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RECONNAISSANCE OF GEOTHERMAL RESOURCES OF LOS ANGELES COUNTY, CALIFORNIA

By

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ABSTRACT

Thermal waters produced from large oil fields are currently the most important geothermal resources in Los Angeles County. Assuming that various technological and economic considerations are favorable, many of these fields are promising sources of heat for diverse applications outside the field operations. Otherwise, the County does not appear to have any large, near-surface geothermal resources.

The oil fields produce thermal water because of both the moderate depths of production and normal to above-normal geothermal gradients. Gradients are about 3.0-3.5°C/100 meters in the Ventura Basin and range from that up to about 5.5-6.0°C/100 meters in the Los Angeles Basin. The hottest fields in the County are west of the Newport-Inglewood Structural Zone.

The Los Angeles Basin has substantially more potential for uses of heat from oil fields than does the Ventura Basin because of its large fields and dense urban development. Produced fluid temperatures there range from ambient air to boiling, but most are in the 100-150°F range. Daily water production ranges from only a few barrels at some fields to over a million barrels at Wilmington Oil Field; nearly all fields produce less than 50,000 barrels/day. Water salinity generally ranges from about 15,000-35,000 mg/liter NaCl. Fields with the most promise as sources of heat for outside applications are Wilmington, Torrance, Venice Beach, and Lawndale.

The centralized treatment facilities are the most favorable sites for extraction of heat within the oil fields. Because of the poor water quality, heat exchangers will likely be required rather than direct circulation of the field water to users. The best sites for applications are commercial-industrial areas and possibly institutional structures occupied by large numbers of people.

The attitudes of the field operators in the County toward heat-extraction from the fields range from positive to negative with most neutral or negative. Many believe that such projects will not be economic. Several operators are interested, however, in possible extraction of heat from their operations for outside uses.

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INTRODUCTION

PURPOSE OF STUDY

The main purpose of the study was to identify the geothermal resources of Los Angeles County, California, with an emphasis on preliminary evaluation of the county's oil fields as sites for extraction of heat from produced thermal waters. The results of the study are primarily intended to aid planning by county officials for possible use of the geothermal resources. The U.S. Department of Energy funded the study under its agreement with the Division of Mines and Geology, California Department of Conservation, to assess low- and moderate-temperature geothermal resources in California.

DEFINITIONS USED

"Geothermal resources", as used in this report, are any natural sources of thermal waters (greater than about 25°C) regardless of depth of occurrence. Included under this definition are the thermal waters produced from oil fields, even though the waters must be pumped from relatively great depths (approximately 2,000-10,000 feet) under a normal to above-normal geothermal gradient. The terms "anomalous" or "abnormal" refer to geothermal features that are hotter than would be expected for a particular depth or area. Geothermal resources not discussed in this report include geopressured and hot dry rock.

LOCATION OF STUDY

The area of study included the County of Los Angeles and a narrow fringe just outside its borders. The county is situated in southern California (Figure 1) and includes two of the Channel Islands, Santa Catalina and San Clemente. Because of their isolation, low population, and relatively unfavorable geologic conditions as sites for geothermal resources, these islands were not included in the study.

FIGURE 1 - Location of Los Angeles County in California.

PHYSIOGRAPHY AND CLIMATE

The county's physiography and climate are highly varied. From northeast to southwest, the main geographic features are Antelope Valley (part of the Mojave Desert), San Gabriel Mountains, San Fernando Valley, Santa Monica Mountains, San Gabriel Valley, and Los Angeles Basin. Elevations range from sea level at the coast to over 2,500 meters in the San Gabriel Mountains. Summers are warm to hot and dry, and winters are mild with limited to moderate precipitation, mostly in the form of rain. The mean annual air temperatures of the Los Angeles Basin and Newhall area are about 17°-18°C, while that of the Palmdale (Antelope Valley) area is about 17°C.

CULTURAL DEVELOPMENT

The population of Los Angeles County (1980 Census) is about 7.5 million, nearly all concentrated in the southern third of the county (Figure 2). The San Fernando and San Gabriel Valleys and the Los Angeles Basin are the most densely populated. In the north, the small Newhall and Lancaster-Palmdale areas are the only major population centers. The rest of the county is rural, especially Antelope Valley and the rugged San Gabriel Mountains.

The southern part of the county offers unlimited applications for any heat derived from geothermal resources. Industrial, commercial, and residential areas are both abundant and commonly intermixed.

PREVIOUS STUDY OF GEOTHERMAL RESOURCES

Although numerous geologic studies of all portions of the county have been conducted, no detailed assessment of the county's geothermal resources has been done. This is probably because the county lacks spectacular examples of anomalous geothermal activity, such as hot springs or volcanism, that would stimulate such work. Also, until very recently, most interest in geothermal resources was in

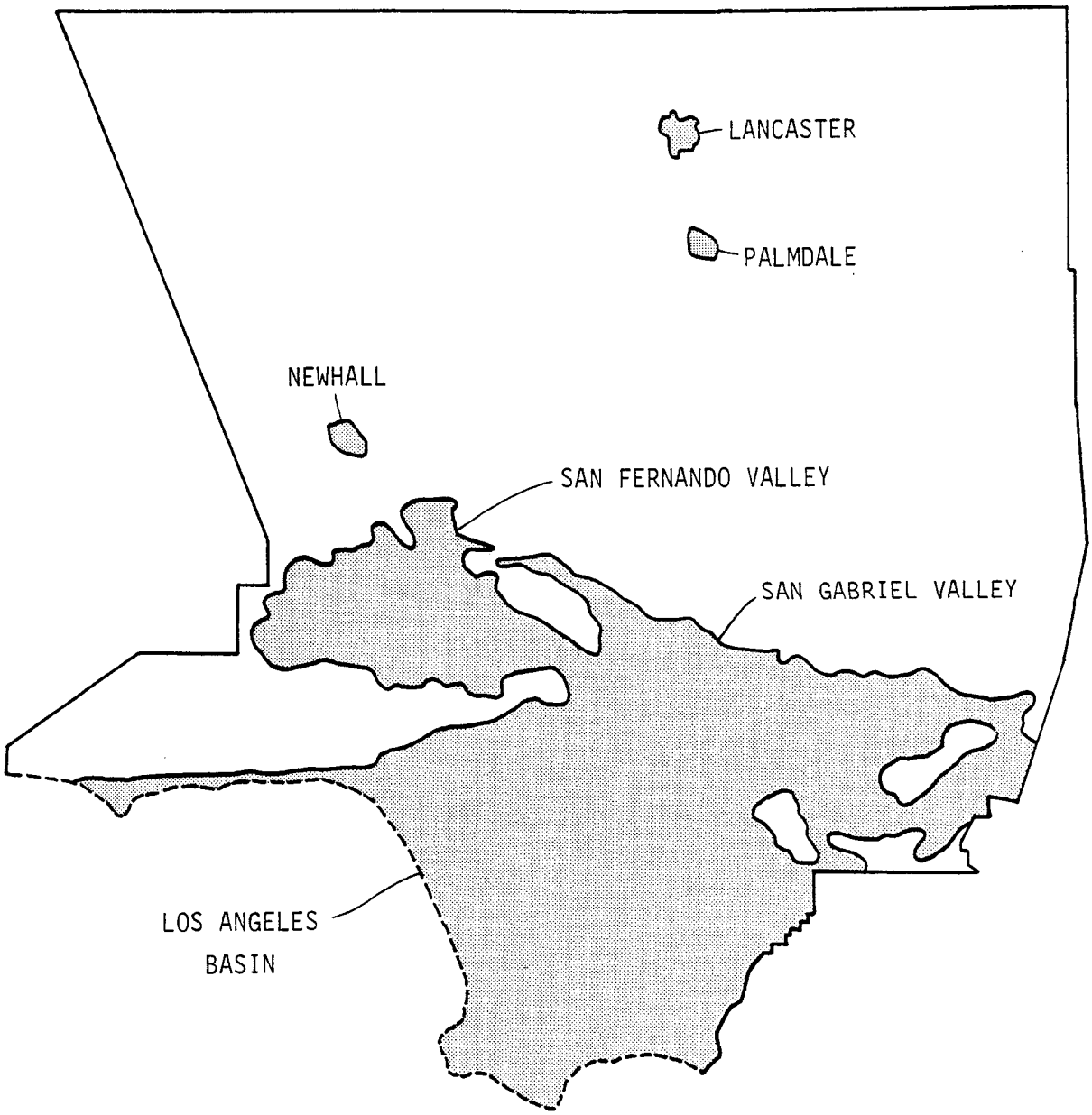

FIGURE 2 - Areas of dense residential and commercial development in Los Angeles County (stippled pattern). (Modified from California Division of Mines and Geology, 1980.)

their potential to generate electricity. Anything incapable of that was generally ignored. Recent public and private interest in low- and moderate-temperature geothermal resources (<150°C) for uses that include space conditioning, agriculture, and industrial processes has changed this attitude substantially.

The only known studies of the geothermal resources of the county are three brief reports produced by the Engineering Geology Section of the County Engineer's office (Robinson, 1974; Keene, 1974; Saltzman, 1978). Of these, the report by Saltzman (1978) is the most comprehensive and useful. Nonetheless, the study was very brief and did not discuss the possibilities of oil fields as sources of thermal water for non-electrical applications.

PROCEDURES USED IN THIS STUDY

Full-time work on the project began in late November 1980 and was completed at the end of August 1981. Most data were obtained from files and reports of the California Division of Oil and Gas and from written and oral correspondence with many oil companies. A small amount of data was derived from published and unpublished reports obtained elsewhere.

Many individual oil fields and several abnormally warm geothermal phenomena in the county were visited. The majority of work was concentrated in the oil fields of the Los Angeles Basin.

Units of measurement used by the geothermal industry are most commonly in the metric system; this convention is observed in this report regarding springs, water wells, and geothermal gradients. The petroleum industry prefers the English system, however, when it measures depths, temperatures, and volumes. Consequently, that convention is observed when production data from oil fields are discussed.

Readers interested primarily in the evaluation of the oil fields as sources of geothermal energy can turn to page 34 for the beginning of that discussion.

ACKNOWLEDGEMENTS

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Of special recognition are the many individuals in the California Division of Oil and Gas, our sister agency, who provided both access to abundant data and exceptionally useful guidance and advice. Richard Strehle's contributions are particularly noteworthy.

Special thanks is extended to all of the oil operators (listed in Appendix D) who responded to our questionnaire or otherwise provided data. Their cooperation was essential to the completion of this study. Paul Cronmiller, W.H. Garrison, Harry Krebs, David Lefler, and several individuals with Pauley Petroleum, Incorporated provided very useful discussions and information.

Finally, I am grateful to people in the Division of Mines and Geology who helped compile the report: Emily Kishi, calculation of geothermal gradients; Yukie Ota and Danielle Riordan, typing; and Ed Foster and Jeffrey Tambert, drafting. Jon Lloyd, Rudy Strand, and Gary Taylor provided helpful reviews of the manuscript.

GEOTHERMAL SETTING OF LOS ANGELES COUNTY

Surficial evidence of abnormally warm sources of geothermal energy in Los Angeles County is relatively scarce, considering the size of the county. Thermal springs and thermal water wells (Figure 3, Table 1) are neither abundant nor significantly hot (>50°C). Volcanic rocks are sparsely distributed (Figure 4) and are not known to be younger than Miocene age (5-25 millions years B.P.), which indicates no obvious young sources of magma that could produce geothermal anomalies. Measurements of heat flow in the county are few (Diment and others, 1975; Henyey and Wasserburg, 1971), but the data suggest that the county is part of a relatively hot crustal region that extends both along the coast of California and through the entire desert region of the state. As will be discussed later, geothermal gradients determined in this and previous studies suggest above-normal subsurface temperatures for the Los Angeles Basin, while the Ventura Basin appears to have normal temperatures.

DIVISION OF COUNTY INTO GEOTHERMAL PROVINCES

For ease of evaluation and presentation, the county was divided into seven geothermal provinces based upon the six major geologic structural zones that slice through the county (Figures 4, 5). Each province is discussed briefly below, and a summary of the provinces' features is presented in Table 2.

Mojave

North of the San Andreas Fault Zone in Los Angeles County is the westernmost edge of the Mojave Desert. Known locally as Antelope Valley, the province is a large, gently undulating alluvial plain, broken only by a few "islands" of Mesozoic bedrock and some low hills along the San Andreas Fault Zone.

Anomalous geothermal features are indicated by possibly two or three water wells. Two of the wells were reported in the 1950's and 1960's to be

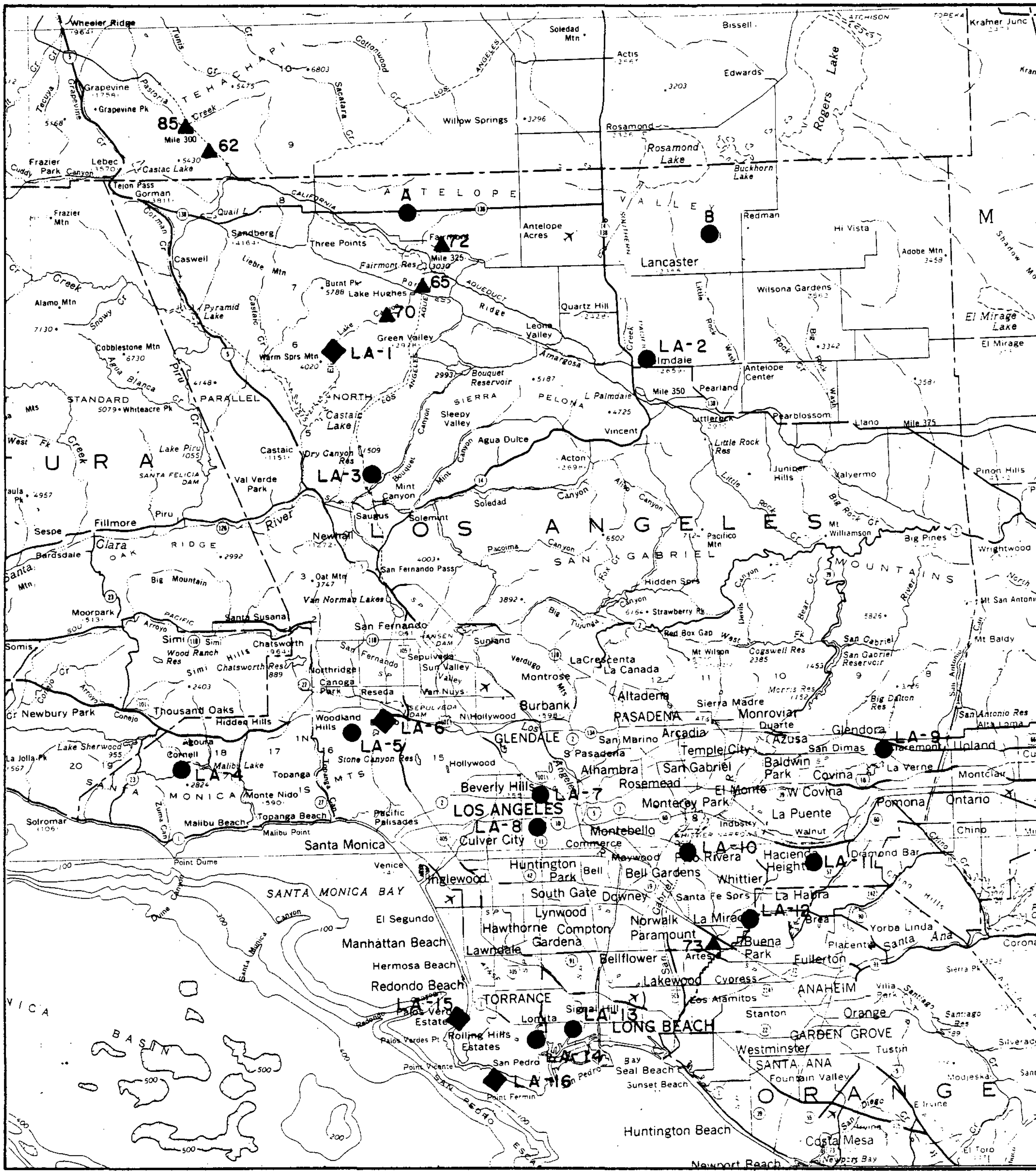


FIGURE 3 - Locations of thermal springs and thermal water wells in Los Angeles County. Diamonds are springs, circles are wells. Codes refer to identification of springs and wells as presented in Table 1 . Small triangles with numbers are locations of heat flow measurements (numbers are in milliwatts/meter^2). Figure is from Geothermal Resources of California (Calif. Division of Mines and Geology, 1980).

TABLE 1 - Thermal springs and thermal wells in Los Angeles County.

NAME	CODE	TEMPERATURE (°C)	FLOW RATE (L/min)	TDS(mg/L)	DEPTH (M)
THERMAL SPRINGS:					
Warm Springs	LA-1	32°	5-10	1,210	--
El Encino Springs	LA-6	31°	50-100	1,160	--
Whites Point Hot Springs	LA-16	46°(?)	0(?)	?	--
Malaga Cove	LA-15	25°	?	?	--
THERMAL WATER WELLS:					
IN/16W-14K1 S	LA-5	36°		1,690	
1S/9W-1F1 S	LA-9	36°		600	
3S/11W-14H4 S	LA-12	34°		410	
5S/13W-8D1 S	LA-14	31°		1,530	
8N/15W-22A2 S	A	37°		630	
8N/11W-35J1 S	B	31°		?	
QUESTIONABLE THERMAL WATER WELLS:					
6N/12W-13N1 S	LA-2	27°		190	
4N/16W-1Q1 S	LA-3	28°		1,050	
2S/14W-14C2 S	LA-8	27°		430	
2S/11W-8N1 S	LA-10	29°		600	
4S/13W-27N1 S	LA-13	28°		270	
EXPLORATORY WELLS:					
Seminole Hot Springs	LA-4	46°	0	565	915
Bimini Hot Springs	LA-7	40°	380(?)	1,800	534
Alvarado Hot Springs	LA-11	44°		7,740	1,525

TDS - total dissolved solids in milligrams/liter
L/min - liters/minute
M - meters

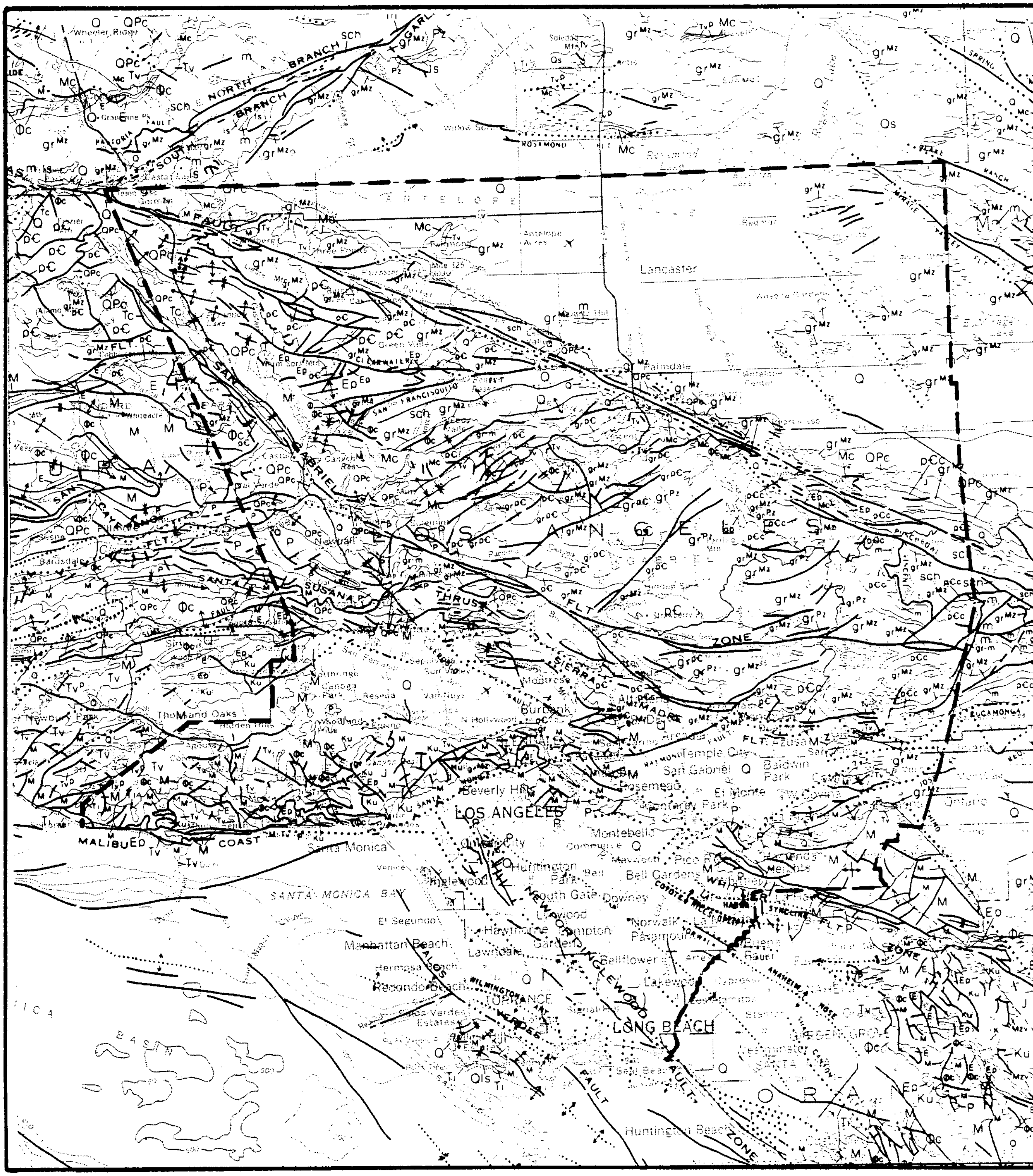


FIGURE 4 - Geology of Los Angeles County. Generalized symbols for rock types are listed in Figure 4b. Map from California Division of Mines and Geology (1977), scale 1:750,000.

FIGURE 4a

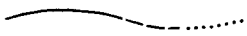
Key to rock types shown in Figure 4

AGE	TYPE			
	Marine Sedimentary	Non-marine Sedimentary	Volcanic	Plutonic
QUATERNARY	Q	Qls, Qpc		
TERTIARY	P, M, E, Ep	Mc, Φc	Tv, Ti	
MESOZOIC	Ku, J, KJf			gr^{Mz}
PALEOZOIC				gr^{Pz}
PRE-CAMBRIAN	p€			$gr^{p€}$

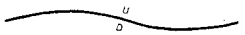
MIXED OR UNDIFFERENTIATED BASEMENT ROCKS OF PRE-CENOZOIC AGE: sch, m, pCc, gr-m

SYMBOLS

Geologic boundary.



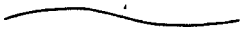
Fault traces, solid where well located; dashed where approximately located or inferred; and dotted where concealed by younger rocks or by lakes or bays. Fault traces are queried where continuation or existence is uncertain. Many concealed faults in the Great Valley are based on maps of selected subsurface horizons, so locations shown are approximate and may indicate structural trends only. All offshore faults, based on acoustic-reflection profile records, are dashed. For faults color-coded according to recency of movement, see FAULT MAP OF CALIFORNIA, GEOLOGIC DATA MAP 1 (1975).



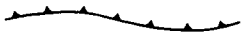
Upthrown side (relative or apparent).

Downthrown side (relative or apparent).

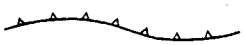
Arrows indicate relative or apparent direction of lateral movement.



Arrow indicates direction of dip.

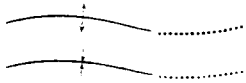


Thrust fault (barbs on upper plate). Fault surface generally dips less than 45°, but locally may have been subsequently steepened.



Coast Range thrust, the upper boundary of a long-inactive, late Mesozoic subduction zone (barbs on upper plate). Extends from Oregon southward nearly to Santa Barbara, but has discontinuous outcrop owing to its modification by younger faults and concealment by overlying deposits; locally, Coast Range thrust is very steep.

Regional strike and dip of stratified rocks.



Anticlinal fold.

Synclinal fold.

Dotted offshore and where concealed under alluvium in the Great Valley and elsewhere. Concealed folds may be confined to certain units, and their location may be approximate.

Volcano or cinder cone. Most were active in Pleistocene time; some are Holocene, and a few are late Pliocene.

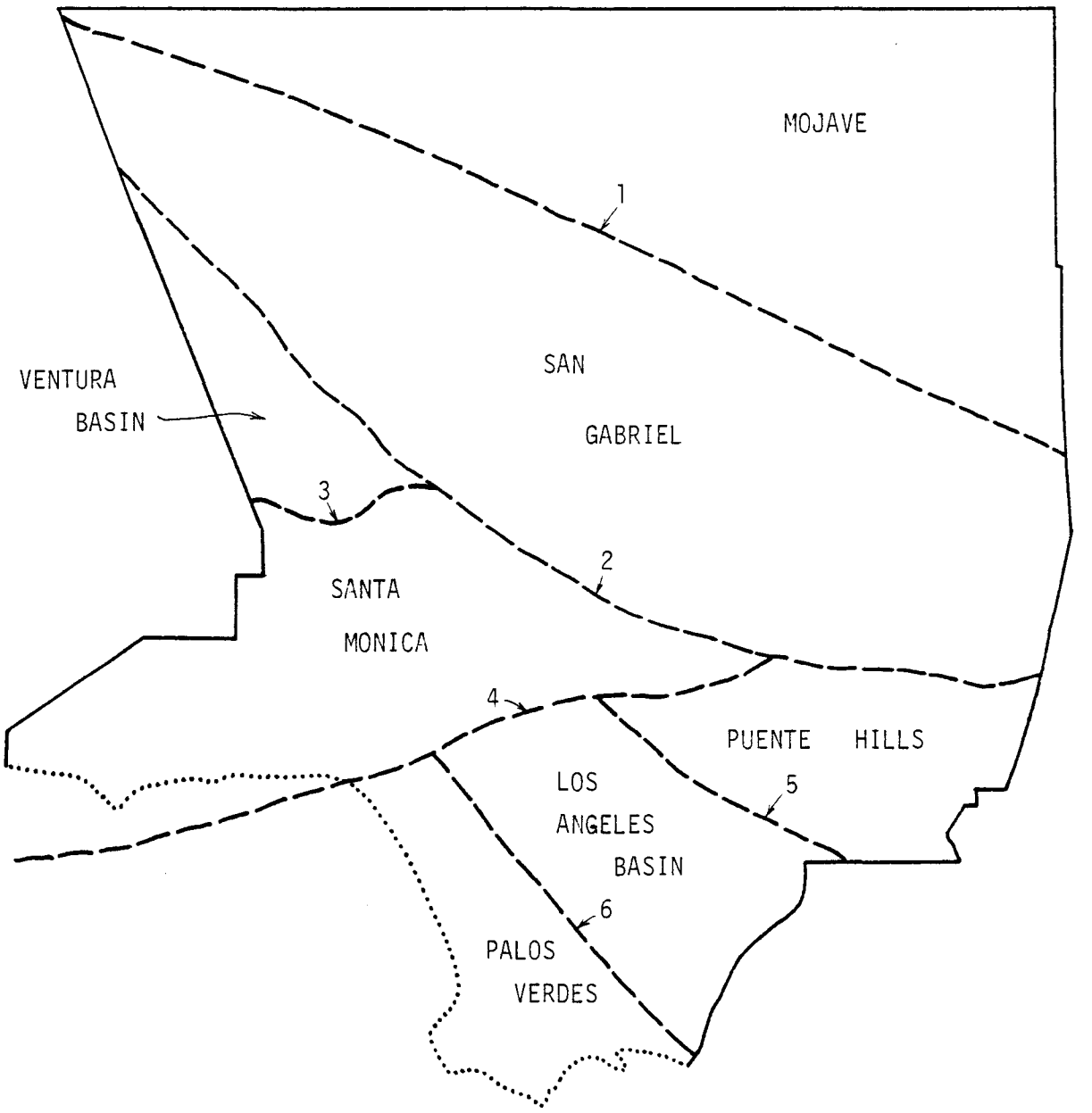


FIGURE 5 - Simplified geothermal provinces of Los Angeles County based on major structural boundaries. 1) San Andreas Fault Zone, 2) San Gabriel-Sierra Madre Fault Zone, 3) Santa Susana Fault Zone, 4) Santa Monica-Raymond Hill Fault Zone, 5) Whittier Fault Zone, 6) Newport-Inglewood Structural Zone. Scale 1:750,000.

TABLE 2

RELATIVE GEOTHERMAL POTENTIAL OF THE SEVEN GEOTHERMAL PROVINCES OF LOS ANGELES COUNTY

PROVINCE	RATING	SETTING	COMMENTS
MOJAVE	Fair	Alluviated basin; plain	Some thermal water associated with faults(?)
SAN GABRIEL	Poor	Basement high; mountains	Mostly fracture-control; rugged, rural terrain
VENTURA BASIN	Fair	Sedimentary basin; hills	Mildly thermal water associated with oil fields
SANTA MONICA	Fair	Basement high and sedimentary basin; mountain and valley	Potential at Encino unknown (fracture-controlled?)
PALOS VERDES	Good	Basement high and shallow sedimentary basin; hills and plain	Thermal water associated with oil fields
LOS ANGELES BASIN	Poor to Fair	Deep sedimentary basin; plain	Basement too deep to provide attractive heat source; warm oil fields at north end of province
PUENTE HILLS	Fair?	Shallow sedimentary basin; hills and valley	Thermal water associated with oil wells

over 30°C; one (A) is southwest of Fairmont, and the other (B) is northeast of Lancaster (California Department of Water Resources, 1980). The Fairmont well is being monitored by the University of Southern California for study of techniques for earthquake prediction. The Lancaster well was not visited and its use is unknown. The well (LA-2) in Palmdale had several temperatures reported in the middle 20's°C range (California Department of Water Resources, 1980), but these were possibly affected by ambient air temperatures and may not be truly anomalously warm. Research of the microfiche data of the California Department of Water Resources for other monitored water wells in this province indicated average temperatures in the 10 to low 20's°C range. A seasonal variation in these temperatures, caused by ambient air temperatures, is obvious in many cases.

San Gabriel

The San Gabriel geothermal province is bounded on the north by the San Andreas Fault Zone and on the south by the San Gabriel-Sierra Madre Fault Zone. The province is almost exclusively mountainous and is very sparsely populated. Rocks are predominantly pre-Cenozoic crystalline basement (Figure 4); Tertiary and Quaternary sediments are exposed along the westernmost portion.

Weakly anomalous geothermal phenomena are known at only two localities. A warm spring (LA-1) rises along the Clearwater Fault approximately where the fault intersects Elizabeth Lake Canyon. The measured temperature in 1981 was 32°C at a flow of about 5-10 liters/minute. A county-operated rehabilitation center is only a few hundred meters from the spring, which issues from a fracture in the bedrock. A pumphouse (Photo 2, Appendix E) near the

orifice provides unknown quantities of water to a nearby emergency reservoir for firefighting. The temperature of the pumped water is probably not much different from that of the spring, however. The well (LA-3) north of Saugus is questionably anomalously warm as its only recorded temperature of 28°C (California Department of Water Resources, 1980) could have been influenced by ambient conditions.

The only geothermal potential of this province appears to be from water that rises along deep-seated fractures. The paucity of sedimentary basins suggests that there will probably be no large sources of thermal waters within the province.

Ventura Basin

The Ventura Basin geothermal province, bounded approximately by the San Gabriel Fault Zone and the Santa Susana Thrust Zone, is the site of a small cluster of oil fields that marks the easternmost extension of the east-west trending Ventura Basin. The basin is a prominent sedimentary trough that extends into the Pacific Ocean. The province is mountainous and contains a small valley approximately in its center that contains the city of Newhall. Rocks are mostly Cenozoic marine sediments that have been folded and faulted to provide traps for petroleum.

No anomalously warm springs or water wells are known in the province. The oil fields provide modest amounts of low-temperature thermal water; the resource potential of the fields is discussed later in this report.

Santa Monica

The Santa Monica geothermal province is characterized by a basement high (Santa Monica Mountains) and a sedimentary basin (the densely populated San Fernando Valley). Evidence of known anomalous geothermal features includes a spring and well at the north base of the Santa Monica Mountains. El Encino

Springs (LA-6, Photo 1) supplies about 50-100 liters/minute of 31°C-water to a small duck pond in a historical park. A few kilometers to the west is a water well (LA-5) whose measured temperatures ranged from 19°C to 44°C in the 1950's and 1960's. The spring's temperature appears to have been consistent through this century (Waring, 1915), whereas the well's temperature has varied substantially. Possibly the waters that feed the spring are rising from a fault, which acts as a conduit for uninterrupted movement of mildly warm water. The well probably taps an aquifer that is recharged by a combination of deep-seated thermal water, which rises along a concealed fault, and shallow, cool ground water whose sporadic influxes cause the variation of temperature.

The old Seminole Hot Springs resort (LA-4) in the Santa Monica Mountains is now known as Seminole Springs and is the site of a large trailer park (Photo 3). The "springs" are an old exploratory hole drilled for oil in the early 1900's. The well used to be artesian at about 40°C-45°C, but more recently part of the well's casing collapsed and now the well must be pumped. The water is estimated by the current managers (personal communication, 1981) to be about 30°-35°C and it must be heated artificially to about 40°-42°C before it is used in a whirlpool at the trailer park.

The San Fernando Valley is underlain by a bowl-shaped accumulation of sediments that may be about 5,500 meters maximum thickness near the center of the valley. The sediments serve as a large reservoir for ground water in the valley; temperatures at water well-heads reported by the California Department of Water Resources (1980) are in the 15°-25°C range, which is not unusually warm for this climate and latitude.

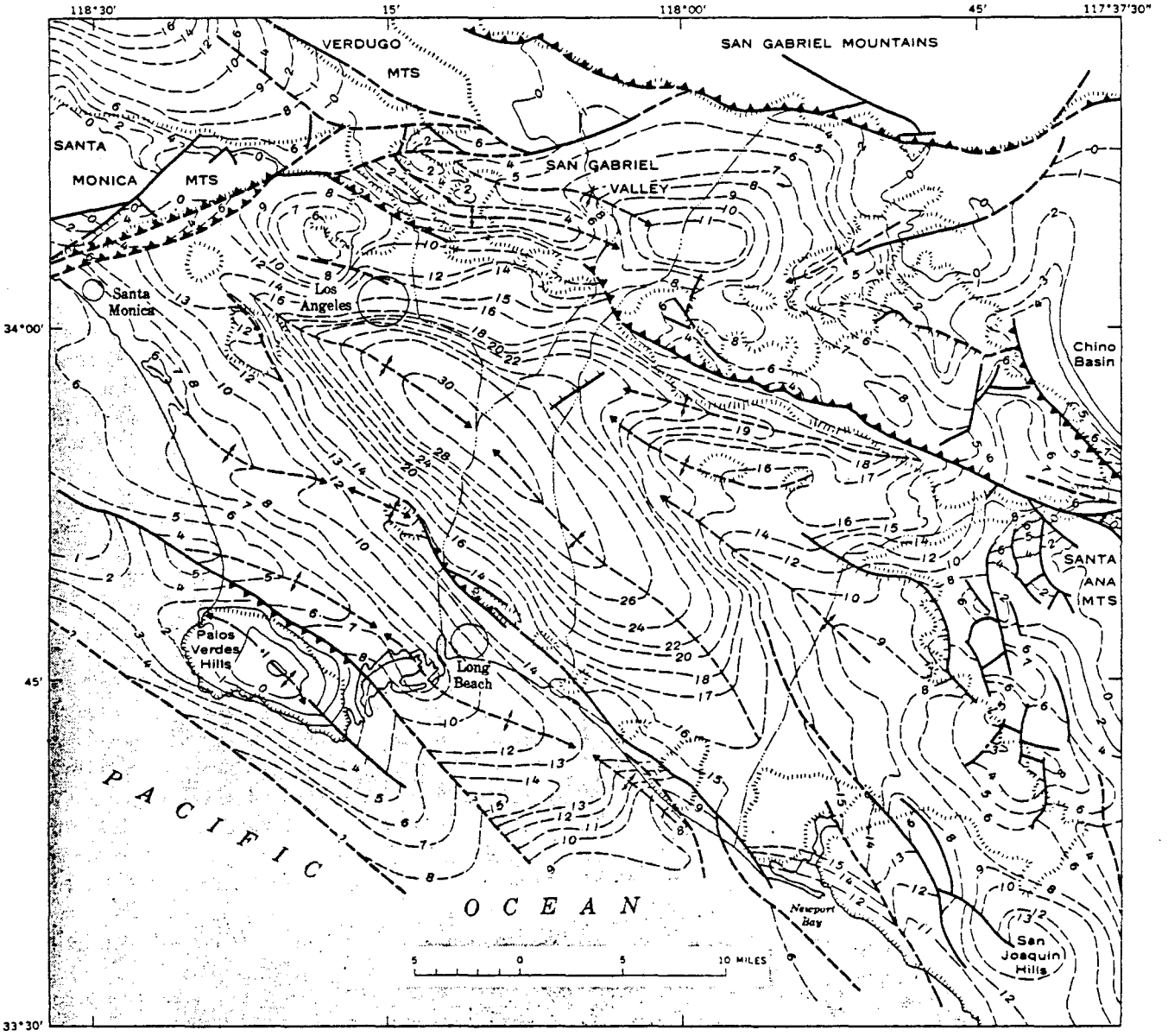
Palos Verdes

The Palos Verdes geothermal province is the westernmost of three provinces that make up the geologic Los Angeles Basin. The province is bounded on the east by the Newport-Inglewood Structural Zone and on the north by the Santa Monica Fault

Zone. Except for the Miocene-and-older rocks exposed on the uplifted basement of the Palos Verdes Peninsula, the province is covered by Quaternary alluvium at the ground surface. The alluvium is underlain by Cenozoic marine sediments that overlie basement at a thickness of about 1,500-4,000 meters (Figures 6,7). This is a relatively shallow basement depth compared to the main part of the Los Angeles Basin, east of the Newport-Inglewood Structural Zone, where the basement lies at depths ranging from about 4,000 to 10,000 meters. This shallow thickness of sediments has produced high geothermal gradients relative to the rest of the basin, as will be discussed later. The gradients and the presence of some of the largest oil fields in the county give the Palos Verdes geothermal province the highest geothermal potential of all seven provinces.

The only known thermal springs are on the Palos Verdes Peninsula, and are probably a result of deeply-circulated water that rises along fractures in the bedrock. A resort operated at White Point Hot Springs (LA-16) on the ocean edge many years ago, but all that remains now is a small fountain and the broken-up foundation of a swimming pool that was probably fed by the springs. A search of the reported site of the springs was made twice at low tide, but no hot water was found. The only evidence of thermal springs is many small fractures in the bedrock that are wholly or partially filled with calcite. The fracture-control and general geologic setting indicates a very small resource, probably even when the resort was in operation. Possibly the resort's demise was caused by the cessation of spring activity. The unnamed spring at Malaga Cove (LA-15) is also minor and probably results from similar geologic conditions.

A few water wells (LA-13, LA-14) in the Wilmington area are mildly warm, but the temperature of one (LA-13) may have been influenced by ambient conditions. Neither is conclusive evidence of a geothermal anomaly.



EXPLANATION

Structure contours
Drawn on basement rock surface. Dashed where inferred. Contour interval is 1000 feet except where odd-numbered contours dropped for clarity; numbers are zero or minus except at crest of Palos Verdes Hills. Datum is mean sea level

Fault
Dashed where approximately located; queried where doubtful

Reverse fault
Dashed where approximately located; teeth on upthrown side

Normal fault
Hachures on downthrown side

Anticline
Showing direction of plunge

Syncline
Showing direction of plunge

FIGURE 6 - Structure contours on basement surface in Los Angeles Basin (after Yerkes and others, 1965).

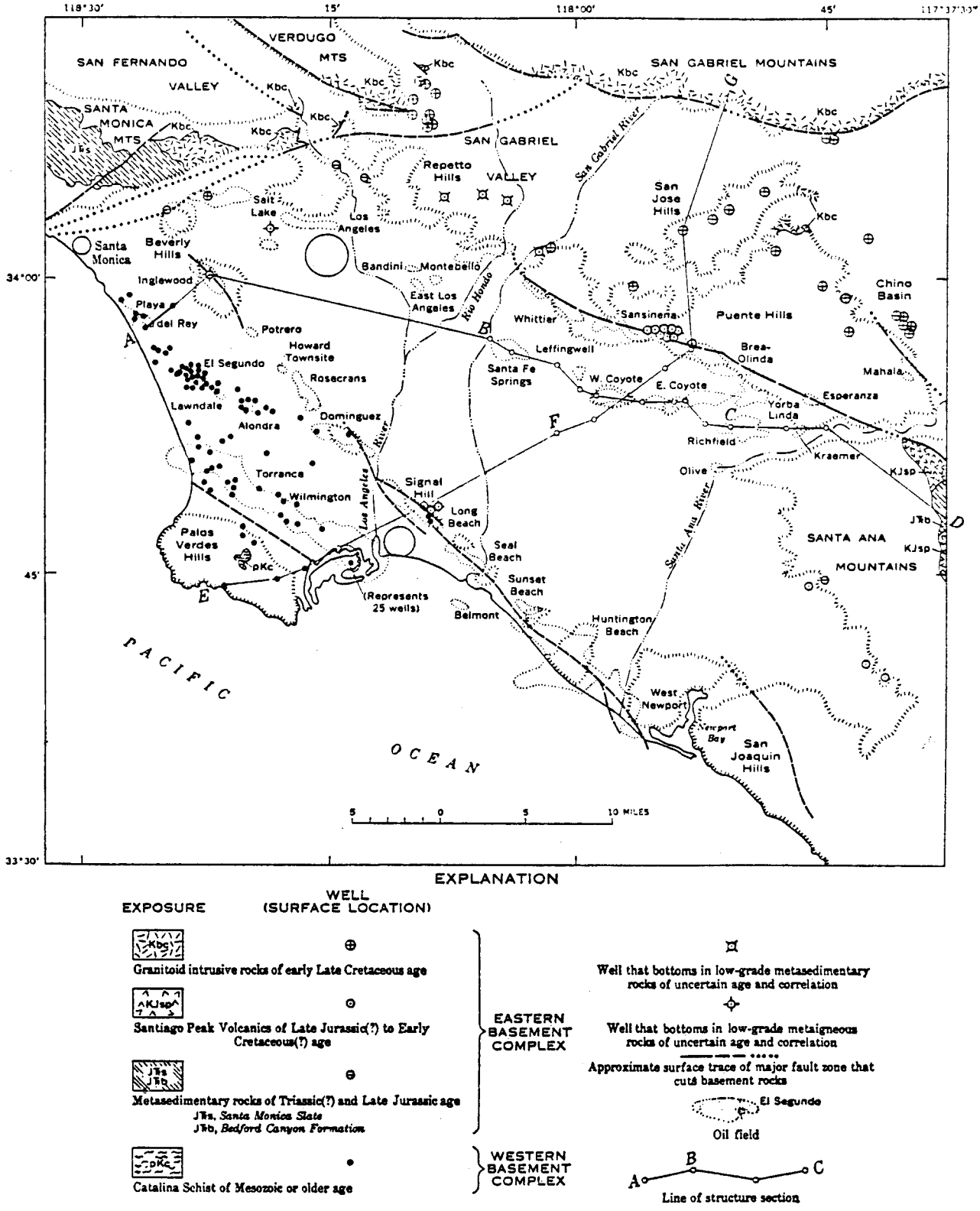


FIGURE 7 - Exposures of basement rocks and surface locations of wells that bottom in basement rocks (after Yerkes and others, 1965).

Los Angeles Basin

The Los Angeles Basin geothermal province is the mostly flat, densely populated area between the Newport-Inglewood Structural Zone and the Whittier Fault Zone. It corresponds with the deepest part of the marine sedimentary basin that is generally termed the "Los Angeles Basin"; maximum depth to basement is about 10,000 meters in the Downey-Norwalk area (Figure 6). The province's northwesternmost part (northwest of downtown Los Angeles) is underlain by a dome-like portion of the basement upon which only about 2,000-3,000 meters vertical thickness of sediment are deposited. This area is considered to be the warmest part of the province, while the area of maximum depth to basement is the coolest. The latter area is less attractive for finding hot water at shallow depths.

Bimini Hot Springs (LA-7), in the "warm" area of the province, was actually an unsuccessful exploratory hole drilled for oil near 3rd Street and Vermont Avenue at the turn of this century. It reportedly produced about 380 liters/minute of 40°C-water while it operated as a resort and sanitarium (Waring, 1915). The resort is not known to be in operation today, however. The temperature of a water well (LA-8) several kilometers south of Bimini may have been affected by ambient air temperatures.

Puente Hills

The Puente Hills geothermal province includes both the Puente Hills, east of the Whittier Fault zone, and the flat to rolling San Gabriel Valley, south of the Raymond Hill and Sierra Madre Fault Zones. The Hills are composed largely of Tertiary sediments, and the Valley is a sedimentary basin filled to a maximum depth of approximately 3,500 meters. The Valley probably has geothermal characteristics very similar to those of the San Fernando Valley as both are somewhat alike in size, shape, and thickness of deposited sediment.

No evidence of unusually warm temperatures were noted in this province. A brief survey of water well temperatues in the San Gabriel Valley, reported by the California Department of Water Resources (1980), indicated most were in the 15°-25°C range, similar to the San Fernando Valley. Alvarado Hot Springs (LA-11) is not a spring, but another exploratory hole for oil and gas. Drilled to over 1,500 meters depth, its reported temperature (44°C) is not anomalous. The site was not visited during this study nor was a mildly warm well (LA-9) near the east edge of the county.

GEOTHERMAL POTENTIAL OF THE MAJOR STRUCTURAL BOUNDARIES

The previous section discussed briefly the geothermal characteristics and potential of seven major areas, but not the characteristics of the structural boundaries that separate the areas (Figure 5). The boundaries are major zones of fractures in the Earth's crust, the geothermal importance of which should not be ignored. Interest in them mainly involves their roles as potential conduits for thermal water that may rise from great depths, heated either by the geothermal gradient or by a body of magma. Probably the most dramatic example in this region of a structural zone that serves as a conduit for hot water is the Newport-Inglewood Structural Zone's relationship to the Seguro 1 well in the Huntington Beach Oil Field, which is in Orange County. Temperatures estimated at over 200°C at depths less than 3,000 meters were encountered while drilling the well in the late 1940's. The well is within the structural zone and apparently intersected a fracture or fractures that served as open conduits along which deep-seated thermal water could rise. The field is one of the warmest in the Los Angeles Basin, with a geothermal gradient of about 5°C/100 meters (Tutschulte and Nichols, 1950).

As discussed earlier, shallow bodies of magma do not appear to act as sources of geothermal heat in the county. Therefore, the water that rises from great depths along fault zones probably derives its heat from the geothermal gradient. With these ideas in mind, brief discussions of the major structural boundaries are presented below.

San Andreas Fault Zone

The San Andreas Fault Zone is a vertical right-lateral strike-slip zone notable for the absence of thermal springs along most of its length in California. This is true of the portion in Los Angeles County, nor is there any other obvious evidence of anomalous thermal activity (thermal water wells, mineralization, young volcanic rocks) along this segment. Evidently, the regional tectonic pattern of compression and strike-slip motion, combined with accumulations of fault gouge in the zone have "closed" the fault zone in this area to any significant upward movement of thermal water.

San Gabriel-Sierra Madre Fault Zone

This zone is characterized by right-lateral strike-slip motion that is translated into thrust movement as the zone swings from its northwest trend in the Newhall area to its east-west trend in the San Gabriel Valley area; the latter movement is pushing the San Gabriel Mountains over the valley.

The zone is not known to have any thermal phenomena such as thermal springs or thermal wells, which would indicate an "open" conduit. Apparently, the compressional movement along the zone, especially in the southeast area, has closed the zone to movement of heated water from depth.

Santa Susana Thrust

The boundary between the Ventura Basin and Santa Monica Provinces is poorly defined, but for simplicity it was chosen as the Santa Susana Thrust. The compressional nature of the zone does not favor the movement of thermal water from depth. No thermal springs or thermal wells are known to be associated with the fault zone. A search of records of electric logs on file with the California Division of Oil and Gas did not reveal any unusual bottom-hole temperatures in oil wells associated with or north of the zone.

Santa Monica-Raymond Hill Fault Zone

The Santa Monica (west) portion of this zone is apparently the site of thrusting of the Santa Monica Mountains over the Los Angeles Basin. The Raymond Hill (east) portion of the zone is a steeply-dipping reverse fault (Bryant, 1978), with possible left-lateral movement. Neither zone is known to have any associated thermal phenomena probably because of the compressional ("closed") motion of the zone. A review of bottom hole temperatures in oil wells drilled into the zone did not indicate any unusual temperatures.

Whittier Fault Zone

The Whittier Fault Zone is composed primarily of steeply-dipping reverse faults that have elevated the Puente Hills area relative to the flat portion of the Los Angeles Basin. Several large oil fields are situated along the zone, but unusually high temperatures were not noted from research of electric logs from wells in the fields. There are no known thermal springs or thermal water wells along the zone except for a water well (LA-10) of questionable thermal character.

Newport-Inglewood Structural Zone

Probably of most interest of the six structural zones because of both its location in a densely populated area and its association with Seguro 1, the Newport-Inglewood Structural Zone is an incipient right-lateral strike-slip fault zone that has not yet completely broken the ground surface (Barrows, 1974). No thermal springs or thermal water wells are known to be associated with the zone, although numerous oil fields align with it. As will be discussed later, of possible significance is the apparent increase in geothermal gradient of the oil fields from northwest to southeast, starting with Potrero Oil Field and ending with Newport Oil Field in Orange County.

A search of hundreds of electric logs from oil wells drilled in the fields along the zone did not reveal any unusually high temperatures, such as at Seguro 1. Nor are the geothermal gradients exceptionally high. The zone is evidently closed enough by both compressional movement and the formation of gouge so that circulation of thermal water is severely inhibited.

Undoubtedly, some fractures are able to yield hot water, but these are probably scarce, and the odss of intersection of these with wells may be very low. Based on historical performance, the zone in Los Angeles County does not appear a promising prospect for discovery of thermal water of abnormally high temperatures.

GEOTHERMAL GRADIENTS IN THE COUNTY AS DETERMINED FROM OIL WELLS

Temperatures measured in exploratory and production wells while the wells are being drilled serve as a rapid means of finding anomalously warm geothermal areas. Also, the gradients provide an estimate of the subsurface temperatures to be expected at particular depths. The temperatures are recorded on electric logs, soundings run down the borehole to determine rock properties. A maximum-reading thermometer is attached to the log device, and, as the device traverses the length of the hole, the highest temperature encountered is recorded on the thermometer. It is generally assumed that the highest

temperature is at the bottom of the hole, although there are exceptions.

When the logs are run, the borehole is still filled with drilling mud, which has not necessarily reached the temperature of the surrounding rocks. If circulation of the mud in the hole has been lengthy and if the time between cessation of circulation and measurement of the temperature is very short, then the maximum recorded temperature will be lower than the true, "static" formation temperature. The discrepancy between measured temperature and static formation temperature thus varies according to the circulation time and the time between cessation of circulation and measurement of the borehole's temperature. It probably takes at least a few days for a borehole's temperature to equilibrate with the surrounding rock. In the meantime, the temperature rises exponentially to the static formation temperature (Schoeppel and Gilarranz, 1966).

For this study, all electric logs from production and exploratory wells in Los Angeles County on file at the California Division of Oil and Gas were searched for bottomhole temperatures and depths. Wells in the southernmost townships of the Wilmington Oil Field were not researched in detail because the temperatures are extremely inconsistent due to radical directional drilling, as will be explained later. Because of the effects of circulation of ground water and ambient air temperatures, all temperatures measured at less than 1,500 feet (457 meters) were not used. Temperature data from wells drilled prior to 1945 were not used because the techniques of electric-log soundings were relatively new at that time and were not as reliably consistent as measurements taken in more recent years.

The search of log records resulted in temperatures (many of them multiple readings) for about 4,500 wells in the Los Angeles Basin and about 1,200 wells in the Ventura Basin. Temperatures recorded in exploratory holes in the rest of the county were very sparse and did not indicate anomalously warm areas.

An equation for correction of measured temperatures in boreholes to approximate equilibrium values was developed during a project sponsored by the American Association of Petroleum Geologists that performed a geothermal survey of North America (Kehle, 1972, 1973; Wallace and others, 1979):

$$\frac{T_S = T_M + 7.689 \times 10^{-14} D^4 - 3.888 \times 10^{-9} D^3 + 3.619 \times 10^{-5} D^2 + 2.702 \times 10^{-1} D}{100} \quad (1)$$

where T_S = equilibrium temperature in °F

T_M = measured temperature in °F

D = depth of measured temperature in feet

The formula was determined statistically from temperature data obtained from 602 oil wells in Texas and Louisiana (Kehle, 1972). The range of corrections is 0°-33°F, with the maximum correction applied at about 12,000 feet. Unfortunately, the correction formula is based on depth only and not on circulation data. It also tends to make excessively large corrections for shallow depths (less than 3,000-4,000 feet, 915-1,220 meters). Nonetheless, the formula was used in this study for lack of anything better. A more realistic and reliable technique to correct temperatures was discussed by Fertl and Wichmann (1977) and Dowdle and Cobb (1975). This method requires information on circulation time as well as multiple temperature readings at the same depth at different times after circulation stops. Because almost none of the data on file with the Division of Oil and Gas included the latter information, the technique was not used.

All temperatures were easily corrected with a programmable calculator and were used later to calculate an approximate geothermal gradient (change of temperature with depth) for each well. The geothermal gradient was calculated using the basic formula for a straight line:

$$T = ax + b \qquad (2)$$

where T = temperature in °F

a = geothermal gradient in °F/ft.

x = depth in feet

b = mean annual air temperature

Kehle (1973) discussed a correction to this calculated gradient that used uncorrected bottomhole temperatures and a rearranged version of formula (1) in order to reduce the excessive corrections at shallow depths. Information on this correction was not received for the present study, however, until after the original correction technique (formula 1) had already been applied to all bottomhole temperatures and subsequent gradient calculations.

In all cases, a mean annual air temperature of 64°F was selected, which is about average for both the Los Angeles and Ventura Basins. The geothermal gradient was converted to °C/100 meters by multiplying by 182.28.

When only a single temperature was recorded, that temperature and its depth and the mean annual temperature of 64°F at 0 feet depth were used to determine the gradient. When multiple readings were made at different depths, these and the 64°F at 0 feet depth were entered into the programmable calculator and a linear regression (least squares fit) was computed to determine the gradient.

All calculated gradients were used to compile <u>relative</u> geothermal gradient maps of both the Los Angeles and Ventura Basins (Plates 1 and 3). Where many gradients were clustered in a small area (generally a section in a township), a mean value was computed and this value plotted as a representative gradient at the approximate areal center of the group. Contouring of the gradients was not attempted because of the lack of control when temperatures were recorded under non-equilibrium hole conditions. The temperature corrections reduce the effects of non-equilibrium somewhat, but in most cases, the calculated gradients are probably still lower than the true gradients. For this reason, the strength

of the calculations and their display on Plates 1 and 3 lies in their relative rather than absolute values. As such, "groupings" of relative ranges of gradients are presented on Plate 1. The highest gradients suggest the warmest areas, while the lowest gradients suggest the coolest areas. Groupings were not made on Plate 3 because of the close similarity of the gradients in all areas.

In some cases on Plate 1, the gradients plotted do not necessarily coincide with the description of the groupings in the legend. One example is the Inglewood Oil Field, which has gradients among the highest calculated for the map. Most wells in this field are very shallow, however (less than 3,500 feet). Regardless of the applied corrections, geothermal gradients calculated from bottomhole temperatures in shallow wells tend to be excessively high. The shallower the well, generally the more abnormally high the gradient. Consequently, fields with an abundance of shallow wells will have relative gradients calculated from bottomhole temperatures skewed to the high side. Whittier Oil Field is another field with shallow wells that show similar effects.

In contrast, fields with predominantly directional drilling, such as in the northern Los Angeles Basin, will have relative gradients skewed toward the low side. The logs for directionally drilled wells list "depth" as the length of the hole rather than the true vertical depth. If the hole is radically slanted from the vertical and is long, the resultant calculated gradient will be abnormally low. The solution to this problem, of course, is to calculate the true vertical depth of the hole, but generally this involves time-consuming research of well histories that don't always have directional surveys available.

Several sources of data (Tutschulte and Nichols, 1950; unpublished data from oil companies that is mostly listed in Appendix B) were used in addition to the data on bottomhole temperatures to determine approximate absolute geothermal gradients for all of the oil fields. The results are tabulated in

Appendix B and discussed briefly in the next sections.

It is emphasized that the absolute gradients are best averages and may differ significantly from actual subsurface conditions; true geothermal gradients in a sedimentary basin almost never follow a straight-line curve because of variations in rock type, influences of groundwater, and circulation of water along fault zones. In the case of geothermal gradients determined from bottomhole temperatures, the more readings made in a hole, the closer the value to the true geothermal gradient. Holes with only one temperature reading are the least reliable.

Geothermal Gradients in Los Angeles Basin

As presented in Plate 1 and Appendix B, geothermal gradients in the Los Angeles Basin (about 3.0 - 6.0°C/100 meters) are about the same or well above the average for continental crust, which is considered in this study to be about 3.0°C/100 meters. The highest gradients are in the Palos Verdes geothermal province, in the northernmost part of the Los Angeles Basin province, and possibly in a small area of the Puente Hills province, although data for this area are meager. The lowest gradients seem to be associated with the deepest part of the sedimentary basin in the Los Angeles Basin province. Moderate gradients are associated with the Newport-Inglewood Structural Zone and the Whittier Fault Zone.

The most important variable that seems to affect geothermal gradients in the Los Angeles Basin is depth to basement (Figure 6). Shallow depths (basement "highs") generally coincide with high gradients, whereas the greatest detphs (basement "lows") generally coincide with low gradients. Examples are the Torrance, Wilmington, and Venice Beach Oil Fields, which lie along anticlinal axes. Their gradients are the highest in the Basin (5.5 - 6.0°C/100 meters) and the depths to basement are only about 1,200-3,000 meters (Figure 6, Plate 1).

Similarly, high gradients seem to characterize the fields northwest of downtown Los Angeles where a "hill" of basement rises to within about 1,800 meters of the ground surface. In contrast, the deeper parts of the sedimentary basin (6,000-10,000 meters), which include the Santa Fe Springs Oil Field, are characterized by the lowest gradients, although data are sparse where the depth to basement is greatest (Plate 1).

Evidently, the areas of shallow depth to basement have higher gradients because the basement, which is composed of warm crystalline rocks that have high thermal conductivities compared to the overlying sediments, is brought closer to the ground surface. The cover of sediments acts as a "blanket" of insulation (low thermal conductivity) that is warmed by the basement. Consequently, the sediments are heated more than those at equivalent depths elsewhere where the basement is much deeper. This degree of warming is reflected in the measured temperatures in the oil wells. If the sediment cover is too think (basement very near the ground surface), however, the insulation is not adequate to retain as much heat. If sediments are very thick (Los Angeles Basin province), the basement is at too great a depth to heat the shallower parts of the sediment cover. The effects of insulation then act disadvantageously so that temperatures measured at equivalent depths are not as high as those in the areas of shallow basement.

It is not clear what effect extensional and compressional tectonism have on geothermal gradients in the Los Angeles Basin. Areas of tension produce normal faults ("open" fractures), whereas areas of compression produce thrust and reverse faults ("closed" fractures). Both types of stress are present in strike-slip fault zones such as the Newport-inglewood, although one type may dominate over the other. For example, it appears that the geothermal gradients of the oil fields along the Newoport-Inglewood zone increase from

the Potrero Oil Field to the Newport Oil Field in Orange County (Table 3). The fields with the lower gradients (Potrero, Howard Townsite, Rosecrans, Dominguez) are characterized by reverse faults (compression), while the fields with higher gradients (Seal Beach, Huntington Beach, Newport) are characterized by normal faults (extension). Furthermore, the Torrance and Wilmington Oil Fields, which have the highest gradients in the Basin, are also dominated by extension (normal faults) rather than by compression (Figure 8). Still, it appears that depth to basement exerts the dominant influence on geothermal gradients in these fields (Huntington is on an anticlinal axis and both Huntington and Newport are on basement highs). It may or may not be coincidental that the fields with the highest gradients are also characterized by tensional stresses.

Geothermal Gradients in Ventura Basin

The technique of using bottomhole temperatures was used to compile a relative geothermal gradient map of the Ventura Basin (Plate 3). Compared to the Los Angeles Basin, the gradients are significantly lower (approximately 3.0°C/100 meters), but still suggest an "average" geothermal gradient for the area. Absolute gradients for most of the fields were more difficult to determine than those in the Los Angeles Basin because of insufficient data. Groupings of the gradients were not performed on Plate 3 because all of the gradients were too similar to allow distinctions.

TABLE 3

ESTIMATED GEOTHERMAL GRADIENTS OF OIL FIELDS

ALONG THE NEWPORT-INGLEWOOD STRUCTURAL ZONE

(Listed from north to south)
Gradients in °C/100 meters

Cheviot Hills	3.6
Inglewood	4.0
Potrero	3.5
Howard Townsite	3.5
Rosecrans	3.5
Dominguez	3.5-4.0
Long Beach	3.5-4.0
Seal Beach	3.8-4.0
Huntington Beach	4.9*
Newport	5.1**

* From Tutschulte and Nichols (1950).

** From Texaco, U.S.A. (unpublished data).

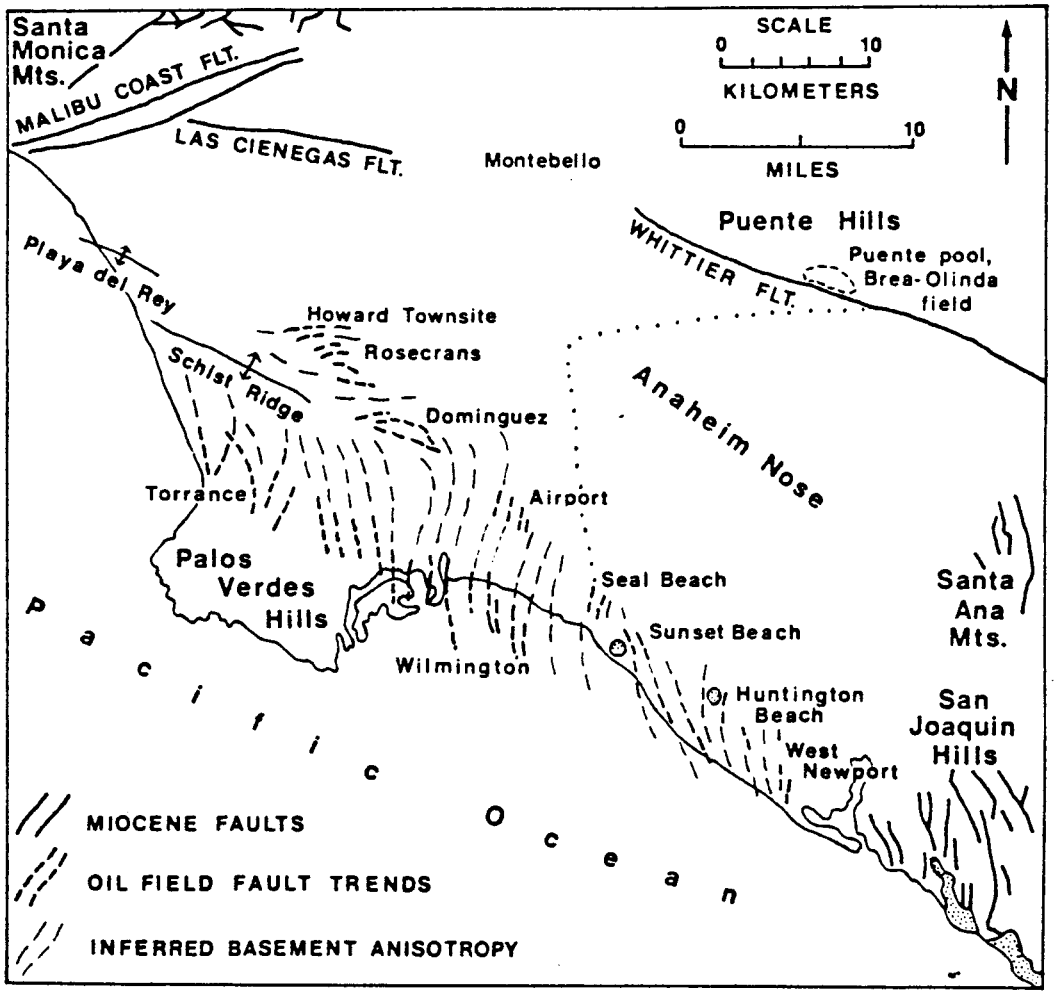


FIGURE 8 - Inferred basement anisotropy in Catalina Schist (basement) based on fault trends in oil fields. Northerly-trending faults are predominantly normal; easterly-trending faults are predominantly reverse. Figure from Yeats (1973).

OIL FIELDS AS SOURCES OF GEOTHERMAL ENERGY

INTRODUCTION OF CONCEPT

Many oil fields in the world, including those in Los Angeles County, produce thermal water and oil (>25°C) mainly because of the general increase of temperature with depth in the Earth's crust. The water and oil produced from depths of a few thousand meters will be warm or hot even without an anomalous high-temperature source of heat, such as a body of magma. Although temperatures of the fluids are generally low-grade (less than boiling) and many fields produce very small volumes, the real attraction of the fields is that they are ready-made sources of geothermal energy. The complex and expensive phases of exploration, development, and production, normally associated with the exploitation of a geothermal resource, are already accomplished because of the production of petroleum. Technologically, all that remains is the extraction and distribution of heat from the waste water from the oil operations. No wells need to be drilled nor facilities constructed to handle the produced fluids. Upon extraction with a heat-exchanger, the heat could be distributed via a secondary fluid to users adjacent to the oil fields; space conditioning and industrial processes are the most likely applications.

FACTORS THAT AFFECT THE USE OF OIL FIELDS FOR GEOTHERMAL ENERGY

There are many factors that will determine if an oil field can be used as a source of geothermal energy. These range from the physical-chemical characteristics of the field to various legal, economic, and cultural considerations. The most important factors regarding the oil fields in Los Angeles County are briefly discussed below.

Temperature and Volume of Produced Fluids

An oil field must provide water in sufficient volumes at high enough temperatures to support substantial energy uses outside of the field operations. The amount of energy gained from the field must justify the expense of installation, use, and maintenance of equipment for the extraction and distribution of

geothermal heat. Of course, the higher the temperature and the larger the volumes of water, the more competitive this form of energy will be with conventional sources of energy.

A good discussion of the temperatures required for various applications is presented in Anderson and Lund (1979).

Retention and Disposal of Heat in Oil Operations

Depending on the properties and modes of operation of an oil field, there may be needs to either retain or dispose of the heat associated with the production of oil and water. Also, in some fields it may not matter whether or not heat is retained in the system; removal of heat will have no adverse effect on the system.

Many oil operators believe that the elevated temperatures of produced oil and water aid separation of the two liquids as well as reduce oil viscosity, thus improving recovery from the reservoir. For these reasons, some operators are reluctant to remove heat from their processes of oil recovery. Commonly, fields with low-gravity (high-viscosity) oil, such as Torrance and Wilmington, are in this category. In some fields, when oil is dispersed in water as tiny droplets (termed an "emulsion") as the fluid enters the process of oil-water separation, naturally-elevated temperatures of the fluid reduce or eliminate the need for "heater treaters", devices which artifically heat the emulsion to separate the oil and water. In these cases where the retention of heat is advantageous, the heat associated with field production is actually an application of a geothermal resource. After the production and treatment processes that use elevated temperatures for efficient recovery, heat could be extracted from the waste water if the water is to be sent to the sewer or other means of surface disposal.

To a much lesser extent, some operators must dispose of heat from the produced fluids. The natural temperatures of the fluids are too high and must be reduced either because of their adverse effects on field equipment or, if the waters are sent to a sewer system, because local statute requires that they be cooled to a certain temperature. Such operations are ideally suited to projects that could apply the heat to beneficial uses. Venice Beach and Lawndale Oil Field are examples.

The third situation arises when the amount of heat in a field operation has no favorable or adverse effect on the operation. Extraction of heat would not adversely affect the reservoir or oil operations, and thus the field could provide energy to outside uses. There is probably no way to know if a field is in this category, however, until heat is actually removed under controlled conditions and the resultant effects on the field monitored.

Chemical Equilibria

Most oil field waters contain large amounts of dissolved solids that are capable of forming precipitates if the chemical or physical characteristics of the water are changed. If the precipitate adheres to a surface, such as a well-casing or pipes in a surface facility, it is termed "scale." The most commonly formed scales in oil field waters and the properties that affect their formation or solution are shown in Table 4.

The main concern with regard to extraction of heat from oil field waters is whether the reduction of temperature will cause formation of scale in production wells, injection wells, or treatment facilities. Also, reduction of temperature may cause formation of precipitates that could be filtered by a rock formation as the water is injected into it. Eventually, the formation will plug so that water can no longer be injected into it.

According to Table 4, calcium carbonate, calcium sulfate, barium sulfate, and strontium sulfate are strongly affected by variations in temperature.

Name	Chemical Formula	Primary Variables
Calcium Carbonate (Calcite)	$CaCO_3$	Partial Pressure of CO_2, Temperature Total Dissolved Salts
Calcium Sulfate		
Gypsum (Most Common)	$CaSO_4 \cdot 2H_2O$	Temperature, Total
Hemi-Hydrate	$CaSO_4 \cdot \frac{1}{2}H_2O$	Dissolved Salts,
Anhydrite	$CaSO_4$	Pressure
Barium Sulfate	$BaSO_4$	Temperature, Pressure,
Strontium Sulfate	$SrSO_4$	Total Dissolved Salts
Iron Compounds		
Ferrous Carbonate	$FeCO_3$	
Ferrous Sulfide	FeS	Corrosion, Dissolved
Ferrous Hydroxide	$Fe(OH)_2$	Gases, pH
Ferric Hydroxide	$Fe(OH)_3$	
Ferric Oxide	Fe_2O_3	

TABLE 4 - Most common scales formed in oil field waters (from Patton, 1977).

SCALE	SOLUBILITY (mg/L)
Gypsum ($CaSO_4.H_2O$)	2,080.0
Strontium Sulfate	114.0
Calcium Carbonate	53.0
Barium Sulfate	2.3

TABLE 5 - Comparative solubilities of scales in distilled water at 25°D (data from Patton, 1977).

Each is discussed briefly below. Methods for determination of solubility of each for specific water chemistry are given in Patton (1977).

Calcium Carbonate:

$$Ca^{+2} + CO^{-2} \rightleftharpoons CaCO_3$$

$$Ca^{+2} + 2HCO_3^- \rightleftharpoons CaCO_3 + H_2O + CO_2$$

Unlike most compounds, calcium carbonate becomes more soluble as the temperature is reduced, thus, scaling may be less likely (Figure 9). Furthermore, the more dissolved solids (other than Ca^{+2}, CO_3^{-2}, HCO_3^-) present, the higher the solubility of $CaCO_3$, which also means less likelihood of scaling. Consequently, the reduction of temperature of oil field waters may be beneficial rather than adverse in regard to formation of $CaCO_3$ scale. It must be kept in mind, however, that if a water does not form $CaCO_3$ scale at the surface, it could form scale in injection wells if the formation temperatures are sufficiently high (Patton, 1977). Also, pressures <u>must</u> be maintained in the system as $CaCO_3$ may precipitate when pressures are reduced.

Calcium Sulfate:

$$Ca^{+2} + SO_4^{-2} \rightleftharpoons CaSO_4$$

As shown in Figure 10 precipitation of calcium sulfate can be either in the hydrous (gypsum) or anhydrous (anhydrite) forms. Below 40°C, gypsum can be expected and its solubility tends to decrease as the temperature is lowered. Above 40°C, the solubility of gypsum increases with decreasing temperature. Anhydrite is more insoluble, however, and may precipitate instead of gypsum, although it should be noted that its solubility also increases with a reduction in temperature. A reduction of pressure, if associated with a reduction of temperature, may cause formation of scale (Patton, 1977).

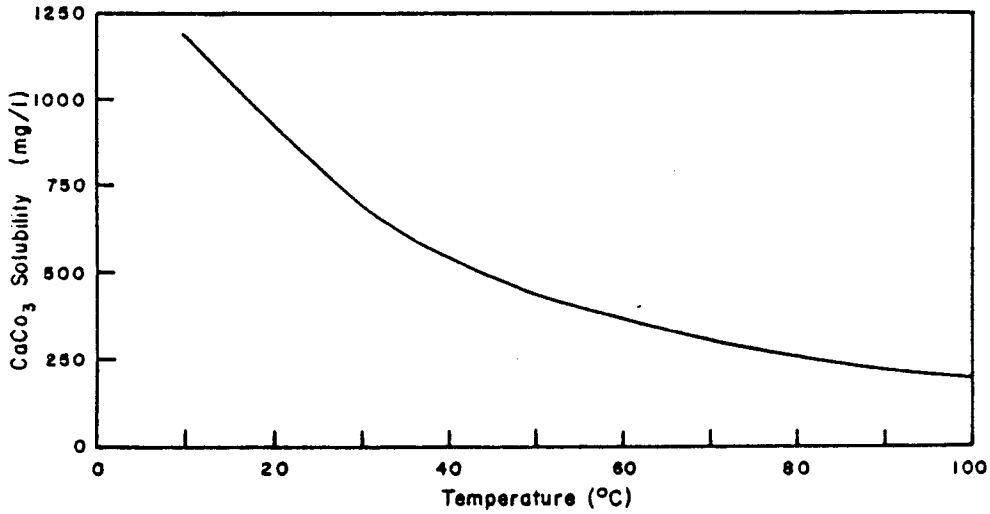


FIGURE 9 - Solubility of calcium carbonate in pure water at 1 bar CO_2 partial pressure (from Patton, 1977).

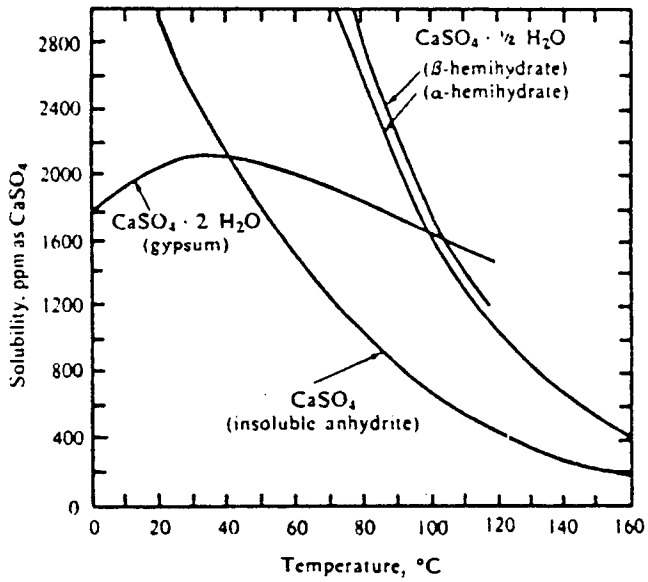


FIGURE 10 - Solubility of calcium sulfate in pure water (from Patton, 1977).

In summary, if temperatures are reduced to no lower than about 40°C, calcium sulfate may not form. If they are reduced below 40°C, scale may form. To counteract the effects of lowered pressure on formation of scale, sufficient pressure should be maintained while the temperature is reduced.

Barium Sulfate:

$$Ba^{+2} + SO_4^{-2} \rightleftharpoons BaSO_4$$

Of the four major precipitates discussed, barium sulfate has by far the lowest solubility (Table 5). This characteristic makes it very likely that scale will form if both barium ions and sulfate ions are present in the water (Patton, 1977). As the temperature is reduced, barium sulfate becomes more insoluble; Patton (1977) estimated that as the temperature is raised from 25°C to 95°C, the solubility is doubled regardless of concentration of dissolved solids.

Strontium Sulfate:

$$Sr^{+2} + SO_4^{-2} \rightleftharpoons SrSO_4$$

Strontium sulfate almost always coprecipitates with barium sulfate (Patton, 1977). As temperatures are reduced, it becomes less soluble, except that its solubility is much greater than that of barium sulfate.

The iron compounds listed in Table 4 usually form scales as a result of corrosion caused by reaction of iron with the gases carbon dioxide, oxygen or hydrogen sulfide. Oil field operations generally have systems to alleviate these problems, however.

Another consideration is the formation of "paraffin", a waxy substance deposited from crude oils as they cool when flowing from the production zone to the treatment and storage facilities. Paraffin is not known to be a problem

in the oil fields of Los Angeles County, possibly because of the petroleum's chemistry or because of the elevated temperatures of the oil and water as they move through the production and treatment systems.

Facilities and Space Requirements

What type of heat-extraction system, where to locate it in the field, and how much space the equipment will take are important considerations.

Heat from a field could be extracted and distributed to a user either by sending the produced thermal waters directly to the user and then returning them to the field for injection or disposal or by installing a heat exchanger in the field that would transfer heat from the produced waters to a secondary fluid that would then circulate to the user. Because all of the fields in Los Angeles County produce highly saline waters that can cause scaling and/or corrosion, the latter technique is more realistic. Distribution of the field waters to outside users would not only disrupt the chemical equilibria of the field's treatment facilities, but also require expensive distribution equipment capable of withstanding attacks of scaling and corrosion.

Produced oil and water in all of the major oil fields in Los Angeles County are collected and treated either at "urban drill sites" or at centralized facilities designed to handle large volumes (Figures 11, 12). Both eliminate the need for local tanks at individual wells. By virtue of the quantities of fluid they process, the two types of facilities are also the best sites in the oil fields for extraction of heat. The urban drill sites are small sites in densely urbanized areas from which many production and injection wells are "directionally" drilled (slanted from the vertical). Oil and water are generally separated at the site and the water is either injected back into the producing zone to sweep more oil out of the reservoir (a "water flood"), injected via

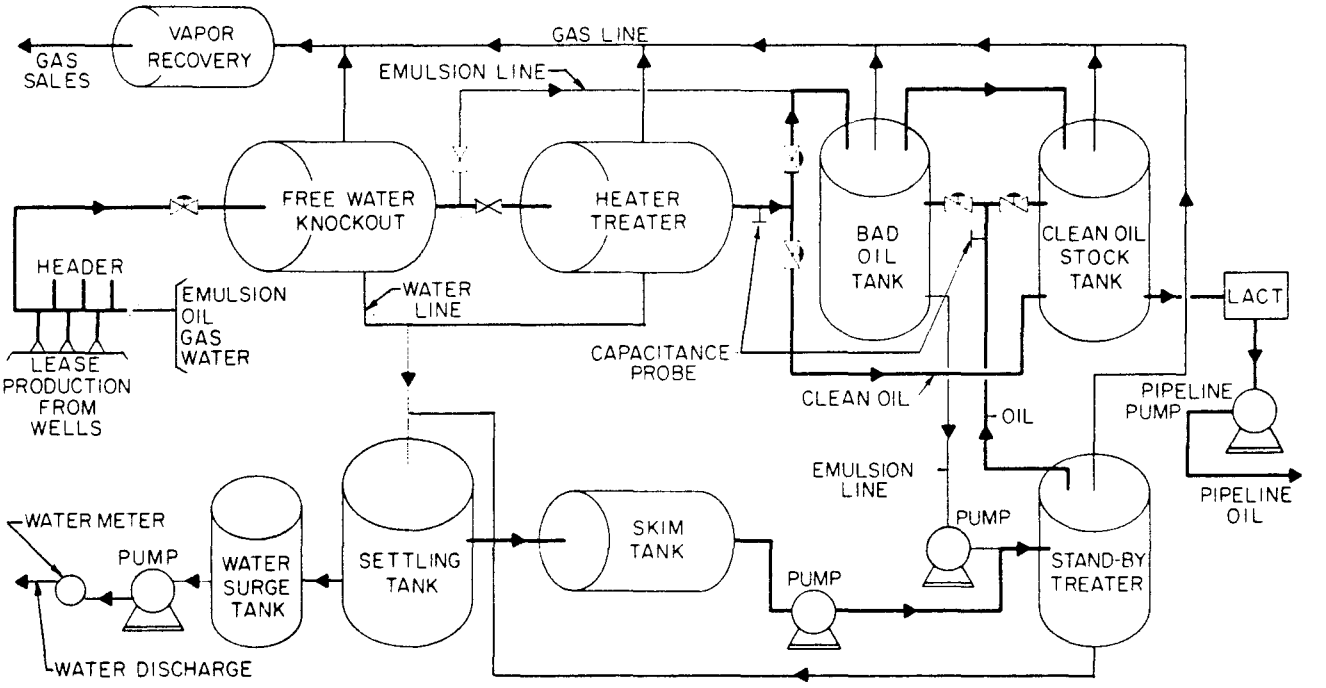


FIGURE 11 - Typical central treatment system for handling oil, gas, water, and emulsion. (Diagram from American Petroleum Institute, 1976).

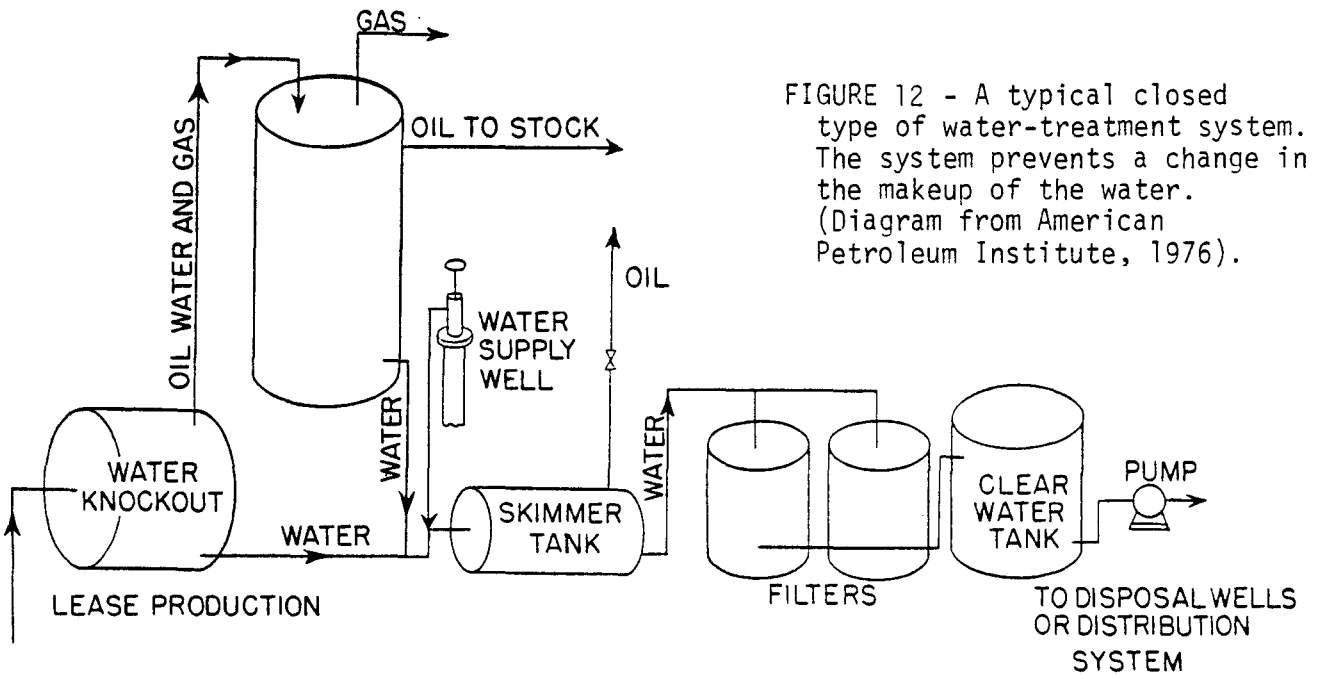


FIGURE 12 - A typical closed type of water-treatment system. The system prevents a change in the makeup of the water. (Diagram from American Petroleum Institute, 1976).

"disposal" wells into a non-producing formation, or disposed of at the surface, such as in a sewer system. The first water-removal process requires the most caution in regard to formation of scale, while the last process allows almost ideal conditions for extraction of heat. One or more of these three processes of handling waste water are also used at the centralized treatment facilities.

Many of the drill sites and central treatment facilities are very compact and have just enough space for essential equipment. Space may or may not be adequate to install heat-extraction equipment at these sites. Many fields are still rural, however, and space is not a problem.

Urban Encroachment on Oil Fields

Frequently, the value of land as a site for oil operations is matched or exceeded by the value of that same land for other uses, such as real estate development (residential, commercial, industrial). Nearly all of the oil fields in the northernmost Los Angeles Basin have been overrun by urban development. Consequently, all oil operations at these fields are conducted from urban drill sites, many of which have limited space for operations. Similarly, operations in other fields have been either severely diminished or abandoned because the value of the land for development of real estate has exceeded the value of the oil in the field. The effects of future urban encroachment on a field should be determined to be compatible with the use of the field for geothermal energy over a long-term period before a system is constructed to extract and use that energy.

Applications of Extracted Heat

The most attractive oil field is one that has high temperatures and volumes of production and is situated in an industrial-commercial area. An alternative is to locate new development adjacent to oil field facilities and design the structures and their uses to take advantage of heat extracted from the field.

Because of the relatively low temperature of fluids produced from the oil fields in Los Angeles County, most potential applications will probably be in low-grade industrial processes and high-occupancy residential and commercial structures. Because of the county's mild climate, energy for heating structures is not in as much demand as energy for cooling them.

Ownership of Heat and Regulation of Its Cost and Use

Before heat is extracted from an oil field and used outside of the field operations, ownership of the legal rights to that heat must be determined. Ownership by the oil operators is not obvious because, in many cases, they only own the rights to extraction of petroleum, especially on land owned by the County of Los Angeles or other non-petroleum interests. Furthermore, when it is established who owns and can sell the heat, it must be determined who will regulate both its use and cost to consumers. Also to be determined is who will be responsible for construction of and maintenance of the heat-extraction equipment that supplies the users.

Future of the Oil Fields as Sources of Heat

Assuming that heat-extraction projects are successfully established in Los Angeles County, the life expectancy of these projects will be strongly tied to the life expectancy of the oil field and its associated operations. Once oil recovery costs exceed the value of the oil in the field, abandonment of operations may be the only alternative; wells will be plugged and surface facilities dismantled and removed. Pressures for development by real estate interests may hasten abandonment as discussed earlier.

The recent decontrol of prices of domestic oil produced in this country has lengthened the life expectancy of the major oil fields in Los Angeles County. Most, if not all, will continue operations past the year 2000. In fact, some operators may expand their operations to produce higher volumes than at present.

It is possible that, when fields do reach the point of abandonment because of depleted reserves, instead of plugging wells and dismantling the treatment facilities, the field operations could be continued to produce thermal water. As production of oil phases out, production of thermal water could be phased in. The critical question, of course, is whether or not such a conversion will be economic; the value of the heat obtained will have to outweigh the cost to produce it. Currently, at the Damson operation in Venice Beach Oil Field, one barrel of oil costs about $0.29 to produce, excluding the costs of drilling and maintenance of wells (David Lefler, personal communication, 1981). Presently, the costs to lift and process water for the heat are too high to justify operation of fields in Los Angeles County for that purpose. In time, perhaps the economic situation will change and "thermal water fields" converted from "abandoned" oil fields will become a reality.

Another idea is that, in the future, new wells could be drilled in the hottest fields to tap hot water at depth. Corson (1981) reported that many district heating projects in the Paris Basin, France, are tapping hot water at moderate depths and temperatures from the underlying sedimentary basin. The Melun district, for example, is withdrawing 70°-73°C (about 160°F) water from wells at depths of 1,800 meters (about 6,000 feet). In comparison, some parts of the Los Angeles Basin would produce boiling water from wells that deep.

Cooperation of the Oil Operators

Of course, any heat-extraction project cannot proceed without the cooperation of one or more field operators. As discussed in the next section, the attitudes of operators vary to extremes depending largely on many of the above factors.

EVALUATIONS OF OIL FIELDS IN LOS ANGELES COUNTY

The oil fields of Los Angeles County are in two major areas, the Los Angeles Basin (Figure 13) and the easternmost part of the Ventura Basin (Figure 14). Of the 72 fields wholly or partially in the county, 54 are active, 37 in the Los Angeles Basin and 17 in the Ventura Basin. The remaining 18 (Table 6) are abandoned or inactive.

The following discussion briefly summarizes the evaluations of the active fields in the county as sources of thermal water for applications. A rating of relative potential of the fields is presented in Table 7. Detailed evaluations and data, including temperatures, geothermal gradients, production, and chemistry, for individual fields are presented in Appendices A, B, and C. Photographs of various operations are in Appendix E.

QUESTIONNAIRE

The most important sources of data used to evaluate the county's oil fields as sources of heat were the California Division of Oil and Gas and the many oil operators in the county. The files and reports of the Division of Oil and Gas are centralized and easily accessible, but data from the operators, who are numerous and geographically dispersed, are not readily available.

Both to save time and to establish a consistent means of collection of opinions, advice, and field data, a questionnaire was sent to 40 major operators in Los Angeles County. A copy of the questionnaire, a tally of its results, and the names and addresses of the contacted operators are presented in Appendix D.

Thirty operators (75%) formally responded to the questionnaire; those that did not respond are noted with an asterisk in Appendix D. The tone of the responses about the concept of heat extraction from oil fields in the county

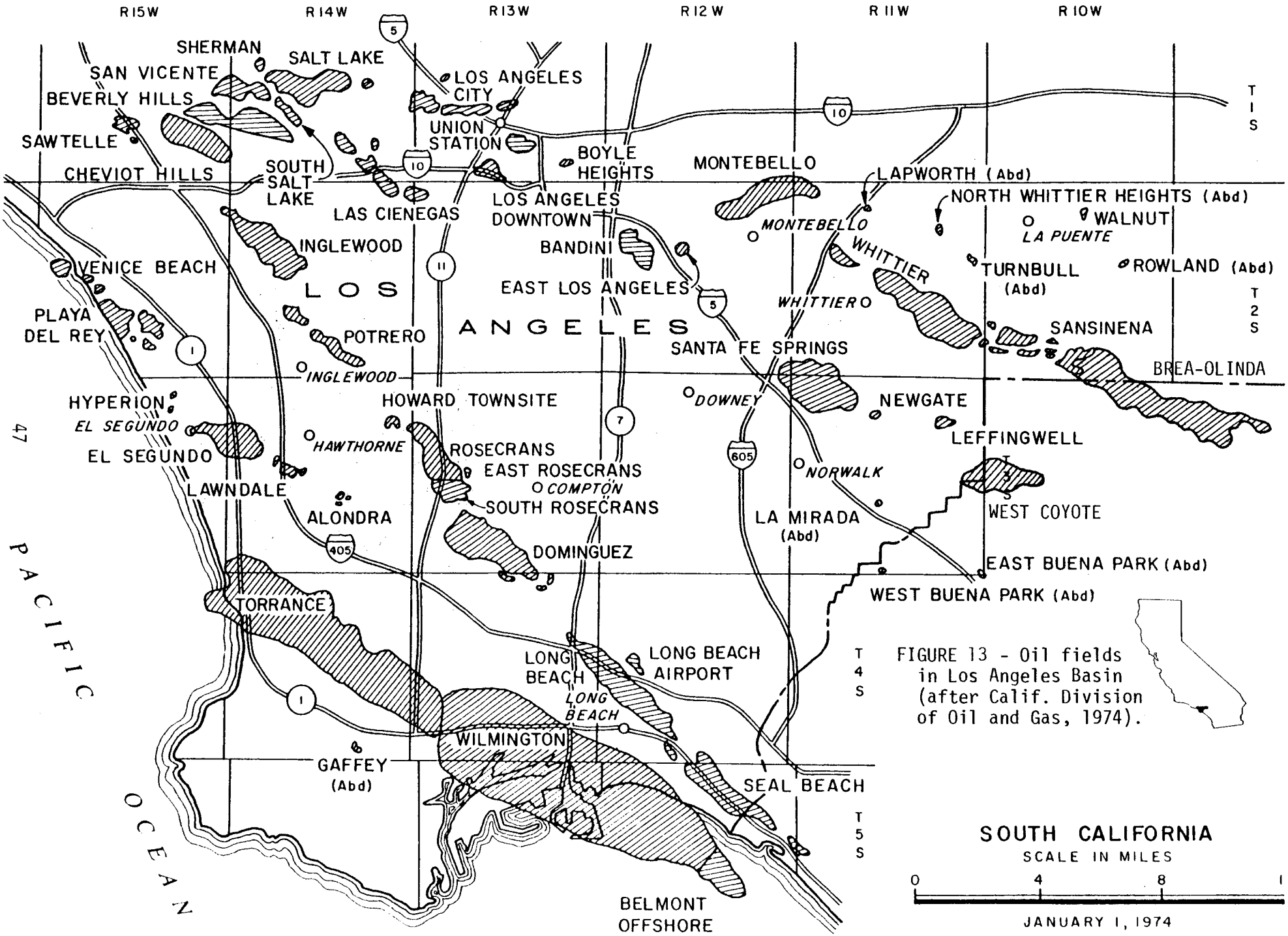


FIGURE 13 - Oil fields in Los Angeles Basin (after Calif. Division of Oil and Gas, 1974).

FIGURE 14 - Oil fields in Ventura Basin (after Calif. Division of Oil and Gas, 1974).

SOUTH CALIFORNIA

SCALE IN MILES

0 4 8 12

JANUARY 1, 1974

TABLE 6

ABANDONED OR IDLE OIL FIELDS IN LOS ANGELES COUNTY

FIELD	YEAR ABANDONED
Bouquet Canyon	1971
Boyle Heights	1973
Canoga Park	Idle since 1963
Canton Creek	Idle since 1970
Charlie Canyon	1963
Elizabeth Canyon	1954
Gaffey	1967
Horse Meadows	1966
La Mirada	1954
Lapworth	1943
Leffingwell	1973
Mission	1977
Ramona North	1947
Rowland	1946
Sherman	1973
Turnbull	1965
Walnut	1977
Whittier Heights	1970

ranged from positive to negative with a preponderance of responses in the neutral to negative range. Many believed that, although the theory of the concept is good, the extraction of heat is not currently economic or desirable for various reasons, which are presented in Appendix D. Significantly, however, no operators had done formal studies of recovery of heat from their operations as a source of useful energy. Chevron made some informal calculations for some of its operations some time ago but found heat extraction to be uneconomic (Bob Schmidt, personal communication, 1981).

Several operators (those in the Venice Beach, Lawndale, Alondra, and El Segundo Oil Fields) were interested in possible use of heat from their operations for adjacent applications because they must cool their waste water before it can be disposed of. Some operators in other fields were enthusiastic about heat extraction, but they most often cited retention of heat in their operations as the greatest hindrance to outside uses. In a few cases, excessive government regulations and interference were cited as major hindrances.

Nearly all operators agreed that the best site for heat extraction from a field would be somewhere within or after the central treatment facility. A heat exchanger would be required because of the poor chemical quality of the water.

The results of the questionnaire, although providing useful insights and opinions, emphasized that there are numerous unanswered questions that probably can't be resolved until major studies are undertaken at individual fields. The results should not be considered conclusive facts but rather <u>initial</u> observations and opinions that could change radically as specific problems are solved. Also, the field operations are forever changing in details; what might not be feasible now, may be feasible in the near future.

OIL FIELDS IN LOS ANGELES BASIN

The oil fields in the Los Angeles Basin (Figure 13) are the most promising sources of geothermal heat in the county. The discussion below is intended to summarize briefly the data presented in Appendices A, B, and C.

Production and Temperatures

Most production in the oil fields of Los Angeles Basin is from Miocene-Pliocene marine sediments less than 6,000 feet deep; the largest proportion is from 3,000-6,000 feet. The deepest known well in the Basin is Central Core Hole 1, an exploratory hole drilled to about 21,000 feet near Watts in the 1970's (Plate 1).

Daily volumes of water produced in the fields range from only a few barrels (1 barrel = 42 gallons = 160 liters) at Hyperion to over a million at mammoth Wilmington. Except for Wilmington, Inglewood, Long Beach, and Torrance, all fields produce less than 50,000 barrels/day (<1,500 gallons/minute). In most fields, water constitutes at least 85% of the produced fluid (oil plus water). Many of the fields produce too little water to be of any use for large-scale applications. Temperatures of produced fluid (oil plus water) range from ambient air to boiling, but are mostly in the 100°-150°F (38°-65°C) range. Approximate volumes and temperatures of production and injection/disposal at most of the Basin's centralized treatment facilities are presented on Plate 2.

Chemistry of Oil Field Waters

Because nearly all field production is from marine sediments, the associated waters are "fossil" sea water that have salinities generally in the range of 15,000-35,000 mg/liter NaCl. In the largest fields, the waters are treated at centralized facilities and injected back into the reservoir as water floods, which are used to sweep additional oil from the reservoir. The smallest fields generally dispose of their produced water via sewer systems.

Scaling and corrosion are problems that develop because of the salinity of the waters, although the degree of each is highly variable depending on the field and the operator. Sometimes problems are encountered when an operator commingles dissimilar produced waters and injects them or when fresh ("make up") water is added to produced water to increase the volume for injection in a water flood. Bacteria, gases, and the scales discussed earlier are all problems to some extent in the the Basin, but each field's problems are unique and must be solved individually. The fluid-treatment systems are commonly elaborate, and some operators may be reluctant to tamper with them for fear that extraction of heat may adversely disrupt the systems' equilibrium.

Locations of Fields and Facilities Relative to Potential Applications

A powerful advantage of the oil fields as sites for heat extraction is that all are near abundant potential applications. Those in commercial-industrial areas are considered the best locations, whereas those in single-home residential areas are the least favorable. Most of the large fields are near or within commercial-industrial areas. Space for facilities is a problem, however, in the fields in the northernmost part of the Basin, in parts of Torrance and Wilmington Oil Fields, and possibly in parts of Long Beach Oil Field.

OIL FIELDS IN VENTURA BASIN

The oil fields of the Ventura Basin (Figure 13) have a much poorer potential as sources of heat than those of the Los Angeles Basin. The gradients are lower, production and temperatures are significantly less, and the potential applications at existing population centers are limited. The discussion

below briefly summarizes the information presented in Appendices A, B, and C.

Production and Temperatures

Production is mostly from Miocene-Pliocene marine sediments that have been folded and faulted. Depths of production are highly variable, but almost all are less than 10,000 feet. In one of the largest fields, Placerita, they are less than 2,000 feet.

Most of the fields are too small to consider as sources of heat; few fields produce more than a few thousand barrels/day of oil plus water. Temperatures are mostly ambient or in the low 100's°F; some are higher because of artificial heating to separate the oil and water.

Chemistry of Oil Field Waters

As in the Los Angeles Basin, the waters here are highly saline because production is mainly from marine sediments. Some have very low salinities, however, because production is from shallow depths that are influenced by fresh water. In most cases, salinities are less than 25,000 mg/liter NaCl.

Because of the generally lower salinities, scaling and corrosion may not be as severe in the Ventura Basin as in the Los Angeles Basin. Nevertheless, each field has its unique chemistry and associated problems, which must be dealt with individually.

Locations of Fields and Facilities Relative to Potential Applications

The Ventura Basin is largely rural and sparsely -populated except for the city of Newhall and vicinity. Most fields are too isolated to serve as sites of heat extraction unless future development were planned in areas adjacent to these fields. The Newhall area is predominantly single-home residential, which is not as desirable for applications as is commercial-industrial areas or sites of high-occupancy use.

RELATIVE RATINGS OF THE OIL FIELDS

Many of the factors discussed earlier regarding the use of the oil fields for geothermal energy were used to estimate the relative potential of each

active field in the county (Table 7). The factors included temperature, volume, chemistry, type of collection-treatment-disposal system, availability of space, proximity to applications, and enthusiasm of the operators. Temperature, volume, and proximity to applications were given the most weight in rating the fields. Each field is discussed in more detail in Appendix A.

The ratings are not rigid, of course, and represent a first estimation by the author. Certainly, more information could change the rating substantially. Nonetheless, those rated as "good" or "excellent" should probably be the first ones investigated for heat-extraction projects.

TABLE 7

RELATIVE POTENTIAL OF OIL FIELDS AS SOURCES OF GEOTHERMAL ENERGY

Symbols Used:
- ++ Excellent or very favorable
- + Good or favorable
- 0 Fair or neutral
- - Poor or unfavorable

LOS ANGELES BASIN

FIELD	Temperature	Volume	Chemistry	Treatment Process	Available Space	Proximity to Applications	Operator Enthusiasm	FINAL RATING
Alondra	++	-	0	++	+	+	++	Good
Bandini	- to 0	0	0	++	+	+	?	Fair
Beverly Hills	+	+	0	+	0 to -	+	0	Good
Brea-Olinda	+	0	0	0	+	-	0	Poor
Cheviot Hills	0	0	0	+	-	0	0	Fair
Coyote West	0 to +	++	+	+	+	-	0	Fair
Dominguez	+	+	0	+	++	++	0	Good
El Segundo	++	0	+	++	+	++	++	Good
Howard Townsite	-	-	0	++	++	+	-	Poor
Hyperion	++	-	+	++	+	0	-	Poor
Inglewood	+	++	0	+	+	++	0	Good
Las Cienegas	+	+	+	+	0 to -	+	0	Good
Lawndale	++	0	0	++	++	++	++	Excellent
Long Beach	+	++	0 to -	+ to 0	0	+	0	Good
Long Beach Air.	-	-	0	+	+	++	-	Poor
Los Angeles City	-	-	++	-	-	0	-	Poor
Los Angeles Dtn.	+	0	0	+	0	+	0	Fair
Los Angeles East	++	0	0	++	++	++	?	Good
Montebello	0	+	+	++	++	+	0	Good
Newgate	0?	-	0	++	+	+	0	Poor
Playa del Rey	++	-	0	-	-	0	-	Poor
Potrero	-	0	0	++	+	+	0 to -	Poor
Rosecrans	-	0	0	+	++	++	0 to -	Poor
Rosecrans East	-	-	0	+	+	+	?	Poor
Rosecrans South	-	-	0	+	+	+	-	Poor
Salt Lake	0	-	+	+	0	+	?	Poor
Salt Lake South	0	0	0	+	?	+	0	Fair
Sansinena	0	0	0	-	+	-	0 to -	Poor
Santa Fe Springs	0	++	+	+	++	++	-	Good
San Vicente	+	0	0	+	0	+	0	Fair
Sawtelle	++?	-	0	+	0?	++	?	Fair?
Seal Beach	+ to 0	+	0 to -	+	++	++	-	Good
Torrance	++	++	0 to -	+ to ++	0 to ++	++	0 to +	Excellent
Union Station	0?	-	-	++	0?	+	0	Poor
Venice Beach	++	+	++	++	+	+	++	Excellent
Whittier	0 to +	+	+	+	++	0 to -	0	Fair
Wilmington	+ to ++	++	0	0 to +	- to ++	++	- to +	Excellent

TABLE 7 (Con't)

RELATIVE POTENTIAL OF OIL FIELDS AS SOURCES OF GEOTHERMAL ENERGY

Symbols Used:
- ++ Excellent or very favorable
- + Good or favorable
- 0 Fair or neutral
- - Poor or unfavorable

VENTURA BASIN

FIELD	Temperature	Volume	Chemistry	Treatment Process	Available Space	Proximity to Applications	Operator Enthusiasm	FINAL RATING
Aliso Cyn.	-	+	+	0?	++	- to 0	-	Fair
Cascade	-	-	++	0	++	0	-	Poor
Castaic Hills	+	-	0	0	++	0	- to 0	Poor
Castaic Jtn.	++?	0	+	0?	++	+	0 to +	Fair
Del Valle	0	0	+	0?	++	-	0	Poor
Hasley Cyn.	+	-	+	0?	++	-	- to 0	Poor
Honor Rancho	+	-	0	+	++	0	- to 0	Poor
Las Llajas	-	-	0	++	++	-	0	Poor
Lyon Cyn.	-	-	0	++	++	-	?	Poor
Newhall	-	-	++	-	++	-	?	Poor
Newhall-Potrero	+?	0	++	+?	++	-	-	Poor
Oak Cyn.	- to +	0	+	0	++	-	0	Poor
Placerita	-	+	++	+	++	+	- to 0	Fair
Ramona	-	-	+	+?	++	-	0	Poor
Saugus	+?	-	0?	+	++	0	?	Poor
Tapia	-	-	++?	+	++	0	0	Poor
Wayside Cyn.	-	-	+	+	++	-	-	Poor

CONCLUSIONS

The thermal waters produced in a number of large oil fields are currently the most important geothermal resources in Los Angeles County. Assuming that various technological and economic considerations are favorable, many of these fields are promising sources of heat for diverse applications. Otherwise, the county does not appear to have any large, near-surface geothermal resources. Thermal springs and thermal water wells are scarce; their low temperatures and small volumes suggest very limited, localized resources that will not have potential beyond small-scale applications.

The major structural zones of the county, particularly the Newport-Inglewood Structural Zone, do not appear to be the sites of anomalous geothermal activity. Any production of high temperature fluids from them, similar to those at the Seguro 1 well at Huntington Beach, would probably be fortuitous.

Geothermal gradients in the county probably range from normal to above normal where 3.0°C/100 meters is considered normal for continental crust. Gradients in the Ventura Basin are estimated to average about 3.0-3.5°C/100 meters. Gradients in the Los Angeles Basin are higher with the highest estimated at about 5.5-6.0°C/100 meters in the Torrance-Wilmington and Venice Beach areas. The cause of the highest gradients is not well understood but may result from the moderately shallow depth of the hot basement, which is insulated by a blanket of sandstones and shales. Furthermore, tensional fractures in the basement may allow deep-seated thermal waters to rise into the overlying sedimentary cover and migrate laterally into the sandstones. Based on the field gradients and production temperatures of oil wells, water of at least 100°C could probably be obtained from depths of about 2,000 meters over much of the area west of the Newport-Inglewood Structural Zone.

Although temperature, volume, and proximity to applications are the most important factors, many other criteria must also be used to determine the geothermal potential of a particular oil field. Among these are chemistry of the waters, methods of treatment and injection or disposal, life expectancy of the field, effects of urbanization, legal and regulatory matters, and cooperation of the field operators.

Most of the fluid produced from the oil fields in the county is thermal water that ranges from about 100°-150°F. Many of the fields in the Los Angeles Basin theoretically could serve as sources of energy for nearby applications other than oil operations. Several are in commercial-industrial areas, which could offer the most favorable applications. The oil fields in the Ventura Basin have significantly less geothermal potential mainly because of their isolation and low volumes of production. Applications would probably be small-scale and limited to those fields along Interstate 5 near Newhall and Castaic Junction.

The most promising fields in the Los Angeles Basin, resource-wise, are those in the Palos Verdes geothermal province, west of the Newport-Inglewood Structural Zone. Fields of particularly high potential are Wilmington, Torrance, and Venice Beach, the latter producing temperatures above boiling. Lawndale has high temperatures and an excellent location even though it produces relatively small volumes (about 2,500 barrels/day). The El Segundo and Alondra fields are very hot but produce very small volumes. Significantly, operators at the Venice Beach, Lawndale, Alondra, and El Segundo fields are enthusiastic about possible uses of heat from their operations for adjacent applications.

Fields with good potential along the Newport-Inglewood Structural Zone are Inglewood, Dominguez, Long Beach, and Seal Beach. In the east part of the Los Angeles Basin, the Montebello and Santa Fe Springs fields are large water producers (>20,000 barrels/day) with temperatures reportedly above 100°F at the treatment

facilities. Although it produces small volumes, the Los Angeles East Oil Field produces fluid temperatures of about 180°F. Of the fields in the north part of the Basin, Beverly Hills and Las Cienegas have the best potential.

The most favorable sites for heat extraction within an oil field are the centralized treatment facilities, which process large volumes of fluid at temperatures generally above 100°F. All of the large fields have these facilities. In most, the waste water from the facilities is injected into the reservoir for water flooding. It is not known if a reduction of the water's temperature by heat extraction would truly have adverse effects on the reservoir efficiency and the surface treatment processes, assuming that the cooled water is injected back into the reservoir. In fields where the waste water is disposed of in a sewer system, the effects of reduction of the water temperature at the end of the treatment process are of no concern. These fields should definitely be explored for possibilities of heat extraction.

In summary, the results of this study are intended to provide a foundation for further study and use of specific geothermal resources in Los Angeles County, especially those available in the oil fields. It was not within the scope of the project to address specific engineering or economic questions as these are best left for separate studies by knowledgeable experts on these subjects. Indeed, the study of heat-extraction from just one oil field will prove to be a complex undertaking. Perhaps a successful heat-extraction project at one oil field will encourage oil operators and the public and private sector to attempt similar projects on a larger scale elsewhere in the county.

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APPENDIX A

DESCRIPTIONS AND ANALYSES OF INDIVIDUAL ACTIVE OIL FIELDS IN LOS ANGELES AND VENTURA BASINS

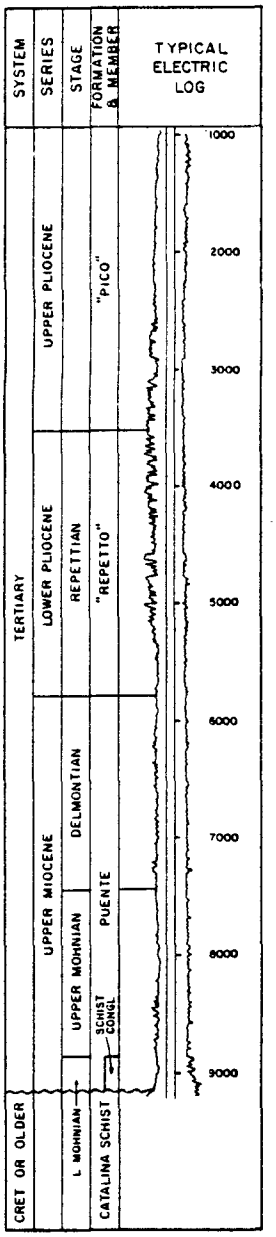
Maps and cross sections are from California Oil and Gas Fields, Volume II, 1974, published by the California Division of Oil and Gas.

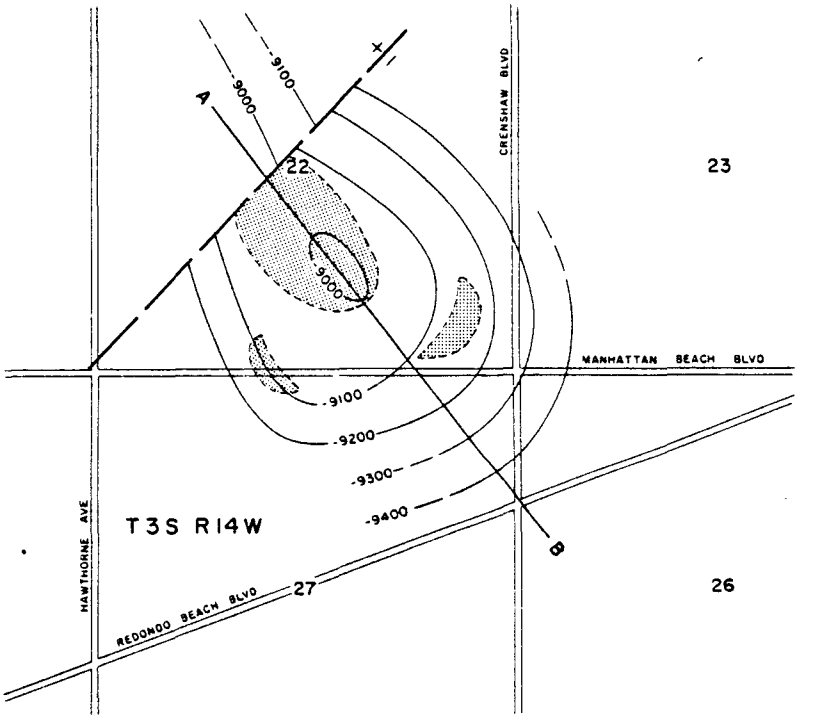
NOTE:

Production limits and zones are shown on maps and cross sections by shaded or pattern areas.

FIELDS IN LOS ANGELES BASIN

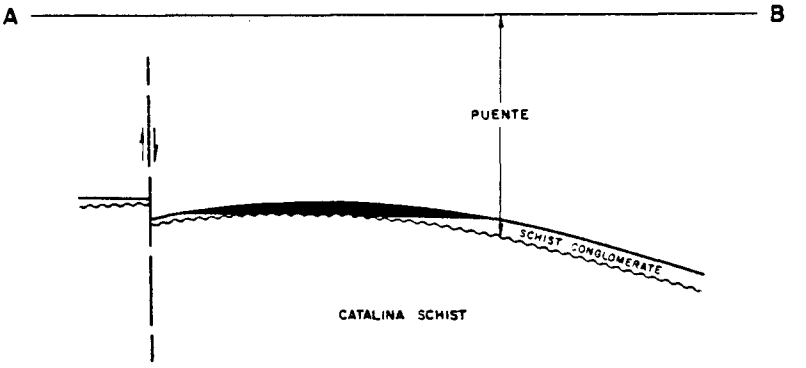
ALONDRA OIL FIELD





CONTOURS ON TOP OF SCHIST CONGLOMERATE

SCALE: 1" = 2400'



ALONDRA OIL FIELD

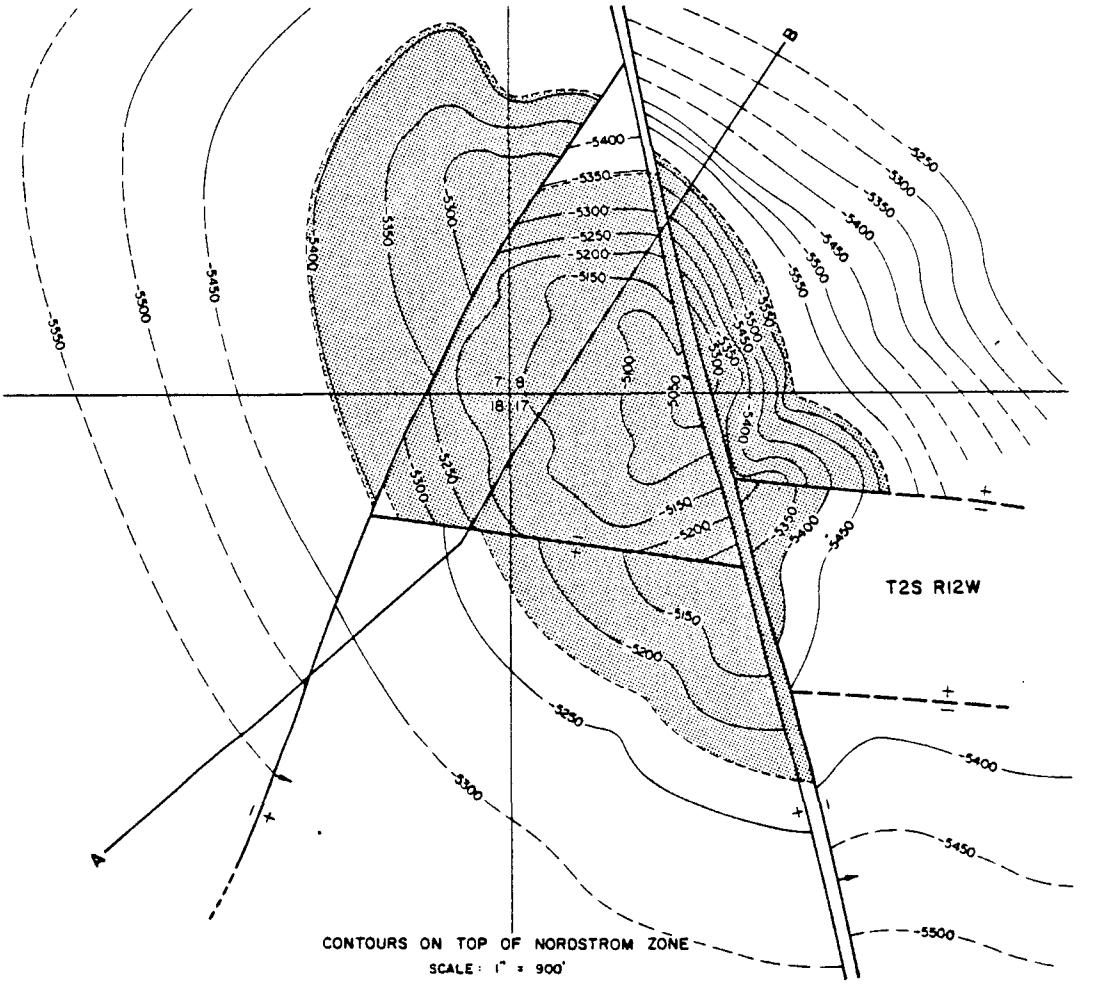
MAJOR OPERATORS (1981): Pauley Petroleum.

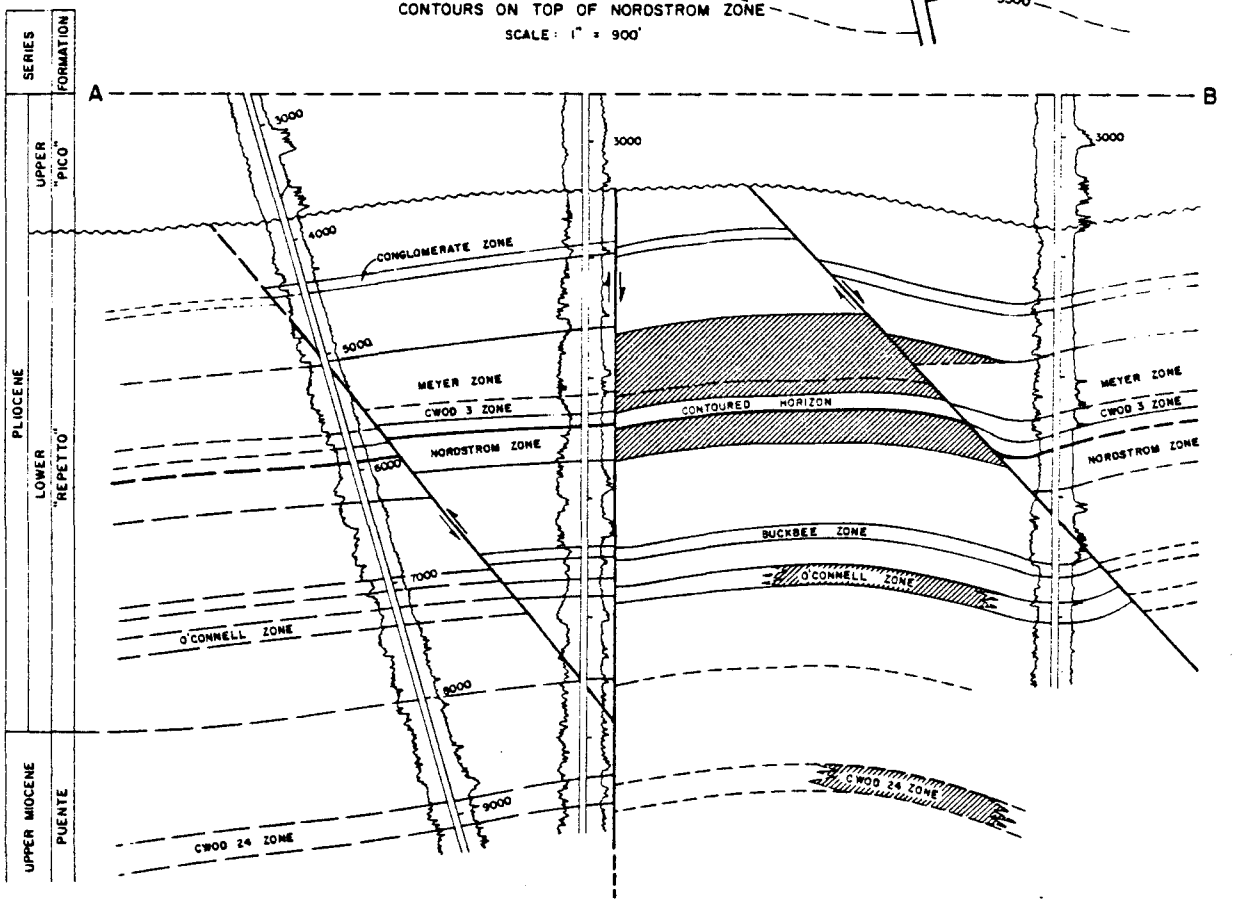
CHARACTERISTICS AND POTENTIAL:

The only well in Alondra (Photo 4) is situated at the south edge of a single-home residential area, adjacent to the Los Angeles County Flood Control Channel. It is across the street from Alondra Park and El Camino College. Production is from about 9,000 feet in the Schist Conglomerate, which is deposited on basement. Because of the high temperatures (175°-210°F) of the produced fluid, local ordinance requires that the waste water be cooled before it is disposed of in the sewer. Consequently, the operator is willing to allow heat extraction for adjacent uses in order to be rid of the excess heat. Unfortunately, water production is only about 500 b/d, the heat content of which is insufficient for widespread application. The operator hopes to increase production to about 1,000 b/d in the near future (D.L. Montgomery, personal communication, 1981).

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 36, no. 2 (1950).

BANDINI OIL FIELD





BANDINI OIL FIELD

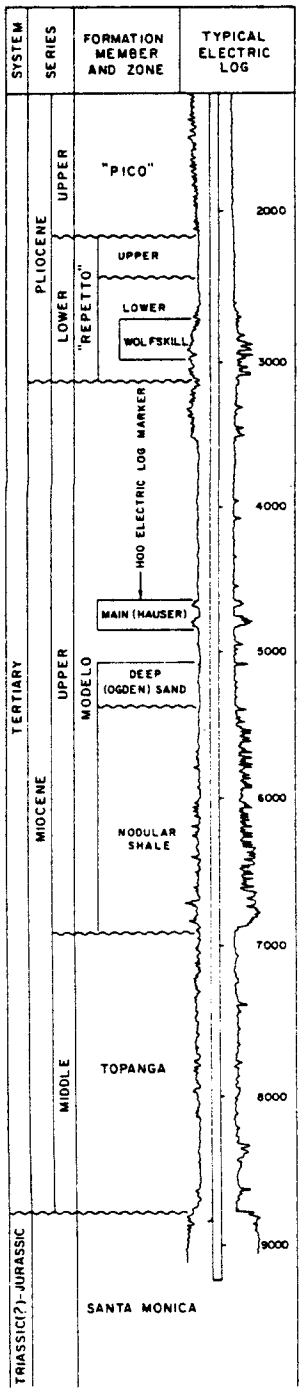
MAJOR OPERATORS (1981): Atlantic Oil, Western Avenue Properties.

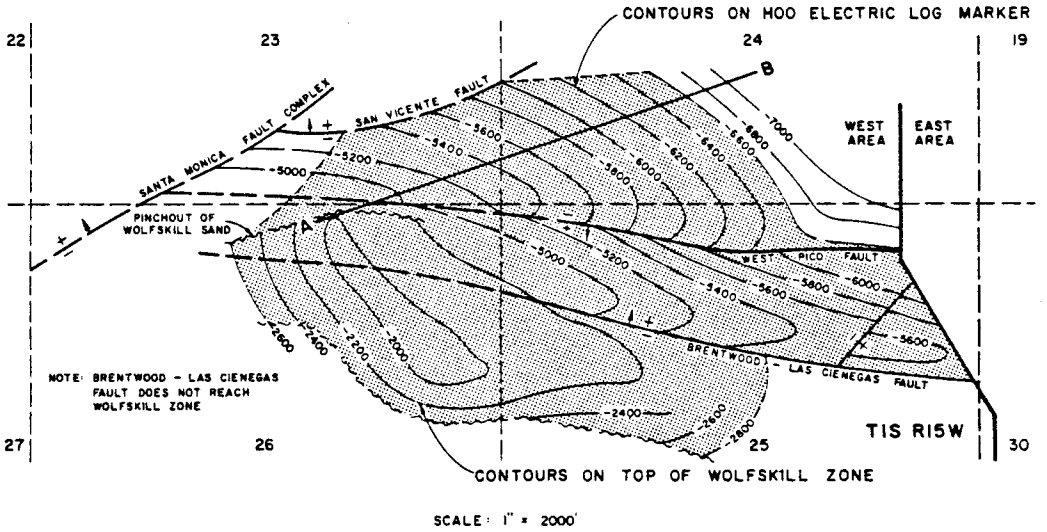
CHARACTERISTICS AND POTENTIAL:

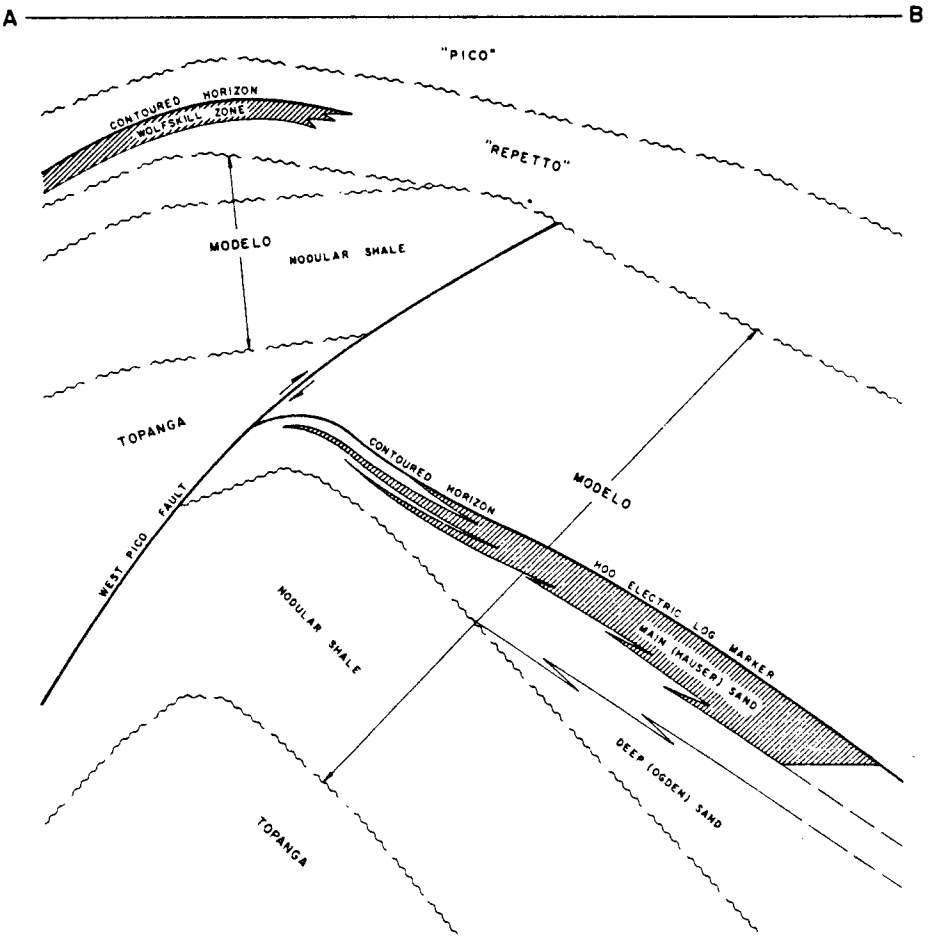
This small field is situated in a heavily commercial-industrialized area that could possibly provide numerous applications of extracted heat. The combined fluid production of the two operators is only about 1,500 b/d, however. Also, because most of the fluid is produced from only about 5,000 feet and because the estimated geothermal gradient of the field is among the lowest in the Los Angeles Basin, the temperatures of the produced fluid are not very high. This limits the heat available for applications, unless the operators plan to increase production substantially in the future. An advantage is that all waste water is disposed of in the sewer system; therefore, there is no need for the operators to retain heat in the water after it leaves the treatment facilities.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 44, no. 1 (1958).

BEVERLY HILLS OIL FIELD
West Area







BEVERLY HILLS OIL FIELD

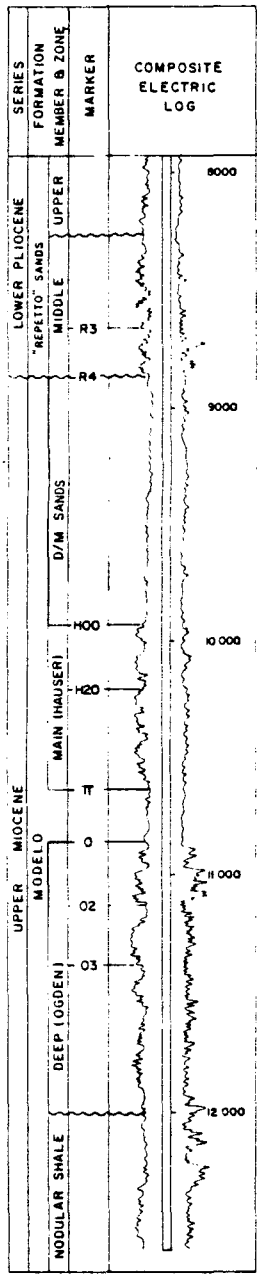
MAJOR OPERATORS (1981): ARCO, Chevron, Gulf, Occidental.

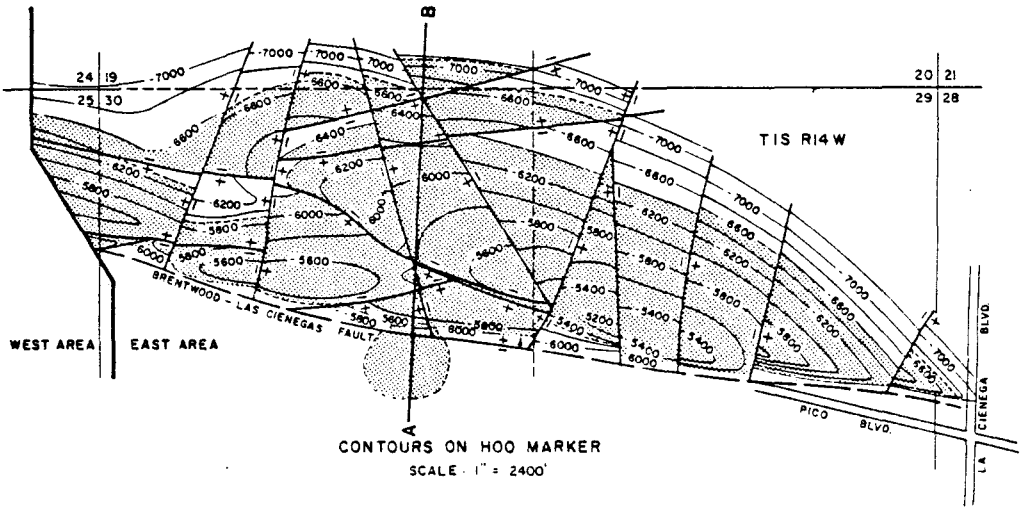
CHARACTERISTICS AND POTENTIAL:

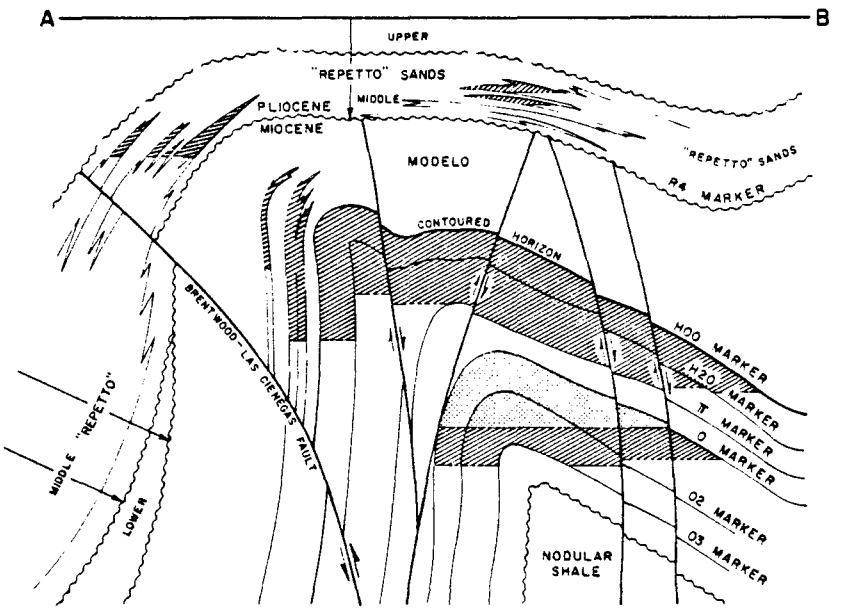
All oil operations in this field are conducted from urban drill sites in the midst of the dense commercial-residential development characteristic of this part of the Los Angeles Basin. In particular, the Packard Drill Site (photo 5), operated by Chevron, is a showcase example of how full-scale oil operations can be conducted in a major oil field that has been overrun by urban development. Water and oil production here is about 22,000 b/d, which is transported by pipeline to Inglewood Oil Field for treatment. Treated water is transported back to the Packard site from Inglewood for water-flood injection. Dick Aseltine of Chevron (personal communication, 1981) reported well-head temperatures of about 140°F at Packard, although this figure wasn't verified. It may be higher because of the deep production. Occidental did not provide data for its West Pico Drill Site, but its production is assumed to be less than Packard as judged from total field production. The West Area is a minor producer (about 2,000 b/d); operations are conducted from several small drill sites operated by Gulf and ARCO. Temperatures of waste water at the Gulf operations are elevated from production temperatures because of the use of heater-treaters. The potential of this field may be limited by space problems at the several drill sites; there may or may not be adequate room for heat exchanger equipment. Otherwise, the drill sites represent self-contained operations that minimize loss of heat from the well-heads to the treatment facility because of the proximity of the two to one another.

REFERENCE: Calif. Div. of Mines and Geology, Bulletin 118, 1943.

BEVERLY HILLS OIL FIELD
East Area

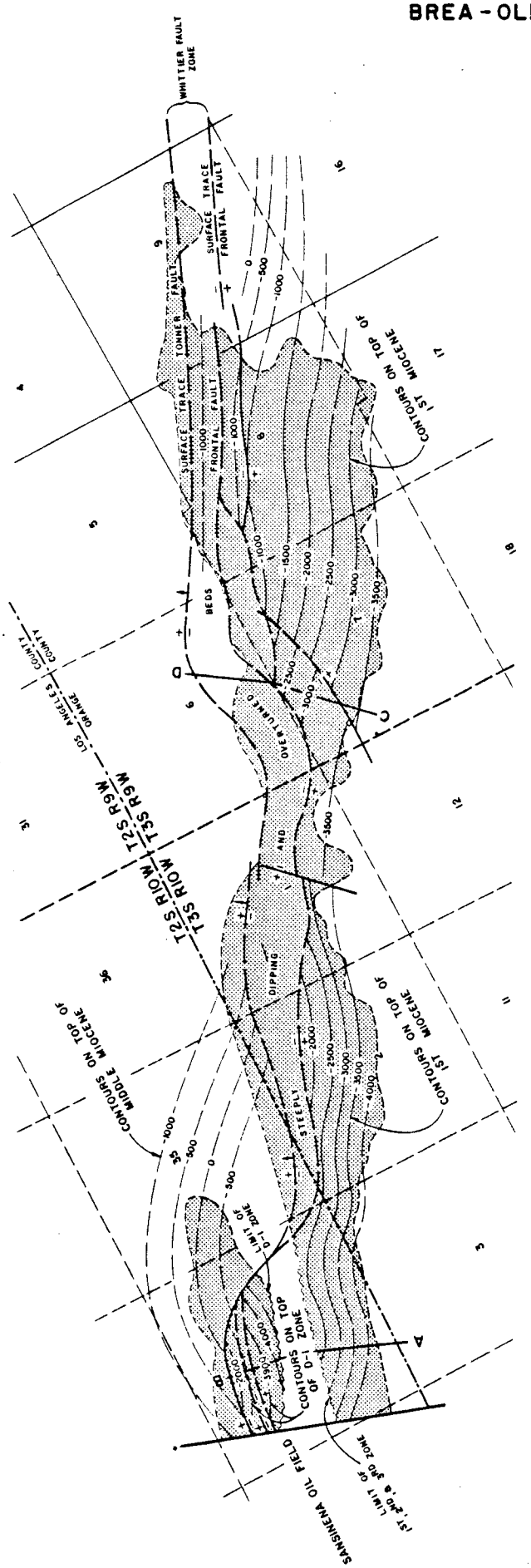


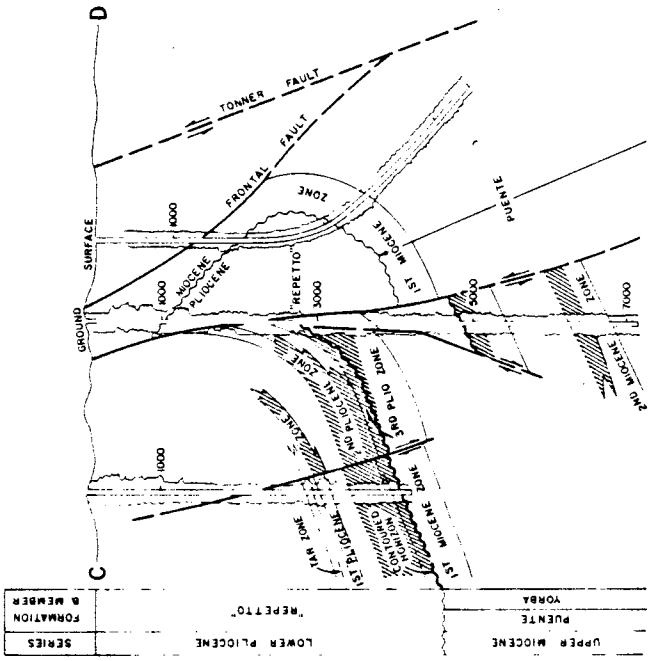


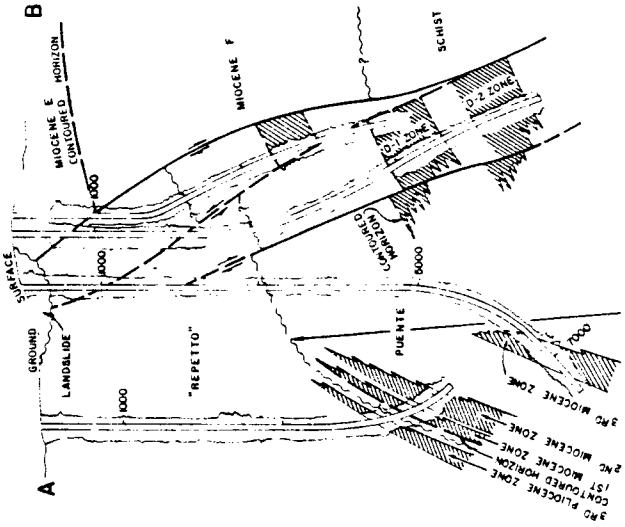


GENERALIZED CROSS SECTION (COURTESY OCCIDENTAL PETROLEUM CORP)

BREA-OLINDA OIL FIELD







BREA-OLINDA OIL FIELD

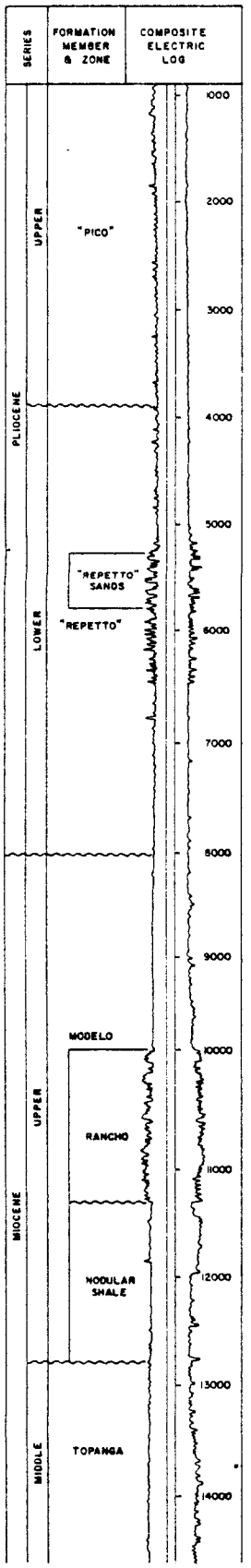
MAJOR OPERATORS (1981): Shell, Union (minor).

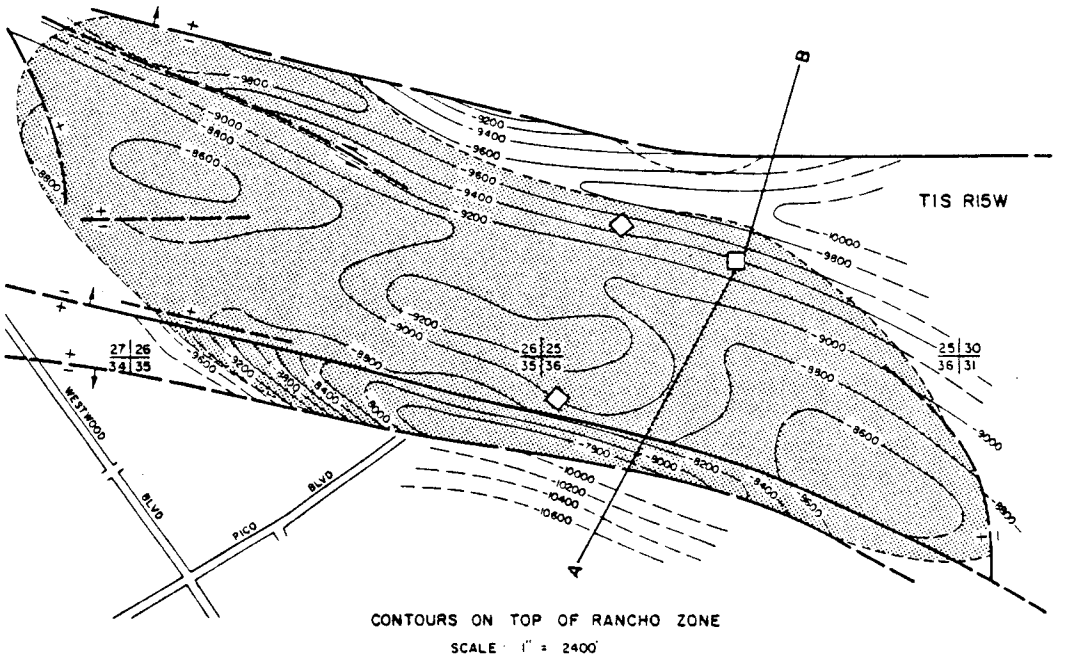
CHARACTERISTICS AND POTENTIAL:

Most of Brea-Olinda is in Orange County; the north part that projects in Los Angeles County is operated almost exclusively by Shell, which did not proivde data on temperatures and volumes for its leases. Based on 1979 statistics, it is estimated that the fluid production for the portion in Los Angeles County is approximately 3,000-4,000 b/d. Most production is from 3,000-7,000 feet, which, coupled with a moderately high geothermal gradient, suggests that production temperatures are at least in the 100°-125°F range. Treatment facilities are centralized at the Yorba Linda Oil Field in Orange County. A water flood is underway, and volumes of injected water are about three times that of produced water. Because of the additional make-up water to conduct this flood, the produced water is probably significantly cooled by dilution after it is sent to the injection pumps. The setting of the field is largely rural hills, thus applications are very limited.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 53, no. 2, part 2 (1967).

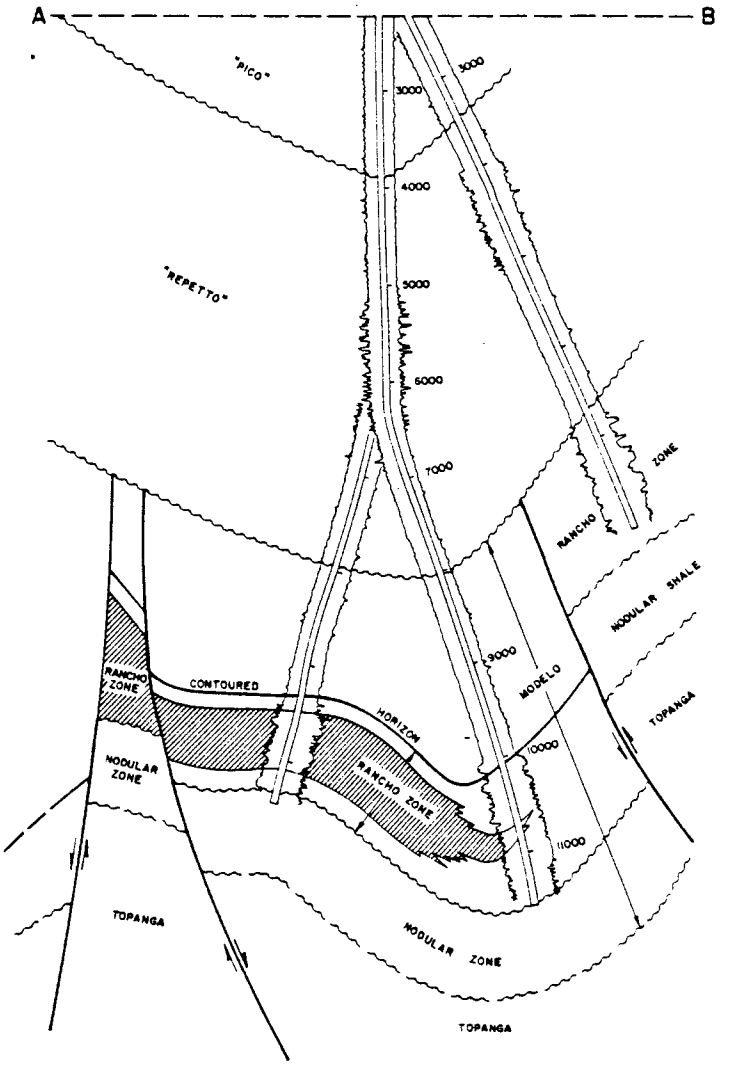
CHEVIOT HILLS OIL FIELD





CONTOURS ON TOP OF RANCHO ZONE

SCALE 1" = 2400'



CHEVIOT HILLS OIL FIELD

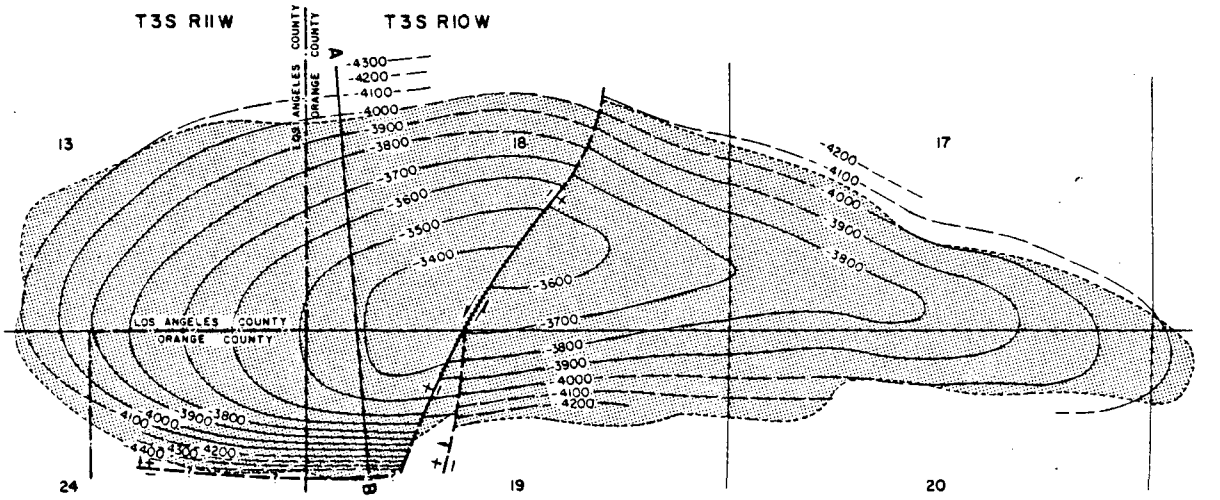
MAJOR OPERATORS (1981): ARCO, Gulf.

CHARACTERISTICS AND POTENTIAL:

All oil operations in Cheviot Hills are conducted from four urban drill sites either within or adjacent to the field boundaries. The field is in an area of dense commercial-residential development, but it has a low water: oil ratio as well as a low volume of produced fluid. Maximum well-head temperatures are about 120°F, and Gulf reported that it uses heater-treaters, evidently to effect better oil-water separation in the treatment process. Although ARCO did not provide any field data, it is assumed that its daily fluid production is also very small. Furthermore, the drill sites probably have little, if any, available space for heat-exchanger operations. In summary, the low fluid volumes and temperatures at the drill sites do not make this field a promising source of heat. Also, because the operators use heater-treaters, it is unlikely they would be enthusiastic about heat extraction in their operations.

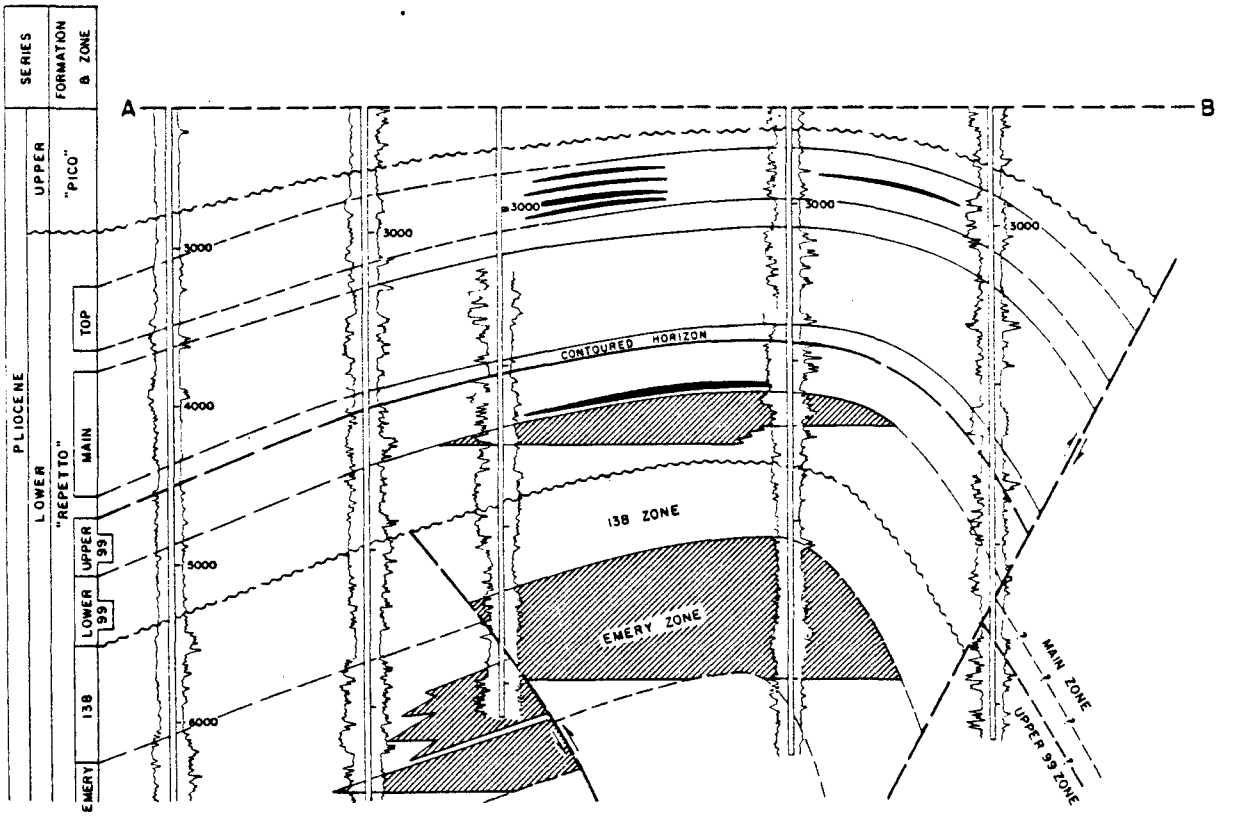
REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 54, no. 1 (1968).

WEST COYOTE OIL FIELD



CONTOURS ON TOP OF UPPER 99 ZONE

SCALE: 1" = 2250'



COYOTE WEST OIL FIELD

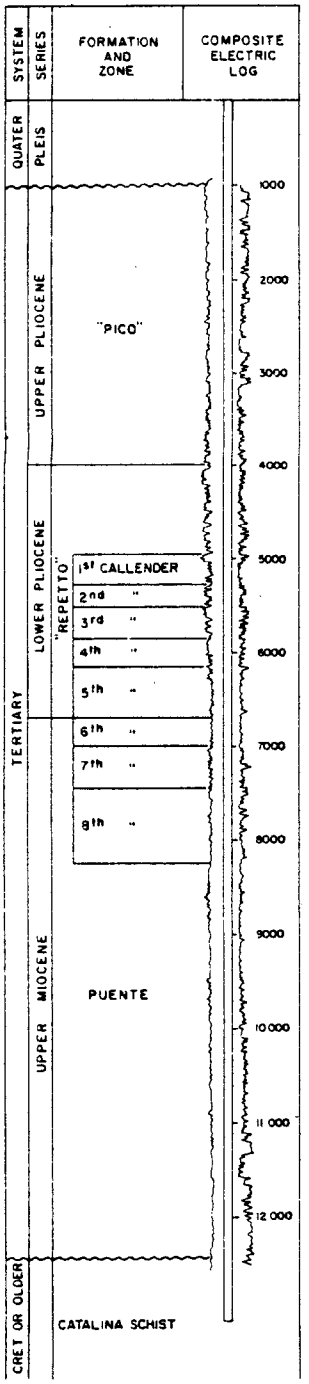
MAJOR OPERATORS (1981): Chevron.

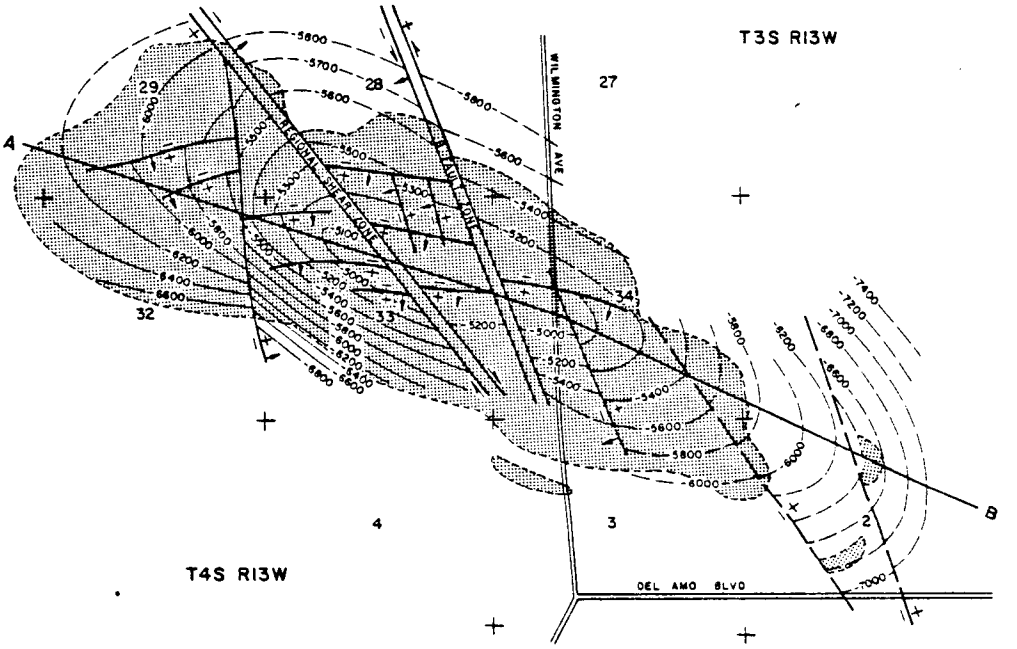
CHARACTERISTICS AND POTENTIAL:

Most of Coyote West is in Orange County as is the central treatment-injection facility; only the westernmost portion is in Los Angeles County. The field is largely rural, but is surrounded by suburban residential development. There is no major industry nearby. All produced fluid is sent to the central facility, which processes a huge volume (approximately 140,000 b/d). The limited information provided by Chevron indicates that temperatures throughout the system are probably not more than 115°-120°F. Most of the water is injected back into the reservoir, while the remainder is disposed of in the sewer system. Because of both the cultural setting of the field and the treatment facility's location in Orange County, this field is probably not a promising candidate for applications in Los Angeles County.

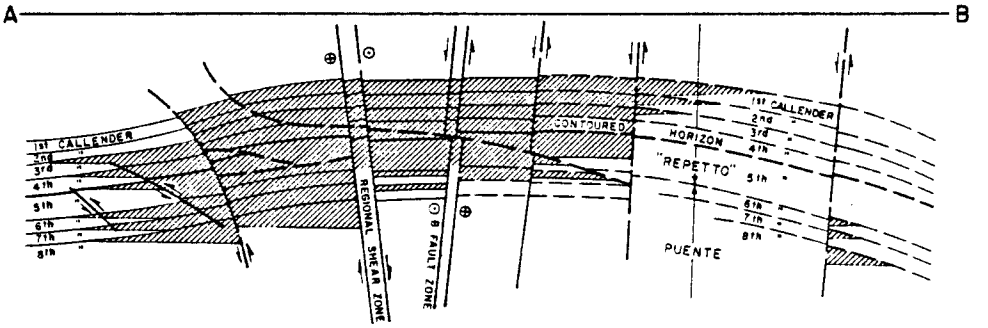
REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 48, no. 1 (1962).

DOMINGUEZ OIL FIELD





CONTOURS ON TOP OF 5th CALLENDER ZONE



DOMINGUEZ OIL FIELD

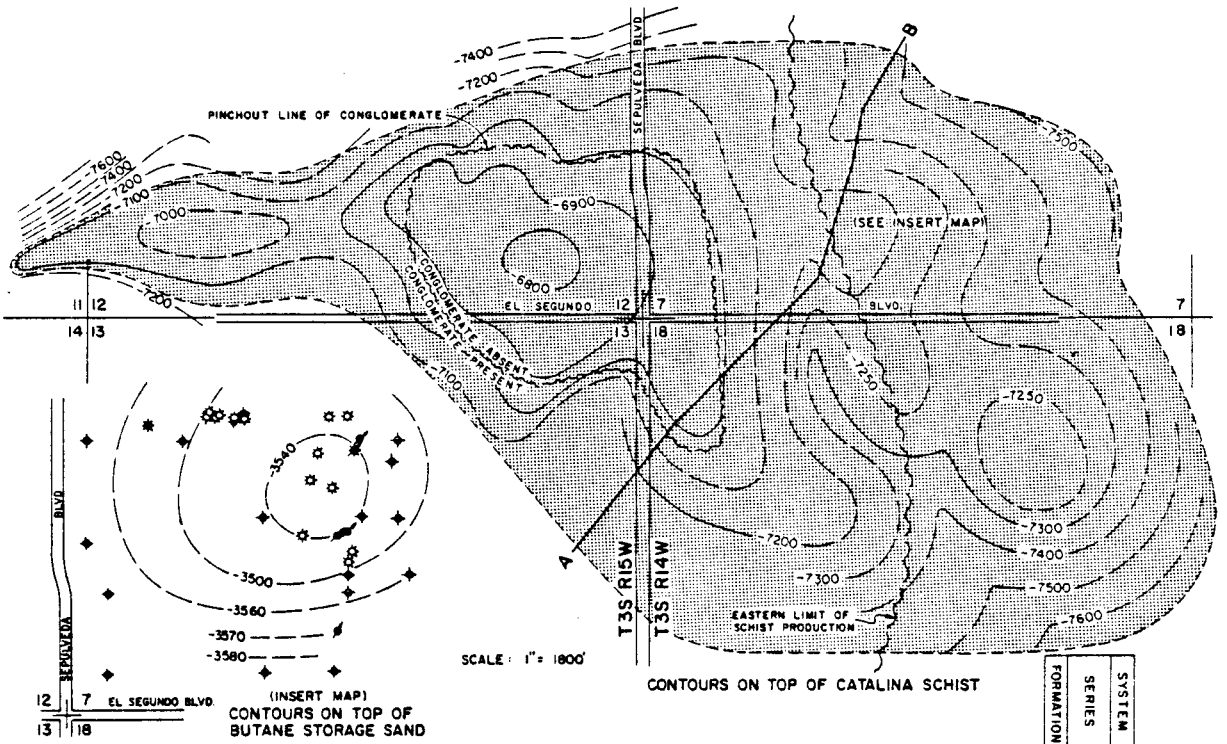
MAJOR OPERATORS (1981): Shell, Union

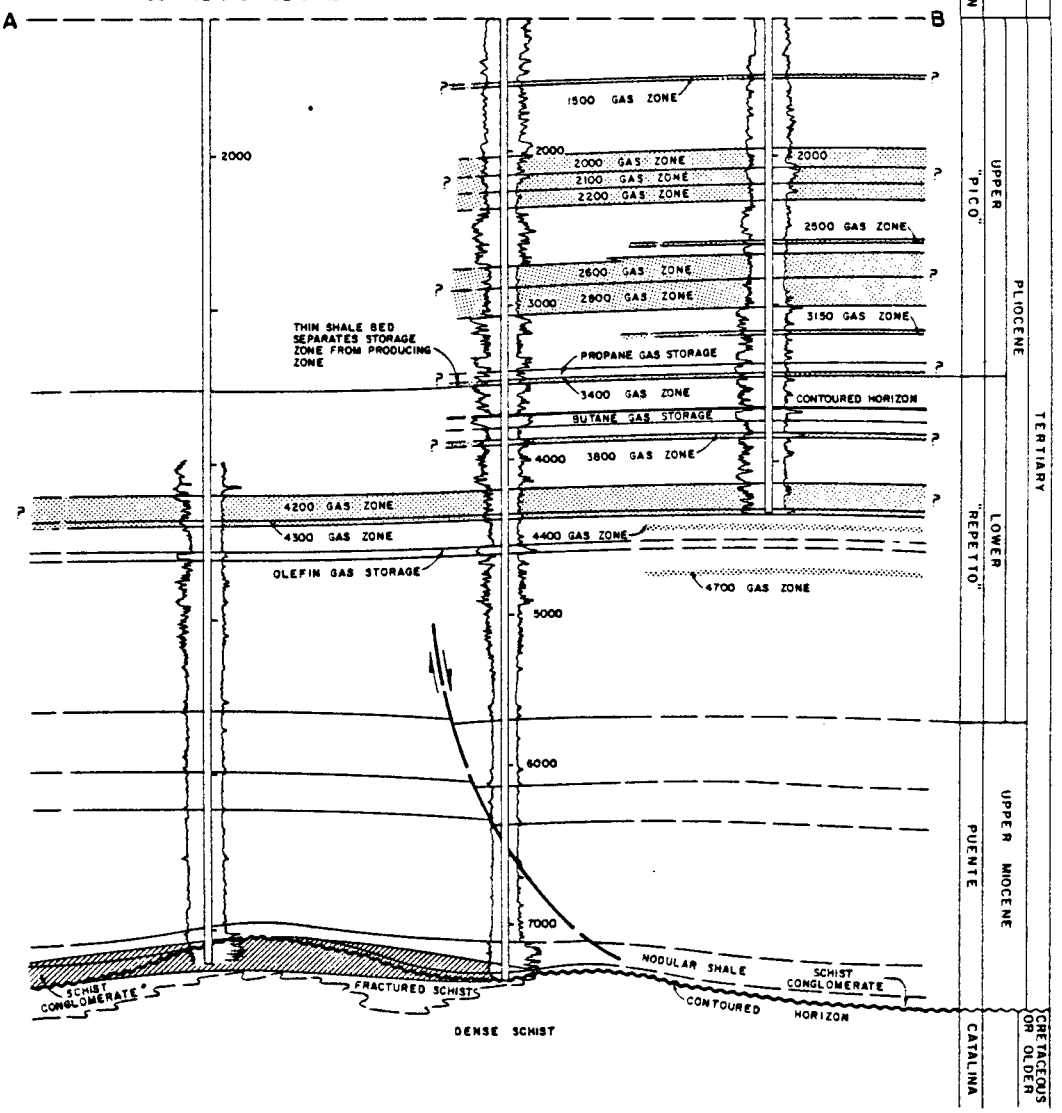
CHARACTERISTICS AND POTENTIAL:

Dominguez is a large, old field that is now surrounded by development. Abundant commercial-industrial development is on the south, east, and north sides, while residential development is on the west side and a small portion of the south side. The field itself is largely restricted to oil operations and some flower nurseries (Photo 6). It is situated on a low mesa that abruptly drops off on its east edge. Union and Shell are the major operators and both have centralized treatment facilities. The Union facility (Photo 7) processes about 9,000 b/d at approximately 125°F incoming temperature. It is situated in a field adjacent to a housing development and across the street from the campus of California State University, Dominguez Hills. Although Shell did not provide complete data, it is estimated that production is about 15,000 b/d at temperatures similar to the Union facility; pipes leading into several injection wells on the Shell Reyes lease were very hot to the touch. Shell reported that it sends about 4,000 b/d at 100°F to the sewer system. The moderately high temperatures and volumes as well as extensive adjacent development gives this field a good potential as a site for heat extraction. The possibility of scaling caused by heat extraction (all water is injected in a water flood) and possible company disinterest must be dealt with, however.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 12, no. 4 (1926).

EL SEGUNDO OIL FIELD





EL SEGUNDO OIL FIELD

MAJOR OPERATORS (1981): Cooper and Brain, Graner, Hagee, T&F, Chevron.

CHARACTERISTICS AND POTENTIAL:

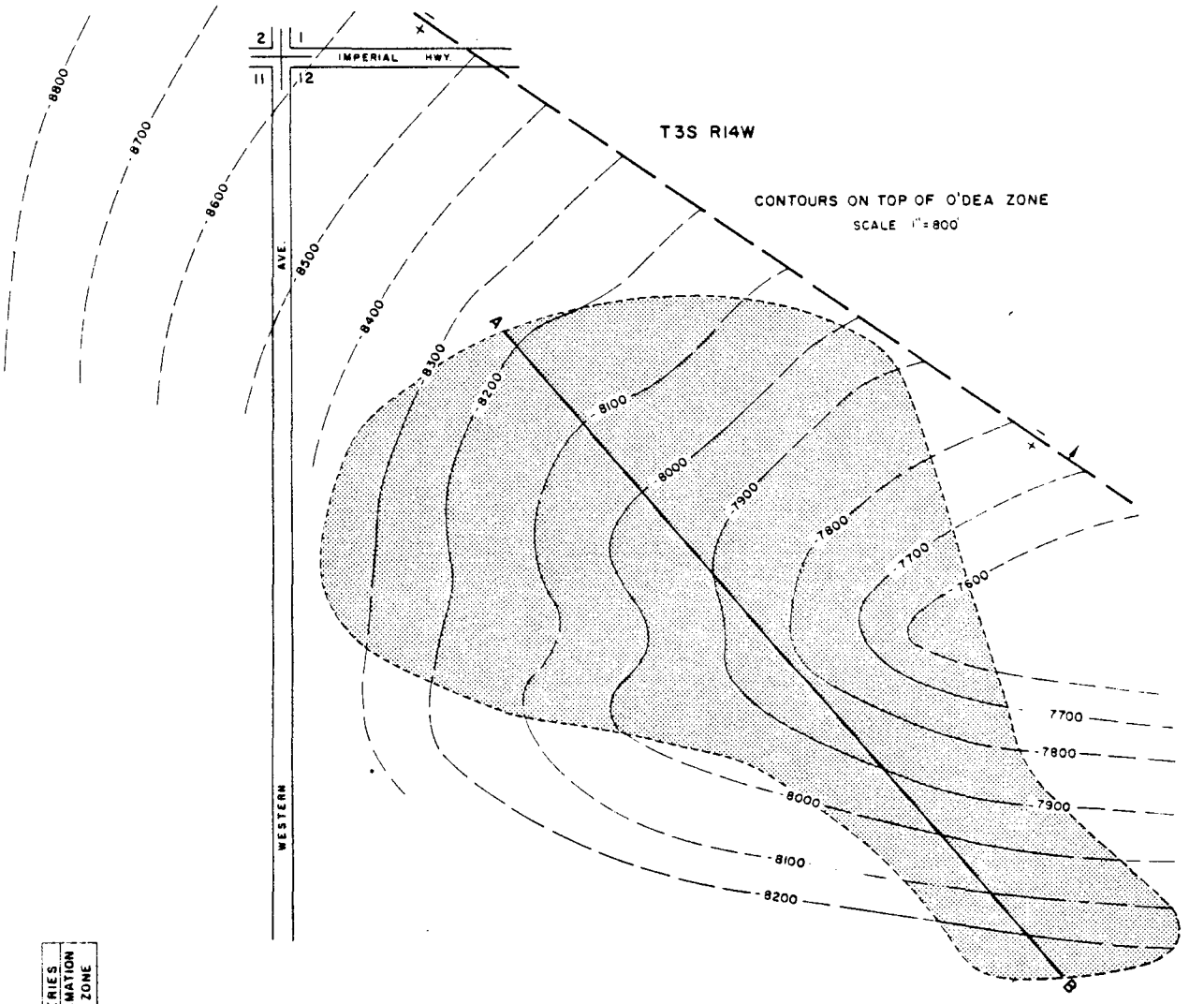
Production has declined to only about half-a-dozen wells in El Segundo, which is being overwhelmed by commercial development. Large commercial-industrial parks now or will occupy the former main production area. Fluid production is about 2,500-3,000 b/d, nearly all of which is water. Estimated well-head temperatures are probably at least 200°F. This production is from several operators; there is no central treatment facility for the field from which heat could be extracted. Graner is the largest operator with about 1,500 b/d. As required by local ordinance, its waste water must be cooled to about 130°F before it is disposed of in the sewer. The operator has been interested in applications of the heat, such as in an adjacent industrial complex. Apparently, none of the commercial concerns there was interested, however. T and F operates two wells several blocks to the west of Graner at similar temperatures but only produces about 500 b/d of fluid. This operator is also interested in disposing of the heat via applications outside of oil operations. In summary, the high geothermal gradient and deep production (7,000 feet) is sufficient to bring near-boiling water to the surface. All significant amounts of waste water are disposed of in the sewer; therefore, all heat is available for extraction (indeed, the operators consider the excessive heat a nuisance). Perhaps future commercial-industrial development could design use of this waste heat into some of its operations.

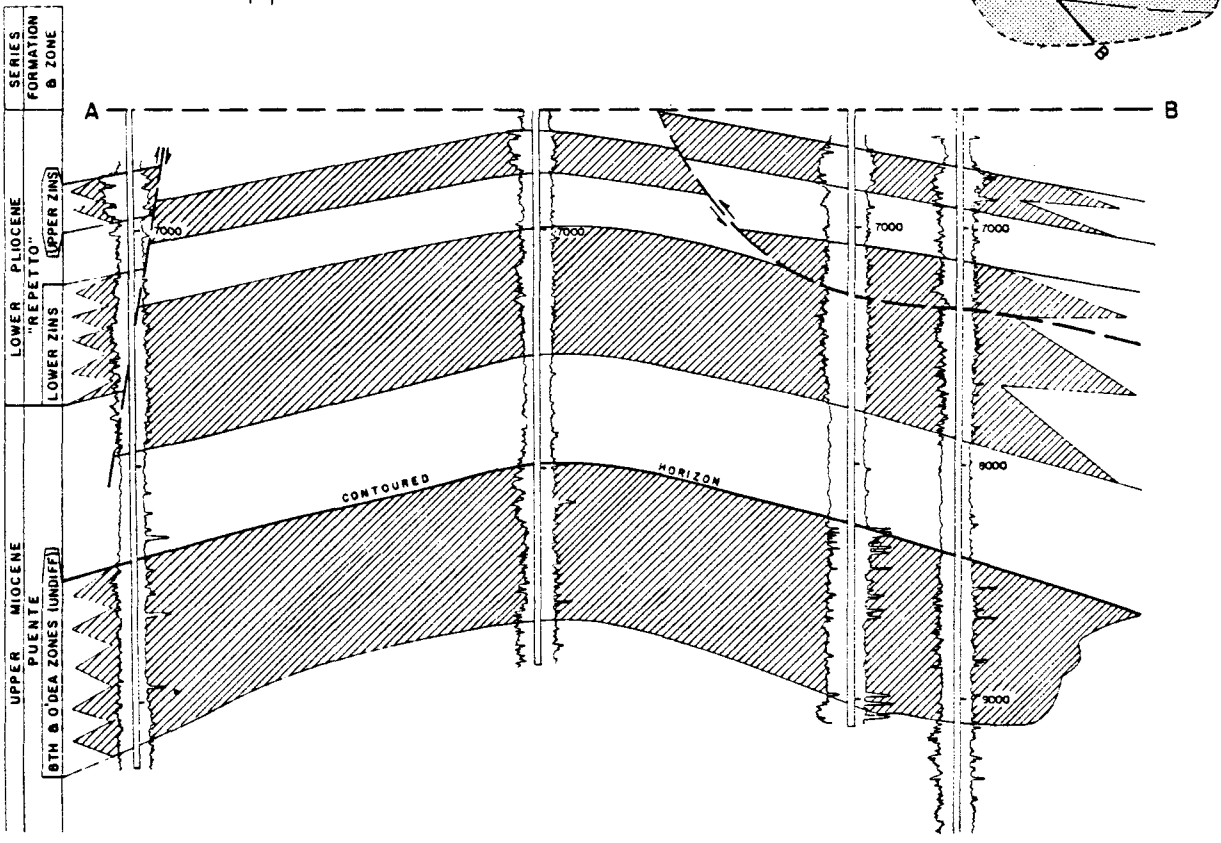
Graner Oil Company
Mr. J.B. Graner
2525 Lemon Avenue
Long Beach, Calif. 90806
(213) 424-8768

T and F Oil Company
Mr. Conrad A. Fischer
P.O. Box 7682
Long Beach, Calif. 90807
(213) 424-2732

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 49, no. 2 (1963).

HOWARD TOWNSITE OIL FIELD





HOWARD TOWNSITE OIL FIELD

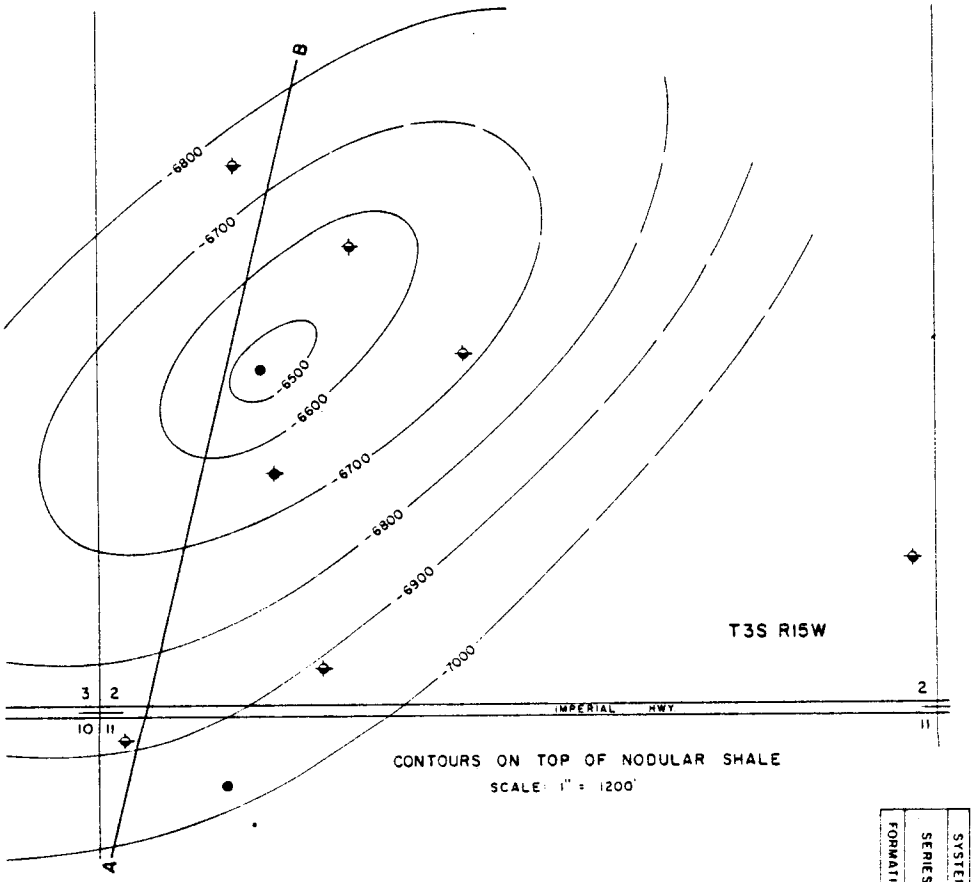
MAJOR OPERATORS (1981): Beren, Shasta Pan

CHARACTERISTICS AND POTENTIAL:

Howard Townsite is situated in an area of mixed commercial-residential-industrial development. The major collection-treatment facility for the field, operated by Beren (Photo 8), is just south of the Southwest Los Angeles College campus. The facility is at the edge of a large open field in which several oil wells are operating. Although the majority of production is from depths of about 7,000-9,000 feet, Beren reported that well-head temperatures are only about 60°-80°F. Also, the treatment facility processes less than 500 b/d, which represents over 75% of the field production. If the temperatures are accurate, the low temperatures as well as the small fluid production do not make this field attractive for heat extraction.

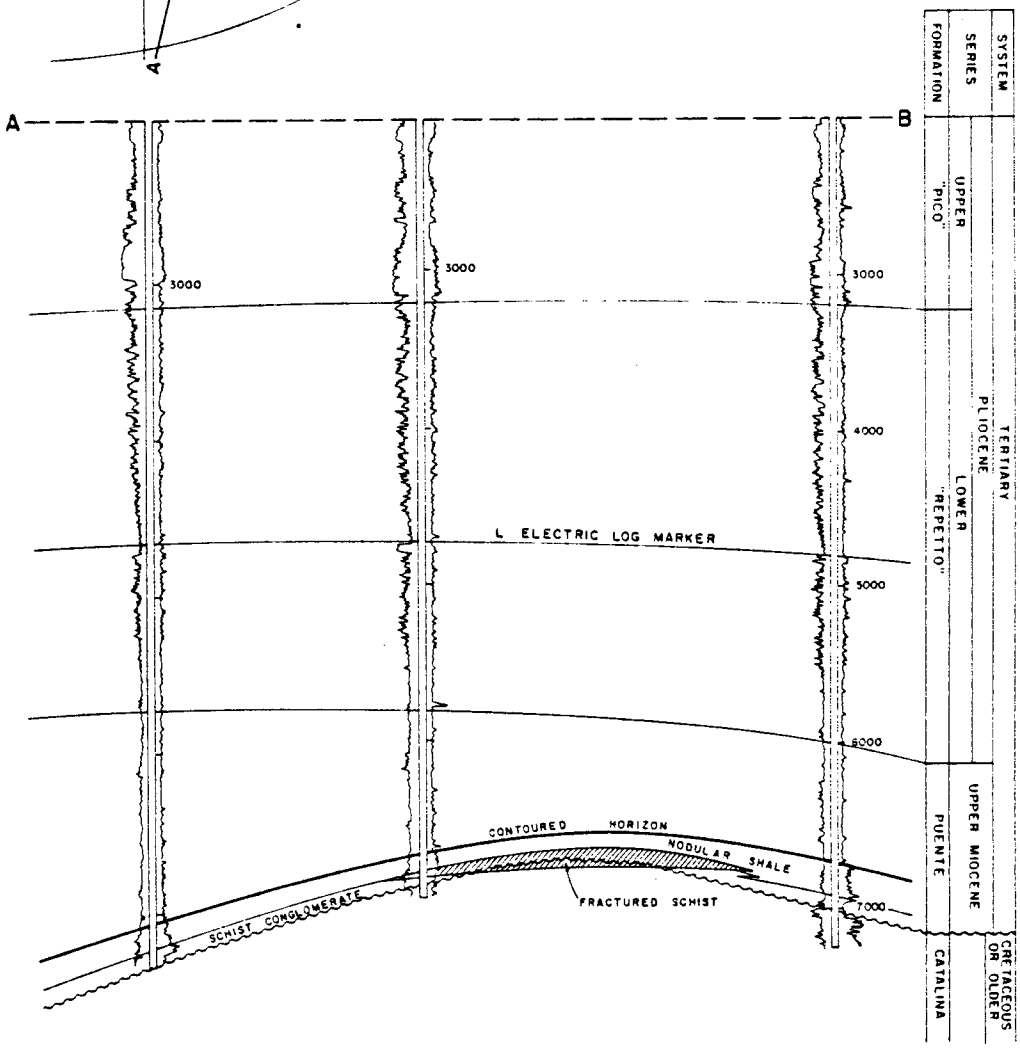
REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 40, no. 2 (1954).

HYPERION OIL FIELD



CONTOURS ON TOP OF NODULAR SHALE

SCALE: 1" = 1200'



HYPERION OIL FIELD

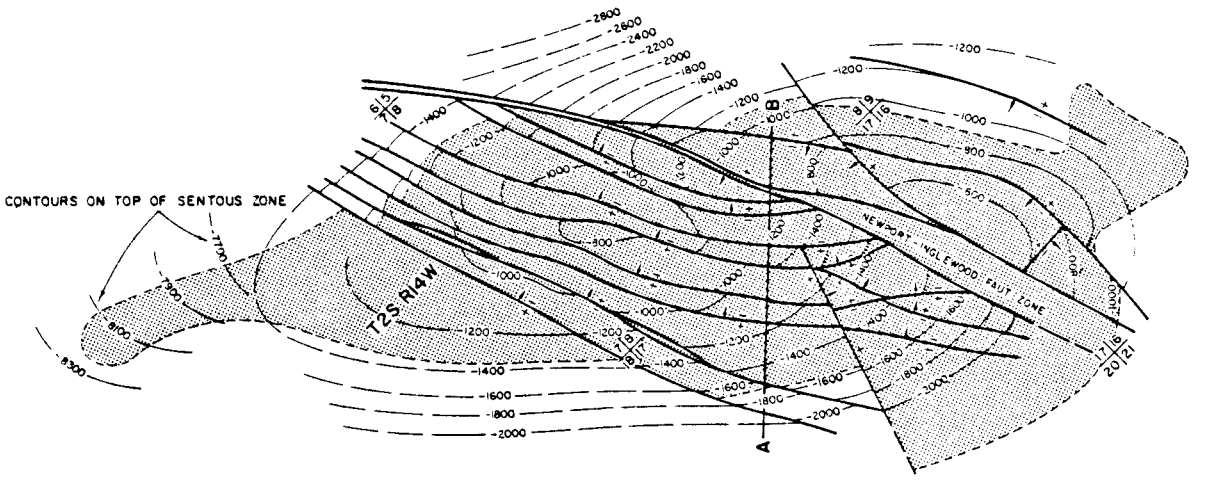
MAJOR OPERATORS (1981): Pauley Petroleum.

CHARACTERISTICS AND POTENTIAL:

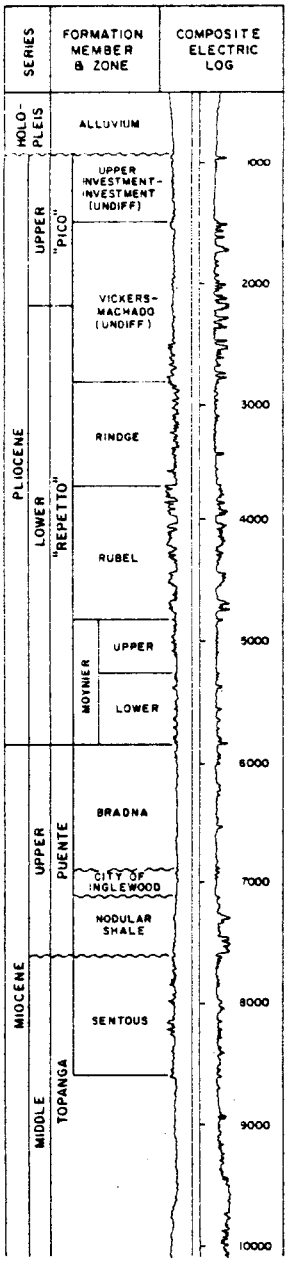
Hyperion is characterized by a relatively high geothermal gradient, but very small fluid production. Water constitutes only 6% of the fluid produced from the field's one well (20-25 b/d). Because of this small production, the field should not be considered a candidate for heat extraction.

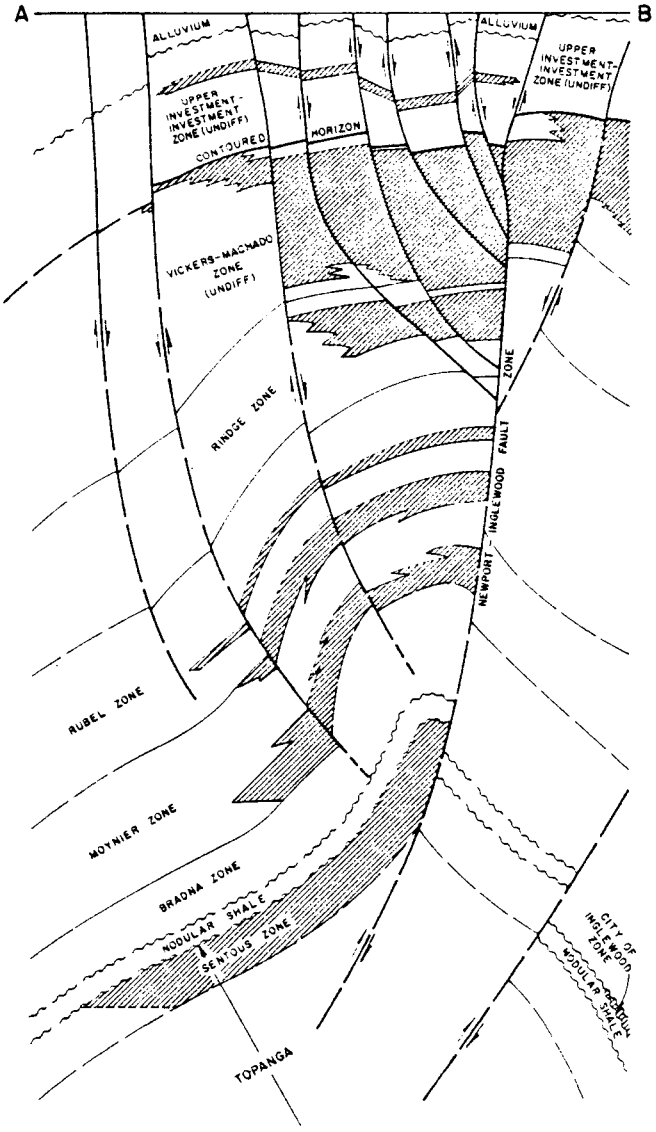
REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif Oil Fields, v. 46, no. 1 (1960).

INGLEWOOD OIL FIELD



CONTOURS ON TOP OF VICKERS ZONE
SCALE 1" = 2900'





INGLEWOOD OIL FIELD

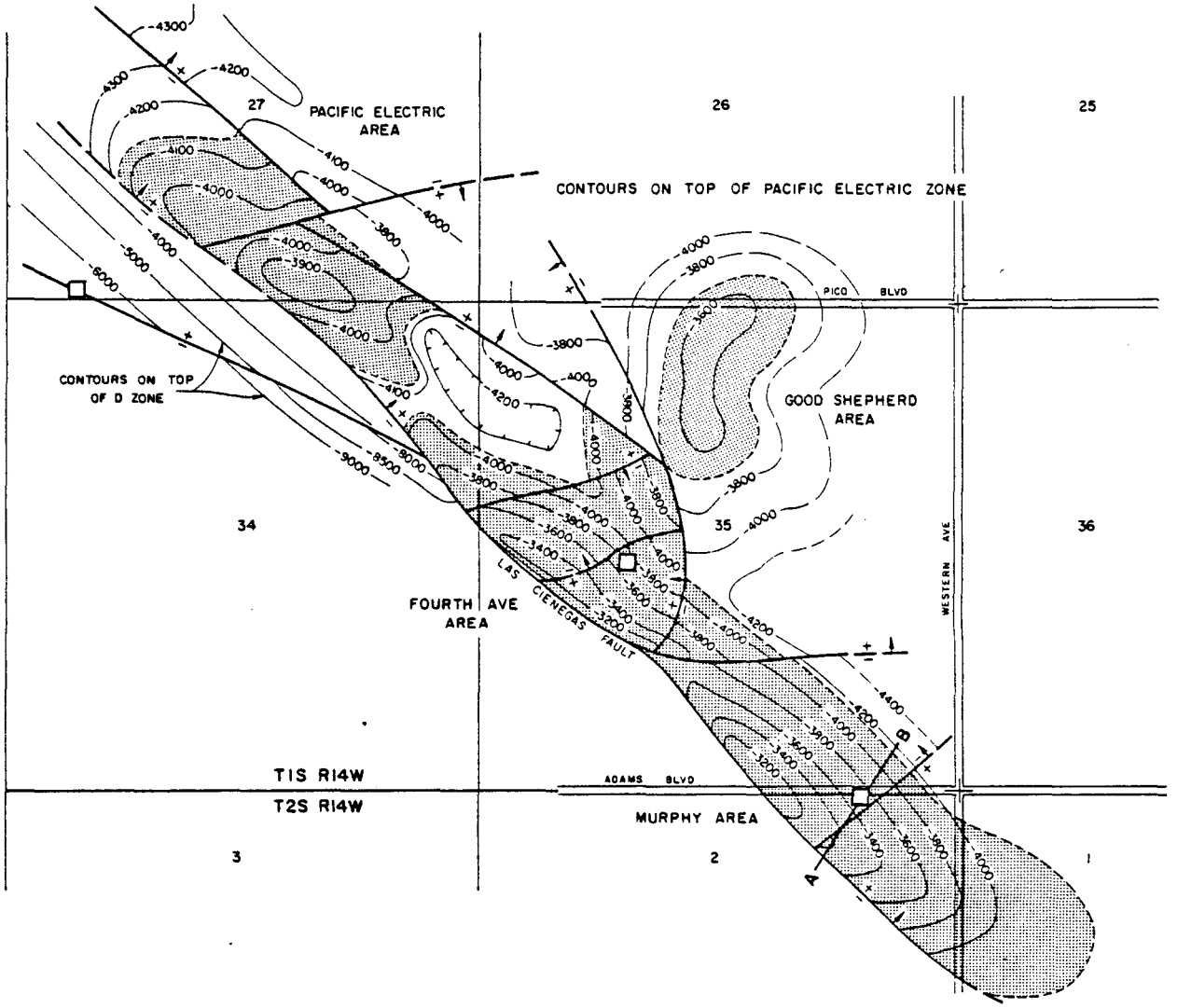
MAJOR OPERATORS (1981): Chevron, Getty, Block (minor).

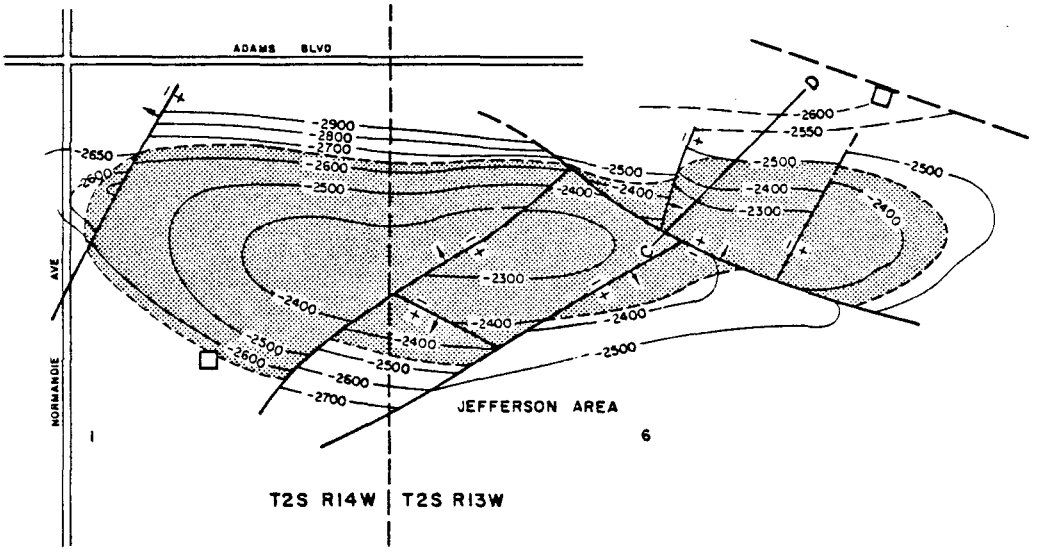
CHARACTERISTICS AND POTENTIAL:

Like several other oil fields in the Los Angeles Basin, Inglewood is a rural island in a sea of commercial and residential development (Photo 9). Occupying much of the Baldwin Hills, it is operated mainly by Chevron and to a lesser extent by Getty. Commercial and industrial development laps at the west and north edges of the Hills, while residential development has encroached from the south and east. The field is the second largest producer of both water and oil in the county (Wilmington is first). Chevron operates two main treatment facilities that handle its Inglewood production as well as that from a few other Chevron operations in the north Basin area. Together, the facilities process approximately 200,000 b/d at estimated entrance and exit temperatures of about 90°-100°F. If accurate, this low range of temperatures weakens the potential of Inglewood as a major source of heat for surrounding applications. The Getty facility processes about 25,000-30,000 b/d in the 100°-120°F range, which is more encouraging. The facility is also situated closer to the commercial-industrial area west and north of the field, whereas the Chevron facilities are more interior. Another weakness of the field is that most production is from less than 5,000 feet. Although the field's geothermal gradient is considered moderately high for the Basin, the shallow depths offset this advantage somewhat.

REFERENCE: Calif. Div. of Mines and Geology, Bulletin 118, 1943.

LAS CIENEGAS OIL FIELD





CONTOURS ON TOP OF UPPER JEFFERSON ZONE

SCALE: 1" = 1600'

LAS CIENEGAS OIL FIELD

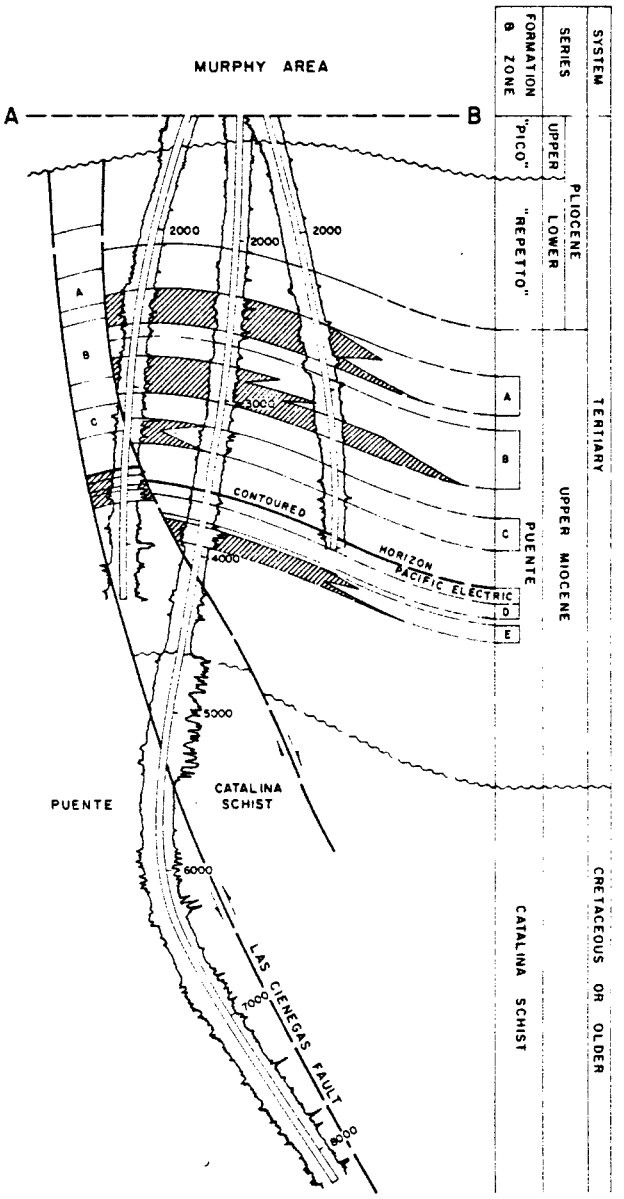
MAJOR OPERATORS (1981): Union, ARCO.

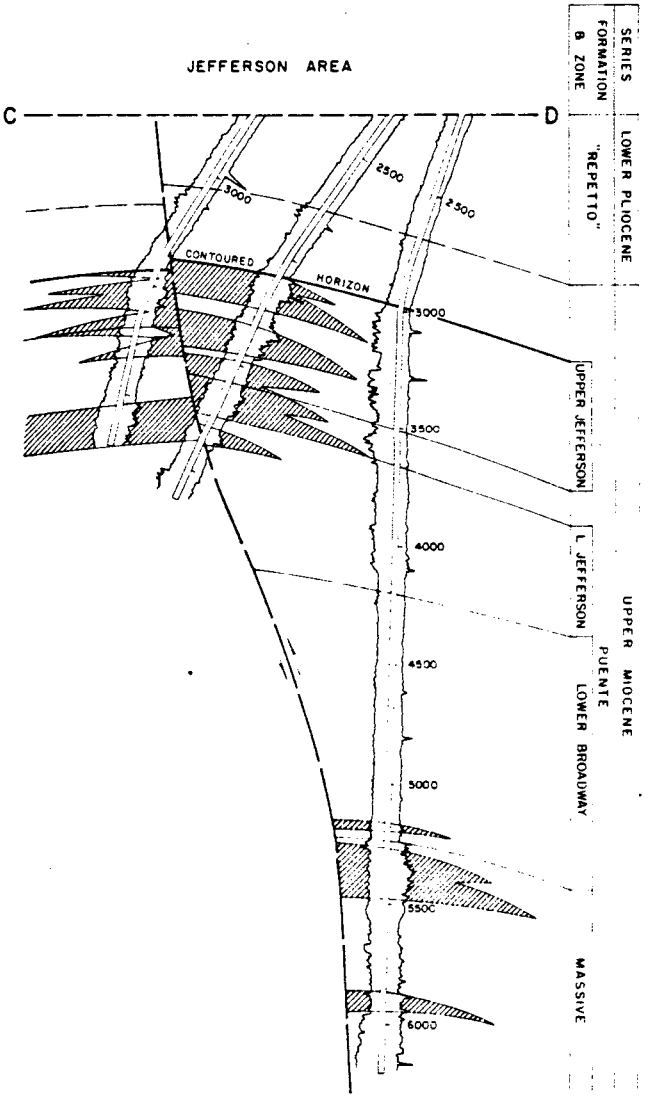
CHARACTERISTICS AND POTENTIAL:

Las Cienegas is composed of five areas that approximately align in a northwest-trending curve. Operations for each are conducted from urban drill sites, all of which are operated by Union except for one ARCO site in the Jefferson area. Fluid production at each site is less than 5,000 b/d; temperatures range from about 90°-150°F depending on the depth of production. The advantage of the field's moderately high geothermal gradient is offset somewhat by the field's generally shallow production (less than 5,000 feet). Possibly the most promising site for heat extraction is the Fourth Avenue Drill Site (Photo 10), which produces about 4,000-5,000 b/d at incoming temperatures of approximately 145°F. Unfortunately, available space at this site, as well as at the other sites, may be limited for potential heat-exchanger equipment. All sites are in commercial-residential areas characteristic of this part of the Los Angeles Basin. Both the Union and ARCO drill sites in the Jefferson area are only about a kilometer from the campus of the University of Southern California.

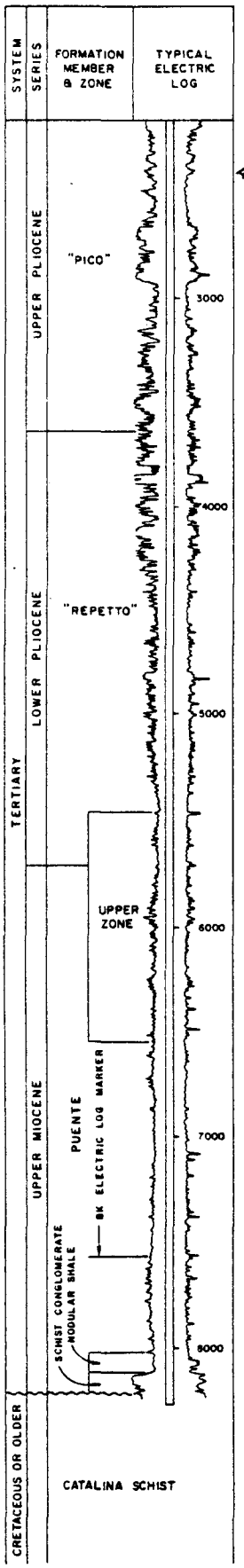
REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 56, no. 1 (1970).

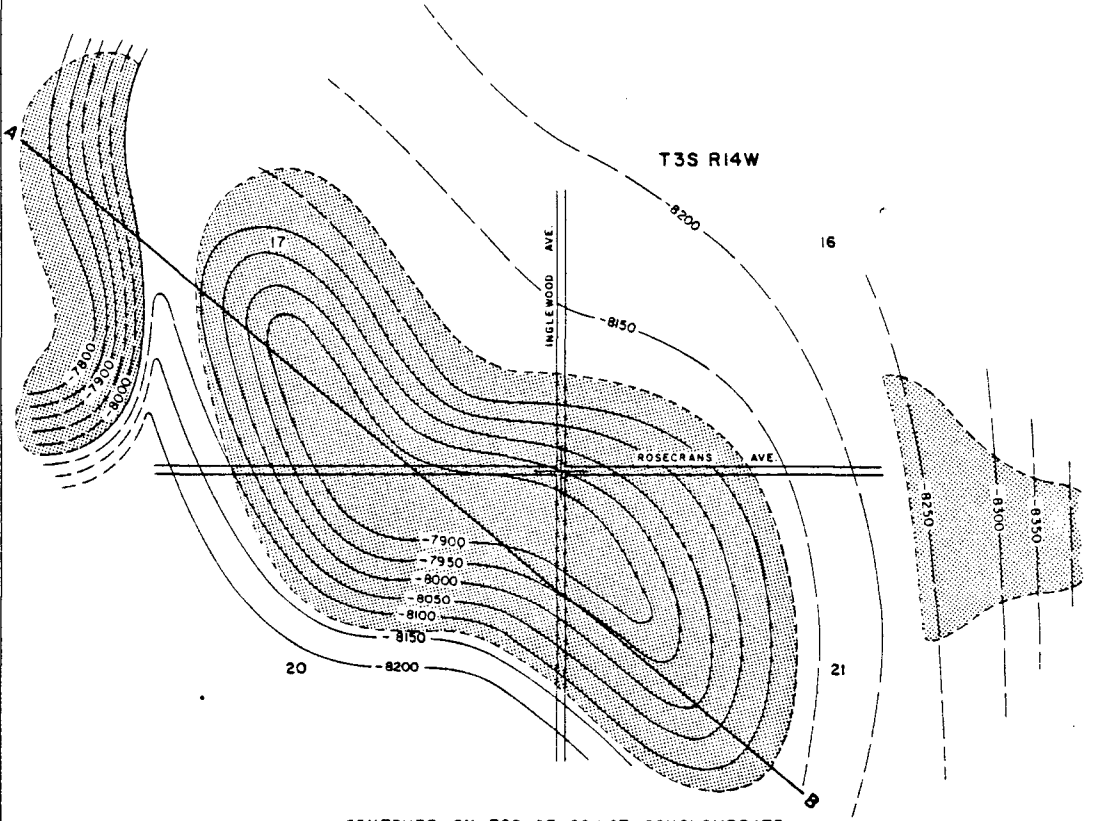
LAS CIENEGAS OIL FIELD



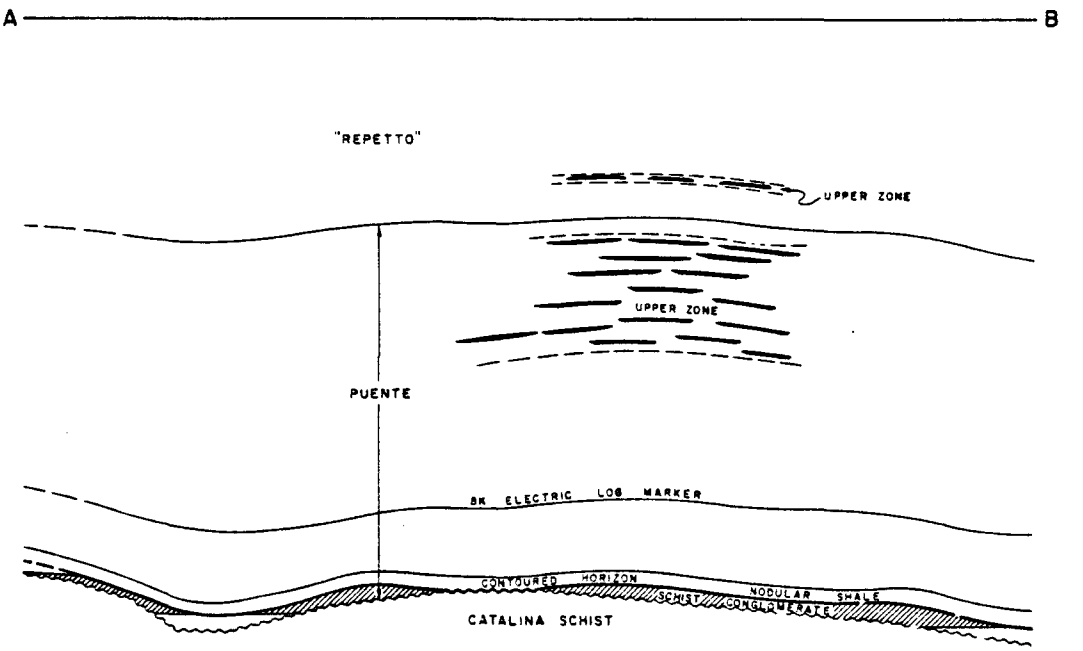


LAWNDALE OIL FIELD





CONTOURS ON TOP OF SCHIST CONGLOMERATE
SCALE: 1" = 1200'



LAWNDALE OIL FIELD

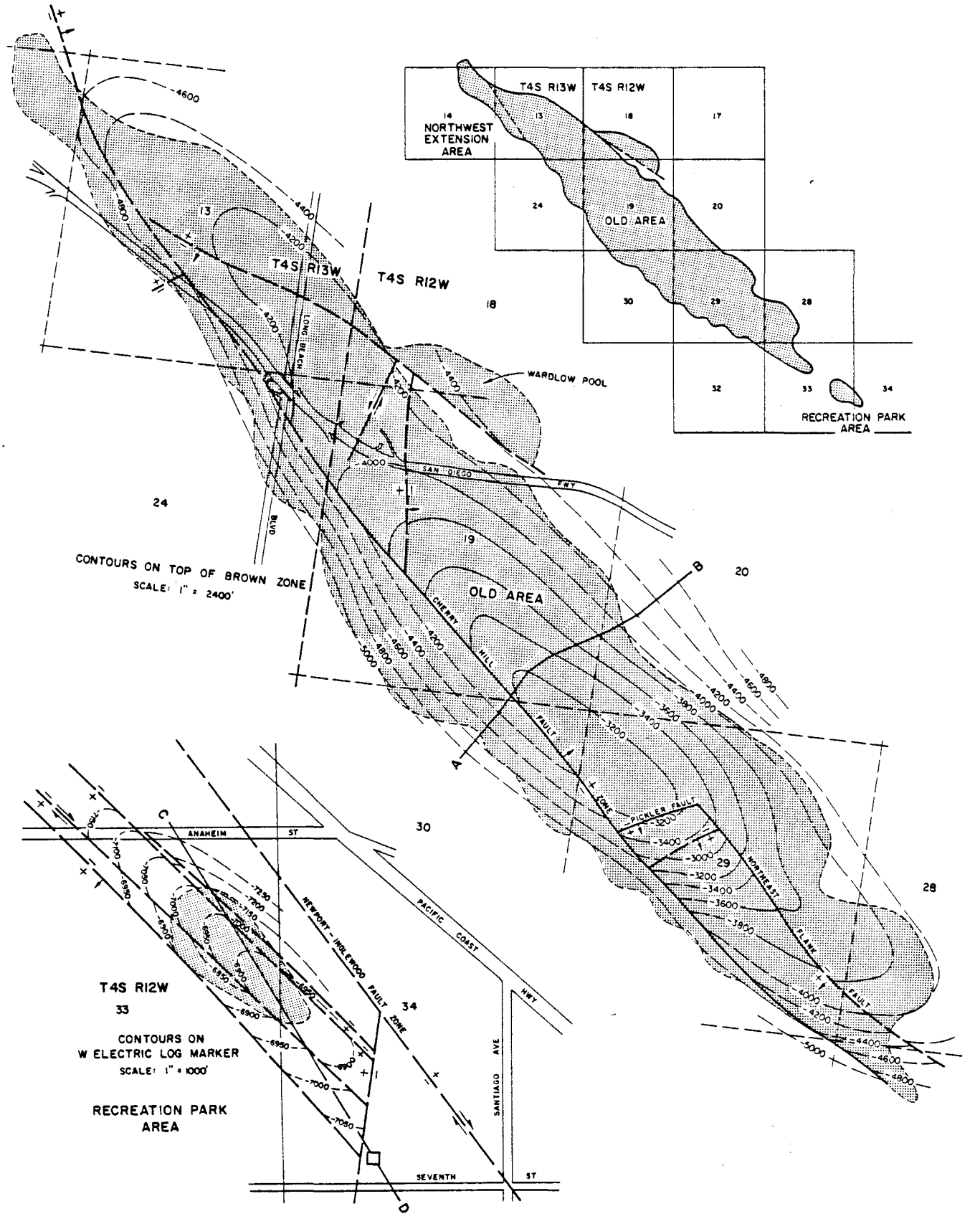
MAJOR OPERATORS (1981): Pauley Petroleum.

CHARACTERISTICS AND POTENTIAL:

This two-well field produces among the highest-temperature fluids of all oil fields in Los Angeles County. Several advantages make the field a strong candidate for heat extraction. Because the fluid temperatures are so high (about 170°-210°F), local ordinance requires that the water be cooled to about 115°-120°F before it can be disposed of in the sewer. For this reason, the operator is interested in some sort of economic project to dispose of the excess heat. The operator also estimates a high zone temperature at 8,000 feet (250°F) and suggests that other wells could be drilled in the field to tap this hot water. The collection-treatment facility for the two wells is in the center of an industrial complex and has adequate space for heat-extraction equipment (Photos 11, 12). Two public schools are less than a kilometer from the facility also. One disadvantage of the field is the relatively small fluid production (about 2,500 b/d). The operator produced about 6,000-7,000 b/d at one time, however, and hopes to attain that figure in the future (D.L. Montgomery, personal communication, 1981).

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 36, no. 2 (1950).

LONG BEACH OIL FIELD



LONG BEACH OIL FIELD

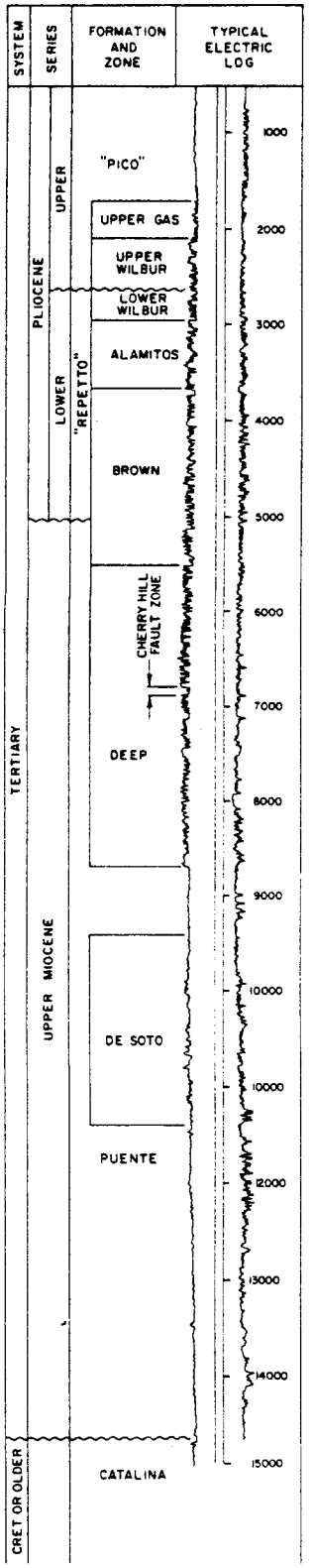
MAJOR OPERATORS (1981): ARCO, Shell, Texaco, Sun.

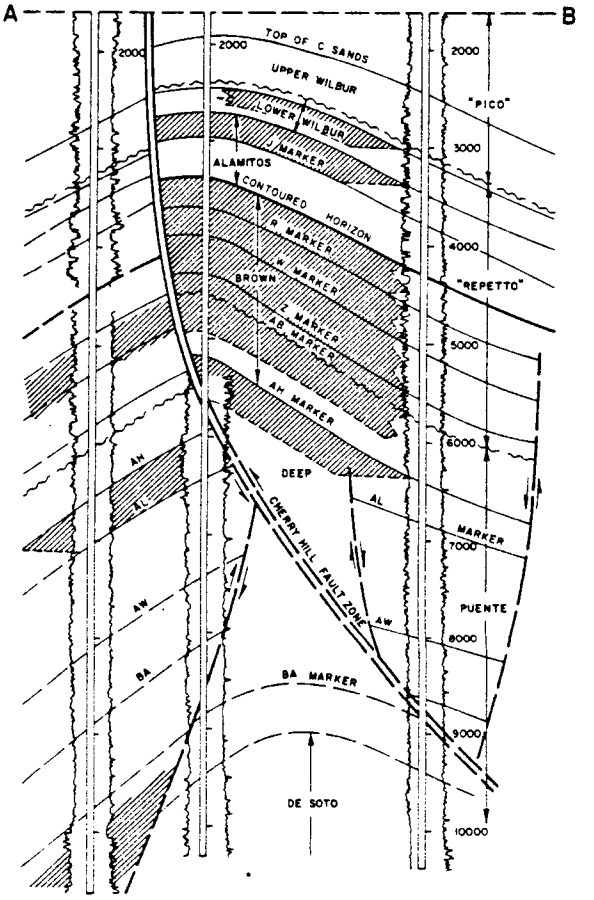
CHARACTERISTICS AND POTENTIAL:

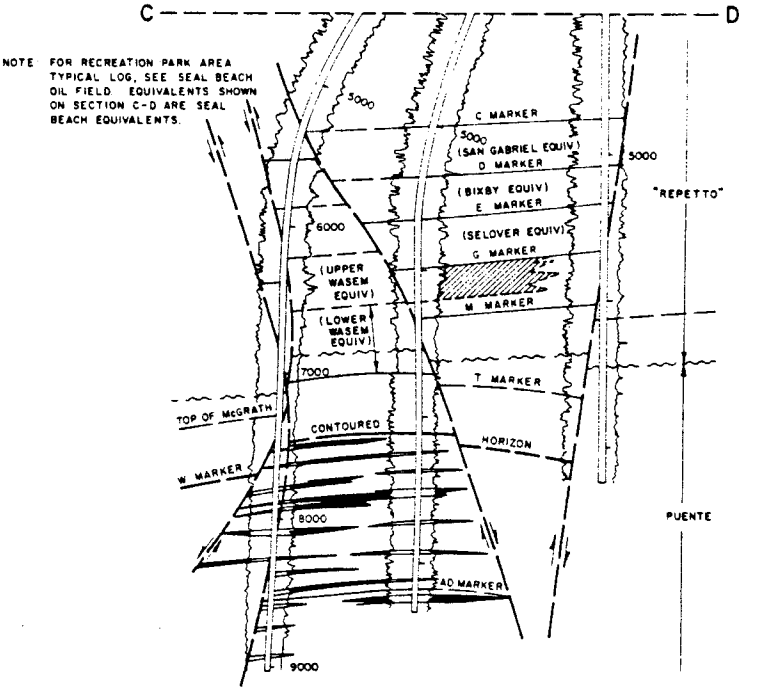
Probably the most famous oil field in California, largely because of its productivity in the 1920's, Long Beach is undergoing a facelift, both in terms of oil operations and real estate development. The field was once a blight on the landscape as its topographic prominence, Signal Hill, was covered with a forest of oil derricks. The derricks are now gone, and most of the field operations are conducted by three unit operators, Texaco, Shell, and ARCO. Each operates a major centralized collection-treatment facility on the flanks of Signal Hill. Texaco processes the largest amount of water (80,000 b/d at 100°-130°F), but has had chemical problems (scaling-corrosion). Shell reported that treatment at its facility is about 14,000 b/d at temperatures of 80°-100°F. ARCO (Photo 13) processes approximately 22,000 b/d and expressed some enthusiasm about heat extraction, but it considered the economics, potential regulations, and space requirements formidable obstacles. Most production is still from wells distributed in a random pattern, although Texaco and Shell are gradually converting to urban drill sites. The single wells are scattered among residential and commercial development that is slowly overtaking Signal Hill. Condominiums and apartments are the most prevalent forms of new construction. Perhaps cooperative projects between these developers and the operators could be initiated to extract heat from the 100°-140°F waters, although space for heat-exchanger equipment at all three facilities may be inadequate. Also, heat extraction might cause scaling, a major concern because all produced water plus makeup water is injected for water-flooding.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 54, no. 1 (1968).

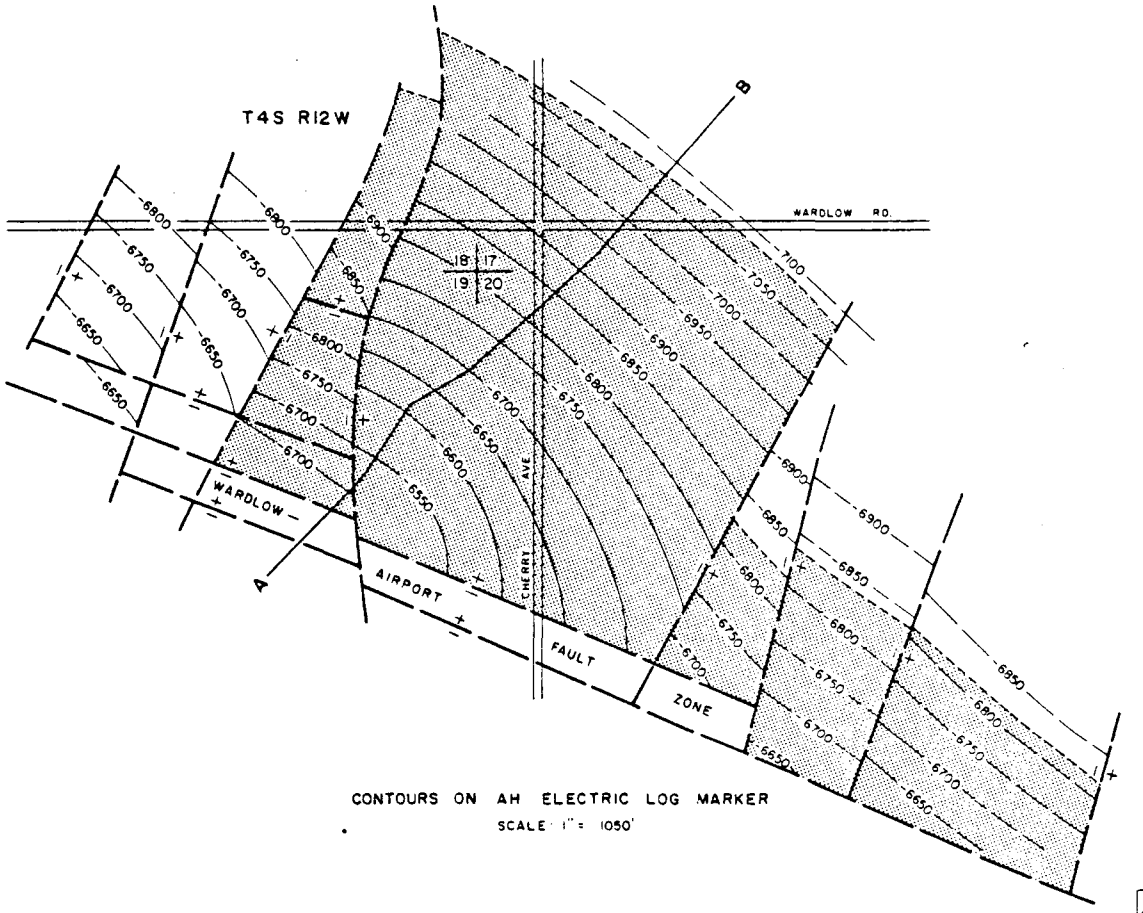
LONG BEACH OIL FIELD





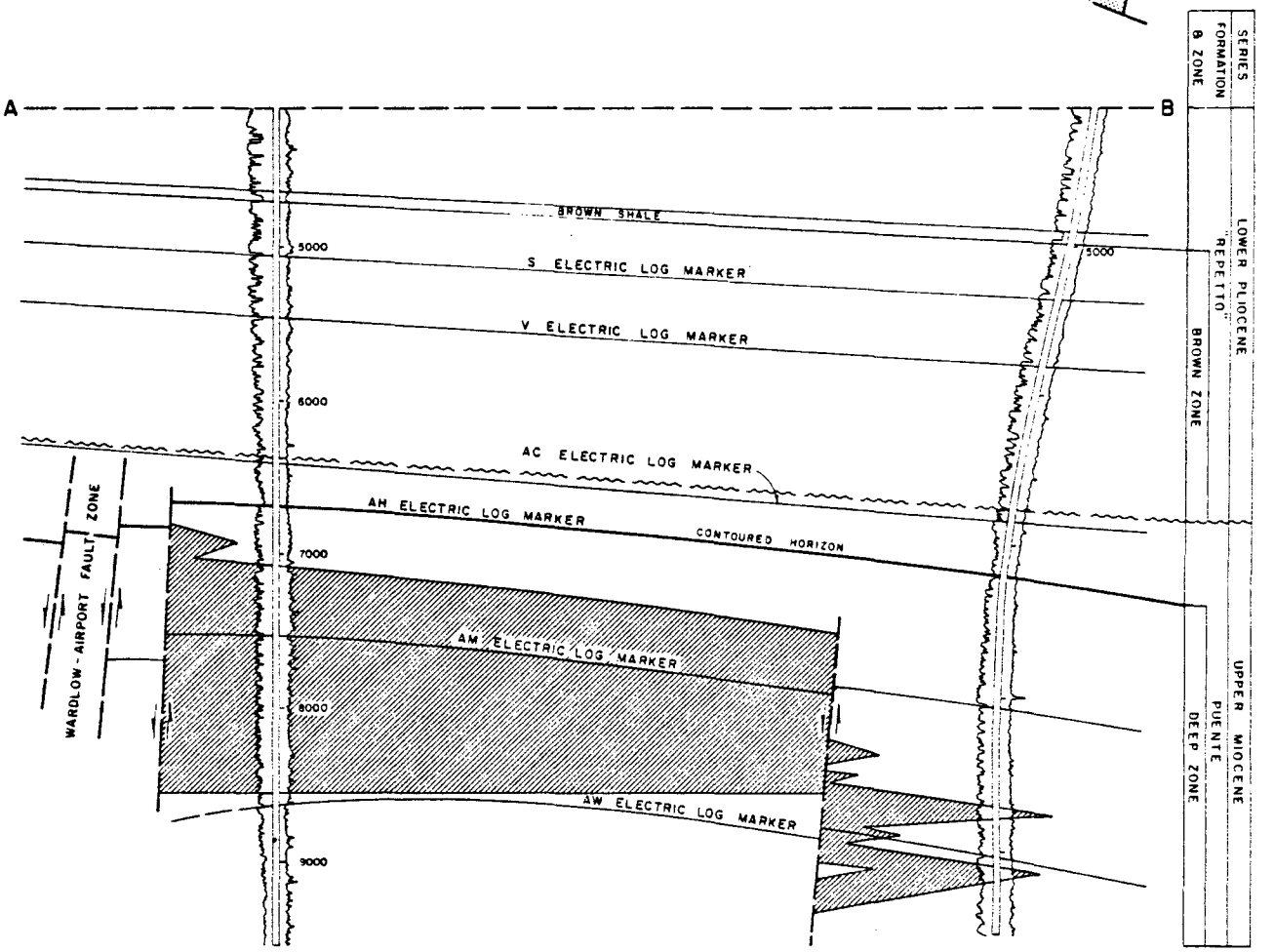


LONG BEACH AIRPORT OIL FIELD



CONTOURS ON AH ELECTRIC LOG MARKER

SCALE 1" = 1050'



LONG BEACH AIRPORT OIL FIELD

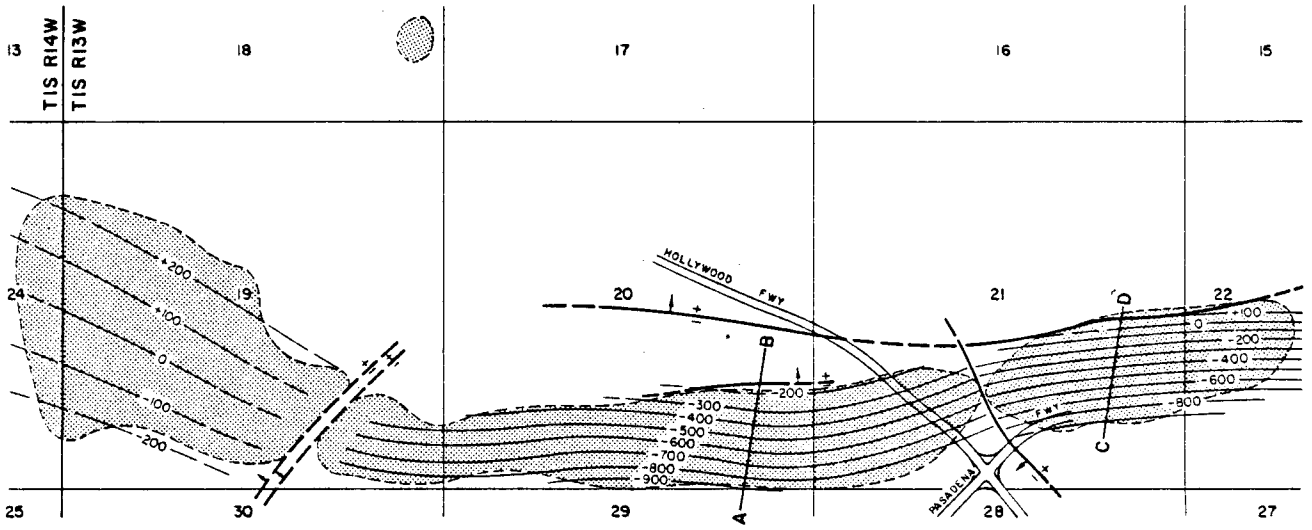
MAJOR OPERATORS (1981): Texaco, Termo.

CHARACTERISTICS AND POTENTIAL:

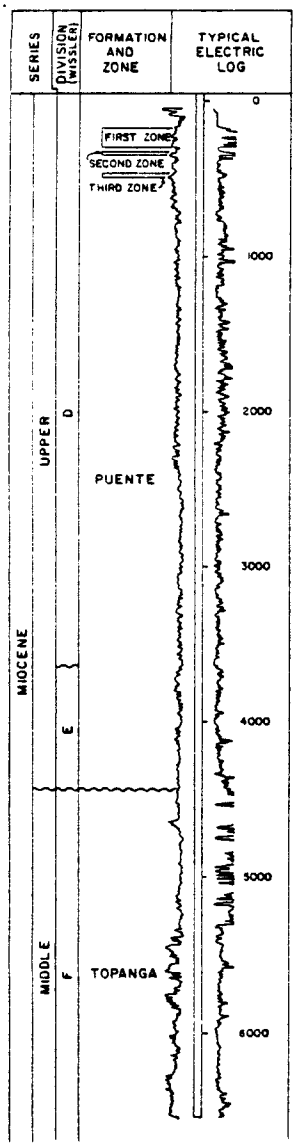
The location of this field's wells in a commercial area and adjacent to Long Beach Airport could offer many applications; however, the field's relatively low fluid production (about 1,000-1,500 b/d) and low well-head temperatures (Texaco reported 80°-100°F) would substantially limit potential uses. During the early 1970's, the waste water was shipped to Long Beach Oil Field for treatment and disposal; it is assumed that this process is still used today.

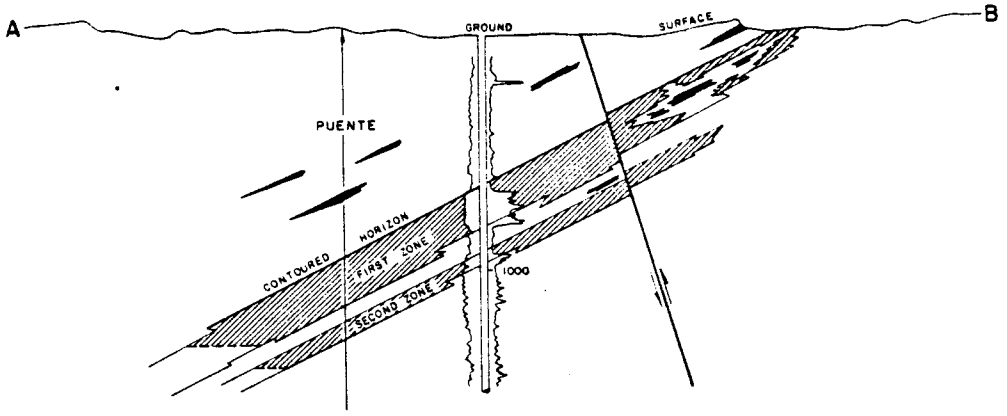
REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 50, no. 1 (1964).

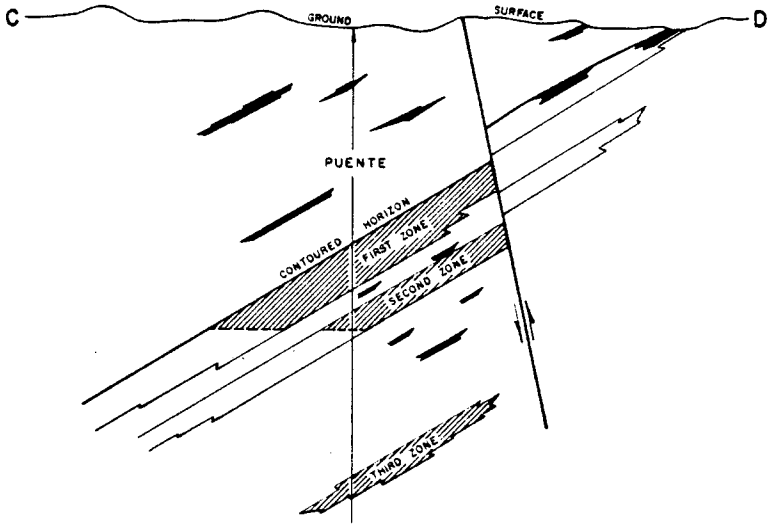
LOS ANGELES CITY OIL FIELD



CONTOURS ON TOP OF FIRST ZONE







LOS ANGELES CITY OIL FIELD

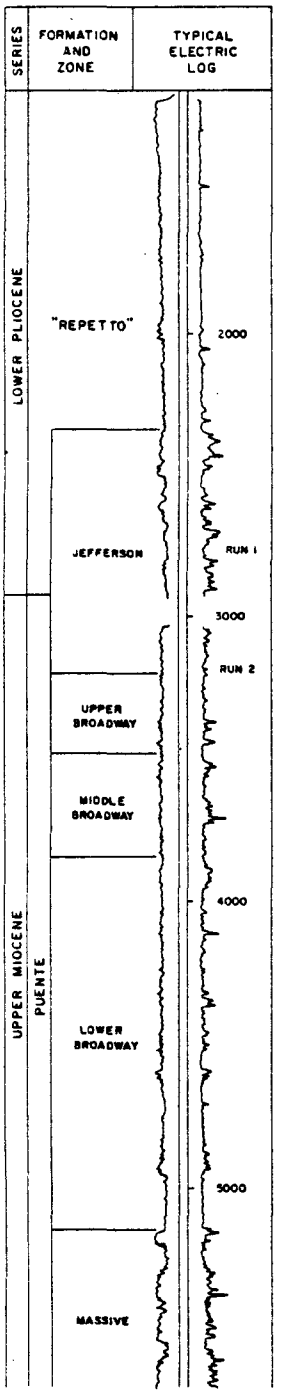
MAJOR OPERATORS (1981): Manley.

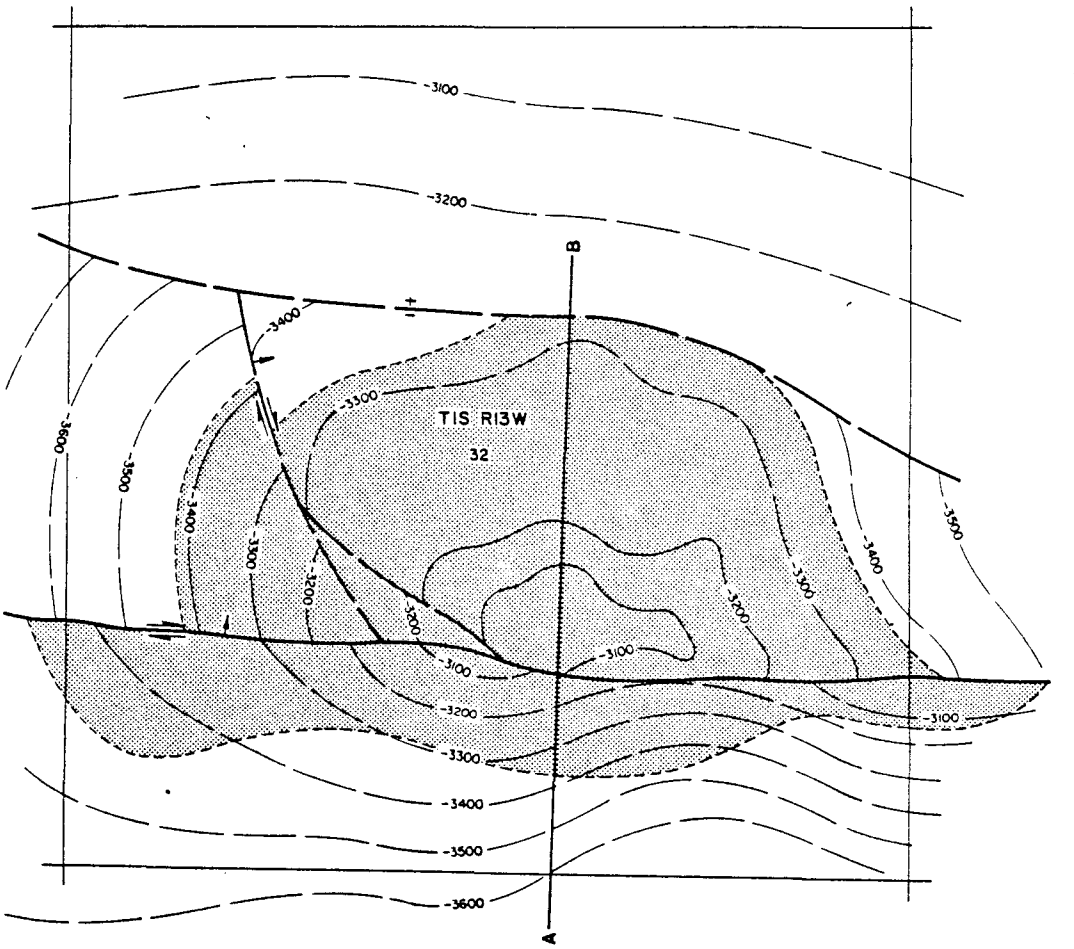
CHARACTERISTICS AND POTENTIAL:

One of the first oil fields to be developed in Los Angeles County, most of Los Angeles City's numerous oil wells are now abandoned. Although it appears to have one of the higher geothermal gradients of fields in the Los Angeles Basin, several conditions weaken this field's potential for heat extraction. First, the fluid production is very low, generally less than 1,000 b/d. Second, the reservoir is one of the shallowest in the Basin; it averages about 1,000 feet. Consequently, temperatures are not much above ambient as reported by Manley. Third, field facilities are scattered in different locations, which could make heat extraction impractical.

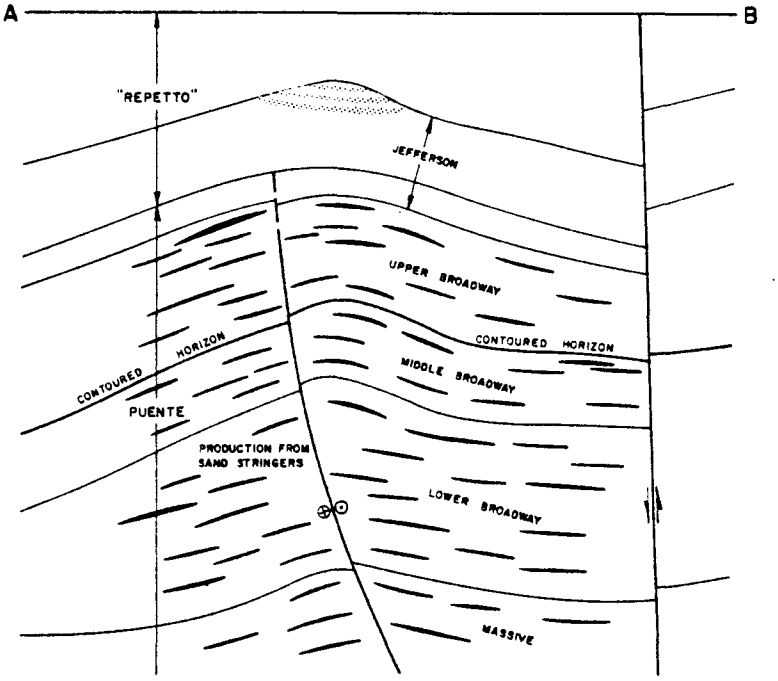
REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 47, no. 1 (1961).

LOS ANGELES DOWNTOWN OIL FIELD





CONTOURS ON TOP OF MIDDLE BROADWAY



LOS ANGELES DOWNTOWN OIL FIELD

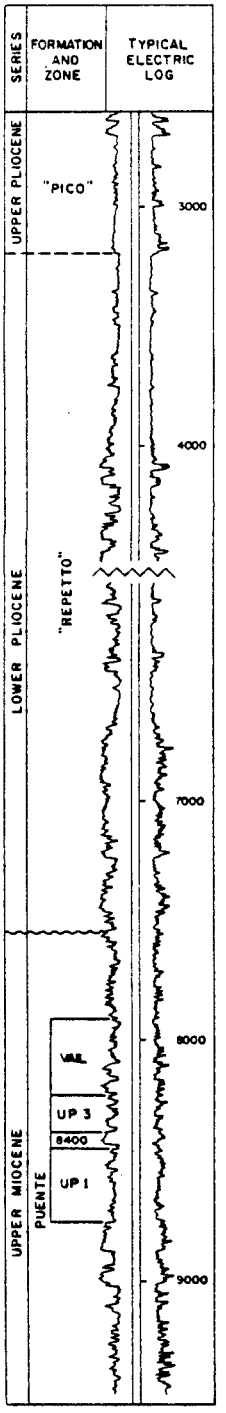
MAJOR OPERATORS (1981): Chevron.

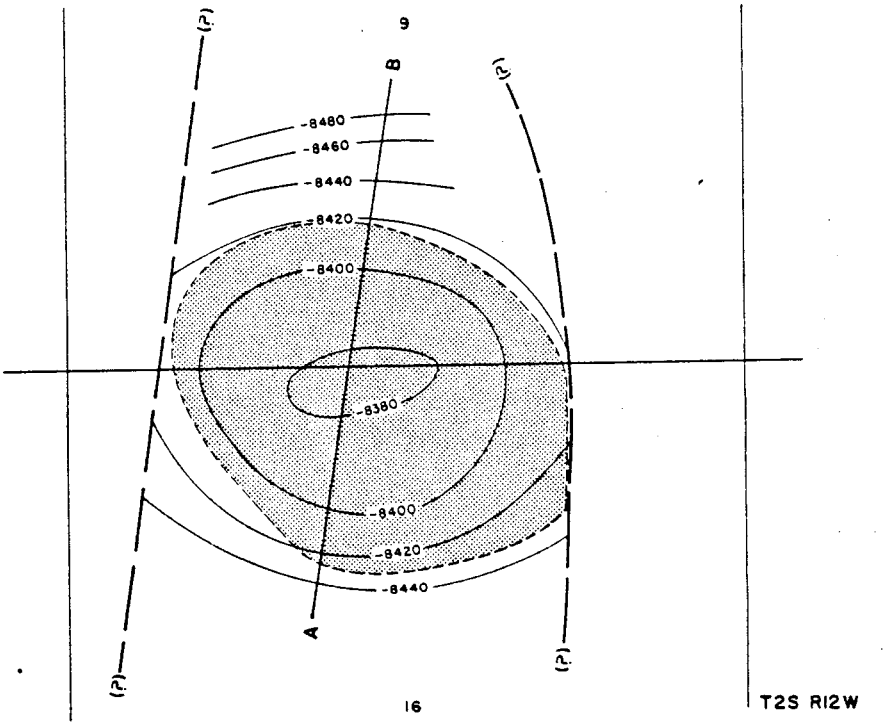
CHARACTERISTICS AND POTENTIAL:

Operations for Los Angeles Downtown are conducted by Chevron from the Broadway Drill Site, which is situated in a commercial-residential area. Although Chevron did not provide temperature data for the field, it is estimated that the geothermal gradient is relatively high, similar to those of nearby fields. Because most production is from less than 5,000 feet, it is expected that temperatures of produced fluids are in the range of 100°-125°F. Volumes are also modest at about 3,500-4,000 b/d. These characteristics favor only small-scale applications at best.

REFERENCE: None.

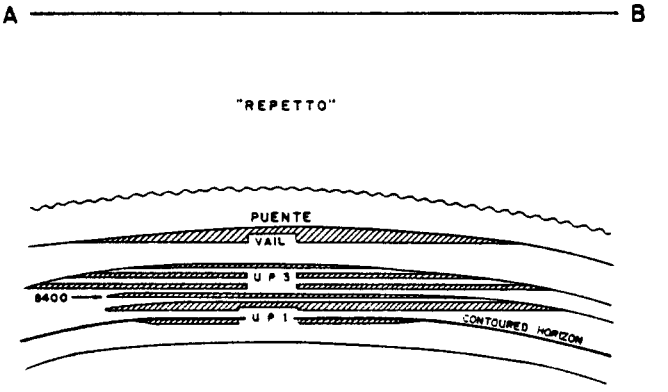
EAST LOS ANGELES OIL FIELD





CONTOURS ON TOP OF UP 1 ZONE

SCALE: 1" = 1500'



LOS ANGELES EAST OIL FIELD

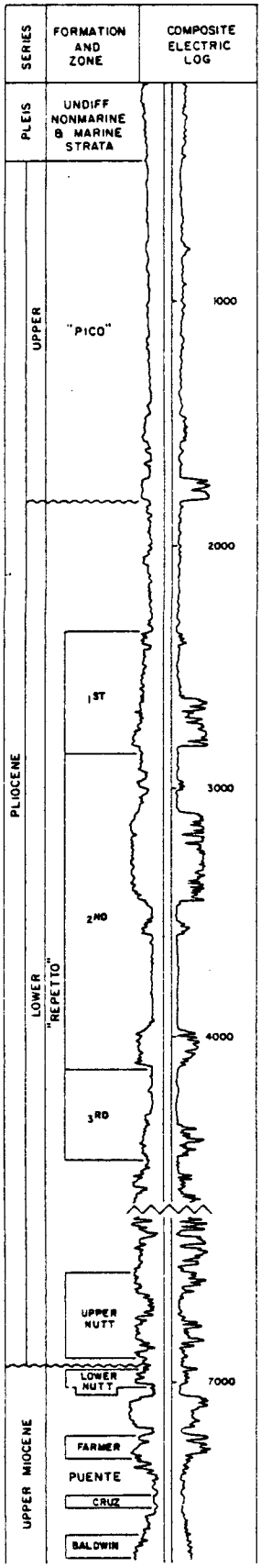
MAJOR OPERATORS (1981): Western Avenue Properties.

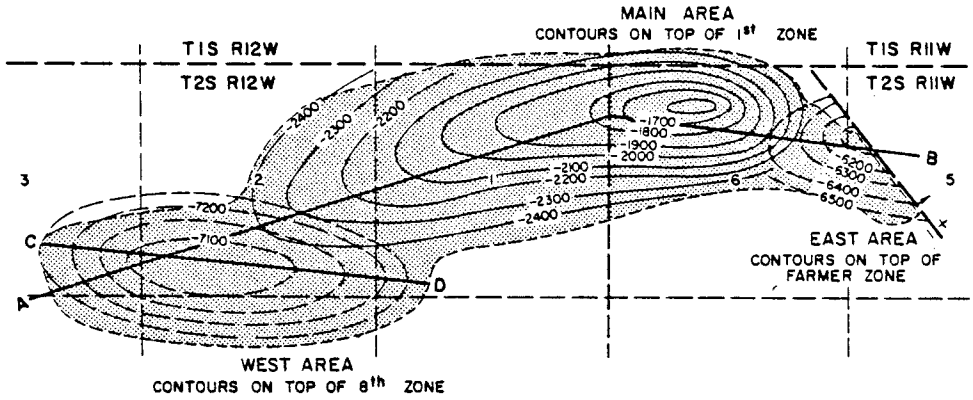
CHARACTERISTICS AND POTENTIAL:

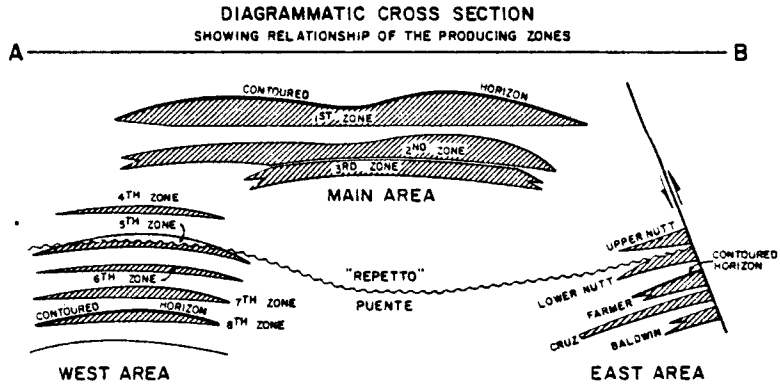
Several advantages make this field a potential site for heat extraction, although it is unknown if the operator would be willing to cooperate in such a venture. Notwithstanding the average geothermal gradient, the deep production zones (8,000-9,000 feet) provide fluid to the central treatment facility at an estimated 180°F. The operator reported, however, that upon discharge to the sewer system, all waste water is close to ambient temperaure. The facility, which processes all fluid produced in the field (about 3,000 b/d), is centrally situated in a large industrial complex. It is on the corner of a large, vacant lot, consequently, space is not a problem for potential heat extraction.

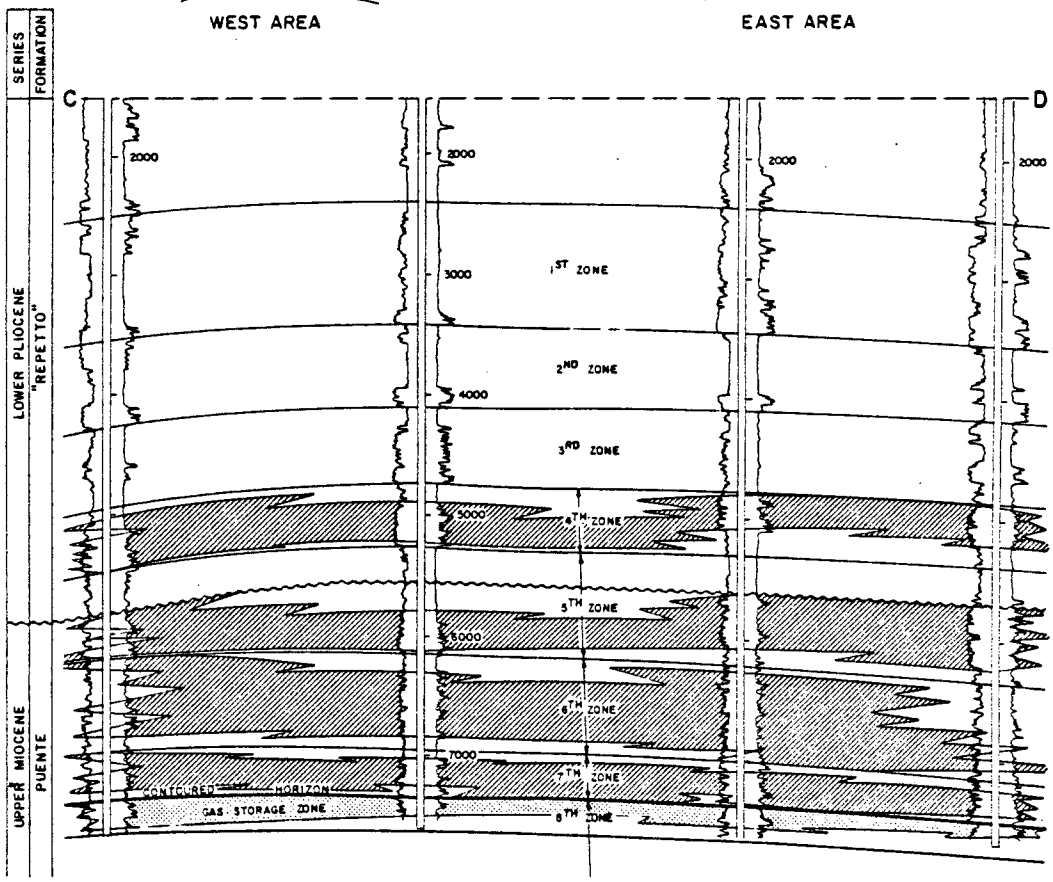
REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 38, no. 1 (1952).

MONTEBELLO OIL FIELD









MONTEBELLO OIL FIELD

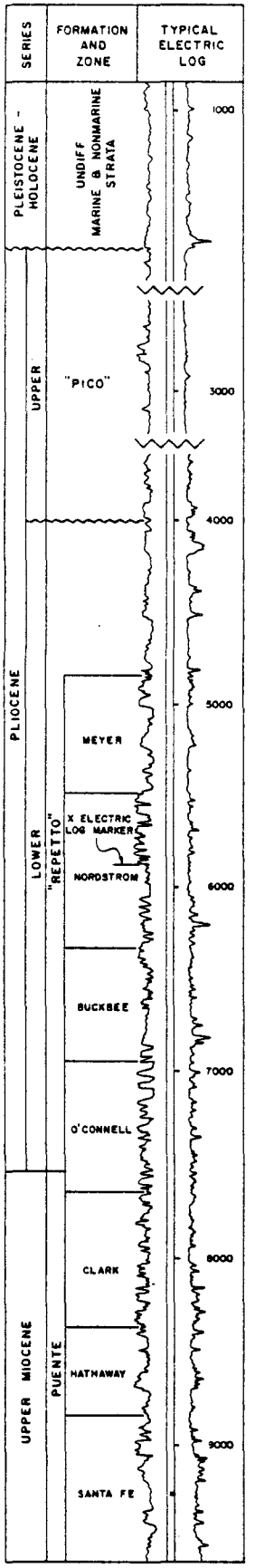
MAJOR OPERATORS (1981): Chevron, Texaco, Energy Production and Sales.

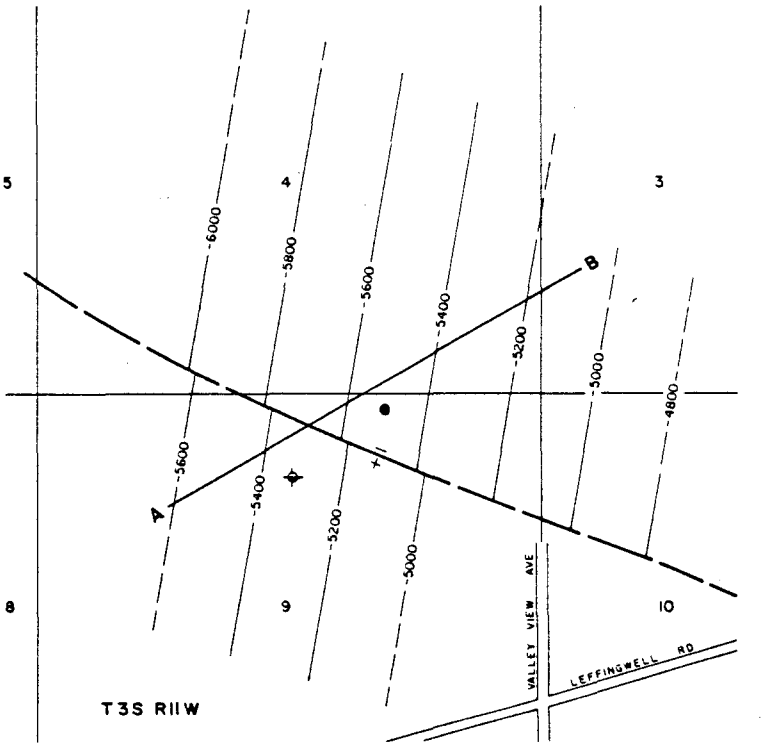
CHARACTERISTICS AND POTENTIAL:

One of the largest water producers in the Los Angeles Basin, Montebello is largely rural within its boundaries as well as on its south and east sides (Photo 14). Urban and commercial development has encroached on the southwest, west, and, to some extent, north sides. Chevron is the main operator with a single, large treatment facility to handle nearly all of the field production. The water production is approximately 22,000 b/d at incoming and outgoing temperatures estimated to be about 100°-115°F. About 70% of the water is disposed of in the sewer, therefore, the heat could be extracted with little or no detriment to the oil operations. Because of the relatively low temperatures, however, the amount of heat available would be somewhat limited. The temperatures can probably be explained by both the low-to-moderate geothermal gradient as well as by the commingled production from many zones. Zone production ranges from about 2,000 to 8,000 feet, the effect of which is to dilute the hot, deeper production with cooler, shallow waters.

REFERENCE: Calif. Div. of Mines and Geology, Bulletin 118, 1943.

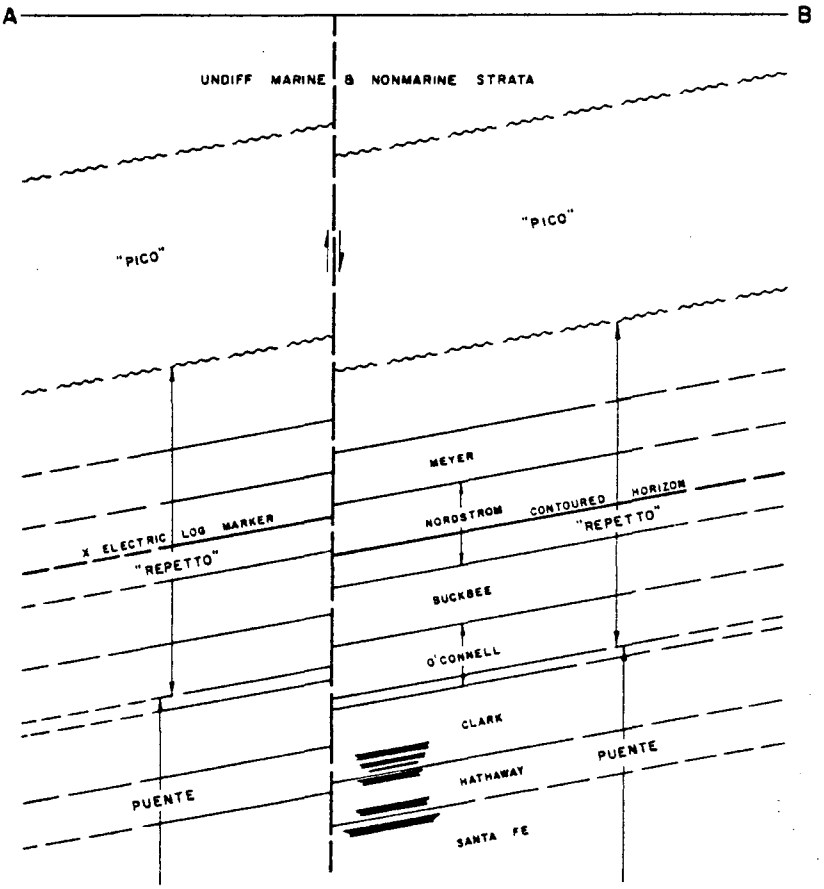
NEWGATE OIL FIELD





CONTOURS ON X ELECTRIC LOG MARKER

SCALE: 1" = 2000'



NEWGATE OIL FIELD

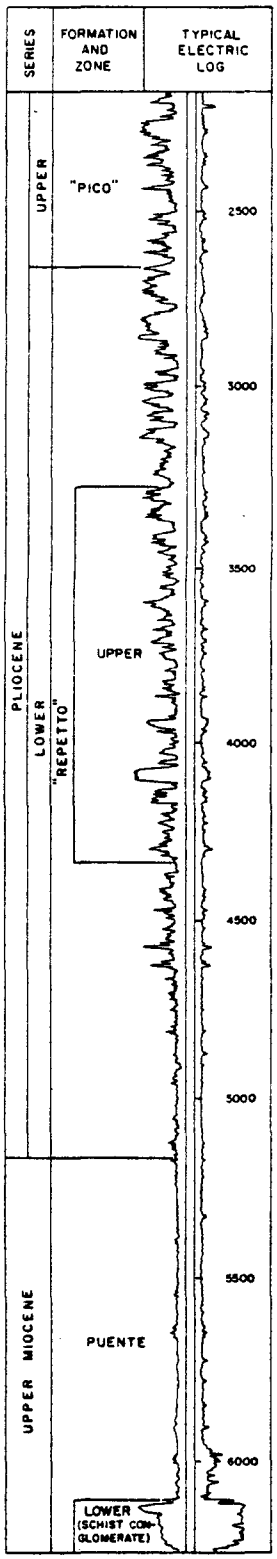
MAJOR OPERATORS (1981): Gulf.

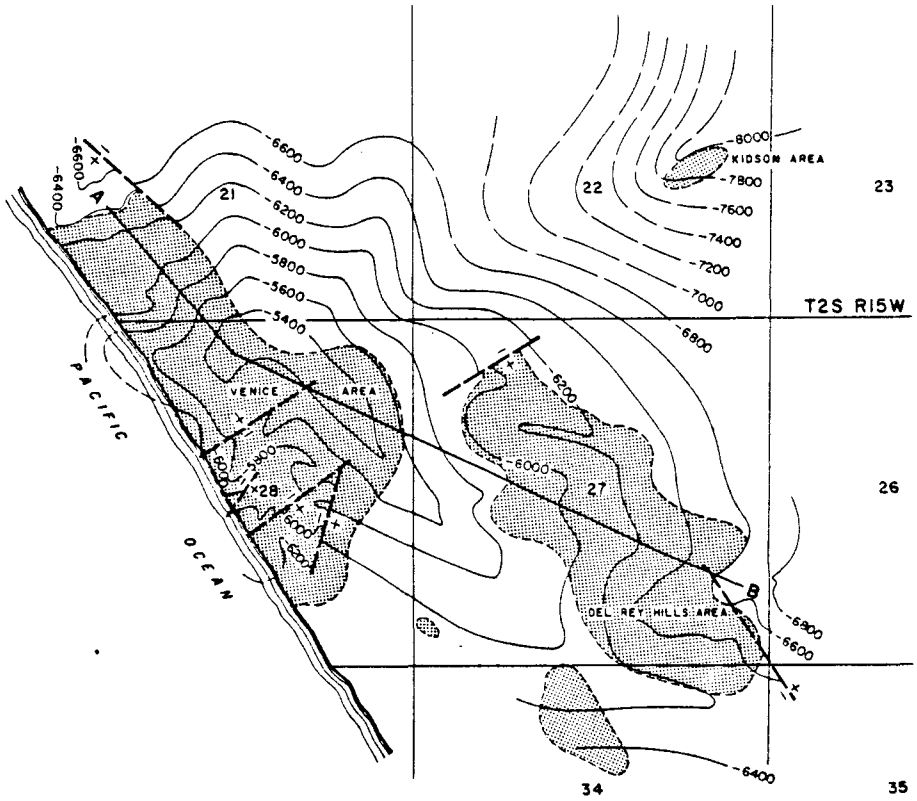
CHARACTERISTICS AND POTENTIAL:

Although it produces from about 8,000-9,000 feet, the single well in this field has a well-head temperature of only about 100°F according to the operator. The extremely low fluid production (25-50 b/d) makes this field operation impractical as a site for heat extraction.

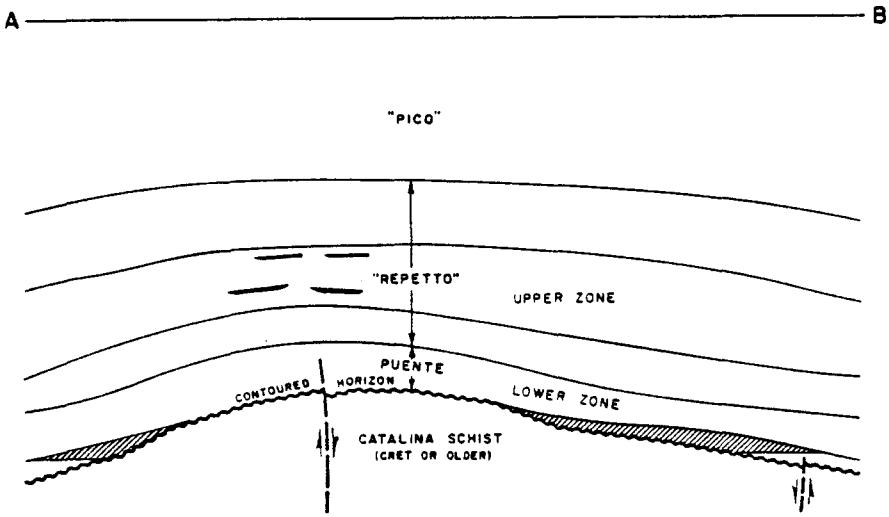
REFERENCE: None.

PLAYA DEL REY OIL FIELD





CONTOURS ON TOP OF CATALINA SCHIST



PLAYA DEL REY OIL FIELD

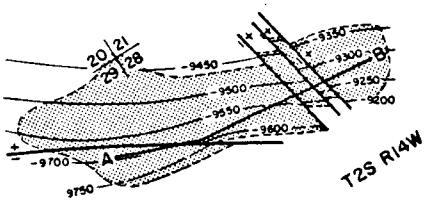
MAJOR OPERATORS (1981): Southern California Gas Company.

CHARACTERISTICS AND POTENTIAL:

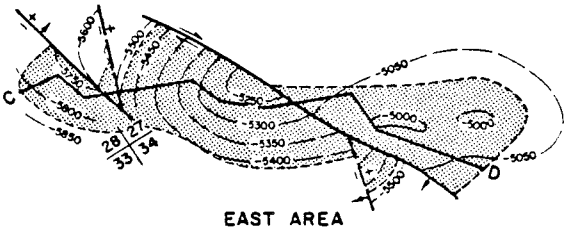
All formal oil operations have ceased in this field and its reservoirs are now used for storage of natural gas. Because of this present use, any associated oil and water production is sporadic and thus would not provide a reliable, consistent source of thermal water. The field's potential as a source of thermal waters is theoretically one of the best in the Los Angeles Basin, however. The geothermal gradient is estimated to be about 5.0-5.5°C/100 meters, which implies that fluids of approximately 225°-250°F would be expected at 6,000 feet depth. The field is characterized by suburban residential development in its southern part and the large Marina del Rey harbor development in its northern part.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 39 (1959).

POTRERO OIL FIELD

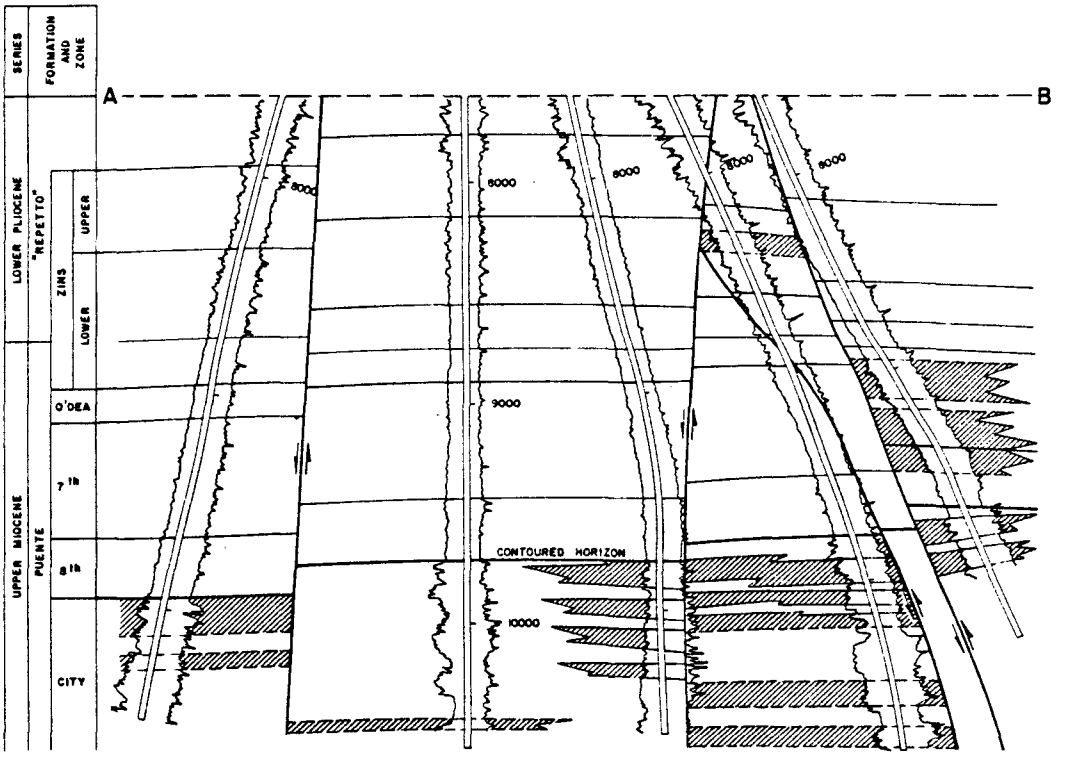


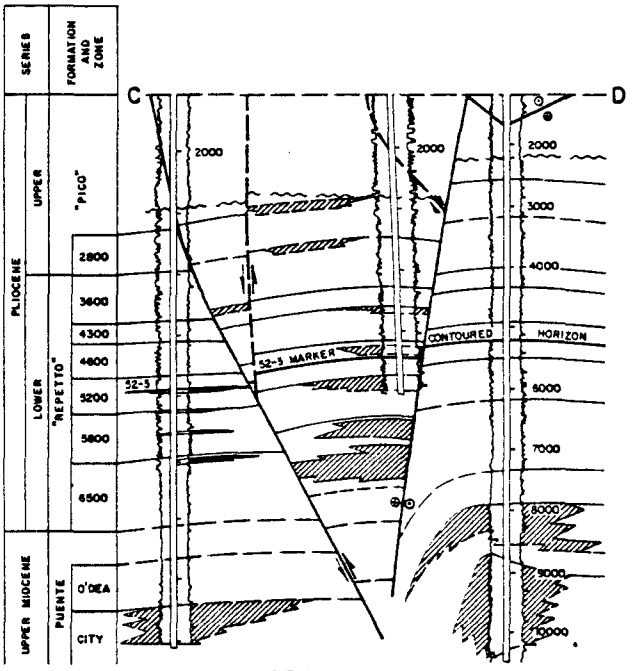
INGLEWOOD CITY AREA
CONTOURS ON TOP OF CITY ZONE



EAST AREA
CONTOURS ON 52-3 ELECTRIC LOG MARKER

SCALE: 1" = 2600'





POTRERO OIL FIELD

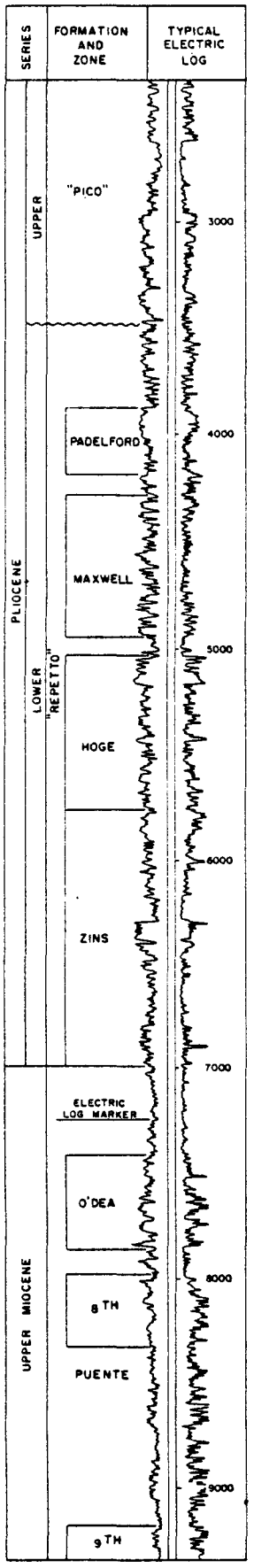
MAJOR OPERATORS (1981): Mobil, Getty.

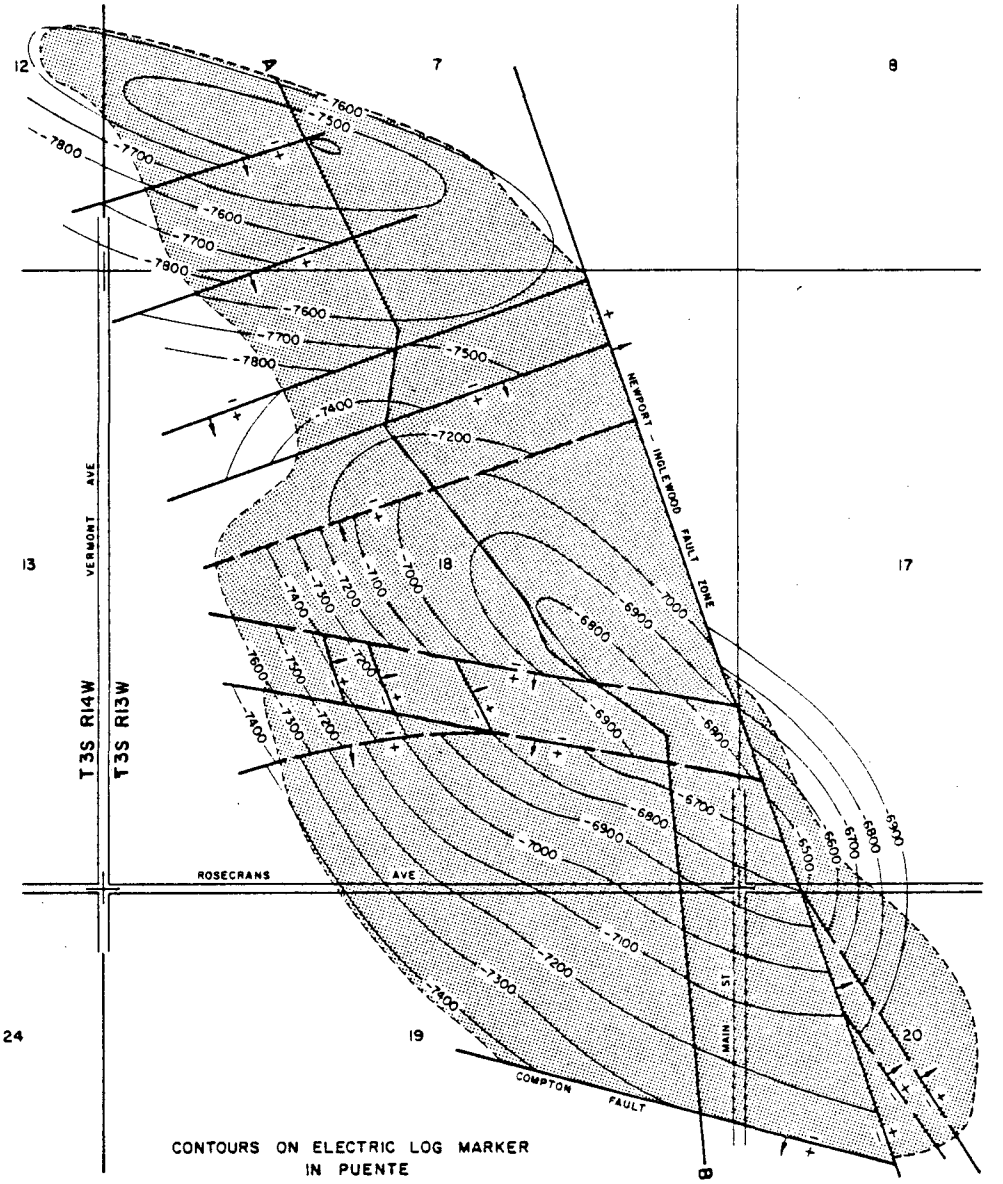
CHARACTERISTICS AND POTENTIAL:

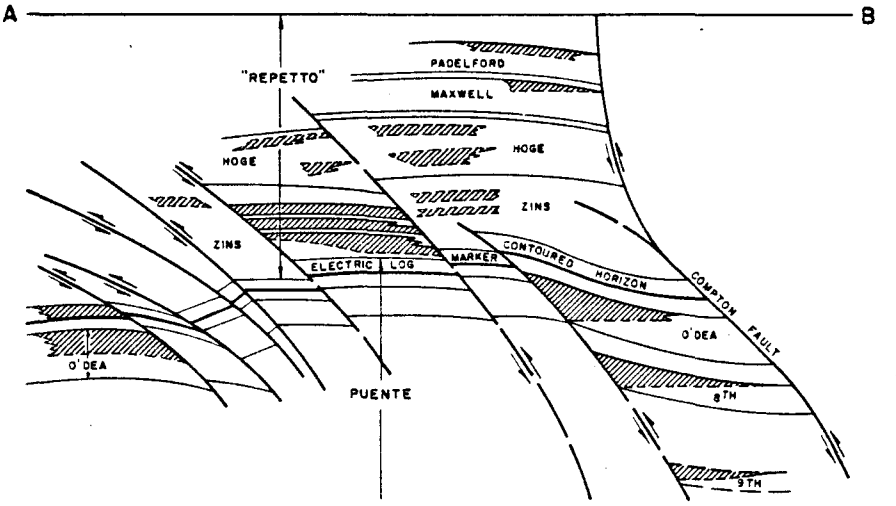
The average geothermal gradient and commingled production from a wide range of depths (3,000-9,000 feet approximately) indicate limited potential for the areas of Potrero, which are situated in an urbanized region of mixed commercial-residential-industrial development. The Inglewood City Area produces very little fluid (about 100 b/d), therefore, it is impractical as a site for heat extraction. The East Area produces substantially more fluid and could be considered as a source for limited heat extraction. An advantage of both areas is that all waste water is apparently disposed of in the sewer; after discharge from the treatment facility, heat could be extracted from the water.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 47, no. 2 (1961), v. 44, no. 1 (1958).

ROSECRANS OIL FIELD







ROSECRANS OIL FIELD

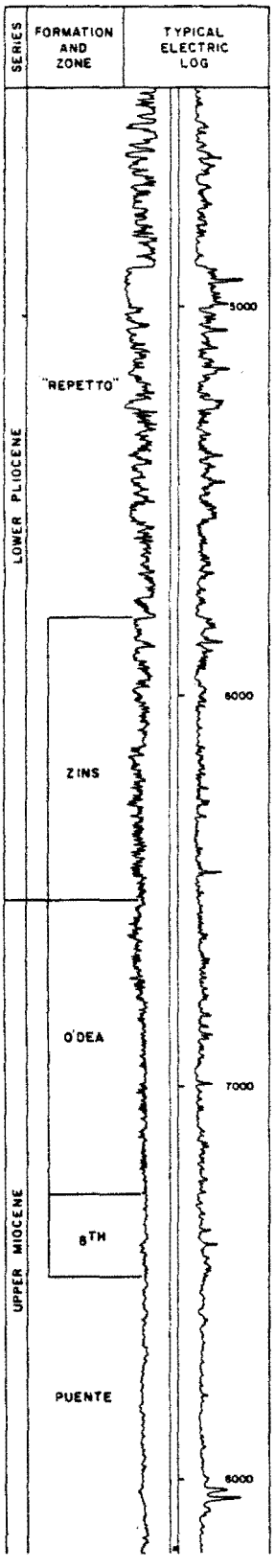
MAJOR OPERATORS (1981): Beren, Gulf, Marmac, Sun.

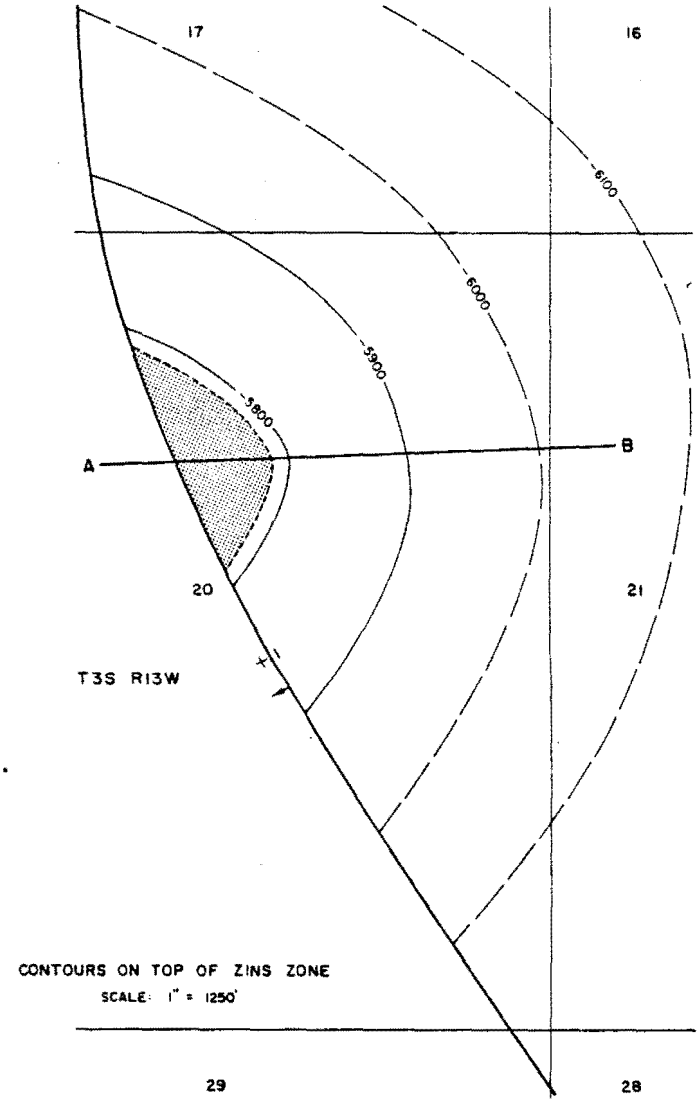
CHARACTERISTICS AND POTENTIAL:

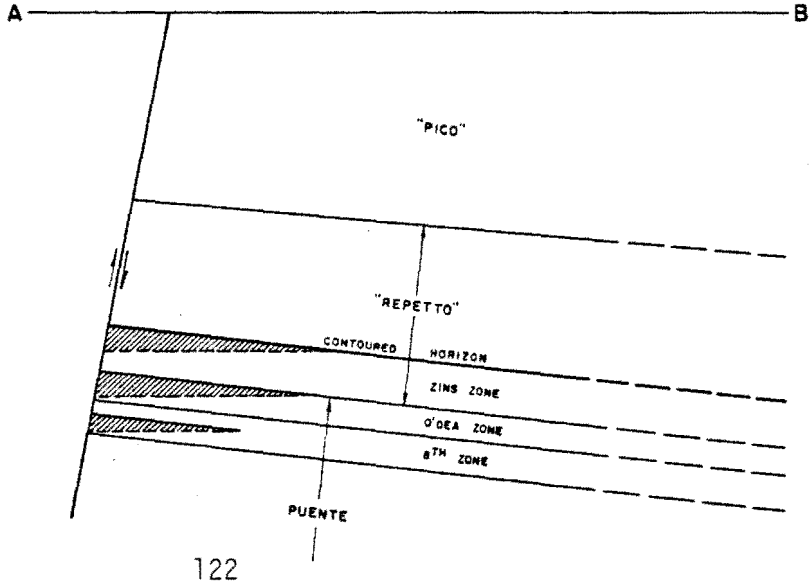
The main advantage of Rosecrans is its location in the midst of a large industrial-commercial area. Unfortunately, reported fluid temperatures are not high (well-head; 60°-100°F), and produced volumes (4,000-5,000 b/d) are inadequate for widespread applications. The collection-treatment facility operated by Beren (Photo 16) processes most of the field production and is situated in an industrial complex. A large vacant area bounds the facility on the south and west sides.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 40, no. 2 (1954).

EAST ROSECRANS OIL FIELD







ROSECRANS EAST OIL FIELD

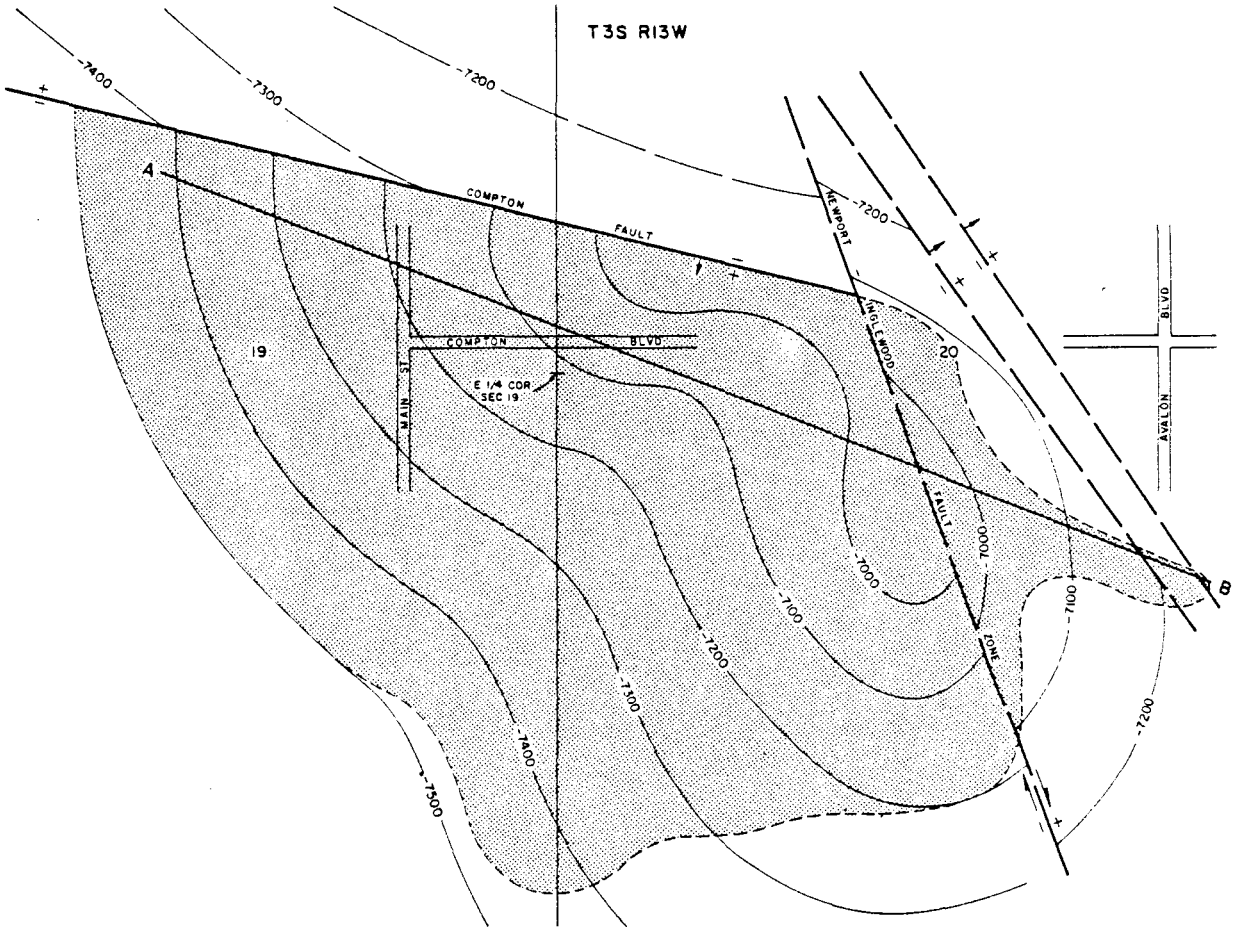
MAJOR OPERATORS (1981): Gardena.

CHARACTERISTICS AND POTENTIAL:

Because of this field's very low fluid production (15-20 b/d), it should not be considered as a site of heat extraction. Most production is from about 6,000 feet; considering the average geothermal gradient of the field, production temperatures are probably similar to those at Rosecrans Oil Field.

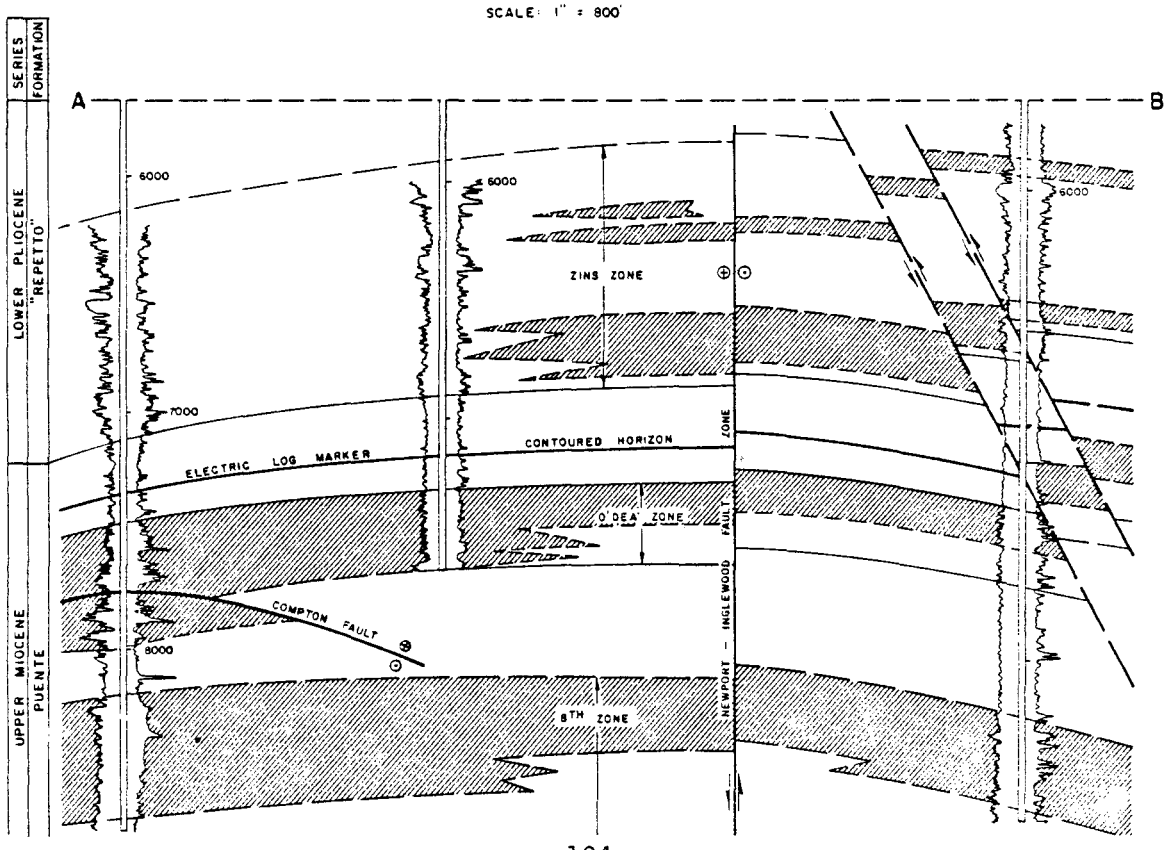
REFERENCES: None.

SOUTH ROSECRANS OIL FIELD



CONTOURS ON ELECTRIC LOG MARKER IN PUENTE

SCALE: 1" = 800'



ROSECRANS SOUTH OIL FIELD

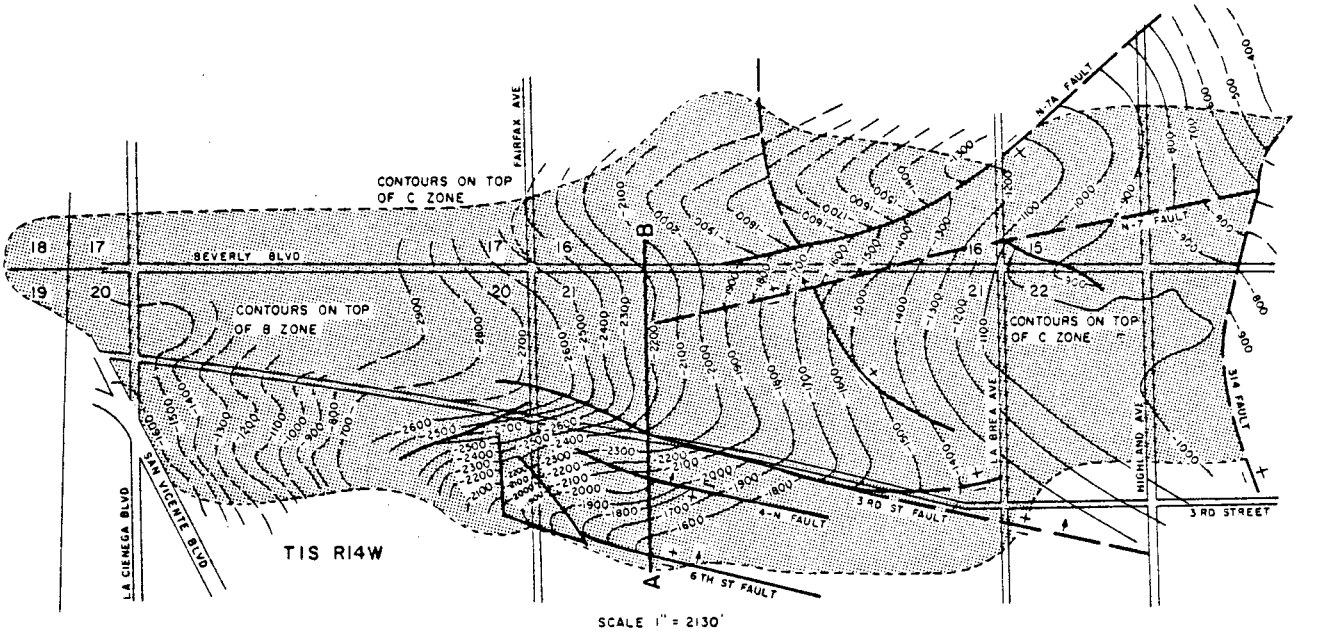
MAJOR OPERATORS (1981): Beren, Marmac, American Titan (minor).

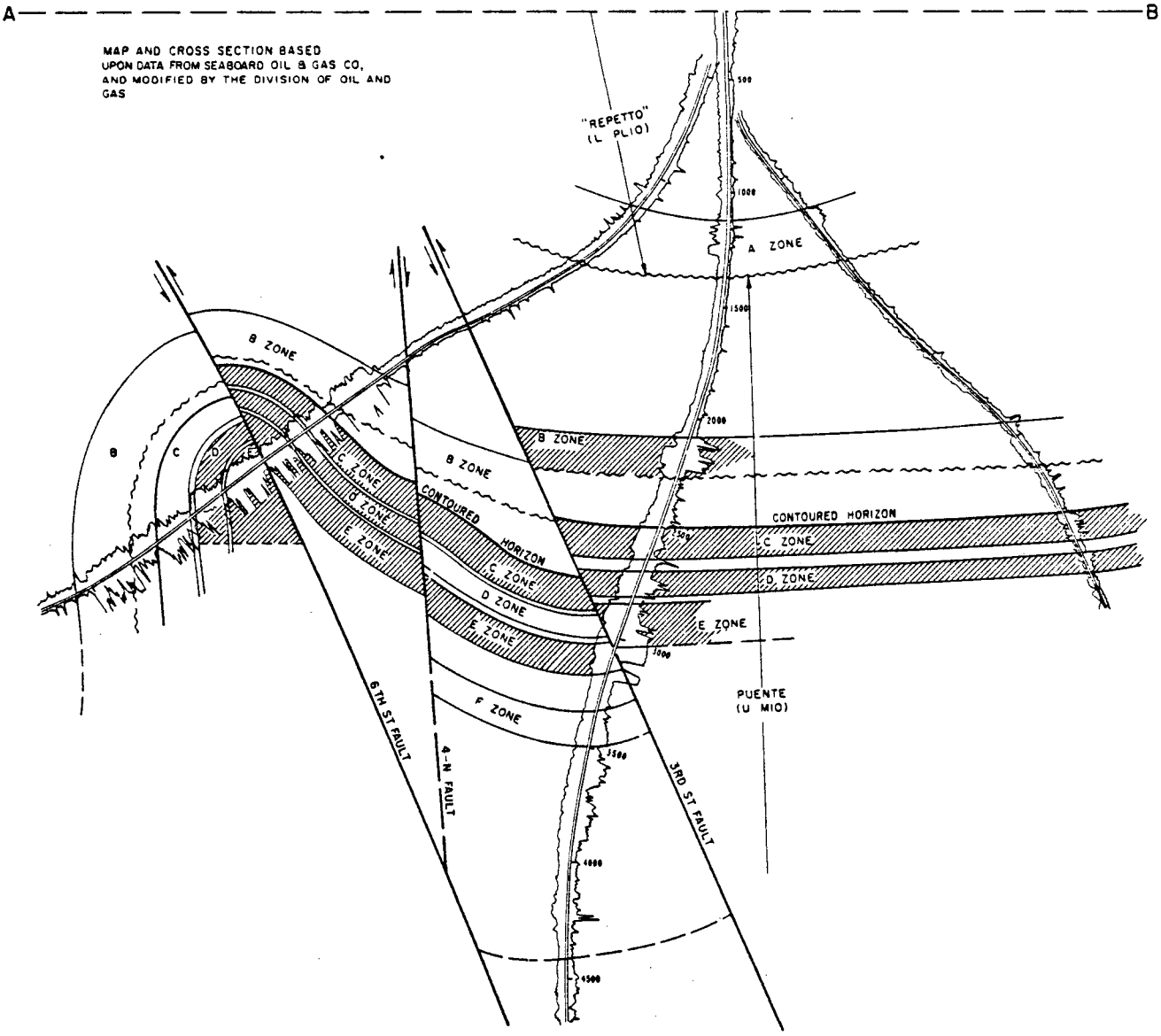
CHARACTERISTICS AND POTENTIAL:

The low estimated production temperatures and small volume of produced fluids (approximately 200-300 b/d) of this field are insufficient for significant applications.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 40, no. 2 (1954).

SALT LAKE OIL FIELD





SALT LAKE OIL FIELD

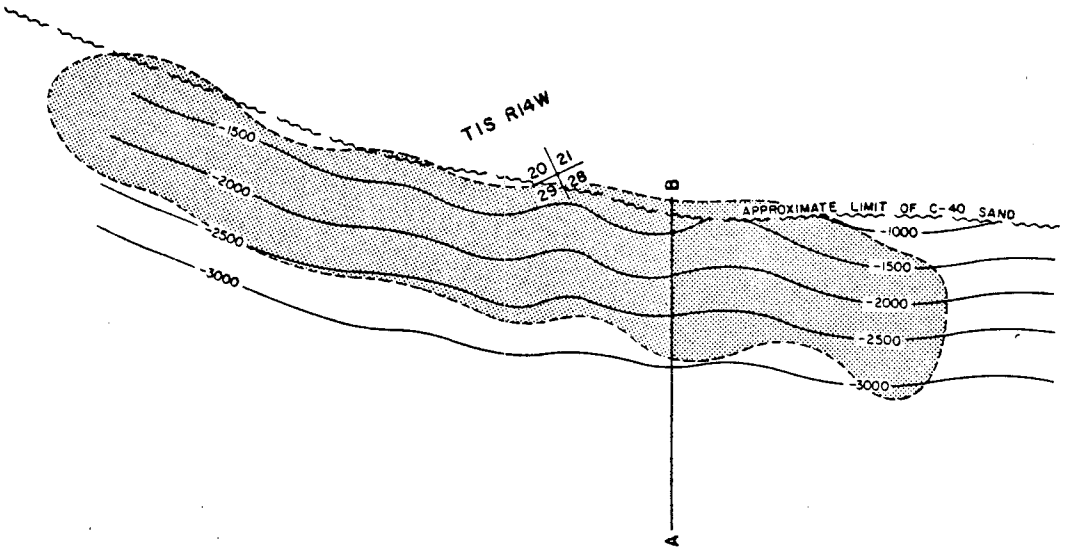
MAJOR OPERATORS (1981): Seaboard (subsidiary of McFarland), Chevron (minor).

CHARACTERISTICS AND POTENTIAL:

All oil operations in Salt Lake are conducted from two urban drill sites, both of which are in commercial-residential areas. Nearly all production is from the Beverly Drill Site operated by Seaboard; the remainder is from Chevron's San Vicente Drill Site. Production temperatures are not known for this field, but it is inferred that they are lower than those at Beverly Hills Oil Field because of the shallowness of the producing zones (less than 3,000 feet). Fluid production from the field is relatively small (1,000-1,500 b/d), which precludes any large-scale applications.

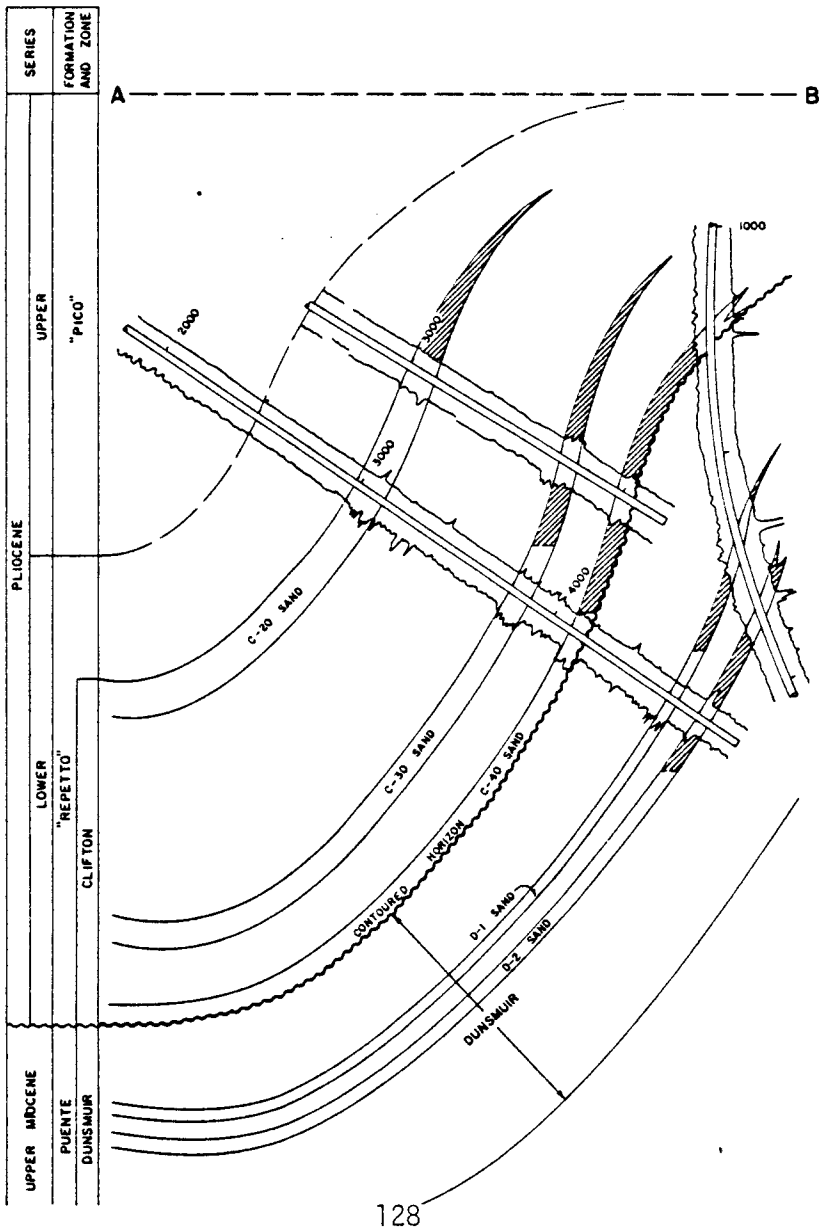
REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 49, no. 1 (1963).

SOUTH SALT LAKE OIL FIELD



CONTOURS ON BASE OF C-40 SAND

SCALE: 1" = 1200'



SALT LAKE SOUTH OIL FIELD

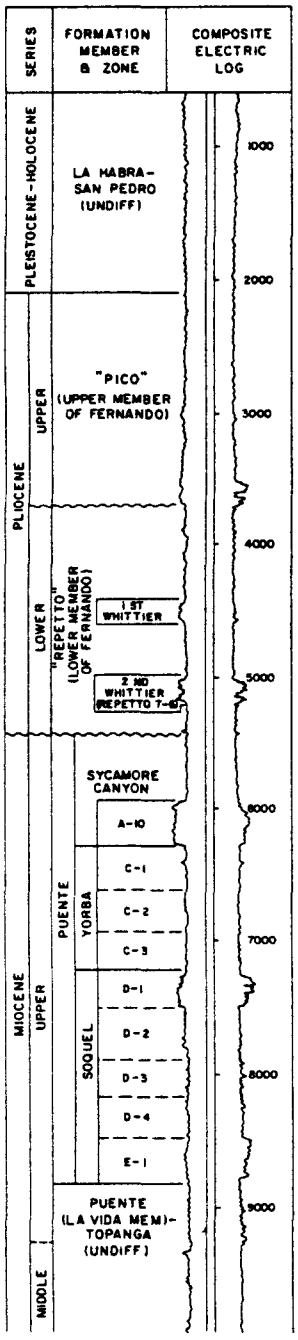
MAJOR OPERATORS (1981): Chevron.

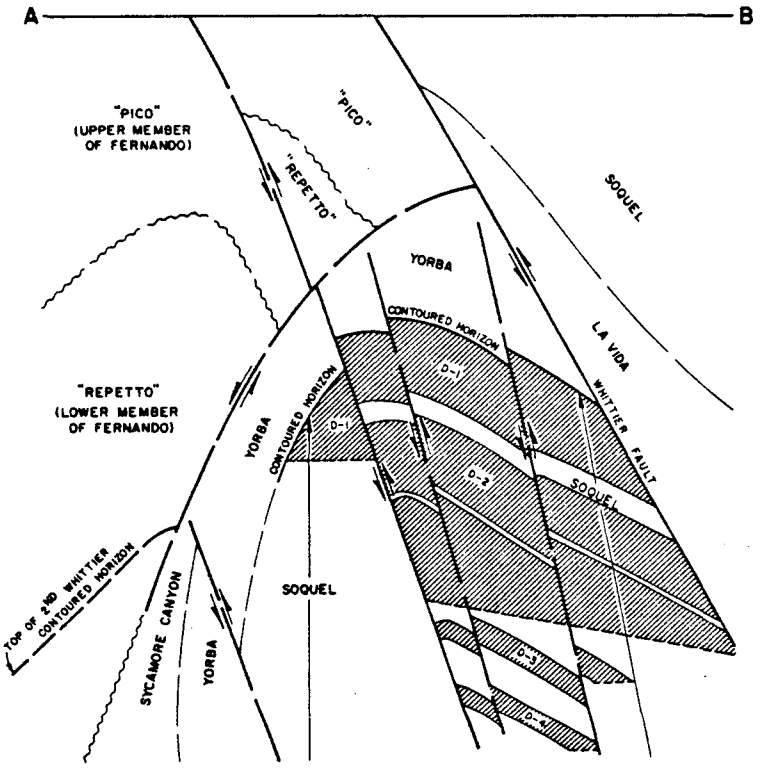
CHARACTERISTICS AND POTENTIAL:

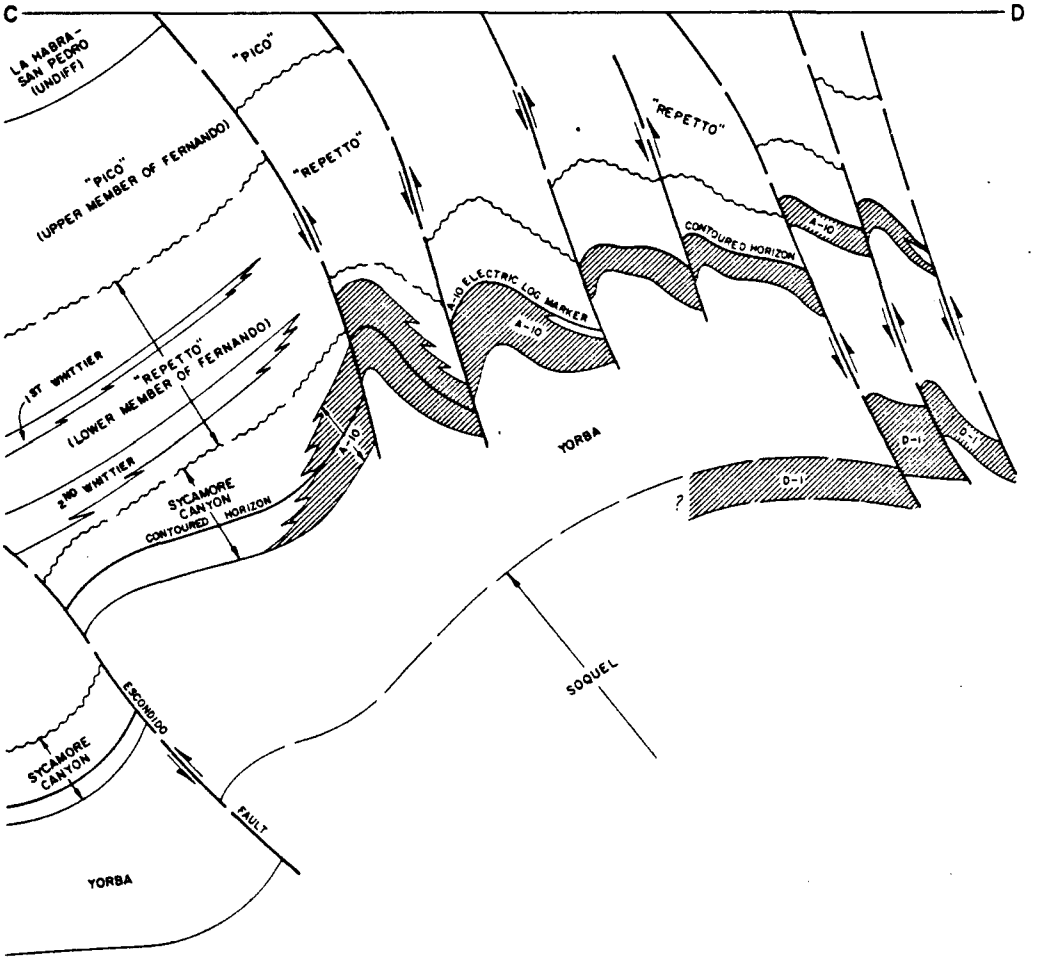
All operations in this field are conducted from the Packard Drill Site operated by Chevron. Water and oil production at this facility is about 22,000 b/d, most of which is from the Beverly Hills Oil Field; fluid production at Salt Lake South averages about 3,500 b/d. The field is estimated to have a moderately high geothermal gradient, but this is difficult to determine because of the lack of available zone temperatures and the artificial effects of directional drilling on log temperatures. Because the potential of this field is based on the characteristics of the Packard Drill Site, the reader is referred to the discussion of Beverly Hills Oil Field in this appendix.

REFERENCES: None.

SANSINENA OIL FIELD







SANSINENA OIL FIELD

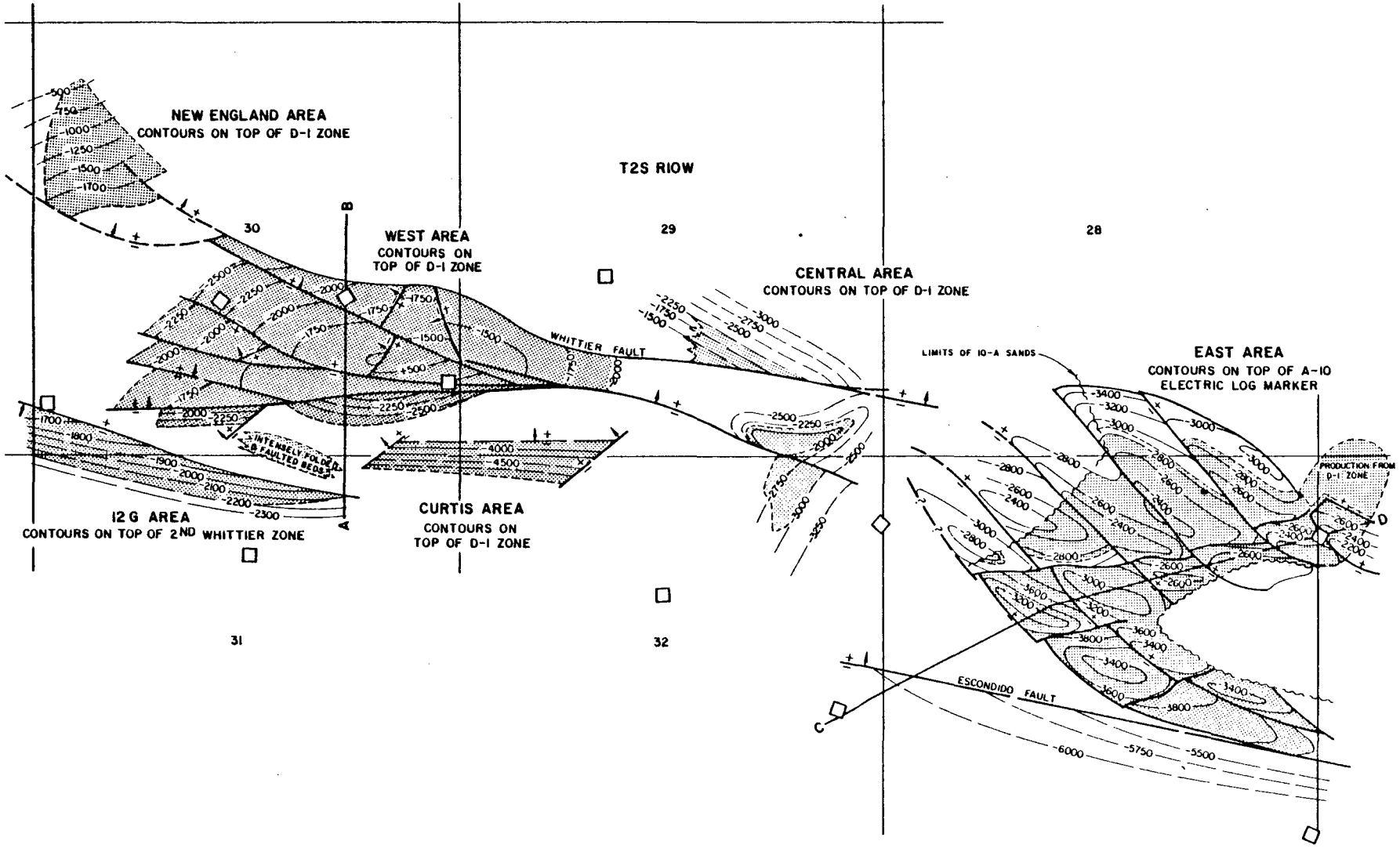
MAJOR OPERATORS (1981): Union, McFarland, Gulf (minor).

CHARACTERISTICS AND POTENTIAL:

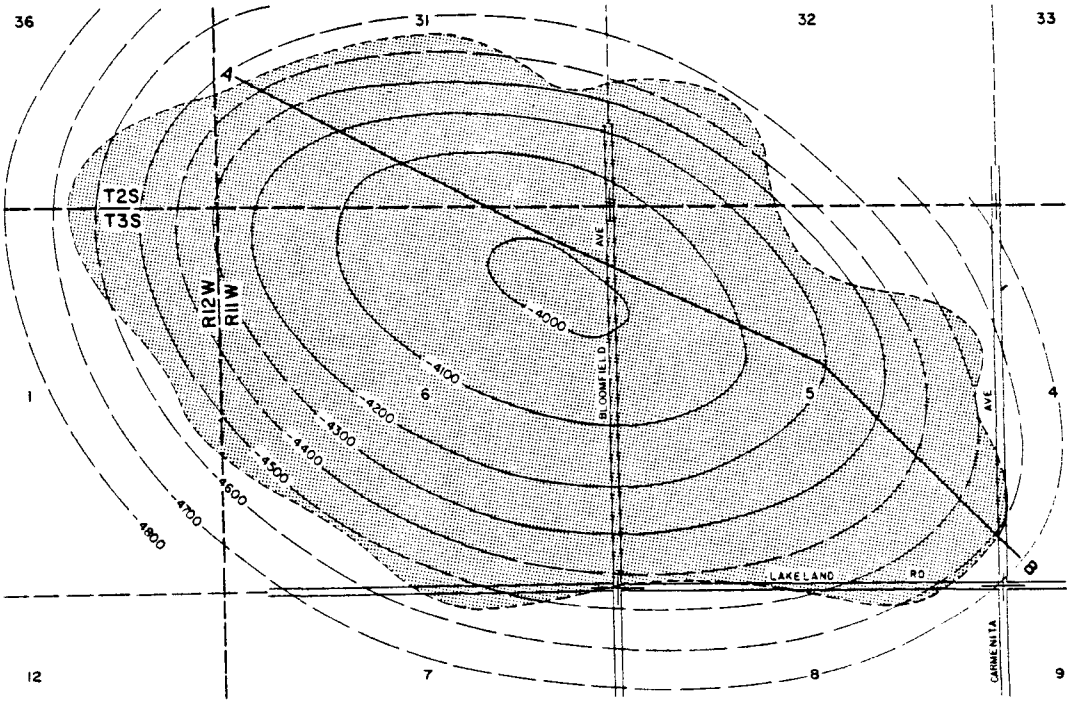
Sansinena is composed of five small producing areas whose operations are mainly conducted from many small drill sites. The field is hilly, characterized by a mixed rural and residential setting. Daily fluid production is about 2,500 barrels for the entire field; water composes a little less than half of this total. Most production is from less than 5,000 feet, consequently, temperatures of produced fluids are unremarkable. Union (written communication, 1981) reported average production temperatures of about 100°F at its drill sites. Several characteristics make this field a weak candidate for heat extraction. These include: 1) There are many treatment facilities scattered over a large area. Fluids produced at any one site may thus be inadequate to support any important applications. 2) The area's topography and cultural development do not favor large-scale applications. 3) The production temperatures are relatively low.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 59, no. 1 (1974).

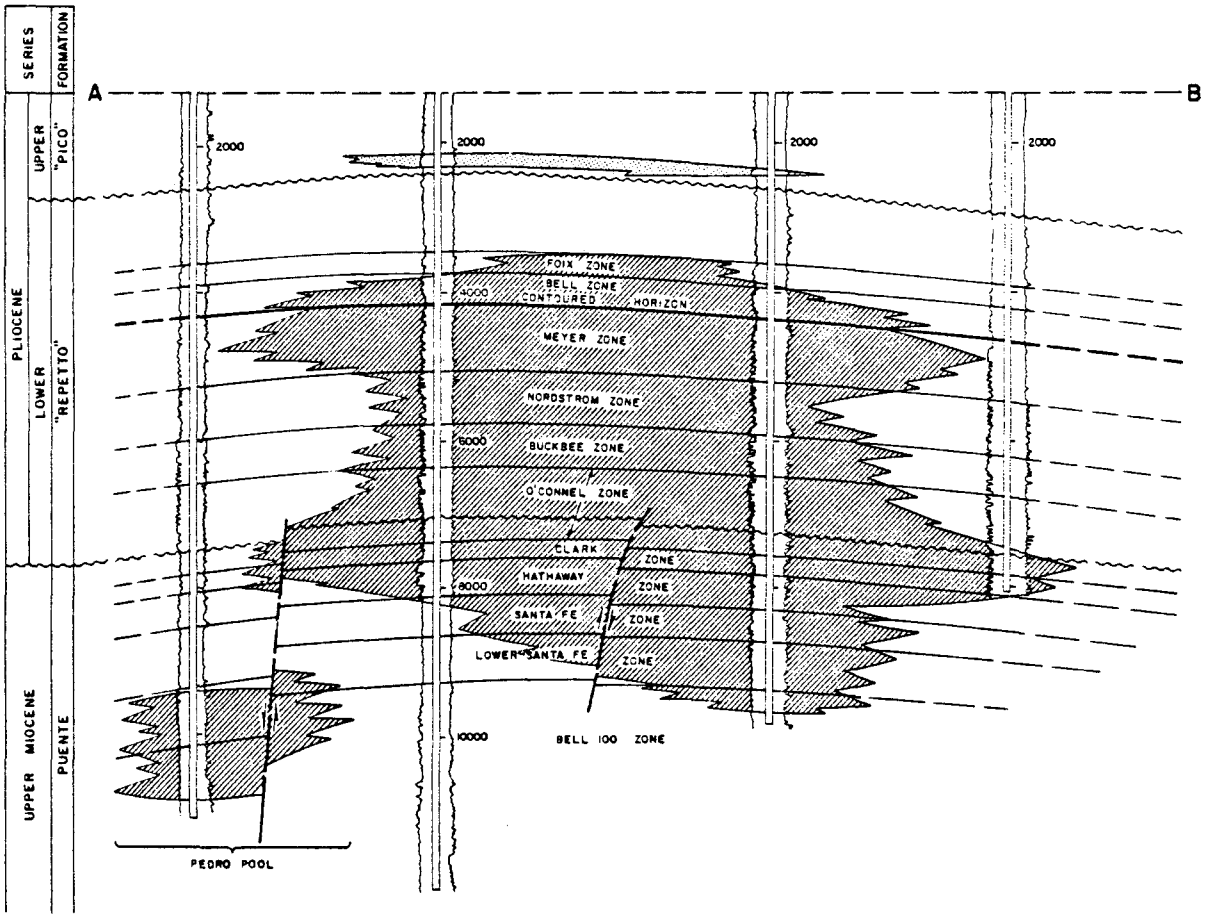
SANSINENA OIL FIELD



SANTA FE SPRINGS OIL FIELD



CONTOURS ON TOP OF MEYER ZONE



SANTE FE SPRINGS OIL FIELD

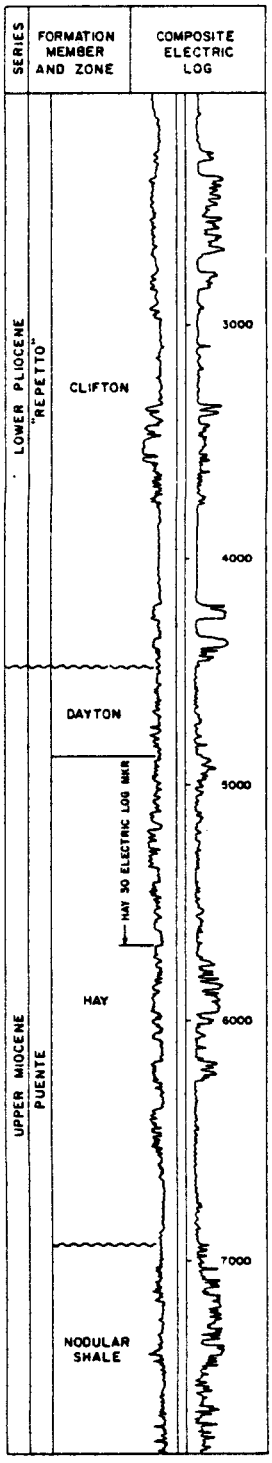
MAJOR OPERATORS (1981): Mobil, Union, Shell, Pyramid (minor).

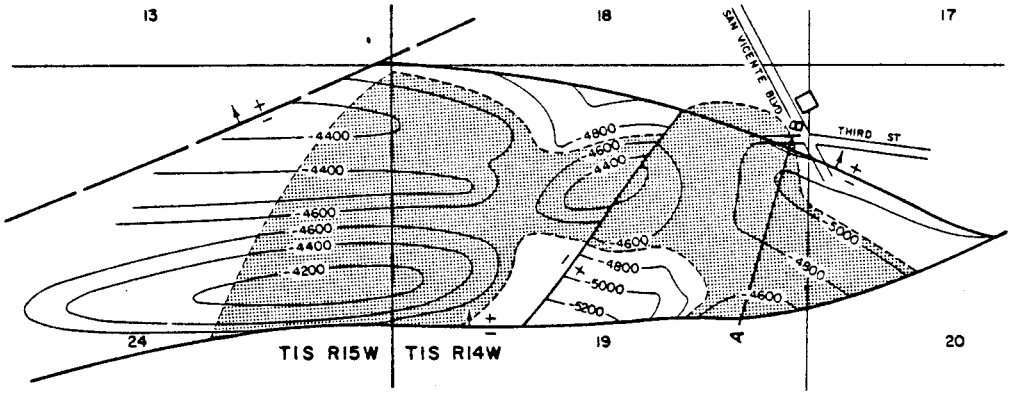
CHARACTERISTICS AND POTENTIAL:

Situated in a developing commercial-industrial area, Santa Fe Springs is one of the oldest oil fields in the county. The producing area is essentially flat with much of it vacant expect for oil operations (Photo 17). Commercial development (warehouses, office space) is slowly invading the area, however. Field production of 44,000 b/d is sent to a single treatment facility operated by Mobil (Photo 18), which is unit operator for the field. The incoming temperature of this volume, reported by Mobil, is about 105°F. This relatively low temperature is probably the result of commingling of waters from many different levels of production (3,000-10,000 feet) as well as a low geothermal gradient. Furthermore, there is some field evidence that the large amount of water that is injected for water-flooding has gradually begun to cool the reservoir slightly. Also, several of the injection wells show some scaling at these low temperatures. In summary, the field has an excellent location and a large volume of produced water at a single facility with abundant vacant space, but the low temperature diminishes these favorable points somewhat.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 43, no. 2 (1957).

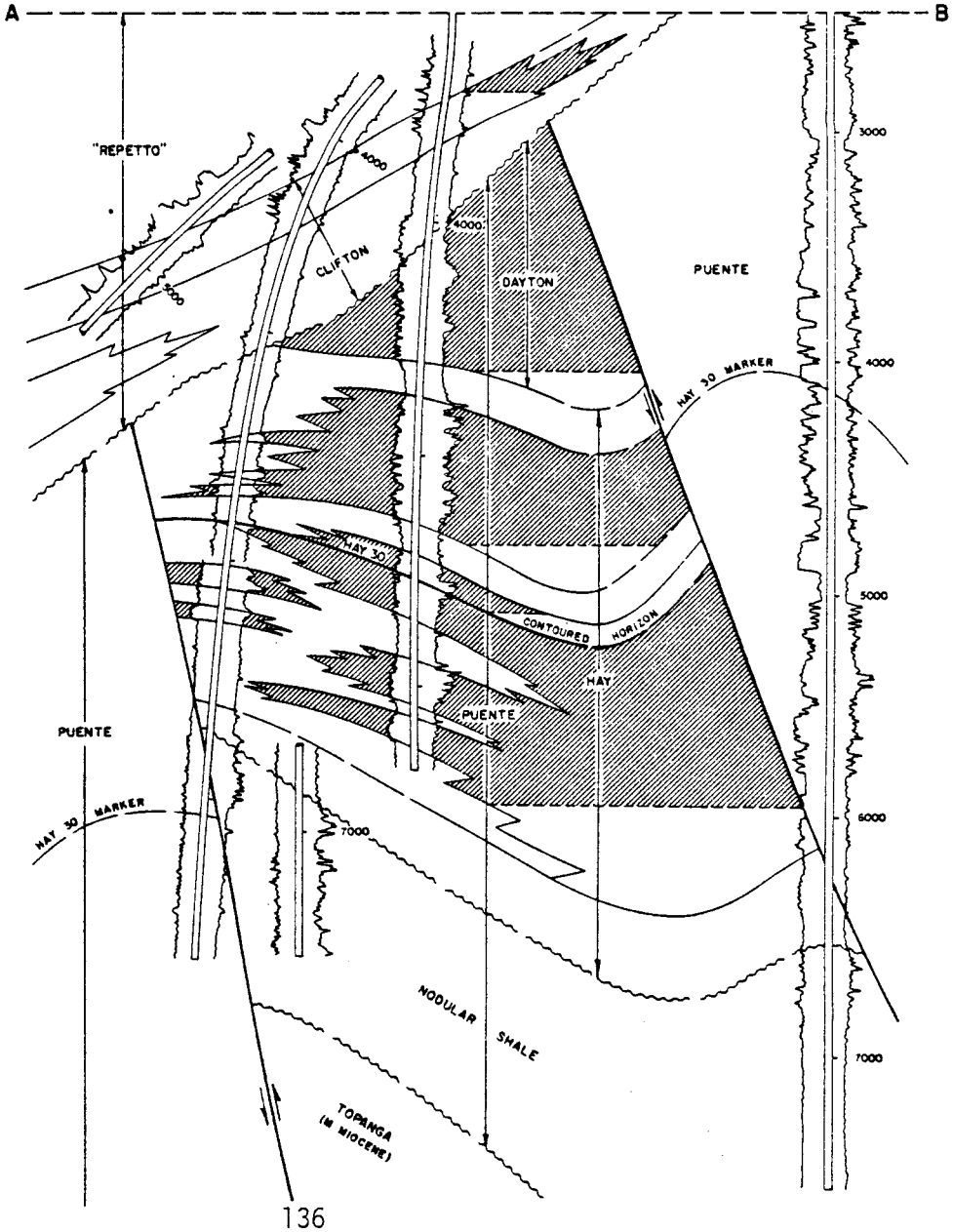
SAN VICENTE OIL FIELD





CONTOURS ON HAY 30 ELECTRIC LOG MARKER

SCALE: 1" = 2400'



SAN VICENTE OIL FIELD

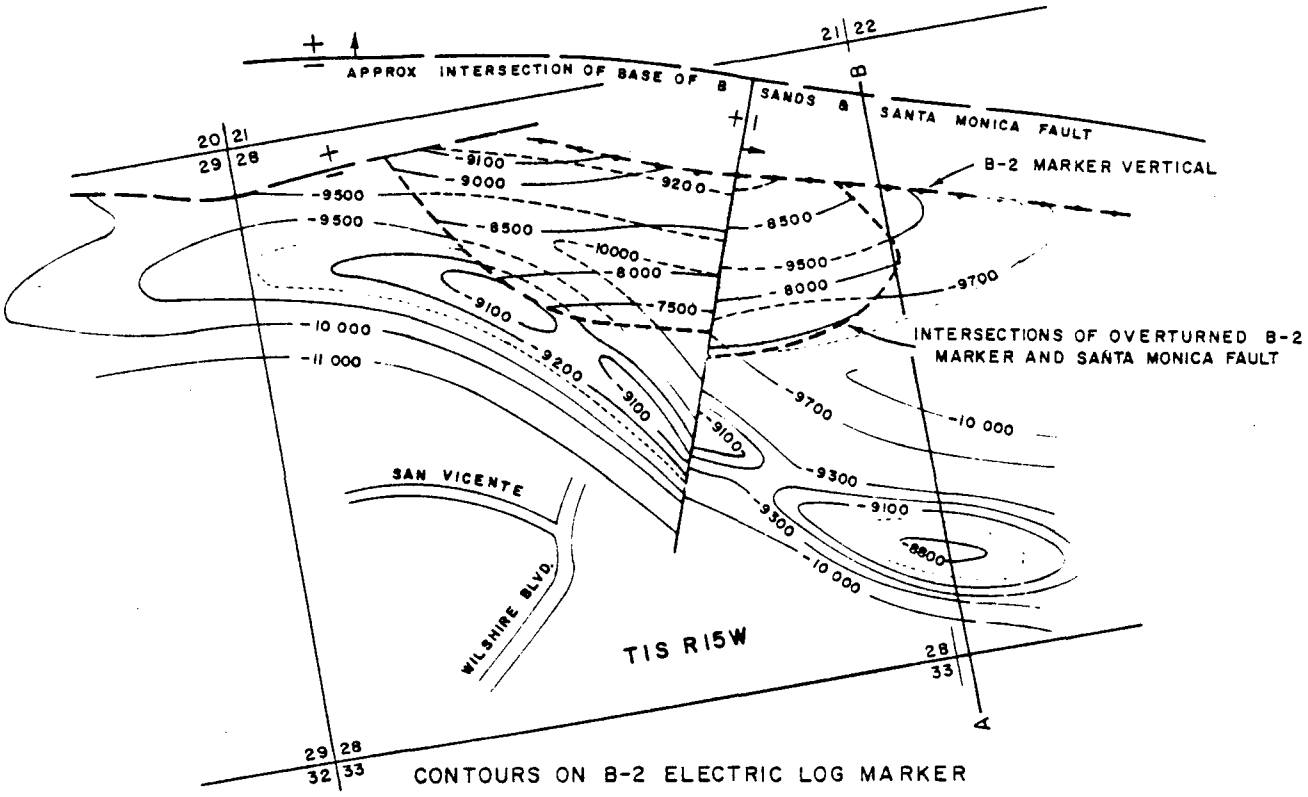
MAJOR OPERATORS (1981): Chevron.

CHARACTERISTICS AND POTENTIAL:

Chevron's San Vicente Drill Site is the only site of operations for this field. The site is in the same commercial-residential setting characteristic of all oil field operations in the northernmost part of the Los Angeles Basin. Zone temperatures indicate a moderately warm field, although fluid production averages only about 4,000-5,000 b/d, which suggests limited applications. Produced fluids are transported by pipeline to a Chevron treatment facility at the Inglewood Oil Field. Water for injection is sent back to San Vicente from that facility.

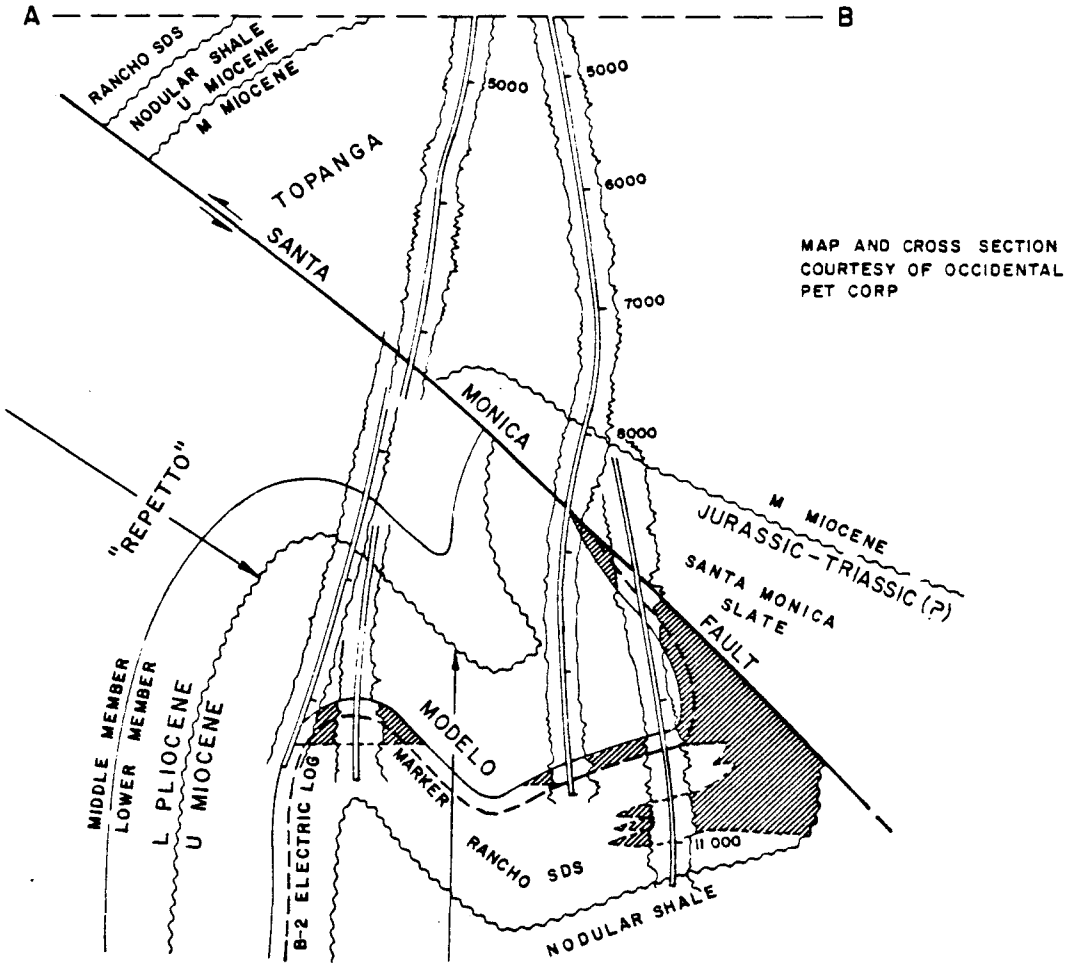
REFERENCE: None.

SAWTELLE OIL FIELD



CONTOURS ON B-2 ELECTRIC LOG MARKER

SCALE: 1" = 1600'



MAP AND CROSS SECTION COURTESY OF OCCIDENTAL PET CORP

SAWTELLE OIL FIELD

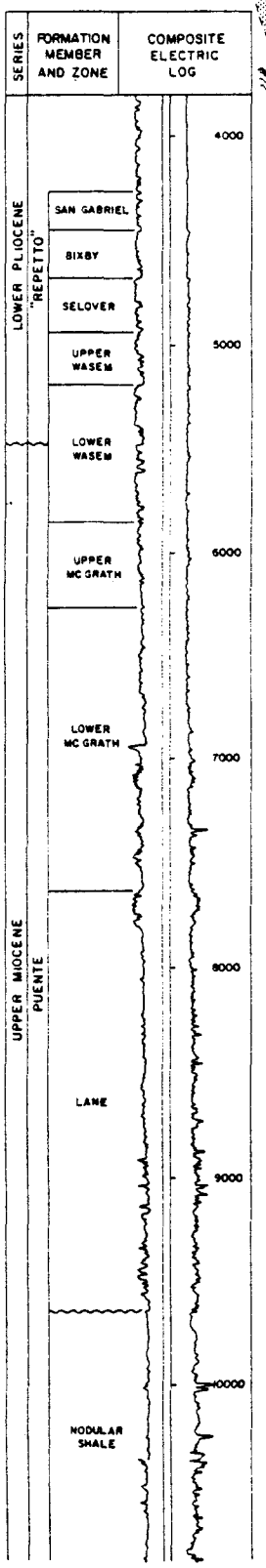
MAJOR OPERATORS (1981): Occidental.

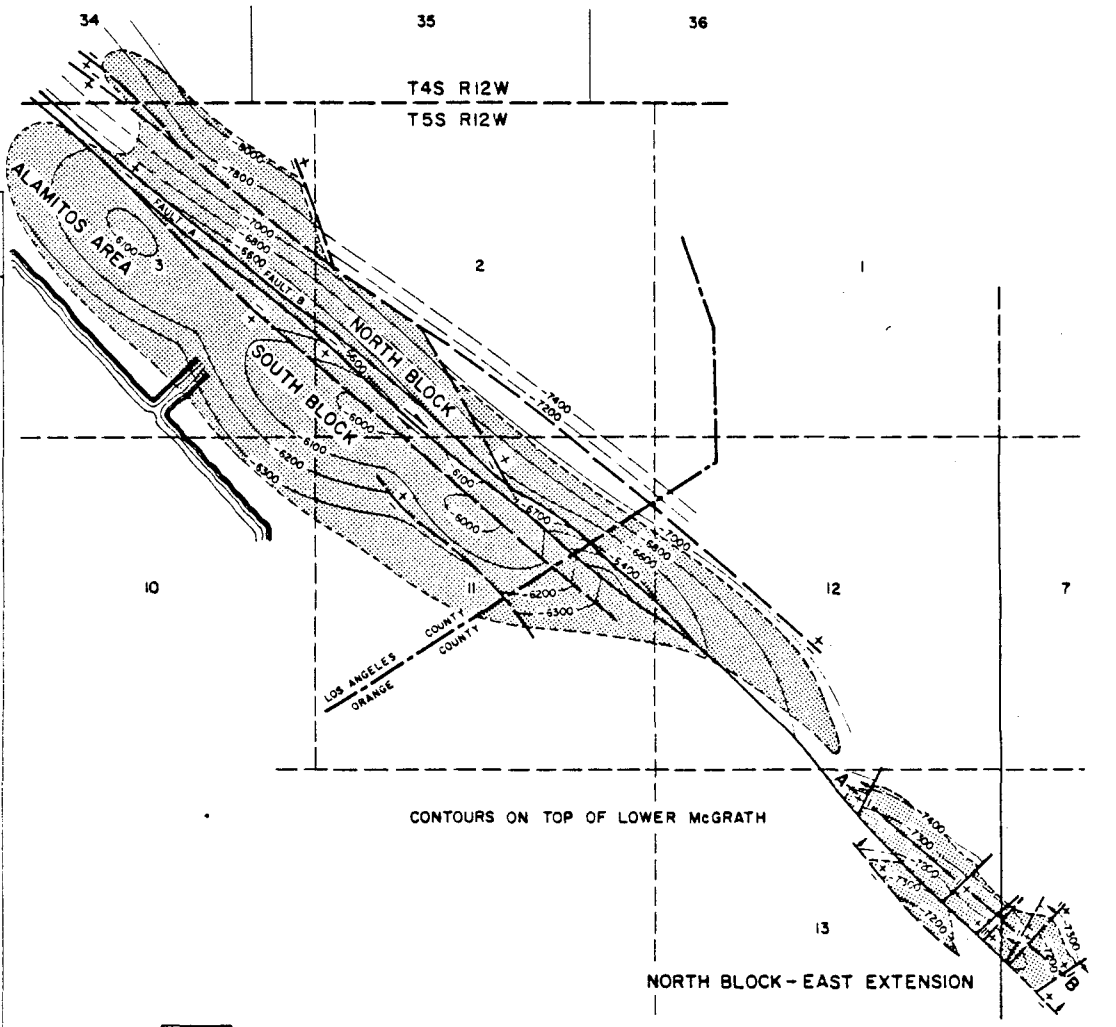
CHARACTERISTICS AND POTENTIAL:

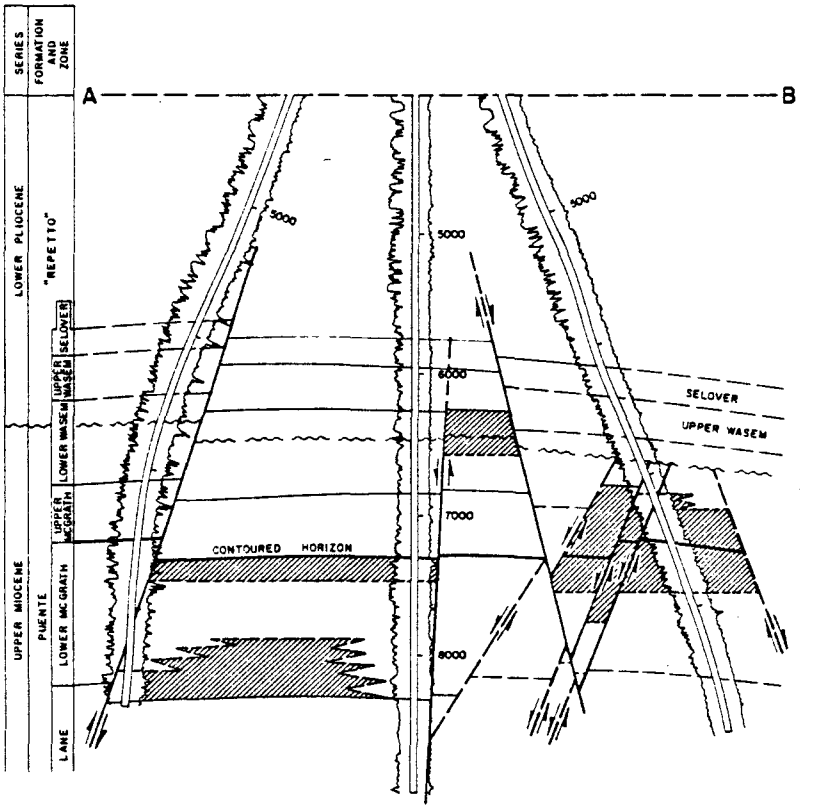
All operations in Sawtelle are conducted from the Sawtelle Drill Site, which is near hospital facilities operated by the U.S. Veterans Aministration. Production temperatures are unknown, but it is expected that they are hot (150°-200°F?) because of the great depth (about 10,000 feet) of the field's single producing zone. Fluid production is about 2,000 b/d (equal amounts of water and oil), which is small, but if the temperatures are significantly high, some application might be made at the Veterans Administration facility. Most waste water is disposed of in wells rather than by injection for water-flooding. Consequently, if scaling is not a problem, heat could be extracted from this water as it is discharged from the treatment facility at the drill site. Equipment for heat extraction may be limited by the space available at the drill site, however.

REFERENCE: None.

SEAL BEACH OIL FIELD







SEAL BEACH OIL FIELD

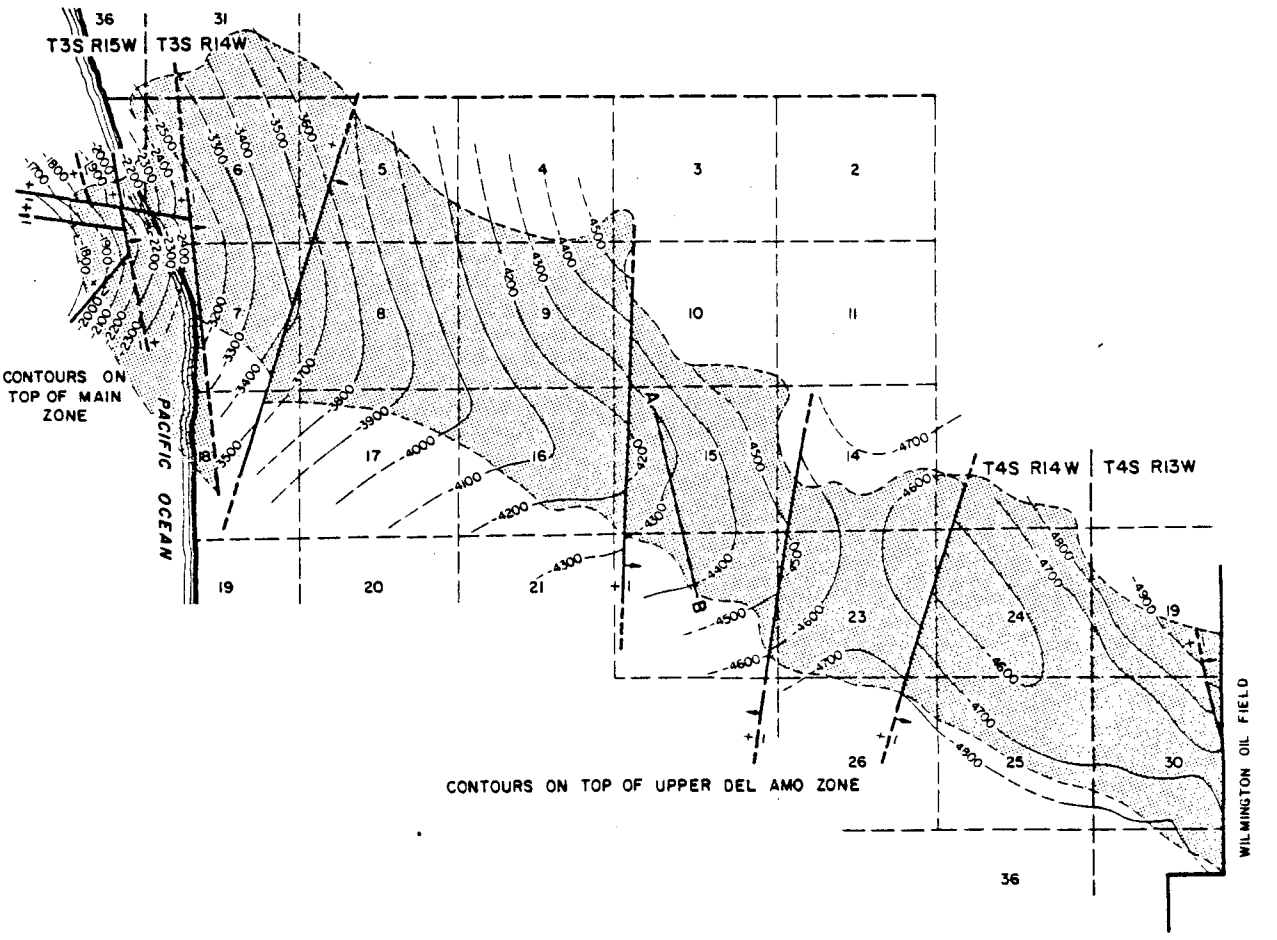
MAJOR OPERATORS (1981): Conoco, Getty, Marina Pacifica.

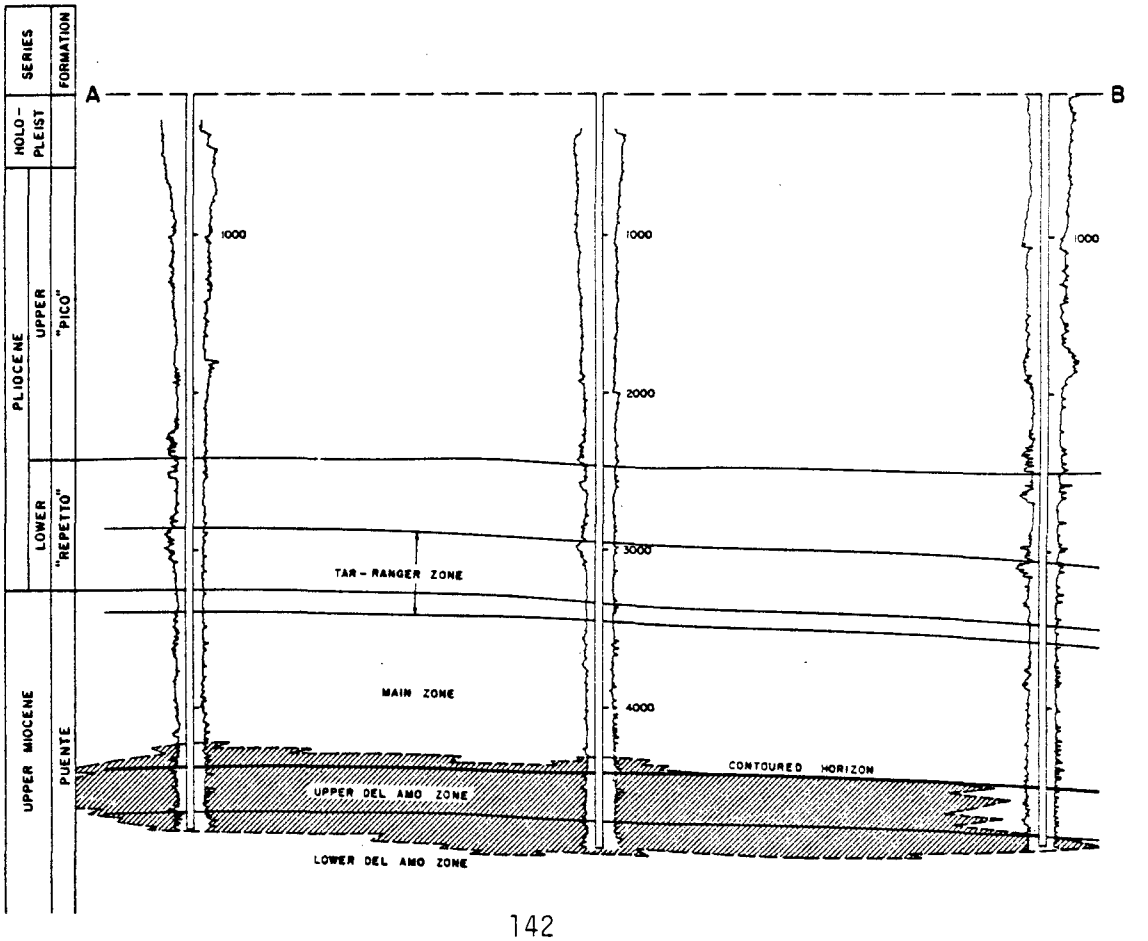
CHARACTERISTICS AND POTENTIAL:

The southernmost field along the Newport-Inglewood Structural Zone in Los Angeles County, Seal Beach is estimated to have a moderately high geothermal gradient relative to other oil fields in the Basin. In addition, it is one of the larger water producers in the county. The field is still largely rural with some adjacent residential and commercial development, especially on the west side. Conoco and, to a lesser extent, Getty and Marina Pacifica are the main operators in the Los Angeles County portion of the field. Conoco operates a centralized treatment facility that processes about 15,000 b/d of fluid at 120°F. The company's representatives who responded to the questionnaire were not enthusiastic, however, about extraction of heat from their facility. The Getty operation processes only about 800-900 b/d at ambient temperatures. In summary, Seal Beach has good potential for applications for several reasons: 1) Good volumes of production with a moderate temperature. 2) Abundant open space for heat-exchanger equipment. 3) Nearby residential and commercial development. 4) Much of the waste water is disposed of at the surface rather than injected. A serious drawback to this potential, however, may be the unwillingness of Conoco to cooperate in such a venture.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations, Calif. Oil Fields, v. 16, no. 2 (1930), v. 13, no. 3 (1927).

TORRANCE OIL FIELD





TORRANCE OIL FIELD

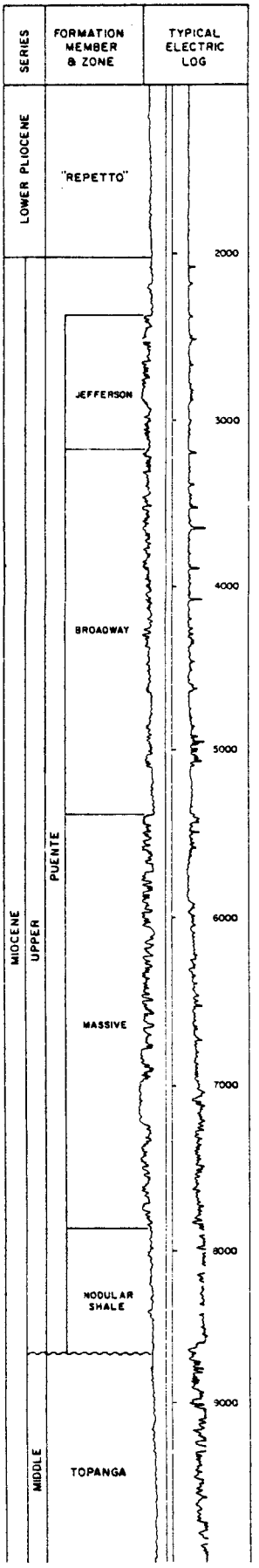
MAJOR OPERATORS (1981): Santa Fe Energy, Del Amo, American Pacific International, Petro-Lewis, Superior, Mobil.

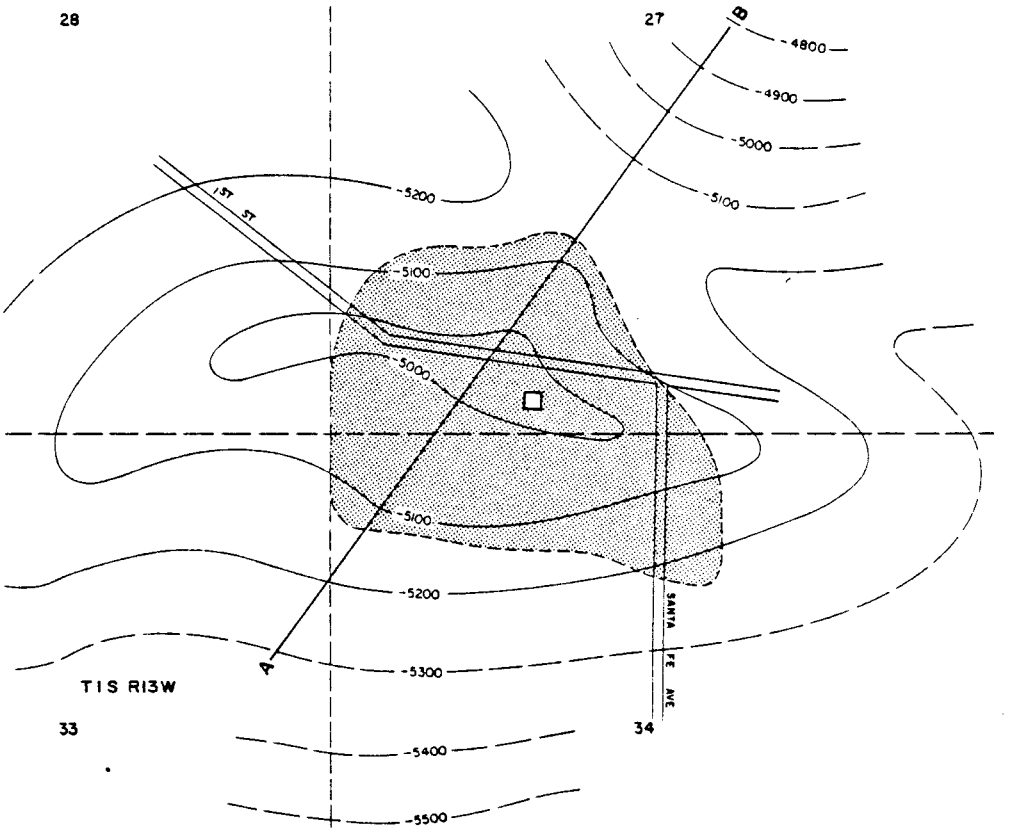
CHARACTERISTICS AND POTENTIAL:

One of the oldest and largest oil fields in Los Angeles County, Torrance is situated in an area of mixed residential and commercial-industrial development. Although the field still has some vacant areas, the pressures of development have forced many operators to consolidate their operations into urban drill sites and centralized treatment facilities. Production is predominately from only about 2,000-4,500 feet, but the high geothermal gradient of the field is responsible for some of the highest production temperatures-versus-depth in the county. The incoming temperatures (approximately 120°-150°F) and the large volume of produced water (over 50,000 b/d) give this field one of the highest potentials of any for heat extraction. The main question, however, is whether the operators would be able to or willing to cooperate in a heat-extraction project. Of the three main operators (Santa Fe Energy, American Pacific International, Superior), American Pacific is possibly the most interested, although it apparently has limited space at its treatment center. Currently, this operator's waste water (16,000 b/d at 130°F) is disposed of in the sewer, thus the heat could be extracted without detriment to the oil operations. Most of the waste water at the other operations in the field is injected as part of water-flood projects, however. This fact may hinder potential heat-extraction, especially if retention of heat in the reservoir is desirable to improve oil recovery. Because of the high geothermal gradient, a future consideration, if economically favorable, could be the drilling of shallow wells (less than 5,000 feet) or conversion of old oil wells strictly to obtain hot water from this field.

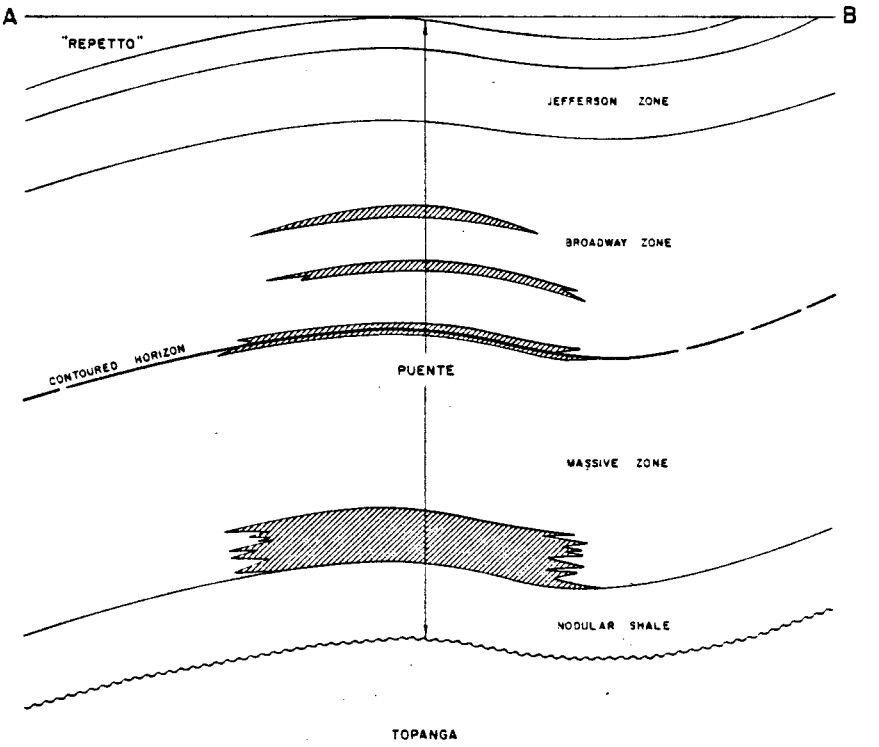
REFERENCE: Calif. Div. of Oil and as, Summary of Operations - Calif. Oil Fields, v. 42, no. 2 (1956); v. 51, no. 1 (1965).

UNION STATION OIL FIELD





CONTOURS ON TOP OF MASSIVE ZONE
SCALE: 1" = 1200'



UNION STATION OIL FIELD

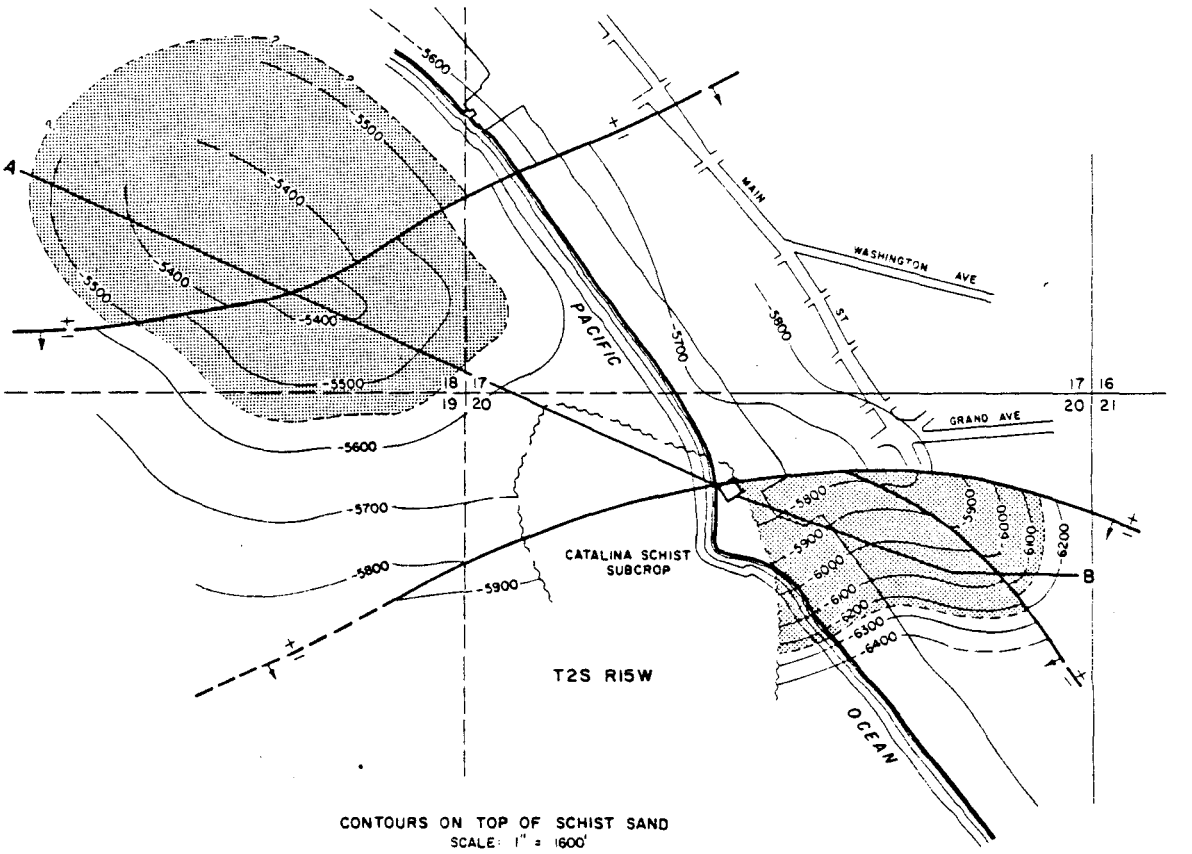
MAJOR OPERATORS (1981): Chevron.

CHARACTERISTICS AND POTENTIAL:

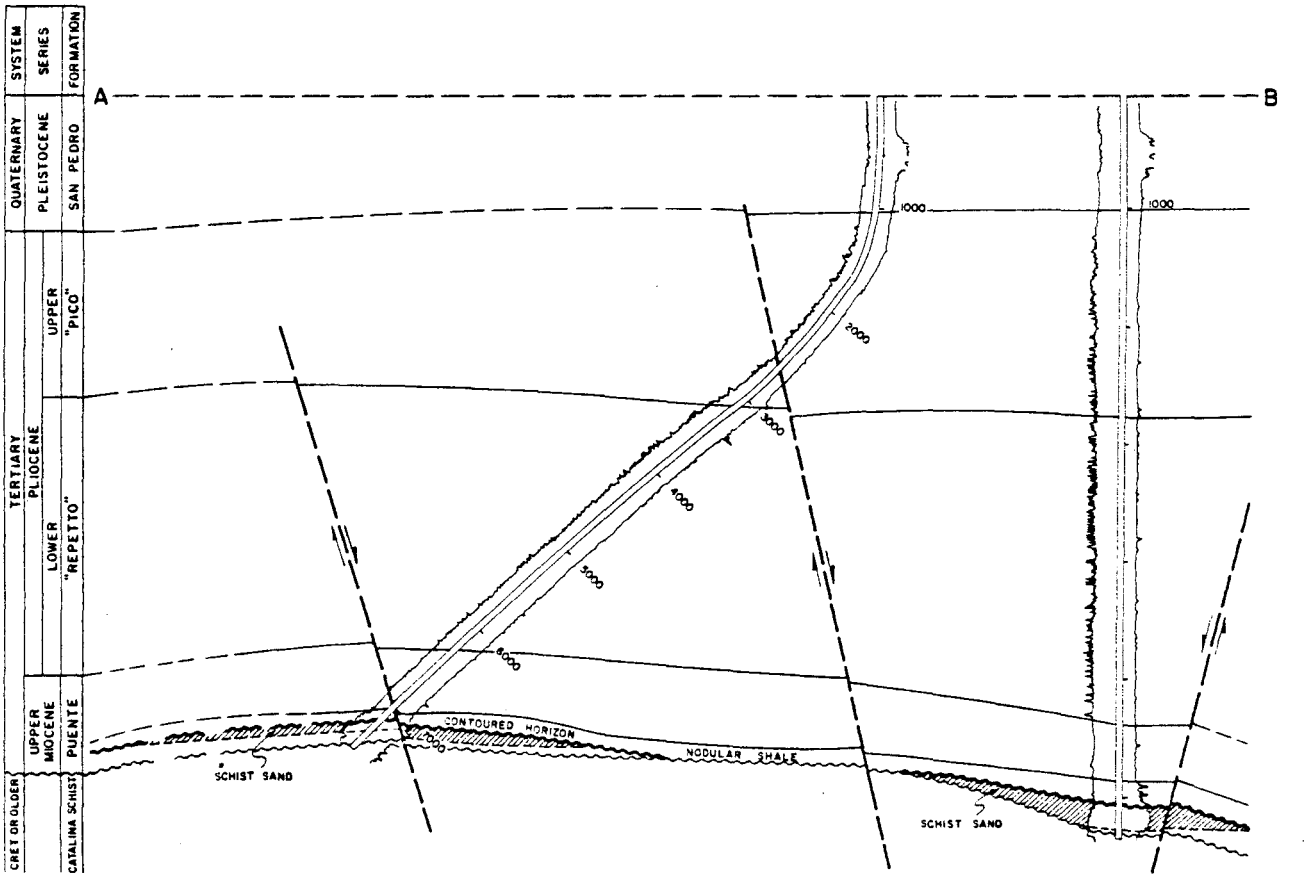
All operations in Union Station are conducted from the Garey Drill Site, which is in a commercial area just south of downtown Los Angeles. Fluid production from the site is very small (about 200-300 b/d), which would preclude any large-scale heat extraction from this field. Most production is from less than 5,000-6,000 feet, therefore, production temperatures are likely much less than 150°F.

REFERENCE: None.

VENICE BEACH OIL FIELD



CONTOURS ON TOP OF SCHIST SAND
SCALE: 1" = 1600'



VENICE BEACH OIL FIELD

MAJOR OPERATORS (1981): Damson.

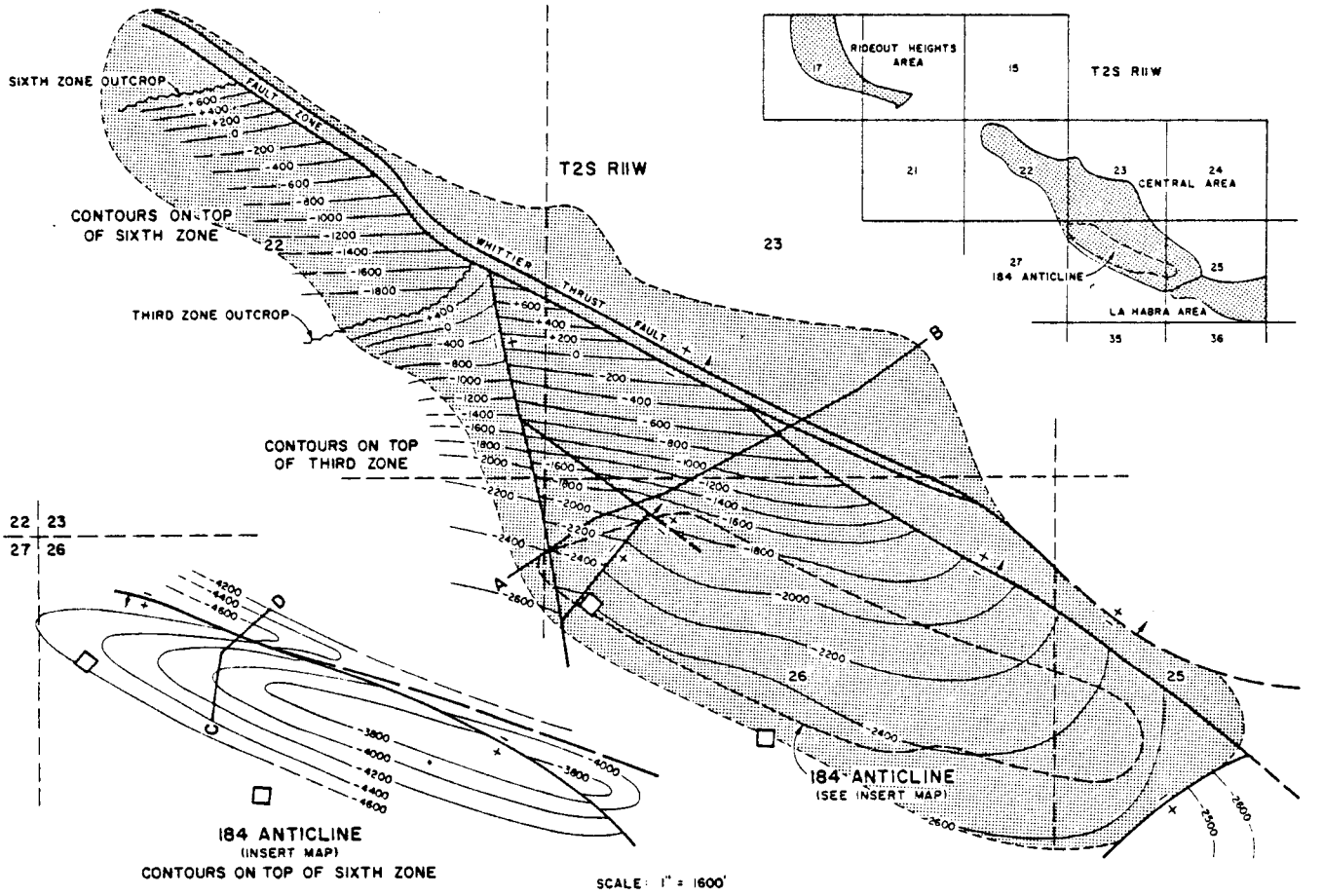
CHARACTERISTICS AND POTENTIAL:

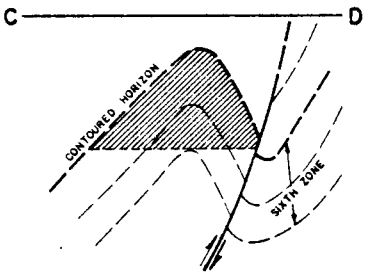
Venice Beach is one of the hottest fields in the Los Angeles Basin, apparently caused by the optimum conditions of shallow depth to basement and low conductivity of sediments. The small urban drill site that is the center of all operations for this field offers an excellent opportunity for use of waste heat from a compact facility. The facility is on the ocean-front in a recreational beach area just west of a commercial-residential area (Photos 19, 20, 21). Production is from two small areas, one onshore at about 6,000 feet and the other offshore to the northwest at about 5,500 feet. Production temperatures are in the 220°-240°F range at about 8,000 b/d, most of which is water. The operator hopes to raise this volume to about 16,000 b/d by the end of 1981 (David Lefler, personal communication, 1981). Significantly, the operator must cool the water to about 150°F before it is disposed of by well back into the reservoir. Otherwise, the high heat causes problems with bearing seals and cavitation of the injection pumps. The operator has no need for the heat and expressed a willingness to possibly cooperate in a project to extract heat for uses outside the oil operation. It appears also that heat extraction could be allowed down below 100°F. Overabout a six-year period at this operation, the reservoir temperature does not seem to have decreased even with injection of the 150°F water back into the reservoir. Furthermore, the wells and treatment equipment

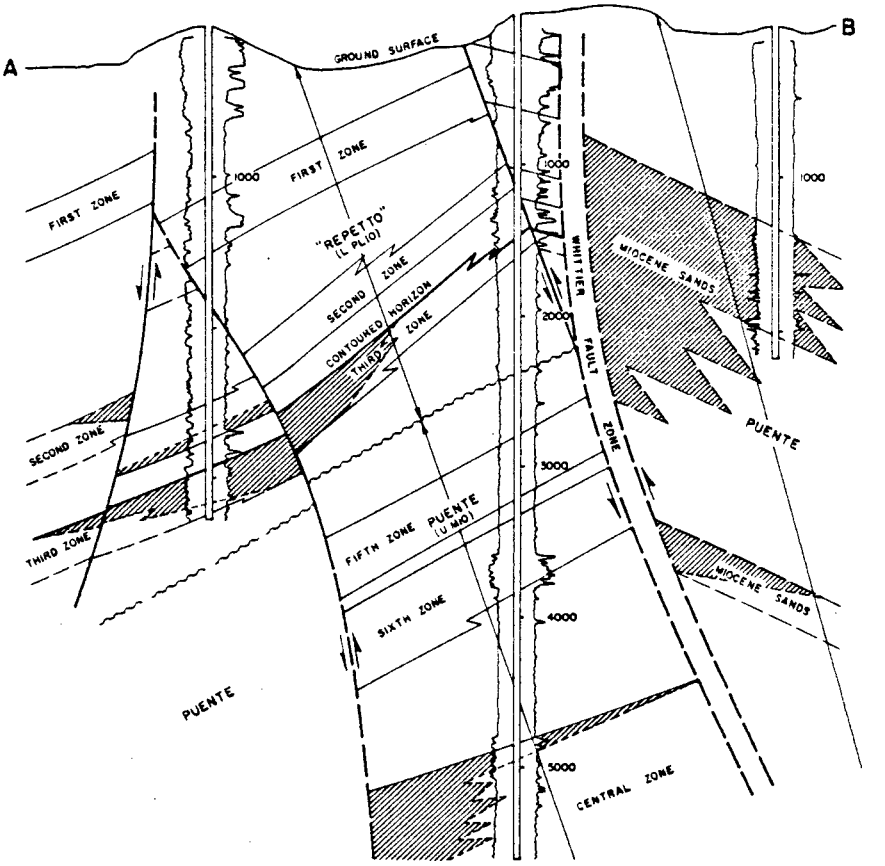
do not have scaling or corrosion problems. Although the facility is small, there may be adequate space for a heat-exchanger apparatus depending on the design.

REFERENCE: None.

WHITTIER OIL FIELD
Central Area







WHITTIER OIL FIELD

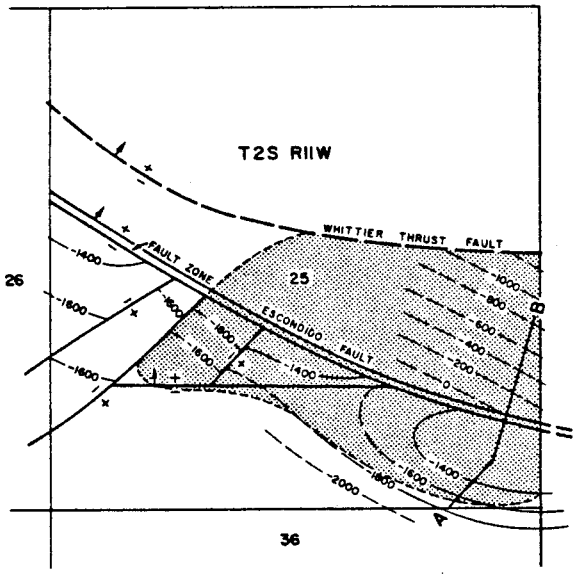
MAJOR OPERATORS (1981): Chevron, Mitchell, McFarland (minor).

CHARACTERISTICS AND POTENTIAL:

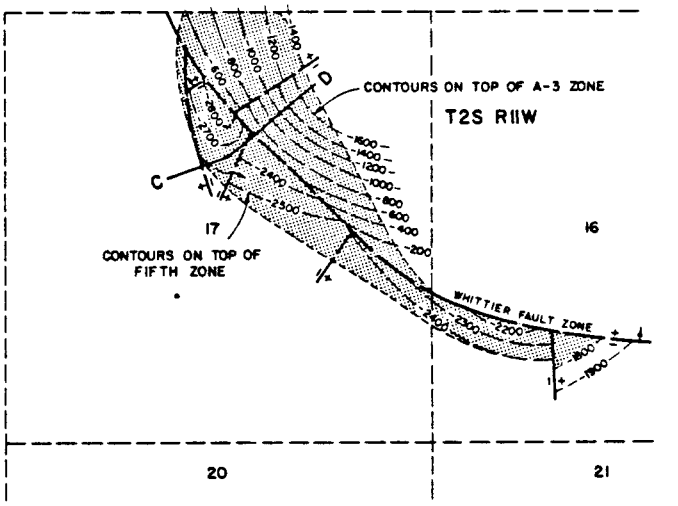
This field is situated in the relatively rugged, rural Puente Hills, just east of the city limits of Whittier. The predominant field production is from the Central Area where Chevron operates a single treatment facility. The facility, which is adjacent to a large suburban residential area, processes approximately 21,000 b/d of water estimated at about 100°-115°F. Most of this water is injected back into the reservoir as a water-flood. The Rideout Heights Area to the northwest is much smaller, with fluid production at less than 2,000 b/d. The field as a whole has limited potential mainly because of its setting and moderately low temperatures. The adjacent residential development is mainly single homes, which represent a relatively poor prospect for applications. Also, there may be a desire to retain what heat there is in the water in order to increase the efficiency of the water flood. Furthermore, the production is mostly from less than 5,000 feet, which probably explains the low temperatures.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 15, no. 4 (1930), v. 50, no. 1 (1964), v. 51, no. 1 (1965), v. 48. no. 2 (1962).

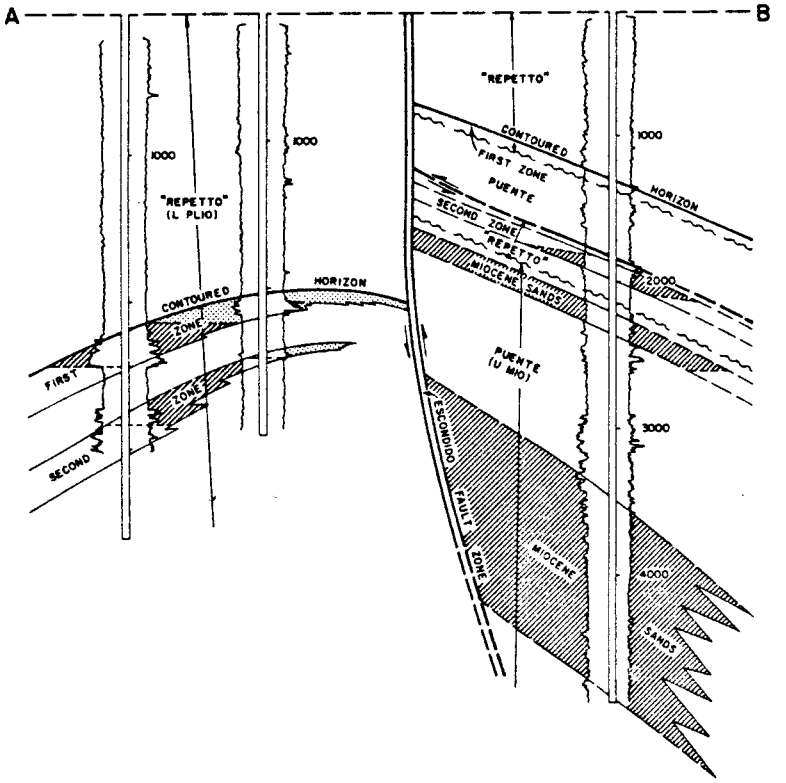
WHITTIER OIL FIELD
La Habra and Rideout Heights Areas

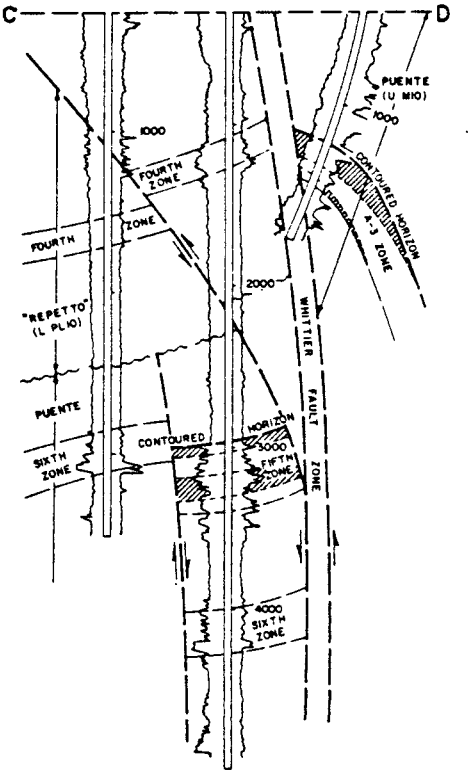


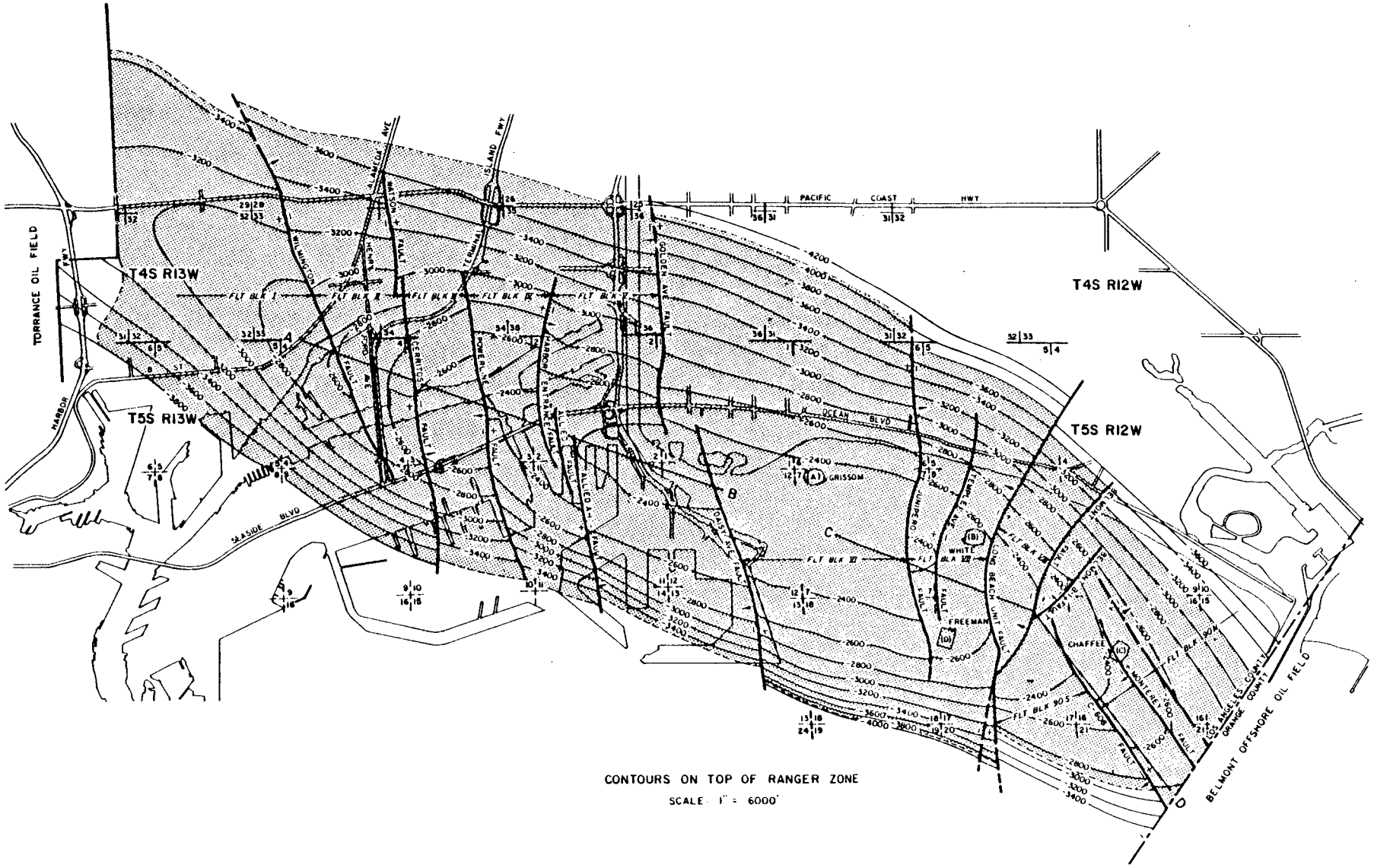
LA HABRA AREA
CONTOURS ON TOP OF FIRST ZONE



RIDEOUT HEIGHTS AREA
CONTOURS ON TOP OF A-3 ZONE AND ON TOP OF FIFTH ZONE







CONTOURS ON TOP OF RANGER ZONE

SCALE 1" = 6000'

WILMINGTON OIL FIELD

WILMINGTON OIL FIELD

MAJOR OPERATORS (1981): Long Beach Oil Development, Mobil, Chevron, Champlin, Powerine, Exxon, Sun, THUMS.

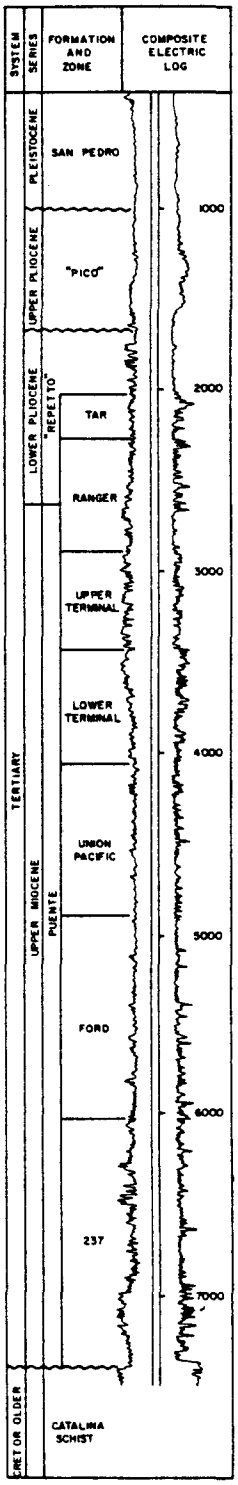
CHARACTERISTICS AND POTENTIAL:

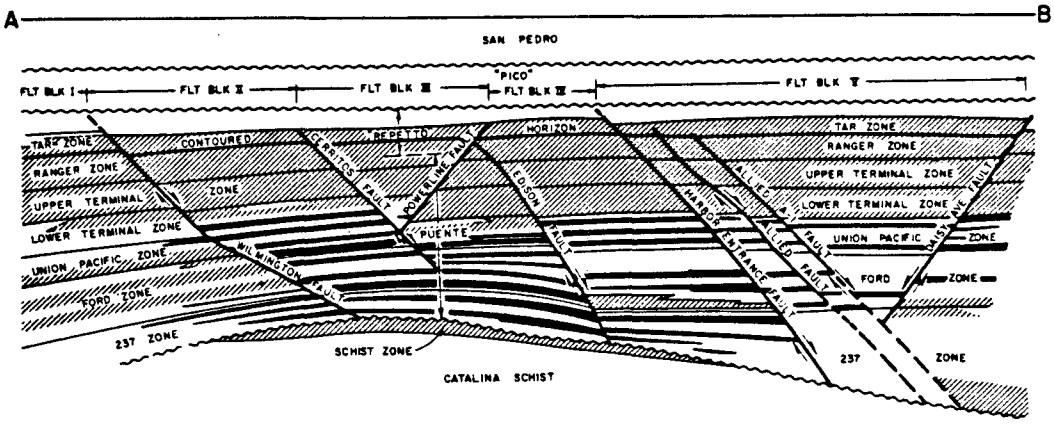
Production of oil and water at Wilmington dwarfs all other fields in Los Angeles County. Daily water production is approximately 1.2 million barrels, which is almost 8 times more than Inglewood, the second-place producer. Wilmington also has one of the highest geothermal gradients of any field (estimated 5.5-6.0°C/100 meters) with most production from less than 5,000 feet. This fortuitous combination of enormous production and moderately high temperatures from shallow depths gives Wilmington the highest resource potential of all fields in the county. Unfortunately, many of the operators are not enthusiastic about heat extraction for outside applications because of their desire to retain as much heat as possible in their oil operations to aid in the recovery of oil. They believe that the heat in the injected water helps reduce oil viscosity, which aids production. The heat also eliminates the need for heater treaters in many operations, which are used to break up emulsions and aid the separation of oil and water. Another possible hindrance to heat extraction is the scarcity of space for oil operations in the heavily industrialized Long Beach Harbor and on the four drilling islands offshore. Operations are less crowded in the old northwest part of the field, characterized by a mixture of commercial, industrial, and residential development. Here, Exxon, Champlin, Mobil, and Sun have large treatment facilities and most of their wells are drilled in the old-style patterned fashion, which requires much space for operations. Of these operators, Exxon may be the

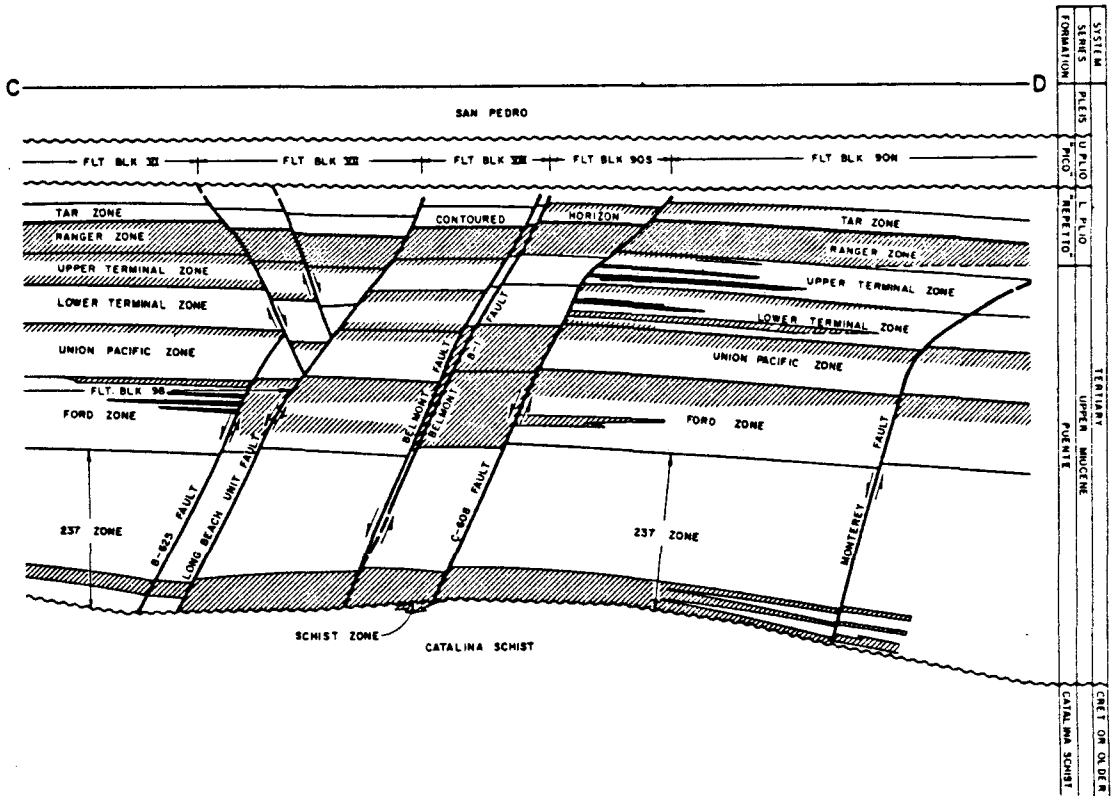
most receptive to heat-extraction projects. In the new area (Long Beach Harbor, San Pedro Bay), nearly all operations (THUMS, Long Beach Oil Development, Powerine, Chevron) are conducted from compact drill sites and centralized treatment facilities (Photos 22, 23). All operators here desire to retain the produced heat in their oil operations for more efficient oil recovery; most production and injection temperatures are in the 110°-140°F range. The approximate temperatures and quantities of water processed by all eight major operators at their treatment facilities are listed in Appendix B.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 48, no. 1 (1962): v. 26 (1941); v. 50, no. 2 (1964); v. 34, no. 2 (1948); v. 43, no. 1 (1957).

WILMINGTON OIL FIELD

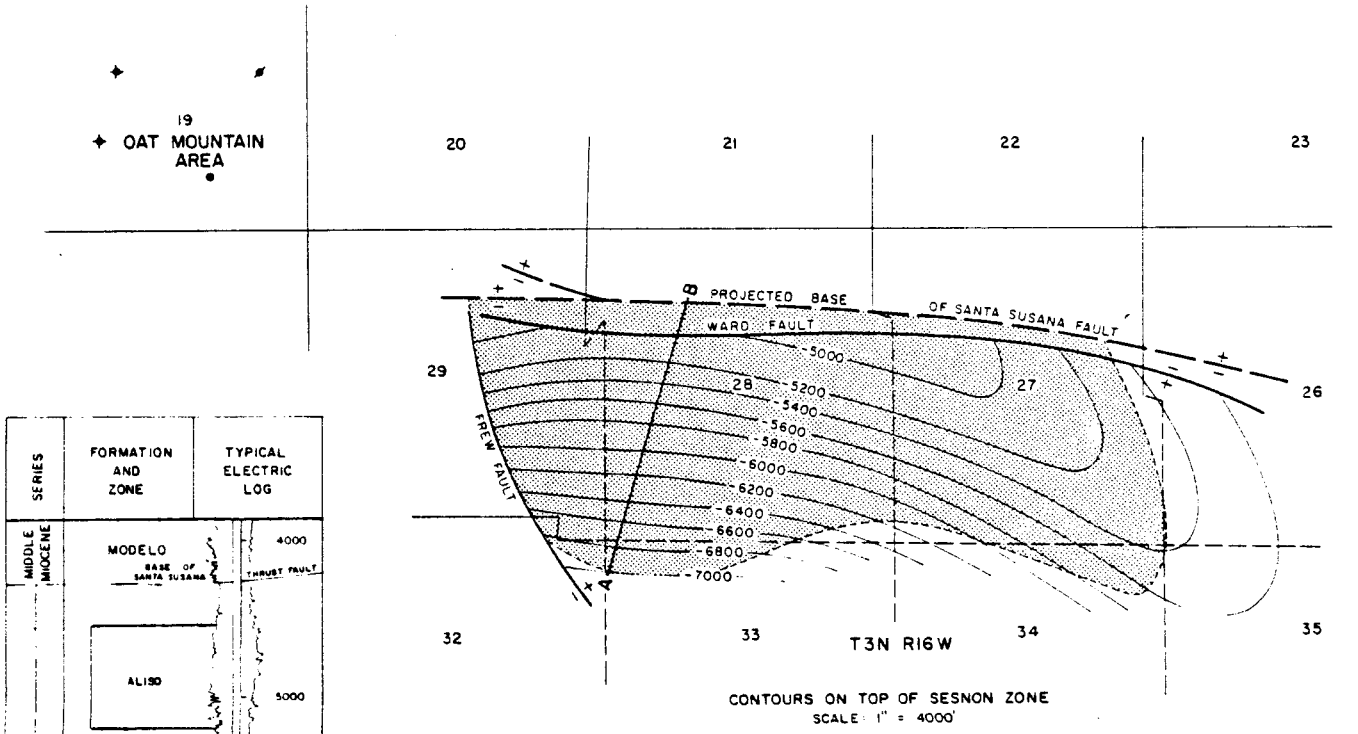




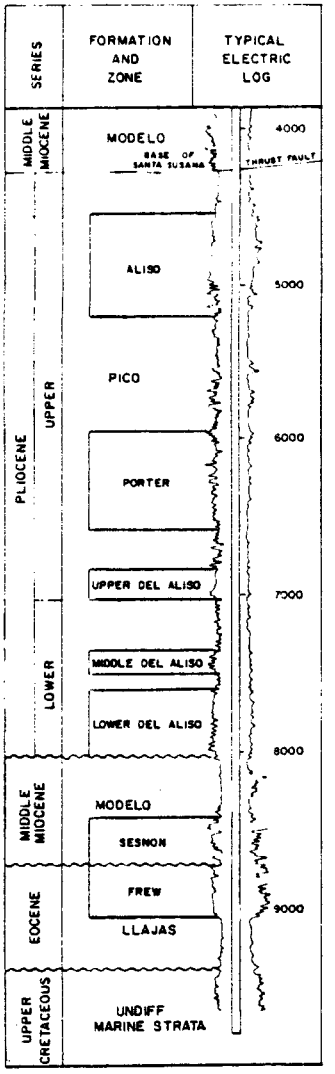


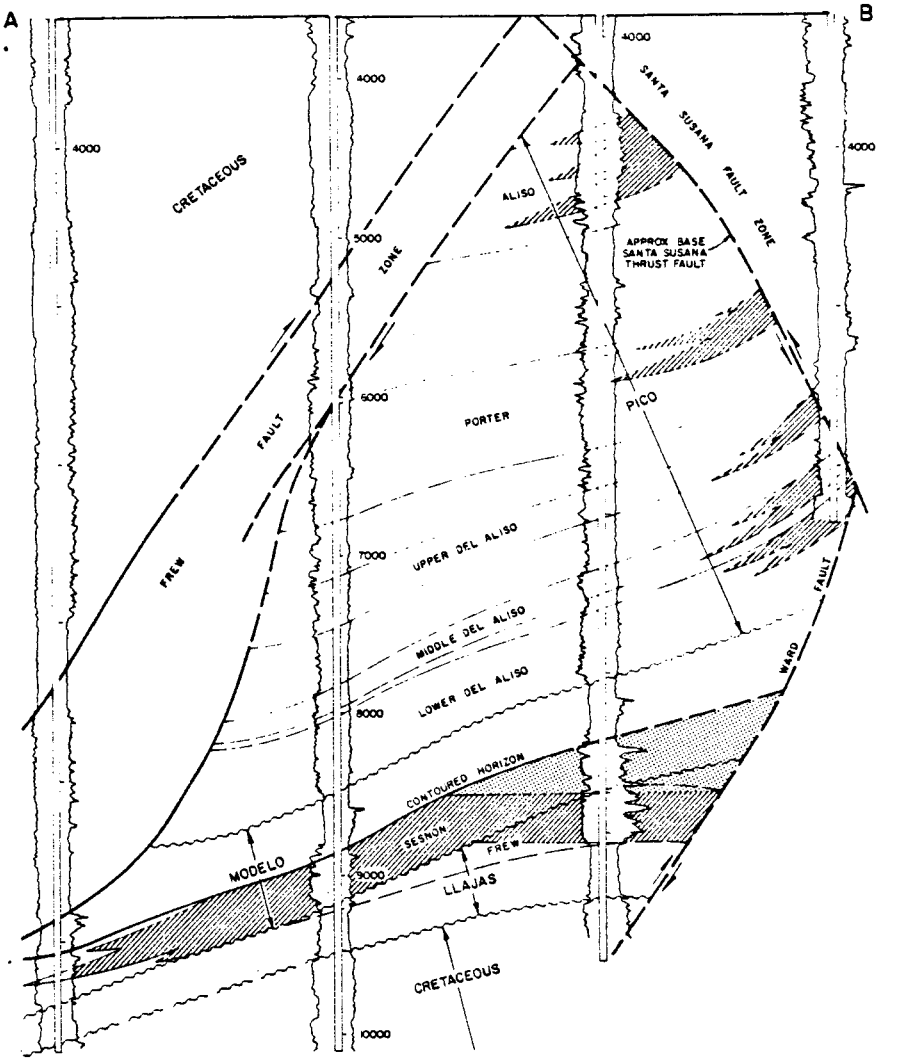
FIELDS IN VENTURA BASIN

ALISO CANYON OIL FIELD



CONTOURS ON TOP OF SESNON ZONE
SCALE: 1" = 4000'





ALISO CANYON OIL FIELD

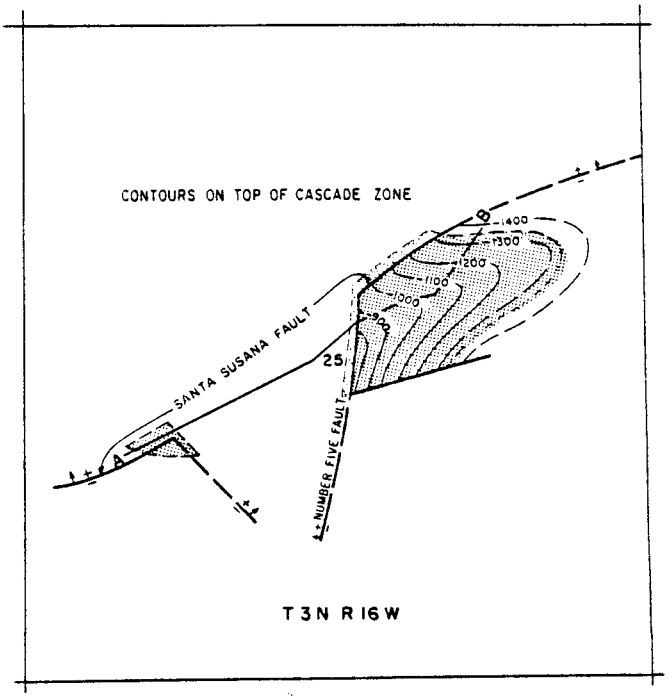
MAJOR OPERATORS (1981): Getty, Southern California Gas Company.

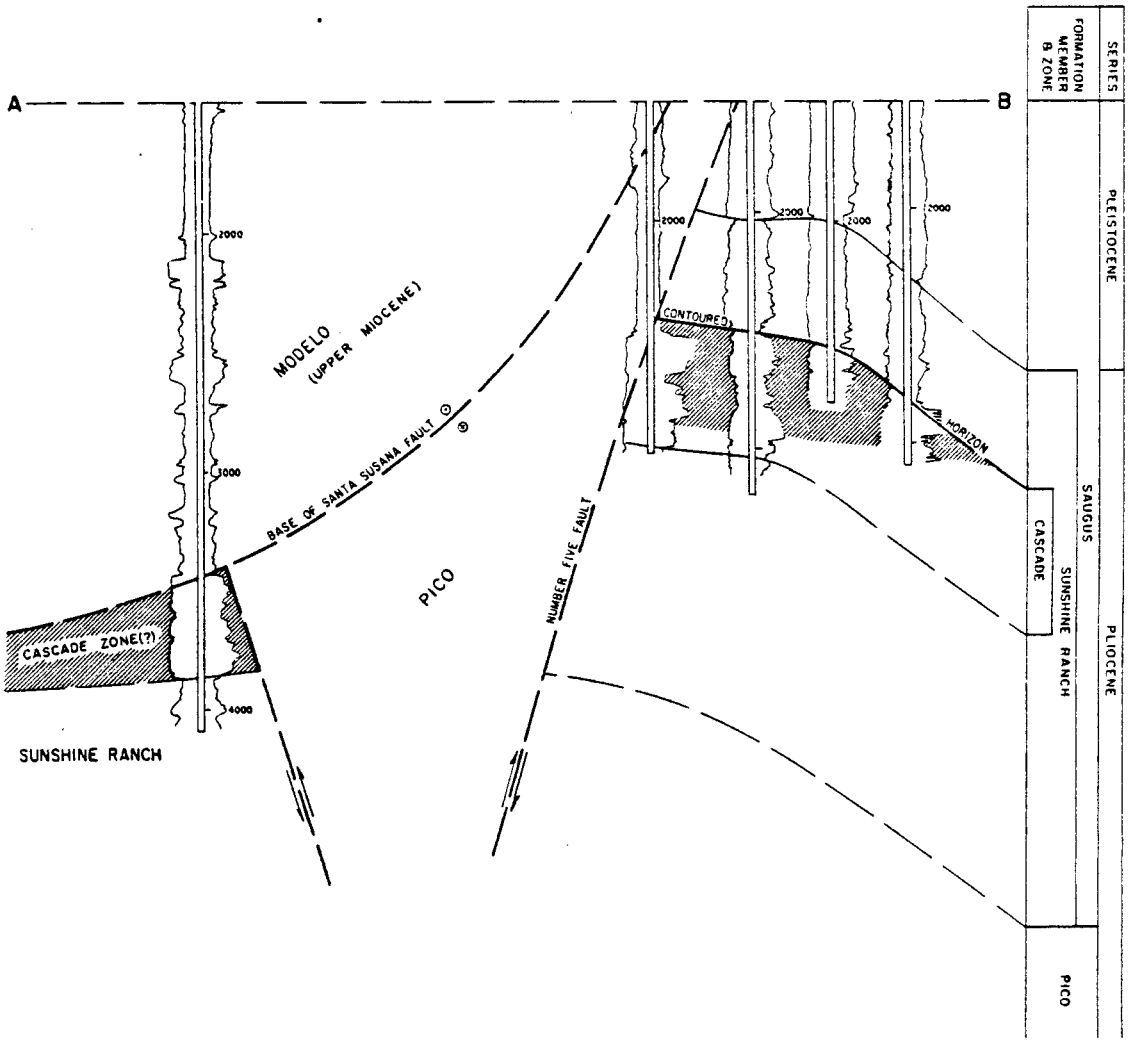
CHARACTERISTICS AND POTENTIAL:

Aliso Canyon is in a hilly, rural area that bounds the north edge of the San Fernando Valley; suburban tract homes have encroached to the south edge of the field. The field is both the largest oil producer and second largest water producer in the Los Angeles County portion of the Ventura Basin. Fluid production averages about 12,000-13,000 b/d, which is still small, however, in comparison to many of the Los Angeles Basin fields. Most of this production is by Getty, which reported that treatment facility temperatures are only in the 80°-90°F range, too low to provide any significant amount of heat. A little over half of the waste water is disposed of in wells, while the remainder is injected into the reservoir as part of a water-flood project. It is not known if the treatment facilities are centralized or are scattered around the field. In summary, if Getty's reported temperatures are accurate, they would severely restrict the potential applications of any extracted heat. Also, the field's rural character and proximity to suburban residential development, rather than industrial development, are additional limitations.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations-Calif. Oil Fields, v. 45, no. 1 (1963).

CASCADE OIL FIELD





CASCADE OIL FIELD

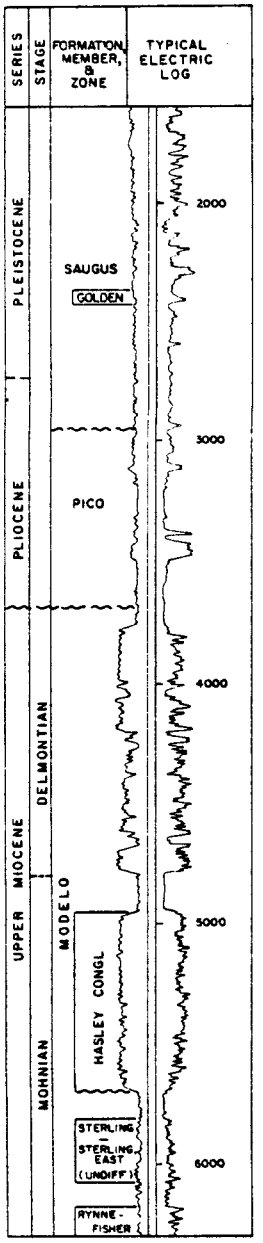
MAJOR OPERATORS (1981): MCOR

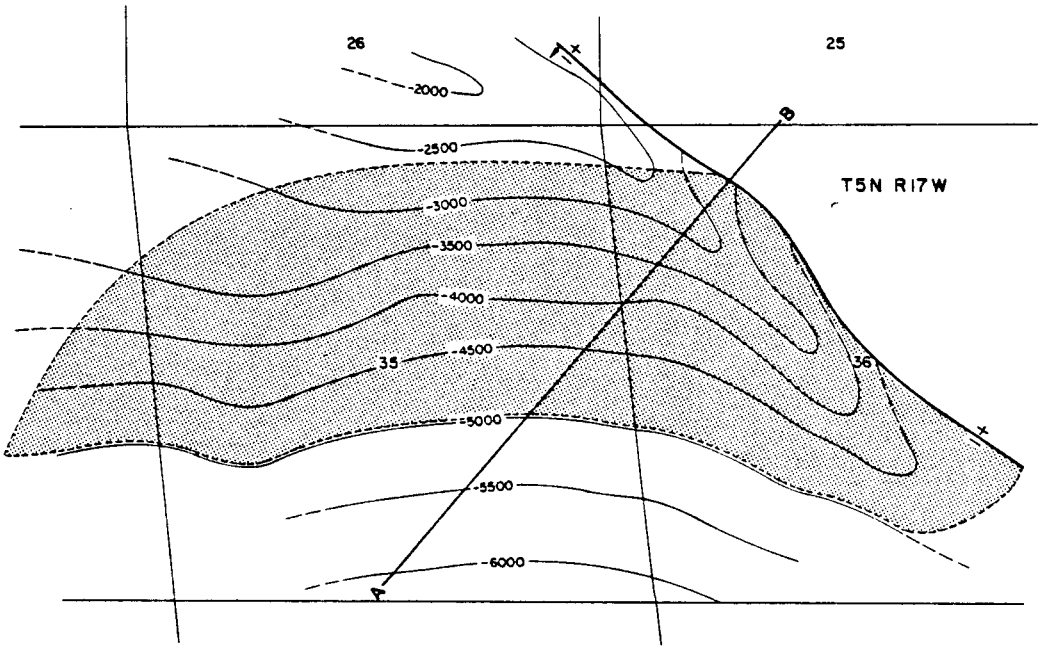
CHARACTERISTICS AND POTENTIAL:

Because of both its shallow reservoir depth and small volume of production, this field has poor potential for any sort of heat extraction. Temperatures at the treatment facility are ambient according to the field's single operator, and water volumes average only about 150-200 b/d.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 49, no. 1 (1963).

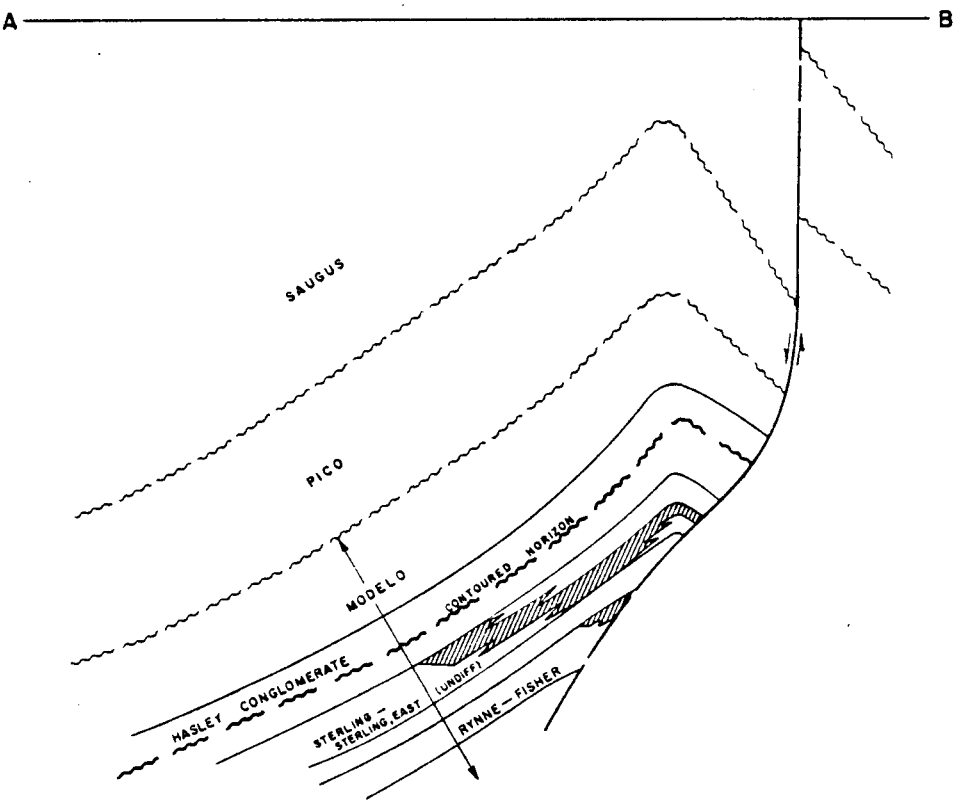
CASTAIC HILLS OIL FIELD





CONTOURS ON BASE OF HASLEY CONGLOMERATE

SCALE: 1" = 2000'



CASTAIC HILLS OIL FIELD

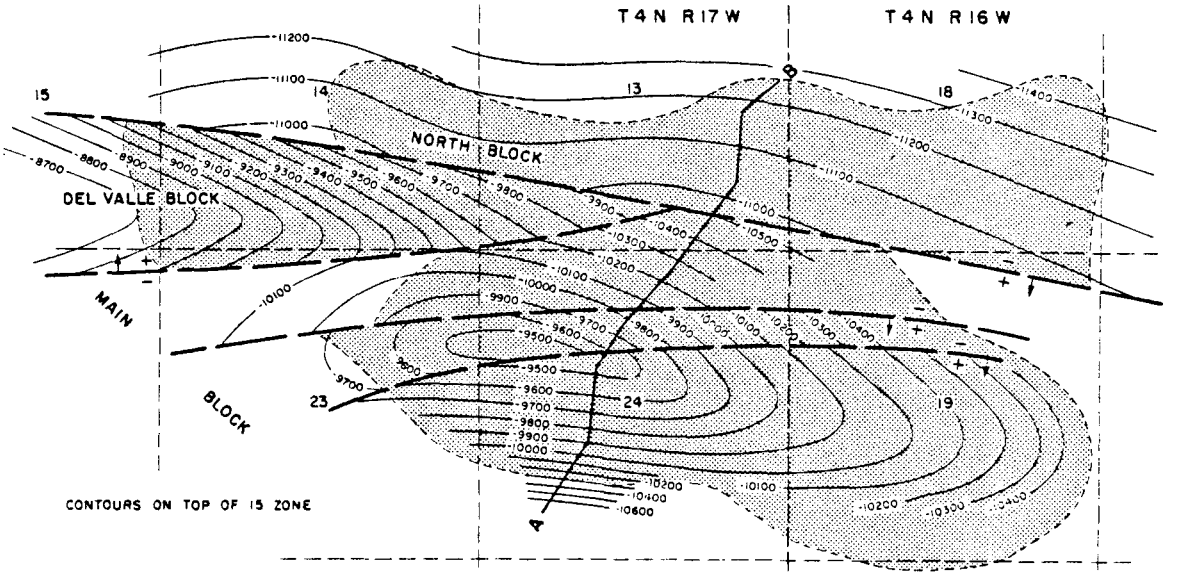
MAJOR OPERATORS (1981): Decalta, Texaco (minor).

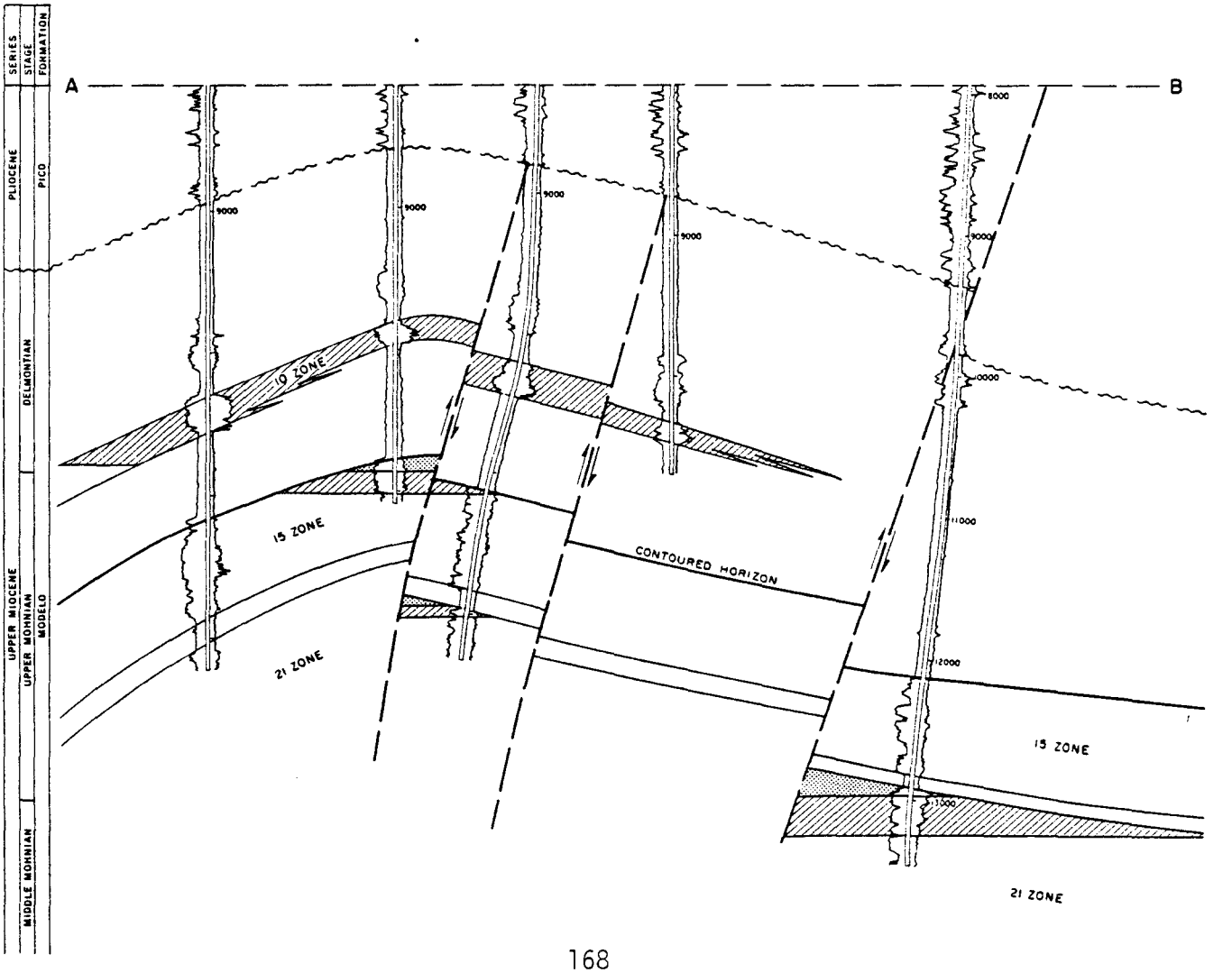
CHARACTERISTICS AND POTENTIAL:

There is limited potential for heat extraction in Castaic Hills mainly because of the small volume of production (about 300-400 b/d water plus oil). The treatment process (dehydration tank) at the Decalta facility actually raises the temperature of the waste water such that exit temperatures of the water are about 140°F. The field is adjacent to Interstate 5 in a rural, hilly area.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 39, no. 1 (1953).

CASTAIC JUNCTION OIL FIELD





CASTAIC JUNCTION OIL FIELD

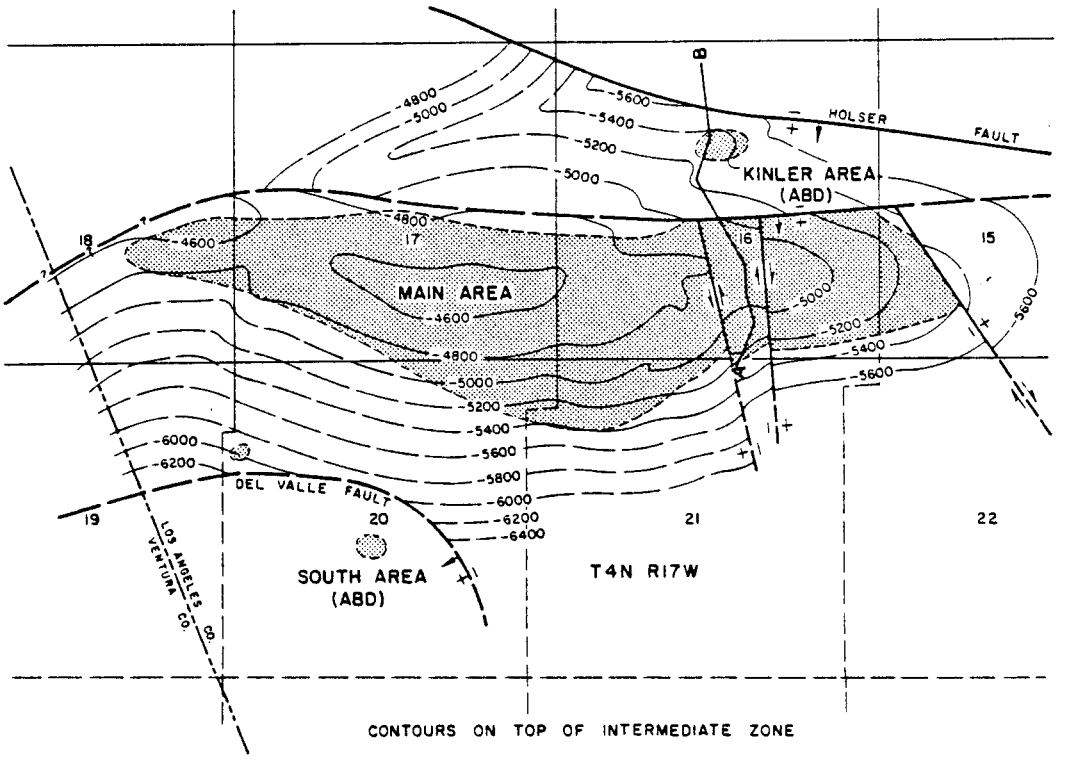
MAJOR OPERATORS (1981): Exxon.

CHARACTERISTICS AND POTENTIAL:

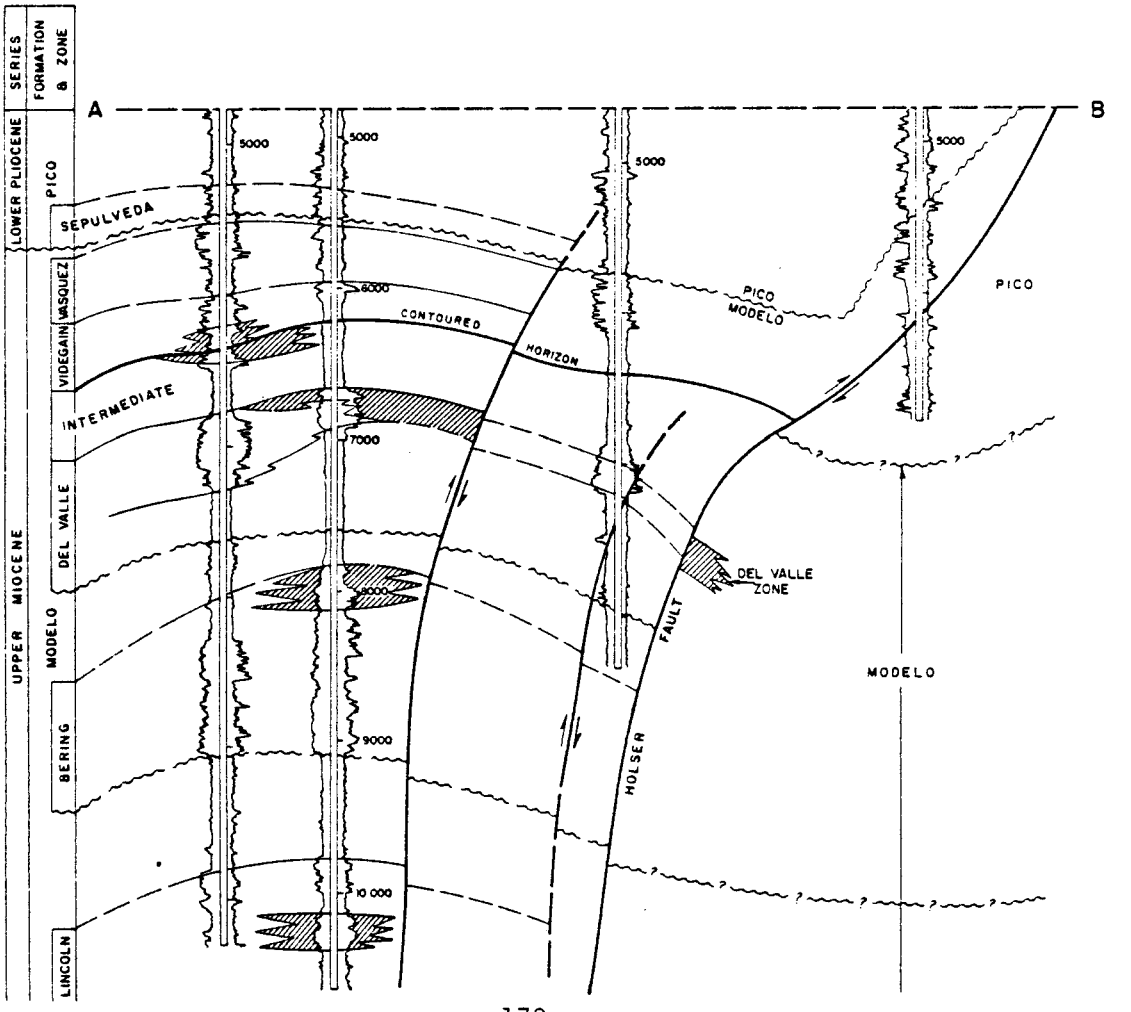
Castaic Junction, which is one of the larger producers in the Ventura Basin (about 2,500-3,000 b/d water plus oil), is in a hilly area near the intersection of Interstate 5 and State Route 126. It is adjacent to Six Flags Magic Mountain amusement park and could be a source of heat for small-scale applications. Unfortunately, the operator in this field did not provide data on temperatures or production. Although the geothermal gradient is estimated to be less than 3.0°C/100 meters, the unusually deep production zones (9,000-12,000 feet) probably issue moderately warm water. It is not known if there is a centralized treatment facility, but the above-discussed characteristics warrant further investigation of this field for small-scale applications.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 52, no. 2, part 2 (1966), v. 39, no. 2 (1953).

DEL VALLE OIL FIELD



CONTOURS ON TOP OF INTERMEDIATE ZONE



DEL VALLE OIL FIELD

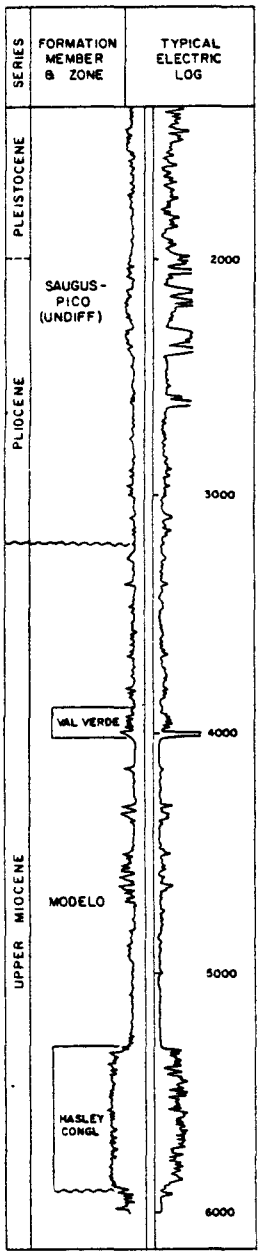
MAJOR OPERATORS (1981): Chevron, Union, Marathon.

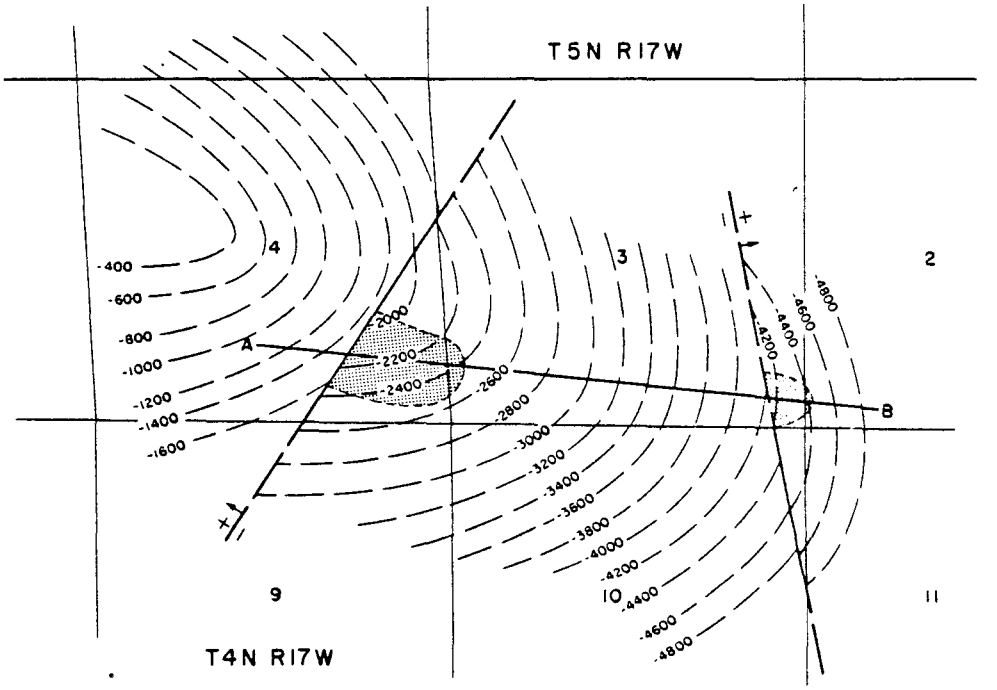
CHARACTERISTICS AND POTENTIAL:

Del Valle is situated in a rural, hilly area north of State Route 126 in the Santa Clara River Valley. Total water production from the three main operators in the field is about 1,500-2,000 b/d. This amount, combined with the average geothermal gradient, the intermediate production depths (about 5,000-7,000 feet), and the ruralness of the area, suggest very limited potential at best for heat-extraction and applications from this field.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 50, no. 2 (1964).

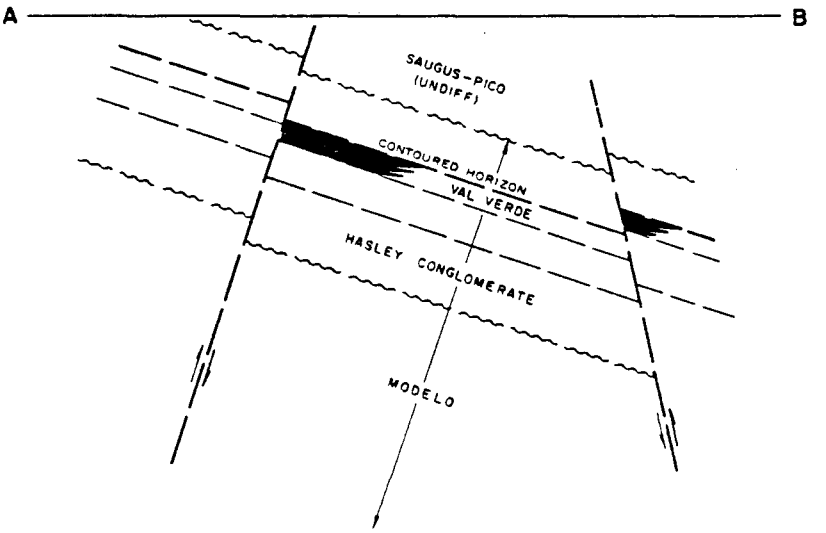
HASLEY CANYON OIL FIELD





CONTOURS ON TOP OF VAL VERDE

SCALE: 1" = 2800'



HASLEY CANYON OIL FIELD

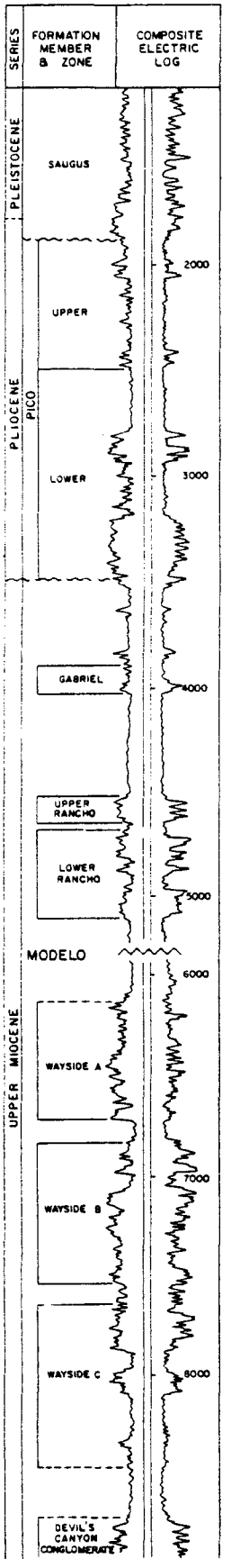
MAJOR OPERATORS (1981): Petrominerals, Decalta.

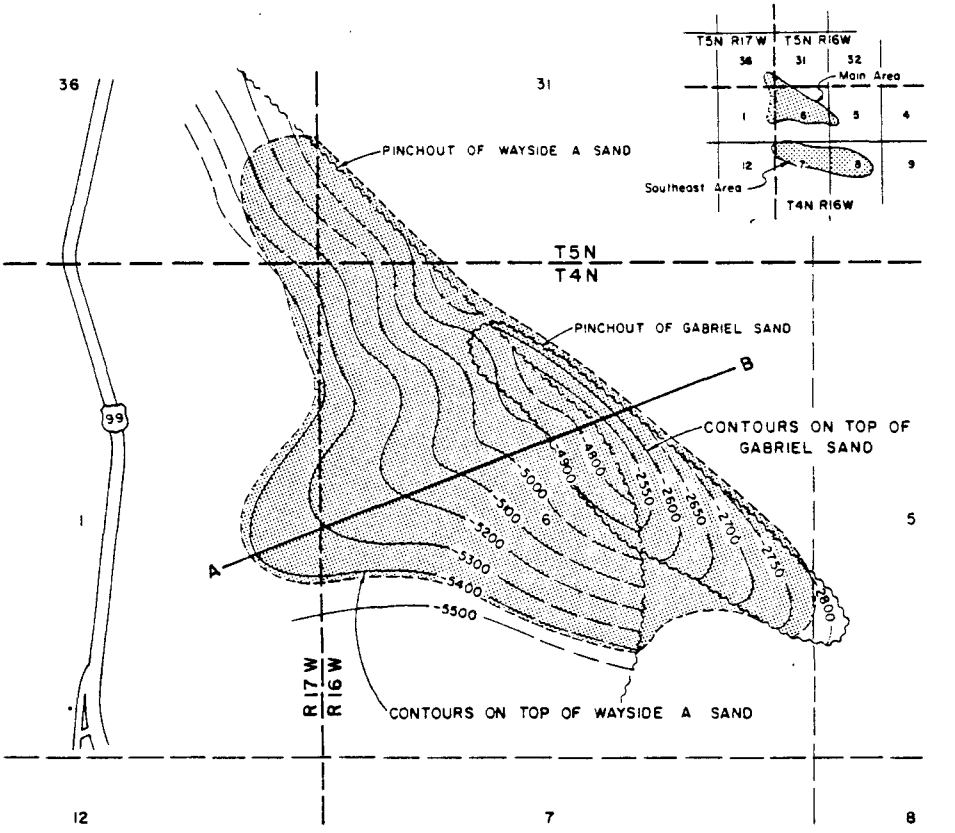
CHARACTERISTICS AND POTENTIAL:

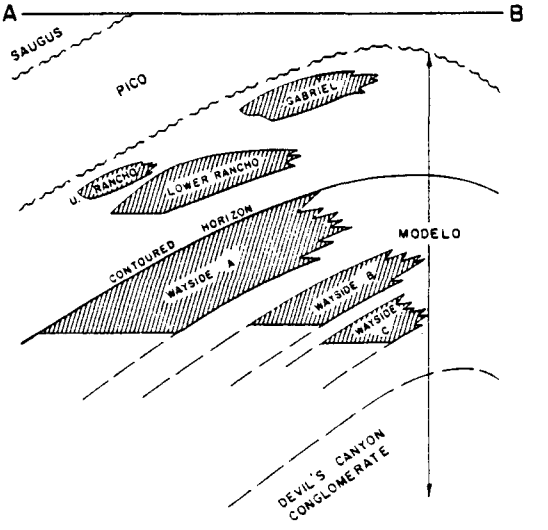
This small, remote field has essentially no potential for a heat extraction project mainly because of its small volume of production (only about 85 b/d water). The geothermal gradient is about average with production from a single zone approximately 4,500 feet deep. The operator uses a dehydration tank for oil-water separation, which raises the initial water temperature from 125°-130°F to about 160°F.

REFERENCE: None.

HONOR RANCHO OIL FIELD
Main Area







HONOR RANCHO OIL FIELD

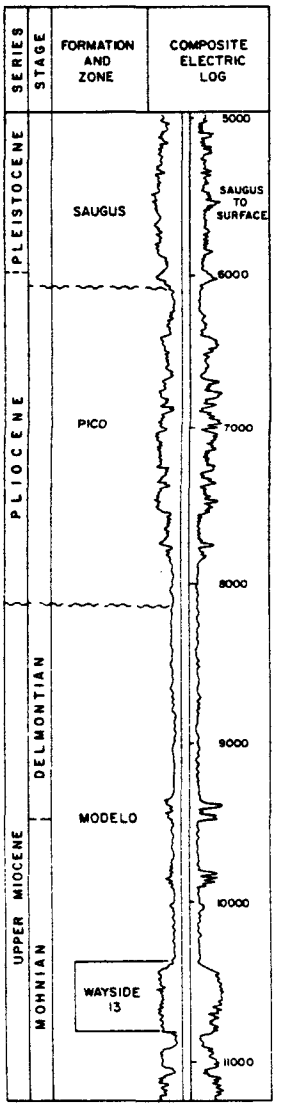
MAJOR OPERATORS (1981): Texaco, Southern California Gas Company.

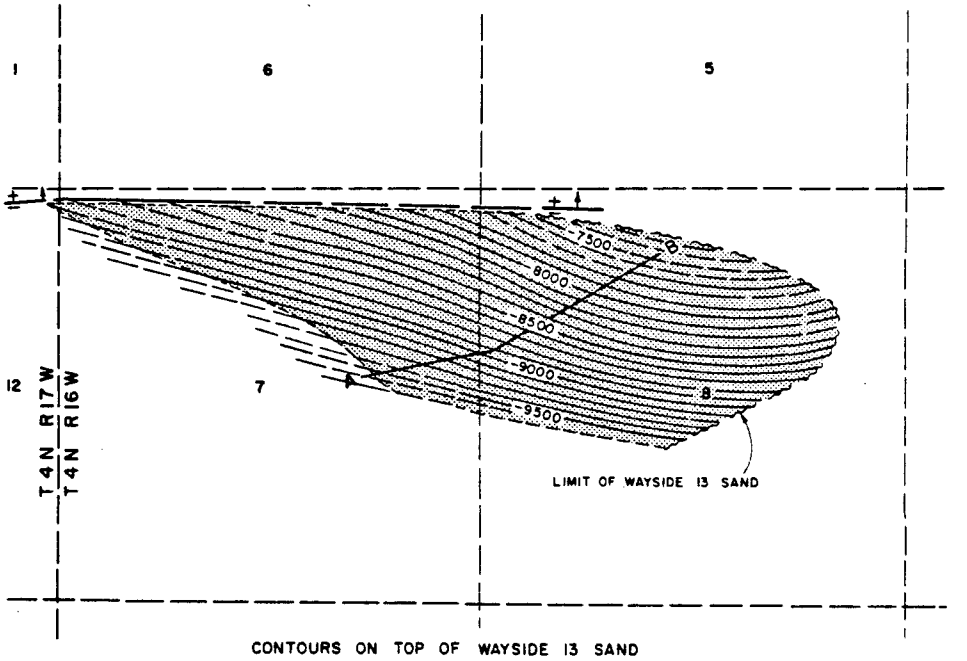
CHARACTERISTICS AND POTENTIAL:

Honor Rancho is near Castaic Junction in a sparsely settled area that contains the Wayside Honor Rancho, operated by the County of Los Angeles. The main operator is Texaco, which did not provide temperature or production data for the field. Of the two areas that comprise the field, the Southeast Area is of less interest because it serves mainly as a gas storage reservoir. Fluid production in the Main Area averages about 1,000-1,500 b/d; much, if not all, of the waste water is disposed of via wells. Production depths are about 5,000-6,000 feet, consequently, well-head temperatures may be on the order of 100°-125°F. Applications could be made at the honor ranch, but the small water production would likely keep these small-scale.

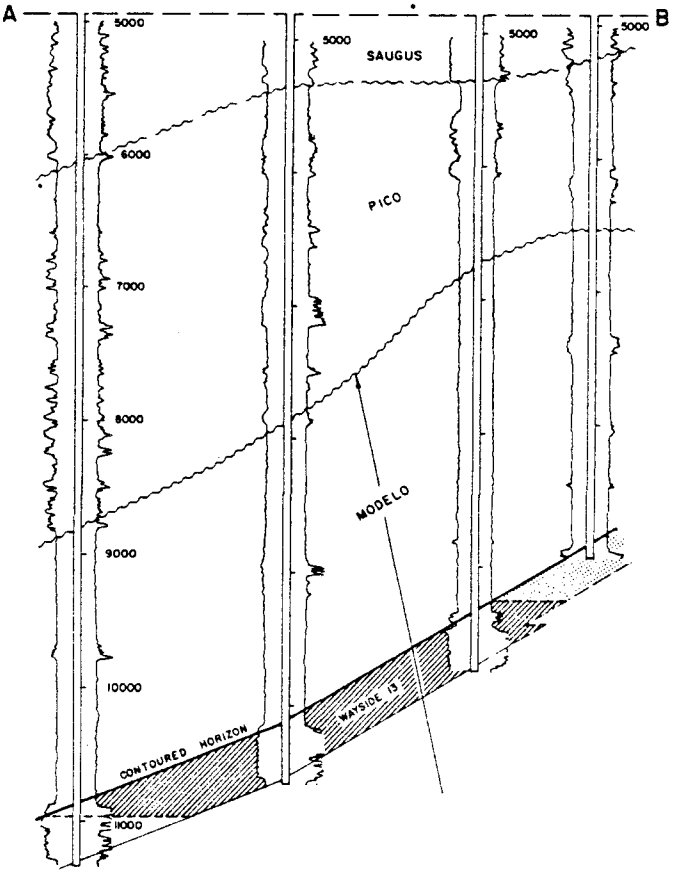
REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 39, no. 1 (1953).

HONOR RANCHO OIL FIELD
Southeast Area

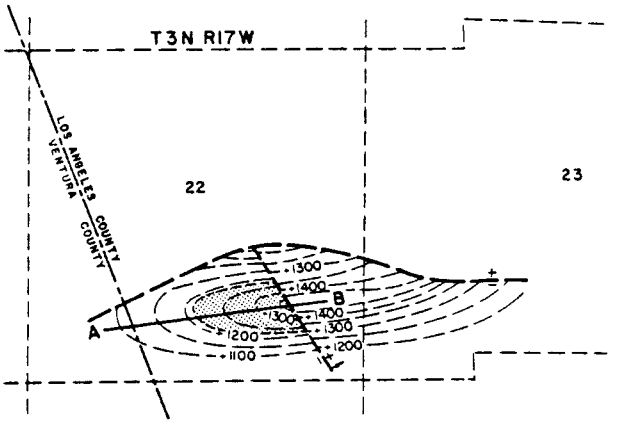




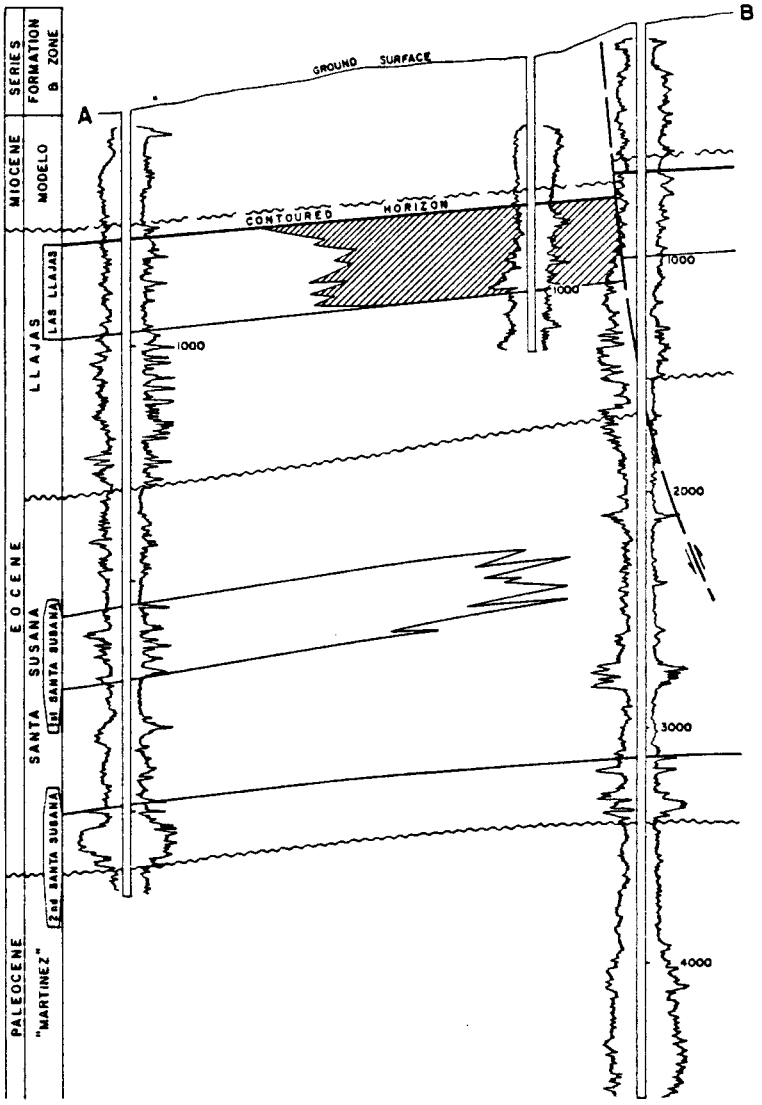
CONTOURS ON TOP OF WAYSIDE 13 SAND



LAS LLAJAS OIL FIELD



CONTOURS ON TOP OF LAS LLAJAS ZONE



LAS LLAJAS OIL FIELD

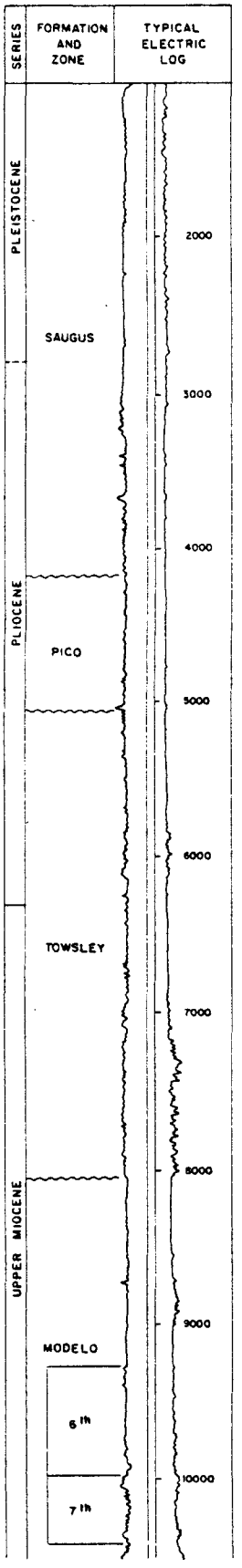
MAJOR OPERATORS (1981): Union.

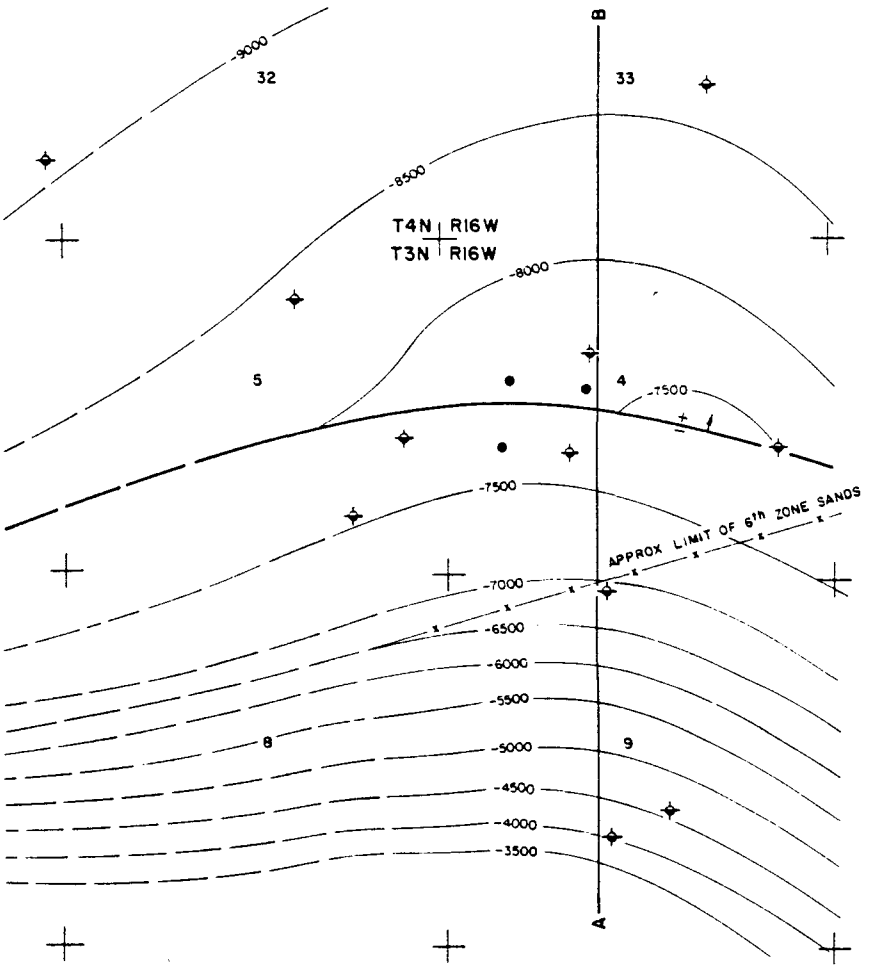
CHARACTERISTICS AND POTENTIAL:

This field has essentially no potential as a site for heat extraction because of its small fluid production (10-15 b/d) and extreme isolation from developed areas.

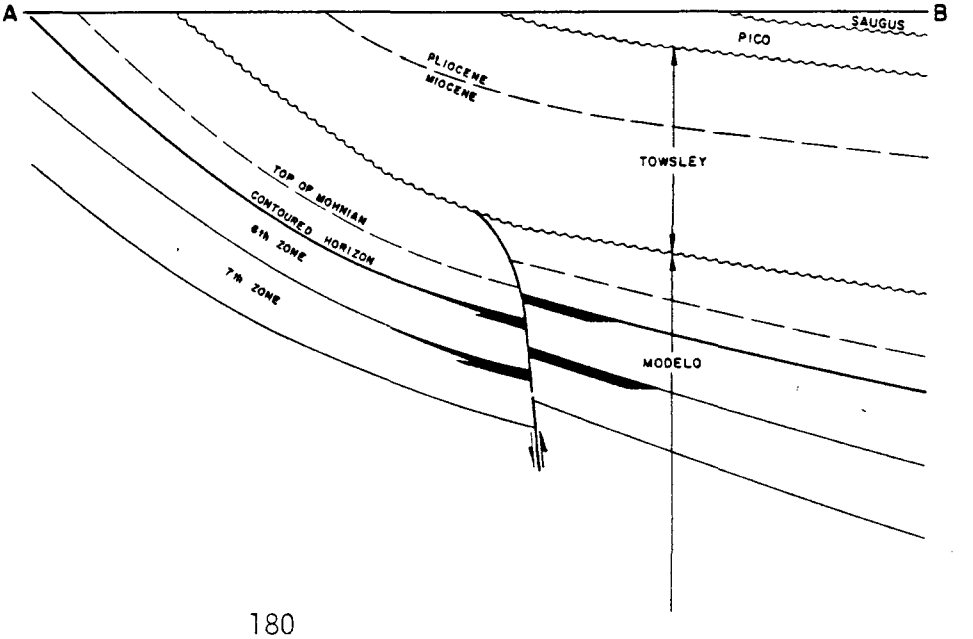
REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 49, no. 2 (1963).

LYON CANYON OIL FIELD





CONTOURS ON TOP OF 6th ZONE



LYON CANYON OIL FIELD

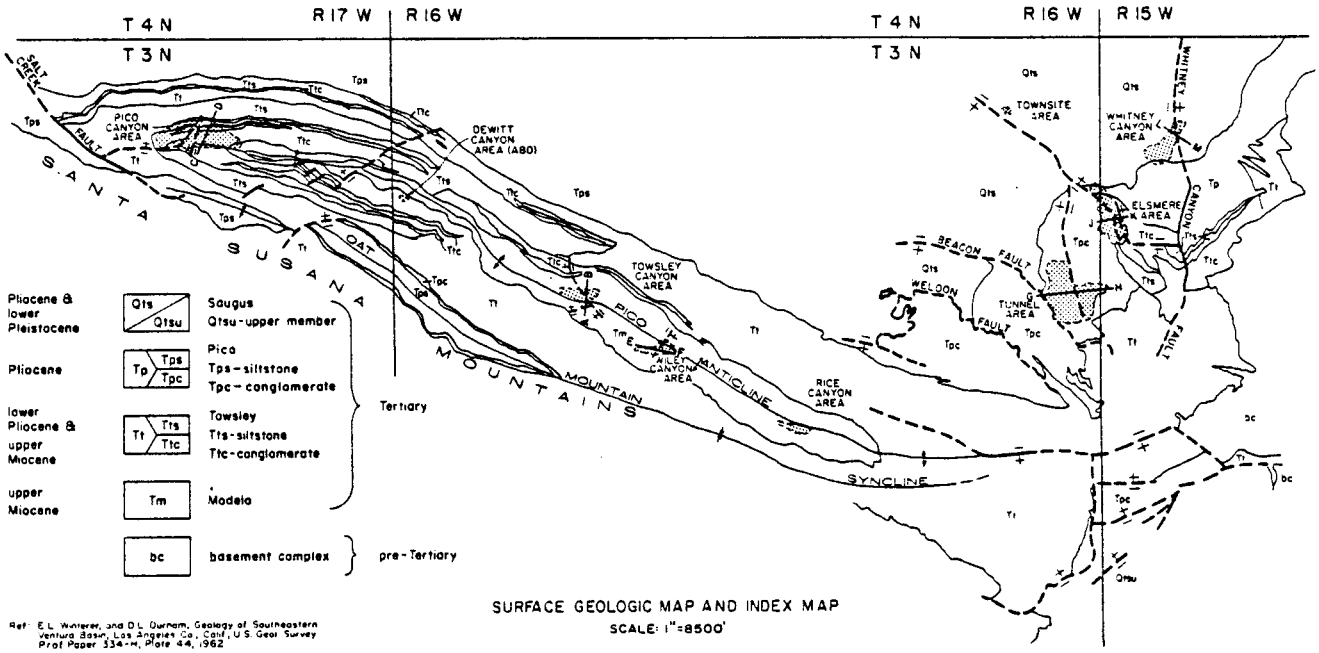
MAJOR OPERATORS (1981): Hydrocarbons Limited.

CHARACTERISTICS AND POTENTIAL:

A fluid production of only about 25 b/d eliminates this field as a potential site of heat extraction.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 59, no. 1 (1974).

NEWHALL OIL FIELD

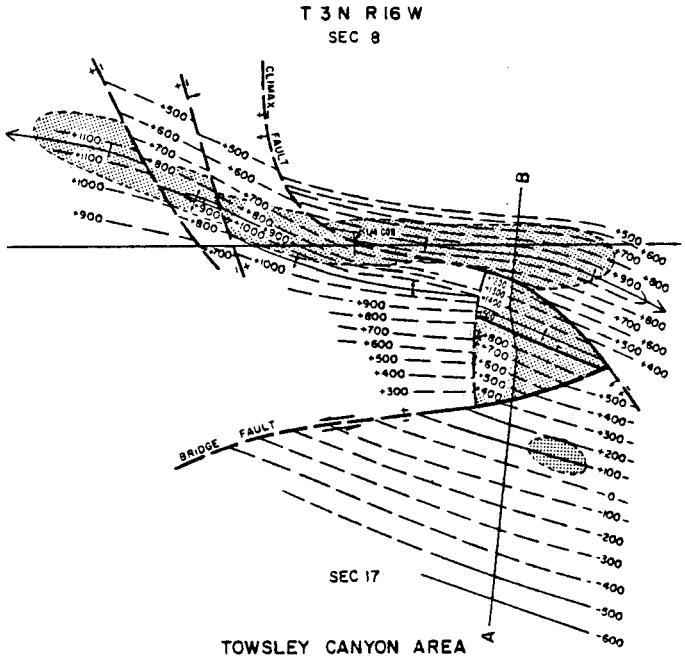


Ref: E. L. Winterer, and D. L. Durham, Geology of Southeastern Ventura Basin, Los Angeles Co., Calif., U.S. Geol Survey Prof Paper 334-H, Plate 44, 1962

SURFACE GEOLOGIC MAP AND INDEX MAP

SCALE: 1"=8500'

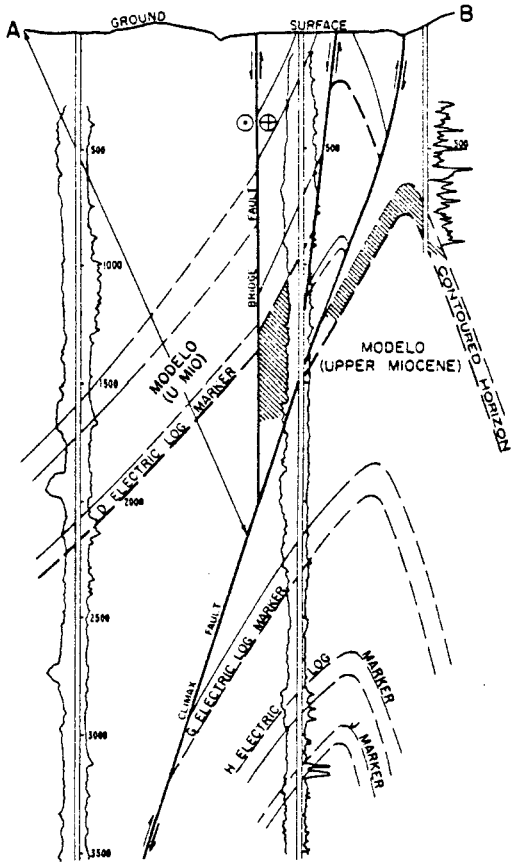
DEFINITIVE SUBSURFACE DATA AVAILABLE ONLY FOR THE TOWSLEY CANYON AREA.



TOWSLEY CANYON AREA

CONTOURS ON D ELECTRIC LOG MARKER

SCALE : 1" = 800'



NEWHALL OIL FIELD

MAJOR OPERATORS (1981): Chevron, International Oil and Mining, Morton and and Dolley, Jacob Albert, Western Pacific Oil and Gas.

CHARACTERISTICS AND POTENTIAL:

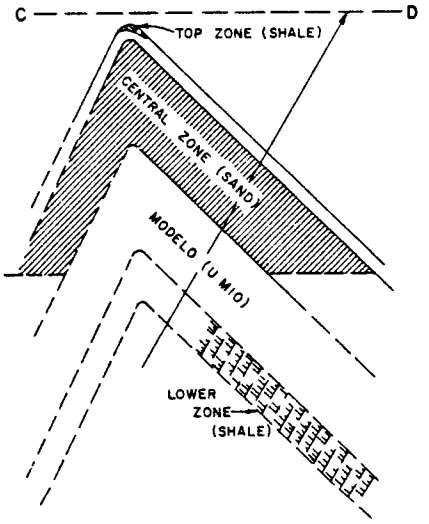
A severe disadvantage of Newhall, besides its low fluid production (about 250 b/d) and shallow production depths (less than 3,000 feet), is that the field is broken up into about half-a-dozen widely-spaced production areas. These three characteristics and the isolation of the areas eliminate this field from serious consideration as a site of heat extraction.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 20, no. 2 (1934), v. 52, no. 1 (1966).

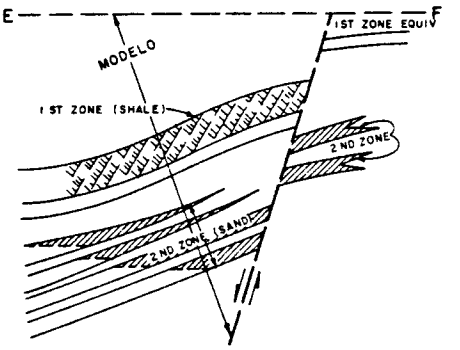
NEWHALL OIL FIELD

GENERALIZED CROSS SECTIONS OF AREAS
OTHER THAN TOWSLEY CANYON AREA
(TOWSLEY CANYON AREA IS SHOWN ON PRECEDING PAGE)

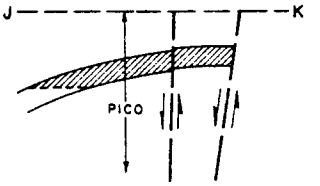
PICO CANYON AREA



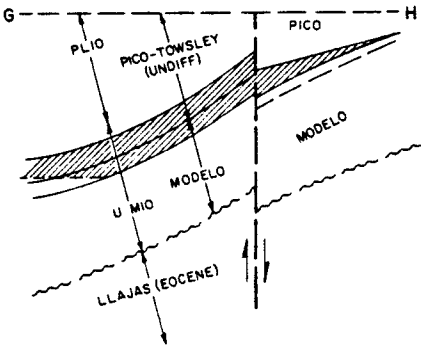
WILEY CANYON AREA



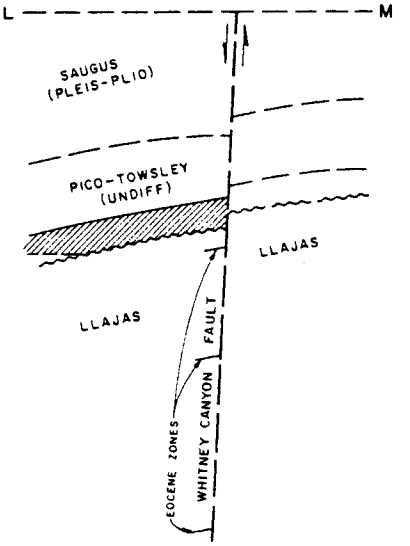
ELSMERE AREA



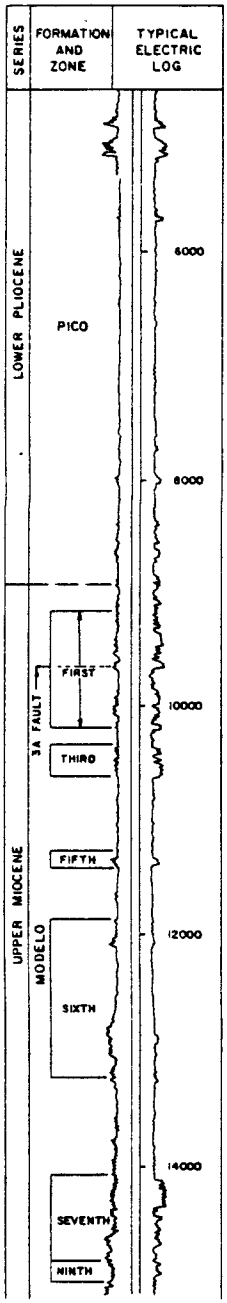
TUNNEL AREA

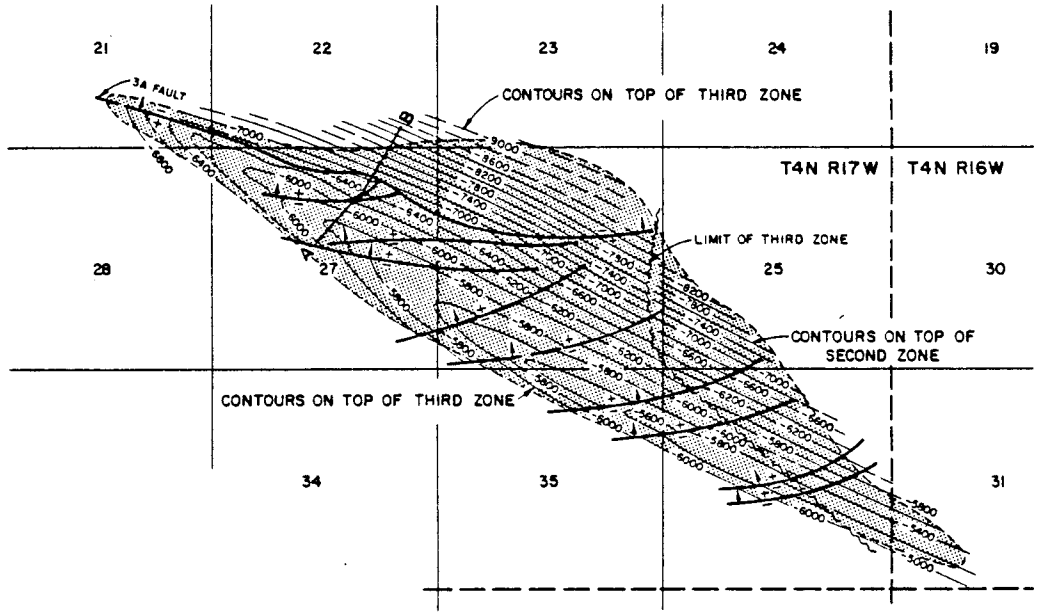


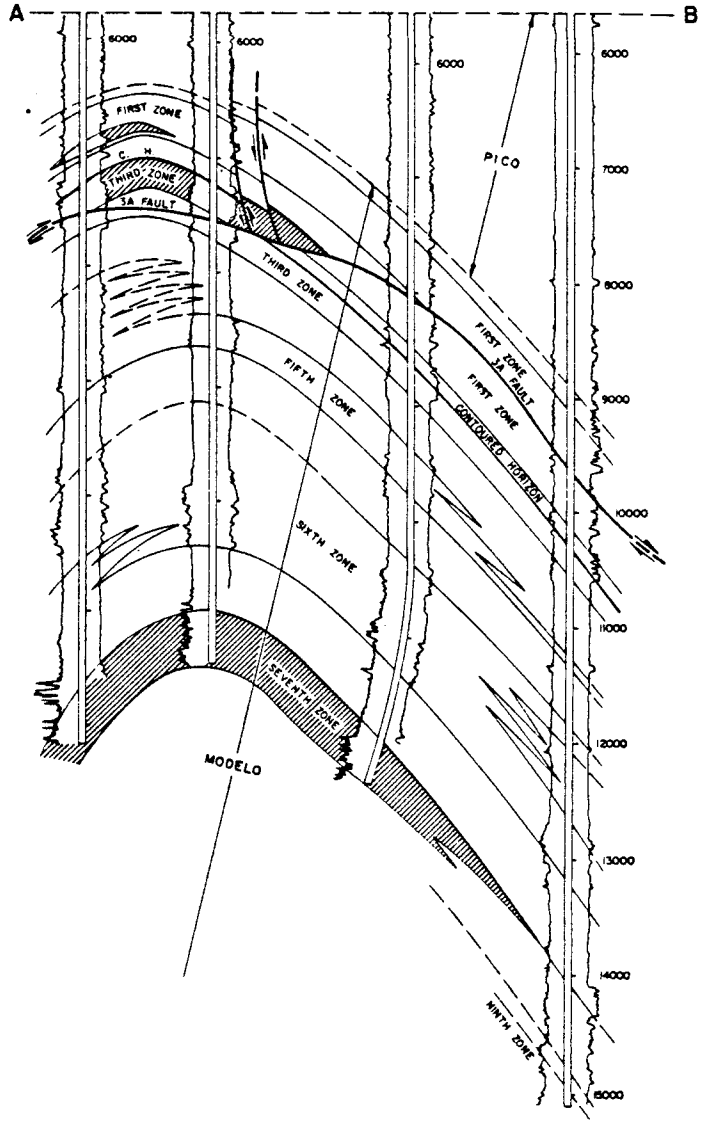
WHITNEY CANYON AREA



NEWHALL-POTRERO OIL FIELD







NEWHALL-POTRERO OIL FIELD

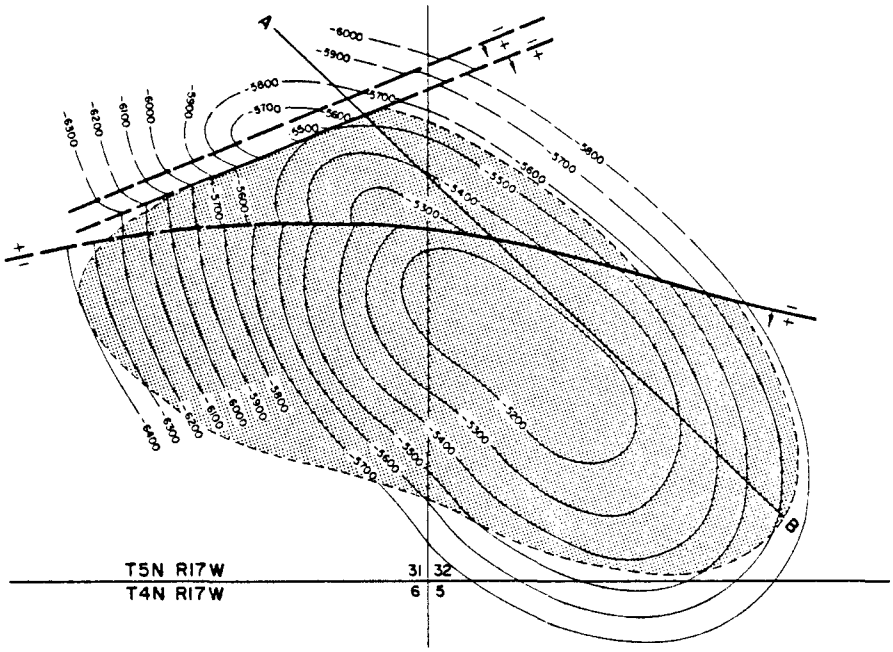
MAJOR OPERATORS (1981): Sun.

CHARACTERISTICS AND POTENTIAL:

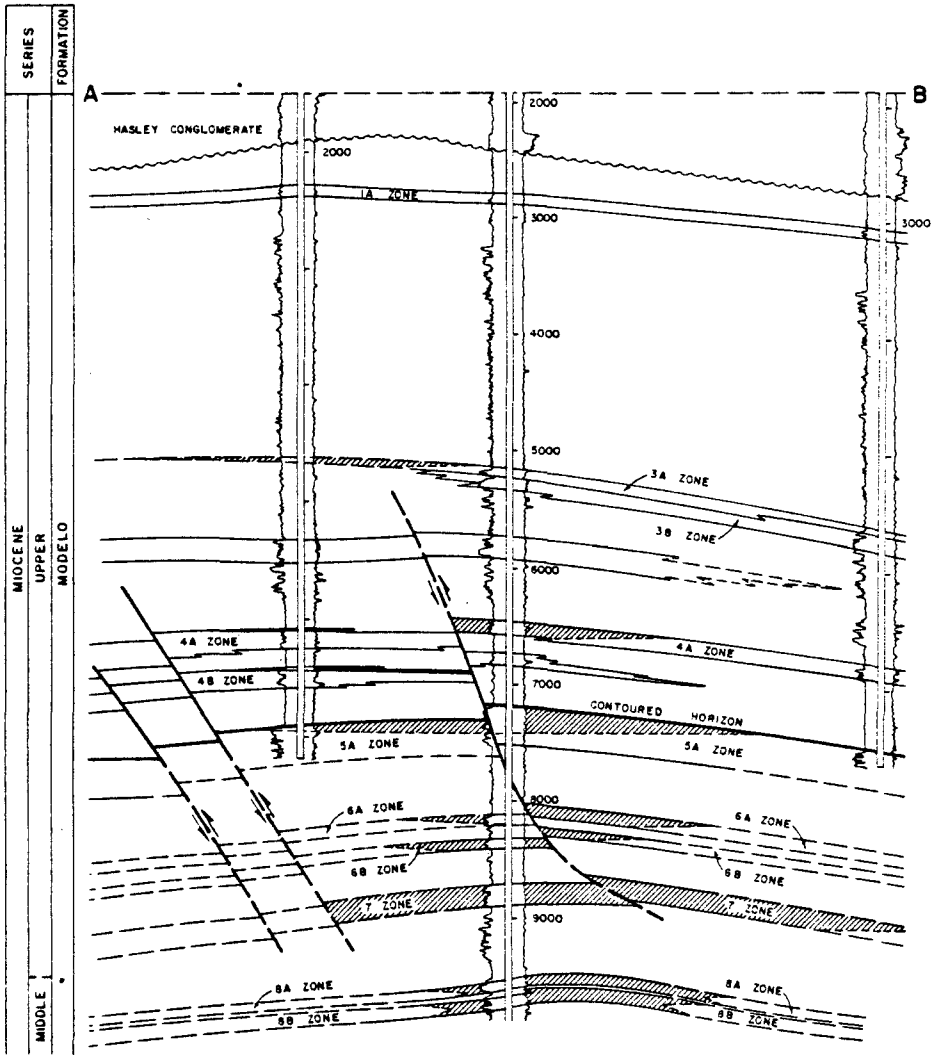
Newhall-Potrero is southwest of Castaic Junction in an isolated, hilly area that may be unattractive for heat-extraction projects. Production temperatures were not provided by Sun, the only operator, but well-log temperatures indicate an average geothermal gradient for the field. Fluid production is about 3,000 b/d, which is one of the largest in the Los Angeles County portion of the Ventura Basin. This amount is insufficient, however, to sustain any large-scale applications of heat extraction.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 29, no. 1 (1943), v. 51, no. 2 (1965).

OAK CANYON OIL FIELD



CONTOURS ON TOP OF 5A ZONE
SCALE: 1" = 1600'



OAK CANYON OIL FIELD

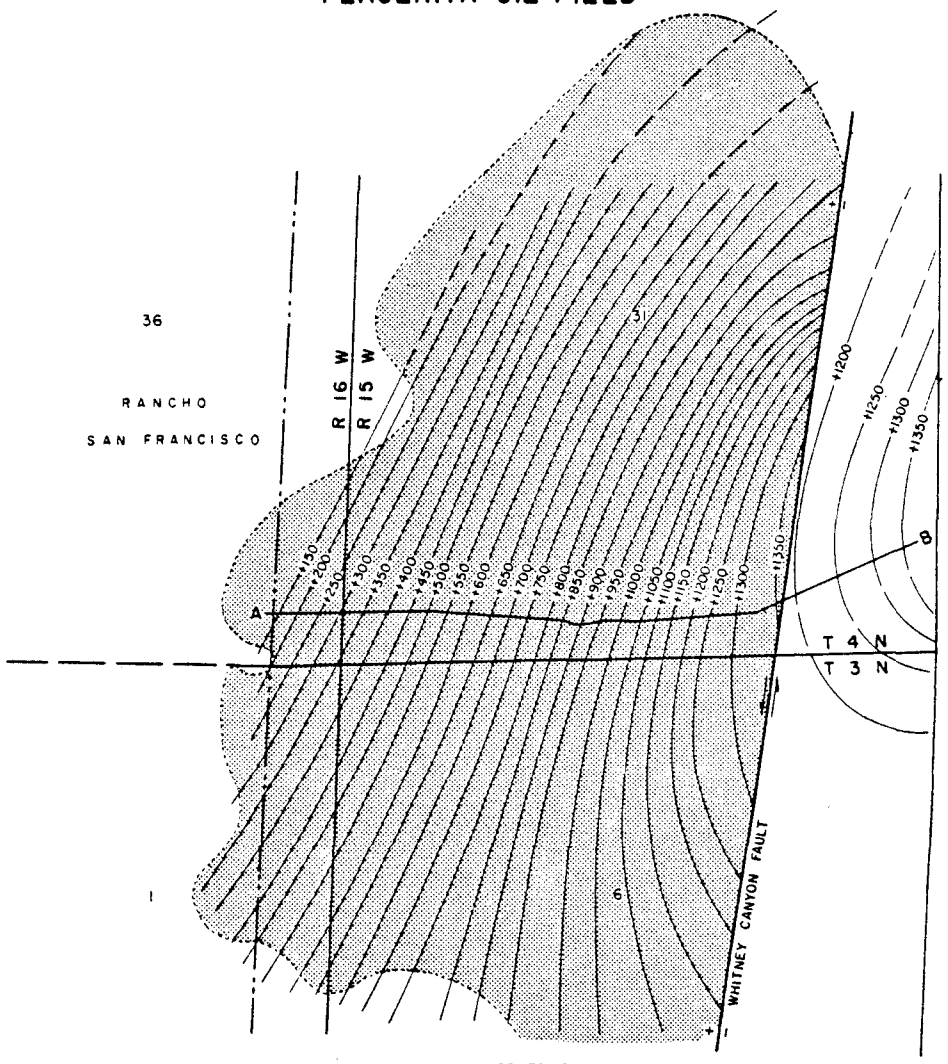
MAJOR OPERATORS (1981): Gulf, McFarland.

CHARACTERISTICS AND POTENTIAL:

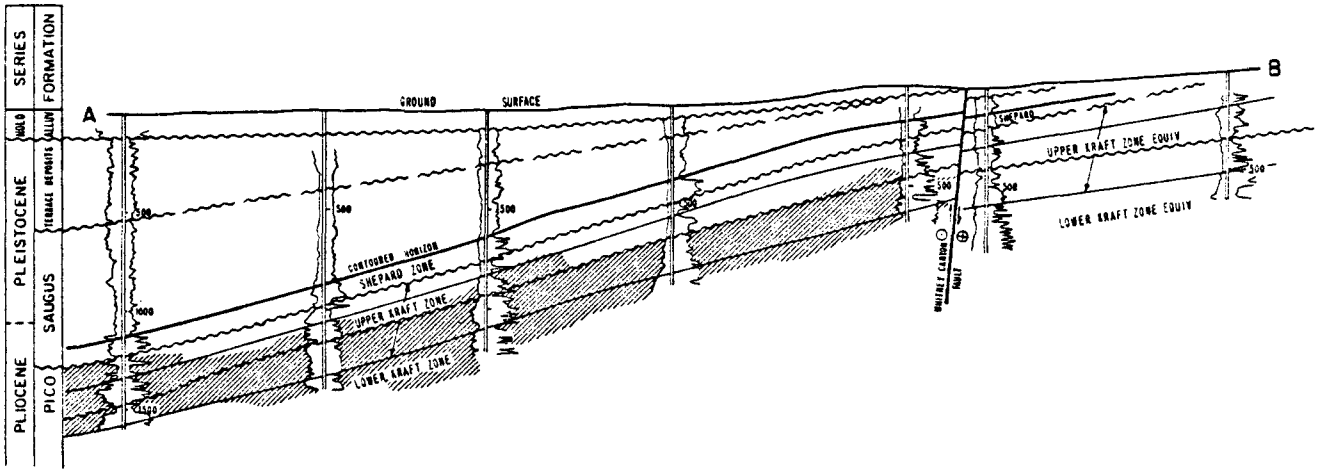
Gulf, the main field operator, uses a process in its treatment facilities here that increases the incoming initial water temperature from about 85°-90°F to 120°-130°F as the water is sent to injection or disposal wells. Fluid production is on the order of a few thousand b/d, which is insufficient to provide heat for any large-scale projects. The main drawback of the field is its isolation in a hilly, rural area. This, as well as the relatively low volumes, severely limits the potential of this field for heat extraction.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 44, no. 2 (1958).

PLACERITA OIL FIELD



CONTOURS ON TOP OF SHEPARD ZONE
SCALE 1" = 1650'



PLACERITA OIL FIELD

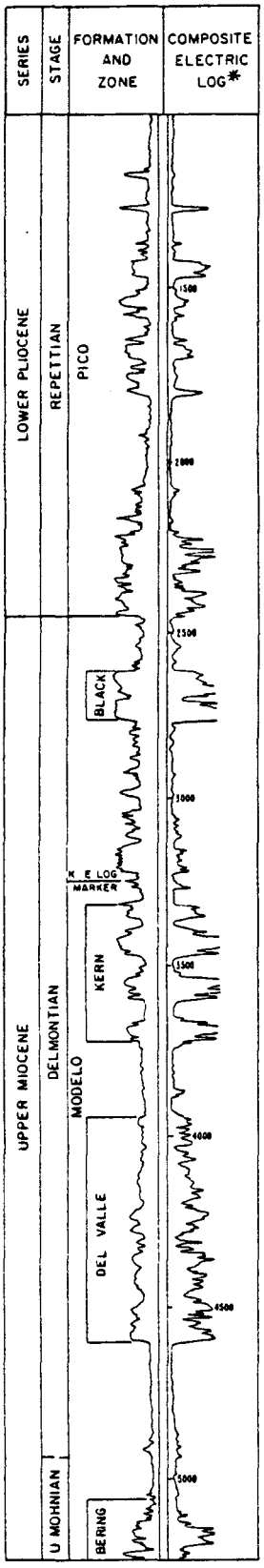
MAJOR OPERATORS (1981): Crown Central Petroleum, Petro Resources, Chevron, Grace Petroleum.

CHARACTERISTICS AND POTENTIAL:

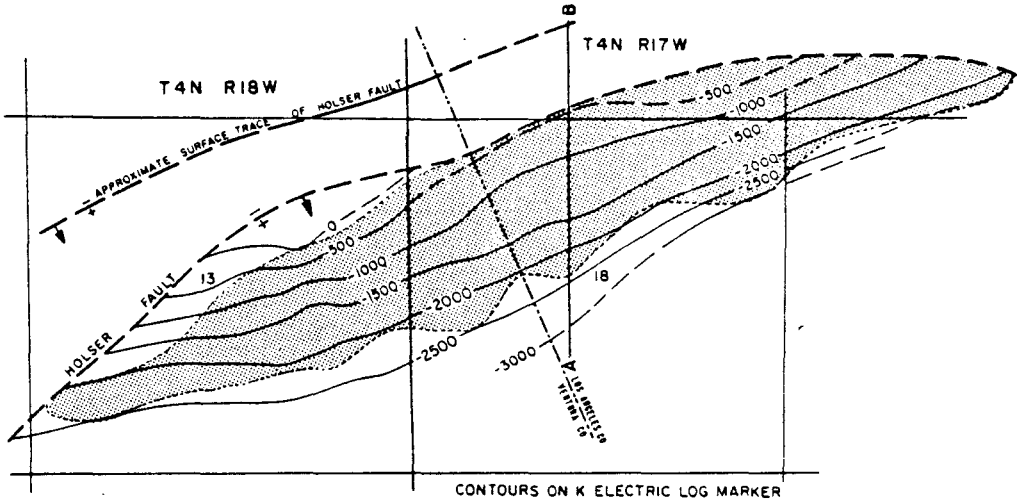
Placerita is the largest water producer and the third largest oil producer in the Los Angeles County portion of the Ventura Basin (Photo 15). It has a distinct advantage over most of the other Basin fields in that it is astride a major transportation artery (State Route 14, an excellent freeway) and is adjacent to the only significant area of population in the region (Newhall). Another advantage is the high water production of about 25,000 b/d. Unfortunately, the reservoir is so shallow (500-2,000 feet) that high temperatures do not complement the large quantities of produced water; well-head temperatures are likely less than 100°F, probably in the ambient range. Some minor cyclic steam-flooding has been undertaken in the field, probably to reduce the oil viscosity, which is high. As a result, the operators may be reluctant to allow extraction of heat, unless it is from the waste water sent to disposal wells, which handle close to half of the produced water. If extraction were allowed, the available heat would be substantially limited by the low reservoir temperatures.

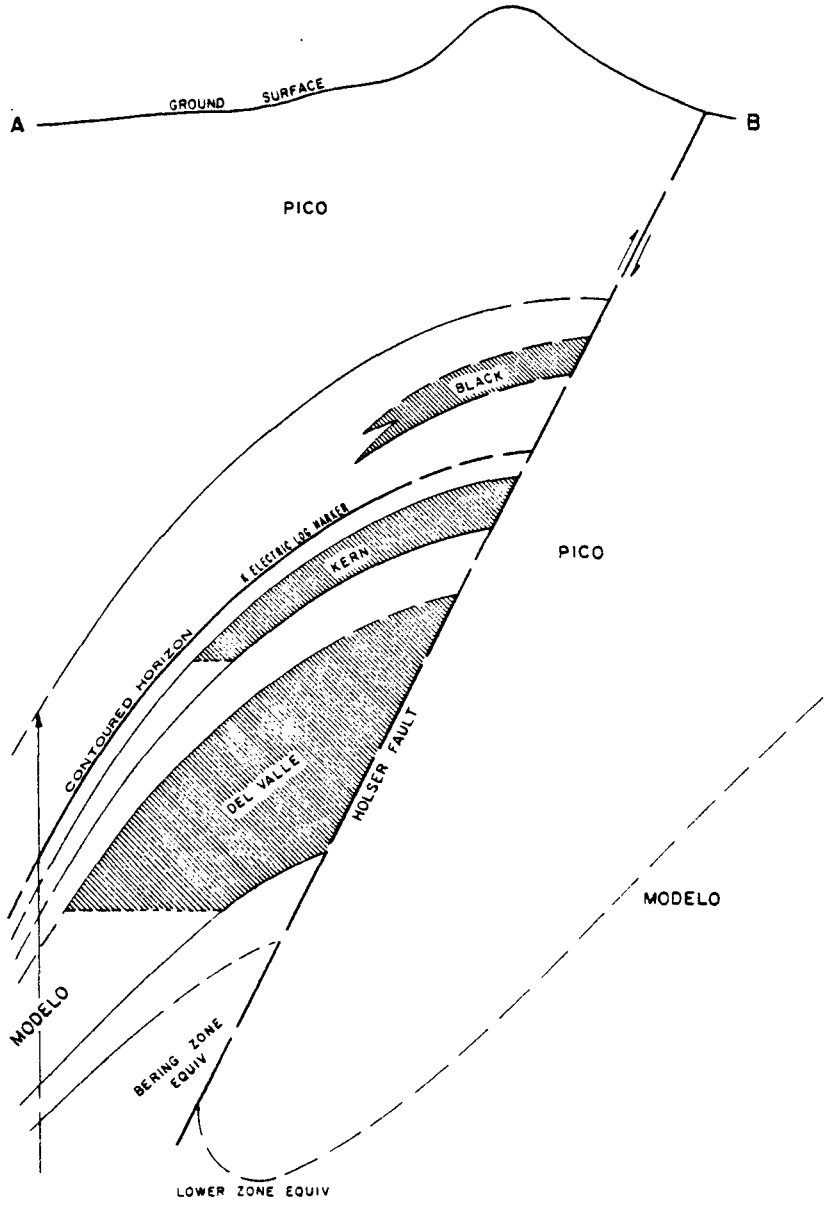
REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 35, no. 2 (1949), v. 48, no. 1 (1962).

RAMONA OIL FIELD



*ABOVE HOLSER FAULT





RAMONA OIL FIELD

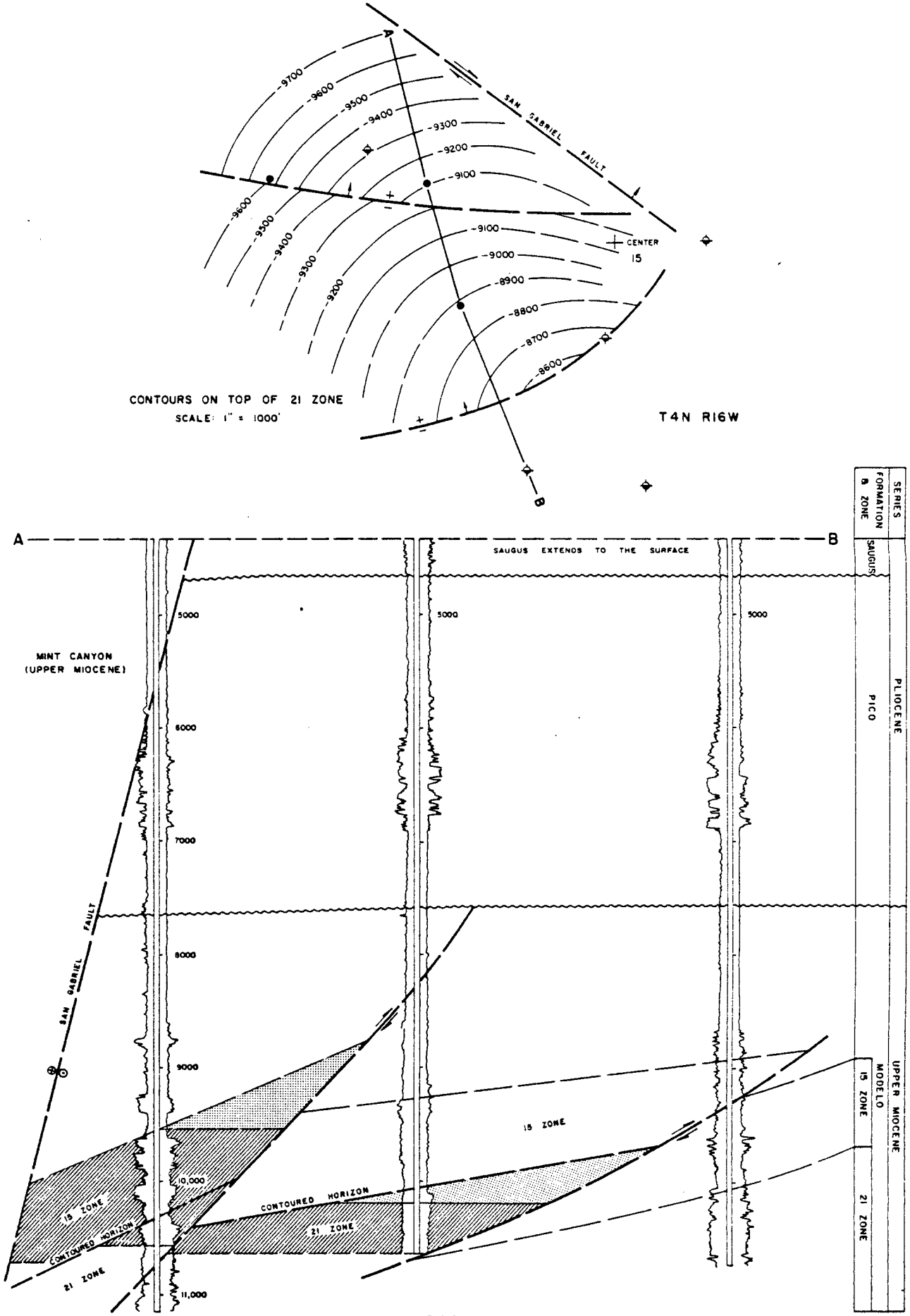
MAJOR OPERATORS (1981): Texaco, Chevron.

CHARACTERISTICS AND POTENTIAL:

Only about a third of this field's production is from Los Angeles County; the remainder is from Ventura County. Both its low fluid production (200-250 b/d) and its isolation in a rural, hilly area make this field's potential for heat extraction very poor.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 37, no. 1 (1951).

SAUGUS OIL FIELD



SAUGUS OIL FIELD

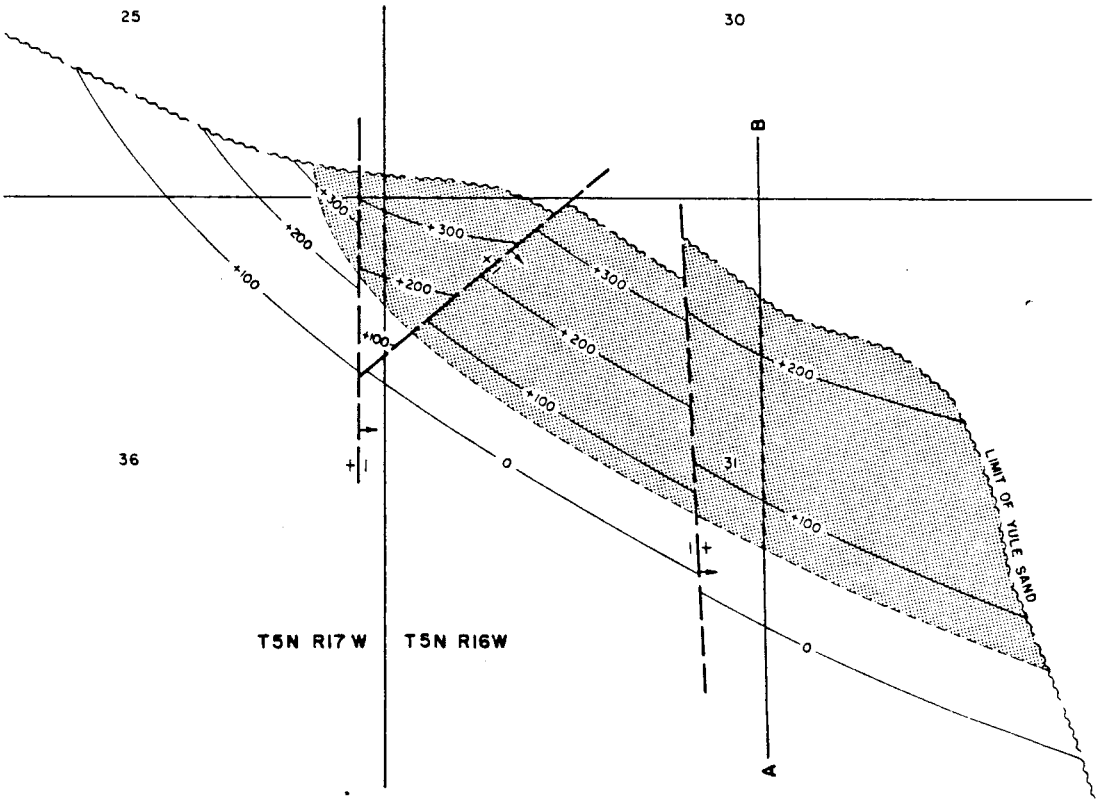
MAJOR OPERATORS (1981): James C. Thomas.

CHARACTERISTICS AND POTENTIAL:

Saugus is too small (less than 100 b/d total fluid production) to serve as a site for heat extraction. Produced-fluid temperatures may be hot, however, because of the depth of production (greater than 9,000 feet).

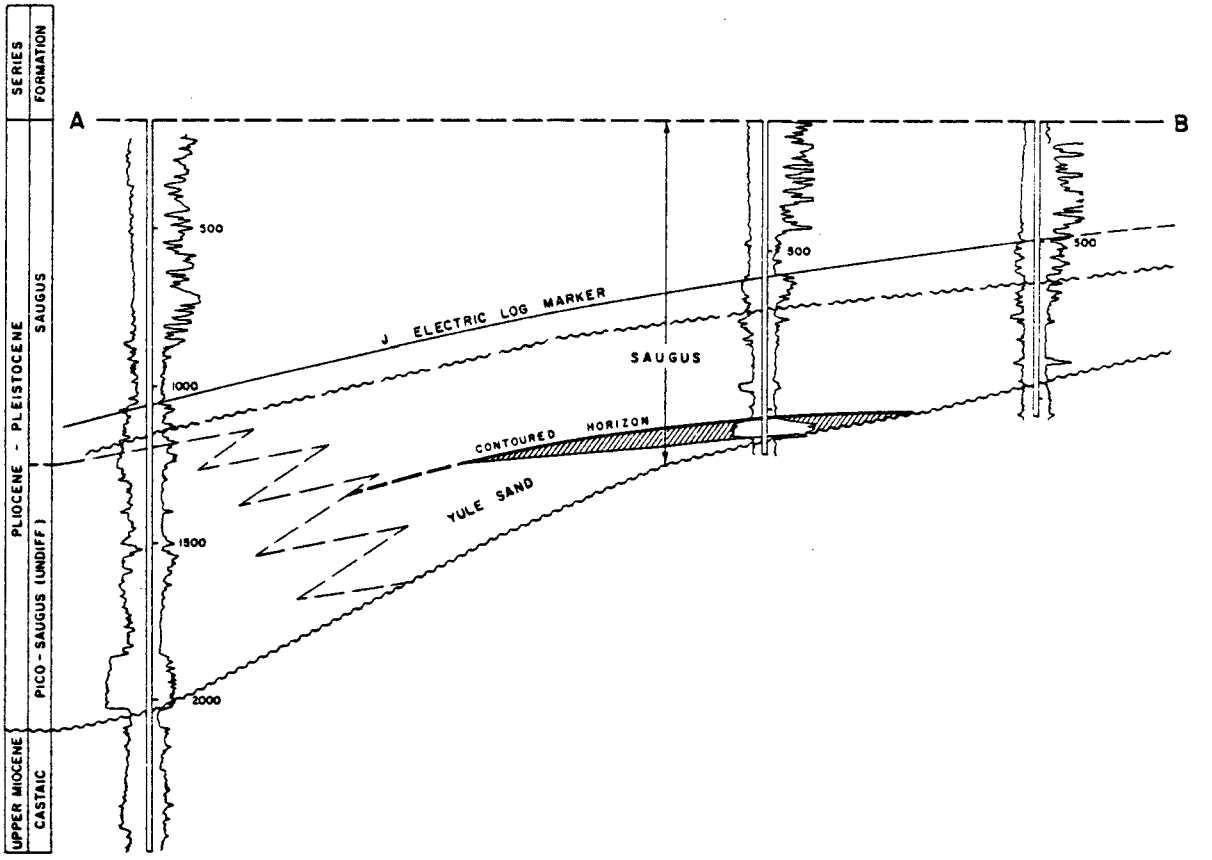
REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 48, no. 2 (1962).

TAPIA OIL FIELD



CONTOURS ON TOP OF YULE SAND

SCALE: 1" = 1000'



TAPIA OIL FIELD

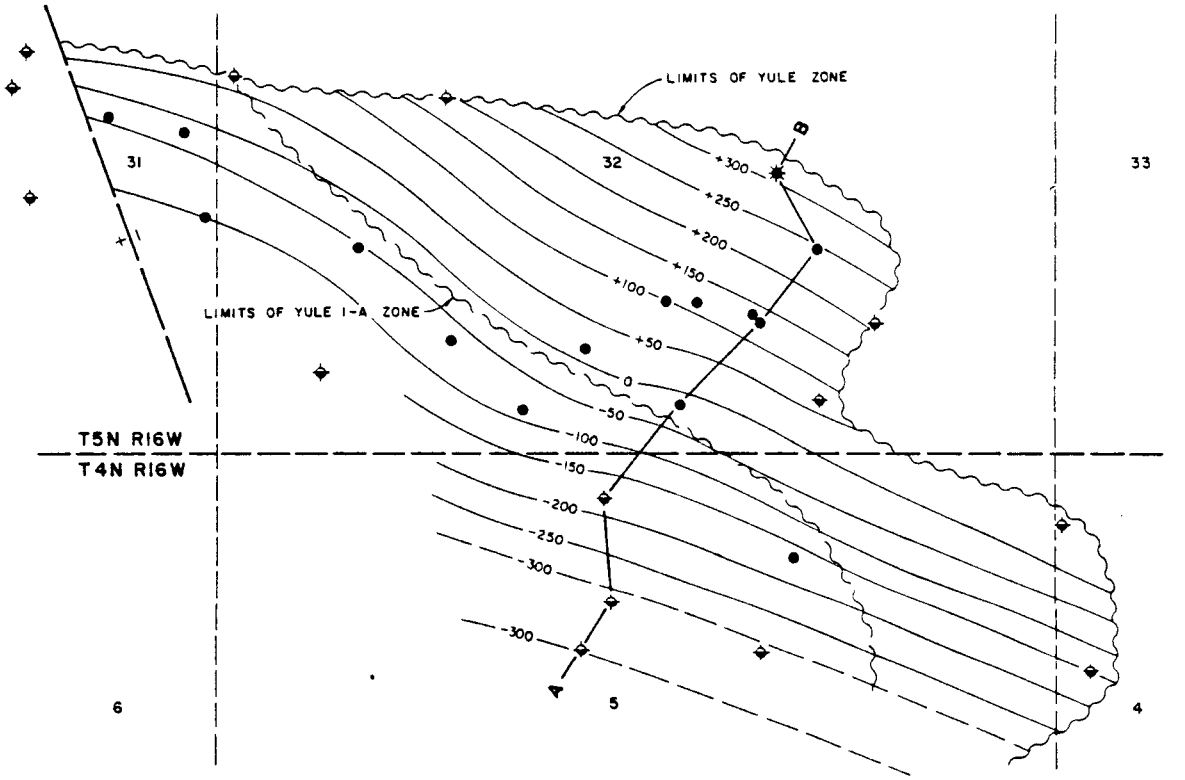
MAJOR OPERATORS (1981): Crown Central Petroleum.

CHARACTERISTICS AND POTENTIAL:

Besides the low volumes of fluid production (about 200 b/d), the extreme shallowness of this field's production zone (about 1,000-1,500 feet) makes this field a poor candidate for heat extraction.

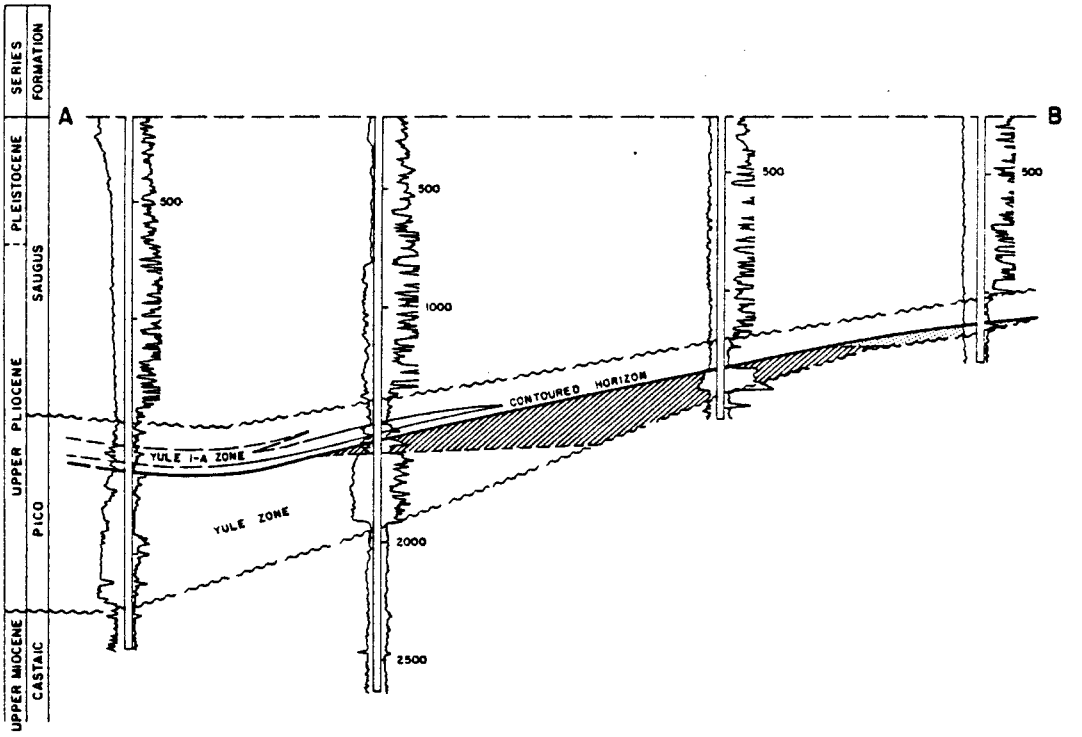
REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 45, no. 1 (1959).

WAYSIDE CANYON OIL FIELD



CONTOURS ON TOP OF YULE ZONE

SCALE: 1" = 1200'



WAYSIDE CANYON OIL FIELD

MAJOR OPERATORS (1981): Texaco.

CHARACTERISTICS AND POTENTIAL:

The only production zone in Wayside Canyon is about 1,500 feet deep, which is too shallow to provide a significant source of heat. Also, fluid production is only about 500 b/d. These two characteristics make this field unattractive for heat extraction.

REFERENCE: Calif. Div. of Oil and Gas, Summary of Operations - Calif. Oil Fields, v. 53, no. 1 (1967).

APPENDIX B

TEMPERATURE AND PRODUCTION DATA FOR ACTIVE OIL FIELDS IN LOS ANGELES AND VENTURA BASINS

NOTES:

1) Blank areas indicate that data weren't available.

2) Code for determination of zone temperatures by operators.

   A Temperature survey

   B Well logs

   C Surface discharge

   D Geothermal gradient

   E Estimated

3) 1979 production and injection statistics are for portions of fields in Los Angeles County only. Source of data: California Division of Oil and Gas, 1980, 65th Annual Report of the State Oil and Gas Supervisor.

4) "Injection" refers to volumes used for enhanced-recovery water-flood projects, whereas "disposal" refers to volumes discharged at the surface (e.g., sewer system) or injected into wells with no intention of use for enhanced-recovery projects.

5) Volumes under "Treatment Facility" refer to water processed.

LOS ANGELES BASIN

FIELD NAME	OPERATOR	ZONE	TEMP. (°F)	APPROX. DEPTH (Ft.)	DETERMINED BY	GRADIENT °C/100 METERS	LEASE	WELL HEAD TEMP. (°F)	TREATMENT FACILITY ENTER TEMP. (°F)	TREATMENT FACILITY ENTER VOLUME (B/D)	TREATMENT FACILITY EXIT TEMP. (°F)	TREATMENT FACILITY EXIT VOLUME (B/D)	GRADIENT (All °C/100 m data)	PRODUCTION 1979 OIL (BBLS)	PRODUCTION 1979 WATER (BBLS)	% WATER	1979 INJECTION (BBLS)	1979 DISPOSAL (BBLS)
ALONDRA	Pauley	Schist Conglom-erate	250°	9,000	E	3.8	Park Bodger	175°-210°	160°-180°	650	120° (E)	500	3.7-3.8	1,426	141,914	99	None	141,914 into sewer
BANDINI													3.4	31,593	483,298	94	None	483,298 into sewer
	Western Ave. Prop.						Southside	80°-120°	80°-90°	900	80°-90°	900						
	Atlantic						C.W.O.D.			500 (E)		500 (E)						
BEVERLY HILLS West Area	Gulf	Main Repetto Rancho A1 A3 A7 G1 G2	120°-159°		A, B		20th Century Fox	120°	110°	280	135°	280	3.8-4.0	169,384	338,853	67	None	166,460 into wells
		Main	176°	5,000	B	4.1	Community 6193	115°	110°	247	135°	247						
		Main	167°	5,000	B	3.8	Community 7260	115°										

FIELD NAME	OPERATOR	ZONE	TEMP. (°F)	APPROX. DEPTH (Ft.)	DETERMINED BY	GRADIENT °C/100 METERS	LEASE	WELL HEAD TEMP. (°F)	TREATMENT FACILITY ENTER TEMP. (°F)	ENTER VOLUME (B/D)	EXIT TEMP. (°F)	EXIT VOLUME (B/D)	GRADIENT (All °C/100 m data)	PRODUCTION 1979 OIL (BBLS)	WATER (BBLS)	% WATER	1979 INJECTION (BBLS)	DISPOSAL (BBLS)
East Area													3.9-4.0	2,753,576	6,806,863	71	9,889,363	None
	Chevron	Main (Hauser)	190°	6,000		3.8	Packard Drill Site	140° (E)	110°-140°	18,000	110°	28,000						
		Repetto (Dunsmuir)	166°	5,000		3.7				Sent to Inglewood Oil Field for treatment								
	Occidental	Main (Hauser)	200°	6,350		3.9	West Pico Drill Site											
		Repetto (Dunsmuir)	185°	5,200		4.2												
BREA-OLINDA													3.5-4.0	389,837	826,529	68	2,638,544	None
	Shell	Lower B 3rd Miocene C	175° 195°	4,900 5,700		4.1 4.2	Puente		Water sent to Yorba Linda Oil Field in Orange County									

FIELD NAME	OPERATOR	ZONE	TEMP. (°F)	APPROX. DEPTH (Ft.)	DETERMINED BY	GRADIENT °C/100 METERS	LEASE	WELL HEAD TEMP. (°F)	TREATMENT FACILITY ENTER TEMP. (°F)	TREATMENT FACILITY ENTER VOLUME (B/D)	TREATMENT FACILITY EXIT TEMP. (°F)	TREATMENT FACILITY EXIT VOLUME (B/D)	GRADIENT (All °C/100 m data)	PRODUCTION 1979 OIL (BBLS)	PRODUCTION 1979 WATER (BBLS)	% WATER	1979 INJECTION (BBLS)	1979 DISPOSAL (BBLS)
CHEVIOT HILLS													3.6	167,123	94,804	36	None	258,785 into wells
	Gulf	Rancho	197°	9,400	B	2.6	20th Cent. Fox Rancho	120°	105°	186	140°	186						
		"	214°	9,200	A	3.0	Community Fox Hills	115°										
		"	228°	9,200	A	3.3	Community West L.A.	120°	110°	13	100°	13						
		"	215°	9,200	A	3.0	Community 7260 Rancho	120°										
		"	235°	9,000	B	3.5	Aladdin	115°	110°	15	140°	15						
		"	208°	9,000	B	2.9	Aladdin II											
COYOTE WEST													3.5-3.6	302,886	10,154,027	97	9,561,440	
	Chevron								100°-115° (E)	140,000	100°-115° (E)	140,000						
DOMINGUEZ													3.5-4.0	779,149	9,465,639	92	7,225,917	
	Union						Hellman		108°	1,120								
							West Unit	≤140°	135°	4,275		9,000						
							Callender		116°	3,780								
							Dominguez Estates		88°	60								

FIELD NAME	OPERATOR	ZONE	TEMP. (°F)	APPROX. DEPTH (Ft.)	DETERMINED BY	GRADIENT °C/100 METERS	LEASE	WELL HEAD TEMP. (°F)	TREATMENT FACILITY ENTER TEMP. (°F)	TREATMENT FACILITY ENTER VOLUME (B/D)	TREATMENT FACILITY EXIT TEMP. (°F)	TREATMENT FACILITY EXIT VOLUME (B/D)	GRADIENT (All °C/100 m data)	PRODUCTION 1979 OIL (BBLS)	PRODUCTION 1979 WATER (BBLS)	% WATER	1979 INJECTION (BBLS)	1979 DISPOSAL (BBLS)
EL SEGUNDO	Shell	E-2 E-3 E-4-U5 E-L56	157° 165° 170° 175°	4,350 4,775 5,100 6,200		3.9 3.9 3.8 3.3	Reyes	100°-120°			98°-100°	4,000 to sewer	4.0-4.5	36,336	867,309	96	None	17,498 into wells
	Graner	Schist		6,800			Elsie Community	200°	190°-200°	1,500	130°	1,400						
	T and F	Schist Conglomerate		7,200			El Segundo	180°-200°	180° (E)	465	150° (E)	435						
HOWARD TOWNSITE	Beren	O'Dea	210°	8,200	A	3.3		60°-80°	60°	484	60°	484	3.5	65,310	236,240	78	None	236,240
HYPERION	Pauley						Loftus			1-2		1-2	4.0-4.5	7,785	454	6	None	454

FIELD NAME	OPERATOR	ZONE	TEMP. (°F)	APPROX. DEPTH (Ft.)	DETERMINED BY	GRADIENT °C/100 METERS	LEASE	WELL HEAD TEMP. (°F)	TREATMENT FACILITY ENTER TEMP. (°F)	TREATMENT FACILITY ENTER VOLUME (B/D)	TREATMENT FACILITY EXIT TEMP. (°F)	TREATMENT FACILITY EXIT VOLUME (B/D)	GRADIENT (All °C/100 m data)	PRODUCTION 1979 OIL (BBLS)	PRODUCTION 1979 WATER (BBLS)	% WATER	1979 INJECTION (BBLS)	1979 DISPOSAL (BBLS)
INGLEWOOD													4.0	3,562,762	57,828,745	94	52,449,460	
	Getty		140°		B		Vickers		116°	25,000-30,000	108°	24,600						
	Chevron							70°-120° (E)	90°-100° (E)	110,000 Non-unit Facility	90°-100° (E)	75,000						
									90°-100° (E)	89,000 (Unit) Facility	90°-100° (E)	62,000						
LAS CIENEGAS Fourth Avenue Area													4.0-4.2	112,181	1,608,215	93	1,798,266	4,686 into wells
	Union	Lower C	190°	7,800		2.9			145°	4,181								
Good Shepherd Area													4.0	50,414	802,842	94	None	
	Union	PE	150°	4,000		3.9												
Jefferson Area													4.0-4.2	476,101	1,901,613	80	1,901,613	
	Union								95°	1,932								
Murphy Area													4.0-4.5	549,167	1,002,385	65	523,267	733,907 into well
	Union	A	128°	2,250		5.2			96°	1,550								
		B	136°	2,600		5.1												
		C	150°	3,300		4.8												
		PE	155°	3,600		4.6												
Pacific Electric Area													4.0-4.2	80,224	776,143	91	776,143	
	Union								122°	2,080								

FIELD NAME	OPERATOR	ZONE	TEMP. (°F)	APPROX. DEPTH (Ft.)	DETERMINED BY	GRADIENT °C/100 METERS	LEASE	WELL HEAD TEMP. (°F)	TREATMENT FACILITY ENTER TEMP. (°F)	ENTER VOLUME (B/D)	EXIT TEMP. (°F)	EXIT VOLUME (B/D)	GRADIENT (All °C/100 m data)	PRODUCTION 1979 OIL (BBLS)	PRODUCTION 1979 WATER (BBLS)	% WATER	1979 INJECTION (BBLS)	1979 DISPOSAL (BBLS)
LAWNDALE													4.2-4.5	12,925	307,792	96	None	307,792
	Pauley	Schist Conglo-merate	250° (E)	8,000	B	4.2	S.F.L.I.	175°-210°	170°-190°	2,500	120°	2,500						
LONG BEACH													3.5-4.0	3,291,838	44,302,522	93	48,951,596	
	Texaco	Wilbur	120°	2,500	D	4.1	Signal Hill West Unit	100°-130°	100°-130°	30,000		30,000						
		Alamitos	130°	3,000	D	4.0												
		U. Brown	145°	3,800	D	3.9	Croswell	72°-92°										
		L. Brown	165°	4,700	D	3.9	Marquis	72°-92°										
		Deep	185°	5,700	D	3.9	Reedy	80°-100°	80°	3,650	80°	3,650						
							Dubois											
							Robinson	75°-95°										
							Schilling	80°-100°										
	ARCO	Alamitos	130°	3,500		3.4	Signal Hill East Unit		130°-135°	22,000	100°-110°	45,000						
		U. Brown	145°	4,395		3.4												
		L. Brown	145°	5,100		2.9												
		Deep	175°	6,000		3.4												
	Pyramid	Brown	130°		B		Fulton-McKee	120°	120°	250	100°	250						

FIELD NAME	OPERATOR	ZONE	TEMP. (°F)	APPROX. DEPTH (Ft.)	DETERMINED BY	GRADIENT °C/100 METERS	LEASE	WELL HEAD TEMP. (°F)	TREATMENT FACILITY ENTER TEMP. (°F)	TREATMENT FACILITY ENTER VOLUME (B/D)	TREATMENT FACILITY EXIT TEMP. (°F)	TREATMENT FACILITY EXIT VOLUME (B/D)	GRADIENT (All °C/100 m data)	PRODUCTION 1979 OIL (BBLS)	PRODUCTION 1979 WATER (BBLS)	% WATER	1979 INJECTION (BBLS)	1979 DISPOSAL (BBLS)
LONG BEACH AIRPORT	Shell	Alamitos North	131°	3,000		4.1	Signal Hill Central Unit	100°-140°	80°-100°	14,000	80°-95°	14,000	3.2-3.5	68,814	351,188	84	None	351,188
		Alamitos Crestal	131°	3,000		4.1												
		Upper Brown North	152°	3,700		4.3												
		Upper Brown Crestal	152°	3,600		4.5												
		Lower Brown	161°	4,500		3.9												
		Deep	190°	5,800		4.0												
LOS ANGELES CITY	Texaco							80°-100°					3.8-4.0	36,302	273,022	88	None	273,022
LOS ANGELES DOWNTOWN	Manley	First, Second, Third	100° (E)				Various Wells		Ambient	500-1,000 (E)	Ambient	500-1,000 (E)	4.0	246,690	1,265,259	83	1,299,845	
LOS ANGELES EAST	Chevron						Broadway Drill Site			3,500 (E)		3,500 (E)	3.5-3.7	52,080	997,423	95	None	997,423 into sewer
	Western Ave. Prop.						U.P. Unit and Edison		180	2,700	80-90	2,700						

FIELD NAME	OPERATOR	ZONE	TEMP. (°F)	APPROX. DEPTH (Ft.)	DETERMINED BY	GRADIENT °C/100 METERS	LEASE	WELL HEAD TEMP. (°F)	TREATMENT FACILITY ENTER TEMP. (°F)	TREATMENT FACILITY ENTER VOLUME (B/D)	TREATMENT FACILITY EXIT TEMP. (°F)	TREATMENT FACILITY EXIT VOLUME (B/D)	GRADIENT (All °C/100 m data)	PRODUCTION 1979 OIL (BBLS)	PRODUCTION 1979 WATER (BBLS)	% WATER	1979 INJECTION (BBLS)	1979 DISPOSAL (BBLS)
MONTEBELLO													3.5	552,652	8,809,544	94	2,298,826	
	Chevron								100°-115° (E)	22,000	100°-115° (E)	22,000						
	Texaco						Prugh	80°-100°										
							Anita Baldwin Piuma and Briano	75°-95° 70°-90°	80°	65		65						
NEWGATE	Gulf	Hathaway	244°	8,300	A	4.0	Newgate Unit A	100°	95°	29	90°	29	3.5-4.0	6,016	11,886	66	None	11,886 into sewer
PLAYA DEL REY													5.0-5.5	48,287	1,044,520	96	None	1,044,520 into sewer?
POTRERO East Area													3.5	45,140	315,615	87	None	315,615 into sewer?
	Getty		180°		B		Cypress			4,100	81°	4,460						
Inglewood City Area													3.5	46,367	27,811	37	None	27,811 into sewer?
	Mobil									100 (E)		100 (E)						

FIELD NAME	OPERATOR	ZONE	TEMP. (°F)	APPROX. DEPTH (Ft.)	DETERMINED BY	GRADIENT °C/100 METERS	LEASE	WELL HEAD TEMP. (°F)	TREATMENT FACILITY ENTER TEMP. (°F)	ENTER VOLUME (B/D)	EXIT TEMP. (°F)	EXIT VOLUME (B/D)	GRADIENT (All °C/100 m data)	PRODUCTION 1979 OIL (BBLS)	WATER (BBLS)	% WATER	1979 INJECTION (BBLS)	DISPOSAL (BBLS)
ROSECRANS													3.5	304,552	1,389,650	82	395,683	735,468 into wells
	Beren	Lower Zins	195°	7,200		3.3	(Various)	60°-80°	60°	2,375	60°	2,375						
		O'Dea	210°	7,500	A	3.6												
	Texaco						Howard Park	80°-100°	80°	35								
	Gulf	O'Dea	195°	7,500	A	3.2	Universal Trust	100°	95°	33	90°	33						
ROSECRANS EAST													3.5	5,268	1,236	19	None	1,236 into sewer?
ROSECRANS SOUTH													3.5	39,483	56,634	59	None	56,634
	Beren	O'Dea	210°	7,500	A	3.6	(Various)	60°-80°	60°	86	60°	86						
SALT LAKE													4.0-4.2	192,217	245,398	56	None	79,980 into wells
	Seaboard						Beverly Drill Site			500-1,000 (E)								
SALT LAKE SOUTH													4.0	325,339	910,736	74	None	910,736 to Inglewood Oil Field
	Chevron						Packard Drill Site		See	Beverly	Hills							

FIELD NAME	OPERATOR	ZONE	TEMP. (°F)	APPROX. DEPTH (Ft.)	DETERMINED BY	GRADIENT °C/100 METERS	LEASE	WELL HEAD TEMP. (°F)	TREATMENT FACILITY ENTER TEMP. (°F)	TREATMENT FACILITY ENTER VOLUME (B/D)	TREATMENT FACILITY EXIT TEMP. (°F)	TREATMENT FACILITY EXIT VOLUME (B/D)	GRADIENT (All °C/100 m data)	PRODUCTION 1979 OIL (BBLS)	PRODUCTION 1979 WATER (BBLS)	% WATER	1979 INJECTION (BBLS)	1979 DISPOSAL (BBLS)
SANSINENA													3.5-4.0					
Central Area														22,696	12,839	36	None	12,839 into sewer?
Curtis Area														31,305	11,336	27	None	11,336 into sewer?
	Gulf	Repetto (D-2)	150°	5,100	B	3.1	Curtis	90°	85°	3	120°	3						
East Area														102,548	65,614	39	3,329	62,285 into sewer?
New England Area														10,783	2,390	18	None	2,390 into sewer?
	McFarland	Upper Miocene	125°	3,000		3.7												
West Area														325,139	266,296	45	None	697 into well 266,599 into sewer?
	Union						Various Drill Sites		100°	1,463								
SANTA FE SPRINGS													3.5	758,047	16,102,160	96	12,059,886	
	Mobil	Meyer	150°	4,380		3.6	Santa Fe Springs Unit	120°	105°	44,000								
		Clark-Hathaway	210°	7,370		3.6												
		Santa Fe	220°	8,300		3.4												
	Pyramid	Meyer	120°	4,600	B	2.2	Jalk	90°-100°	110°	500	90°-100°	500						
	Texaco						Matern	80°-100										

FIELD NAME	OPERATOR	ZONE	TEMP. (°F)	APPROX. DEPTH (Ft.)	DETERMINED BY	GRADIENT °C/100 METERS	LEASE	WELL HEAD TEMP. (°F)	TREATMENT FACILITY ENTER TEMP. (°F)	ENTER VOLUME (B/D)	EXIT TEMP. (°F)	EXIT VOLUME (B/D)	GRADIENT (All °C/100 m data)	PRODUCTION 1979 OIL (BBLS)	WATER (BBLS)	% WATER	1979 INJECTION (BBLS)	DISPOSAL (BBLS)
SAN VICENTE													4.0-4.2	524,860	945,071	64	807,853	
	Chevron	Dayton Hay	161° 179°	3,500 5,000		5.1 4.2	San Vicente Drill Site		110°-140°	4,700	110° (E)	7,700						
SAWTELLE													3.3-3.5	307,855	325,805	51	None	299,775 into wells
	Occidental						Sawtelle Drill Site			1,000 (E)		1,000 (E)						
SEAL BEACH													3.8-4.0	659,595	6,140,348	90	1,565,093	673,738 into wells
	Conoco	Wasem	175°	5,250		3.9	Bixby	Ambient to 140°	120°	15,000	120°	8,000						
	Getty						Bryant	74°		800-900	70°	850						

FIELD NAME	OPERATOR	ZONE	TEMP. (°F)	APPROX. DEPTH (Ft.)	DETERMINED BY	GRADIENT °C/100 METERS	LEASE	WELL HEAD TEMP. (°F)	TREATMENT FACILITY ENTER TEMP. (°F)	TREATMENT FACILITY ENTER VOLUME (B/D)	TREATMENT FACILITY EXIT TEMP. (°F)	TREATMENT FACILITY EXIT VOLUME (B/D)	GRADIENT (All °C/100 m data)	PRODUCTION 1979 OIL (BBLS)	PRODUCTION 1979 WATER (BBLS)	% WATER	1979 INJECTION (BBLS)	1979 DISPOSAL (BBLS)
TORRANCE													5.5-6.0	1,929,140	18,999,044	91	13,741,624	2,662 into well 5,254,758 into sewer
	Del Amo	Main	164°	3,500	B	5.2	Del Amo	100°-110°	80°	100	60°	100						
	Mobil	Tar	130°	3,200	A	3.8	South Torrance Unit	120°	105°	3,000		3,000 (E)						
	Decalta	Ranger	116°	2,200	A	4.3	Simmons	96°	100°	6	160°	5						
	Santa Fe	Main Del Amo	125° 170°	3,600 4,300	A B	3.1 4.5	Torrance Unit	125°	120°	15,000	115°	17,000						
	American Pacific Int.						Marina Drill Site		130°	16,000	130°	16,000 Sewer						
	Superior	Main	165°	3,560		5.2	Joughin Unit	125°-150°	142°	19,000	135°	19,000						

FIELD NAME	OPERATOR	ZONE	TEMP. (°F)	APPROX. DEPTH (Ft.)	DETERMINED BY	GRADIENT °C/100 METERS	LEASE	WELL HEAD TEMP. (°F)	TREATMENT FACILITY ENTER TEMP. (°F)	TREATMENT FACILITY ENTER VOLUME (B/D)	TREATMENT FACILITY EXIT TEMP. (°F)	TREATMENT FACILITY EXIT VOLUME (B/D)	GRADIENT (All °C/100 m data)	PRODUCTION 1979 OIL (BBLS)	PRODUCTION 1979 WATER (BBLS)	% WATER	1979 INJECTION (BBLS)	1979 DISPOSAL (BBLS)
UNION STATION													3.8-4.0	46,493	61,701	57	None	61,701 into sewer
	Chevron						Garey Drill Site			250-500 (E)		250-500 (E)						
VENICE BEACH													5.5-6.0	78,353	3,243,050	98	None	3,243,650 into wells
	Damson	Schist Sand	240°	6,000	C	5.4	Venice Drill Site	220°-240°	220°	8,000	150°-160°	8,000						
	McFarland	Upper Schist Sand	180° 240°	4,000 6,000		5.3 5.4												
WHITTIER																		
Central Area													3.5-3.7	388,901	6,315,192	94	5,452,159	
	Chevron								100°-115°	21,000	100°-115°	21,000						
	McFarland						City of Whittier	70°	70°	<1	70°	<1						
La Habra Area														27,818	105,680	79	None	
Rideout Heights Area													3.6-3.8	349,728	262,151	43	389,620	
	Mitchell						Rideout Heights	100°-110° (E)	100° (E)	600	<100°	400						

FIELD NAME	OPERATOR	ZONE	TEMP. (°F)	APPROX. DEPTH (Ft.)	DETERMINED BY	GRADIENT °C/100 METERS	LEASE	WELL HEAD TEMP. (°F)	TREATMENT FACILITY ENTER TEMP. (°F)	TREATMENT FACILITY ENTER VOLUME (B/D)	TREATMENT FACILITY EXIT TEMP. (°F)	TREATMENT FACILITY EXIT VOLUME (B/D)	GRADIENT (All °C/100 m data)	PRODUCTION 1979 OIL (BBLS)	PRODUCTION 1979 WATER (BBLS)	% WATER	1979 INJECTION (BBLS)	1979 DISPOSAL (BBLS)
WILMINGTON													5.5-6.0	44,769,410	432,087,814	91	451,671,483	16,424,797 into wells
	Decalta	Ranger	120°	3,600	A	2.8	Watson	100°	105°	75	160°	70						
	Mobil	Tar	130°	2,000	A	6.0	Ford	150°	130°	650								
		Ranger	140°	3,050		4.5	Terminal	120°	105°	2,500								
		Upper Terminal	135°	3,400		3.8	ISCO											
		Union Pacific	180°	4,200		5.0												
		Ford-237	170°	5,000	A	3.9												
	Powerine						Parcel "A"	135°	135°	41,300	110°	41,300						
	Long Beach Oil Dev.	Tar	124°	2,200	A	5.0	Various		125°	48,000 (XY	104° Unit)	48,000						
		Ranger	136°	2,500	A	5.3			130°	98,000 (Z1-2	110° Unit)	98,000						
		Upper Terminal	154°	3,000	A	5.5												
		Lower Terminal	172°	3,500	A	5.6												
		Union Pacific	188°	4,000	A	5.7												
		Ford	212°	4,550	A	5.9												
		237	235°	5,550	A	5.6												
	Exxon	Tar					Wilmington Townlot Unit	140°	125°-135°	85,000	135°	85,000						
		Ranger Upper Terminal	150°															
	Chevron						L.A.C.F. C.D.		110°	7,000	120°	7,000						

FIELD NAME	OPERATOR	ZONE	TEMP. (°F)	APPROX. DEPTH (Ft.)	DETERMINED BY	GRADIENT °C/100 METERS	LEASE	WELL HEAD TEMP. (°F)	TREATMENT FACILITY ENTER TEMP. (°F)	TREATMENT FACILITY ENTER VOLUME (B/D)	TREATMENT FACILITY EXIT TEMP. (°F)	TREATMENT FACILITY EXIT VOLUME (B/D)	GRADIENT (A) °C/100 m data)	PRODUCTION 1979 OIL (BBLS)	PRODUCTION 1979 WATER (BBLS)	% WATER	1979 INJECTION (BBLS)	1979 DISPOSAL (BBLS)
	Champlin						U.P.	103°-136°	120°	180,000 (Mainland	117° Unit)	283,000						
									115°	240,000 (Island Unit)	112°	178,000						
	THUMS	Ranger	140°	2,650	A	5.2	Long Beach Unit	100°-120°	122°-126°	130,000	100°-110°	130,000						
		Upper Terminal	144°	2,900	A	5.0				(Pier J)								
		Lower Terminal	162°	3,600	A	5.0			120°-130°	90,000	100°-110°	90,000						
		Union Pacific	186°	4,500	A	4.9				(Grisson)								
		Ford	216°	5,600	A	5.0			120°-130°	50,000	100°-110°	50,000						
										(White)								
									120°-130°	40,000	100°-110°	40,000						
										Chaffee								
									120°-130°	80,000	100°-110°	80,000						
										Freeman								
	Sun	Ranger	150°	3,500	B	4.5	NWU		105°	11,000	50°-70°	24,000						
	Argo	Ranger	148°	3,500		4.4												

VENTURA BASIN

FIELD NAME	OPERATOR	ZONE	TEMP. (°F)	APPROX. DEPTH (Ft.)	DETERMINED BY	GRADIENT °C/100 METERS	LEASE	WELL HEAD TEMP. (°F)	TREATMENT FACILITY ENTER TEMP. (°F)	TREATMENT FACILITY ENTER VOLUME (B/D)	TREATMENT FACILITY EXIT TEMP. (°F)	TREATMENT FACILITY EXIT VOLUME (B/D)	GRADIENT (All °C/100 m data)	PRODUCTION 1979 OIL (BBLS)	PRODUCTION 1979 WATER (BBLS)	% WATER	1979 INJECTION (BBLS)	1979 DISPOSAL (BBLS)
ALISO CANYON													2.8-3.0					
Main Area	Getty						Porter Standard-Sesnon		87° 87°	10,000	80° 80°	4,800 3,100		576,483	4,032,700	87	1,630,881	2,318,401 into wells
							Fernando Fee		87°		80°	1,400						
Oat Mountain Area														28,129	43,465	61	None	39,305 into well
CASCADE													3.0	58,592	55,072	48	55,072	
	MCOR	Cascade	100°	2,600	E	2.5	Cascade	90° (E)	Ambient	180	Ambient	180						
CASTAIC HILLS													2.8-3.0	33,846	43,424	56	66,976	
	Decalta	Sterling	130°	4,500	A	2.7	CHU	110°	100°	290	140°	280						
CASTAIC JUNCTION													2.8	273,851	739,626	73	979,658	
DEL VALLE													3.0	81,482	614,848	88	474,050	142,258 into wells
	Marathon	Vasquez-Videgain	140°	4,500	B	3.1	Vasquez			245		245						

FIELD NAME	OPERATOR	ZONE	TEMP. (°F)	APPROX. DEPTH (Ft.)	DETERMINED BY	GRADIENT °C/100 METERS	LEASE	WELL HEAD TEMP. (°F)	TREATMENT FACILITY ENTER TEMP. (°F)	ENTER VOLUME (B/D)	EXIT TEMP. (°F)	EXIT VOLUME (B/D)	GRADIENT (All °C/100 m data)	PRODUCTION 1979 OIL (BBLS)	WATER (BBLS)	% WATER	1979 INJECTION (BBLS)	DISPOSAL (BBLS)
HASLEY CANYON													3.0-3.4	83,226	36,877	31	None	36,877
	Decalta	Val Verde	145°	4,300	A	3.4	Sterling	125°	130°	85	160°	82						
HONOR RANCHO													3.0	242,299	528,754	69	None	424,869 into wells
LAS LLAJAS													3.5	2,585	1,602	38	None	1,602
LYON CANYON													3.0	6,553	1,838	22	None	1,838
NEWHALL																		
Pico Canyon Area													2.8-3.0	9,512	4,427	32	3,457	
Townsite Area													3.0	1,047	679	39	None	679
Towsley Canyon Area													3.0	421	10	2	None	10
Tunnel Area													3.0-3.2	16,569	21,290	56	None	21,472 into wells
Whitney Canyon Area														4,937	14,391	74	None	14,391
NEWHALL-POTRERO													3.0	403,174	627,936	61	970,775	
	Sun	1st, 2nd, 3rd	170°	7,000	B	2.8												
		5th	200°	10,000	B	2.5												
		6th	205°	10,500	B	2.4												
		7th	230°	12,000	B	2.5												

FIELD NAME	OPERATOR	ZONE	TEMP. (°F)	APPROX. DEPTH (Ft.)	DETERMINED BY	GRADIENT °C/100 METERS	LEASE	WELL HEAD TEMP. (°F)	TREATMENT FACILITY ENTER TEMP. (°F)	TREATMENT FACILITY ENTER VOLUME (B/D)	TREATMENT FACILITY EXIT TEMP. (°F)	TREATMENT FACILITY EXIT VOLUME (B/D)	GRADIENT (All °c/100 m data)	PRODUCTION 1979 OIL (BBLS)	PRODUCTION 1979 WATER (BBLS)	% WATER	1979 INJECTION (BBLS)	1979 DISPOSAL (BBLS)
OAK CANYON													3.0-3.2	214,183	392,344	65	1,543,525	464,120 into wells
	Gulf	1A 3A 3B	155°	5,700	A	2.9	USL-F	90°	85°	121								
		3A 3B 3C 3D 6 7 8A 8B	115°-180°	9,000	A	2.3	USL-G	95°	90°	159	130°	357						
		6 7 8A 8B	180°	9,000	A	2.3	USL-H	95°	90°	77								
		3A 3B	155°	5,200	A	3.2	GM Lechler	90°	85°	65	125°	65						
		6 7 8A 8B	180°	9,000	A	2.3	BF Gilmore	90°	85°	26	120°	26						
		6 7 8A 8B	180°	9,000	A	2.3	LW Gilmore	90°	85°	12	120°	12						
		4A 4B 5A	160°-175°	7,200	D	2.8	O.C. Unit	115°	110°	1,436	120°	1,436						
	McFarland	1A	126°	3,000	A	3.8	Lechler	68°	68°	10-20	68°	10-20						
		3B	152°	5,200	A	3.1												

FIELD NAME	OPERATOR	ZONE	TEMP. (°F)	APPROX. DEPTH (Ft.)	DETERMINED BY	GRADIENT °C/100 METERS	LEASE	WELL HEAD TEMP. (°F)	TREATMENT FACILITY ENTER TEMP. (°F)	TREATMENT FACILITY ENTER VOLUME (B/D)	TREATMENT FACILITY EXIT TEMP. (°F)	TREATMENT FACILITY EXIT VOLUME (B/D)	GRADIENT (All °C/100 m data)	PRODUCTION 1979 OIL (BBLS)	PRODUCTION 1979 WATER (BBLS)	% WATER	1979 INJECTION (BBLS)	1979 DISPOSAL (BBLS)
PLACERITA													2.8-3.0	299,320	8,446,529	97	4,860,360	3,165,448 into wells
	Petro Resources	Kraft		1,000			Various	90°	Ambient	2,000	100°	2,000						
RAMONA													3.0-3.2	48,579	31,378	39	None	31,378
	McFarland	Del Valle	140°	4,500	E	3.1	Orduno	60°	60°	<1	60°	<1						
SAUGUS													2.8	2,431	29,038	92	None	29,003 into well
TAPIA													3.0	14,640	54,789	79	None	54,789 into well
WAYSIDE CANYON													3.0	39,581	126,116	76	None	126,116

APPENDIX C

CHEMISTRY OF OIL FIELD WATERS IN LOS ANGELES AND VENTURA BASINS

Table C-1: Salinity of zone waters.

Data from California Oil and Gas Fields, Volume II, 1974, published by the California Division of Oil and Gas.
*Detailed chemistry for this field is listed in Table C-2.

Table C-2: Chemical analyses of selected field waters.

1) All constituents in milligrams/liter.

2) T = trace

3) TDS (top figure) - sum of constituents.

   TDS (bottom figure) - determined by evaporation.

4) +K: Figure given is Na+K (K is a minor constituent).

TABLE C-1

FIELD	AREA	PRODUCING ZONE	DEPTH TO TOP (FT.)	SALINITY (PPM)
ALISO CANYON	Main	Aliso	4,300	17,100
		Porter	5,050	17,100
		Del Aliso	6,500	17,100
		Sesnon	8,100	12,000
		Frew	8,650	15,400
	Oat Mtn.	Porter	6,750	17,100
		Del Aliso	7,170	17,100
		Sesnon	7,650	12,000
		Frew	8,850	15,400
ALONDRA	---	Schist Conglomerate	9,000	18,800
BANDINI *	---	Conglomerate	4,200	25,700
		Meyer	4,500	31,500
		C.W.O.D. 3	5,000	31,500
		Nordstrom	5,200	31,500
		O'Connell	6,500	11,100
		C.W.O.D. 24	8,400	12,000
BEVERLY HILLS *	East	Main (Hauser)	9,900	14,400
		Deep (Ogden)	10,800	18,800
	West	Wolfskill	2,500	26,700
		Main (Hauser)	4,500	14,400
BREA-OLINDA *	---	1st,2nd,3rd (Miocene)	4,000	15,400
		D1, D2	5,000	17,100
CASCADE	---	Cascade	2,550	90
CASTAIC HILLS *	---	Sterling	5,500	20,300
		Sterling East	5,900	20,500
		Rynne-Fisher	6,000	20,500
CASTAIC JUNCTION	---	10	8,400	13,700
		15	9,400	23,900
		21	10,200	17,100
CHEVIOT HILLS	--	"Repetto" Sands	4,800	25,700
		Rancho	8,800	15,000

FIELD	AREA	PRODUCING ZONE	DEPTH TO TOP (FT.)	SALINITY (PPM)
COYOTE WEST *	---	Main	3,300	13,000
		Upper 99	4,100	13,000
		Lower 99	4,400	13,000
		138	4,900	17,100
		Emery	5,500	28,500
DEL VALLE	Main	Gas Zone	3,800	21,800
		Sepulveda	5,000	13,700
		Vasquez	5,500	13,700
		Videgain	6,000	14,500
		Intermediate	6,300	14,500
		Del Valle	6,900	15,400
		Bering	8,000	16,200
		Lincoln	10,000	17,100
DOMINGUEZ*	---	1st Callender	3,950	32,000
		2nd "	4,250	32,100
		3rd "	4,530	31,300
		4th "	4,830	30,400
		5th "	5,300	32,300
		6th "	5,870	29,900
		7th "	6,360	29,800
		8th "	7,050	24,100
EL SEGUNDO	---	Pliocene (Gas)	1,490-4,180	1,200-21,400
		Nodular Shale	7,000	17,400
		Schist	7,250	18,000
HASLEY CANYON *	---	Val Verde	4,800	9,600
HONOR RANCHO	Main	Gabriel	3,800	21,400
		Upper Rancho	5,200	10,300
		Lower Rancho	5,400	10,300
		Wayside A	6,200	24,800
		Wayside B	6,300	24,800
		Wayside C	6,400	24,800
	South-east	Wayside 13	10,000	27,400
HOWARD TOWNSITE*	---	Zins	5,650	25,700
		O'Dea	8,100	23,900
		8th	8,600	23,900
HYPERION	---	Nodular Shale	6,835	13,700
		Schist Conglomerate	7,045	13,700
		Schist	7,125	13,700

FIELD	AREA	PRODUCING ZONE	DEPTH TO TOP (FT.)	SALINITY (PPM)
INGLEWOOD *	---	Upper Investment	950	3,400
		Investment	1,050	25,700
		Vickers-Machado	1,500	29,100
		Rindge	2,400	30,800
		Rubel	3,400	30,800
		Moynier	4,200	34,200
		Bradna	8,000	34,200
		Sentous	8,200	34,200
		City of Inglewood (Marlow Burns)	9,000	34,200
LAS CIENEGAS *	Fourth Ave.	A	2,500	17,100
		B	2,750	18,800
		C	3,500	18,800
		Pacific Electric	4,000	22,200
	Good Shepherd	Pacific Electric	3,900	22,200
		D	4,250	22,200
	Jefferson	Upper Jefferson	2,900	26,500
		Lower Jefferson	3,500	26,500
		C	4,600	26,500
		Lower Broadway	5,100	20,500
		Massive	5,500	23,400
		Pacific Electric	6,420	26,500
	Murphy	A	2,500	17,100
		B	2,750	18,800
		C	3,500	18,800
		Pacific Electric	3,900	22,200
		D	4,100	22,200
		E	4,200	22,200
	Pacific Electric	Pacific Electric	4,100	22,200
		D	4,300	22,200
LAS LLAJAS	---	Las Llajas	700	19,800
LAWNDALE*	---	Schist Conglomerate	7,900	20,500
LONG BEACH*	Northwest	Alamitos	4,040	27,400
	Extension	Brown	5,230	30,800

FIELD	AREA	PRODUCING ZONE	DEPTH TO TOP (FT.)	SALINITY (PPM)
	Old	Upper Wilbur	2,000	29,100
		Lower Wilbur	2,400	29,900
		Alamitos	2,800	27,400
		Brown	3,600	30,800
		Deep	5,300	22,200
		DeSoto	7,500	12,000
	Recre-ation Park	Upper Wasem	6,000	25,700
		McGrath	6,900	25,700
LONG BEACH AIRPORT	---	Deep	8,200	22,200
LOS ANGELES CITY	---	First	900	1,000
		Second	1,100	3,200
		Third	1,500	3,400
LOS ANGELES DOWNTOWN*	---	Jefferson (Gas)	2,000	14,700
		Upper Broadway	2,900	23,400
		Middle Broadway	3,100	23,400
		Lower Broadway	3,500	23,400
		Massive	4,800	23,400
LOS ANGELES EAST	---	Vail	8,100	23,100
		U.P. 3	8,400	23,100
		8400	8,500	23,900
		U.P. 1	8,560	23,900
LYON CANYON	---	Sixth	9,130	21,400
		Seventh	9,775	21,900
MONTEBELLO*	---	1st	2,200	14,000
		2nd	3,500	14,000
		3rd	4,500	14,000
		4th	4,800	14,500
		5th	5,700	14,500
		6th	6,100	15,400
		Cruz	6,900	17,100
		Baldwin	7,000	20,500
		7th	7,200	23,900
		8th	7,650	25,700
NEWGATE	---	Clark	7,700	24,800
		Hathaway	8,400	24,800
		Santa Fe	8,900	15,400
NEWHALL	Towsley Canyon	Unnamed	90-2,200	4,300

FIELD	AREA	PRODUCING ZONE	DEPTH TO TOP (FT.)	SALINITY (PPM)
NEWHALL-POTRERO	---	First	6,500	6,000
		Second	6,900	6,000
		Third	7,400	6,000
		Fifth	9,300	6,800
		Sixth	9,700	6,000
		Seventh	11,500	6,800
		Ninth	14,200	6,000
OAK CANYON	---	1A	2,400	14,000
		3A	5,350	14,000
		3B	5,450	14,000
		4A	6,825	14,000
		4B	6,950	14,000
		5A	7,240	14,000
		6A	8,130	14,000
		6B	8,380	14,000
		7	8,720	14,000
		8A	9,550	14,000
		8B	9,650	14,000
PLACERITA	---	Shepard	600	1,710
		Upper Kraft	800	1,710
		Lower Kraft	1,700	4,300
PLAYA DEL REY	Del Rey Hills	Lower	6,200	20,500
	Venice	Upper	4,000	8,600
		Lower	6,400	20,500
POTRERO*	East	2,800	2,800	30,300
		3,600	3,600	29,200
		4,300	4,300	29,100
		4,600	4,500	28,200
		5,200	4,930	13,300
		5,800	5,500	21,400
		6,500	6,230	24,100
		O'Dea	7,800	13,700
		City	8,800	8,600
	Ingle-wood City	8th	9,475	7,500
		City	9,750	11,100

FIELD	AREA	PRODUCING ZONE	DEPTH TO TOP (FT.)	SALINITY (PPM)
RAMONA	---	Black	2,500	17,800
		Kern	3,500	16,900
		Del Valle	4,500	9,700
		Lower	7,700	9,400
ROSECRANS*	---	Padelford	3,750	33,300
		Maxwell	4,250	30,800
		Hoge	4,820	29,100
		Zins	5,700	28,600
		O'Dea	7,200	29,200
		8th	8,200	26,500
		9th	9,100	23,900
ROSECRANS EAST	---	Zins	5,800	29,100
		O'Dea	6,800	29,100
		8th	7,500	29,100
ROSECRANS SOUTH	---	Zins	6,200	28,900
		O'Dea	7,300	29,100
		8th	8,600	26,700
SALT LAKE	---	C	2,300	7,200
SALT LAKE SOUTH	---	Clifton	1,000	24,300
		Dunsmuir	4,575	27,400
SANSINENA	12G	D-1	4,700	20,500
	Central	C-1	3,720	20,500
	East	C-2	3,600	20,500
		A-10	4,200	20,500
		D-1	4,700	20,500
		C-1	6,400	20,500
	New England	D-2	3,300	20,500
	West	D-1	2,900	20,500
SANTA FE SPRINGS*	---	Foix	3,580	4,300
		Bell	3,900	5,600
		Meyer	4,600	7,700
		Nordstrom	5,400	11,100
		Buckbee	6,000	17,100
		O'Connell	6,700	24,800
		Clarke-Hathaway	7,400	29,100
		Santa Fe	8,200	15,400
		Bell 100	9,100	17,100

FIELD	AREA	PRODUCING ZONE	DEPTH TO TOP (FT.)	SALINITY (PPM)
SAN VICENTE*	---	Clifton	2,000	24,300
		Dayton	3,200	27,400
		Hay	4,200	28,900
SAWTELLE*	---	Rancho	9,500	21,000
SEAL BEACH*	Alamitos	Selover	4,100	27,400
		Wasem	4,600	25,700
		McGrath	5,500	33,000
	North Block	San Gabriel	2,610	30,800
		Selover	3,470	27,400
		Wasem	3,820	25,700
		McGrath	6,500	33,000
	South Block	Bixby	4,100	30,800
		Selover	4,100	27,400
		Wasem	4,600	25,700
		McGrath	5,500	33,000
		Lane	7,600	10,300
TORRANCE*	Torrance	Tar-Ranger	2,800	30,800
		Main	3,300	31,600
		Del Amo	4,200	30,800
UNION STATION	---	Broadway	2,900	39,300
		Massive	5,100	41,000
VENICE BEACH*	Onshore	Schist sand	6,000	9,400
WAYSIDE CANYON	---	Yule 1-A	1,500	13,000
		Yule	1,600	13,000
WHITTIER*	Central	1st	900	5,100
		2nd	1,300	5,700
		3rd	1,600	3,800
		6th (184)	4,050	17,600
	La Habra	1st	900	5,100
		2nd	1,150	5,700
		3rd	1,400	3,800
WILMINGTON*	Onshore	Tar	2,200	30,800
		Ranger	2,500	31,600
		Upper Terminal	3,000	30,800
		Lower Terminal	3,500	30,800
		Union Pacific	4,000	34,200
		Ford	4,550	25,700
		237	5,550	23,900
		Schist	5,850	17,100

TABLE C-2

FIELD NAME AND SOURCE	DATE	Na	NH_4	Ca	Mg	Ba	Fe	SO_4	Cl	OH	CO_3	HCO_3	B_4O_7	I	SiO_2	SALINITY AS NaCl	TDS	B	S	RESISTIVITY IN OHM-METERS	pH	HARDNESS ($CaCO_3$)	ALKALINITY ($CaCO_3$)
BANDINI																							
Meyer Zone	9/22/65			505	180		3	0	16,880			281				25,892	28,113				7.4	2,000	
Nordstrom Zone	2/12/65			410	166			T	18,956			244				29,457	31,345				7.6	1,700	
BEVERLY HILLS																							
Main(Hauser) Zone	12/11/67	9,064	111	630	123	0	0.2	12.1	11,611	0	0	6,710	280	27	109	19,145	28,677			0.29 at 72°F	7.1		
Repetto(Dunsmuir) Zone	7/69	9,110	200	735	255	55	3.28	T	15,550	0	0	1,410	280	90	110	25,650	28,450			0.245 at 75°F			
Ogden Zone	6/4/74	5,735	85	385	145	23	6.9	8	9,075	0	0	1,615	200	60	60	14,960	18,005	56		0.411 at 75°F	7.2		
Repetto(Wolfkskill) Zone	1966	10,476		648	415		0.1	31.7	18,226		0	440			72		30,095		0		7.5	3,320	
P-12 Well (Zone Unknown)	5/13/68	8,490	50	490	80	15	1.8	10	12,600	0	0	2,630	300	75	185	20,800	24,900	84		0.283 at 75°F	7.0		
Repetto(Dunsmuir) Zone	2/8/67	6,416	404	1,158	158	<5.0	0.2	30	12,510			845	377	18	16	20,621	21,980	105		0.30 at 75°F	7.1		
Main(Hauser) Zone	5/5/69	7,520	115	275	115	20	0.94	5	11,900	0	0	960	380	95	100	19,600	21,750	106					
BREA-OLINDA																							
Menchego-Fisher 2 Well (Zone Unknown)	11/15/63	7,015 (+K)		552	39	0		50	11,005		0	329				18,135	18,990 21,558			0.35 at 73°F	7.8	1,540	
C Zone	10/10/68			16	5			5	3,690		0	440				6,080					8.1	60	
C Zone	11/18/68	5,299 (+K)		155	13	0	18	2	7,870		0	1,050				13,000	14,389 14,630				7.7	440	

Above sample (C Zone) was submitted in a metal can.

FIELD NAME AND SOURCE	DATE	Na	NH_4	Ca	Mg	Ba	Fe	SO_4	Cl	OH	CO_3	HCO_3	B_4O_7	I	SiO_2	SALINITY AS NaCl	TDS	B	S	RESIS-TIVITY IN OHM-METERS	pH	HARD-NESS ($CaCO_3$)	ALKALINITY ($CaCO_3$)
CASTAIC HILLS																							
82-35 Well (Zone Unknown)	4/21/76	173		40	22			310	57		0	200			8		812	2		12.3 at 68°F	8.0	190	164
COYOTE WEST																							
Emery Zone	1/7/53	7,565	0	328	73			T	12,000	0	0	512	121	12	20		20,632	34		0.333 at 77°F	7.6		
Main and Upper 99 Zones	3/18/53	4,373	25	74	102			T	7,100	0	0	73	163	8	70		12,023	45		0.540 at 77°F	7.5		
DOMINGUEZ																							
Reyes Lease (Treated-filtered)	Early 1959	12,132	40	570	214	58	2	0	19,300		0	345	261				32,922				6.9		
East(E-405) Pool	Early 1959	11,660	130	116	67	70		0	18,105		0	830	212				31,190				7.1		
1st Zone (East Central)	10/28/53	10,400		510	339	<1		1	18,700		0	550					30,537	37			7.4		
2nd Zone (East Central)	1957	10,800	140	539	392		0	0	18,800		0	256	130				34,516				7.4		
8th Zone (West)	3/7/60	8,690		223	79			8.2	11,400		0	4,470					23,000				7.4		
3rd Zone (West Central)	7/5/56	11,399		670	302			1	19,469		0	304					32,879						
4th Zone (West Central)	7/5/56	11,196		616	331			7	19,035		0	460					33,212						
HASLEY CANYON																							
Sterling 1-10 Well (Zone Unknown)	9/21/77	4,802		96	63		<0.1	23	7,333		30	634			21		12,886	46	0	0.46 at 77°C	8.2	496	

FIELD NAME AND SOURCE	DATE	Na	NH_4	Ca	Mg	Ba	Fe	SO_4	Cl	OH	CO_3	HCO_3	B_4O_7	I	SiO_2	SALINITY AS NaCl	TDS	B	S	RESISTIVITY IN OHM-METERS	pH	HARDNESS ($CaCO_3$)	ALKALINITY ($CaCO_3$)
HOWARD TOWNSITE																							
O'Dea and 8th Zones	8/4/69	10,888 (+K)		384	123	52		0	15,425		0	2,610				25,420	29,482 31,220		0		7.8	1,480	
INGLEWOOD																							
Rubel Zone (East)	11/5/59	10,500		440	219			0	17,100	0	0	671	197	90	30		29,247	55		0.238 at 77°F	7.7		
Injection Plant (Chevron)	4/9/59	10,608		517	432			15	18,000	0	0	781	131	15	43		30,565	36		0.22 at 77°F	7.5		
Rubel Zone (West)	3/18/70			480	29	223	0.1	1.0	15,500								41,000				7.6		
Vickers Zone (West)	11/17/53	11,162	9	504	409			5	19,000	0	0	439	92	44	19		31,682	26		0.208 at 77°F	7.3		
Vickers Lease (Getty) (Zone Unknown)	4/30/66	10,400	190	315	440	10	2.2	<5	17,730	0	0	756	167	76	38	29,230	30,124						
Injection Plant (Getty)	5/29/80	K=100 7,340	97.2	224	233	<1	23.5	<5	17,870	0	0	778	134		66.1	29,460	27,030			0.258 at 75°F	7.8		
LAS CIENEGAS																							
Good Shepherd Area (Composite)	1/12/79	8,120	85	225	100	61	0.3	3.0	12,800	0	32	725	208	26	54	21,100	22,440			0.357 at 75°F	7.6		
Murphy Area (Composite)	10/14/71	K=280 8,880		580	340	10		<10	14,800		<10	825					26,800						
"	10/19/71	K=150 8,500		380	310	10		<1	14,700		50	470					27,100				8.1		
"	10/19/71	K=108 9,000		460	270	9		5	15,100		65	450					30,200						
"	12/7/78	K=175 8,375	102	780	600	10	4.9	3	15,300	0	0	1,040	228	74	67		26,780	63.6		0.27 at 77°F	6.8		

FIELD NAME AND SOURCE	DATE	Na	NH_4	Ca	Mg	Ba	Fe	SO_4	Cl	OH	CO_3	HCO_3	B_4O_7	I	SiO_2	SALINITY AS NaCl	TDS	B	S	RESISTIVITY IN OHM-METERS	pH	HARDNESS ($CaCO_3$)	ALKALINITY ($CaCO_3$)
Massive Zone (Jefferson Area)	7/17/69	7,717		344	156		25.6	26	12,300			1,098			35	20,283	21,702			0.34 at 68°F	7.1		
LAWNDALE																							
Schist Conglomerate Zone	7/3/69	7,230	55	55	15	T	0.31	85	10,150	0	0	1,840	250	10	105	16,750	20,000			0.348 at 75°F	7.8		
LONG BEACH																							
Central Unit Zone																				All at 75°F			
Alamitos	1/18/72	10,835	100	755	335	40	10	T	19,005	0	0	285	125	50	45	31,330	31,605			0.223	7.1		
"	1/18/72	10,855	85	630	460	55	5	T	19,040	0	0	500	115	50	70	31,385	31,890			0.220	7.1		
"	1/18/72	9,470	95	350	420	17	3.8	T	16,380	0	0	360	105	35	55	27,000	27,315			0.255	7.6		
Alamitos and Upper Brown	1/18/72	10,795	80	500	460	52	3.5	T	18,865	0	0	225	115	50	25	31,095	31,195			0.223	7.7		
Upper Brown	1/18/72	10,895	110	660	265	67	14	T	18,790	0	0	205	150	70	25	30,975	31,275			0.222	7.1		
" "	1/18/72	8,410	80	405	260	64	65	T	14,430	0	0	240	115	65	10	23,785	24,195			0.283	7.5		
Upper and Lower Brown	2/1/72	12,965	65	925	390	95	22	T	32,550	0	0	475	170	160	15	37,170	38,115			0.198	6.6		
Lower Brown	1/18/72	9,090	110	315	225	55	1.3	T	15,175	0	0	495	300	70	50	25,015	26,080			0.266	8.3		
Deep	1/18/72	7,955	100	385	45	29	7	5	11,415	0	0	2,975	300	35	80	18,815	25,420			0.309	7.4		
East Unit Zone																				All at 68°F			
Alamitos-north	9/30/74	11,003		640	510	44	6	23	19,350		0	400			138	31,908	32,106	36		0.19	7.8	3,700	328
Alamitos-south	10/4/74	10,385		480	608	35	4	4	18,350		0	502			62	30,259	30,425	30		0.26	7.7	3,700	412
" "	10/11/74	10,620		640	535	45	4	4	18,900		0	312			44	31,166	31,092	33		0.36	7.7	3,800	256

FIELD NAME AND SOURCE	DATE	Na	NH_4	Ca	Mg	Ba	Fe	SO_4	Cl	OH	CO_3	HCO_3	B_4O_7	I	SiO_2	SALINITY AS NaCl	TDS	B	S	RESIS-TIVITY IN OHM-METERS	pH	HARD-NESS ($CaCO_3$)	ALKALINITY ($CaCO_3$)
Upper Brown-north	10/16/74	10,839		720	292	65	1	5	18,750		0	190			41	30,878		40		0.25	7.7	3,000	156
" " "	9/30/74	10,544		720	389	58	4	9	18,550		0	227			98	30,589	30,582	41		0.19	7.7	3,400	186
" " -south	10/11/74	10,810		640	340	57	12	5	18,650		0	276			35	30,754	30,805	37		0.36	7.7	3,400	226
" " "	10/14/74	11,069		600	535	58	32	4	19,550		0	273			34	32,238	32,128	35		0.25	7.4	3,700	224
Lower Brown-north	10/17/74	9,991		640	389	67	13	18	17,500		0	322			44	28,858	28,964	47		0.27	7.7	3,200	264
Deep-north	10/16/74	7,492		480	146	25	3	5	11,400		0	2,464			47	18,799	22,127	90		0.35	7.6	1,800	2,020
" "	9/30/74	7,161		360	219	38	2	20	10,750		0	2,696			161	17,727	21,466	97		0.33	7.8	1,800	2,210
" -south	10/14/74	8,709		480	243	0	10	5	12,850		0	3,660			59	21,190	26,124	108		0.23	7.4	2,200	3,000
West Unit Zone																							
Alamitos	7/20/61	10,983 (+K)		600	510			0	19,300		0	327					31,721			0.193 at 82°F	7.6	3,608	
Brown	7/20/61	10,716		656	403			0	18,700		0	283					30,758			0.195 at 81°F	7.1	3,300	
NWLBU 9-6 Well (NW extension)	1/26/77			1240	70	110	6.5	16	18,700								38,400				7.4		
NWLBU 5-2 Well (NW extension)	1/26/77			1070	110	120	5.0	12	16,300								34,100				7.2		
LOS ANGELES DOWNTOWN																							
Broadway Zone	6/15/64	8,980	42	260	175	0	0.4	440	14,180	0	0	500	182	93	24	23,380	24,876			0.269 at 75°F	7.3		

FIELD NAME AND SOURCE	DATE	Na	NH_4	Ca	Mg	Ba	Fe	SO_4	Cl	OH	CO_3	HCO_3	B_4O_7	I	SiO_2	SALINITY AS NaCl	TDS	B	S	RESISTIVITY IN OHM-METERS	pH	HARDNESS ($CaCO_3$)	ALKALINITY ($CaCO_3$)
MONTEBELLO																							
Composite (Zones Unknown)	1/3/61	7,523	55	315	158	9	1	1	12,340			595	103	0	41	20,320	21,140			0.280 at 75°F	7.2		
1st Zone	12/12/51	5,272	30	184	131			T	8,700	0	0	323	1	25	57		14,723	0.2		0.435 at 77°F	7.5		
POTRERO																							
Cypress Lease (Zones Unknown)	6/13/74	10,815	105	575	265	70	7	T	17,870	0	0	1,270	195	75	65	29,455	31,780			0.231 at 75°F	7.2		
ROSECRANS																							
Padelford Zone	8/23/72			520	292	0	3	0	17,750			232				26,529	30,000				7.3	2,500	
O'Dea Lease (Zones Unknown)	8/22/72			560	243	0	12	0	18,000			561				27,371	30,000				7.1	2,400	
Zins Zone	7/70	11,051	18	641	243		T	0	17,500		0	2,136	388	20	35		32,031	108			7.4		
Injection Plant (Beren)	11/78	11,100	104	520	290	71	6.7	<5	18,200	0	0	1,340	180	105	110	30,000	32,300			0.219 at 75°F	7.3		
SANTA FE SPRINGS																							
Clark Zone	1967	8,030 (+K)		794	35	0		40	12,870		0	1,714			37.5	20,410	23,488 24,800				7.3		
SF-241 Well (Zone Unknown)	1967	9,647 (+K)		692	36	0		10.6	14,540		0	2,873			3.9	23,970	27,817 32,200				7.4		
Meyer Zone	1967	4,419 (+K)		76	30	2.2		4.8	6,666		0	626			19.5	10,990	11,827 12,000				7.8		
8-A-Bonnet 5 Well (Zone Unknown)	1967	4,224 (+K)		86	21	2.6		1.4	6,560		0	281			24.8	10,735	11,175 10,750				7.7		

FIELD NAME AND SOURCE	DATE	Na	NH_4	Ca	Mg	Ba	Fe	SO_4	Cl	OH	CO_3	HCO_3	B_4O_7	I	SiO_2	SALINITY AS NaCl	TDS	B	S	RESIS-TIVITY IN OHM-METERS	pH	HARD-NESS ($CaCO_3$)	ALKALINITY ($CaCO_3$)
Santa Fe Zone	1967	6,290 (+K)		653	34	0		52.3	10,070		0	1,452			44.6	15,985	18,554 19,800				7.8		
SF-146-E Well (Zone Unknown)	1967	7,219 (+K)		827	13	0		13.4	11,130		0	2,555			31.5	18,341	21,765 21,800				7.2		
O'Connell Zone	1967	10,440 (+K)		478	106	0		21.1	16,380		0	1,470			45.0	26,540	28,897 27,800				7.4		
SF-145-E Well (Zone Unknown)	1967	9,603 (+K)		363	67	11.9		4.8	14,750		0	1,522			8.0	24,320	26,315 27,800				7.9		
Buckbee Zone	1967	5,108 (+K)		70	25			61.4	7,730		0	510			23.8	12,740	13,508 13,800				7.9		
SF-143-A Well (Zone Unknown)	1967	5,918 (+K)		120	33	0		53.8	8,860		0	904			31.0	14,615	15,892 14,200				7.9		
SAN VICENTE																							
Clifton Zone	8/24/69	9,210	235	335	220	30	85	10	14,750	0	0	1,805	215	60	70	24,300	27,750	60		0.256 at 75°F	7.2		
Dayton Zone	8/23/69	9,830	95	540	235	40	13	5	16,650	0	0	360	310	50	60	27,450	28,250	86		0.236 at 75°F	6.8		
Hay Zone	8/23/69	10,640	280	320	245	70	5	20	17,515	0	0	1,050	255	75	120	28,850	30,650	71		0.227 at 75°F	7.4		
SAWTELLE																							
Sawtelle 1 Well (Zone Unknown)	5/5/71	8,620	24	480	210	<0.1	1.3	20	14,213			883	104	8	57	23,430	24,699			0.046 at 78°F	8.0		
Injection Water (Zones Unknown)	1971	K=110 7,000	97	1,720	41	8.3	0.1	38.2	13,380	0	0	970	304	10	25.3	21,964	23,705			0.279 at 72°F	5.7		

FIELD NAME AND SOURCE	DATE	Na	NH_4	Ca	Mg	Ba	Fe	SO_4	Cl	OH	CO_3	HCO_3	B_4O_7	I	SiO_2	SALINITY AS NaCl	TDS	B	S	RESISTIVITY IN OHM-METERS	pH	HARDNESS ($CaCO_3$)	ALKALINITY ($CaCO_3$)
SEAL BEACH																							
San Gabriel and Bixby Zones	1/8/73	11,015	115	560	310	98	8	T	18,865	0	0	335	155	105	50	31,100	31,645			0.221 at 75°F	7.3		
Injection Water	10/27/78	9,640	75	370	105	48	17	<5	14,800	0	0	1,835	255	60	105	24,400	27,800			0.282 at 75°F	7.5		
Bixby 31 Well (Zone Unknown)	1/8/73	9,610	95	385	110	44	10	T	14,680	0	0	2,125	235	50	70	24,200	28,215			0.260 at 75°F	7.2		
Selover Zone	1977	9,110	105	330	100	48	26	22	14,000	0	0	1,755	240	40	50	23,080	26,600			0.297 at 75°F	7.9		
Bixby 5 Well (Zone Unknown)	3/12/73	10,145	150	595	190	93	7.9	T	17,020		0	795	215	80	60	28,055	29,740			0.239 at 75°F	6.9		
Composite (Zones Unknown)	6/8/72	K=100 7,500	130	595	180	97	14	T	16,840		0	830	215	65	65	27,760	26,960	60		0.242 at 75°F	7.2		
TORRANCE																							
Composite (Zones Unknown)	8/30/78			330	33	77	14	10	12,616			786					20,434				7.6	960	
Main Zone	1971?	(+K) 12,335		425	209	40	0.1	5	19,437		6	1,272			225		33,964		3		8.3	1,920	1,052
Main Zone(?)	5/13/77	6,340	190	260	150	20	3	8	10,195	0	0	1,355	135	36	92	16,805	18,865			0.41 at 75°F	7.2		
Composite (Tar, Ranger, Main Zones)	11/18/68	9,900	250	375	325	15	0.55	5	16,700			1,000	140	10	200	27,500	29,000			0.291 at 75°F	7.2		
VENICE BEACH																							
Composite (Zone Unknown)	1961	9,811	90	301	146	41.5	1.8	3.0	15,530			1,071	251	65	54	26,600	27,365			0.247 at 75°F	7.7		

FIELD NAME AND SOURCE	DATE	Na	NH_4	Ca	Mg	Ba	Fe	SO_4	Cl	OH	CO_3	HCO_3	B_4O_7	I	SiO_2	SALINITY AS NaCl	TDS	B	S	RESIS-TIVITY IN OHM-METERS	pH	HARD-NESS ($CaCO_3$)	ALKALINITY ($CaCO_3$)
WHITTIER																							
2nd Zone (Murphy Area)	2/3/53	1,514	30	45	18			T	336	0	0	3,707	71	0	39		5,760	20		1.666 at 77°F	7.9		
3rd Zone (Murphy Area)	2/19/57	1,177	10	40	5			0	680	0	288	1,538	11	0	24		3,773	3		2.13 at 77°F	8.6		
6th Zone (Central Area)	8/25/66	7,250	68	100	58	T	3	0	10,710	0	0	1,476	202	17	38	17,650	19,922	56		0.31 at 75°F	7.8		
W-5 Well (Rideout Heights Area) (Zone Unknown)	8/4/78	7,870	55	580	485	13	13	T	14,300	0	0	580	105	20	143	23,600	24,300			0.302 at 75°F	7.5		
M-W 268 Well (Zones Unknown)	9/23/65	6,720	72	253	31	5.0	14	14	9,640	0	0	2,210	241	12	28		19,240	67		0.51 at 75°F	7.5		
1st Zone (Central Area)	4/12/67	1,280	15	20	30	0	0.2	120	570	0	0	2,515	15	T	50	940	4,615	4		1.95 at 75°F	8.3		
WILMINGTON																							
Tar Zone (Fault Block I)	8/10/65	11,640	88	322	280	25	T	0	19,290	0	0	226	181	76	37	31,800	32,165			0.202 at 75°F	7.6		
Ranger Zone (Fault Block I)	8/10/65	10,050	190	349	265	19	<0.1	<2.0	16,880	0	0	525	129	127	43	27,820	28,577			0.222 at 75°F	7.7		
Ranger Zone	7/7/76	10,200	265	540	385	50	250	<5	17,375	0	0	1,490	217	74	75	28,640	31,440			0.243 at 75°F	7.0		
Ranger Zone (Fault Block V)	11/12/64	8,825	230	425	455	16	0.1	18	15,600	0	0	775	120	125	50			15		0.255 at 75°F	7.6		
Composite (Fault Block I)	2/6/66	10,880	112	212	445	18	0.7	0	18,080	0	0	805	214	144	74	29,810	30,984			0.22 at 75°F	8.2		
Injection Water (J-2 Treatment Facility)	10/6/78	9,100	170	400	450	43	0.5	34	15,900	0	0	900	<2	13	150	26,200	27,200			0.244 at 75°F	7.3	2,860	

FIELD NAME AND SOURCE	DATE	Na	NH_4	Ca	Mg	Ba	Fe	SO_4	Cl	OH	CO_3	HCO_3	B_4O_7	I	SiO_2	SALINITY AS NaCl	TDS	B	S	RESISTIVITY IN OHM-METERS	pH	HARDNESS ($CaCO_3$)	ALKALINITY ($CaCO_3$)
Gaspur Zone (shallow aquifer)	?	9,730	4	650	1,270	0	5.1	1,875	18,230	0	0	440	4.3	3.6	20								
Ford Zone (Fault Block VI)	?	9,027	200	877	25	55	0.1	4	14,641			2,123	211	37	40	24,127	27,200						
Lower Terminal Zone (Fault Block VI)	?	10,490	144	565	241	200	0.3	10	18,012			305	178	60	52	29,683	30,145						
Lower Terminal Zone (Fault Block I)	5/19/72	10,740	170	535	235	44	2	T	18,085	0	0	590	245	70	80	29,810	30,835			0.228 at 75°F	7.5		
Injection Water (Mainland Plant)	1976	8,700	175	600	485	25	2.2	185	15,530	0	0	920	85	45	70	25,595	26,840			0.271 at 75°F	7.0		
Injection Water (Terminal Island Plant)	1976	9,635	215	600	500	31	2.9	90	17,090	0	0	1,050	80	50	90	28,170	29,470			0.250 at 75°F	6.9		
Union Pacific Zone (Fault Block I)	5/19/72	10,540	225	645	235	85	3	T	18,010	0	0	730	255	80	120	29,690	31,070			0.227 at 75°F	7.0		
Ranger and Upper Terminal Zones (Fault Block I)	1971	10,590	215	660	335	48	5	T	18,545	0	0	465	195	85	65	30,570	31,245			0.220 at 75°F	7.2		
Source water for injection (Fault Block I)	5/2/69	9,990	10	430	1,210	T	3.60	2,650	17,500	0	0	430	15	0	20	28,850	32,300			0.224 at 75°F	7.1		

APPENDIX D

RESULTS OF QUESTIONNAIRE SUBMITTED TO OIL FIELD OPERATORS IN LOS ANGELES COUNTY

LIST OF OPERATORS CONTACTED BY QUESTIONNAIRE

*Did not respond to questionnaire

American Pacific International, Inc.
Mr. David R. Johnson
612 N. Francisca
Redondo Beach, Calif. 90277
(213) 379-0014

ARCO Oil and Gas Company
Mr. A.P. Beer
P.O. Box 147
Bakersfield, Calif. 93302
(805) 831-1600

Atlantic Oil Company*
Mr. Virgil M. Radcliffe
P.O. Box 497
Paramount, Calif. 90723
(213) 633-5151

Beren Corporation
Mr. J. Roy White
2160 First of Denver Plaza
Denver, Colorado 80202
(303) 892-6541

Champlin Petroleum Company
Mr. Roger S. Glanville
Mr. Paul Cronmiller
420 Henry Ford Avenue
Wilmington, Calif. 90744
(213) 432-6923

Chevron U.S.A., Inc.
Mr. W.D. Edman
P.O. Box 605
La Habra, Calif. 90631
(213) 694-7345

Conoco, Inc.
Mr. Robert H. Lucacher
290 Maple Court, Suite 128
Ventura, Calif. 93003
(805) 642-6021

Crown Central Petroleum Corp.
Mr. Diem D. Vuong
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Newhall, Calif. 91321
(805) 255-6066

Damson Oil Corporation
Mr. David Lefler
P.O. Box 690
Venice, Calif. 90291
(213) 392-3053

Decalta International Corporation
Mr. W.M. Petersen
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Del Amo Energy Company
Mr. John W. Parkin
P.O. Box 2031
Torrance, Calif. 90503
(213) 540-5515

Energy Production and Sales Co.*
Mr. Greg Wagner
777 South Main Street, Suite 78
Orange, Calif. 92668
(714) 542-3941

Exxon Company, U.S.A.
Mr. E.C. Hutchinson
P.O. Box DO
Ventura, Calif. 93002

Getty Oil Company
Mr. R.O. Callaway
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Ventura, Calif. 93001
(805) 643-2154

Gulf Oil Exploration and Production Co.
Mr. P.L. Terwilliger
P.O. Box 1392
Bakersfield, Calif. 93302
(805) 395-6202

Long Beach Oil Development Co.
Mr. Harry J. Krebs
P.O. Box 1330
Long Beach, Calif. 90801
(213) 436-9918

Manley Oil Company
Mr. Bruce Manley
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(213) 628-5674

Marathon Oil Company
Mr. Vern Cozby
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Marmac Resources Co.*
Mr. Richard Russell
552 W. 127th Street
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(213) 757-9391

McFarland Energy, Inc.
Mr. L.P. Sacre
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Santa Fe Springs, Calif. 90670
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MCOR Oil and Gas Corporation
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Mitchell Energy Corp.
Mr. A.D. Hollis
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Mobil Oil Corporation
Mr. R.L. Pedersen
Mr. S.R. McGavran
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(303) 572-2060 (Pedersen)
(213) 683-5920 (McGavran)

Occidental Exploration and Prod. Co.*
Mr. David T. Pearson
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(213) 273-2471

Pauley Petroleum, Inc.
Mr. R.H. Greutert
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Petro-Lewis Corporation*
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(805) 327-4555

Petrominerals Corporation*
P.O. Box 10378
Santa Ana, Calif. 92711
(714) 554-7800

Petro Resources, Inc.
Mr. Joe D. Rose
4200 Easton Drive
Bakersfield, Calif. 93309
(805) 323-4118

Powerine Oil Company
Mr. W.H. Garrison
910 S. Windham Ave.
Long Beach, Calif. 90802
(213) 437-1284

Pyramid Oil Company
Mr. J.I. Hathaway
P.O. Box 3225
Santa Fe Springs, Calif. 90678
(213) 944-6789

Santa Fe Energy Company
Mr. G.H. Sampson
2850 Monterey St.
Torrance, Calif. 90503
(213) 328-3962

Shell Oil Company*
Mr. D.E. Gunderson
P.O. Box 92047
Worldway Center
Los Angeles, Calif. 90009
(805) 648-2751

Southern California Gas Company
Mr. John H. Jensen
810 S. Flower Street
Los Angeles, Calif. 90017
(213) 689-2853

Sun Production Company
Mr. Ben D. Park
P.O. Box 55060
Valencia, Calif. 91355
(805) 257-6256

Superior Oil Company
Mr. A.W. Mophett
Mr. Jim Oberlander
P.O. Box 66
Torrance, Calif. 90507
(213) 326-4002

Termo Company*
Mr. David E. Combs
P.O. Box 2767
Long Beach, Calif. 90801
(213) 595-7401

Texaco, U.S.A.
Mr. Leo McCann
Mr. Phil Sheehan
707 Walton Street
Long Beach, Calif. 90806
(213) 385-0515 (McCann)
(213) 774-8733 (Sheehan)

THUMS Long Beach Company
Mr. Paul J. Westrup
840 Van Camp Street
Long Beach, Calif. 90801
(213) 436-9211

Union Oil Company of California*
Mr. J.D. Grimes
P.O. Box 2212
Santa Fe Springs, Calif. 90670
(213) 945-1221

Western Avenue Properties*
Mr. Gene Kozlowski
8100 Electric Avenue
Stanton, Calif. 90680
(714) 828-8330

CALIFORNIA DIVISION OF MINES AND GEOLOGY
Geothermal Section - 2815 "O" Street, Sacramento, California 95816

QUESTIONNAIRE ON PROPERTIES AND USES OF THERMAL WATERS
PRODUCED FROM OIL FIELDS IN LOS ANGELES COUNTY, CALIFORNIA

Please return questionnaire to Chris T. Higgins at the above address. Use extra sheets if space provided is inadequate to answer questions.

1. _____
Name of Company

2. _____
Person Responsible for Completion of Questionnaire

_____
Address City State Zip Code

( ) _____
Telephone Number

3. Has your company made studies on the extraction and use of waste heat from oil field waters for uses other than oil field operations? If so, may the Division of Mines and Geology obtain a copy of each report of investigation?

0 Yes 30 No

4. Is there significant excess heat that is not being used in a productive way in your field operations?

4 Yes 25 No

Please describe:

(See following section in appendix for comments.)

5. Would the extraction of heat from the waters adversely or favorably affect your field operations in any way?

____ Yes Favorable 2 Adverse 10 13 No

Please describe:

(See following section in appendix for comments.)

6. If the effects of extracting heat from the water are adverse, could they be minized in an economic way?

5 Yes 11 No

(See following section in appendix for comments.)

7. What would be the best location in your operations to extract heat from the water (well-head, treatment-center intake, etc.)?

(See following section in appendix for selections.)

8. Would you consider your oil leases a renewable source of thermal water if properly managed (see question 17)?

7 Yes 20 No Unknown 2

9. Would it be feasible to phase in thermal water production as your oil operations phase out because of depletion of the petroleum reserves?

4 Yes 19 No Unknown 2

(See following section in appendix for comments.)

10. Do your drilling records generally indicate that additional thermal waters could be produced by perforation of presently cased-off non-oil-bearing and/or water producing zones?

5 Yes 20 No Unknown 2

11. What is your overall opinion of the idea of using the heat from oil field waters as a source of energy? Please summarize the most important factors that would affect the practicality of such a project.

(See following section in appendix for comments.)

INDIVIDUAL FIELDS (Please answer the following for each field in which your company is an operator.)

12. What are the temperatures (C or F) of the waters from each of the producing zones? How were those temperatures determined?

Field	Zone	Temperature	How determined

(Data are compiled in Appendix B.)

13. What is the range of temperatures of the water as it comes from the well-heads in each field?

Field	Lease Name	Temperatures

(Data are compiled in Appendix B.)

14. What is the temperature and average rate of flow (bbls/day) of produced water as it enters the water collection and treatment facilities in each field?

Field	Treatment Facility	Temperature	Volume

(Data are compiled in Appendix B.)

15. What is the temperature and average rate of flow (bbls/day) of the treated water as it is sent from the treatment facilities to injection or disposal wells?

Field	Facility	Temperature	Volume

(Data are compiled in Appendix B.)

16. Please indicate (preferably on a map) the location of the water collection centers and treatment plants for your operations in each field.

(Locations are compiled on Plate 2.)

17. Does the history of production temperatures suggest a "reheating" of the injected water at depth, resulting in the maintenance of a temperature equilibrium of each field?

Field	Effect of Production/Injection on Temperature Equilibrium

(See following section in appendix for comments.)

18. If temperature information on your company's wells is not readily available, would you permit the Division of Mines and Geology to obtain this data, either by inspection of pertinent records, or by direct measurement of your wells (well-heads, tank storage, treatment centers, etc.)?

19 Yes 1 No 6 NA

19. Can you please provide the results of chemical analyses of water produced from each field, both before and after treatment for injection or disposal?

11 Yes 13 No

20. If the answer to question 19 is "No", would you permit the Division of Mines and Geology to collect water samples from your wells for chemical analysis?

18 Yes 0 No

ADDITIONAL COMMENTS (Please make them if you desire to amplify any of the answers above.)

(Compiled under appropriate questions.)

Alternative Answer Sheet, Questions 12-15

Field	Lease Name	Zone	(#12) Waters from each of the producing zones		(#13) Range of temp. as it comes from well-heads	(#14) Produced water as it enters water collection and treatment facilities		(#15) Treated Water as it is sent from the treatment facilities to injection or disposal wells		Treatment Facility
			Temp	How temp(s) determined		Temp	Volume	Temp	Volume	

COMMENTS BY OPERATORS ON INDIVIDUAL QUESTIONS

QUESTION 4

THUMS Long Beach Company (Wilmington):

Heat is beneficial to breaking up of emulsions.

Effectivness of water drive using injected water is greater at higher temperatures.

Long Beach Oil Development Company (Wilmington):

Heat is beneficial to reduction of oil viscosity and increased oil recovery.

Pauley Petroleum, Inc. (Lawndale, Alondra):

Heat is dissipated from a hot well in the Lawndale Field. Fluid must be cooled before it is disposed in the sewer.

American Pacific International, Inc.(Torrance):

Heat from produced fluid is disposed with fluid into sewer system.

Damson Oil Corporation (Venice Beach):

Water is produced at above-boiling temperatures and must be collected before it is injected back into producing zone.

QUESTION 5

Champlin Petroleum Company (Wilmington):

Extraction of heat would lower injection temperatures, thus reducing reservoir temperatures. This would increase oil viscosity, which would reduce oil recovery.

ARCO Oil and Gas Company (Long Beach, Las Cienegas):

Extraction of heat would require space, equipment, and operating costs.

THUMS (Wilmington):

Biggest adverse effect would be possible decrease in effective space for oil field operations.

QUESTION 5 (continued)

Long Beach Oil Development (Wilmington):

Extraction of heat would increase viscosity and reduce oil recovery.

Powerine Oil Company (Wilmington):

Reduction of reservoir temperature increases oil viscosity, which results in a more adverse mobility ratio.

Pauley Petroleum (Lawndale, Alondra):

It could shorten retention time now required for cooling the produced water.

Del Amo Energy Company (Torrance):

Crude oil produced is extremely viscous, therefore retention of heat helps to reduce viscosity.

Conoco, Inc. (Seal Beach):

Heat is needed to affect good wash tank separation.

Mitchell Energy Corporation (Whittier):

Do not have room for additional equipment.

Exxon Company U.S.A. (Wilmington):

Heat must be retained in treatment system to allow efficient separation of oil and water.

Damson (Venice Beach):

The extraction of heat would be an advantage because produced water must be cooled before it is injected into the reservoir.

QUESTION 6

ARCO:

Adverse effects are mostly economic. They can be eliminated by making heat extraction an economic self-supporting entity.

QUESTION 7

Number in parentheses indicates number of operators who selected this location.

Well-head (1)

Treatment center intake (3)

Discharge from heater-treater (2)

Discharge after passing all tanks (1)

Inside tank farm near wash tanks (2)

Free water knockouts (1)

Downstream of filter at treatment center (1)

Downstream of heater-treater system (1)

Flotation cell discharge (1)

Treatment center (unspecific) (5)

Discharge from treatment center (3)

QUESTION 9

ARCO:

Process is feasible technologically. As oil operations phase out, the fiscal responsibility of operating, maintaining and eventually abandoning the systems and wells would have to be shifted to the heat recovery project. Private enterprise would have to have an economically justifiable project in order to call it feasible.

Gulf Oil Exploration and Production Company:

Phasing in thermal water production as oil operations phase out would not normally be practical because 1) in shallow steam flood reservoirs, the heat is normally scavenged by injection of cool waters; 2) in deep reservoirs where formation temperatures are high, the costs to lift the water to the surface are excessive.

QUESTION 9 (continued)

American Pacific International:

Possible depending on economics.

QUESTION 11

Champlin:

Produced water temperature is the most important factor, closely followed by water quality.

ARCO:

Most important factor is economics followed by excessive governmental regulations.

THUMS:

The idea would be practical if the layout of the oil field permitted placement of heat exchangers and other equipment necessary for the project.

Long Beach Oil Development:

Not practical because: 1) Water is at too low temperature considering depth to be drilled to produce same. 2) Water is extremely corrosive and would be costly to produce. 3) Lifting costs for high volumes of water would be high.

Powerine:

Main consideration for Wilmington lease is that land is at a premium, therefore, costs of project would have to be economic. Also, costs for lifting fluid is high.

Mobil Oil Corporation:

Impractical in Los Angeles County.

QUESTION 11 (continued)

Pauley Petroleum:

The concept is feasible as long as it would not interfere with the oil operations. A nearby market for the heat is essential. The heat-exchanger system would have to be designed so that temporary interruptions or reduced volumes of water could be handled satisfactorily. Water production rates usually increase over the life of a producing oil field. Compensation to the land owner, mineral rights owner and operator must be considered.

Texaco Inc.:

If the heat is available, it should be used. Factors to consider are: 1) costs, 2) surface area requirements, 3) economics, and 4) quantity and quality of heat.

Del Amo:

Not practical in this case.

Marathon Oil Company:

Transportation of the hot water from the oil field would be the most important consideration. If the facilities for converting the heat to energy were very far away, some sort of energy would have to be expended to retain the heat.

Manley Oil Company:

Unless large amounts of heat are available, costs of set up and operation would make recovery impractical.

Beren Corporation:

There are insufficient volumes or temperatures of water in the Beren leases to be an efficient source of energy. It is doubted that any system could be economically feasible in the forseeable future.

McFarland Energy, Incorporated:

Could be feasible where there is a large, constant volume of water that is extremely hot. The water would have to have low salinity to avoid corrosion effects in a heat exchanger.

QUESTION 11 (continued)

Petro Resources, Incorporated:

Impractical for the Placerita Field (reservoir is too shallow).

Decalta International Corporation:

The concept may have merit depending upon the logistics and proximity to prospective processing areas.

Gulf:

Extracting heat from oil field waters as a source of energy can be both feasible and practical providing that an adequate supply of thermal water can be obtained at the surface with a low lifting cost. Factors that would effect the practicality of such a project would include: 1) There remains sufficient heat in the water after it has passed through the separating/treating facility. 2) Heat from the water could not be extracted upstream of the treating facility (i.e. heater treater, wash tank, or free water knockout vessel) because the heat is required for the efficient separation of the oil and water.

Conoco:

It is not economically feasible.

Getty Oil Company:

The idea of using heat from oil field waters is generally a good idea. However, we feel the costs involved would far outweigh the benefits. Some of the areas which must be considered are the following: 1) Many water bearing zones contain brackish water. Circulation of this brine solution would undoubtedly produce a severe corrosion problem. 2) The water would have to be pumped to the surface. Pumps would also be needed if the water is to be reinjected. The cost and maintenance of the pumps must be considered. 3) Insulated surface facilities (pipelines, pumps, storage tanks, etc.) would have to be used to retain the heat before the water reaches the desired destination.

QUESTION 11 (continued)

Getty Oil Company (continued)

4) If the water is not to be reinjected water disposal and surface subsidence must be considered. 5) To make this type of project economically feasible, a significant temperature differential would be required. We do not feel that the Los Angeles County oil fields we operate have a great enough temperature differential to sustain this type of project.

Mitchell Energy:

The idea is good but the following must be considered:

1) Temperature of water must be fairly high before heat transfer would be practical. 2) Must be realistic volume of water. 3) Many operating areas within the city limits of Los Angeles do not have the space for much more equipment. If they do have the space, the permit process would cancel the project.

Crown Central Petroleum Corporation:

The idea is good.

MCOR Oil and Gas Corporation:

Any utilization of heat as a source of energy should be exploited. However, we have yet to see waters associated with oil and/or gas production that have sufficient heat or sufficient volumes to warrant heat exchange to form useful energy. The most important factors are adequate heat and volumes near the source where energy is to be utilized.

Sun Production Company (Wilmington, Newhall-Potrero, Long Beach):

We do not believe that the available heat from our relatively low-temperature reservoirs justifies the equipment to extract heat.

American Pacific International:

We favor any secondary recovery of energy from waste heat, regardless of the source. First consideration is economics; second is amount of space

QUESTION 11 (continued)

American Pacific International (continued):

available to conduct the recovery process. Space is at a premium on this company's lease in the Torrance Oil Field.

Damson:

The idea is good.

Chevron U.S.A., Inc. (numerous fields in county):

The temperature is not high enough to make offsite uses practical.

Santa Fe Energy Corporation (Torrance):

The oil field waters have been utilized as a source of heat in many of our oil fields in the past and present. Currently, the existing temperature enables us to treat the oil with no outside heat source except in case of upsets in the tank farm.

Exxon:

It is possible that waste heat could be recovered from the 135°F - water that leaves the Wilmington Townlot Unit Central Facility. The previously produced Ford Zone (4,000 - 5,000 feet deep) is a possible source of thermal waters, although recompletion of wells to that zone would be very costly and uneconomic at this time.

Superior (Torrance):

The temperature of the produced water at Torrance will remain consistent for an extended period in the future, but cannot be expected to increase. Produced water would have to be chemically treated to remove salts and scale-building particles to be effectively used in a heat-exchange. Limited space at the collection facility site could possibly be a hindrance (residential housing surrounds the facility site).

QUESTION 17

THUMS (Wilmington):

No history of production temperatures has been established and maintained.

Champlin (Wilmington):

The temperature of produced fluids has been dropping in recent years.

Long Beach Oil Development (Wilmington):

Due to injection of colder fluids, formation temperatures have shown a reduction in heat.

Powerine (Wilmington):

During the period 1959 to 1964, all injected water originated from shallow (300 ft.) salt water sands (Gaspur Zone). This had a cooling effect on the reservoir. Since 1964, a combination of produced water and Gaspur Zone water has been injected which has slightly cooled or has tended to maintain the reservoirs in equilibrium.

Mobil (mainly Santa Fe Springs):

No. There is such a large volume of water being injected that the formation water is being lowered.

Del Amo (Torrance):

Produced fluid temperature is constant.

Gulf (Beverly Hills, Cheviot Hills, Oak Canyon, Rosecrans, Sansinena, Santa Fe Springs):

No major effect on the above listed fields.

ARCO (Long Beach):

Injection of 90° - 110° F water has reduced the temperature of some subzones up to 10°F in the vicinity of the well bore.

QUESTION 17 (continued)

Marathon (Del Valle):

No.

Beren (Howard Townsite, Rosecrans, South Rosecrans):

No.

McFarland (Whittier, Ramona, Oak Canyon):

No information available.

Petro Resources (Placerita):

No.

Getty (Inglewood, Potrero, Aliso Canyon, Seal Beach):

The temperature equilibrium is minimally affected by production and injection in all the Los Angeles County fields.

Conoco (Seal Beach):

Probably yes.

Mitchell (Whittier):

No information available.

MCOR (Cascade):

Unknown.

Exxon (Wilmington):

No lowering of temperatures in Wilmington has been noticed, although detailed studies of this haven't been undertaken.

Santa Fe Energy (Torrance):

E-log temperatures in the production zone have shown a decline of about 20°F from 1970 to 1980, although this evidence is not conclusive that zone temperatures have dropped.

Chevron (many fields):

All cycled water appears to be reheated to some extent.

Damson (Venice Beach):

Reheating seems to occur.

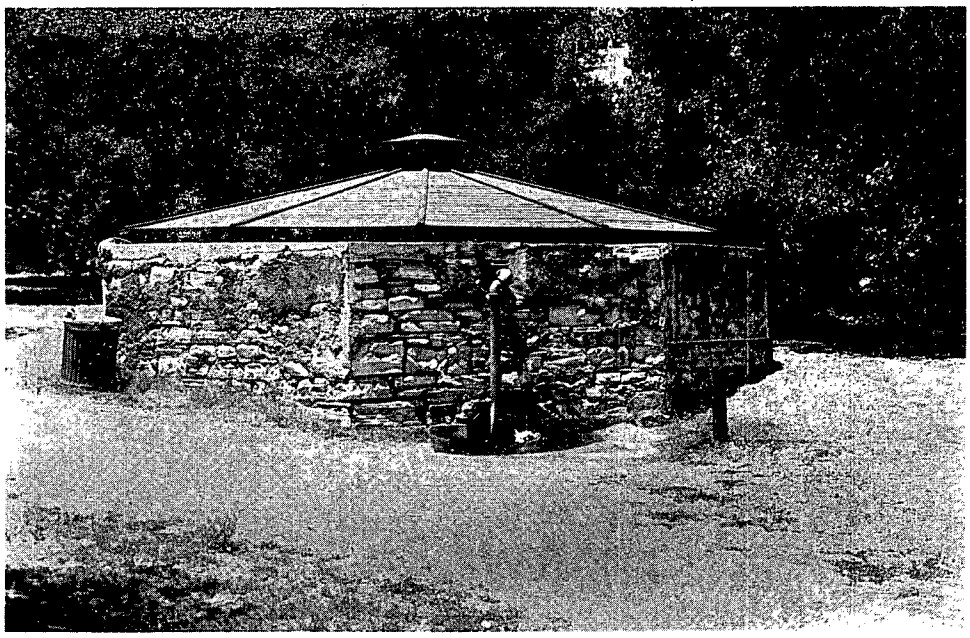
QUESTION 17 (continued)

Sun (Wilmington, Newhall-Potrero):

Unknown, but would expect some reheating; have not noticed diminished produced-water temperatures.

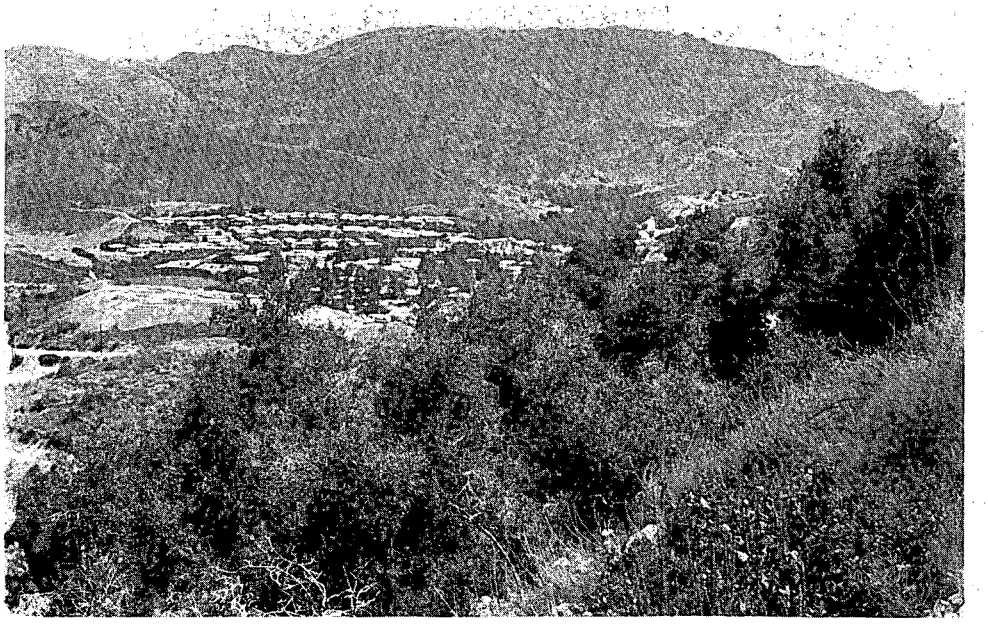
APPENDIX E

PHOTOGRAPHS OF SELECTED OIL FIELD OPERATIONS AND GEOTHERMAL FEATURES IN LOS ANGELES COUNTY

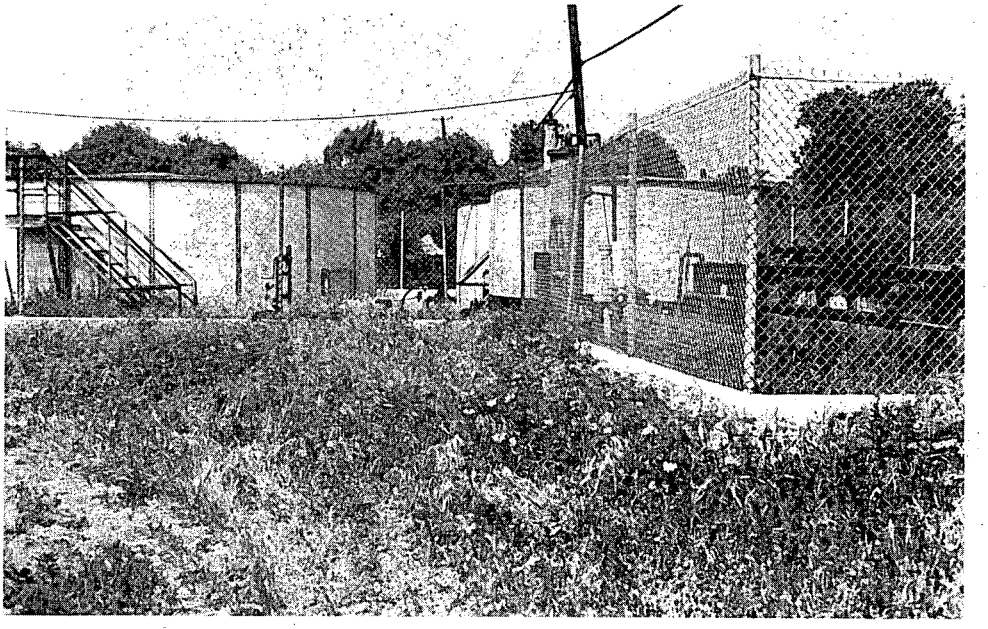


1 - Encino Warm Springs in the city of Encino, San Fernando Valley. Spring water exits from near base of the vertical pipe.

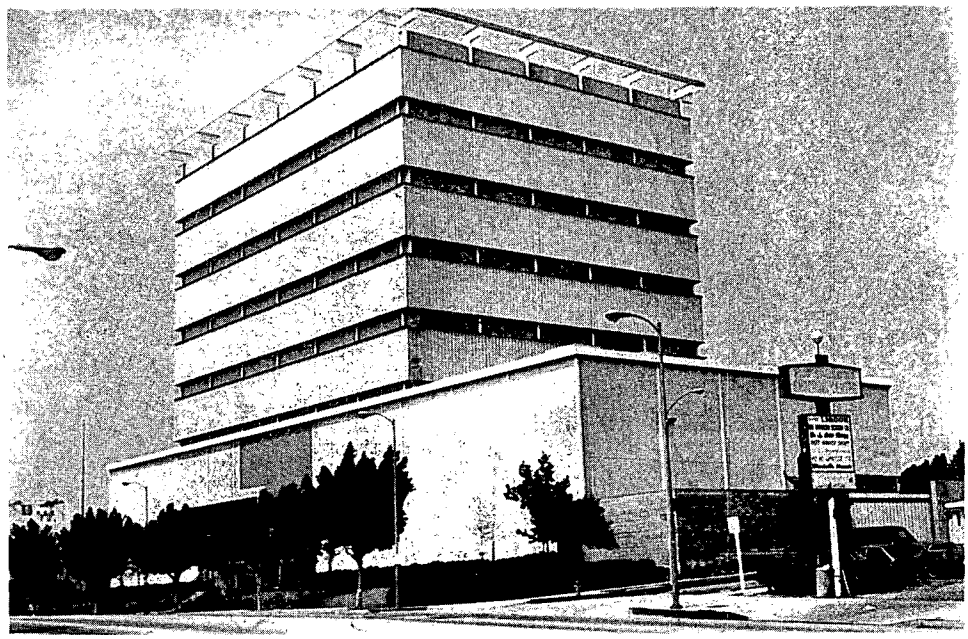
2 - Setting of warm spring in Elizabeth Lake Canyon, near a county rehabilitation center. The only spring found is behind the pumphouse shown in this photo.



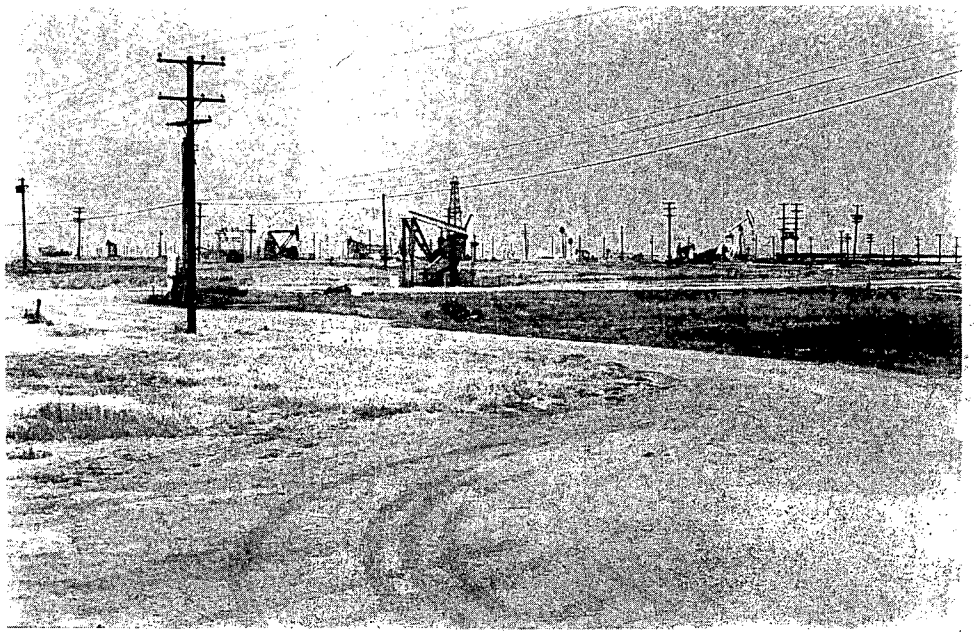
3 - Setting of the trailer park developed next to Seminole Hot Springs. The "springs" are actually an old oil exploratory hole, which, by virtue of its depth, brought up warm water.



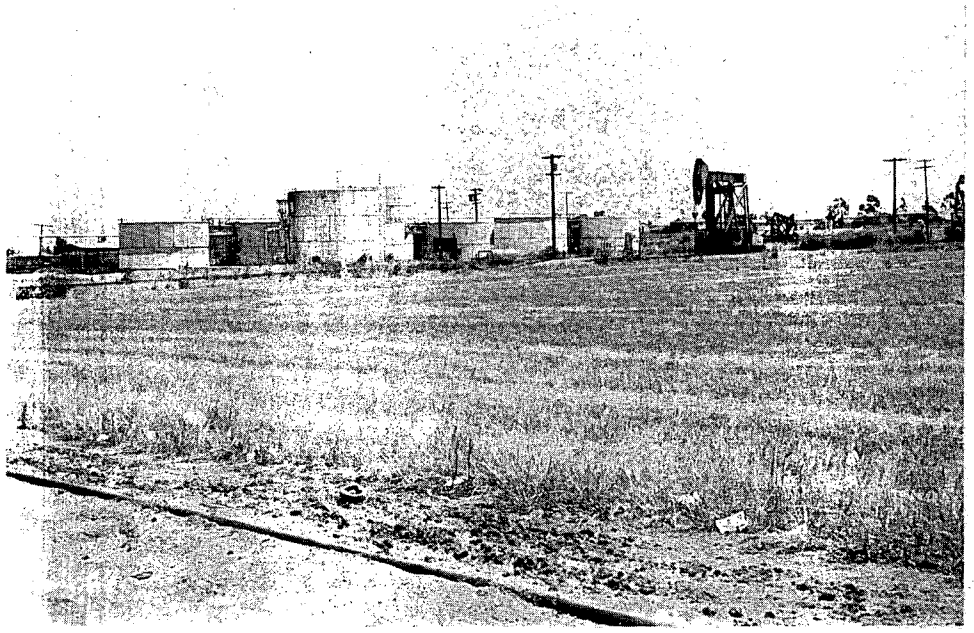
4 - Pauley Petroleum's tank farm at the Alondra Oil Field. Water temperatures produced here are similar to those at the Lawndale Oil Field. El Camino College is across the street from this operation.



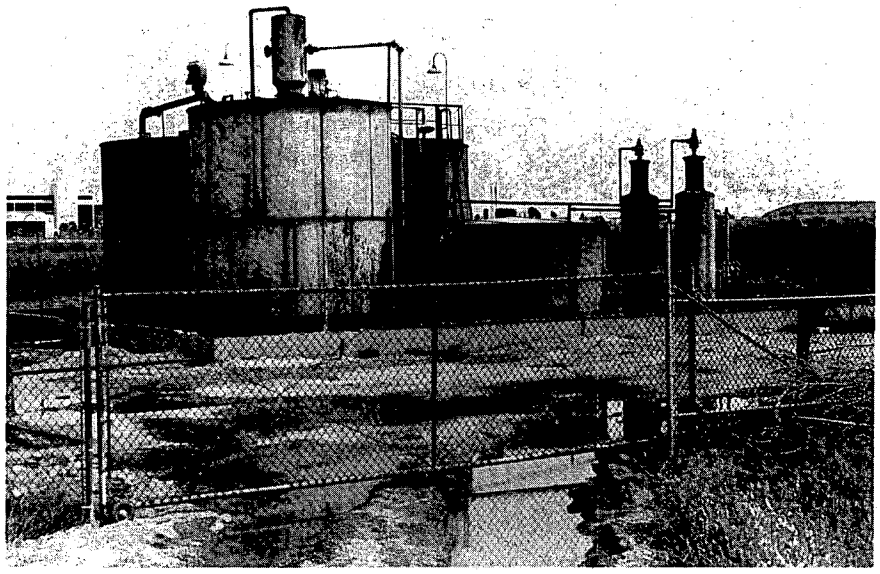
5 - The Packard Drill Site, operated by Chevron, in the Beverly Hills Oil Field. About 80-90 wells have been directionally drilled from within this structure, which is designed to keep oil operations as unobtrusive as possible.



6 - A portion of the Shell lease at Dominguez Oil Field. The field is largely rural, but is surrounded on all sides by commercial-industrial development and lesser amounts of residential development.

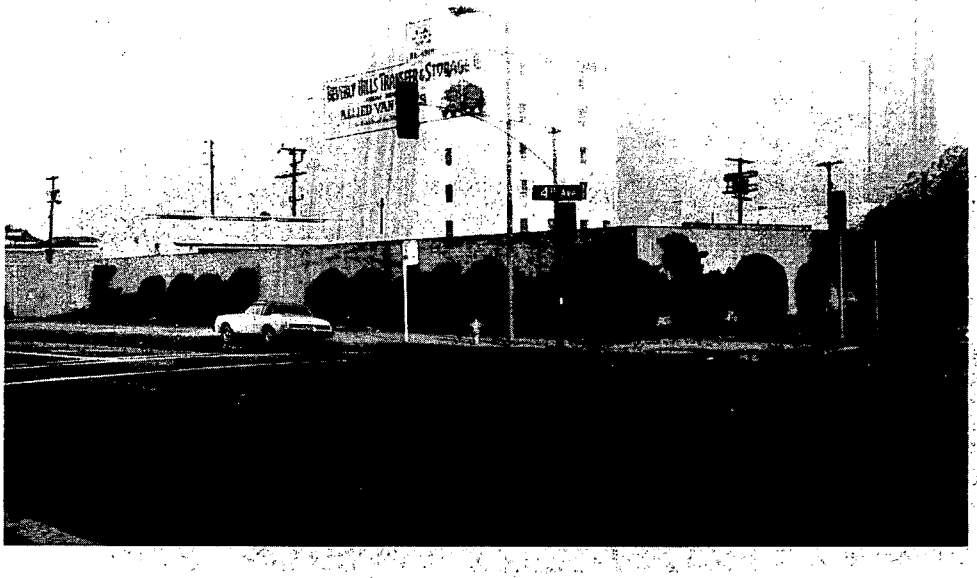


7 - Union Oil Company's collection and treatment facility at the Dominguez Oil Field. The facility is in a field across the street from California State University, Dominguez Hills.

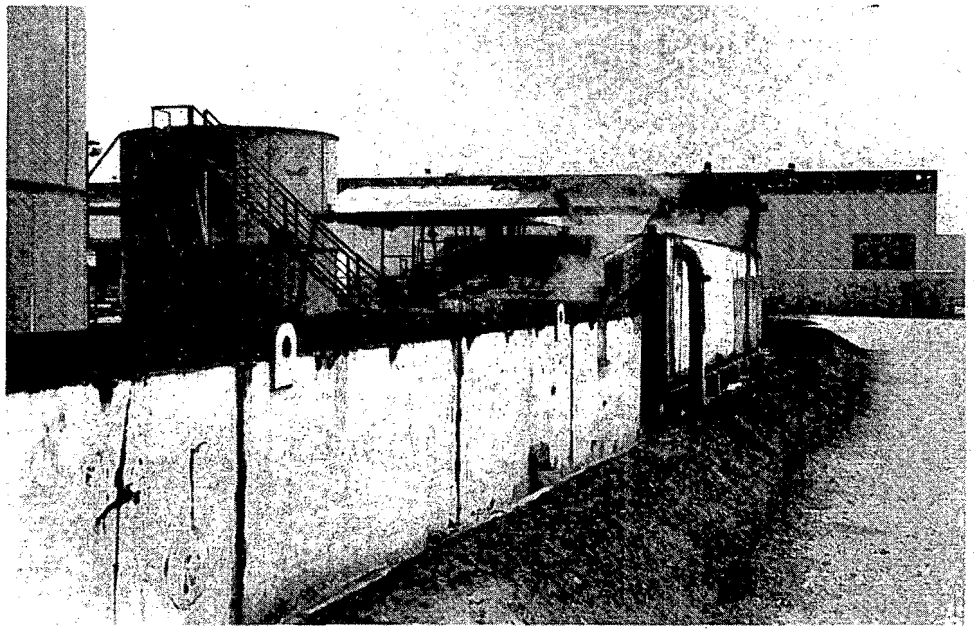


8 - Beren Corporation's collection facility at the Howard Townsite Oil Field. Buildings of Southwest Los Angeles College can be seen in the background.

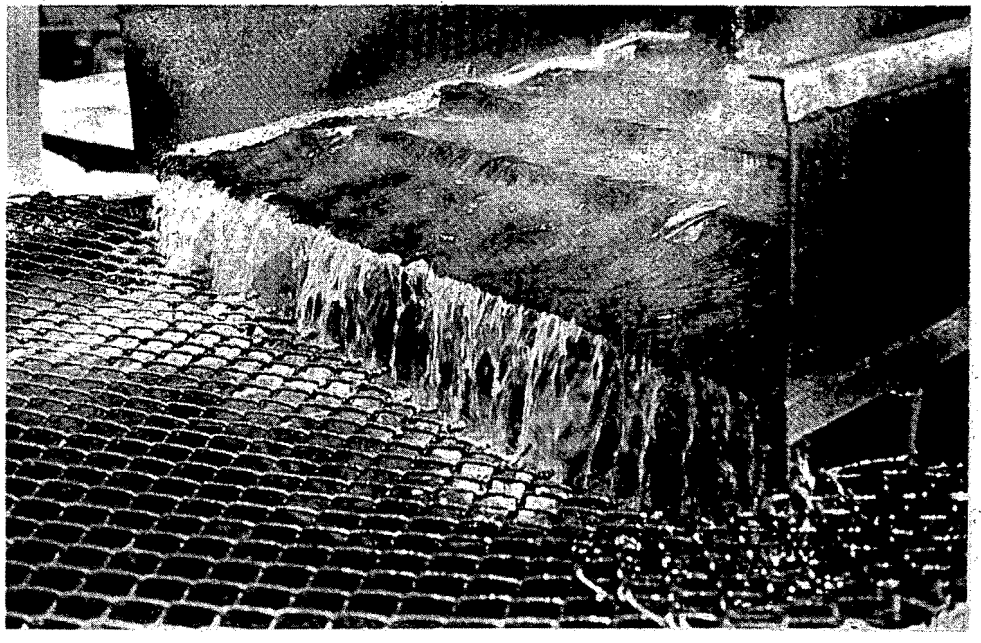
9 - Baldwin Hills (middle distance) and San Gabriel Mountains (far distance) as viewed from the Playa del Rey terrace. Much of the Baldwin Hills is restricted to oil operations (Inglewood Oil Field) only.



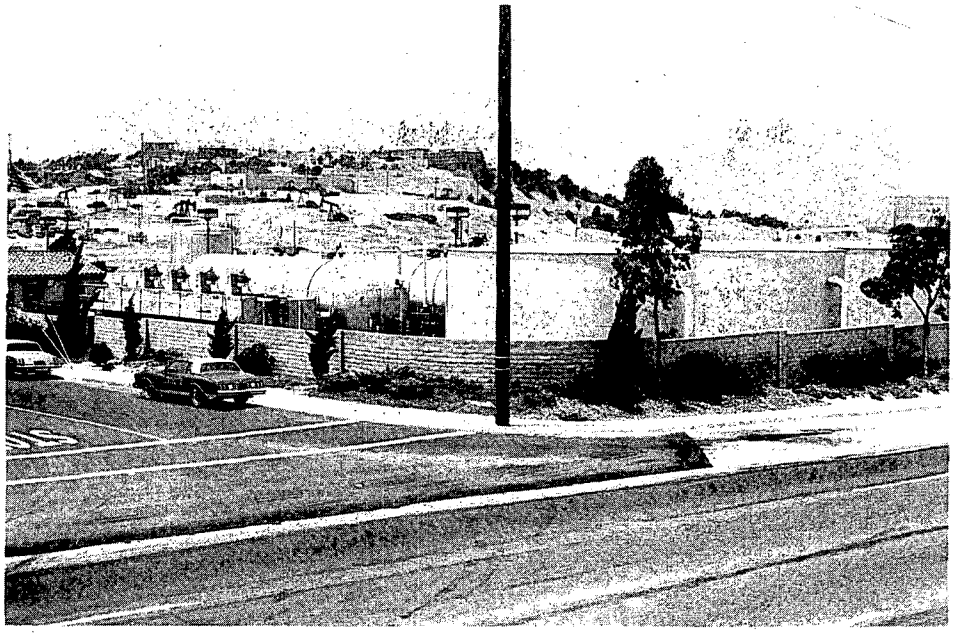
10 - The Union Oil Company's Fourth Avenue Drill Site in the Las Cienegas Oil Field. About 20 wells have been directionally drilled from this site.



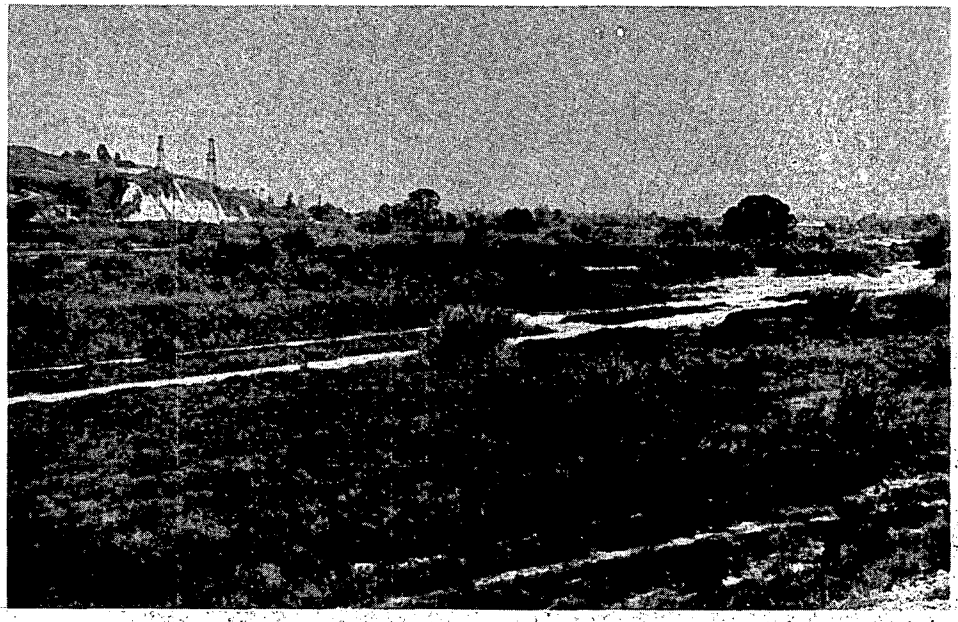
11 - Baker tanks used to cool produced water from the Lawndale Oil Field. Steam is visible above the riffles. Part of a surrounding industrial park can be seen in the background.



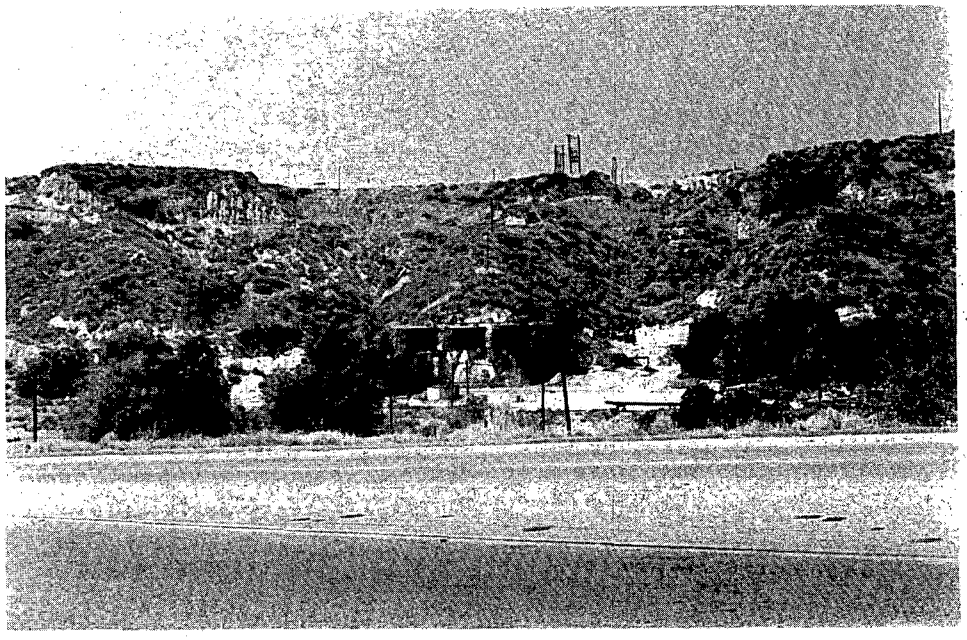
12 - Cooling riffles at Pauley Petroleum's Lawndale facility (close-up of previous photo). Water at this point is about 155°F.



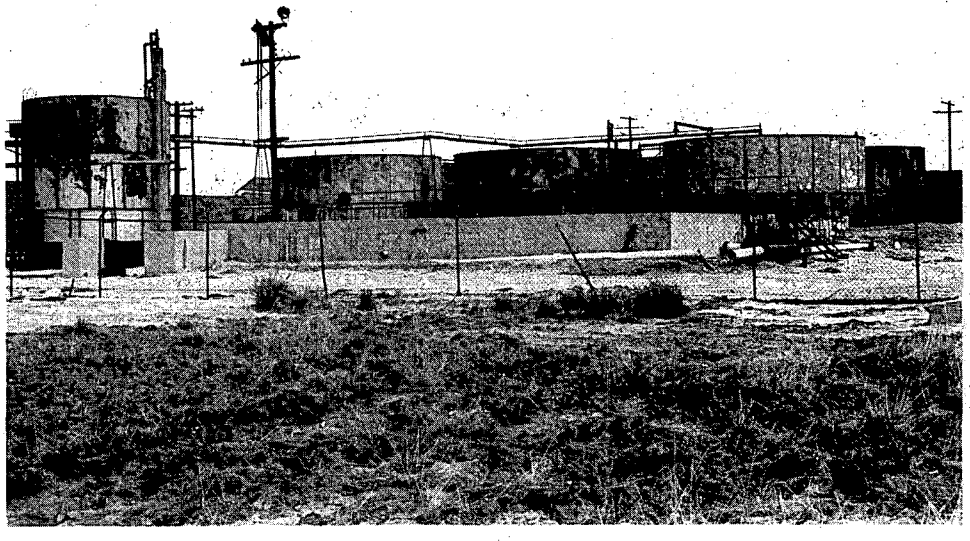
13 - ARCO Oil and Gas Company's Signal Hill East Unit treatment facility in the Long Beach Oil Field. The urbanization of Signal Hill can be seen in the background.



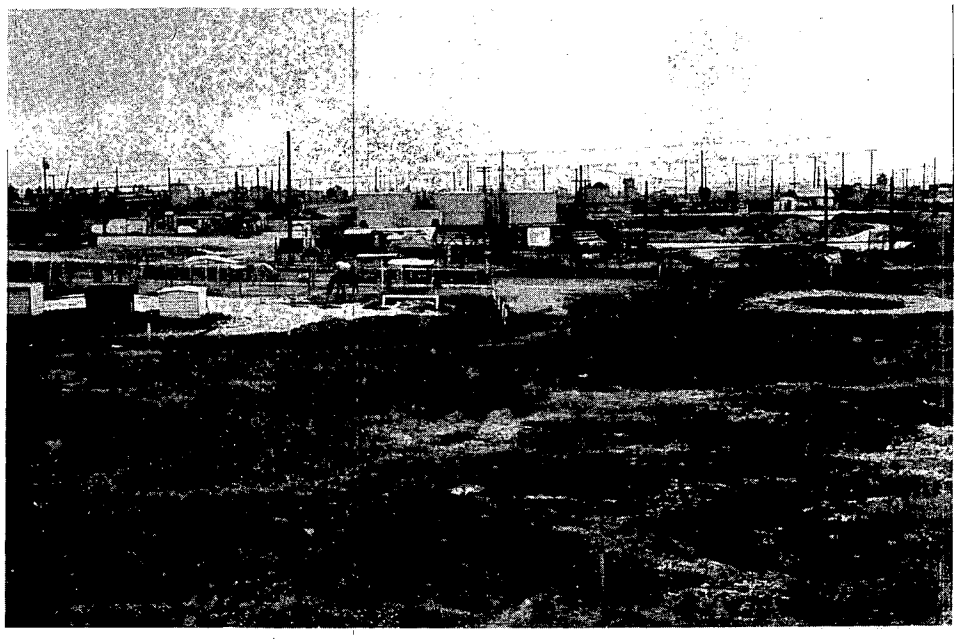
14 - View northeast of the Montebello Oil Field from Whittier Narrows Dam. The field is largely rural, but is being encroached by development on its southwest edge.



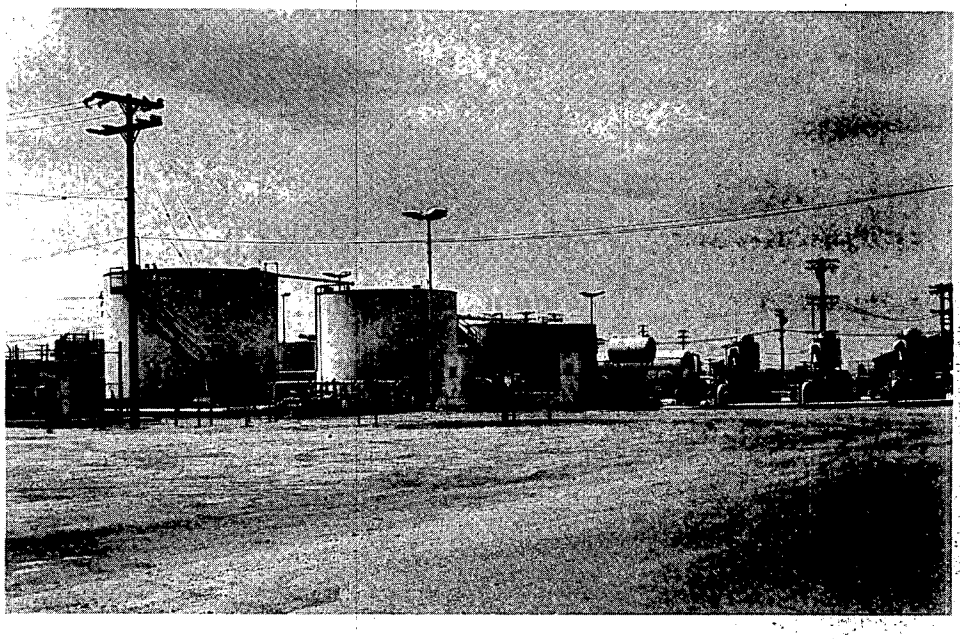
15 - A portion of the Placerita Oil Field in the Ventura Basin. The topographic character of all fields in the Basin are somewhat similar to this view.



16 - Beren Corporation's tank farm in the Rosecrans Oil Field.

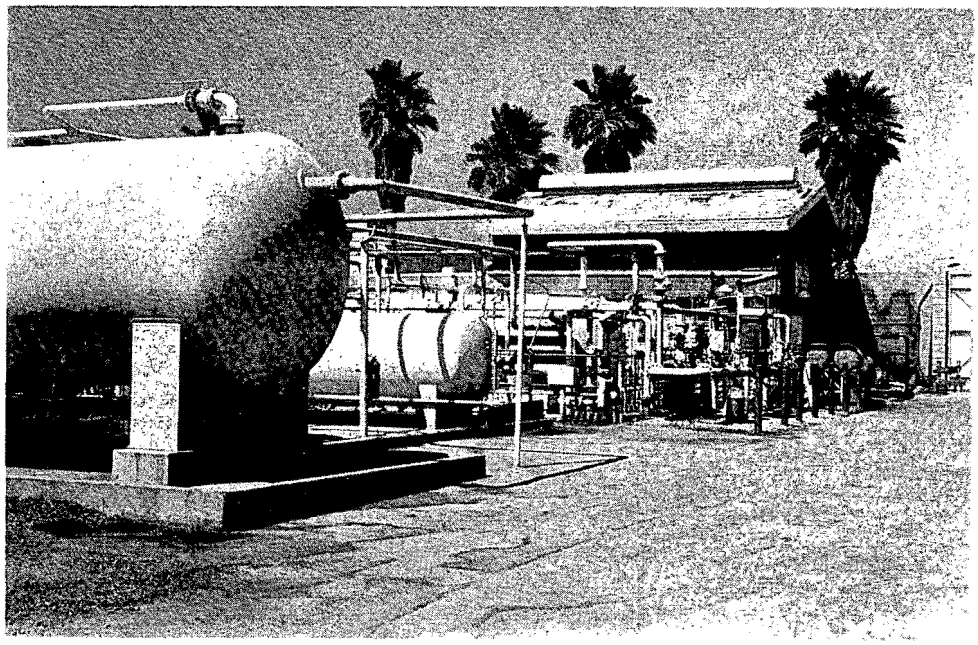


17 - Eastward view of a portion of the Santa Fe Springs Oil Field. Much of the field is surrounded by commercial-industrial development.

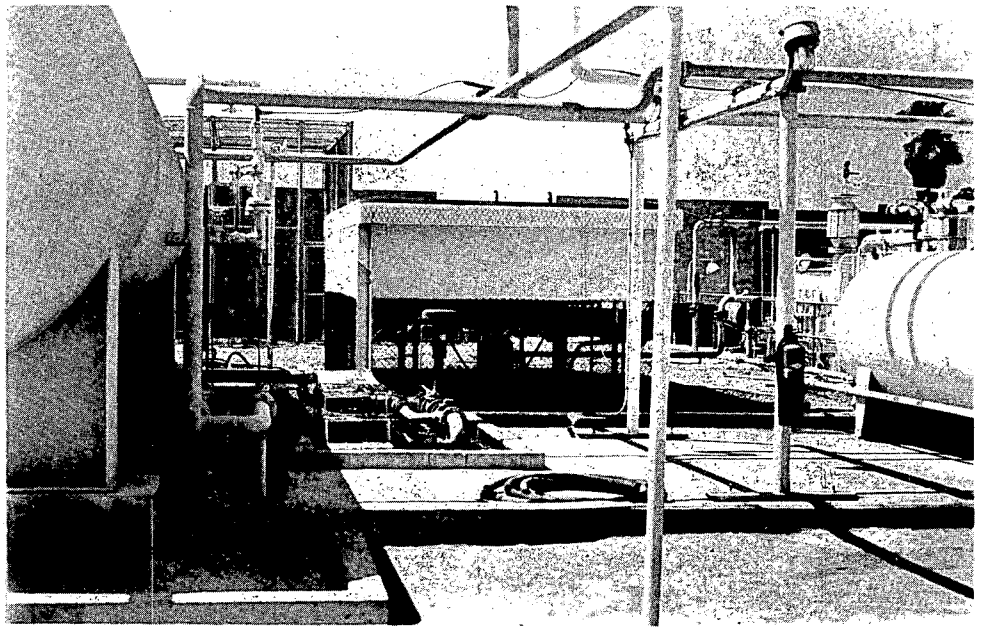


18 - Mobil Oil Corporation's collection-treatment-injection facility at the Santa Fe Springs Oil Field. The facility handles all fluids produced in the field.

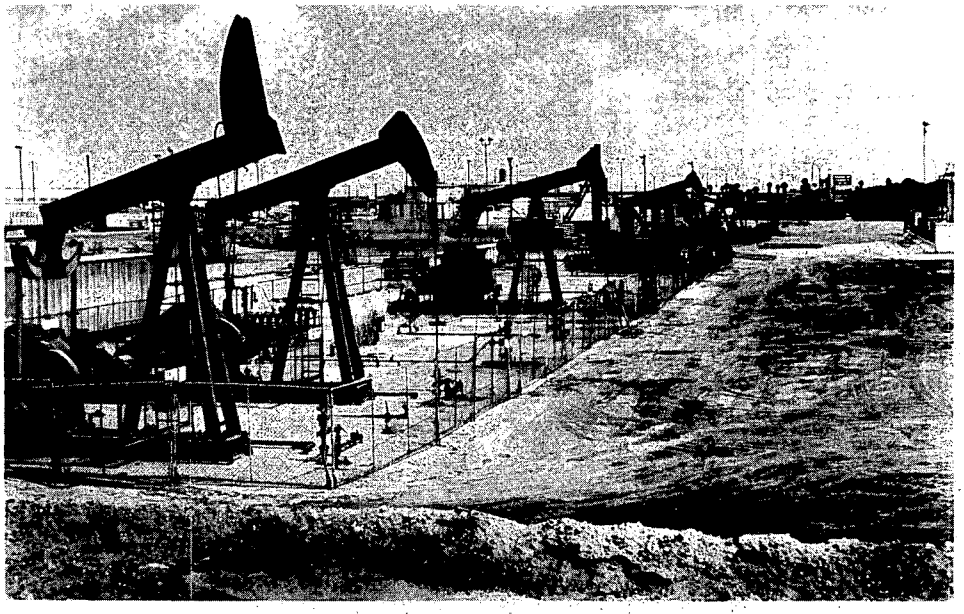
19 - Damson Oil Corporation's facility at Venice Beach. The facility is adjacent to the "Speedway," a boardwalk-like thoroughfare closed to automobiles.



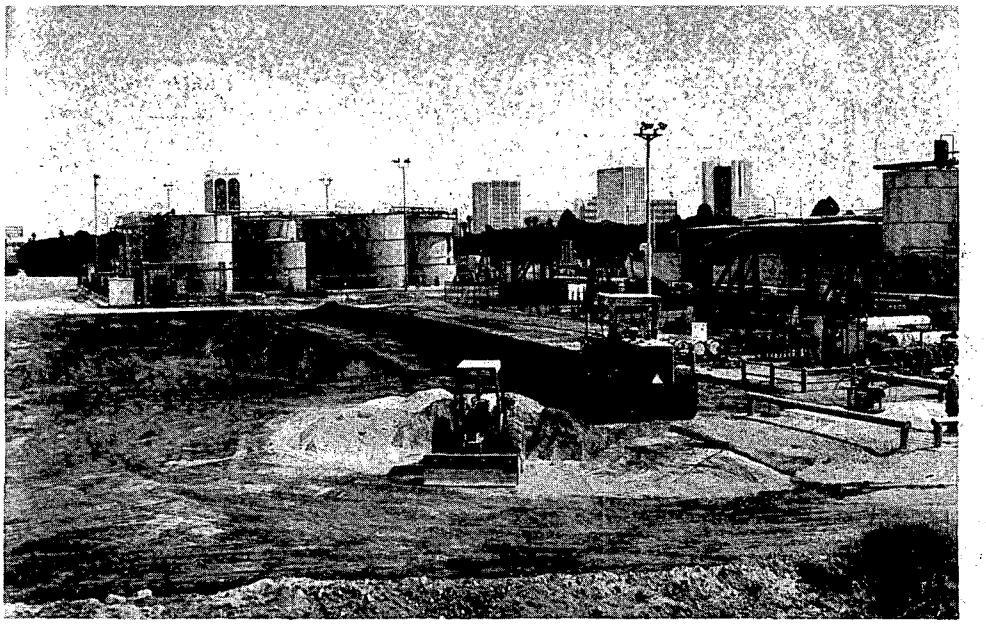
20 - Major portion of oil-water separation apparatus at the Damson Venice Beach facility. Incoming fluids from well heads initially enter free water knockout at left.



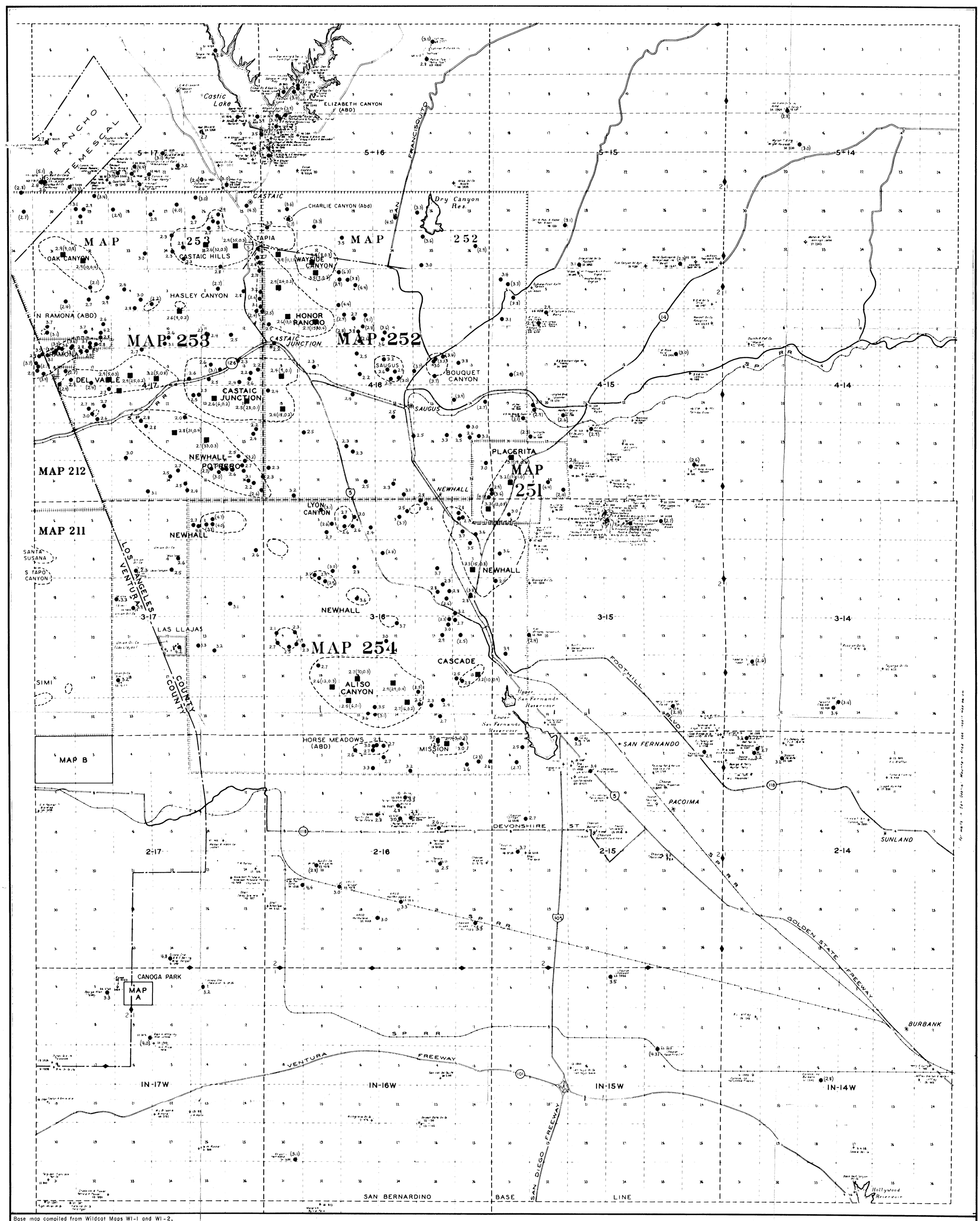
21 - Forced-air heat exchanger (center) at Damson's Venice Beach facility. Water enters exchanger from knockout at left at about 220°-240°F and is cooled to about 150°-160°F before disposal.



22 - Several pumping units operated by Long Beach Oil Development Company in the Wilmington Oil Field, near Long Beach Harbor.



23 - Powerine Oil Company's operation in the Long Beach Harbor area. The company's brine treatment facility is left of center. Buildings of downtown Long Beach are in the background.



Base map compiled from Wildcat Maps WI-1 and WI-2, published by the California Division of Oil and Gas.

APPROXIMATE RELATIVE GEOTHERMAL GRADIENTS IN VENTURA BASIN, CALIFORNIA AS DETERMINED FROM BOTTOMHOLE TEMPERATURES OF OIL WELLS

Gradient data compiled by Chris T. Higgins
with assistance from Emily Kishi

1981

2 1 0 1 2 3 4 MILES

8000 4000 0 4000 8000 12,000 16,000 FEET

2 1 0 1 2 3 4 KILOMETERS

SCALE
(Approximately 1:48,000)

N W E S

EXPLANATION

● 3.6 — *Gradient determined from single well (figures in parentheses indicate gradient determined from only one temperature recording).*

■ 3.5 (36,0.3) — *Mean gradient determined from many wells in a section. Location of symbol is approximate center of areal distribution of gradients determined in section. Number of wells is first figure in parentheses; second figure is standard deviation.*

▲ 3.8 (20,0.5) — *Mean gradient determined from wells at an urban drillsite. Figures in parentheses are same as described above.*

ALL GRADIENTS ARE IN °C/100 METERS.

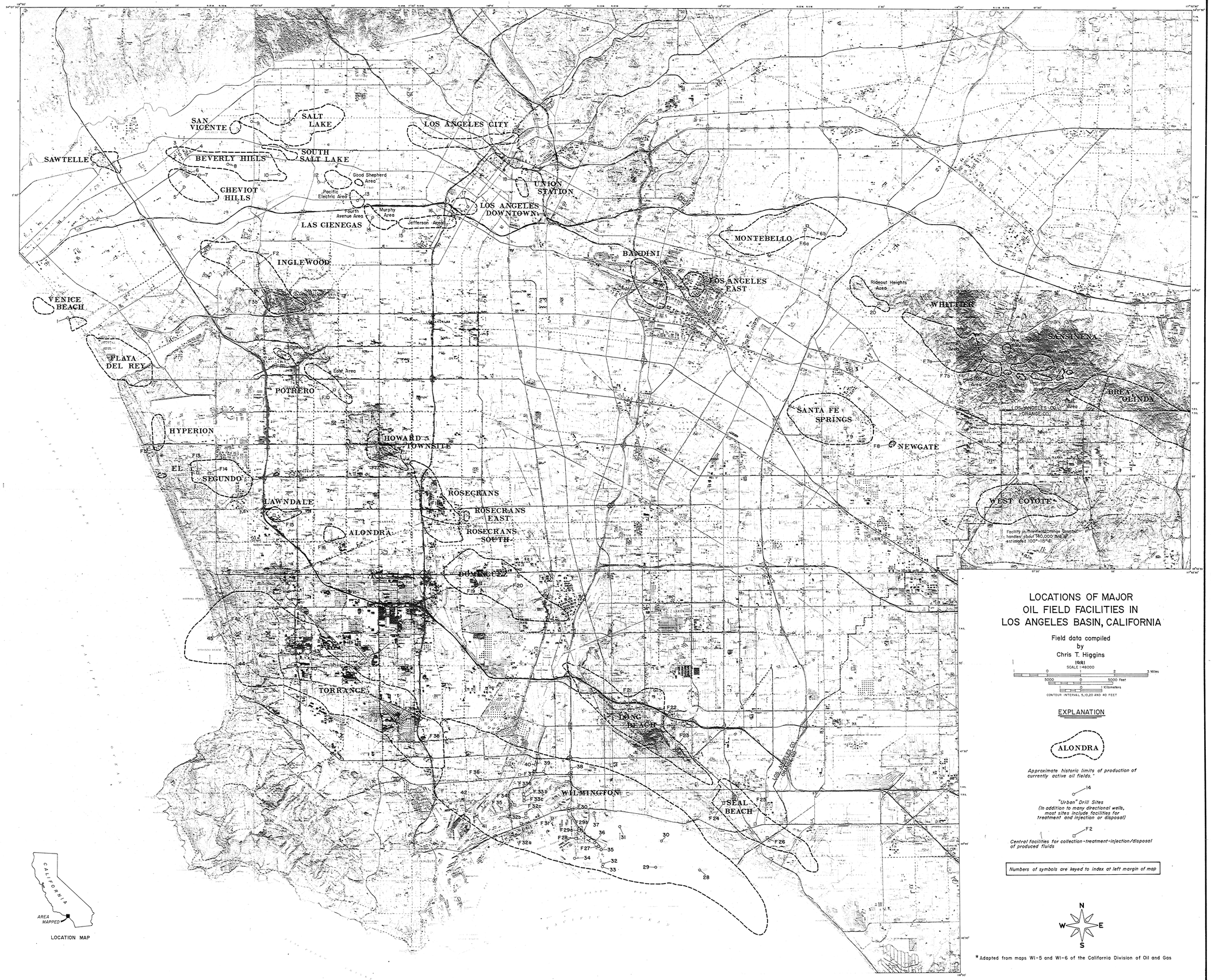
All gradients were determined from bottomhole temperatures measured in oil wells and wildcat wells. The temperatures were corrected using a technique described in the text, which attempts to allow for the non-equilibrium hole conditions associated with measurements of the temperatures.

ALONDRA — *Productive limits of oil fields.*

● 57 - 6,383 — *Year of abandonment of hole and total depth of hole in feet.*

MAP 125 — *Field map number and boundary (maps available from California Division of Oil and Gas).*

⊕ — *Abandoned exploratory hole (no temperature data obtained).*



INDEX TO MAJOR FACILITIES IN OIL FIELDS

DRILL SITES

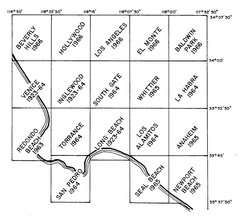
Operator (name of site) P = water production or intake I = injection or disposal b/d = barrels/day Blank indicates data unavailable

1 - Damson (Venice Beach) P = 8,000 b/d at 215°-230°F, I = 8,000 b/d at 150°-160°F
2 - Occidental (Sawtelle) P = 1,000 b/d?, I = 800-1,000 b/d?
3 - Gulf (Century)
4 - Gulf (Olympic)
5 - ARCO (Rancho)
6 - Gulf (Pico)
7 - ARCO (Hillcrest)
8 - Occidental (West Pico)
9 - Chevron (San Vicente) P = 4,700 b/d water, 2,000 b/d oil at 110°-140°F, I = 7,700 b/d at 110°F
10 - Chevron (Packard) P = 18,000 b/d water, 3,000 b/d oil at 110° - 140°F, I = 29,000 b/d at 110°F
11 - Seaboard (Beverly Blvd.) P = 1,000 b/d?
12 - Union (Pacific Electric) P = 2,040 b/d at 120°F, I = 2,000 b/d?
13 - Union (Church Avenue) P = 4,181 b/d at 165°F, I = 5,000 b/d?
14 - Union (Murphy) P = 1,150 b/d at 96°F
15 - Union (Jefferson) P = 1,932 b/d at 95°F
16 - ARCO (St. James) P = 3,000 b/d?
17 - Chevron (Broadway) P = 4,200 b/d?, I = 3,500 b/d?
18 - Chevron (Garey) P = 250-500 b/d?, I = 250-500 b/d?
19 - Atlantic (Bandini) P = 500 b/d?
20 - Mitchell (Rideout Heights) P = 600 b/d at 100°F, I = 400 b/d at 90°-100°F
21 - Union (Sansinena Z)
22 - Union (Sansinena 1)
23 - Union (Sansinena S)
24 - Union (Sansinena 3) P = 1,463 b/d at 100°F
25 - Union (Sansinena 11)
26 - Union (Sansinena 8)
27 - Union (Sansinena 9)
28 - THUMS (Chaffee Island) P = 40,000 b/d at 120°-130°F, I = 40,000 b/d at 100°-110°F
29 - THUMS (Freeman Island) P = 80,000 b/d at 120°-130°F, I = 80,000 b/d at 100°-110°F
30 - THUMS (White Island) P = 50,000 b/d at 120°-130°F, I = 50,000 b/d at 100°-110°F
31 - THUMS (Grissom Island) P = 90,000 b/d at 120°-130°F, I = 90,000 b/d at 100°-110°F
32 - L.B.O.D., THUMS (J-6)
33 - L.B.O.D., THUMS (J-5)
34 - L.B.O.D. (S-1)
35 - L.B.O.D., THUMS (J-3)^
36 - L.B.O.D., THUMS (J-1)
37 - Powerine, Chevron (Magnolia)
38 - Mobil (Pico)
39 - Sun (TWU 72)
40 - Sun (TWU 79)
41 - Exxon (Pacht St.)
42 - Exxon (Fries Ave.)
43 - Del Amo (Torrance)
44 - Petro-Lewis (Prospect Ave.)
45 - American Pacific Int. (Redondo Beach) P = 16,000 b/d

COLLECTION-TREATMENT-INJECTION/DISPOSAL FACILITIES

*Location approximate

*F1 - Getty (collection-treatment-injection plant) P = 25,000-30,000 b/d at 116°F, I = 24,000 b/d at 108°F.
F2 - Chevron (Unit collection-treatment-injection plants) P = 89,000 b/d at 90°-100°F, I = 89,000 b/d at 90°-100°F.
F3 - (a) Chevron (Non-unit collection plant) P = 110,000 b/d at 90°-100°F.
(b) Chevron (Non-unit treatment-injection plant) I = 110,000 b/d at 90°-100°F.
F4 - Western Properties (collection-disposal) P = 900 b/d at 80°-90°F, I = 900 b/d at 80°-90°F.
F5 - Western Properties (collection-disposal) P = 2,700 b/d water, 300 b/d oil at 100°F, I = 2,700 b/d at 80°-90°F.
F6 - (a) Chevron (collection plant) P = 22,500 b/d at 115°F(?).
(b) Chevron (treatment-injection plant) I = 22,500 b/d at 110°F(?).
F7 - (a) Chevron (collection plant) P = 21,200 b/d at 115°F(?).
(b) Chevron (treatment-injection plant) I = 21,200 b/d at 110°F(?).
F8 - Gulf (collection-disposal) P = 29 b/d at 95°F, I = 29 b/d at 90°F.
F9 - Mobil (collection-treatment-injection plant) P = 44,000 b/d at 105°, I = 44,000 b/d.
F10 - Getty (collection-disposal) P = 4,100 b/d, I = 4,460 b/d at 85°F.
F11 - Mobil (collection-disposal) P = 100 b/d (?).
F12 - Pauley (collection-disposal) P = 1-2 b/d, I = 1-2 b/d.
F13 - T and F (collection-disposal) P = 465 b/d at 100°F(?), I = 435 b/d.
F14 - Graner (collection-disposal) P = 1500 b/d at 200°F, I = 1400 b/d (?) at 130°F.
F15 - Pauley (collection-disposal) P = 2,500 b/d at 170°-190°F, I = 2,500 b/d at 120°F.
F16 - Pauley (collection-disposal) P = 550 b/d at 160°-180°F, I = 550 b/d at 120°F.
F17 - Baron (collection-disposal) P = 488 b/d at 60°F, I = 488 b/d at 60°F.
F18 - Baron (collection-disposal) P = 2,861 b/d at 60°F, I = 2,861 b/d at 60°F.
F19 - Union (collection-treatment-injection plant) P = 9,200 b/d at 108°-135°F.
*F20 - Shell (collection-treatment-disposal) I = 4,000 b/d at 90°-100°F.
F21 - Texaco (collection-treatment-injection plant) P = 80,000 b/d at 100°-130°F.
F22 - Shell (collection-treatment-injection plant) P = 14,200 b/d at 90°-100°F, I = 14,200 b/d at 80°-95°F.
F23 - ARCO (collection-treatment-injection plant) P =22,000 b/d at 130°-135°F, I = 45,200 b/d at 100°-110°F.
F24 - Marina Pacific (collection-disposal) P = 500-1,000 b/d?
*F25 - Conoco (collection-treatment-disposal plant) P = 15,000 b/d at 120°F, I = 8,000 b/d at 120°F.
F26 - Getty (collection-disposal) P = 800-900 b/d at 76°F, I = 850 b/d at 70°F.
F27 - THUMS (J-2 collection-treatment-injection plant) P = 130,000 b/d at 120°-126°F, I = 130,000 b/d at 100°-110°F.
F28 - L.B.O.D. (J-1-2 collection-treatment-injection plant) P = 98,000 b/d at 130°F, I = 98,000 b/d at 110°F.
F29 - (a) Powerine (treatment-injection plant) I =41,300 b/d at 110°F.
(b) Powerine (collection) P = 41,300 b/d at 120°F.
F30 - Chevron (collection-disposal) P = 7,000 b/d at 110°F, I = 7,000 b/d at 120°F.
F31 - L.B.O.D. (EM collection-treatment-injection plant) P = 48,000 b/d at 125°F, I = 48,000 b/d at 100°F.
F32 - (a) Chanslite (Island injection plant) I = 178,000 b/d at 112°F.
(b) Chanslite (treatment plant).
(c) Chanslite (Island collection) P = 240,000 b/d at 119°F.
F33 - (a) Chanslite (Mainland injection plant) I = 203,000 b/d at 117°F.
(b) Chanslite (Mainland collection) P = 180,000 b/d at 120°F.
(c) Chanslite (treatment plant).
F34 - Mobil (Ford collection) P = 650 b/d at 130°F.
F35 - Mobil (Terminal ISCO collection) P = 2,500 b/d at 105°F.
F36 - Exxon (Central) collection-treatment-injection plant) P = 85,000 b/d at 125°-135°F, I = 85,000 b/d at 130°F.
F37 - Sun (TWU collection-treatment-injection plant) P = 11,000 b/d at 105°F, I = 24,000 b/d at 90°-70°F.
F38 - Mobil (S. Torrance Unit collection-treatment-injection plant) P =3,000 b/d at 100°F, I = 2000 b/d(?).
F39 - SuperFoo (Doughnie Unit collection-treatment-injection plant) P = 19,200 b/d at 142°F, I = 19,200 b/d at 135°.
F40 - Santa Fe Energy (Torrance Unit collection-treatment-injection plant) P = 15,000 at 120°F, I = 17,000 b/d at 115°F.
F41 - American Pacific Int.(collection-treatment-disposal-plant) P = 16,000 b/d at 130°F, I = 16,000 b/d at 130°F.



INDEX MAP TO QUADRANGLES

LOCATION MAP

LOCATIONS OF MAJOR OIL FIELD FACILITIES IN LOS ANGELES BASIN, CALIFORNIA

Field data compiled by Chris T. Higgins
1981

SCALE 1:48000

0 2 3 Miles
5000 0 5000 Feet
0 1 Kilometers
CONTOUR INTERVAL 5,10,20 AND 40 FEET

EXPLANATION

ALONDRA

*Approximate historic limits of production of currently active oil fields.**

14

"Urban" Drill Sites (In addition to many directional wells, most sites include facilities for treatment and injection or disposal)

F2

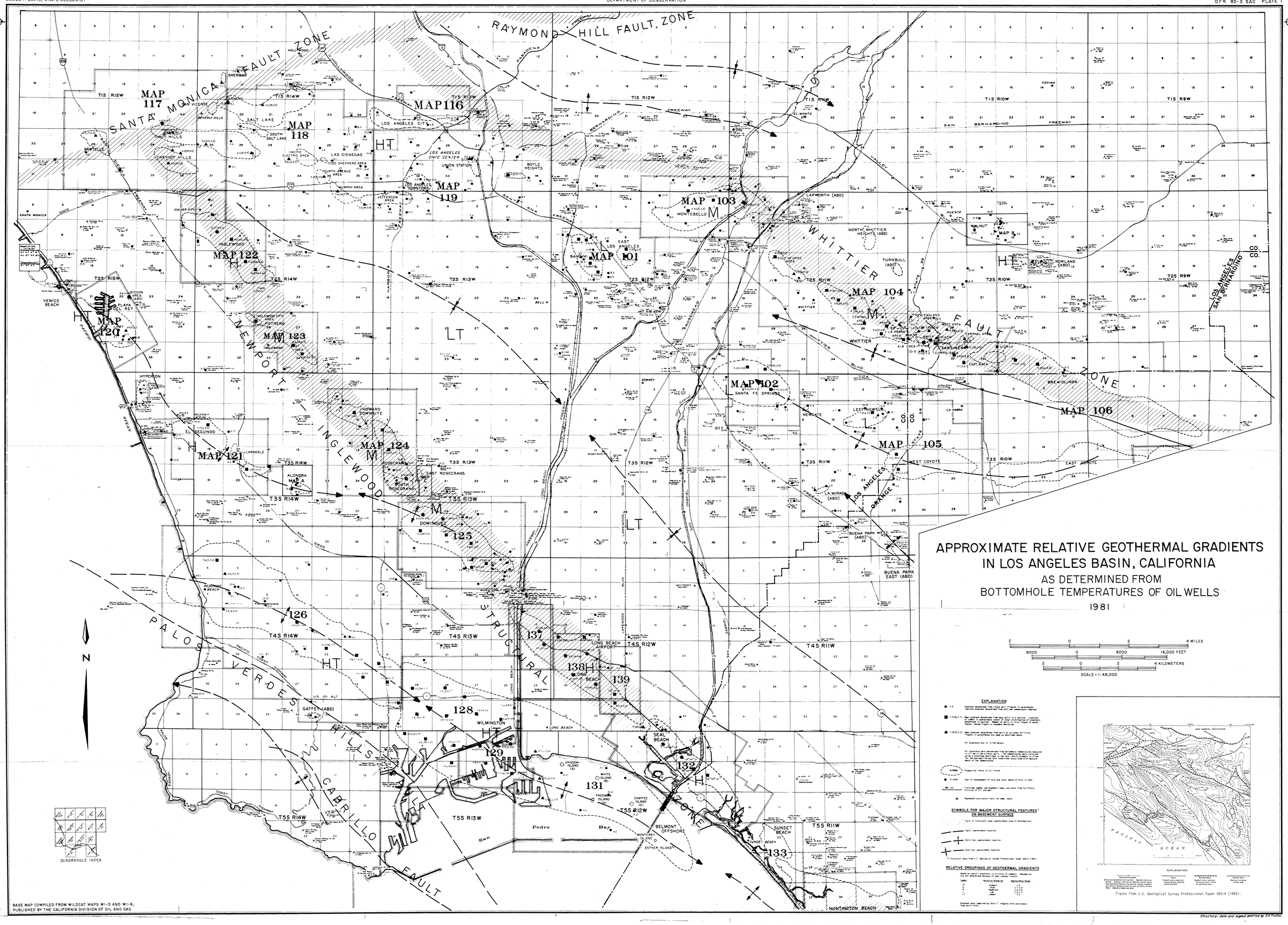
Central facilities for collection-treatment-injection/disposal of produced fluids

Numbers of symbols are keyed to index at left margin of map

N W E S

*Adapted from maps WI-5 and WI-6 of the California Division of Oil and Gas

Topographic Base Map by U.S. Geological Survey
Reduced from 1:24 000 Scale Quadrangle Maps


APPROXIMATE RELATIVE GEOTHERMAL GRADIENTS
IN LOS ANGELES BASIN, CALIFORNIA
AS DETERMINED FROM
BOTTOMHOLE TEMPERATURES OF OIL WELLS
1981
SCALE = 1:48,000
EXPLANATION
SYMBOLS FOR MAJOR STRUCTURAL FEATURES* ON BASEMENT SURFACE
RELATIVE GROUPINGS OF GEOTHERMAL GRADIENTS
QUADRANGLE INDEX
BASE MAP COMPILED FROM WILDCAT MAPS WI-5 AND WI-6,
PUBLISHED BY THE CALIFORNIA DIVISION OF OIL AND GAS
RAYMOND HILL FAULT, ZONE
SANTA MONICA FAULT ZONE
NEWPORT-INGLEWOOD
WHITTIER FAULT ZONE
PALOS VERDES HILLS
CABRILLO FAULT
STRUCTURAL ZONE
MAP 116
MAP 117
MAP 118
MAP 119
MAP 101
MAP 102
MAP 103
MAP 104
MAP 105
MAP 106
MAP 120
MAP 121
MAP 122
MAP 123
MAP 124
125
126
128
129
131
132
133
137
138
139
LOS ANGELES CO.
SAN BERNARDINO CO.
ORANGE CO.
PACIFIC OCEAN
Pedro Bay
HUNTINGTON BEACH
LONG BEACH
WILMINGTON
SEAL BEACH
BELMONT OFFSHORE
SUNSET BEACH
LONG BEACH AIRPORT
EXPLANATION
Figure from U.S. Geological Survey Professional Paper 420-A (1965).
Structural data and legend drafted by Ed Foster