually utilized packed columns of dried, sieved soils which bear little resemblance physically or biologically to natural soil profiles.

While an acceptable methodology for determining minimum lot sizes necessary to protect well water in various localities within the El Toro area is not available, adherence to the provisions of the recently revised Monterey County septic tank systems ordinance⁽²²⁾ should provide reasonable local protection from well contamination. The regulations contained in this ordinance were compared with guidelines outlined in the EPA Design Manual for Onsite Wastewater Treatment and Disposal

Systems⁽¹⁷⁾, and the provisions of the county ordinance were found to be comprehensive and compatible with current understanding of wastewater treatment by septic systems. Nonetheless, we believe that some areas of El Toro area will be prone to localized quality problems. Based on earlier discussions of the nature of septic leachates, the movement of leachates, and the removal processes which purify leachates, the following general statements can be made concerning the likelihood of localized water quality problems caused by domestic wastewater in the study area:

1. The unconsolidated materials of the Alluvium and Basal Sand Formations, while providing considerable purification of wastewater, are characterized by high percolation rates, and consequently a longer path of flow is required for complete purification. In areas where shallow wells are present, there is a likelihood of localized pollution by contaminants that would be removed by filtration, adsorption, or microbial degradation if time and distance allowed.
2. Areas of the El Toro watershed where surface materials are part of the Paso Robles or Santa Margarita Formations are well suited for wastewater treatment by septic systems and should not result in groundwater contamination. The finer, more consolidated, materials of these formations offer intermediate percolation rates and good contaminant removal.
3. Areas where outcroppings of shale or granite dominate have significant problems with percolation rates and assimilative capacity. The low permeability of these formations prevents movement of the effluent away from the leach fields and can cause failure of the leaching process due to saturation of the surrounding soil with effluent. Due to both local pooling of effluent and the high surface slopes which are common in these outcrops, surfacing of effluents down-slope may occur. What little percolation does occur in the granite and shale will pass essentially

untreated through fissures in the rock, and consequently nearby wells which draw water from these formations could be contaminated.

Thus it is clear that, although overall water quality issues do not prevent full development of the El Toro area, localized water quality problems will result if development does not take local hydrogeological conditions into account. In the following section (Section XI) water quality and quantity considerations are combined in order to define the water supply adequacy of various parts of the El Toro area.

XI. GROUNDWATER SUPPLY ADEQUACY

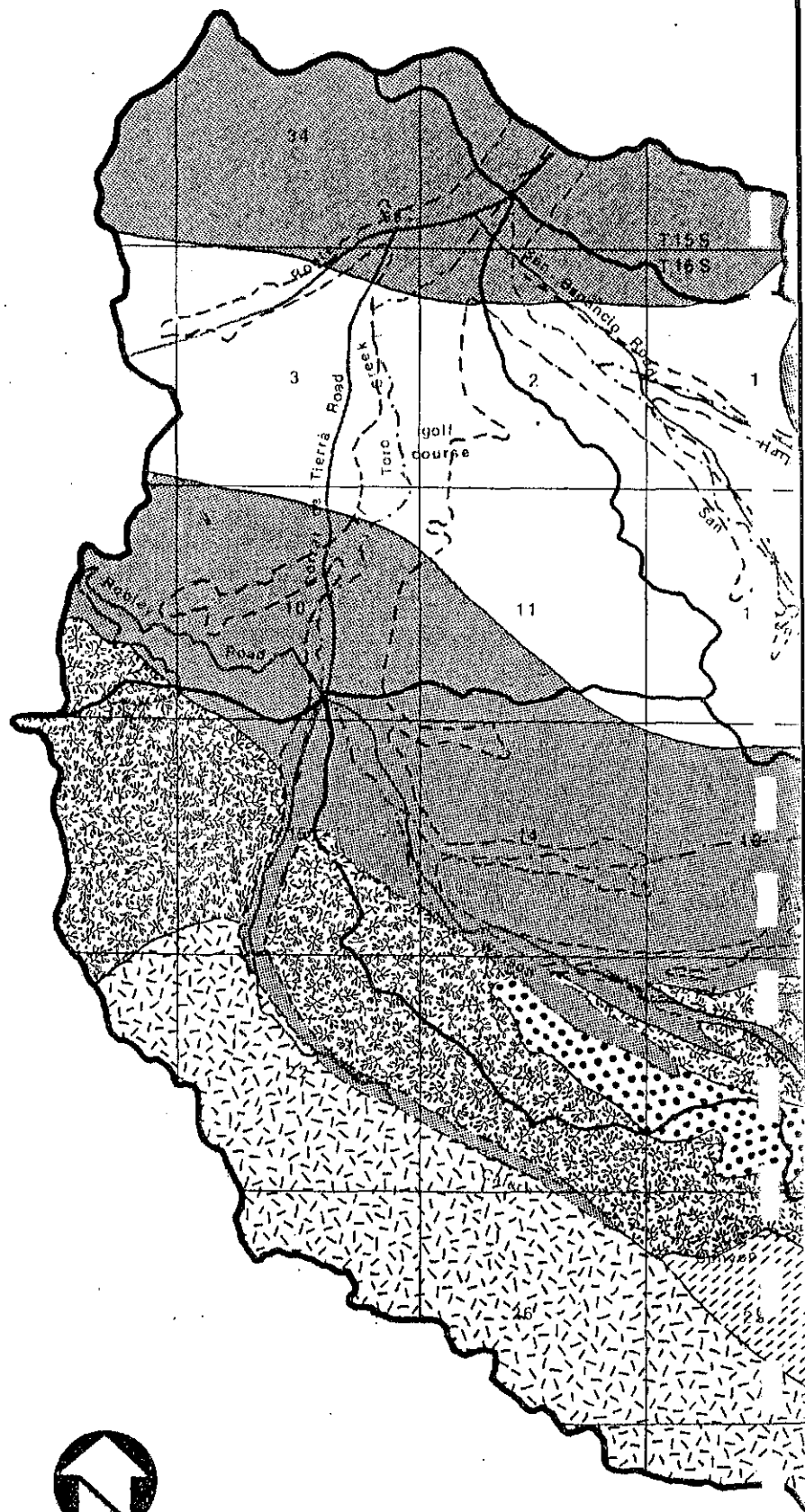
Groundwater quantity and quality issues, presented independently in Sections IX and X of this report, will be jointly discussed in this report section to provide guidance for the wise management of the El Toro area.

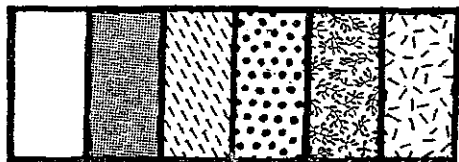
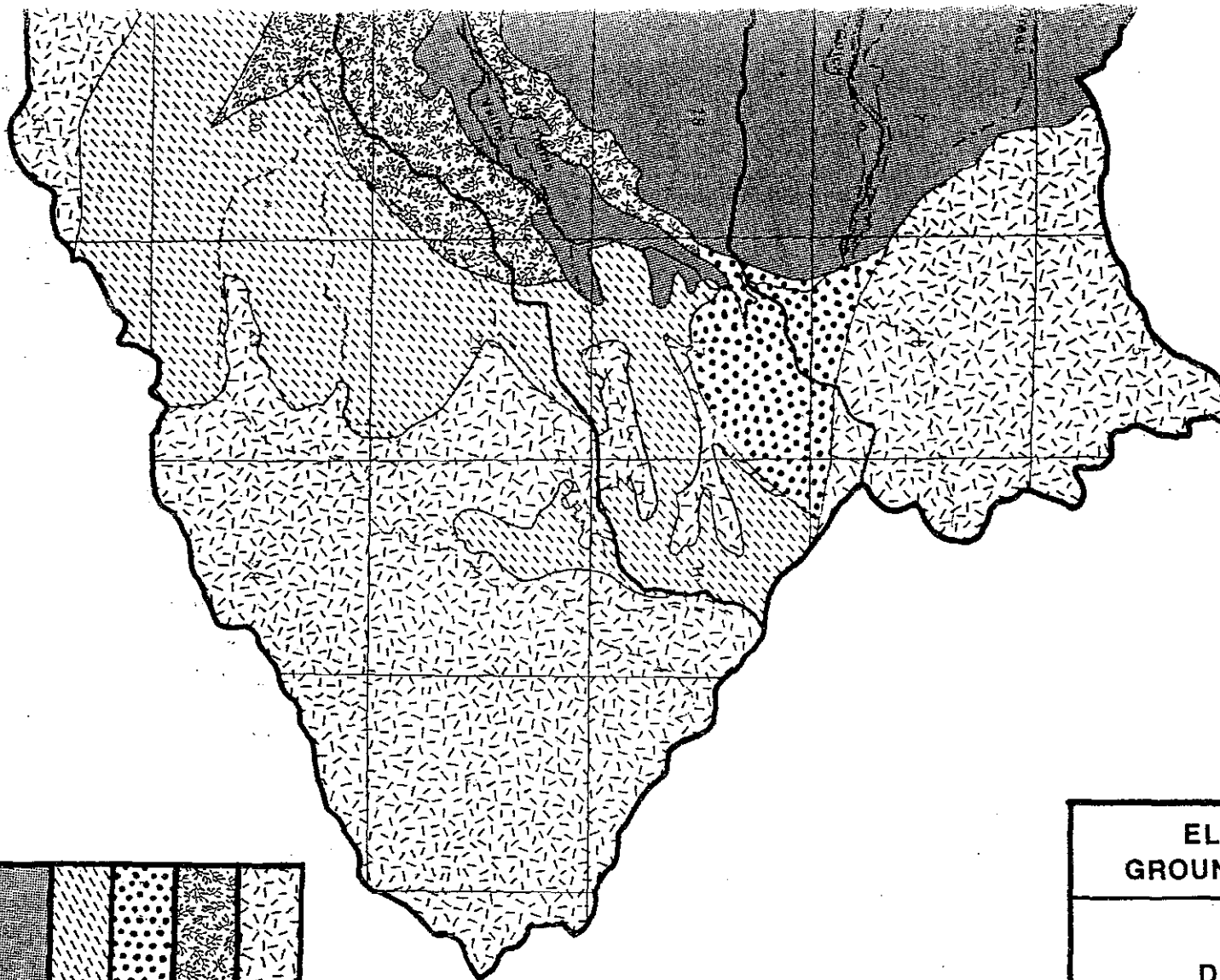
A. Assessment of Overall Groundwater Supply Adequacy

Analyses of overall groundwater quantity and quality within each subarea at several levels of development provide evidence that adequate supplies of groundwater with acceptable water quality will be available for domestic use. Significant long term depletion of the El Toro groundwater resource (as evidenced by widespread lowering of the water table through overdraft, productive wells going dry, or generalized reductions in well yields) has not been observed. Projected population growth to the year 2000 will not cause significant deterioration of the overall groundwater quality or overtax the safe groundwater yield in the study area. Even at the projected full development population, no significant problems with overall groundwater quantity or quality are anticipated.

B. Definition of Water Supply Zones

While the overall quantity and quality of the groundwater system is adequate, zones within the area of study can be designated with different suitabilities for development based on water resource issues. Figure 21 and Table 16 locate and describe six zones of water supply adequacy based upon the following issues:





ZONES

I
II
III
IV
V
VI

EL TORO AREA GROUNDWATER STUDY

DEFINITION OF WATER SUPPLY ZONES

ANDERSON-NICHOLS & CO., INC.

Scale 1 in. = 4000 ft. figure 21

Table 16: Characteristics of Water Supply Zones

Zone	Zone Characteristics	Water Quantity Issues	Water Quality Issues
I	Exposed granite; minimal or zero aquifer thickness; typically very high slopes; little vegetation	• minimal or no recharge • minimal or no storage • adequate water supply limited to fracture zones • generally poor water availability	• minimal or no assimilative capacity for septic effluent • problems with surfacing of septic discharge downslope • installation of effective septic systems may be very expensive • low percolation rates
II	Exposed Monterey Shale; unknown thicknesses of underlying Basal Sands aquifer; artesian conditions in part of Basal Sands; typically high slopes	• low recharge through shale • moderate water availability in Basal Sands only in portion subject to adequate recharge • low pumping rates in shale	• poor water quality in shale, fair in Basal Sands • minimal assimilative capacity for septic effluent in shale • problems with surfacing of septic recharge • installation of effective septic systems may be expensive • low percolation rates
III	Exposed Santa Margarita Sandstone or Aromas-Paso Robles unsaturated; moderate to high slopes; typically thin aquifers	• minimal storage • moderate recharge • unknown water availability	• good assimilative capacity • fair water quality

Table 16: Characteristics of Water Supply Zones (continued)

Zone	Zone Characteristics	Water Quantity Issues	Water Quality Issues
IV	Exposed Basal Sands; unknown aquifer thickness; recharge confined by faults; typically high slopes	• moderate recharge • moderate storage • unknown water levels • isolated aquifer with local recharge only	• fair water quality • potential for well contamination from septic systems
V	Significant thicknesses of alluvium, Aromas-Paso Robles and Santa Margarita Sandstone; wide range in slopes	• saturated thickness of 0 - 600 feet • good recharge • moderate storage • moderate water availability	• fair water quality • good assimilative capacity in areas not covered by alluvium • potential for well contamination from septic systems in areas of alluvium
VI	Significant thicknesses of alluvium, Aromas-Paso Robles, and Santa Margarita Sandstone; wide range in slopes	• saturated thickness greater than 600 feet • good recharge • high storage • high water availability	• fair water quality • good assimilative capacity in areas not covered by alluvium • potential for well contamination from septic systems in areas of alluvium

- 1) Water quantity
 - a) reliability of aquifer recharge
 - b) amount of storage
- 2) Water quality
 - a) natural water quality
 - b) assimilative capacity for septic effluent (based on percolation rates and purification ability)

The designation of the zones overlooks some small areas that might have been individually delineated or characterized, but were not, in order to reduce the complexity of this assessment. The zones are numbered in order of the increasing suitability of the area for development based on water supply issues. Inherent in this assessment are two important assumptions:

- 1) All areas will be served by on-site septic tank systems.
- 2) Water will not be redistributed within the area or imported from other areas.

Considering only water supply issues, any location in El Toro is appropriate for development if the site is sewered and supplied by water from another location. If only one of these two options (sewerage or the importation of water) is allowed in an area, then some zones rated poorly in Table 16 may become favorable for development. For example, if an adequate groundwater supply exists under Monterey Shale outcrops at a location where a septic tank is not to be used, the minimal assimilative capacity of the shale for septic effluent will no longer be a factor in preventing development of the site.

The best water supply zone, VI, is located in a northwest portion of the study area, where large volumes of storage, good recharge capabilities, and potable water are found. In areas covered by alluvium within zone VI, high percolation rates and shallow well depths can combine to increase the possibility of contamination of wells by septic effluent. Placement of wells and septic systems must be carefully planned to avoid contamination in these locations.

Zones IV and V are areas of moderate water availability and fair natural water quality. The quantity of stored water in these zones, though not as large as that found in Zone VI, appears to be substantial and recharge capabilities are adequate. Rapid percolation and shallow well depths in those portions of zone V covered by alluvium and in the Basal Sands of zone IV can lead to contamination of wells from septic systems. High slopes in parts of these two zones may make the installation of septic systems expensive.

The remaining three zones, I, II, and III, all have at least one serious deficiency in their water supply characteristics that will hinder their development. Zone III consists of two areas of Aromas-Paso Robles and Santa Margarita Sandstone outcrops with largely unexplored volumes of groundwater storage. All indications suggest that the magnitude of the stored water is severely limited. Within zone II, areas upgradient from the Corral de Tierra Fault exhibit moderate availability of water in the Basal Sand Formation, but all parts of this zone have minimal capacity for assimilating septic effluent due to the shale outcrops. The granite outcrops, zone I, exhibit poor quantities of water and low assimilative capacities for septic effluent.

This generalized assessment of six water supply zones in the El Toro study area should provide significant guidance for the wise management of the area. However, this evaluation is not intended as a predictor of water supply capabilities on a site-by-site basis, and its use in such a detailed analysis requires the consideration of additional localized data.

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