El Sur Ranch
Hydrologic Investigation

Prepared for:

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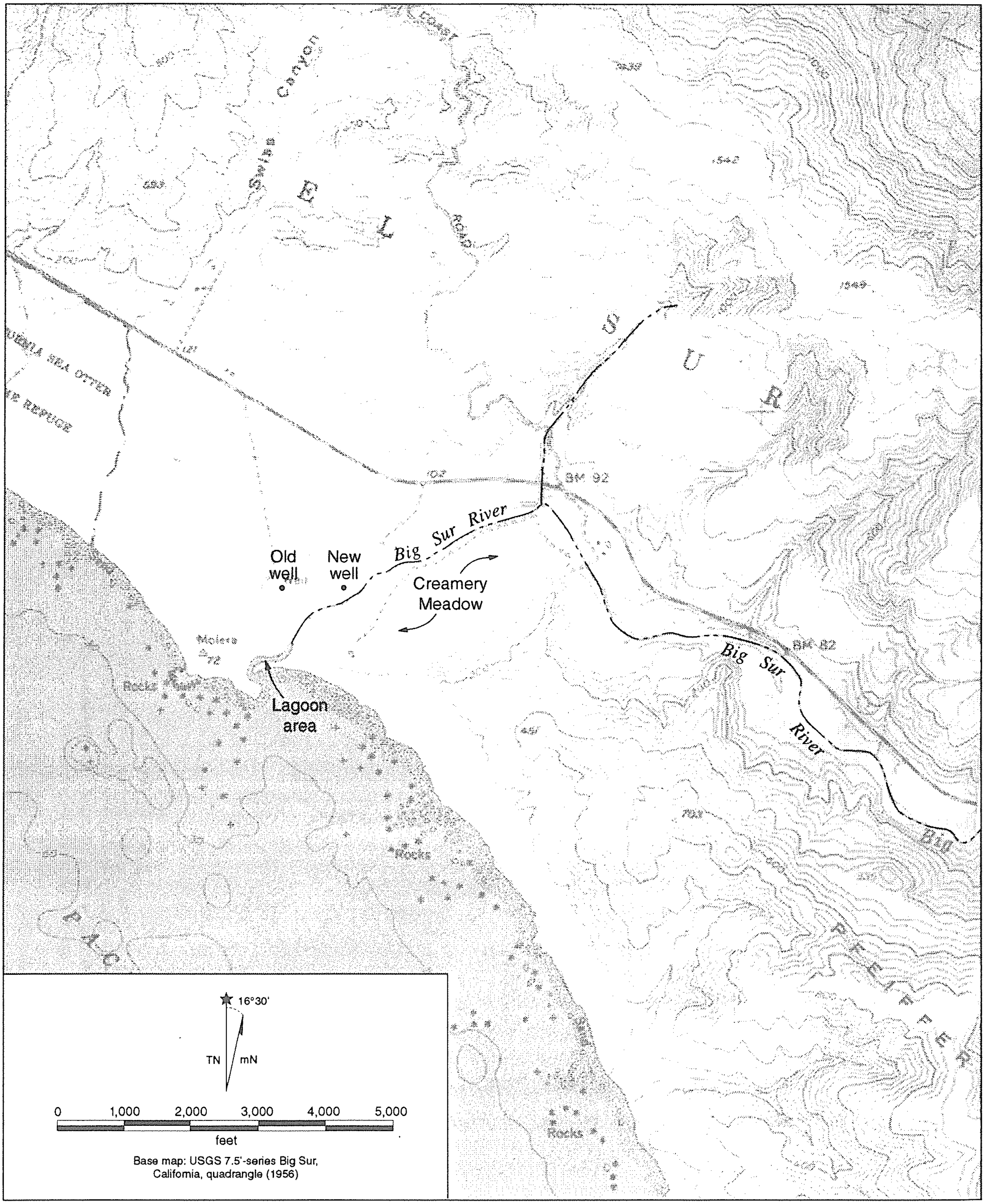
April 1999



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Executive Summary

In 1992, the El Sur Ranch filed Application 30166 with the State Water Resources Control Board (SWRCB) to appropriate 1,800 acre-feet per year (af/yr) of Big Sur River underflow at a combined maximum pumping rate of 5.84 cubic feet per second (cfs) from two agricultural wells. The water rights application is for the continued pumping of water via these two agricultural wells located in the Andrew Molera State Park on the north side of the Big Sur River. The water rights application was protested by the California Department of Fish and Game (DFG), California Department of Parks and Recreation (DPR), and California Sportfishing Protection Alliance based on the possible effects of groundwater pumping on the flow of the Big Sur River and lagoon, and the possibility of impacts on riparian vegetation, steelhead trout, and other aquatic organisms. The beneficial use of the water is for pasture irrigation and no significant change in irrigation practices is anticipated.

The well sites are located near the mouth of the Big Sur River in Andrew Molera State Park, south of the city of Monterey, on the Big Sur Coast in Monterey County. The El Sur Ranch is located just north of Andrew Molera State Park and includes approximately 290 acres of irrigated pasture on the coastal bluff, which is approximately 50 feet higher in elevation than the mean high-water channel of the Big Sur River. The El Sur Ranch old well was constructed in the mid 1950s. The second well, the El Sur Ranch new well, was constructed in 1985 under terms of the easement with DPR. Water from the two wells is pumped up to the El Sur Ranch through two mains that join into a singular main before continuing to the upper pastures. A series of laterals and sublaterals provide water to checks where the water is used to irrigate approximately 290 acres of pasture using flood irrigation methods. The irrigation system was engineered in the 1950s, and water has been continuously put to beneficial use since its construction.

Issues related to the hydraulic continuity between the El Sur Ranch wells and the Big Sur River and lagoon need to be resolved before issuance of the water rights permit. The purpose and objectives of this investigation were to:

- determine the extent, if any, to which irrigation pumping from the El Sur Ranch wells may influence surface flows, depth, and water quality of the Big Sur River and its lagoon;

- develop a credible, systematic description of the seasonal variation in lagoon conditions such that the effect, if any, of the pumping on lagoon habitat can be reasonably evaluated; and

- determine the extent, if any, to which pumping from El Sur Ranch wells may affect groundwater levels in Creamery Meadow and affect the ability of riparian forest species to become established and survive.

This report documents all the work conducted, describes the environmental setting, and presents the collected data and analysis of these data sets, including the results of the drilling and aquifer testing program. This report does not evaluate irrigation water requirements or efficiency and does not analyze potential impacts on fisheries or riparian resources. The findings of this report are presented below.

FINDINGS

- *The groundwater system and Big Sur River are hydraulically closely coupled*

Groundwater levels are in dynamic equilibrium with riverflow during winter runoff events and the recharge from the river is indicated in the drawdown plots for the aquifer test. No impermeable layers were found that might impede percolation in or near the river channel in well logs or during the geomorphologic survey. The high aquifer transmissivity is conducive to rapid exchange of water between the river and aquifer.

- *The source of the water pumped by the El Sur Ranch wells is groundwater storage and induced river seepage*

Deep groundwater is not a significant source of water to the wells because all available geologic evidence (well logs and the geophysical survey) indicate the presence of a clay confining layer throughout the lower end of the groundwater basin at a depth just below the depth of the irrigation wells (approximately 30 feet below the ground surface). Likewise, rainfall recharge and subsurface inflow from bedrock and marine terrace areas surrounding the basin contribute minor amounts of recharge that are much smaller than the recharge capability of the river and that would not support present pumping amounts. Underflow from upgradient areas contributes recharge to the groundwater basin storage.

- *Well pumping does not significantly decrease flow, stage, or velocity in the river or lagoon*

In all but critically dry years, the maximum possible rate of streamflow depletion with both wells operating simultaneously (6 cfs) is substantially less than the amount of summer base flow in the river (10-20 cfs) plus groundwater underflow (5 cfs). Monitoring of lagoon stage during 1998 indicated that stage is controlled primarily by the height of the beach berm between the lagoon and the ocean. In critically dry years, induced seepage from the Big Sur River can be a substantial percent of total flow. It could slightly increase the likelihood of discontinuity of surface flow when flow reaches exceptionally low levels. Under those circumstances, however, discontinuous flow is likely to occur even in the absence of pumping (see below).

- *Naturally low riverflow was the primary cause of intermittent flow in 1990*

Summer and fall base flows in 1990 dropped to as low as 5 cfs at the U.S. Geological Survey (USGS) gage and ranks among the lowest flows ever recorded. Flows exceeded those levels 95-99% of the time during the period of record for the gage. The duration of flow discontinuity in 1990 also indicates that the El Sur Ranch wells were not the primary cause of the low flows. Discontinuous flow persisted for approximately 2 months and El Sur Ranch records demonstrate that the wells were presumably in continuous operation during that time. Diversions below the USGS gage were probably a minor factor contributing to flow discontinuity in 1990 because an inventory of diversions suggests that net diversions in summer are probably on the order of only 0.03-0.04 cfs. not

- *Pumping of the El Sur Ranch wells does not affect groundwater levels and riparian vegetation in Creamery Meadow*

The lack of measurable drawdown at the Creamery Meadow observation well during the aquifer test indicates that drawdown from the El Sur Ranch wells does not extend beyond the river. This is consistent with the abundant evidence that the aquifer and river are hydraulically coupled and with the conceptual model of the river as a fully penetrating recharge boundary. Given the hydrogeologic and streamflow conditions at the site, one would not expect significant amounts of drawdown to propagate beyond the river channel.

- *Wave overwash is the likely source of salinity in the lagoon and El Sur Ranch wells*

Monitoring of lagoon stage and salinity during 1998 revealed that seawater enters the lagoon during periods of above-average tide height (i.e., during new and full moons). Site visits confirmed that wave overwash of the beach berm was the mechanism of saltwater influx into the lagoon. Wave-smoothed sand and kelp debris were observed on both sides of the berm. The water level in the lagoon is always higher than the average water level in the ocean; therefore, seawater cannot seep steadily through the berm and into the lagoon. The fairly high coincidence of historical salinity peaks in the wells with full or new moons suggests that the wells induce seepage out of the lagoon and that the subsurface travel time from the lagoon to the wells is rapid (less than 2 days). Given the shallow depths of the irrigation wells and the presence of a laterally extensive shallow clay horizon, direct intrusion of seawater to the wells (i.e., saltwater flowing beneath an entirely freshwater lagoon) is considered very unlikely. Also, the freshwater head (water level) in the lagoon appears to be at least 1 foot above sea level. If this head is uniform throughout the thickness of the aquifer (i.e., vertical flow in the aquifer is negligible near the lagoon and beach berm), it is sufficient to repel seawater intrusion to a depth of 40 feet in the aquifer, which includes all of the aquifer strata above the clay layer.

mention ranch salinity control level 1 mmho

In addition effect of pumping on salinity are limited due to cessation of pumping at 1 mmoh of salinity

Chapter 1. Introduction

PROJECT BACKGROUND AND PURPOSE

In 1992, the El Sur Ranch filed Application 30166 with the State Water Resources Control Board (SWRCB) to appropriate 1,800 acre-feet per year (af/year) of Big Sur River underflow at a combined maximum pumping rate of 5.84 cubic feet per second (cfs) from two agricultural wells. The project involves the continued pumping of water via these two agricultural wells located in Andrew Molera State Park on the north side of Big Sur River on the central-California coast (Figure1). The use of the wells predates the formation of the park in 1971, when land for the park was deeded to the California Department of Parks and Recreation (DPR) by El Sur Ranch. Continued operation of these private wells within the state park boundary is authorized under an easement granted to El Sur Ranch by DPR. The amount of pumping has been essentially the same since the mid-1950s. The beneficial use of the water is for pasture irrigation.

The water rights application was protested by the California Department of Fish Game (DFG), DPR, and California Sportfishing Protection Alliance because of the possible effects of groundwater pumping on the flow of Big Sur River and lagoon, and the possibility of impacts on riparian vegetation, steelhead trout, and other aquatic organisms.

This study was undertaken to address the issue of hydraulic continuity between the El Sur Ranch wells and the Big Sur River, which was determined to be the priority issue. The purpose and objectives of this investigation were to:

- determine the extent, if any, to which irrigation pumping from the El Sur Ranch wells may influence surface flows, depth, and water quality of the Big Sur River and its lagoon;
- develop a credible, systematic description of the seasonal variation in lagoon conditions such that the effect, if any, of the pumping on lagoon habitat can be reasonably evaluated; and

- determine the extent, if any, to which pumping from El Sur Ranch wells may affect groundwater levels in Creamery Meadow and affect the ability of riparian forest species to become established and survive.

Accordingly, the report was organized to measure, compile, and analyze basic data (Chapter2) to address the following key questions using all relevant information regarding the hydrologic system (Chapter 3):

- Are the groundwater system and Big Sur River hydraulically coupled?
- What is the source of the water pumped by the El Sur Ranch wells?
- Does well pumping decrease flow, stage, or velocity in the river and lagoon?
- Does well pumping affect groundwater levels and riparian vegetation in Creamery Meadow?
- What is the source of salinity in the lagoon and the El Sur Ranch wells?
- What caused the river to dry up in 1990?

Technical Memorandum 1 (TM1), dated August 1997, was prepared to document the proposed data-collection plan and the results of the preliminary data evaluation. TM1 provided an inventory and evaluation of available historical data, documented available reference material, presented an evaluation of local hydrogeology, documented the results of the initial geophysical survey and drilling, and described a proposed hydrologic testing and monitoring program.

This report presents all available hydrologic and geomorphologic information relevant to the main issues identified above. This information includes historical data (e.g., precipitation, streamflow, pumping, electrical conductivity of pumped water), recent monitoring data collected for this study (river, lagoon, and well-water levels and conductivity from 1997 through 1998), and the results of aquifer tests conducted for this study. Because the conclusions regarding the main issues often draw on multiple types of data, the discussion of the issues follows a comprehensive presentation of the basic data.

Chapter 2. Measurement, Compilation, and Analysis of Basic Data

PHYSIOGRAPHY

The project site is located near the mouth of Big Sur River in Andrew Molera State Park on the central California coast south of the city of Monterey (Figure 1). The El Sur Ranch is located north of the Andrew Molera State Park on raised marine terraces. The Big Sur River watershed is in the Santa Lucia Mountains, where the river flows westerly through steep terrain. The stream gradient drops significantly after entering the valley at the Pfeiffer Burns Campground, where the river changes course and runs northwesterly and parallel to State Route 1, as shown on Figures 2 and 3. As it flows through Andrew Molera State Park, Big Sur River turns abruptly west about 0.75 mile before it empties into the ocean. Beyond the turn, the river enters a gently sloping floodplain surrounded by the marine terraces. Several hundred yards before it enters the ocean, Big Sur River forms a lagoon contained by a transient sandbar. The irrigation wells are located a few hundred feet from the north bank of the river, directly across from Creamery Meadow and approximately 1 mile west of State Route 1.

HISTORY OF GROUNDWATER USE AND AGRICULTURAL ACTIVITIES

The old El Sur Ranch irrigation well number 1 (Figure 3) was constructed in the mid-1950s. According to a pumping test conducted by Pacific Gas and Electric Company (PG&E) in 1992, this well has a pumping capacity of roughly 1,500 gallons per minute (gpm). The pumping rate measurement was approximate because of nonideal wellhead plumbing for measuring flows. The second of the two active irrigation wells (El Sur Ranch well number 5, identified as map symbol 5 on Figure 3) was constructed in 1985 under terms of the easement with DPR. The maximum pumping rate measured during this investigation was 1,150 gpm. Water from the two wells is pumped up to El Sur Ranch through two mains joined into a single main that continues to the upper pastures. A series of laterals and sublaterals provides water to checks, where it is used to irrigate roughly 290 acres of pasture by flood irrigation. Flood irrigation is a widely accepted agricultural practice in California and is considered a beneficial use of water. This beneficial use has continued at the El Sur Ranch since the irrigation system was engineered and constructed in the 1950s.

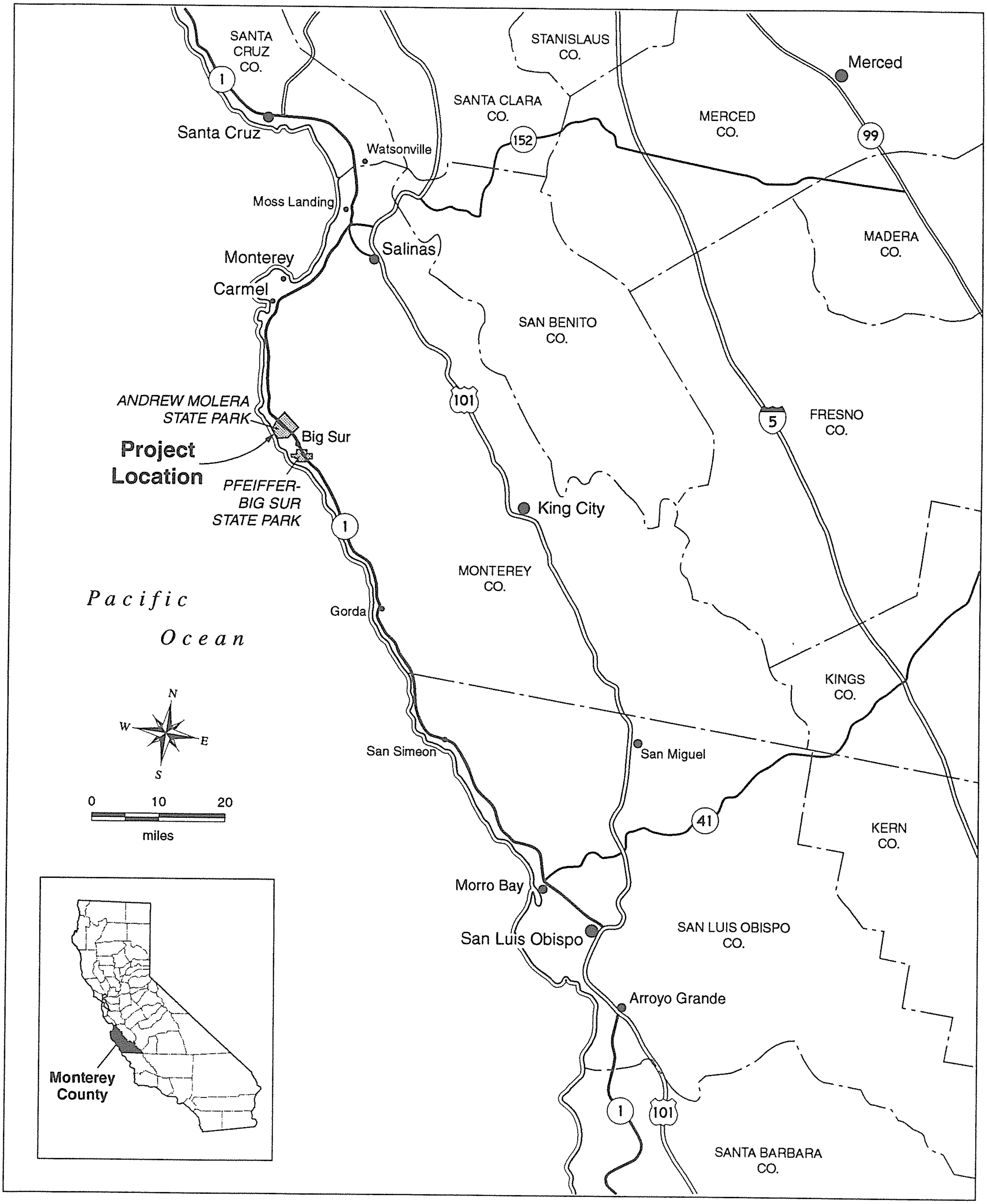

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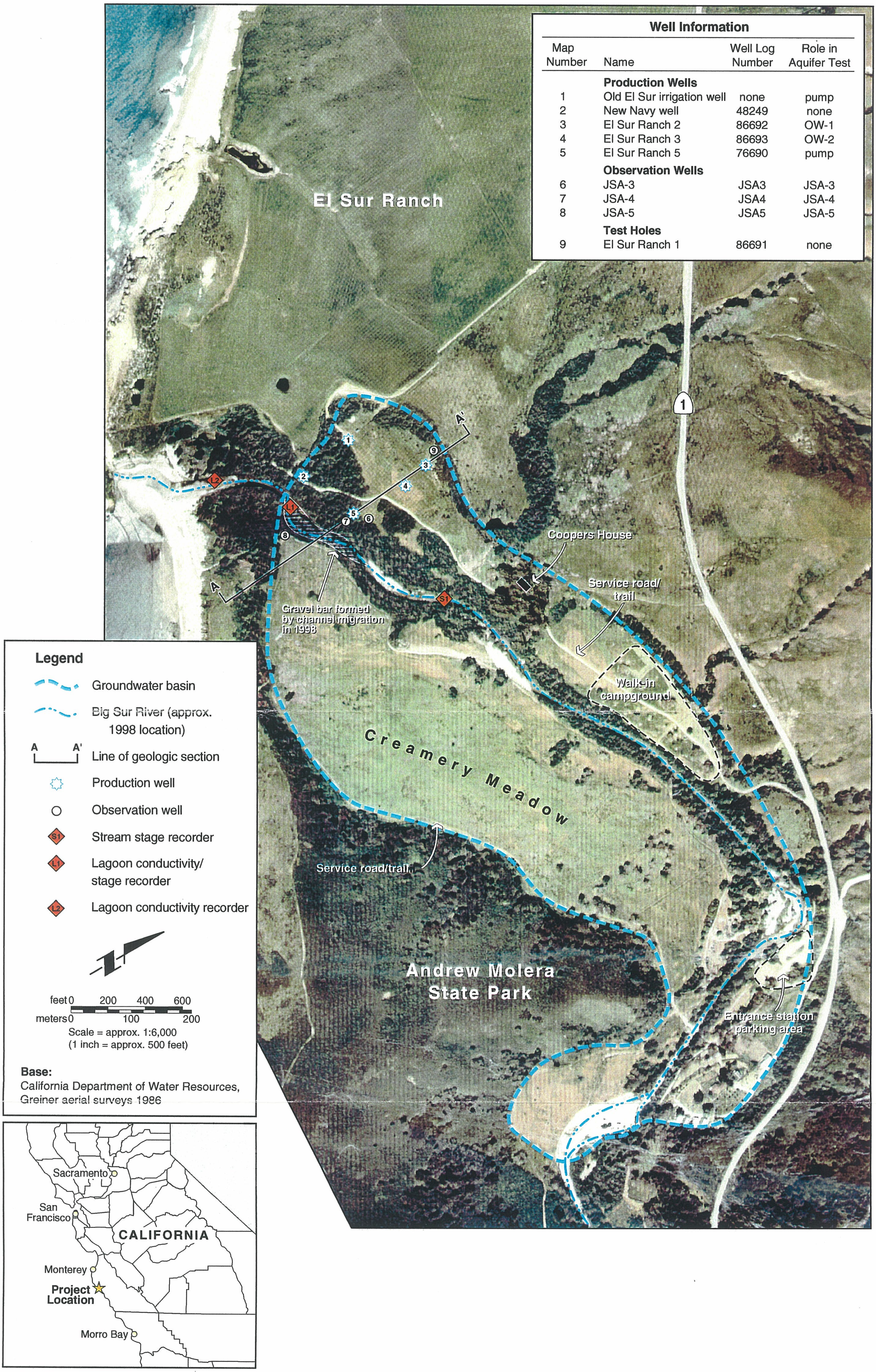
Figure 1
General Site Location



Well Information

Map Number	Name	Well Log Number	Role in Aquifer Test
	Production Wells		
1	Old El Sur irrigation well	none	pump
2	New Navy well	48249	none
3	El Sur Ranch 2	86692	OW-1
4	El Sur Ranch 3	86693	OW-2
5	El Sur Ranch 5	76690	pump
	Observation Wells		
6	JSA-3	JSA3	JSA-3
7	JSA-4	JSA4	JSA-4
8	JSA-5	JSA5	JSA-5
	Test Holes		
9	El Sur Ranch 1	86691	none

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Figure 3
Locations of Groundwater Basin, Wells, and Monitoring Network

PRECIPITATION AND CLIMATE

The area has a Mediterranean climate with cool, wet winters and dry summers. Winter storms approaching the Santa Lucia Mountains experience orographic uplift, resulting in high amounts of precipitation in the upper Big Sur watershed, compared to inland areas in the rain shadow of the mountains or to coastal locations lower in the watershed. Fog and high winds are typical along the Big Sur coast during summer months. The fog and wind dominate the microclimate of the Big Sur area, lowering the morning and evening temperatures and reducing solar radiation. There are strong prevailing southerly winds from midday into late afternoon.

Daily and monthly precipitation records for the U.S. National Weather Service rain gage located at Big Sur State Park (an elevation of 240 feet above sea level) were used in this investigation to characterize seasonal and long-term climatic trends, evaluate the relationship between streamflow and precipitation, and develop a water budget for the lower reach of the river. Data are available from 1914, although records for 1913, 1981, and 1982 are incomplete. Table A1.1 in Appendix A presents monthly precipitation data for each calendar year for the period of record and Table A1.2 shows the same data sorted by annual total precipitation. Annual precipitation is plotted in Figure4, with colored bars indicating the classifications for each year as either dry, below normal, normal, above normal, or wet. The data show that the year when the lower Big Sur River was observed to become intermittent (1990) was the second driest year on record. Annual precipitation was only 18 inches, or 46% of the long-term average of 39.7 inches. The two preceding years were also classified as 'dry'.

STREAMFLOW

Historical Gaged Flows at Pfeiffer-Big Sur State Park

The U.S. Geological Survey (USGS) has operated a stream gage at Pfeiffer-Big Sur State Park since 1950. The gage is located approximately 7 miles upstream of the El Sur Ranch wells. Streamflow in Big Sur River is characterized by high peak flows in response to rainfall followed by recession to a base flow that persists throughout the dry season. The base flow is supported by gradual drainage of water stored in bedrock fractures and unconsolidated alluvial deposits in the upper watershed, which has a total area of 46.5 square miles. The magnitude of summer base flow in a given year appears to be related primarily to total precipitation during the preceding winter. This relationship can be seen in Figure 5, which shows daily rainfall and daily streamflow at the USGS gage during calendar years 1989-1996. The pristine upper watershed is almost entirely undeveloped; there are no reservoirs or major diversions above the USGS gage. Streamflow is somewhat depleted as a result of domestic well pumping along the reach between the gage and Andrew Molera State Park.

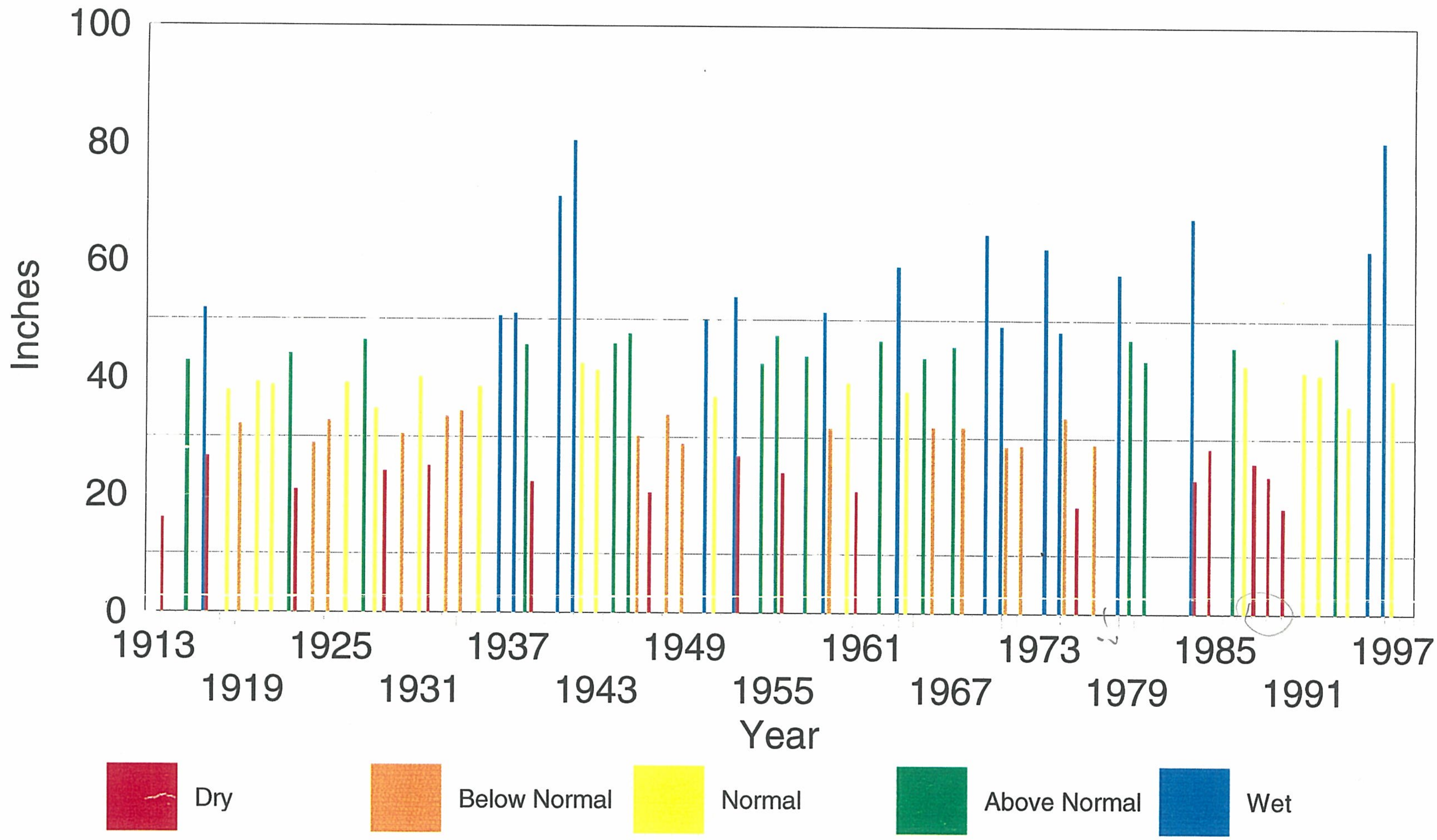

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Figure 4
Annual Precipitation at Big Sur Classified by Type of Year (Inches)

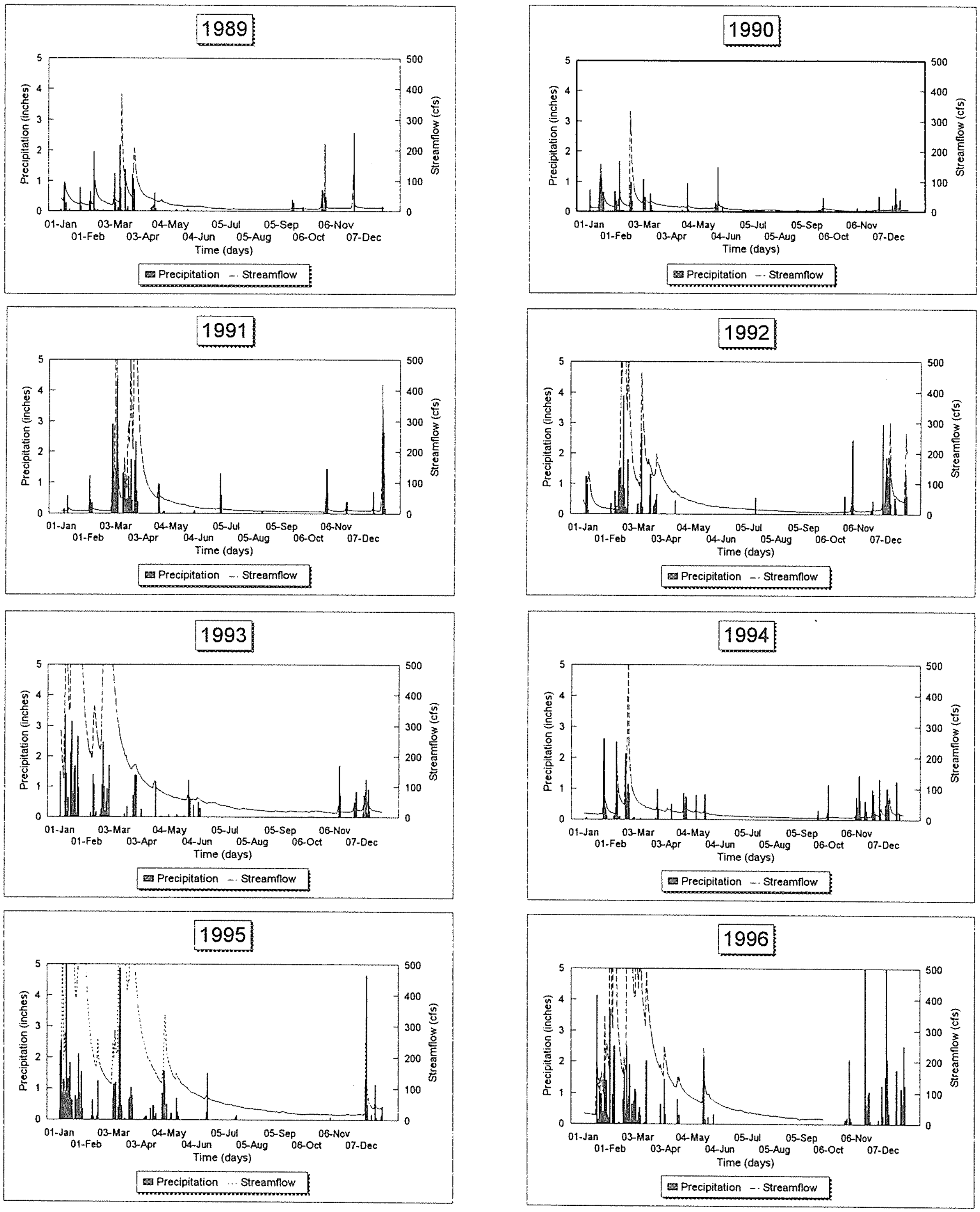

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Figure 5
Historical Precipitation at Pfeiffer Big Sur State Park and Streamflow of the Big Sur River near Big Sur

Monthly flow statistics for the period of record are presented in Table 1. Mean monthly flows in June, July, and August, 1998, were the highest recorded for those months. The minimum mean monthly flow for almost all months was in water years 1977 or 1991. The smallest 7-day minimum flow of record was 2.9 cfs in November 1990, occurring shortly after the period of intermittent flow in Andrew Molera State Park. Flow-duration curves of daily flows in June, July, August, and September are shown in Figure 6 and indicate the frequency distributions of daily flows in those months. The flow at the USGS gage in July and August 1990 (when intermittent flow was reported downstream of the gage) was 5 cfs. The curves indicate that base flow in those months exceeded 5cfs 96-98% of the time. In other words, the flows in July and August 1990 were exceptionally low.

Table 1. Statistics of Mean Monthly Flows from Water Years 1950 Through 1998

	Mean Monthly Flow	Maximum Mean Monthly Flow		Minimum Mean Monthly Flow	
	(cfs)	(cfs)	Water Year	(cfs)	Water Year
October	17.3	86.8	1963	5.08	1991
November	45.3	302	1951	4.97	1991
December	105.7	449	1956	7.52	1991
January	249.3	1047	1997	8.27	1991
February	285.2	1328	1998	11.4	1977
March	226.1	964	1983	16.8	1977
April	145.7	843	1958	9.15	1977
May	68.2	333	1983	8.7	1977
June	39.1	117	1998	6.17	1977
July	23.9	71.4	1998	4.94	1977
August	17.4	42.9	1998	3.8	1977
September	15.3	39.4	1983	4.52	1961

River and Lagoon Stage from 1997 Through 1998

River and Lagoon Stage from 1997 Through 1998

Water-level recorders were installed at two locations in the Big Sur River and lagoon near the El Sur Ranch wells during summer 1997 to investigate the effects of tidal fluctuations and normal pumping operations on stage. The recording equipment for stations S1 and L1 is described in Table 2, and the station locations are indicated in Figure 3. Station S1 was located in a pool upstream of a riffle and above the area influenced by tidal variations in lagoon stage. The location was also selected so the riffle could act as a broad, crested weir and allow for development of a rating curve. On the second site visit in November 1997, the riffle had been considerably altered by

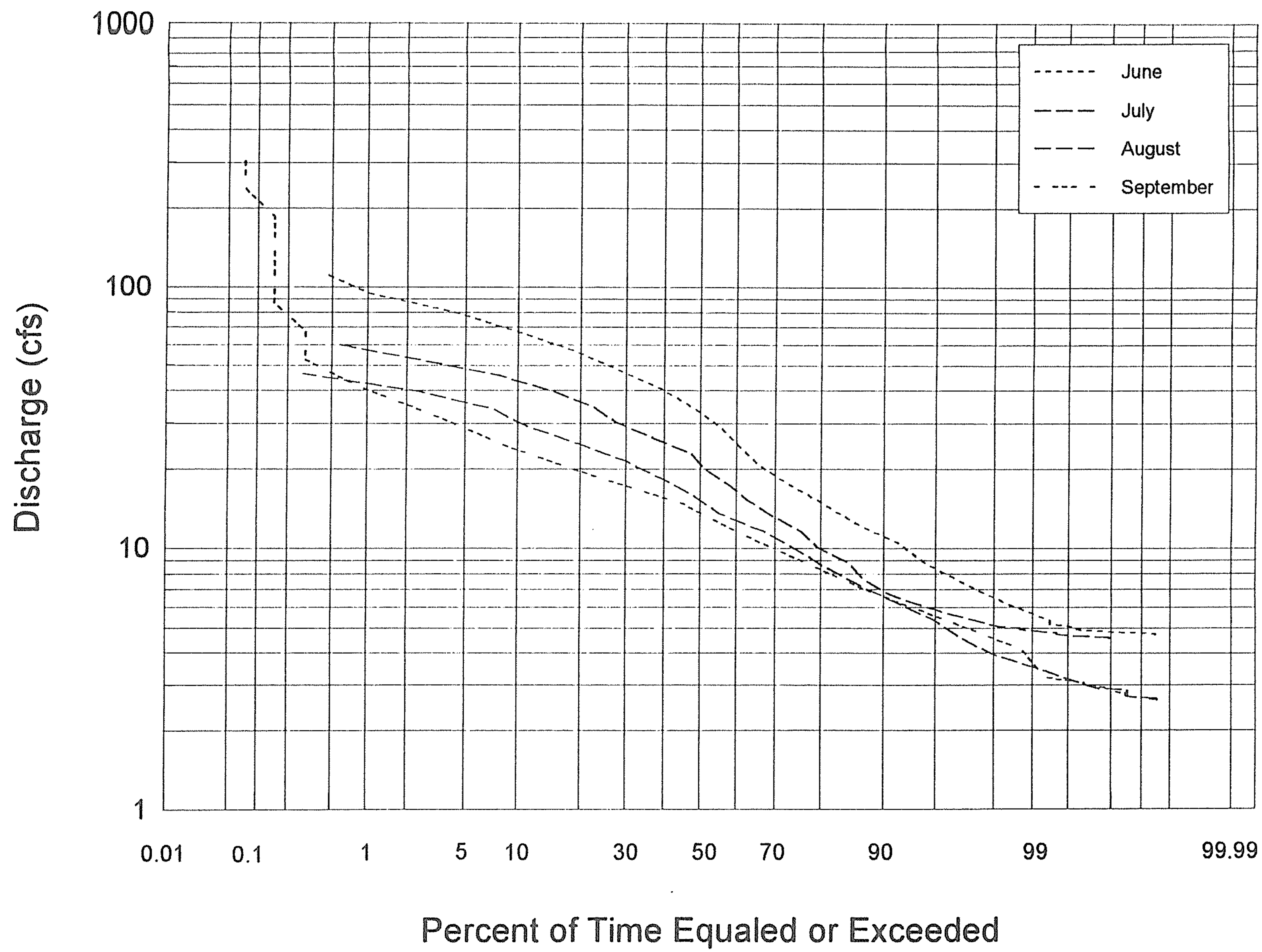

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Figure 6
Big Sur River near Big Sur, CA (USGS Gage no. 1114300)
Flow Duration Curve

park visitors who had placed rocks in the river to provide a dry foot crossing. This prevented development of a rating curve; however, manual discharge measurements were made on several occasions so that the flow could be compared with flow at the USGS gage.

Table 2. Water Level Monitoring Network

Gage ID	Map Number	Location	Period of Record	Collection Interval[1]	Instrumentation	Objectives and Purpose
S1	S1	Big Sur River	8/22/97-10/12/97 7/16/98-10/1/98	1 hour	Global Water WL-14 ™ data logger with pressure transducer (0-3 ft)	Identify pumping related strea depletion.
L1	L1	Upstream end of lagoon	8/22/97-10/12/97 7/16/98-10/1/98	1 hour	Global Water LS4™ multichannel data logger with stage and conductivity probes (0-3 ft and 0-20K μSeimens)	Identify pumping related lago depletion and source of salinit
L2	L2	Downstream end of lagoon	7/16/98-10/1/98	1 hour	Global Water Analogger 100™ data logger and conductivity probe (0-20K μSeimens)	Identify source of salinity
OW1	3	Existing well north side of river	8/22/97-10/1/98	1 hour	Global Water WL-14 ™ data logger with pressure transducer (0-14 ft)	Evaluate an inferred no flow boundary condition
OW2	4	Existing well north side of river	8/22/97 - 1/5/98	1 hour	Global Water WL-14 ™ data logger with pressure transducer (0-14 ft)	Evaluate an inferred no flow boundary condition
JSA3	6	New monitoring well, north side of river	7/16/98-10/1/98	1 hour	Global Water WL-14 ™ data logger with pressure transducer (0-14 ft)	Provide drawdown and recove data during the aquifer test
JSA4	7	New monitoring well, north side of river	7/16/98-10/1/98	1 hour	Global Water WL-14 ™ data logger with pressure transducer (0-14 ft)	Evaluate the recharge effects c stream
JSA5	8	New well in Creamery Meadow	7/16/98-10/1/98	1 hour	Global Water WL-14 ™ data logger with pressure transducer (0-14 ft)	Identify relationship between pumping and groundwater lev the area south of the river

Notes: 1 Data loggers have adjustable recording intervals. During the pump test they were all set to record data at 1 minute intervals.

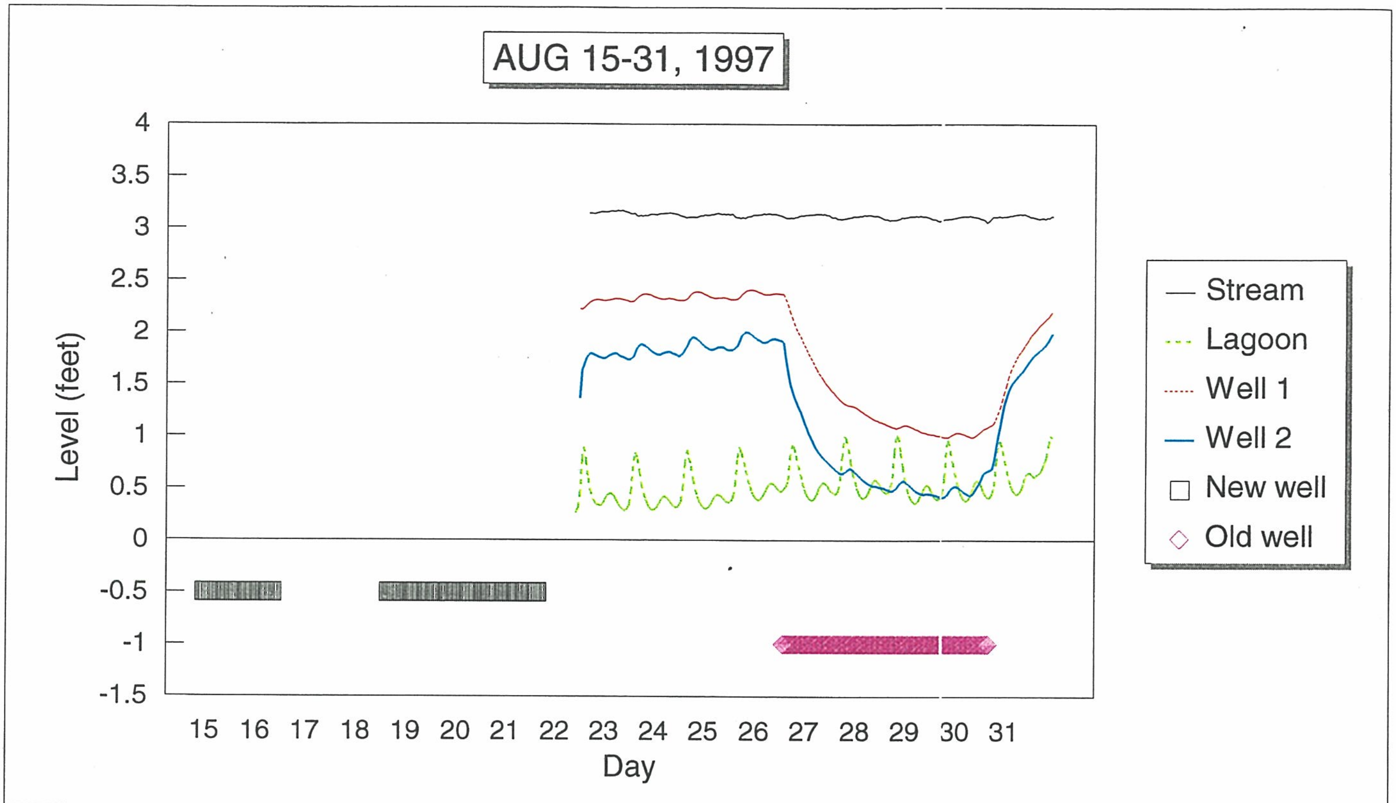
The recording stations were intended to remain in operation until the completion of field activities in October 1998; however, a major storm in early February 1998 caused substantial erosion along the lower Big Sur River and many other central coast streams. State Route 1 was closed as a result of landslides and did not reopen until June, preventing installation of the balance of the monitoring wells and collection of data from the instruments installed the previous summer. Big Sur River scoured its banks on both sides downstream of the 90° bend near the Andrew Molera State Park entrance. The river near the El Sur Ranch wells migrated approximately 60-80 feet southward, encroaching into Creamery Meadow and destroying stations S1 and L1 and monitoring well JSA-5. Parts of the well seal and box were found in the river, but none of the equipment from the stream and lagoon monitoring stations was recovered. New monitoring equipment was ordered and installed in July 1998.

The results of the manual discharge measurements are shown in Table 3. On four of the five measurement dates, flow at station S1 was within 0.4-1.7 cfs (3-5%) of flow at the USGS gage. These differences are on the same order of magnitude as the accuracy of the streamflow measurements, so the differences may not be significant. On the first measurement date (August 22, 1997), flow at station S1 was 8.9 cfs lower than at the USGS gage. The cause of the large flow loss on that date has not been determined. The combined pumping rates of the new El Sur Ranch well (1,500 gpm) and the old El Sur Ranch Well (1,050 gpm) are equivalent to a flow of 6 cfs. Only the new well pump was turned on close to the time of the August 22, 1997 measurement, but even if both well pumps had been on, their combined pumping could not have caused the observed flow difference.

Table 3. Big Sur River Flow Data Collected at Andrew Molera State Park and the USGS Gage

Date	Andrew Molera State Park (Station S1)	USGS Gage @ Pfeiffer Big Sur State Park
August 22, 1997	10.1 cfs	19 cfs
November 11, 1997	15.4 cfs	15 cfs
September 16, 1998	27.4 cfs	29 cfs
September 23, 1998	29.3 cfs	31 cfs
September 25, 1998	29.5 cfs	32 cfs

Hydrographs showing stage at stations S1 and L1 from August 22 through November 15, 1997, are shown in Figures 7a-c, and data for July 23-October 1, 1998 are shown in Figures 8a-c. Also shown in the figures are the periods of operation of each of the El Sur Ranch irrigation wells and water levels in two monitoring wells. A local datum is used for each well and stream station, so the hydrographs indicate only the magnitude and timing of water-level fluctuations. The difference in water levels among the stations or between the stations and sea level is not shown in the figures.



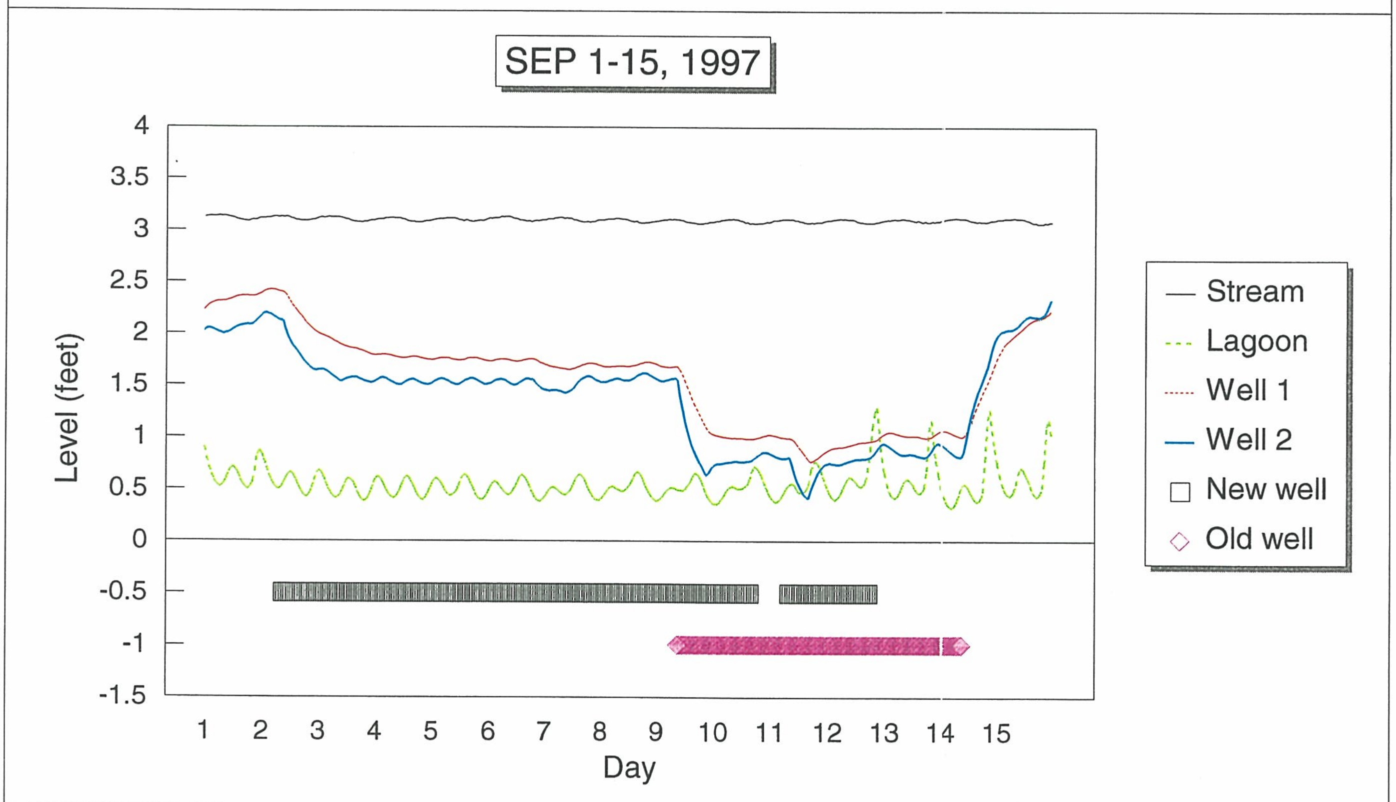


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Figure 7a
Period of Operation for Old and New Irrigation Wells and Water Levels Measured at Selected Monitoring Wells, Big Sur River, and Big Sur River Lagoon during 1997

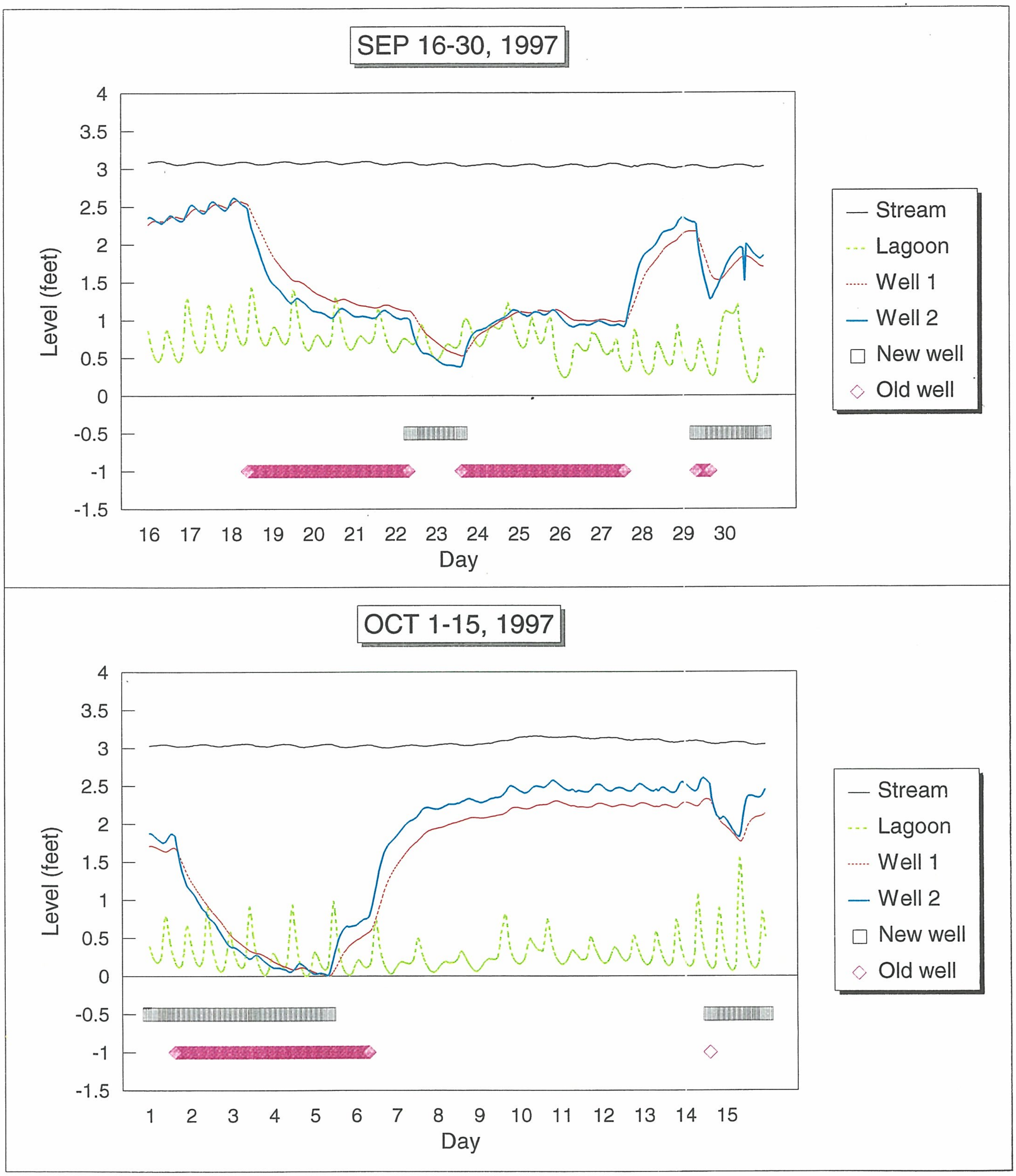

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Figure 7b
Period of Operation for Old and New Irrigation Wells and Water Levels Measured at Selected Monitoring Wells, Big Sur River, and Big Sur River Lagoon during 1997

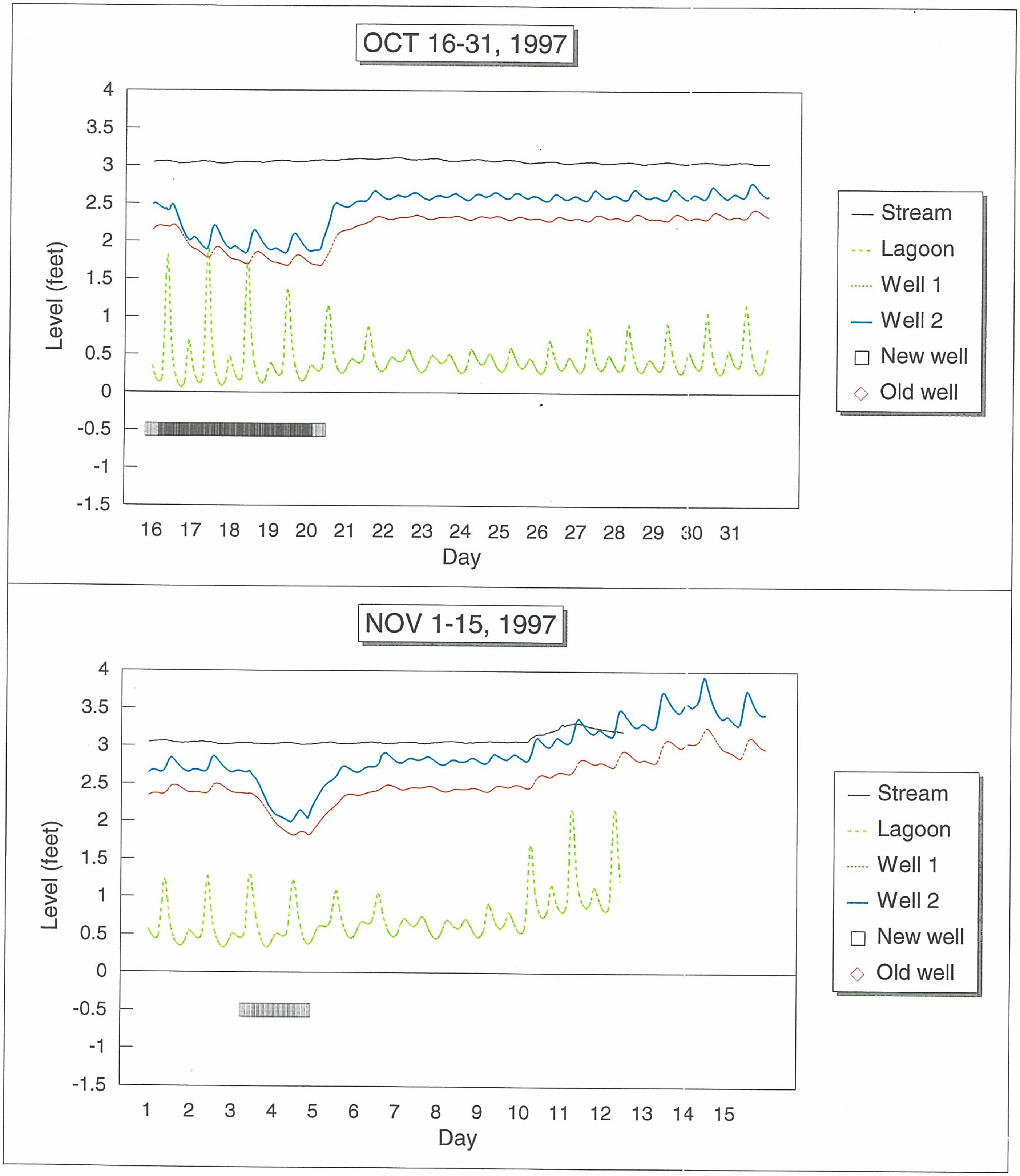

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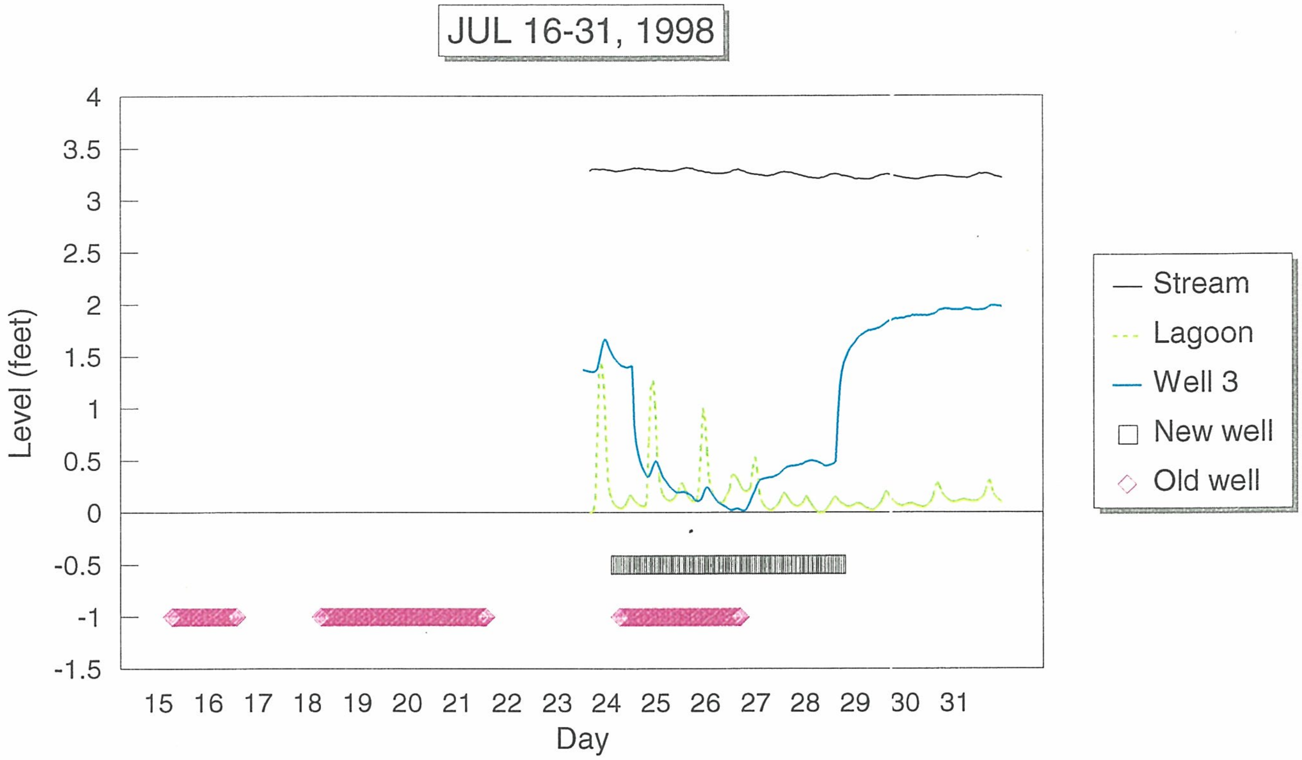
Figure 7c
Period of Operation for Old and New Irrigation Wells and Water Levels Measured at Selected Monitoring Wells, Big Sur River, and Big Sur River Lagoon during 1997



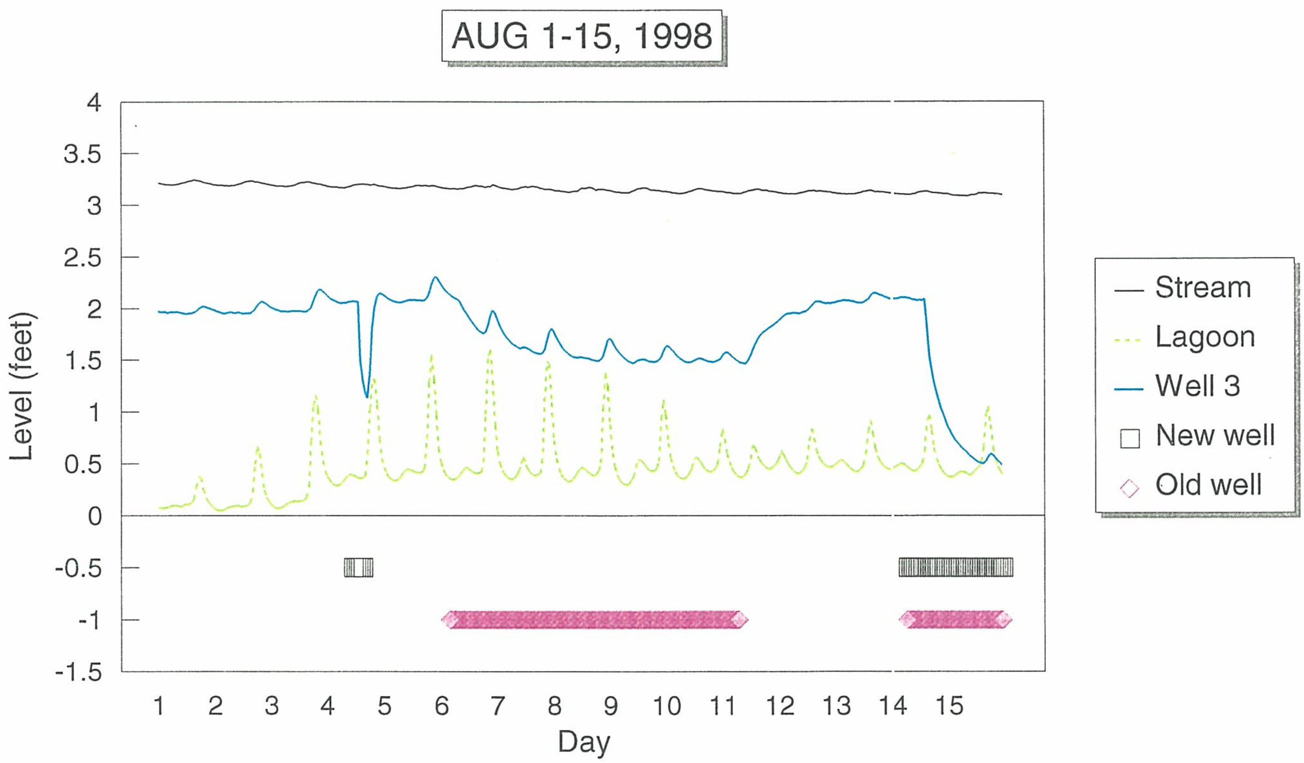


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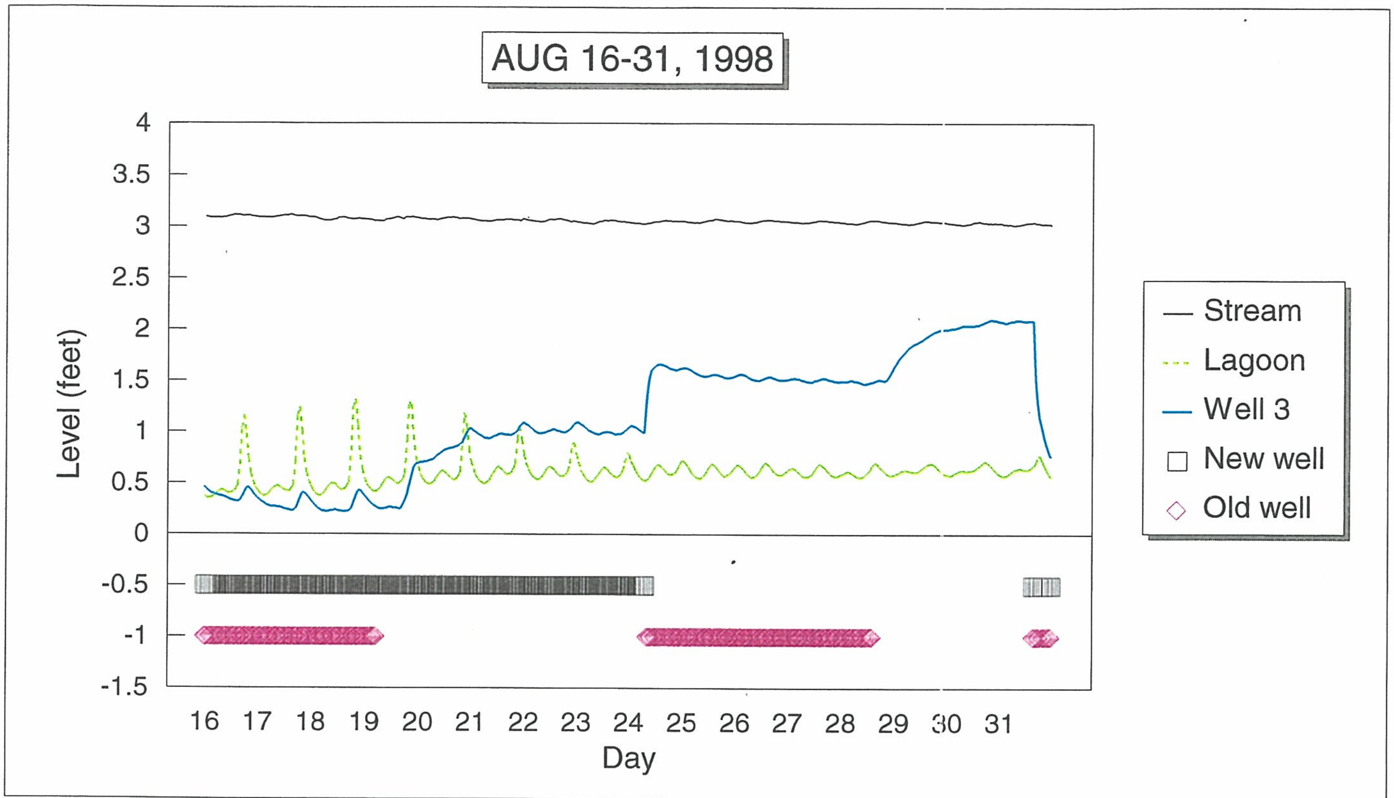
Figure 8a
Period of Operation for Old and New Irrigation Wells and Water Levels Measured at Selected Monitoring Wells, Big Sur River, and Big Sur River Lagoon during 1998



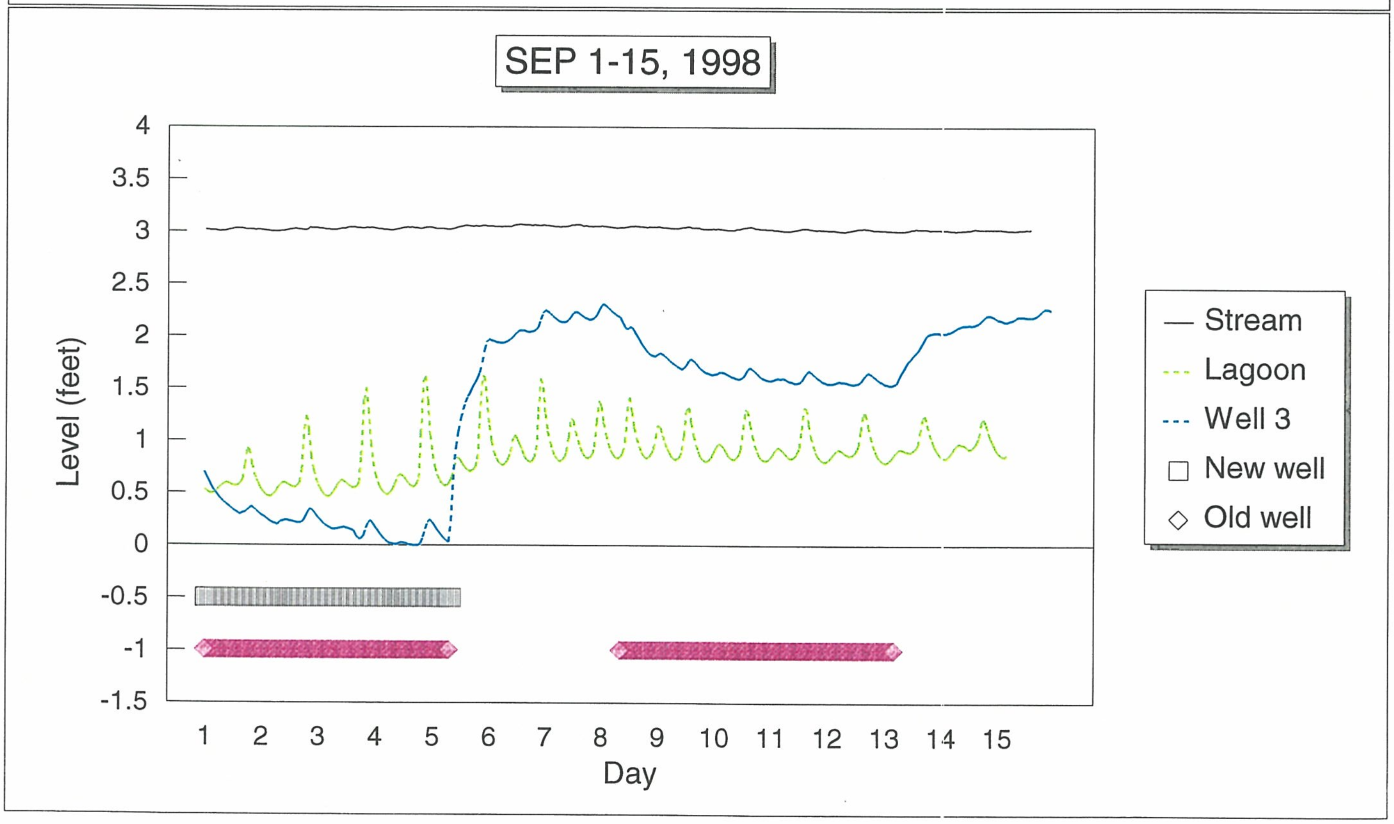


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Figure 8b
Period of Operation for Old and New Irrigation Wells and Water Levels Measured at Selected Monitoring Wells, Big Sur River, and Big Sur River Lagoon during 1998

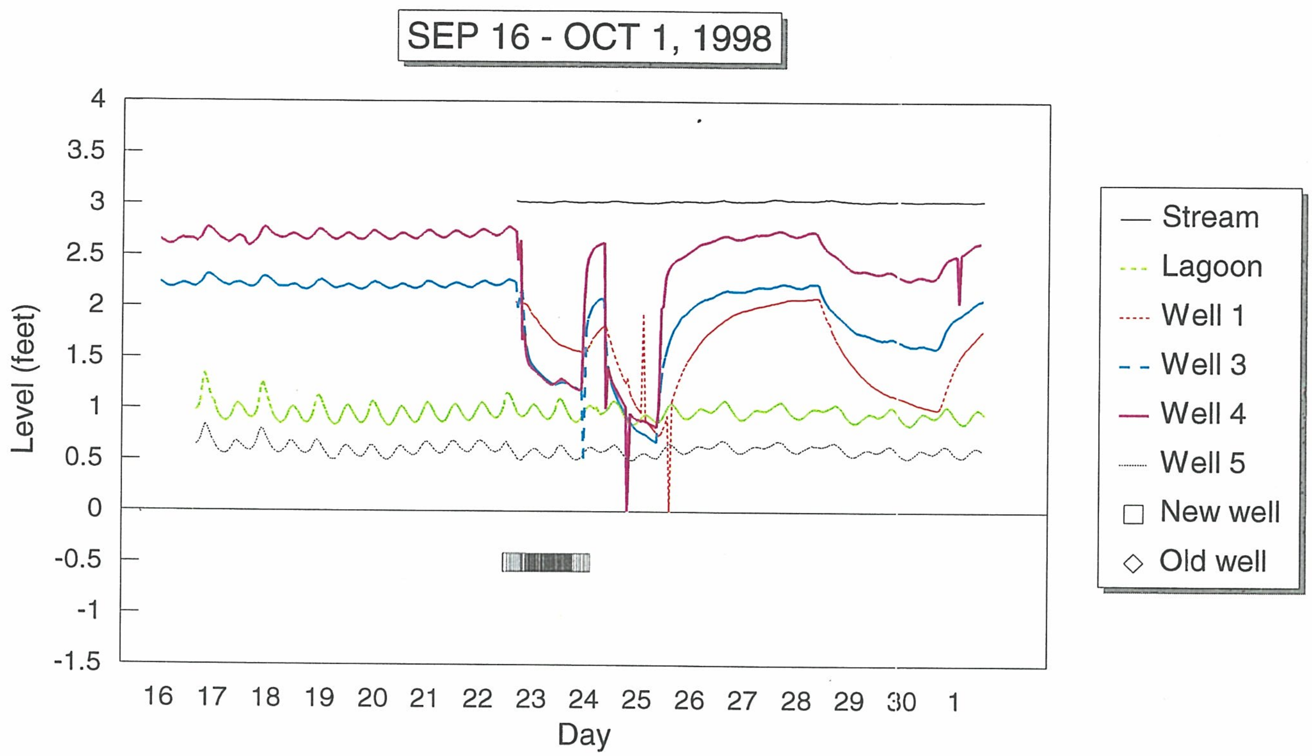

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Figure 8c
Period of Operation for Old and New Irrigation Wells and Water Levels Measured at Selected Monitoring Wells, Big Sur River, and Big Sur River Lagoon during 1998

The hydrographs of stream stage reveal small diurnal stage fluctuations on the order of 0.05foot that are probably the result of flow depletions from open-water evaporation and transpiration by phreatophytic vegetation along the riverbanks. The stream stage fluctuations follow a strict daily pattern, with a minimum stage at approximately 6:00 p.m. In contrast, the lagoon stage exhibits a classic tidal pattern, with 12.5-hour stage cycles up to 0.8 foot in magnitude. A comparison of the pump operation periods with the stage hydrographs indicates that pump operation has no measurable effect on stage in the river or lagoon.

The hydrograph of lagoon stage during 1998 gives evidence that lagoon stage during the dry season is controlled primarily by the height of the beach berm between the lagoon and the ocean. The average lagoon stage increased stepwise throughout the monitoring period from approximately 0.2 foot (above the local station datum) in July (Figure 8a) to approximately 1.0 foot in September (Figure 8b). The upward shifts occurred around August 4 and September 5, which coincided with some of the highest high tides in each month (see "Water Quality" below for additional data regarding lagoon stage and wave overwash during 1998). The incremental shifts in lagoon stage are on the order of 3-4 inches and can be explained by seasonal berm-building processes at the mouth of the river. For creeks and rivers on the central California coast, the first major runoff event in winter typically generates flows large enough to wash out the beach berm that separates the lagoon from the ocean during the dry season. Periodic high flows in response to storm events prevent the berm from reforming during winter. Large waves associated with these storms also tend to erode and steepen the beach faces, storing the sand in nearshore sandbars. In summer, streamflow recedes to a low, steady rate, and the smaller waves in summer tend to move sand from the offshore bars back onto the beach. This depositional process overpowers the erosive capacity of the stream, and a berm is gradually built up between the lagoon and the ocean. The water-level data collected for this study support the conclusion that this berm-building process is the principal factor affecting lagoon stage during the dry season.

On a daily basis, the stage, area, and inland extent of the lagoon fluctuate in response to the tides. As the tide rises, the lagoon elevation rises because the water level gradient across the beach berm decreases, thereby decreasing the rate of seepage through the berm and creating a backwater effect within the lagoon. Surface outflow from the lagoon is controlled by the elevation of the crest of the beach berm where lagoon water overflows into the ocean and by the water level in the lagoon. During site visits for this study, the inland extent of the lagoon was observed to shift horizontally as many as 90-120 feet in response to tidal fluctuations.

Lower Big Sur River Water Budget

A surface-water budget was developed for the lower Big Sur River below the USGS gage to determine the relative importance of tributary inflow, diversions, return flows, and seepage gains and losses as factors influencing dry-season base flow in Andrew Molera State Park. Monthly water budgets were developed to avoid issues related to runoff timing and transient bank storage that would decrease the accuracy of daily budgets. Available estimates of average annual yield of each of the small tributary watersheds downstream of the USGS gage (U.S. Geological Survey 1996) and isohyetal maps of average annual rainfall supported an assumption that runoff per unit area and per inch of precipitation is the same above and below the gage. The rainfall, watershed area, and annual yield data are summarized in Table 4.

Table 4. Tributary Flows to the Big Sur River below the USGS Gage

Stream	Baseflow (gallons per minute)	Average Annual Yield (acre-feet)	Basin Area (sq. miles)	Average Annual Precipitation (in.)
Big Sur River	2,510	171,590	58.5	55
Pheneger Creek	0	1,730	0.8	40
Juan Higuera Creek	367	4,200	1.8	43
Pfeiffer-Redwood Creek	57	2,200	1.0	42
Pfeiffer Creek	0	270	0.1	39
Post Creek	12	2,980	1.4	41

Source: U.S. Geological Survey 1996.

Numerous water right holders and others divert water from Big Sur River between the USGS gage and the project site for residential, commercial, recreation, and irrigation uses. Table 5 shows the estimated mean monthly water demand factors for each user category based on demand rates developed by Monterey County (County of Monterey 1982). Because of limited landscaping in the region it was assumed that 80% of the water diverted for nonagricultural purposes would return to the river or groundwater. Several users divert water out of the basin and none of this water was assumed to return to the watershed.

Because of the lack of small, gaged watersheds in the region and only single flow measurements made on the tributaries to the Big Sur River between the USGS gage and Andrew Molera State Park, an elaborate recession curve was not developed to estimate tributary inflow. The limited data collected by USGS on the tributaries was considered to represent base flow as these measurements were made in late summer. As a worst-case estimate of tributary inflow, the measured flows were assumed to be the minimum flow in each tributary. Monthly flow, in addition to the base flows, was estimated by multiplying the mean monthly precipitation measured at Pfeiffer Big Sur State Park by the runoff per unit area per inch of precipitation and proportionally adjusting the estimated runoff by the ratio of the average annual watershed precipitation to the average annual precipitation measured at Pfeiffer Big Sur State Park. As a result, the estimated tributary inflow may under represent the actual inflow from the end of the rainy season through the early summer (May through July).

Table 6 shows the mean monthly water budget for the lower Big Sur River under average annual climatic conditions. The budget indicates that only three of the five tributary drainages probably support perennial base flow that would contribute to Big Sur River flows in summer. Total inflow from the tributaries in late summer is on the order of 1 cfs, or 4-7% of the amount of flow at the USGS gage. Net diversions by water users amounted to only 0.03-0.04 cfs, or 0.1-0.3% of flow at the gage. These numbers indicate that there is probably a net gain in riverflow downstream of the gage, assuming groundwater storage in Andrew Molera State Park remains in steady equilibrium with the river stage. The net diversions by other users are also much smaller than the potential depletion of streamflow induced by the El Sur Ranch wells (up to 6 cfs instantaneous, perhaps 2.4 cfs averaged over a 6-month irrigation season).

Under drought conditions, diversions would most likely remain approximately the same, but tributary inflow could essentially disappear. Under extreme low-flow conditions with only 5 cfs passing the USGS gage, the net diversions would amount to approximately 0.6-0.8% of base flow, and a slight decrease in flow below the gage and upstream of Andrew Molena State Park would be expected.

Table 5. Water Use Multipliers

Item	Unit	Volume (gpd)
employees	each	15
irrigation	100 sq ft	18.5
grazing	animal	15
restaurant	seat	35
campers	each	30
store	each	100
gas station	200 cars	2000
pools	each	1000
cabin over nighters	each	50
washing machines	each	250
picnickers and back-country campers	each	5
residential units	each	200
meeting hall attendees	each	2
snack bars	each	500
bakery/nursery	each	200

Source: County of Monterey 1982.

Table 6. Average Annual Water Budget for the Big Sur River Between the USGS Gage and Andrew Molera State Park

Month	Big Sur River at USGS Gage		Pheneger Creek	Juan Higuera Creek	Pfeiffer-Redwood Creek	Pfeiffer Creek	Post Creek	Basin Exports	Diversions	Return Flow	Big Sur River at Andrew Molera State Park	
	(cfs)	(gpd)	(gpd)	(gpd)	(gpd)	(gpd)	(gpd)	(gpd)	(gpd)	(gpd)	(gpd)	(cfs)
January	223	143999411	2132846	5708675	2902032	333751	3688026	5600	66307.5	53046	158745880	251
February	267	172501988	1686939	4625699	2312444	263975	2920625	5600	66307.5	53046	184292809	292
March	220	142125092	1284258	3647705	1780010	200963	2227616	5600	66307.5	53046	151246782	239
April	146	94297639	0	528624	81936	0	17424	5600	66307.5	53046	94906762	150
May	66	42469485	0	528624	81936	0	17424	5600	67462.5	53970	43078377	68
June	36	23060587	0	528624	81936	0	17424	5600	122014	97611	23658569	37
July	23	14755415	0	528624	81936	0	17424	5600	122014	97611	15353397	24
August	17	10883977	0	528624	81936	0	17424	5600	122014	97611	11481958	18
September	15	9707680	0	528624	81936	0	17424	5600	66307.5	53046	10316803	16
October	18	11362251	0	528624	81936	0	17424	5600	66307.5	53046	11971374	19
November	47	30073126	1446923	4042771	1995089	226417	2507560	5600	66307.5	53046	40273025	64
December	102	65924326	1843917	5006951	2520003	288539	3190782	5600	66307.5	53046	78755656	125

GEOMORPHOLOGY

A reconnaissance-level geomorphology evaluation was conducted on October 1, 1998, by Mussetter Engineering to describe the processes governing stream channel formation and evolution (Appendix B). This report describes flow regime and channel morphology characteristics that influence stream percolation and stream/aquifer interactions.

In 1990, bank restoration activities took place at the 90° bend in the river within Andrew Molera State Park. The river was rerouted over the bar and the stream went dry downstream. The bar has a very high permeability because the larger materials settle on the inside of the river bend where flow velocities are lower than in the straight reach above the bend. The naturally high permeability could have resulted in higher percolation rates that contributed to discontinuous surface flow under the extremely low-flow conditions occurring at the time. The infiltrated streamflow contributes recharge to the groundwater basin. The riverbed materials remain coarse and permeable to the lagoon and, consequently, in 1990, groundwater was able to seep back into the river about halfway down the groundwater basin and create a reach of live flow upstream of the lagoon.

The Creamery Meadow area was also investigated during the geomorphological survey. The meadow is a fairly flat floodplain surface 6 or more feet above the low-flow river stage. The soil texture exposed along the fresh cutbank on the south side of the channel consisted of 2-3 feet of sandy surface soil underlain by coarse gravels. This stratigraphy was also found in the Creamery Meadow boreholes. The low soil moisture retention of the soil and subsoil combined with the low frequency of flood inundation creates an environment that may be too dry for natural self-regeneration of phreatophytic riparian vegetation, at least in most years.

HYDROGEOLOGY

Sources of Information

The geology of the Big Sur River valley in Andrew Molera State Park defines the boundaries of the groundwater basin and the degree of hydraulic coupling between the surface water and groundwater flow systems. Geologic information was obtained from existing regional geologic maps and reports, water-well drillers' reports for existing wells, geologic and electric logs of monitoring wells installed for this study, and a geophysical survey completed for this study.

The locations of existing and new wells along the lowermost 0.5 mile of the Big Sur River are shown in Figure 3. Monitoring well JSA-3 was drilled on November 13, 1997, using a hollow-stem auger rig. The first 5 feet consisted of sandy soil, with sand, gravel, and cobble deposits found from a depth of 5-25 feet, where a clay layer was encountered. A 2-inch-diameter plastic casing was installed with perforations at 10-25 feet below the ground surface.

Monitoring well JSA-5 located at the west end of Creamery Meadow was originally drilled on November 12, 1997, to a depth of 17 feet where further penetration was stopped by the presence of large rocks and cobbles. The lithology was similar to JSA-3, with sandy soil encountered from 0-5feet and sand, gravel, and cobbles to the completed depth of 17 feet. A 2-inch-diameter plastic casing was installed with perforations from 7-17 feet. High winter streamflow scoured the south bank of El Sur River in the Creamery Meadow area and destroyed the well. JSA-5 was redrilled and reconstructed on September 10, 1998, also using a hollow-stem auger. Beneath a surficial layer of loamy sand, loose sand, gravel, and cobbles were encountered to the total depth of the borehole (30 feet). A 2-inch-diameter plastic casing was installed with perforations at 4-24 feet below the ground surface.

Monitoring well JSA-4 was installed with a mud rotary rig on September 10-12, 1998. A clay layer was encountered at a depth of 26-30 feet. Caving sands and gravels below the clay layer precluded drilling past a depth of 55 feet. Geologic logs of the four wells and an electric borehole log of well JSA-4 are included in Appendix C.

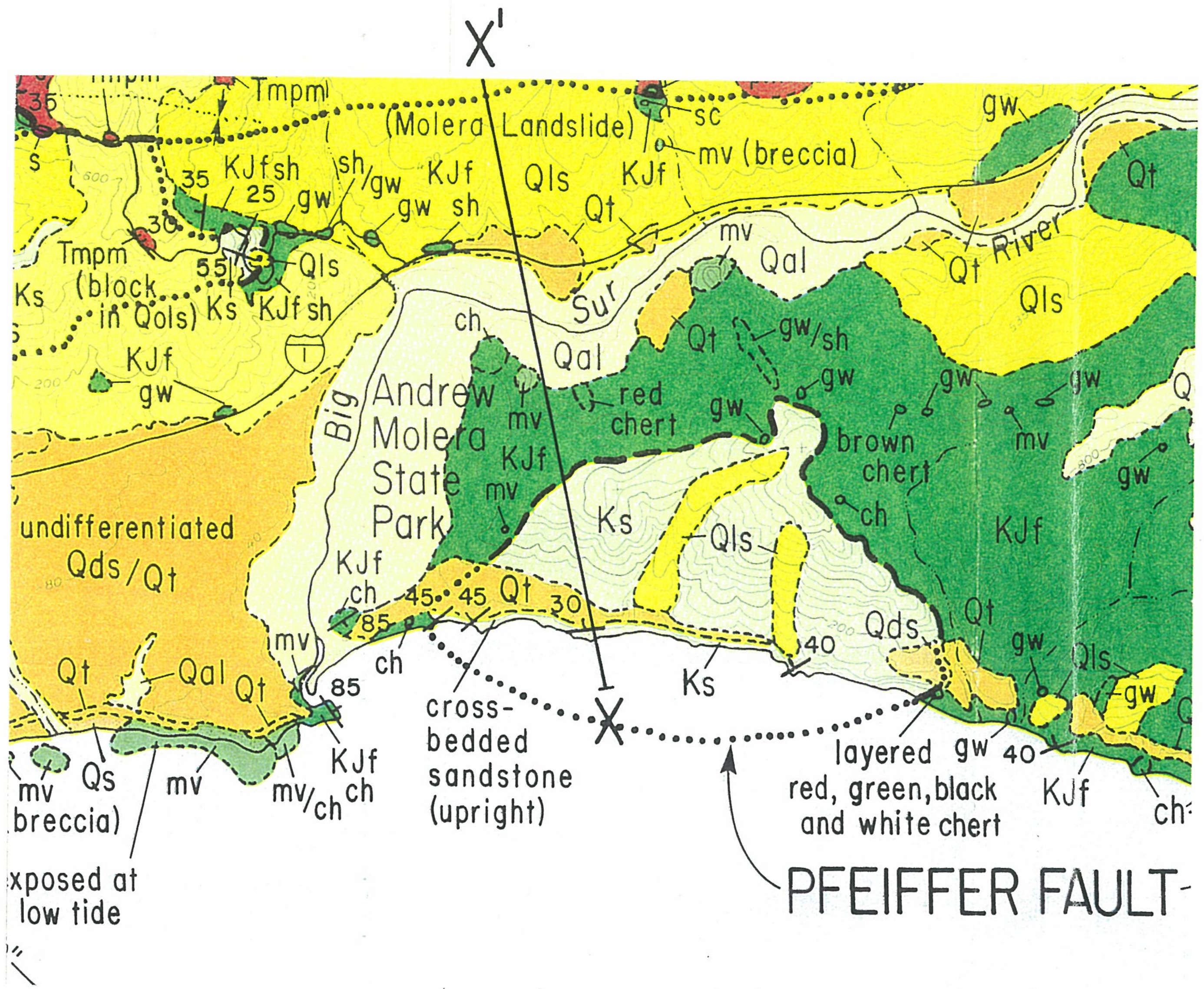
A geophysical survey consisting of 16 very low frequency electromagnetic soundings in the well field and Creamery Meadow areas was completed on July 9, 1997, and October 1, 1998. The soundings easily detected the clay layer at a depth of approximately 30 feet in most of the well boreholes. The geophysical results allowed the surface of the clay layer to be contoured throughout the lower end of the valley. A detailed description of the geophysical survey was provided in a report by Geoconsultants, Inc. (1998), which is included in Appendix D.

Boundaries of the Groundwater Basin

The groundwater basin comprises unconsolidated Quaternary alluvial deposits resting on more-consolidated and less-permeable terrace and bedrock formations, as shown on the geologic map in Figure 9 (Hall 1991). The lateral boundaries of the groundwater basin are created by the contrast in permeability between the alluvial sands and gravels and the adjoining consolidated formations. The total area of the groundwater basin is 133 acres. The basal boundary of the groundwater system tapped by the wells is, for practical purposes, the top of the extensive clay layer found within the unconsolidated deposits.

The oldest and most impermeable formation in the vicinity is the Franciscan Formation (map symbol KJf), which underlies the entire study area (as shown on the site general geologic cross section in Figure 10). It is a melange of fractured sandstone, graywacke, chert, metavolcanics, and other rock types. This bedrock formation stores and transmits small amounts of water in fractures, but its overall storage capacity and permeability are much smaller than those of the sands and gravels in the overlying groundwater basin. The Franciscan Formation forms the southern boundary of the groundwater basin. The groundwater basin is connected to the Pacific Ocean through a notch that was eroded into the Franciscan Formation by the ancestral Big Sur River. The notch is now buried at an unknown depth, but the width of the groundwater basin at the coastline is only about 500 feet.

Figure 9
Surface Geology of the Area Containing the Project Site



Explanation

Qal/Qoal — **Alluvial deposits**
Cobble-pebble gravel, sand, silt, and clay;
Qoal, older alluvial deposits

Qs/Qds — **Dune sand deposits**
Unconsolidated, white to brown, windblown sand of actively moving (Qs) and stabilized sand dunes (Qds)

Qls/Qc, Qls (i), Qls (gw), Qols — **Landslide and colluvial deposits**
Qls, rock and mudflow debris composed of material from source rocks upslope. Some small landslide deposits are omitted, and not all landslide deposits are shown in areas where Franciscan rocks crop out; dominant lithology in debris, e.g., ingneous rocks (i), graywacke (gw)
Qc, loose mass of soil and/or rock fragments
Qols, relatively older rock and mudflow debris

Qt — **Stream and marine terrace deposits**
Stream terrace deposits consist of unconsolidated cobble-pebble gravel, sand, silt, and some clay. Ages presumably Pleistocene and Holocene

QUARTERNARY

Tmp m / e — **Pismo Formation**
Tmpm, Miguelito Member; Light- to dark-colored well-bedded siltstone and claystone
Tmpe, Edna Member; Medium- to fine-grained, light- to dark-colored feldspathic sandstone. Fossils include *Leptopecten discus* (Conrad); Monian Stage, late Miocene in age

TERTIARY

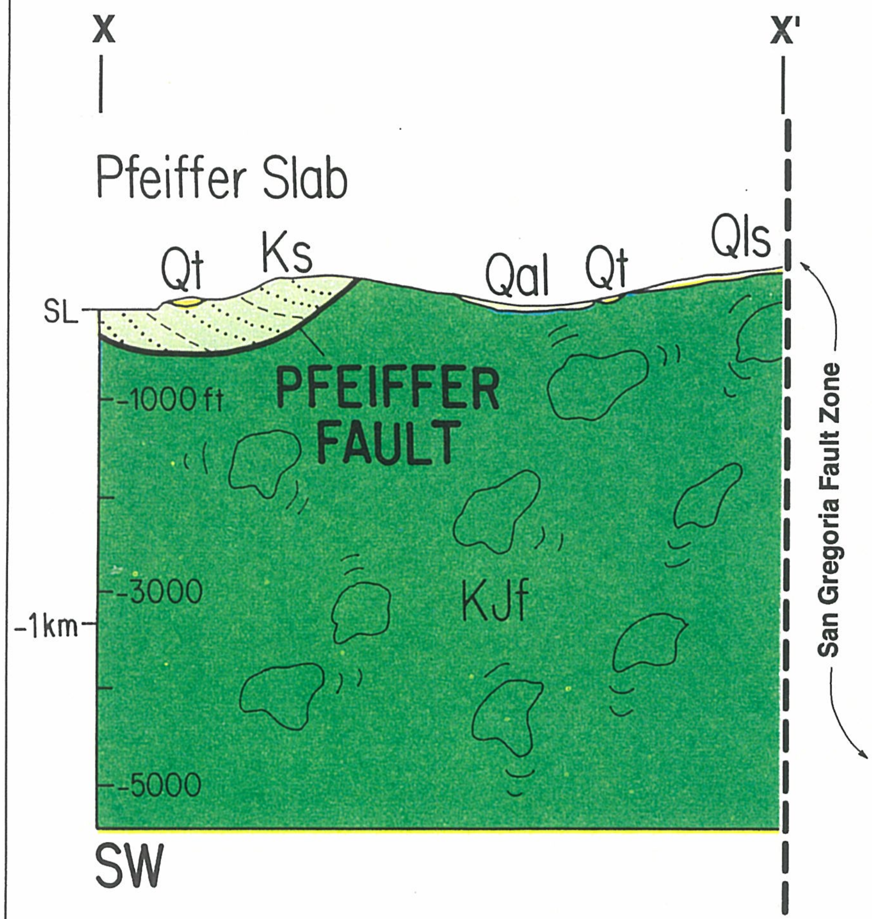
Ks — **Upper Cretaceous sedimentary rocks (Western facies)**
Medium- to coarse-grained brown-weathering gray litho-feldspathic sandstone. Well bedded but sheared. Occurs as slabs (Pfeiffer Slab). Cenomanian to Campanian ages (?)

CRETACEOUS

KJf / mv — **Cretaceous-Jurassic Franciscan melange**
Medium- to coarse-grained brown litho-feldspathic sandstone or graywacke (gw), micrograywacke (gw or sh), chert (ch), metavolcanic rocks (mv), and green (gs) and blue (bs) schist (sch). Conglomerate (cg) and silica carbonates (sc) rare. Pervasively sheared

Franciscan Complex

JURASSIC



Explanation

Qal/Qoal	**Alluvial deposits** Cobble-pebble gravel, sand, silt, and clay; Qoal, older alluvial deposits
Qls/Qc (i) Qls (gw)	**Landslide and colluvial deposits** Qls, rock and mudflow debris composed of material from source rocks upslope. Some small landslide deposits are omitted, and not all landslide deposits are shown in areas where Franciscan rocks crop out; dominant lithology in debris, e.g., ingneous rocks (i), graywacke (gw) Qc, loose mass of soil and/or rock fragments
Qols	Qols, relatively older rock and mudflow debris
Qt	**Stream and marine terrace deposits** Stream terrace deposits consist of unconsolidated cobble-pebble gravel, sand, silt, and some clay. Ages presumably Pleistocene and Holocene
Ks	**Upper Cretaceous sedimentary rocks (Western facies)** Medium- to coarsè-grained brown-weathering gray litho-feldspathic sandstone. Well bedded but sheared. Occurs as slabs (Pfeiffer Slab). Cenomanian to Campanian ages (?)
KJf mv	**Cretaceous-Jurassic Franciscan melange** Medium- to coarse-grained brown litho-feldspathic sandstone or graywacke (gw), micrograywacke (gw or sh), chert (ch), metavolcanic rocks (mv), and green (gs) and blue (bs) schist (sch). Conglomerate (cg) and silica carbonates (sc) rare. Pervasively sheared

QUARTERNARY

CRETACEOUS

JURASSIC

Franciscan Complex

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Figure 10
Subsurface Geology along Section X-X'

The northern boundary of the groundwater basin is formed by marine terrace and dune deposits (Qds/Qt) that are older than the recent river channel deposits. The permeability of the terrace deposits was not tested for this study. Based on observations of similar deposits elsewhere along the central California Coast, the lithology is usually finer grained and more consolidated than recent stream deposits and is sometimes slightly cemented as well. For this study, it was conservatively assumed that the terrace deposits are essentially impermeable and do not yield recharge to the alluvial groundwater basin along the river.

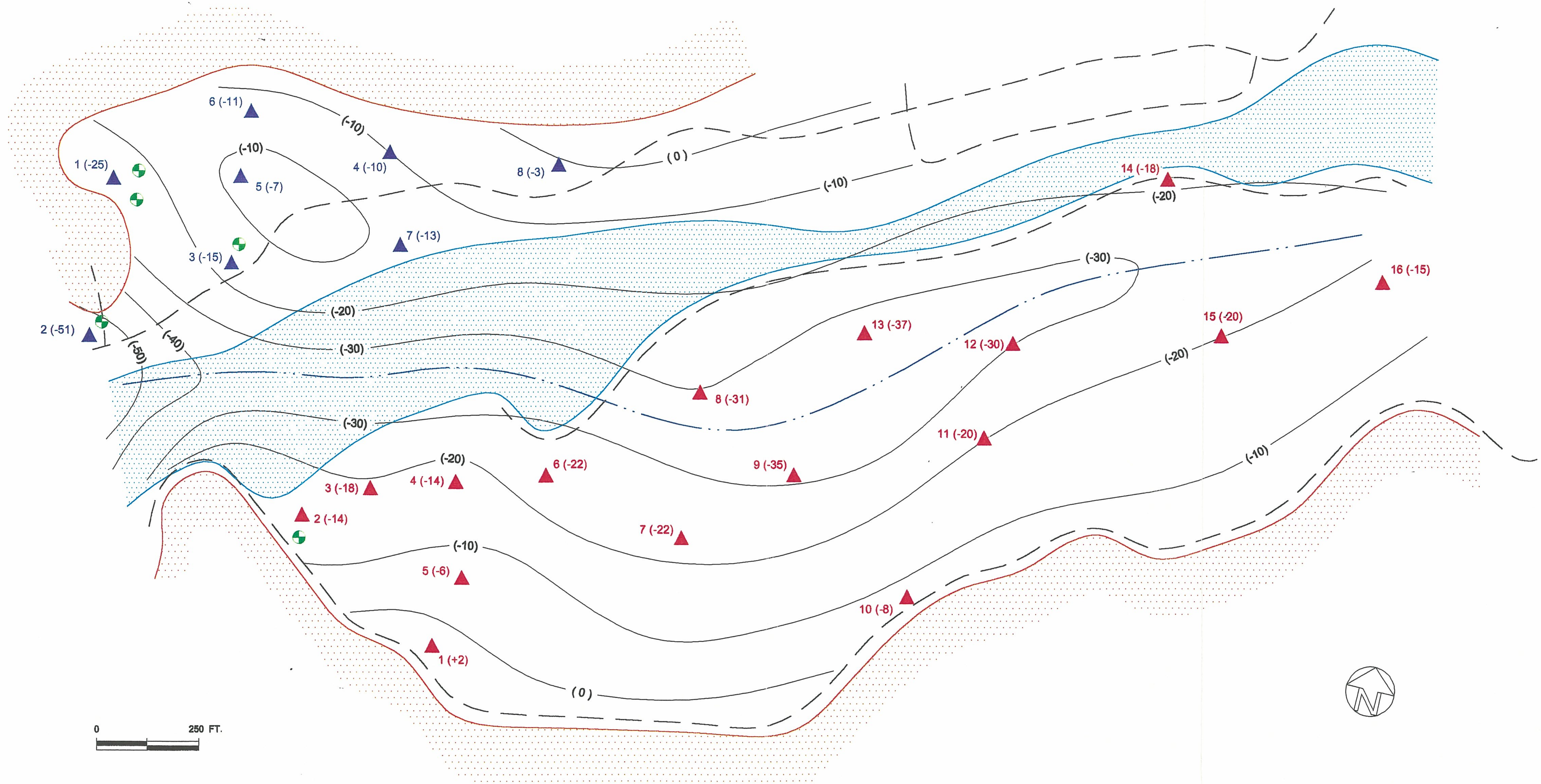
The alluvial basin deposits extend up the Big Sur River approximately 2 miles, but probably become relatively thin along the narrow reach upstream of the entrance station parking lot and the sharp bend in the river channel (from north to west). This upper reach is bounded to the east by landslide deposits consisting of mud and rock debris derived from the Franciscan and other relatively old formations. The landslide deposits are also conservatively assumed to be relatively impermeable and to contribute no inflow to the groundwater basin.

Basin Stratigraphy

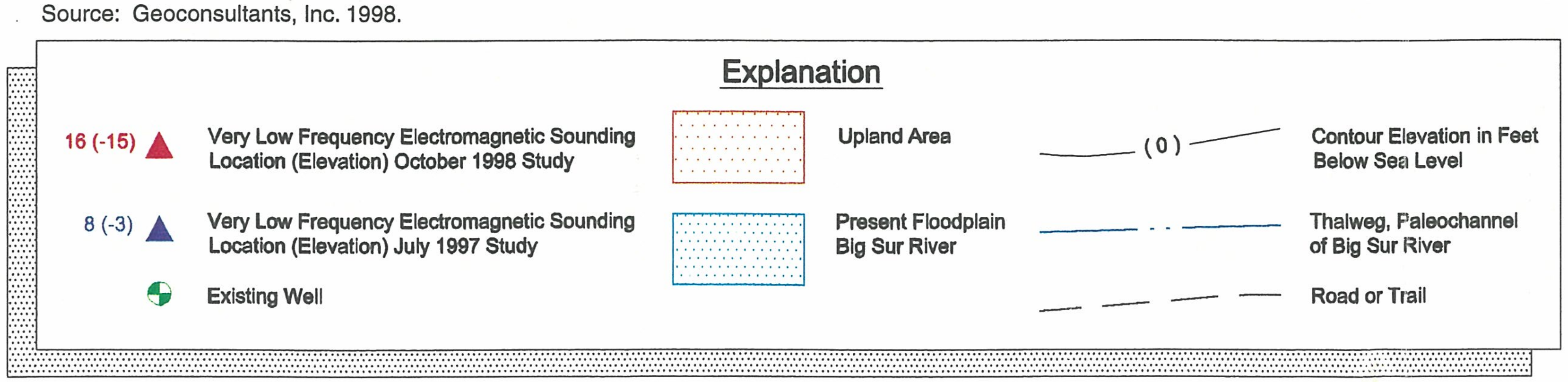
The flow system in the groundwater basin can be divided vertically into two depth zones. A shallow zone of sands and gravels overlies a clay layer that appears to be present throughout the lower end of the groundwater basin and may extend upstream to the entrance station. The clay layer has low permeability and, for practical purposes, functions as the base of the groundwater flow system in the shallow aquifer. The clay was encountered in eight out of the 10 wells and boreholes for which geologic or driller's logs are available. The depth of the top of the clay layer was 20-37 feet below the ground surface. At one of the two remaining wells, bedrock was encountered at a depth of only 18 feet, and the total depth (30 feet) of the other well may not have been large enough to encounter the clay. Driller's or geologic logs for the eight wells or test holes with verifiable locations are included in Appendix C. The logs consistently report a thin surface layer of silty sand underlain by sand and gravel to a depth of 20-37 feet, where the top of the clay layer was encountered. Only one well (JSA-4) penetrated below the clay layer. The underlying materials at that location consisted of sand, gravel, and cobbles to a depth of at least 55 feet.

The areal continuity of the clay layer was confirmed by the geophysical study. The large contrast in resistivity between the clay and the overlying clean sands and gravels created an easily recognizable boundary at all of the electromagnetic sounding points (see Appendix D for details). A contour map of the elevation of the top of the clay layer is shown in Figure 11 and reveals that the clay layer forms a shallow trough ranging in elevation from about sea level near the edges of the groundwater basin to about 30 feet below sea level in the center of the basin. The axis of the trough is not exactly aligned with the present river channel and presumably indicates an ancient channel alignment.

Basin stratigraphy along cross-section A-A' is shown in Figure 12, and the section location is shown on Figure 3. The ground surface elevation along the section line was estimated from the USGS quadrangle map and is only approximate. The cross section shows that information from the



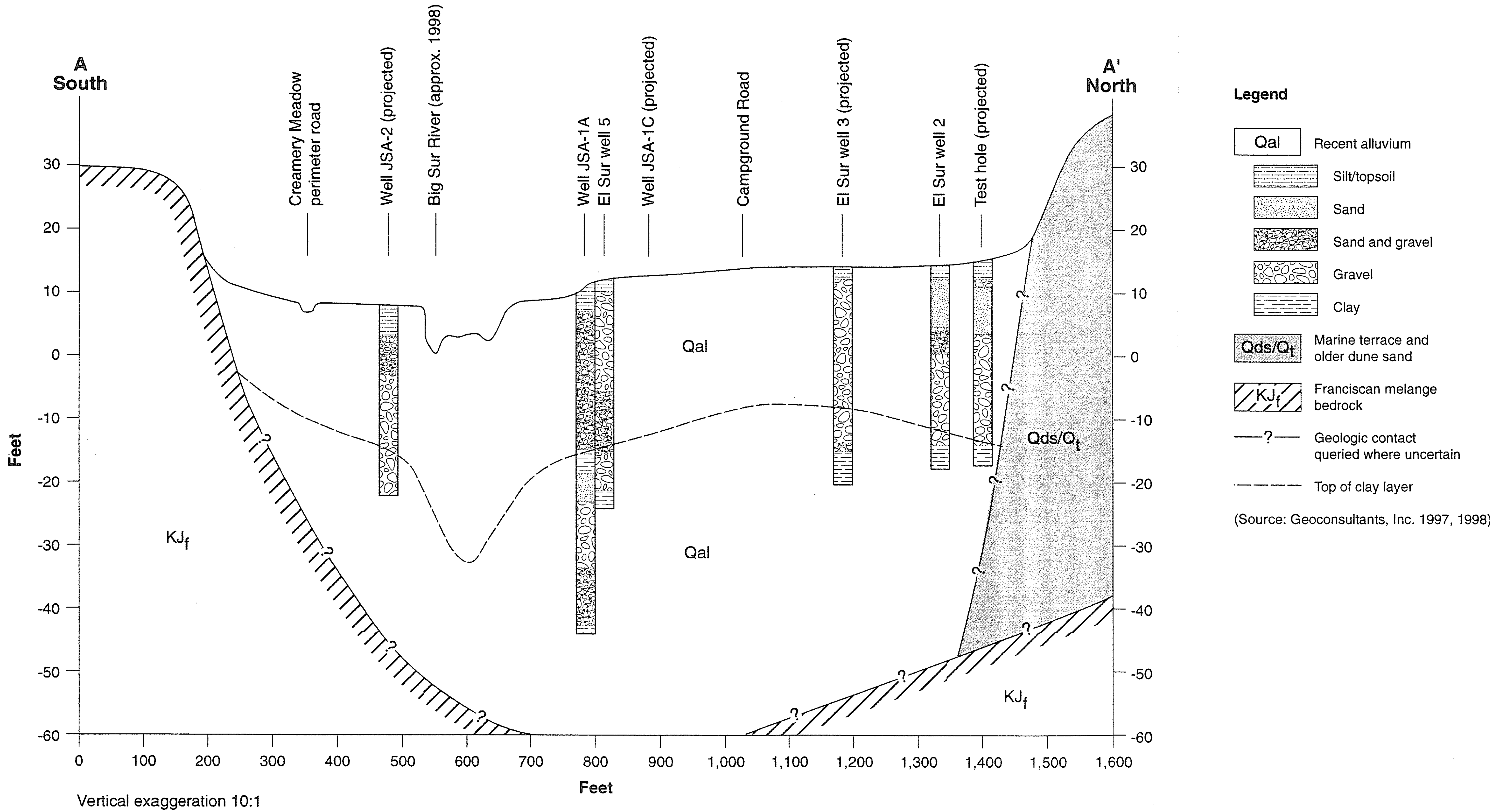
Source: Geoconsultants, Inc. 1998.



*Base modified from aerial photograph, Greiner Aerial Surveys for the State of California, Department of Water Resources, 4/28/86, Scale 1:6000.

Figure 11
Contour Map, Base of Gravels - Creamery Meadow, Andrew Molera State Park Monterey County, California

Figure 12
Geologic Cross-Section A-A'



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well logs and the geophysical survey together provide a consistent picture of basin stratigraphy and the practical limits of the groundwater flow system.

Aquifer Characteristics

Aquifer Test Design

Two aquifer tests were completed: one to determine aquifer characteristics and the other to observe the direct effects on the river and lagoon of operating both El Sur Ranch irrigation wells simultaneously. The latter test was specifically requested by DFG and is referred to in this discussion as the DFG pump test. The specific objectives of the tests were to:

- measure aquifer transmissivity and specific yield for use in estimating the extent and duration of water-level impacts that may be associated with pumping at the irrigation wells and to develop groundwater inflow and outflow estimates for the water budget analysis,

- determine whether pumping causes significant short-term depletion of streamflow as evidenced by recharge boundary effects in the drawdown curves and/or a measurable decrease in flow along the river reach near the well, and

- determine impermeable boundary conditions near the pumping wells.

For the aquifer test, the new El Sur Ranch irrigation well was pumped at a constant rate beginning at 8:32 p.m. on Tuesday, September 22, 1998, and ending at 11:32 p.m. on September 23, 1998, for a total of 27 hours. The test was discontinued when the water levels stabilized at the observation wells. Groundwater levels were collected every minute during the first 2 hours of pumping and during the recovery cycle after the pump was shut off. Data were collected at 15-minute increments during the middle of the test.

The DFG pump test started on Thursday, September 24, 1998, at 9:17 a.m. after water levels had fully recovered from the aquifer test. The new and old El Sur Ranch irrigation wells were pumped continuously for approximately 24 hours until drawdown stabilized and water levels remained constant. The test ended on Friday, September 25, 1998, at 9:30 a.m. Groundwater levels were collected continuously throughout the pumping and recovery cycle.

Water Measurement and Disposal

Accurate measurement of the pumping rate during the test is necessary to ensure a constant rate of pumping and to correctly calculate aquifer characteristics. The pipe configurations at the existing wellheads did not allow for accurate measurement of well discharge because there was not a straight length of pipe where nonturbulent flow could be observed. The wellhead plumbing of the new irrigation well was modified to improve flow measurements during the aquifer test. The pump cage was removed and a 10-foot-long loop was added to the discharge pipe to provide a long pipe section with nonturbulent flow. Before the aquifer test, the pump was turned on to test the meter and to fill the irrigation lines so that the test would be conducted under constant operating pressure. The pumping rate during the aquifer test averaged 1,150 gallons per minute (gpm) and varied less than 5% throughout the duration of the test. No modifications of the old well were made for the DFG pump test. The pumping rate at the old well was assumed to be 1,500 gpm, as measured by PG&E for a pump efficiency test in 1992.

During an aquifer test it is important that the pumped water be disposed of away from the pumping and monitoring wells to prevent any of the water from percolating back to the aquifer and affecting the measured water levels. For the aquifer test and the DFG pump test, water was pumped through the existing irrigation system mains and applied to the pastures on the El Sur Ranch on the terrace north of the groundwater basin. No water was discharged to the river or lagoon during the tests.

Groundwater-Level Measurements During the Aquifer Test and DFG Pumping Test

Monitoring of water levels at the pumping wells was not possible because of the inability to access the well casing. Four monitoring wells were measured during both tests: OW-1, JSA-3, JSA-4, and JSA-5. The data collected at these wells during both tests are presented in Figure 13. Also shown on Figure 13 are the stream stage at S1 and the lagoon levels at L1.

The tidal influence on the wells before the aquifer test can be readily observed in the hydrographs. Water levels in the Creamery Meadow well (JSA-5) were unaffected by the pumping and varied only as a function of tidal influence from the ocean and lagoon. As anticipated, the water levels in OW-1, located between the pumping well and the bluff leading up to the pastures, demonstrated a constant and continuous drawdown during the tests, indicating the presence of a no-flow boundary to the north of the pumping wells.

The relatively small drawdowns, the rapid flattening of the drawdown curves, and the rapid rates of recovery at observation wells JSA-3 and JSA-4 indicate that the Big Sur River and lagoon act as a recharge boundary. No appreciable increases in EC were measured at the pumping well during the aquifer test.

Aquifer Test Results

Measured water levels at the observation wells were corrected for tidal effects before calculating aquifer transmissivity and specific yield. Water levels in well JSA-5 were unaffected by pumping during the test and were used as the basis for estimating tidal variations in the other observation wells. A comparison of pretest hydrographs for 6 days before the aquifer test (Figure 14) indicates that tidal fluctuations in wells JSA-3 and JSA-4 are synchronized with the fluctuations in well JSA-5 but differ in magnitude. A scatterplot of water-level changes over 15-minute intervals in JSA-4 versus changes in JSA-5 is shown in Figure 15 and indicates that the amplitude of

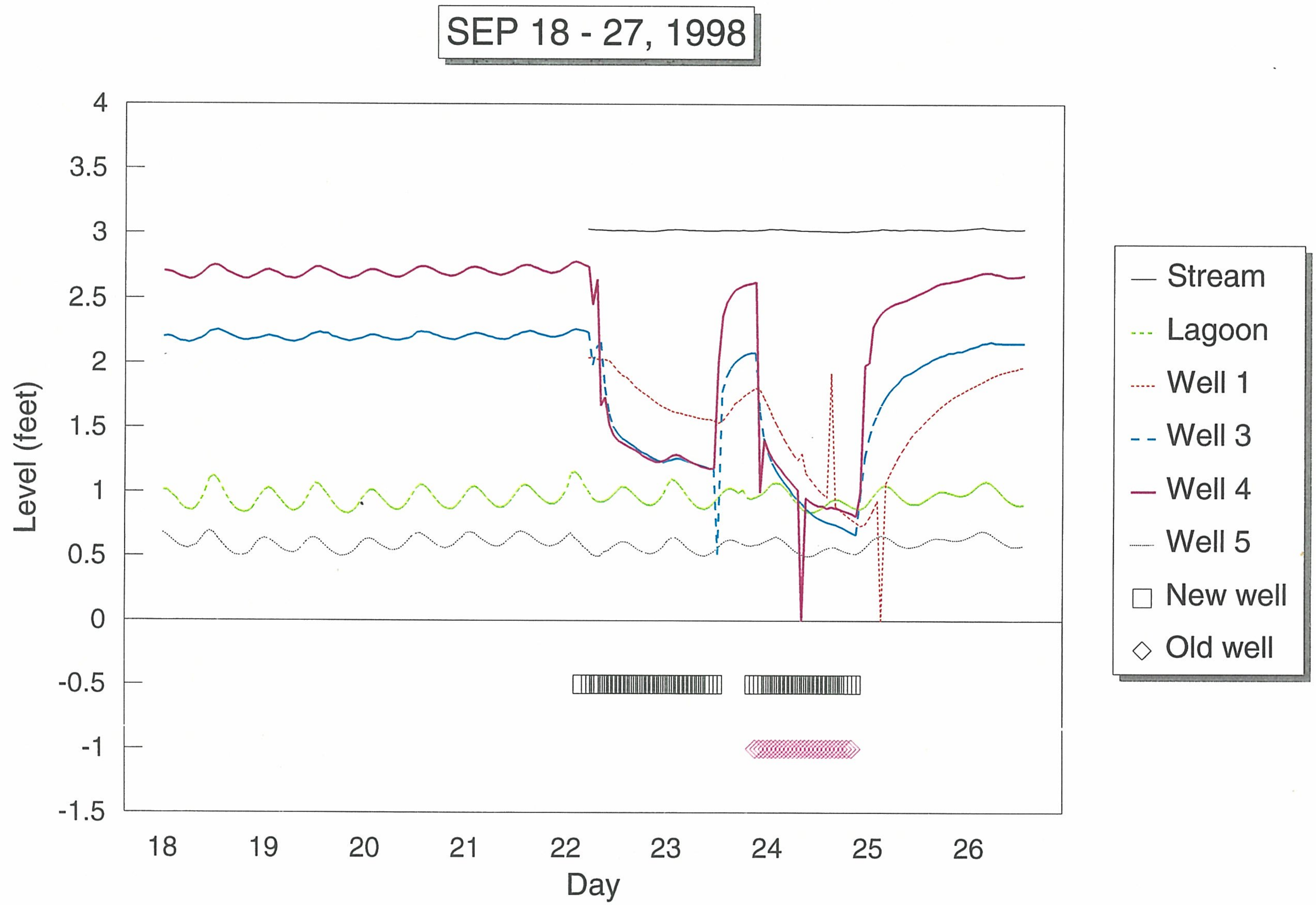

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Figure 13
Water Levels in Monitoring Wells, Big Sur River, and Lagoon during the Aquifer Test of September 22-28, 1998

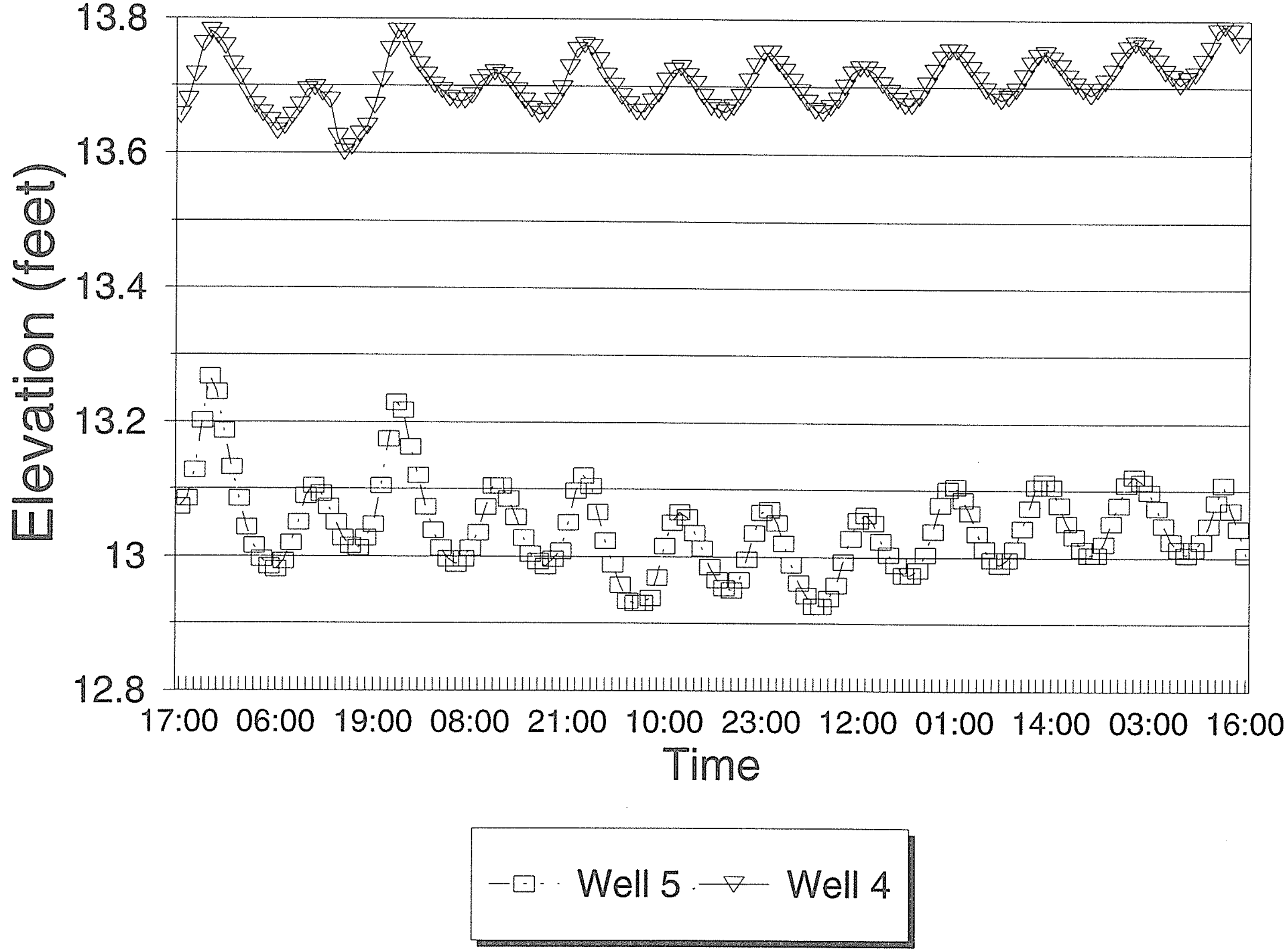

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Figure 14
Raw Water-Level Data for OW-4 and OW-5
(from 16:00 9/16/98 to 20:00 9/22/98)

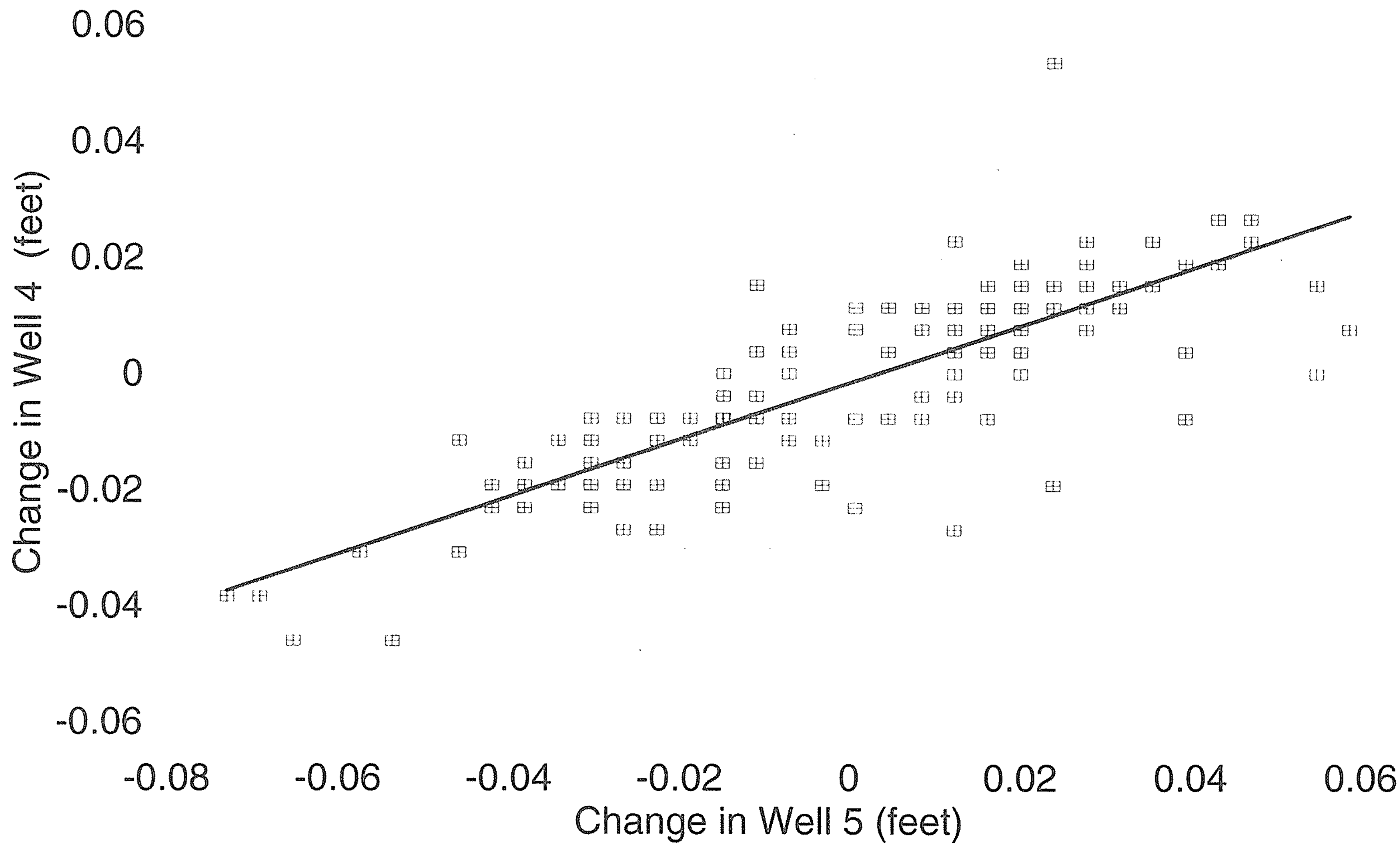

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Figure 15
Relationship between Water-Level Changes at JSA-4 and JSA-5

fluctuations in JSA-4 was 50% of the amplitude at JSA-5. The tidal signal at well JSA-4 during the aquifer test was estimated as 50% of the signal at JSA-5 and subtracted from the measured water levels at JSA-4. Water levels at well JSA-3 during the aquifer test were similarly corrected.

Several type curves for confined, unconfined, and leaky aquifers were used to estimate transmissivity and specific yield from drawdown and recovery data at the pumping and observation wells. The details of this analysis are presented in Appendix E. All of the methods indicated that the aquifer is highly transmissive and capable of conveying large subsurface flows. The test confirmed the presence of a no- or low-flow boundary along the northern edge of the alluvial deposits and a recharge boundary along the river. In short, the aquifer, river, and lagoon form a closely interconnected hydraulic system. Transmissivity is over 600,000 gpd/foot, which is exceptionally high for such a thin aquifer but generally consistent with the extremely coarse sand and gravel lithology. Because of the rapid onset of recharge boundary effects, the calculated specific yield appears low (0.02-0.05) for clean, coarse, well-sorted materials. The expected specific yield for deposits of this type is 0.25-0.35 (Bear 1979).

The aquifer test confirmed the hypothesis related to an impermeable boundary to the north of the wells and the recharge boundary located to the south at the river and lagoon. The analysis of the aquifer test data was complicated by the presence of both an impermeable and recharge boundary. Under these conditions the standard equations and analyses used to calculate the hydraulic parameters produced lower storativity values than one would anticipate from the types of materials indicated by the drillers' logs and geophysical survey. The unconsolidated gravels and cobbles would be expected to have specific yield values in the range of 0.1 to 0.2 (dimensionless). The calculated specific yield from the aquifer test data is much less than this because of the presence of the recharge and impermeable boundary conditions. As such, calculated value of transmissivity using the aquifer test data may be in the range of twice the true transmissivity. A transmissivity equal to half the calculated value would still be quite high and would not alter the conclusions of this study. Additional analytical work or modeling could be used to refine the calculated transmissivity value but is considered unnecessary because it would not be expected to alter the findings and conclusions. Such numerical or analytical work is not needed at this time and would not influence the findings of this investigation.

Stream-Aquifer Interactions

Groundwater Response to Streamflow

Water levels in wells OW-1 and OW-2 were monitored with data loggers from August 1997 through June 1998, and in well OW-3 from July-September 1998. The water levels are plotted together with river stage and irrigation-well pumping schedules in Figures 7 and 8. Midwinter water levels in well OW-1 are shown in Figure 16 together with daily streamflow at the USGS gage. The hydrographs match almost exactly, with groundwater levels responding to even small streamflow events. The similarity between the flow and water-level recessions in March 1998 suggests that

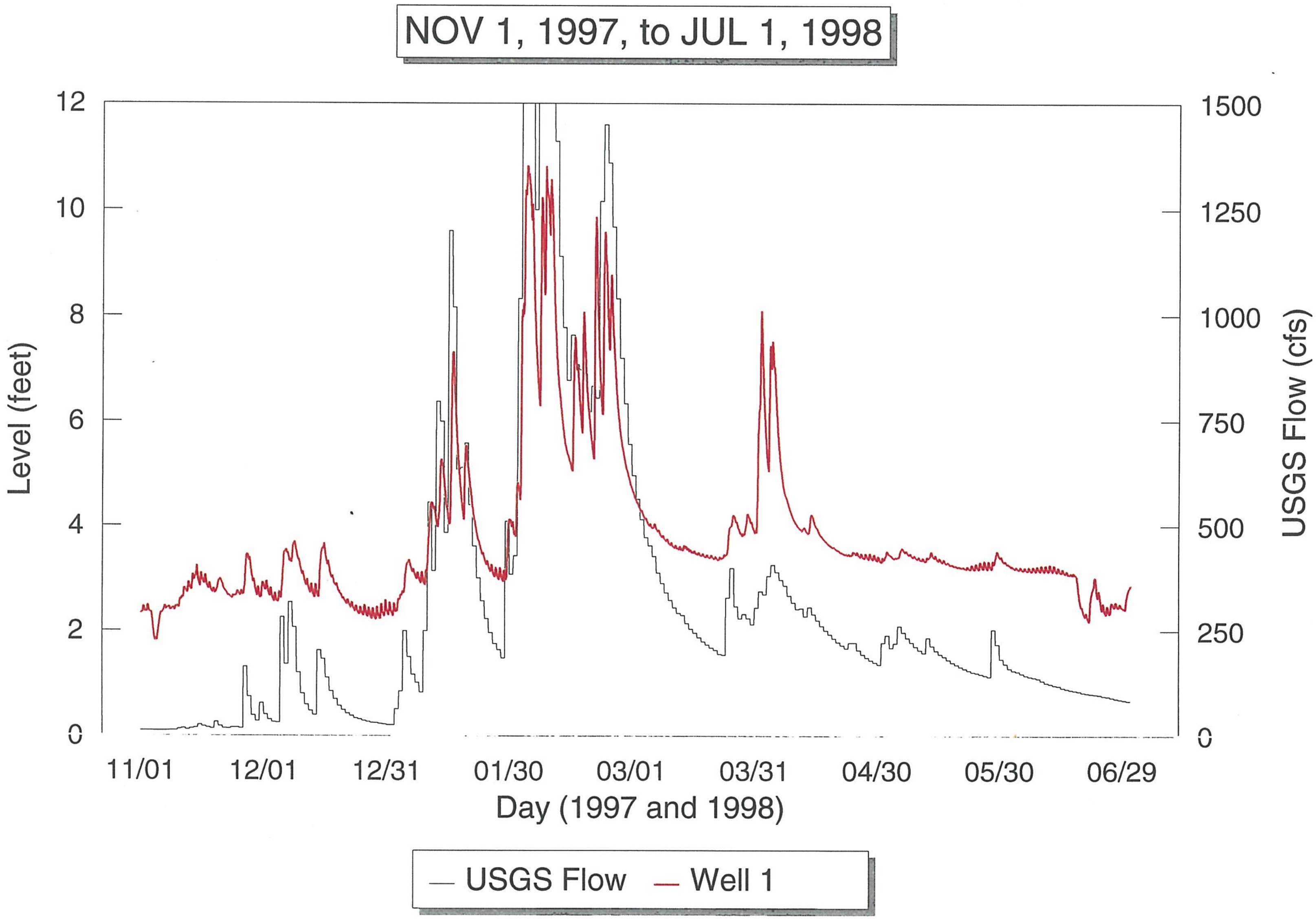

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Figure 16
USGS Mean Daily Streamflow and Hourly Water Level in Monitoring Well 1 during Winter 1997 and 1998

groundwater levels are in dynamic equilibrium with river stage, further confirming that the river and aquifer are closely coupled.

The ability of water to move rapidly between the river and aquifer implies that the prevailing direction of groundwater flow is downvalley, parallel to the river. The slope of the water table most likely closely matches the river gradient. In the absence of groundwater pumping, this seaward groundwater gradient would tend to prevent seawater from intruding into the groundwater basin.

Streamflow Response to Groundwater

Streamflow is affected by natural groundwater discharge and, potentially, by well pumping. The width of the groundwater basin decreases markedly at the downstream end, where the river and alluvium pass through a narrow gap in the Franciscan Formation. This bedrock constriction naturally forces groundwater to seep into the lowermost reach of the river as the path of least resistance to the ocean. Moist, seeping banks were observed above the river level near the upper end of the lagoon, which presumably was discharging groundwater, during some of the site visits. Also, the resumption of streamflow downstream of the intermittent reach in 1990 is further evidence that groundwater discharges into the river. It is noteworthy that groundwater storage was sufficiently large to sustain the lagoon and lowermost reach of the river even during one of the driest years on record and during a period of normal El Sur Ranch operation.

Pumping at the El Sur Ranch wells for normal irrigation operations clearly affects water levels in nearby wells but has no measurable effect on river or lagoon stage. The superimposed time series of pump operation, river stage, and groundwater levels (Figures 7 and 8) show that water levels in observation wells OW-1 and OW-2 decline approximately 1.5 feet in response to pumping at the old irrigation well, 0.5 foot in response to pumping at the new irrigation well, and 2.0 feet in response to pumping at both wells. In spite of ample evidence that the aquifer and river are hydraulically coupled, the pumping did not lower stage in the river or lagoon. Evidently, groundwater storage, underflow from upstream parts of the basin, and the relatively flat stage-flow relationship of the river attenuate the effects of pumping on streamflow sufficiently that the volume of water in the channel and lagoon is not materially diminished during pumping periods.

Groundwater Storage Capacity

As long as flow is present in the Big Sur River, the groundwater basin will remain approximately full. Because of the strong hydraulic connection between the river and the shallow aquifer, the water table tends to remain in equilibrium with the water level (stage) in the river. If river flow were suddenly discontinued, the El Sur Ranch wells could continue to obtain water from storage in the aquifer. The storage capacity of the aquifer is approximately 765 af (assuming a 133-acre surface area, an average depth to the clay layer of 30 feet, an average depth to water of 7 feet, and a specific yield of 25%). Assuming that, on average, each El Sur irrigation well operates half of the time (for an average pumping rate of 1,325 gpm), the wells would discharge a volume of water equal to the entire storage capacity of the groundwater basin in 131 days.

Water Quality

Historical Groundwater Salinity Data

Historically, the salinity of water produced by the El Sur Ranch irrigation wells has often increased abruptly one or more times during the irrigation season, reaching levels that render the water unacceptable for pasture irrigation. El Sur Ranch personnel monitor electrical conductivity (EC) (a measure of salinity) frequently during each irrigation cycle and turn the pumps off if EC exceeds 1.0 millimho per centimeter. Under conditions of the easement for the wells, the data are reported to DPR. Figure 17 shows measured salinity during the irrigation season for 1989 through 1996 and compares it with Big Sur River flow at the USGS gage. Figure 18 presents scatterplots of EC versus streamflow for each year. In general, the groundwater EC is highest when the streamflow is low, although there is no consistent relationship or direct correlation. This would indicate there is no simple mechanism governing the relationship between EC, streamflow, and pumping.

The timing of historical spikes in groundwater salinity at the El Sur Ranch irrigation well usually coincided with a new or full moon, as was the lagoon salinity during summer 1998. High salinity events occurred from 1991 through 1996 and, in several of those years, events were spaced approximately 1 month apart (see Figure 5). The date of onset of each event was compared with the moon phase, which is correlated with tide magnitude. Tides are higher during a new or full moon and wave overwash into the lagoon is consequently more likely. Seventeen separate events were identified during which well salinity abruptly increased to greater than 0.7 millimho per centimeter, and 11 of the events occurred within 2 days of a new or full moon. This frequency of coincidence (65%) is substantially greater than the frequency that would result with random timing of the peaks (36%); therefore, it appears likely that high salinity at the well often (and possibly always) coincides with high salinity in the lagoon.

Water Quality in 1997-1998

The lagoon is primarily a freshwater lagoon with episodes of high EC that result from wave overwash into it. Figure 19 shows lagoon stage and EC from July 23 to September 14, 1998, along with tidal stage at Morro Bay. There were two distinct episodes of elevated EC in the lagoon during that period: one in early August and one in early September. Both of the EC events coincided with the maximum high tides for those months. Other periods of above-average high tides did not result in increased EC at the L2 location. It appears that high tides create the possibility of wave overwash into the lagoon, but that favorable wind and wave conditions are also required. During the site visits to the lagoon, kelp stems and seaweed were observed along both faces of the beach berm and within the lagoon itself.

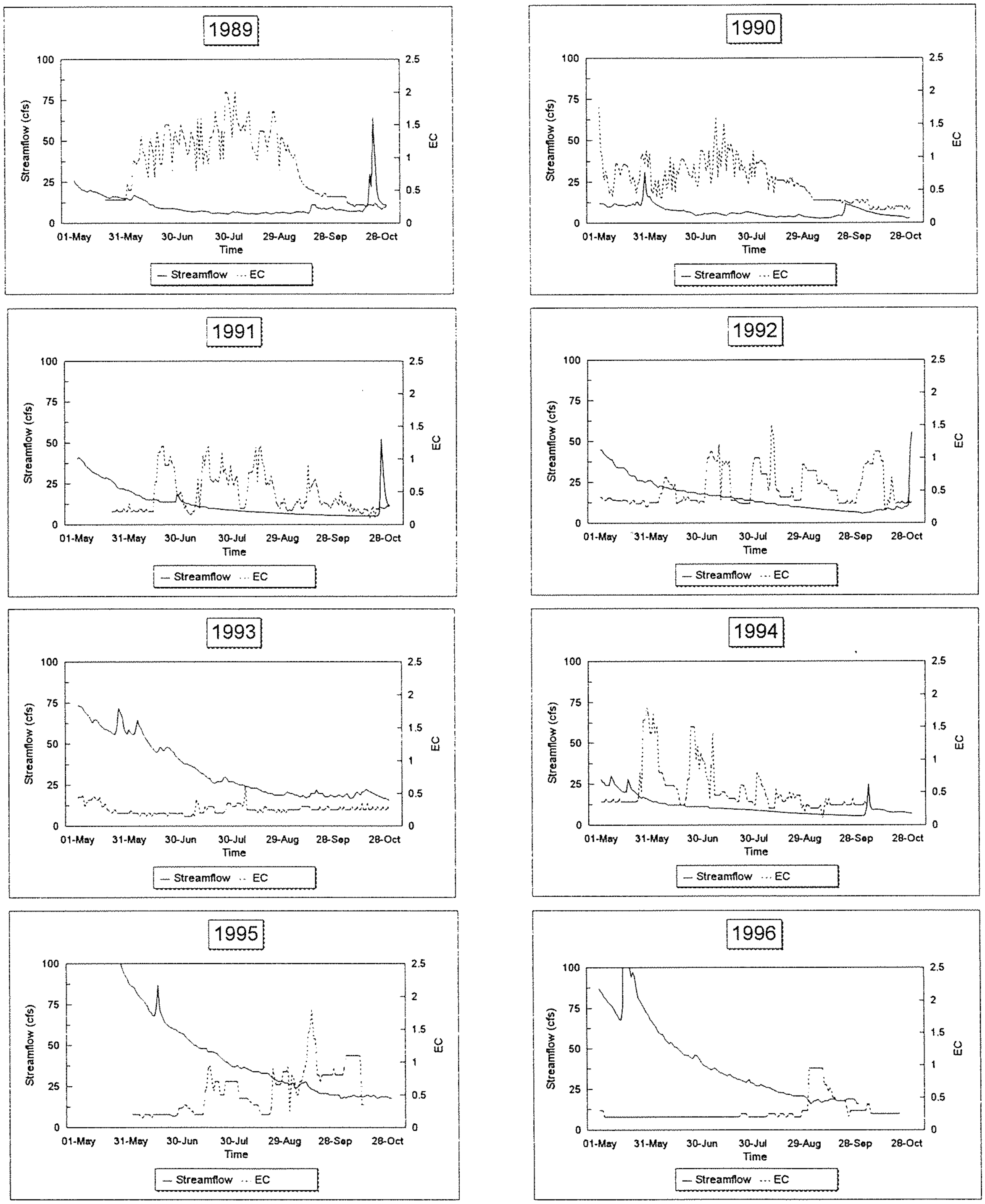

Figure 17
Historical Streamflow of the Big Sur River near Big Sur and Groundwater EC at El Sur Ranch

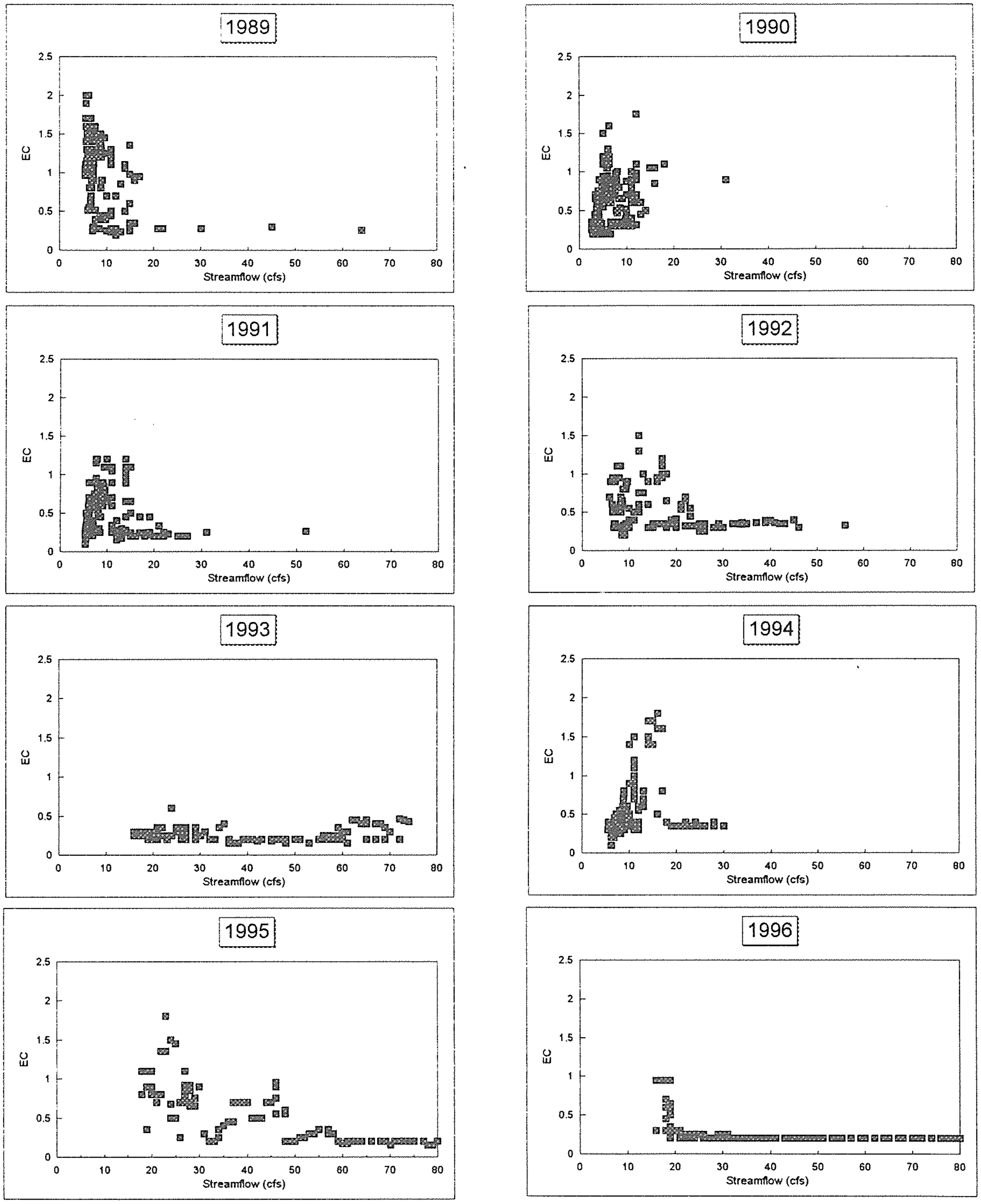

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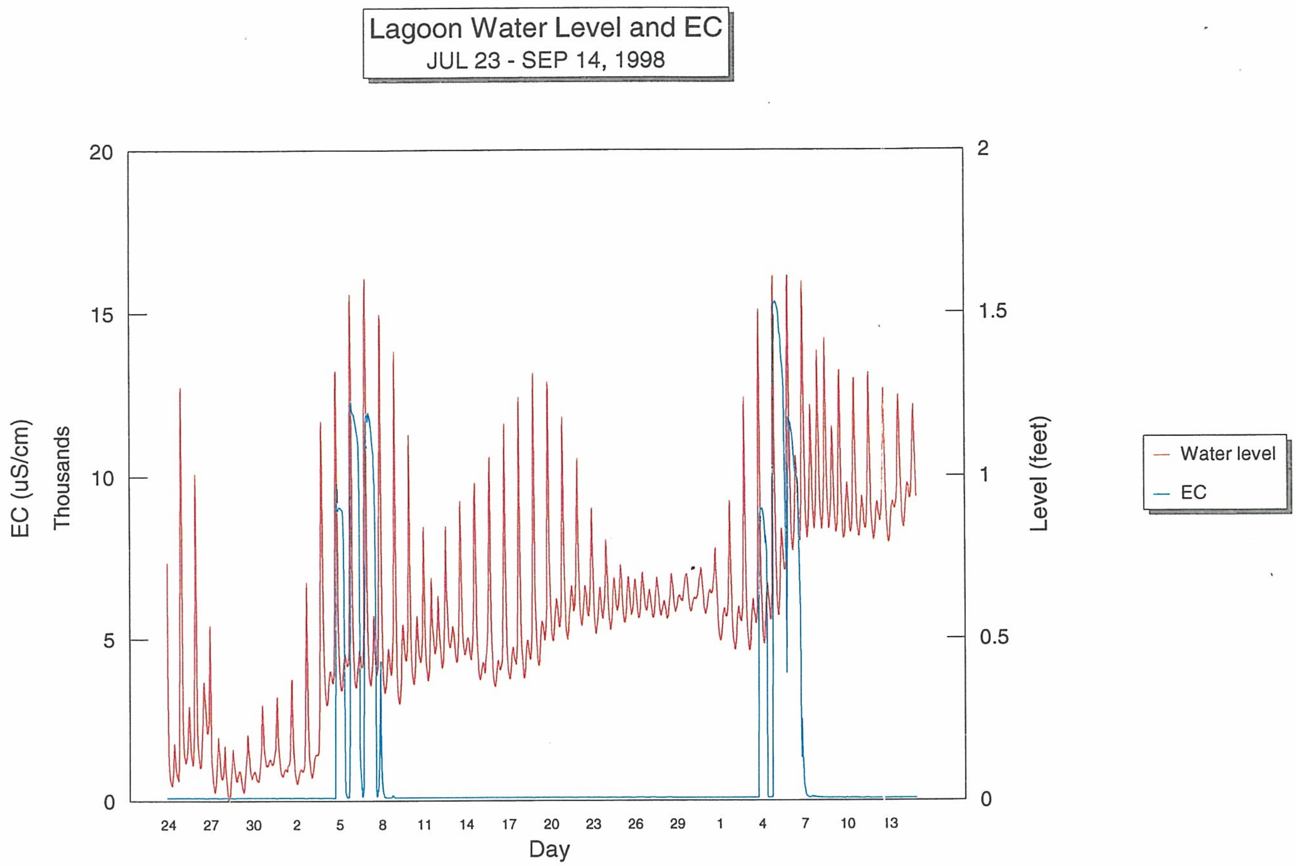
Figure 18
Streamflow of the Big Sur River near Big Sur versus Groundwater EC at El Sur Ranch



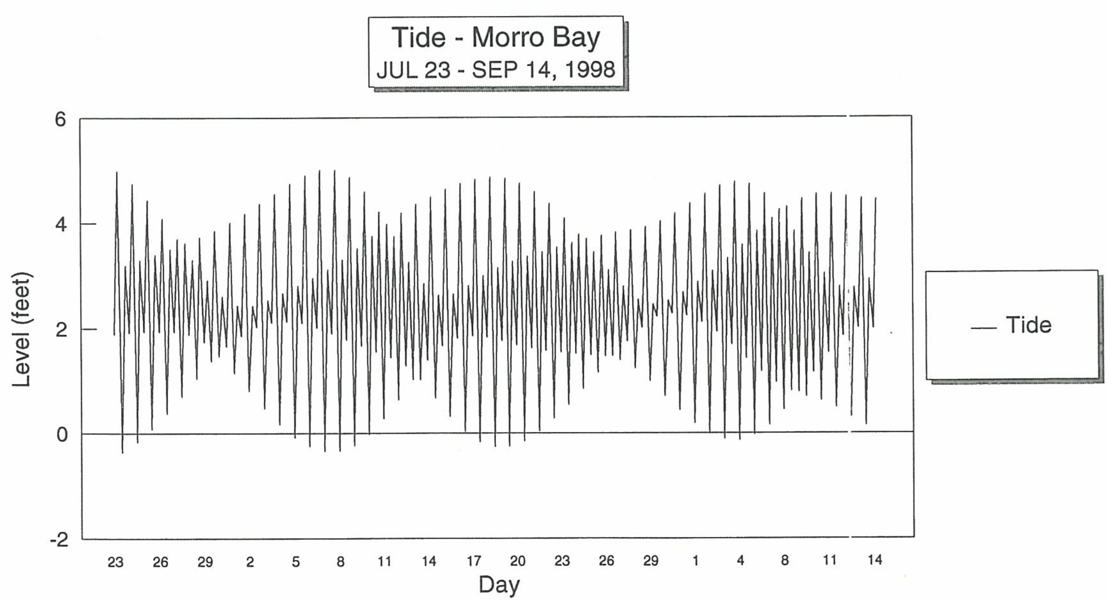


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Figure 19
Water Level and EC in Big Sur River Lagoon and Morro Bay Tides during 1998

Closer inspection of the data for the two EC events shows that riverflow can flush the saltwater from the lagoon in a single tidal cycle. Figure 20 shows the stage, EC, and tide data for August 4-9, 1998, at an expanded time scale, along with groundwater levels at well JSA-3, river stage at station S1, and irrigation well on/off cycles. Figure 21 shows similar data for September 2-8, 1998. The EC at L1 is not plotted because it varied little over the background level during the monitoring period. During the August 4-9 event, EC at site L2 rose abruptly when wave overwash occurred at high tide, then receded gradually back to ambient levels during the subsequent low tide as the salt was flushed out of the lagoon by streamflow. This pattern repeated itself for 3 days. The pump was on during part of this time, but there was no observed influence on lagoon levels or salinity.

A similar pattern occurred during the September 2-8 event. Lagoon EC again rose abruptly on each of 3 successive days, but on one of the days, the salt was not completely flushed out during the intervening low tide.

Water quality samples of the river and new irrigation well were collected during the aquifer test. The laboratory results are presented in Appendix F. The data indicate that the groundwater and surface-water chemistry are similar.

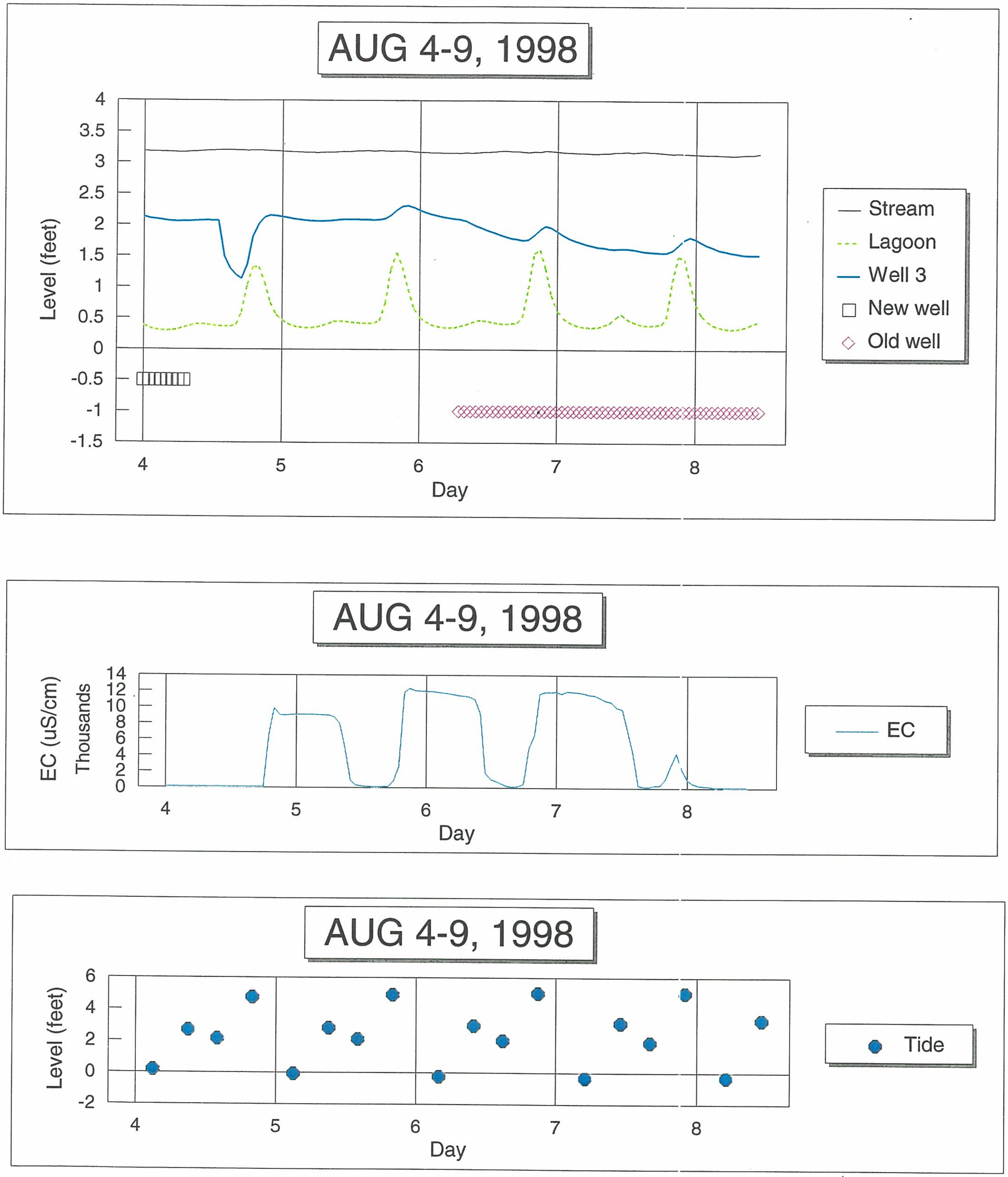

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Figure 20
Water Levels, EC, and High and Low Tides at Morro Bay during August 4-9, 1998

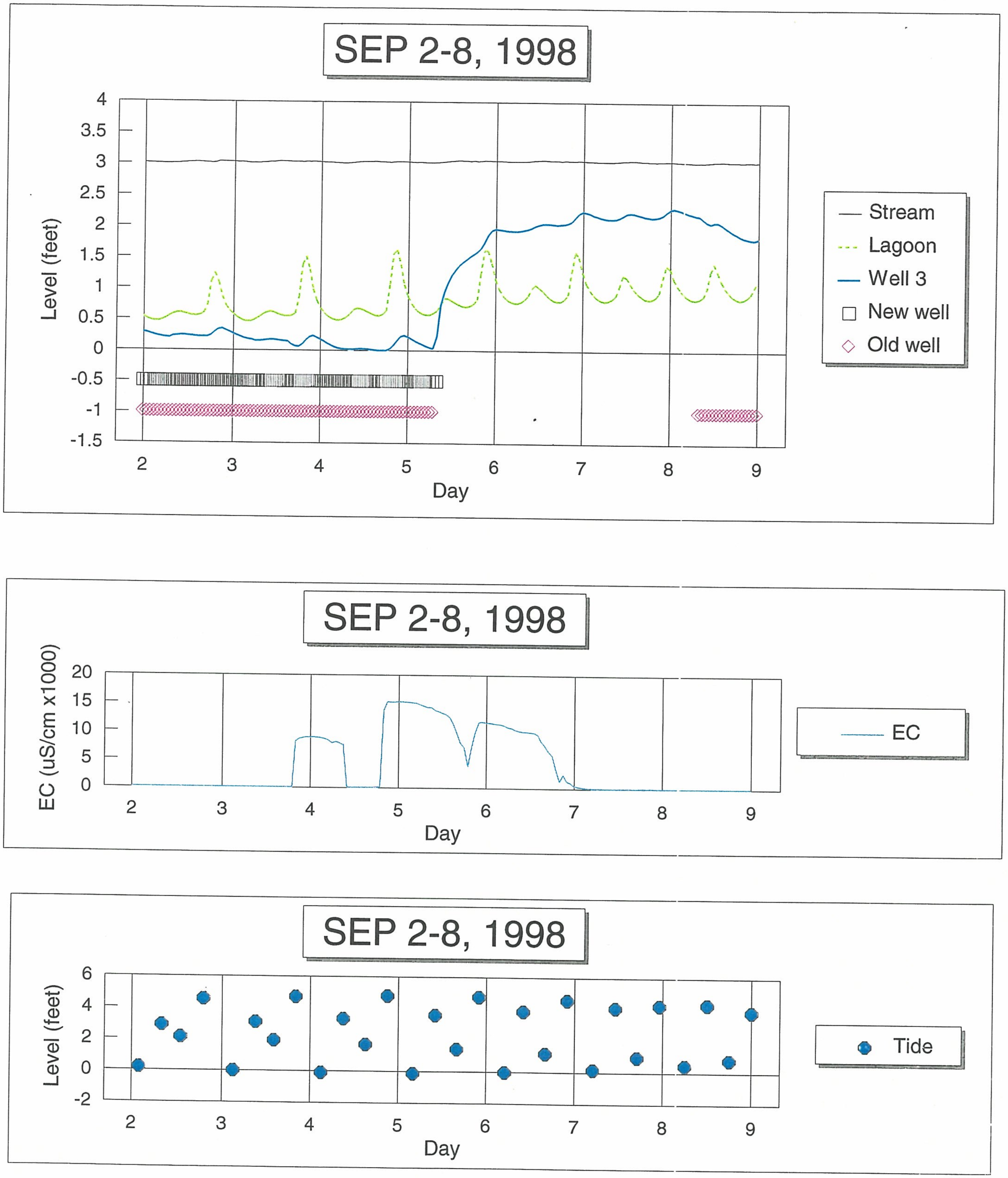

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Figure 21
Water Levels, EC, and High and Low Tides at Morro Bay during September 2-8, 1998

Chapter 3. Evaluation of Important Issues

In this chapter, various pieces of information presented in the above data inventory are brought to bear on each of the important management questions. The quantity and diversity of information allow clear conclusions to be drawn for most of the issues.

THE GROUNDWATER SYSTEM AND BIG SUR RIVER ARE HYDRAULICALLY CLOSELY COUPLED

The river and aquifer are clearly hydraulically coupled. Evidence to support this conclusion consists of the following:

- groundwater levels are in dynamic equilibrium with riverflow during winter runoff events,
- the upward break in slope in the drawdown plots for the aquifer test indicates the presence of a recharge boundary,
- surficial fine-grained layers that might impede percolation were not found in or near the river channel in either well logs or during the geomorphologic survey,
- the high aquifer transmissivity is conducive to rapid exchange of water between the river and aquifer, and
- the timing of salinity peaks in the irrigation wells generally coincides with high tide events when wave overwash is most likely to cause high salinity in the lagoon.

The only evidence that the river and aquifer are not closely coupled is the lack of measurable pumping influence on river and lagoon stage. This may result simply from aquifer attenuation, which spreads the induced seepage along a moderately long reach of the river and from the wide, shallow channel shape, which makes stage relatively insensitive to flow.

THE SOURCE OF THE WATER PUMPED BY THE EL SUR RANCH WELLS IS STORAGE AND INDUCED RIVER SEEPAGE

As in all aquifers, the initial source of water when the wells are first turned on is that stored in the aquifer near the well. Use of this stored water lowers the water level near the well, creating a cone of depression that expands outward. When the cone of depression reaches the river channel, it begins to induce increased seepage out of the river. The cone of depression continues to expand until it encompasses a long enough reach of the river to induce seepage at a rate equal to the pumping rate. At that point, essentially all of the well discharge is sustained by river seepage. This transition from storage-dominated to river-dominated supply of water to the wells occurred over a period of several hours during the aquifer test. When the well is turned off, elevated river seepage continues until the cone of depression has been refilled.

Deep groundwater is not a significant source of water to the wells because all available geologic evidence (well logs and the geophysical survey) indicates the presence of a clay confining layer throughout the lower end of the groundwater basin at a depth just below the depth of the irrigation wells (approximately 30 feet below the ground surface). Likewise, rainfall recharge and subsurface inflow from bedrock and marine terrace areas surrounding the basin contribute minor amounts of recharge that are much smaller than the recharge capability of the river and that would not support present pumping amounts.

WELL PUMPING DOES NOT SIGNIFICANTLY DECREASE FLOW, STAGE, OR VELOCITY IN THE RIVER AND LAGOON

In all but critically dry years, the maximum possible rate of streamflow depletion with both wells operating simultaneously (6 cfs) is substantially less that the amount of summer base flow in the river (10-20 cfs) plus groundwater underflow (5 cfs). Although the principle of conservation of mass suggests that the seepage rate from the river equals the well pumping rate during periods of sustained pumping, the effects on river and lagoon stage and volume are negligible. The effect on river stage was below the detection threshold (0.01foot) during the aquifer test in 1998. Presumably, the induced seepage results primarily in a decrease in flow velocity.

Monitoring of lagoon stage during 1998 indicated that stage is controlled primarily by the height of the beach berm between the lagoon and the ocean. Berm height gradually increases in increments during the dry season as the result of wave-controlled nearshore sediment-transport processes. It is not affected by well operation.

In critically dry years, induced seepage from the Big Sur River can be a substantial percentage of total flow. It could slightly increase the likelihood of discontinuity of surface flow when flow reaches exceptionally low levels. Under those circumstances, however, discontinuous flow is likely to occur even in the absence of pumping (see below).

NATURALLY LOW RIVERFLOW WAS THE PRIMARY CAUSE OF INTERMITTENT FLOW IN 1990

Summer and autumn base flows in 1990 dropped to as low as 5 cfs at the USGS gage, which ranks among the lowest flows recorded. Flows exceeded those levels 95-99% of the time during the period of record for the gage. When flows decrease to as little as 5 cfs, the entire flow of the river can seep into the ground at the upper end of the coastal groundwater basin, even in the absence of well pumping. The estimated subsurface conveyance capacity of the basin is approximately 5 cfs. As flow percolates into the upstream end of the basin and seeps back into the river and lagoon at the lower end, the most likely location for flow to become intermittent is the middle of the groundwater basin. This was reportedly the location of discontinuous flow in 1990. The El Sur Ranch wells are located at the downstream end of the basin, where live flow sustained by groundwater discharge was reportedly present throughout that exceptionally dry season.

Based on its duration, flow discontinuity in 1990 was not primarily caused by the El Sur Ranch wells. Discontinuous flow persisted for approximately 2 months, and the El Sur Ranch pumping records indicate that the wells were not in continuous operation during that time. Because of the strong hydraulic connection between surface water and groundwater and the rapid recovery of groundwater levels when the wells are turned off, periodic pumping would have resulted in periodic rather than continuous flow discontinuity if pumping had been the primary cause.

Diversions below the gage were probably a minor factor contributing to flow discontinuity in 1990 because an inventory of diversions suggests that net diversions in summer are probably on the order of only 0.03-0.04 cfs.

In conclusion, it appears that well pumping could increase the duration and frequency of intermittent flow, but only when flows are exceptionally low and prone to discontinuity.

PUMPING OF THE EL SUR RANCH WELLS DOES NOT AFFECT GROUNDWATER LEVELS AND RIPARIAN VEGETATION IN CREAMERY MEADOW

The lack of measurable drawdown at the Creamery Meadow observation well during the aquifer test indicates that drawdown from the El Sur Ranch wells does not extend beyond the river. This is consistent with the abundant evidence that the aquifer and river are hydraulically coupled and with the conceptual model of the river as a fully penetrating recharge boundary. Given the hydrogeologic and streamflow conditions at the site, one would not expect significant amounts of drawdown to propagate beyond the river channel.

The soil profile observed along the bank where the river cuts into the Creamery Meadow area may provide some clues regarding the cause of drought stress in tree seedlings planted as part of a restoration effort in the meadow. The surficial sandy loam material extended to a depth of only 3-4 feet and was underlain by very coarse gravels and cobbles. The water table is located 7 or more feet below the land surface, within the cobble layer. Therefore, the tree roots would have to penetrate the upper part of the cobble layer to reach the water table. Because of its extremely coarse texture, the cobble layer would have a very low available water capacity. The frequency and amount of irrigation required to maintain plant growth as the roots grow through this xeric layer would be considerably greater than the irrigation amounts needed to sustain roots in the overlying loam. Visual inspection of soil moisture and volunteer herbaceous grass and weed sprouts in and near the drip-irrigated tree seedlings in September 1998 suggested that irrigation may not have been ample enough to support shoot and root growth through the xeric horizon.

WAVE OVERWASH IS THE LIKELY SOURCE OF SALINITY IN THE LAGOON AND EL SUR RANCH WELLS

Monitoring of lagoon stage and salinity during 1998 revealed that seawater enters the lagoon during periods of above-average tide height (i.e., during new and full moons). Site visits confirmed that wave overwash of the beach berm was the mechanism of saltwater influx into the lagoon. Wave-smoothed sand and kelp debris were observed on both sides of the berm. The water level in the lagoon is always higher than the average water level in the ocean; therefore, seawater cannot seep steadily through the berm and into the lagoon. The fairly high coincidence of historical salinity peaks in the wells with full or new moons suggests that the wells induce seepage out of the lagoon and that the subsurface travel time from the lagoon to the wells is rapid (less than 2 days).

Given the shallow depths of the irrigation wells and the presence of a laterally extensive shallow clay horizon, direct intrusion of seawater to the wells (i.e. saltwater flowing beneath an entirely freshwater lagoon) is considered very unlikely. Also, the freshwater head (water level) in the lagoon appears to be at least 1 foot above sea level. If this head is uniform throughout the thickness of the aquifer (i.e. vertical flow in the aquifer is negligible near the lagoon and beach berm), it is sufficient to repel seawater intrusion to a depth of 40 feet in the aquifer, which includes all of the aquifer strata above the clay layer.

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Appendix A. Precipitation Data

Table A1.1: Big Sur State Park Gage
Monthly Accumulated Precipitation (inches)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1913	m	m	m	m	m	m	m	m	m	0.00	0.00	0.00	m
1914	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.59	0.62	13.75	15.96
1915	9.72	14.82	3.75	2.85	3.42	0.00	0.00	0.00	0.00	0.00	0.55	7.58	42.69
1916	21.42	9.41	4.46	0.35	0.43	0.00	0.00	0.00	0.75	2.44	1.35	11.03	51.64
1917	3.59	13.74	2.68	0.71	0.60	0.00	0.00	0.00	0.00	0.00	3.79	1.38	26.49
1918	1.15	7.29	10.94	0.34	0.00	0.00	0.00	0.00	5.41	0.13	8.29	4.29	37.84
1919	1.98	11.14	4.15	0.20	0.08	0.00	0.00	0.00	1.61	0.14	0.36	12.39	32.05
1920	0.95	3.08	9.71	5.94	0.00	0.23	0.00	0.00	0.05	2.39	6.76	10.05	39.16
1921	12.70	2.84	5.23	1.22	2.37	0.00	0.00	0.00	0.36	0.33	1.17	12.48	38.7
1922	4.90	10.24	4.33	0.92	1.19	0.00	0.00	0.00	0.00	3.64	5.89	12.88	43.99
1923	5.24	1.27	0.19	8.88	0.00	0.52	0.00	0.00	0.89	0.25	1.19	2.41	20.84
1924	6.92	1.21	5.01	0.97	0.00	0.02	0.00	0.00	0.00	3.54	5.43	5.64	28.74
1925	3.90	7.25	4.54	3.24	6.97	0.12	0.00	0.00	0.81	0.55	1.48	3.67	32.53
1926	7.03	8.82	0.30	6.85	0.25	0.00	0.00	0.00	0.00	2.29	11.24	2.30	39.08
1927	6.18	13.10	3.05	4.85	0.32	0.26	0.00	0.00	0.12	3.32	4.69	10.46	46.35
1928	1.49	5.27	13.27	2.18	0.27	0.00	0.00	0.00	0.00	0.00	5.55	6.70	34.73
1929	2.14	5.25	6.46	2.17	0.00	1.67	0.00	0.00	0.03	0.00	0.00	6.31	24.03
1930	9.63	6.70	5.94	2.13	1.60	0.04	0.00	0.00	0.17	0.02	3.82	0.27	30.32
1931	9.32	2.14	0.71	0.82	2.01	1.33	0.00	0.00	0.00	0.60	4.97	18.21	40.11
1932	6.90	9.17	2.36	1.49	0.64	0.05	0.00	0.00	0.00	0.09	0.69	3.55	24.94
1933	9.96	1.64	3.55	0.34	1.61	0.36	0.00	0.00	0.03	3.30	0.06	12.38	33.23
1934	2.61	10.99	0.00	0.88	1.34	2.53	0.00	0.00	0.29	2.76	6.78	6.07	34.25
1935	10.60	2.09	5.90	9.77	0.08	0.00	0.00	0.45	0.00	3.28	1.55	4.74	38.46
1936	11.10	20.67	2.78	3.54	1.30	1.03	0.00	0.00	0.06	1.62	0.00	8.42	50.52
1937	7.15	13.46	12.68	1.58	0.00	0.80	0.00	0.00	0.00	0.41	2.42	12.43	50.93
1938	7.35	13.45	15.01	2.79	0.00	0.00	0.00	0.00	0.00	1.84	1.41	3.75	45.6
1939	5.30	3.83	4.92	0.46	1.21	0.00	0.00	0.00	0.57	1.31	0.50	4.21	22.31
1940	22.11	22.39	4.42	2.25	0.94	0.00	0.03	0.00	0.47	1.85	0.78	15.70	70.94
1941	15.76	18.70	13.39	9.55	1.86	0.04	0.00	0.00	0.00	1.49	1.59	18.07	80.45
1942	10.25	5.10	5.75	6.45	2.06	0.00	0.00	0.00	0.00	1.09	6.99	4.79	42.48
1943	13.78	5.98	10.54	2.31	0.00	0.00	0.00	0.00	0.00	2.35	0.79	5.57	41.32
1944	6.76	14.48	1.96	4.60	1.17	0.18	0.00	0.00	0.00	3.84	7.44	5.35	45.78
1945	2.95	12.57	7.25	0.63	0.49	0.25	0.00	0.16	0.07	5.87	4.37	12.96	47.57
1946	2.39	4.88	7.07	0.07	0.82	0.00	0.00	0.00	0.03	0.38	10.99	3.48	30.11
1947	1.15	4.90	5.09	0.94	0.93	0.43	0.00	0.00	0.05	3.57	0.84	2.52	20.42
1948	0.21	3.38	9.06	7.77	1.79	0.03	0.00	0.00	0.00	4.10	0.53	6.83	33.7
1949	4.48	5.57	10.02	0.03	0.13	0.00	0.05	0.02	0.01	0.00	4.67	3.70	28.68
1950	10.26	7.93	4.18	1.71	0.48	0.00	0.01	0.00	0.31	4.90	12.73	7.35	49.86
1951	5.09	2.58	2.36	1.78	1.45	0.00	0.00	0.00	0.00	1.91	4.25	17.44	36.86
1952	17.10	2.66	11.34	1.87	0.76	0.08	0.00	0.00	0.07	0.10	4.72	15.10	53.8
1953	9.77	0.00	3.97	6.31	0.31	0.29	0.00	0.07	0.00	0.32	4.43	1.22	26.69
1954	8.69	5.46	8.73	4.01	0.44	0.51	0.00	0.01	0.00	0.00	7.58	7.05	42.48
1955	8.70	2.16	0.32	4.27	1.19	0.12	0.00	0.00	0.00	0.05	3.29	27.21	47.31
1956	11.18	4.52	0.18	4.21	1.27	0.00	0.00	0.00	0.05	1.72	0.00	0.75	23.88
1957	6.70	7.82	2.86	3.62	7.58	0.23	0.00	0.00	0.56	4.44	1.33	8.66	43.8
1958	8.24	14.80	15.41	9.98	0.49	0.11	0.00	0.00	0.47	0.00	0.41	1.31	51.22
1959	12.87	7.41	0.41	1.10	0.02	0.00	0.00	0.04	8.72	0.00	0.00	0.95	31.52
1960	10.66	9.76	6.42	2.28	0.40	0.00	0.00	0.00	0.00	0.12	6.60	3.09	39.33
1961	4.57	1.68	3.84	1.21	0.49	0.09	0.00	0.00	0.12	0.06	5.05	3.49	20.6
1962	3.96	21.88	4.45	0.62	0.26	0.11	0.00	0.00	0.00	8.15	0.35	6.61	46.39
1963	13.89	11.67	7.80	11.08	0.53	0.08	0.00	0.00	0.03	3.38	10.22	0.41	59.09
1964	5.57	0.40	4.63	0.72	2.69	1.02	0.00	0.00	0.03	2.96	5.87	13.96	37.85

Table A1.1: Big Sur State Park Gage
Monthly Accumulated Precipitation (inches)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1965	8.38	1.78	4.79	4.76	0.13	0.00	0.00	0.07	0.00	0.24	14.97	8.41	43.53
1966	3.54	5.14	0.31	0.89	0.00	0.00	0.12	0.00	0.23	0.00	9.60	11.89	31.72
1967	13.94	1.09	9.34	12.41	0.68	1.14	0.00	0.00	0.18	0.29	1.83	4.51	45.41
1968	8.30	4.23	3.94	1.25	0.50	0.00	0.00	0.21	0.00	1.80	3.38	8.06	31.67
1969	23.50	17.61	2.66	3.90	0.10	0.08	0.00	0.00	0.11	2.43	2.79	11.46	64.64
1970	15.28	4.01	4.47	0.90	0.00	0.55	0.00	0.00	0.00	1.03	12.37	10.35	48.96
1971	3.06	1.08	3.93	2.00	0.88	0.00	0.00	0.00	0.21	0.25	3.66	13.33	28.4
1972	1.36	2.94	0.07	1.42	0.10	0.15	0.00	0.00	0.18	5.20	14.56	2.59	28.57
1973	13.76	17.27	6.40	0.25	0.00	0.00	0.00	0.00	0.12	4.50	9.05	10.82	62.17
1974	9.10	1.27	16.12	5.62	0.00	0.84	0.68	0.00	0.00	2.01	2.40	9.92	47.96
1975	1.91	11.30	11.60	2.56	0.00	0.00	0.04	0.20	0.00	4.64	0.56	0.54	33.35
1976	0.20	2.58	3.50	3.05	0.00	0.17	0.00	2.60	1.68	0.60	1.35	2.40	18.13
1977	2.50	1.01	3.39	0.00	1.64	0.03	0.00	0.00	1.80	0.39	2.95	15.08	28.79
1978	15.87	11.38	10.60	8.26	0.10	0.00	0.00	0.00	0.77	0.00	8.72	2.04	57.74
1979	9.22	8.96	7.25	1.40	0.22	0.00	0.25	0.00	0.00	3.90	6.32	9.19	46.71
1980	14.02	10.82	5.13	2.51	0.99	0.10	0.87	0.00	0.00	8.70	0.00	0.00	43.14
1981	m	m	m	m	m	m	m	m	m	m	m	m	m
1982	m	m	m	m	m	m	m	m	m	2.93	11.60	7.72	m
1983	15.35	13.56	m	8.89	1.37	0.08	0.00	0.10	3.39	2.63	14.22	7.75	67.34
1984	0.35	2.76	2.82	0.75	0.05	0.11	0.04	0.03	0.22	2.96	8.64	4.02	22.75
1985	0.88	3.83	6.83	0.71	0.15	0.26	0.00	0.00	0.68	1.34	8.26	5.13	28.07
1986	8.79	17.06	11.33	0.56	0.23	0.00	0.06	0.00	1.67	0.00	0.69	5.02	45.41
1987	4.94	9.99	9.47	1.43	0.07	0.00	0.00	0.00	0.00	1.94	3.27	11.31	42.42
1988	4.69	1.77	0.61	4.13	1.16	0.42	0.00	0.00	0.00	0.00	4.61	8.33	25.72
1989	2.44	3.09	9.20	1.14	0.16	0.00	0.00	0.00	0.97	3.69	2.59	0.16	23.44
1990	5.53	3.70	2.38	1.06	2.35	0.00	0.00	0.00	0.49	0.01	0.63	1.84	17.99
1991	0.71	4.96	20.72	1.55	0.09	1.91	0.00	0.06	0.00	2.76	0.72	7.82	41.3
1992	2.69	13.00	7.51	0.45	0.00	0.00	0.56	0.02	0.00	3.17	0.56	12.88	40.84
1993	21.04	11.36	2.74	1.46	2.42	0.84	0.00	0.00	0.00	0.26	3.81	3.35	47.28
1994	5.42	9.39	1.34	3.17	1.81	0.00	0.00	0.00	0.32	1.33	6.75	6.06	35.59
1995	26.47	2.22	15.84	5.35	1.86	1.78	0.00	0.00	0.00	0.00	0.00	8.45	61.97
1996	14.65	18.21	3.98	3.07	3.29	0.00	0.00	0.00	0.00	2.83	11.48	22.94	80.45
1997	19.45	0.39	0.22	0.50	0.02	0.20	0.00	1.38	0.00	0.40	9.29	8.09	39.94
1998	17.01	24.30	6.72	4.54	4.93	0.06	0.00	0.00	0.00	m	m	m	m

avg	8.1	7.5	5.8	2.9	0.9	0.3	0.0	0.1	0.4	1.8	4.3	7.6	39.7
min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0
max	26.47	22.39	20.72	12.41	7.58	2.53	0.87	2.6	8.72	8.7	14.97	27.21	80.45

Table A1.2: Big Sur State Park Gage Ranked by Calendar Year Totals Monthly Accumulated Precipitation (inches)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1981	m	m	m	m	m	m	m	m	m	m	m	m	
1982	m	m	m	m	m	m	m	m	m	2.93	11.60	7.72	m
1913	m	m	m	m	m	m	m	m	m	0.00	0.00	0.00	m
1998	17.01	24.30	6.72	4.54	4.93	0.06	0.00	0.00	0.00	m	m	m	m
1914	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.59	0.62	13.75	15.96
1990	5.53	3.70	2.38	1.06	2.35	0.00	0.00	0.00	0.49	0.01	0.63	1.84	17.99
1976	0.20	2.58	3.50	3.05	0.00	0.17	0.00	2.60	1.68	0.60	1.35	2.40	18.13
1947	1.15	4.90	5.09	0.94	0.93	0.43	0.00	0.00	0.05	3.57	0.84	2.52	20.42
1961	4.57	1.68	3.84	1.21	0.49	0.09	0.00	0.00	0.12	0.06	5.05	3.49	20.6
1923	5.24	1.27	0.19	8.88	0.00	0.52	0.00	0.00	0.89	0.25	1.19	2.41	20.84
1939	5.30	3.83	4.92	0.46	1.21	0.00	0.00	0.00	0.57	1.31	0.50	4.21	22.31
1984	0.35	2.76	2.82	0.75	0.05	0.11	0.04	0.03	0.22	2.96	8.64	4.02	22.75
1989	2.44	3.09	9.20	1.14	0.16	0.00	0.00	0.00	0.97	3.69	2.59	0.16	23.44
1956	11.18	4.52	0.18	4.21	1.27	0.00	0.00	0.00	0.05	1.72	0.00	0.75	23.88
1929	2.14	5.25	6.46	2.17	0.00	1.67	0.00	0.00	0.03	0.00	0.00	6.31	24.03
1932	6.90	9.17	2.36	1.49	0.64	0.05	0.00	0.00	0.00	0.09	0.69	3.55	24.94
1988	4.69	1.77	0.61	4.13	1.16	0.42	0.00	0.00	0.00	0.00	4.61	8.33	25.72
1917	3.59	13.74	2.68	0.71	0.60	0.00	0.00	0.00	0.00	0.00	3.79	1.38	26.49
1953	9.77	0.00	3.97	6.31	0.31	0.29	0.00	0.07	0.00	0.32	4.43	1.22	26.69
1985	0.88	3.83	6.83	0.71	0.15	0.26	0.00	0.00	0.68	1.34	8.26	5.13	28.07
1971	3.06	1.08	3.93	2.00	0.88	0.00	0.00	0.00	0.21	0.25	3.66	13.33	28.4
1972	1.36	2.94	0.07	1.42	0.10	0.15	0.00	0.00	0.18	5.20	14.56	2.59	28.57
1949	4.48	5.57	10.02	0.03	0.13	0.00	0.05	0.02	0.01	0.00	4.67	3.70	28.68
1924	6.92	1.21	5.01	0.97	0.00	0.02	0.00	0.00	0.00	3.54	5.43	5.64	28.74
1977	2.50	1.01	3.39	0.00	1.64	0.03	0.00	0.00	1.80	0.39	2.95	15.08	28.79
1946	2.39	4.88	7.07	0.07	0.82	0.00	0.00	0.00	0.03	0.38	10.99	3.48	30.11
1930	9.63	6.70	5.94	2.13	1.60	0.04	0.00	0.00	0.17	0.02	3.82	0.27	30.32
1959	12.87	7.41	0.41	1.10	0.02	0.00	0.00	0.04	8.72	0.00	0.00	0.95	31.52
1968	8.30	4.23	3.94	1.25	0.50	0.00	0.00	0.21	0.00	1.80	3.38	8.06	31.67
1966	3.54	5.14	0.31	0.89	0.00	0.00	0.12	0.00	0.23	0.00	9.60	11.89	31.72
1919	1.98	11.14	4.15	0.20	0.08	0.00	0.00	0.00	1.61	0.14	0.36	12.39	32.05
1925	3.90	7.25	4.54	3.24	6.97	0.12	0.00	0.00	0.81	0.55	1.48	3.67	32.53
1933	9.96	1.64	3.55	0.34	1.61	0.36	0.00	0.00	0.03	3.30	0.06	12.38	33.23
1975	1.91	11.30	11.60	2.56	0.00	0.00	0.04	0.20	0.00	4.64	0.56	0.54	33.35
1948	0.21	3.38	9.06	7.77	1.79	0.03	0.00	0.00	0.00	4.10	0.53	6.83	33.7
1934	2.61	10.99	0.00	0.88	1.34	2.53	0.00	0.00	0.29	2.76	6.78	6.07	34.25
1928	1.49	5.27	13.27	2.18	0.27	0.00	0.00	0.00	0.00	0.00	5.55	6.70	34.73
1994	5.42	9.39	1.34	3.17	1.81	0.00	0.00	0.00	0.32	1.33	6.75	6.06	35.59
1951	5.09	2.58	2.36	1.78	1.45	0.00	0.00	0.00	0.00	1.91	4.25	17.44	36.86
1918	1.15	7.29	10.94	0.34	0.00	0.00	0.00	0.00	5.41	0.13	8.29	4.29	37.84
1964	5.57	0.40	4.63	0.72	2.69	1.02	0.00	0.00	0.03	2.96	5.87	13.96	37.85
1935	10.60	2.09	5.90	9.77	0.08	0.00	0.00	0.45	0.00	3.28	1.55	4.74	38.46
1921	12.70	2.84	5.23	1.22	2.37	0.00	0.00	0.00	0.36	0.33	1.17	12.48	38.7
1926	7.03	8.82	0.30	6.85	0.25	0.00	0.00	0.00	0.00	2.29	11.24	2.30	39.08
1920	0.95	3.08	9.71	5.94	0.00	0.23	0.00	0.00	0.05	2.39	6.76	10.05	39.16
1960	10.66	9.76	6.42	2.28	0.40	0.00	0.00	0.00	0.00	0.12	6.60	3.09	39.33
1997	19.45	0.39	0.22	0.50	0.02	0.20	0.00	1.38	0.00	0.40	9.29	8.09	39.94
1931	9.32	2.14	0.71	0.82	2.01	1.33	0.00	0.00	0.00	0.60	4.97	18.21	40.11
1992	2.69	13.00	7.51	0.45	0.00	0.00	0.56	0.02	0.00	3.17	0.56	12.88	40.84
1991	0.71	4.96	20.72	1.55	0.09	1.91	0.00	0.06	0.00	2.76	0.72	7.82	41.3
1943	13.78	5.98	10.54	2.31	0.00	0.00	0.00	0.00	0.00	2.35	0.79	5.57	41.32
1987	4.94	9.99	9.47	1.43	0.07	0.00	0.00	0.00	0.00	1.94	3.27	11.31	42.42

Table A1.2: Big Sur State Park Gage Ranked by Calendar Year Totals Monthly Accumulated Precipitation (inches)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1942	10.25	5.10	5.75	6.45	2.06	0.00	0.00	0.00	0.00	1.09	6.99	4.79	42.48
1954	8.69	5.46	8.73	4.01	0.44	0.51	0.00	0.01	0.00	0.00	7.58	7.05	42.48
1915	9.72	14.82	3.75	2.85	3.42	0.00	0.00	0.00	0.00	0.00	0.55	7.58	42.69
1980	14.02	10.82	5.13	2.51	0.99	0.10	0.87	0.00	0.00	8.70	0.00	0.00	43.14
1965	8.38	1.78	4.79	4.76	0.13	0.00	0.00	0.07	0.00	0.24	14.97	8.41	43.53
1957	6.70	7.82	2.86	3.62	7.58	0.23	0.00	0.00	0.56	4.44	1.33	8.66	43.8
1922	4.90	10.24	4.33	0.92	1.19	0.00	0.00	0.00	0.00	3.64	5.89	12.88	43.99
1986	8.79	17.06	11.33	0.56	0.23	0.00	0.06	0.00	1.67	0.00	0.69	5.02	45.41
1967	13.94	1.09	9.34	12.41	0.68	1.14	0.00	0.00	0.18	0.29	1.83	4.51	45.41
1938	7.35	13.45	15.01	2.79	0.00	0.00	0.00	0.00	0.00	1.84	1.41	3.75	45.6
1944	6.76	14.48	1.96	4.60	1.17	0.18	0.00	0.00	0.00	3.84	7.44	5.35	45.78
1927	6.18	13.10	3.05	4.85	0.32	0.26	0.00	0.00	0.12	3.32	4.69	10.46	46.35
1962	3.96	21.88	4.45	0.62	0.26	0.11	0.00	0.00	0.00	8.15	0.35	6.61	46.39
1979	9.22	8.96	7.25	1.40	0.22	0.00	0.25	0.00	0.00	3.90	6.32	9.19	46.71
1993	21.04	11.36	2.74	1.46	2.42	0.84	0.00	0.00	0.00	0.26	3.81	3.35	47.28
1955	8.70	2.16	0.32	4.27	1.19	0.12	0.00	0.00	0.00	0.05	3.29	27.21	47.31
1945	2.95	12.57	7.25	0.63	0.49	0.25	0.00	0.16	0.07	5.87	4.37	12.96	47.57
1974	9.10	1.27	16.12	5.62	0.00	0.84	0.68	0.00	0.00	2.01	2.40	9.92	47.96
1970	15.28	4.01	4.47	0.90	0.00	0.55	0.00	0.00	0.00	1.03	12.37	10.35	48.96
1950	10.26	7.93	4.18	1.71	0.48	0.00	0.01	0.00	0.31	4.90	12.73	7.35	49.86
1936	11.10	20.67	2.78	3.54	1.30	1.03	0.00	0.00	0.06	1.62	0.00	8.42	50.52
1937	7.15	13.46	12.68	1.58	0.00	0.80	0.00	0.00	0.00	0.41	2.42	12.43	50.93
1958	8.24	14.80	15.41	9.98	0.49	0.11	0.00	0.00	0.47	0.00	0.41	1.31	51.22
1916	21.42	9.41	4.46	0.35	0.43	0.00	0.00	0.00	0.75	2.44	1.35	11.03	51.64
1952	17.10	2.66	11.34	1.87	0.76	0.08	0.00	0.00	0.07	0.10	4.72	15.10	53.8
1978	15.87	11.38	10.60	8.26	0.10	0.00	0.00	0.00	0.77	0.00	8.72	2.04	57.74
1963	13.89	11.67	7.80	11.08	0.53	0.08	0.00	0.00	0.03	3.38	10.22	0.41	59.09
1995	26.47	2.22	15.84	5.35	1.86	1.78	0.00	0.00	0.00	0.00	0.00	8.45	61.97
1973	13.76	17.27	6.40	0.25	0.00	0.00	0.00	0.00	0.12	4.50	9.05	10.82	62.17
1969	23.50	17.61	2.66	3.90	0.10	0.08	0.00	0.00	0.11	2.43	2.79	11.46	64.64
1983	15.35	13.56	m	8.89	1.37	0.08	0.00	0.10	3.39	2.63	14.22	7.75	67.34
1940	22.11	22.39	4.42	2.25	0.94	0.00	0.03	0.00	0.47	1.85	0.78	15.70	70.94
1996	14.65	18.21	3.98	3.07	3.29	0.00	0.00	0.00	0.00	2.83	11.48	22.94	80.45
1941	15.76	18.70	13.39	9.55	1.86	0.04	0.00	0.00	0.00	1.49	1.59	18.07	80.45

avg	8.1	7.5	5.8	2.9	0.9	0.3	0.0	0.1	0.4	1.8	4.3	7.6	39.7
min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0
max	26.47	22.39	20.72	12.41	7.58	2.53	0.87	2.6	8.72	8.7	14.97	27.21	80.45

Appendix B. Geologic Logs

WELL LOG

OWNER:
Andrew Molera State Park
Big Sur, CA

TYPE OF WORK: New monitoring well

EQUIPMENT: Hollow-stem auger

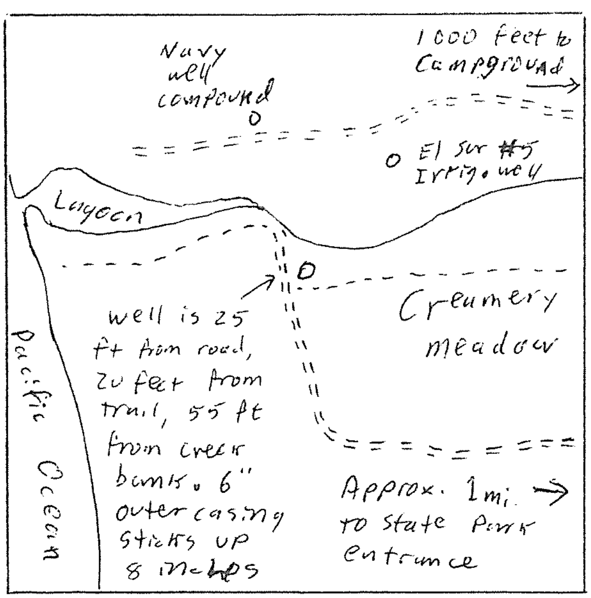
CASING AND PERFORATIONS:
Single-wall PVC
0-4 ft 2-in diam blank
4-24 ft 2-in diam .020 slot

GRAVEL PACK AND SEAL:

0-4 ft	neat cement
4-5 ft	3/8" bentonite chips
6-24 ft	Monterey sand (2/12 Lapis Lustre)
24-30 ft	Native fill (caved)

WELL DEVELOPMENT: None

WELL LOCATION:



GEOLOGIC LOG:

Depth (ft)	Lithology
0-5	Brown silty fine sand with occasional pebbles to 2 cm.
5-10	Gravelly sand. Approx. 33% by vlume is fine dark brown sand, 33% is medium sand (various lithologies, mostly < 1 mm), 33% is large gravel (1-4 cm, rounded to subangular granite and siltstone)
10-30	Coarse caving gravel and cobbles (no cuttings lifted to surface).

LOGGED BY:

Gus Yates, PHg
Jones & Stokes Associates

DATE DRILLED: Sept. 10, 1998

WELL LOG

OWNER:
Andrew Molera State Park
Big Sur, CA

TYPE OF WORK: New monitoring well

EQUIPMENT: Mud rotary

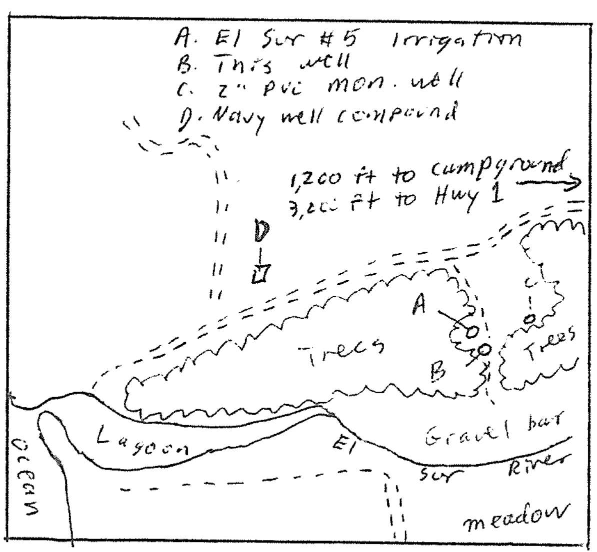
CASING AND PERFORATIONS:
Single-wall PVC
0-7 ft 6-in diam blank
7-28 ft 6-in diam .020 slot

GRAVEL PACK AND SEAL:

0-5 ft	neat cement
5-6 ft	3/8" bentonite chips
6-28 ft	Monterey sand (2/12 Lapis Lustre)
28-38 ft	Backfilled pea gravel with thick bentonite mud.
38-55 ft	Natural caved-in formation, with thick bentonite mud.

WELL DEVELOPMENT:
3 hours air lift with drill rig

WELL LOCATION:



GEOLOGIC LOG: (see also attached e-log)

Depth (ft)	Lithology
0-5	Top soil and sand
5-26	Sand and gravel. Coarse sand to 2-inch gravel (larger material present [occasional heavy rig chatter] but not returned up borehole). Sand fraction (approx. 40% by volume): mostly subangular white quartz with occ. iron stains, dark gray mudstone to graywacke, granite, and minor red chert. Gravel fraction: mostly subangular dark gray mudstone to graywacke, white quartz, rounded granite.
26-30	Clay
30-35	Sand
35-40	Pea gravel
40-45	Loose,caving cobbles
45-55	Sand and small gravel, with some clay near 55 ft. Dominant lithology at all sizes is angular, medium-gray, siltstone, followed by white quartz and minor rounded granite.

LOGGED BY:

Gus Yates, PHg
Jones & Stokes Associates

DATE DRILLED: Sept. 10-12, 1998

GEO-HYDRO-DATA
INCORPORATED

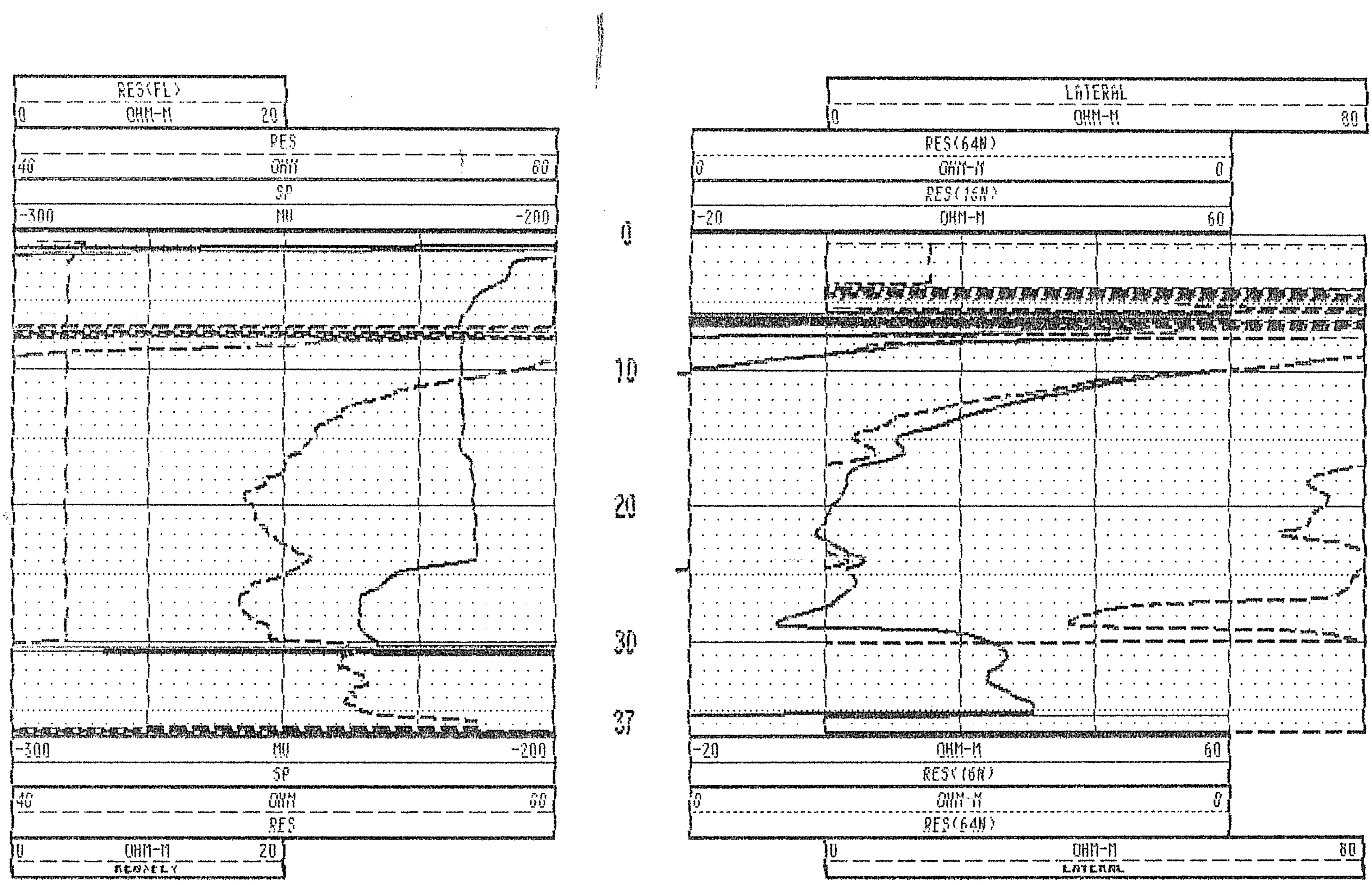
ELECTRIC WELL LOG

COMPANY	: MOLERA STATE PARK			OTHER SERVICES: INVOICE 10680	
WELL	: OBSERVATION 1 A				
LOCATION/FIELD	: MULERA STATE LPARK				
COUNTY	: MONTEREY				
STATE	: CA.				
SECTION	: .	TOWNSHIP	: .	RANGE	: .
DATE	: 09/11/98	PERMANENT DATUM	: G.L.	ELEVATIONS	
DEPTH DRILLER	: 55	ELEV. PERM. DATUM	: .	KB	: .
LOG BOTTOM	: 36.80	LOG MEASURED FROM	: G.L.	DF	: .
LOG TOP	: 0.80	DRL MEASURED FROM	: G.L.	GL	: .
CASING DRILLER	: .	LOGGING UNIT	: 7		
CASING TYPE	: .	FIELD OFFICE	: TEHACHAPI		
CASING THICKNESS	: –	RECORDED BY	: K KEMP		
BIT SIZE	: 7.865	BOREHOLE FLUID	: BENT	FILE	: ORIGINAL
MAGNETIC DECL.	: –	RM	: –	TYPE	: 9041A
MATRIX DENSITY	: –	RM TEMPERATURE	: –	LOG	: 3
FLUID DENSITY	: –	MATRIX DELTA T	: –	PLOT	: 1 9
NEUTRON MATRIX	: .	FLUID DELTA T	: –	THRESH	: 3000
REMARKS	:				

DDRILLED BY: MAGGIORA BROS.

CO;NSULTENT:JONES- STOKES SACRAMENTO, CA

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS



Appendix C. Geoconsultants Report

GEOCONSULTANTS, INC.
Hydrogeology • Ground-Water Exploration & Development •
Ground-Water Resources Management •
1450 Koll Circle, Suite 114, San Jose, California 95112-4612
Phone: (408) 453-2541 Fax: (408) 453-2543
www.geo-consultants.com

October 26, 1998
Project No. G1121-01

Mr. Matt Zidar
Jones & Stokes Associates, Inc.
2600 V Street, Suite 100
Sacramento, CA 95818-1914

**RE: FINAL REPORT
GEOPHYSICAL CHARACTERIZATION
OF EL SUR RANCH
MONTEREY COUNTY, CALIFORNIA
JSA PROJECT NO. 7186**

Dear Mr. Zidar:

In accordance with your authorization dated July 2, 1997, and amended as Task Order No. 2 on September 30, 1998, this report presents the results of the final geophysical survey performed on the Creamery Meadow portion of the Andrew Molera State Park in Monterey County, California. The purpose of the geophysical survey was to determine, to the extent possible, the subsurface geology of the El Sur project area, particularly the depth to bedrock and other lithologic features that would influence groundwater flow, groundwater quality, and stream-aquifer interactions. The field survey was a continuation of geophysical work conducted previously on the north side of the Big Sur River. This final summary provides a description of the underlying geologic conditions on both sides of the Big Sur River, and includes an expanded version of the contour elevation map of the interpreted "base of gravels", continued from that shown on Figure 4 of our previous survey. Figure 1 shows both the locations of the areas surveyed and the contour elevation map of the entire study area.

HYDROGEOLOGIC CONDITIONS

The site surveyed during this phase of the study is known as the Creamery Meadow area of Andrew Molera State Park. The meadow area is located south of the Big Sur River, and just west of the parking area. The meadow is underlain by relatively unconsolidated alluvial materials consisting of cobble-pebble gravel, sand, silt, and clay (Hall, 1991). These are the same materials that underlie the previously surveyed site on the north side of the Big Sur River, and were deposited on the flood plain during Pleistocene time as a result of channel migration within the drainage of the Big Sur River.

To further characterize the depositional basin underlying the site, our field work was directed towards characterizing the subsurface materials, with particular reference to the thickness and extent of the gravel deposits.

FIELD SURVEY

Our field work for this additional phase of surveying was performed on October 1, 1998, and consisted of a site reconnaissance followed by sixteen VLF/EM soundings. The sounding locations are plotted on the Site Plan (Figure 1), and are staked and/or flagged in the field.

VLF/EM Soundings

Sixteen very low frequency electromagnetic (VLF/EM) soundings were performed at the locations shown on the Site Plan (Figure 1). While these soundings generally penetrate to relatively shallow depths, they are ideally suited for surveying in this type of gravel environment. As stated in our previous report (Geoconsultants, Inc. 1997), this type of geophysical method produced excellent data on this site, and is easily performed in areas of minimal access. The VLF/EM soundings were spaced throughout the Creamery Meadow to provide as much information as possible on subsurface conditions. VLF/EM-2 was performed at the monitoring well drilled and installed by Maggiora Bros. Drilling, Inc. in the western portion of the meadow for correlation and calibration purposes. The correlation between our VLF/EM-2 sounding and the drillers log was excellent. The driller reported blue clay at 23 feet, while the interpretation of our sounding data places the blue clay at 22 feet.

All sixteen of the VLF/EM soundings exhibited two layers; an upper layer of higher resistivity, and a lower layer of lower resistivity. The interpretation, as it was in our previous report, is that the upper layer of higher resistivity represents the stream gravels and sands, and that the lower layer of lower resistivity represents the blue clay and silt layer. The VLF/EM sounding data allowed for a determination of the thickness of the upper gravel and sand layer, and the completion of the contour map showing the relative thickness of this unit underlying all areas surveyed. The contour map shows the location of the thalweg of the paleochannel of the Big Sur River. This area has the thickest sections of sand and gravel, and was deposited as the river migrated or changed course over the area through time. It should be noted that VLF/EM soundings completed for this report are shown in red on the accompanying Site Plan, Figure 1, while the VLF/EM soundings completed for the previous report are shown in blue. The following Table A presents a summary of the VLF/EM data.

TABLE A
VLF/EM SOUNDING DATA
CREAMERY MEADOW, MONTEREY COUNTY, CA

VLF/EM Sounding Number	Resistivity of Upper Layer (ohm-meters)	Thickness of Upper Layer (feet)	Resistivity of Lower Layer (ohm-meters)	Total Depth Explored (feet)	Surface Elevation (msl)	Elevation Base of Gravel (msl)
VLF/EM-1	100	8	25	56	10	+2
VLF/EM-2	100	22	22	66	8	-14
VLF/EM-3	300	30	80	115	12	-18
VLF/EM-4	300	27	60	105	13	-14
VLF/EM-5	300	20	80	112	14	-6
VLF/EM-6	300	36	65	115	14	-22
VLF/EM-7	300	40	80	128	18	-22
VLF/EM-8	100	49	25	88	18	-31
VLF/EM-9	300	55	60	125	20	-35
VLF/EM-10	100	12	12	46	20	-8
VLF/EM-11	300	40	30	95	20	-20
VLF/EM-12	300	50	70	125	20	-30
VLF/EM-13	300	56	75	128	19	-37
VLF/EM-14	300	40	58	109	22	-18
VLF/EM-15	300	40	58	109	20	-20
VLF/EM-16	300	40	58	109	25	-15

CONCLUSIONS

We conclude from the additional geophysical evidence that the VLF/EM sounding method was successful in delineating the depth and thickness of the sand and gravel layer in both the Creamery Meadow area of Andrew Molera State Park and the area surveyed previously. We have now provided a more complete subsurface picture of the depositional basin, and located a paleochannel of the Big Sur River, which is roughly defined by the -30-foot contour of the base of gravel map (Figure 1). The paleochannel runs through the meadow roughly parallel to the present course of the river until it meets the bedrock restriction near the present beach trail. This paleochannel is where the thickest accumulations of sand and gravel have been deposited as the river made a course across the floodplain.

LIMITATIONS

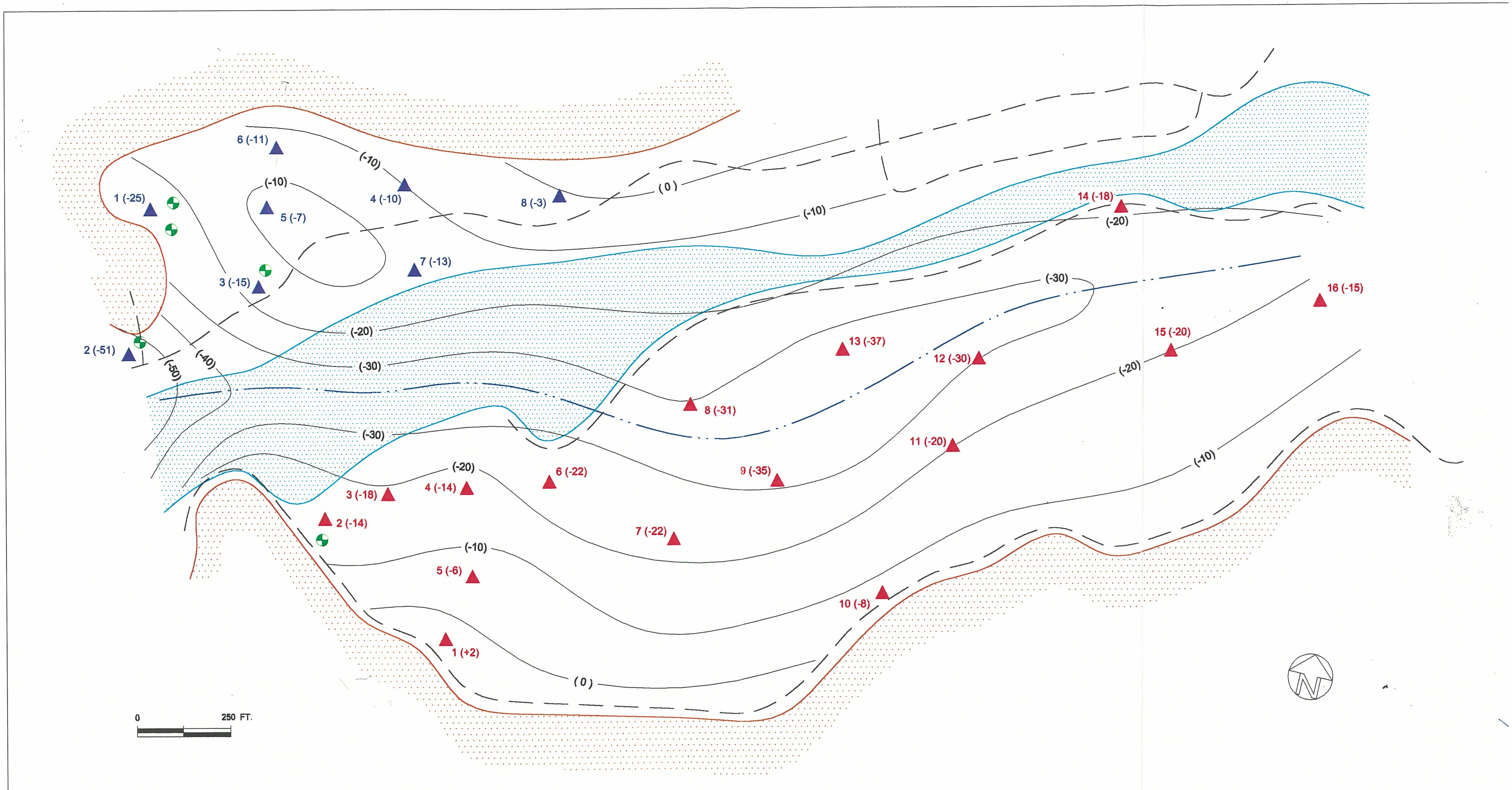
Geoconsultants, Inc. has provided its findings, recommendations, and professional advice after preparing such information in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing under similar conditions in the fields of engineering geology and hydrogeology. This acknowledgment is in lieu of all warranties either express or implied.

It has been a pleasure performing this additional service for you. If you have any questions regarding the data or conclusions, please do not hesitate to call.

Sincerely,
GEOCONSULTANTS, INC.

Keil A. Albert
Staff Geologist

Jeremy C. Wire
Hydrogeologist, HG-93



Explanation

16 (-15) ▲ Very Low Frequency Electromagnetic Sounding Location (Elevation) October 1998 Study	Upland Area	—— (0) ——	Contour Elevation in Feet Below Sea Level
8 (-3) ▲ Very Low Frequency Electromagnetic Sounding Location (Elevation) July 1997 Study	Present Floodplain Big Sur River	—— · ——	Thalweg, Paleochannel of Big Sur River
Existing Well		— — —	Road or Trail

*Base modified from aerial photograph,
Greiner Aerial Surveys for the State of California,
Department of Water Resources, 4/28/86, Scale 1:6000.

FIGURE 1

Contour Map, Base of Gravels
Creamery Meadow, Andrew Molera State Park
Monterey County, California

c:\Drwg\Jobs\G1121-01

Sources: Aerial Photograph*

GEOCONSULTANTS, INC
1450 Koll Circle, Suite 114
San Jose, California 95112

Project No.: G1121-01 10/98

ESR--27

Appendix D. Aquifer Test Data and Analysis Results

Table D.1: Summary of Aquifer Test Data Analysis

Figure No.	Method	Well	T (gpd/ft)	S	Notes
D 1	Boulton type curve (early), analysis of drawdown	OW4	633798	0.0000	
D 2	Boulton type curve (late), analysis of drawdown	OW4	732741	0.0020	
D 3	Jacob semi- log analysis of drawdown	OW4	682719	0.0230	
D 4	Theis with boundary, analysis of drawdown	OW4	683658	0.0225	Used to check calculated distance to the theoretical image well and hence the boundary. With image well at 1775 ft, the boundary would be at 800 ft. River was approx 450 ft.
D 5	Recovery analysis, calculation of residual drawdown				
D 6	Jacob, semi- log analysis of recovery calculated recovery	OW4	653361	0.0237	Extension of drawdown curve to calculate *s'*.
D 7	Jacob analysis of recovery residual drawdown	OW4	646520		S not derived by this method. Plot of s' vs. t/t
D 8	Boutlon unconfined analysis (early)	OW3	732508	0.0006	With Theis Curve
D 9	Boutlon unconfined analysis (late)	OW3	658083	0.0070	With Theis Curve
D 10	Thies analysis of drawdown	OW3	732508	0.0590	
D 11	Jacob semi- log analysis of drawdown	OW3	68513	0.0650	
D 12	Jacob, semi- log analysis of recovery using calculated recovery	OW3	623546	0.0590	Extension of drawdown curve to calculate *s'*. Note that line on the semi- log plot of s' vs t/t' extends well passed origin indicating that water has been added from recharge.
D 13	Jacob, semi- log analysis of recovery residual drawdown	OW3	595825		S not derived by this method. Plot of s' vs. t/t'
D 14	Theis analysis of recovery (Log-Log)	OW3	545068	0.0000	
D 15	Theis Analysis of drawdown	OW1	454974	0.0800	
D 16	Jacob Analysis of drawdown	OW1	642767	0.0500	

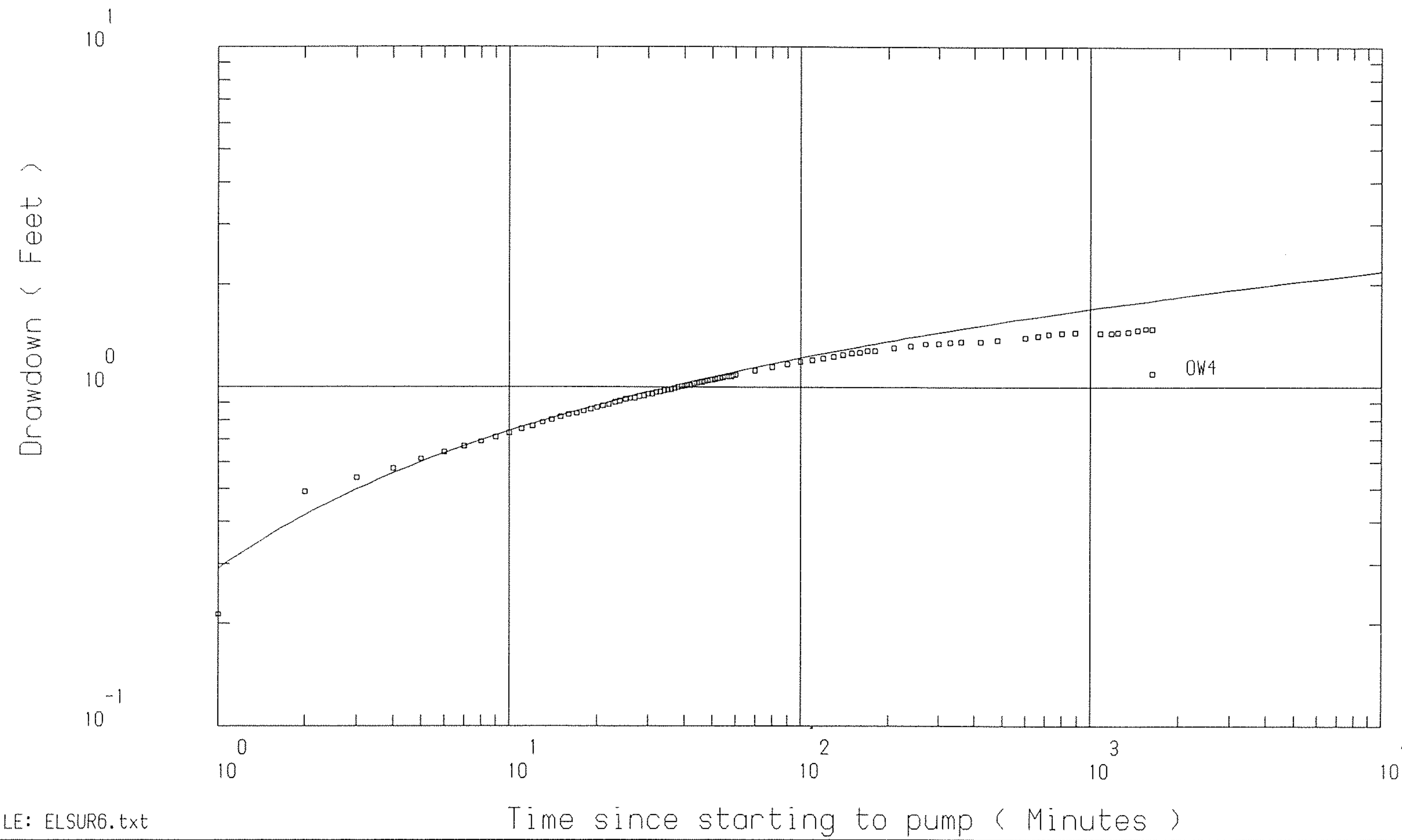
[PUMPING TEST LOG-LOG ANALYSIS : Boulton TYPE CURVE THEIS CURVE]

Observation well : OW4
Distance r = 36.00 FT
Pumping well : EL SUR "NEW"
Pumping rate Q = 1150.00 USG/Min
Transmissivity (early) T = 633798.543 USGPD/FT

Storativity (early) S = 0.00000293

MATCH POINT :

1/ua	=	61910.88	1.00
W(uay,r/M)	=	4.8091550	1.00
Time	=	1.00	0.0000162 Min
Drawdown	=	1.00	0.2079367 FT



FILE: ELSUR6.txt

Figure D 1

[PUMPING TEST LOG-LOG ANALYSIS : Boulton TYPE CURVE THEIS CURVE]

Observation well : OW4
Distance r = 36.00 FT
Pumping well : EL SUR "NEW"
Pumping rate Q = 1150.00 USG/Min

Transmissivity (late) T = 732741.503 USGPD/FT

Storativity (late) Sy = 0.00178844

MATCH POINT :

1/uy	=	117.39	1.00
W(uay,r/M)	=	5.5599173	1.00
Time	=	1.00	0.0085186 Min
Drawdown	=	1.00	0.1798588 FT

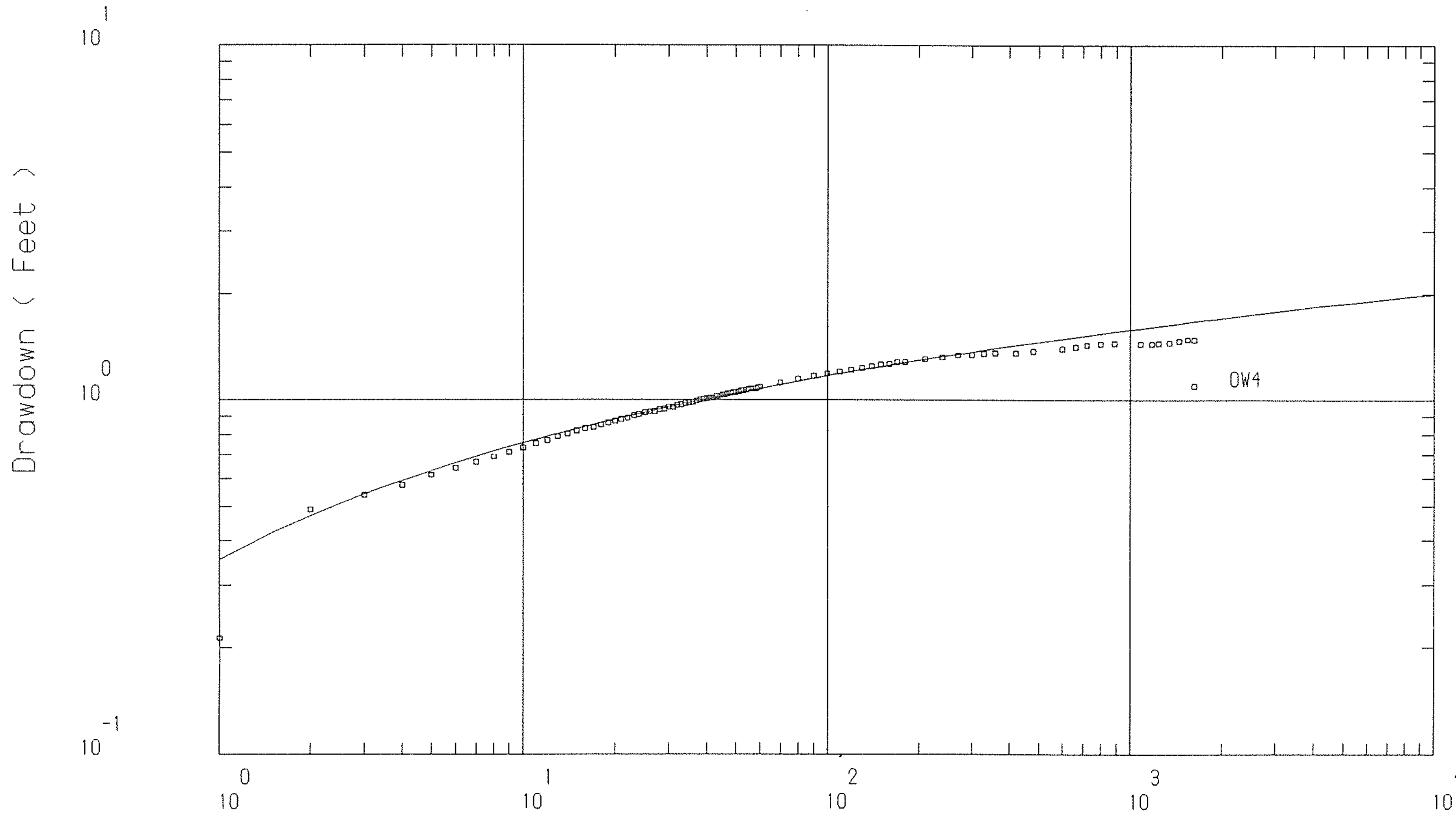


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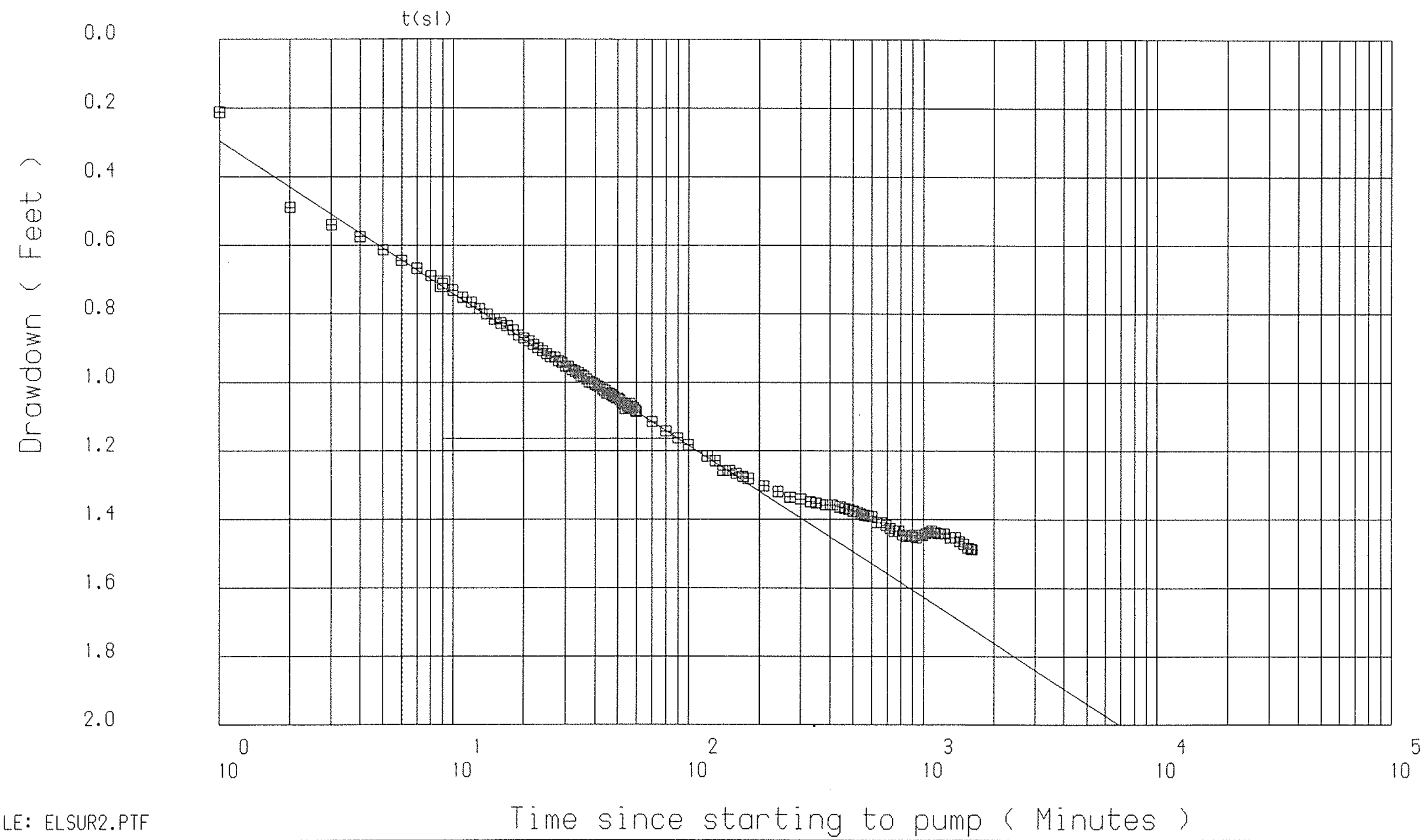
Figure D 2

[PUMPING TEST SEMI-LOG ANALYSIS : JACOB METHOD]

Observation well : OW4
Distance r = 36.00 FT
Pumping well : EL SUR "NEW"
Pumping rate Q = 1150.00 USG/Min

t0 = 0.21500437 Min
ds = 0.44395248 FT
T = 682719.811 USGPD/FT
S = 0.0235962811
t(sl) = 6.04699802 Min



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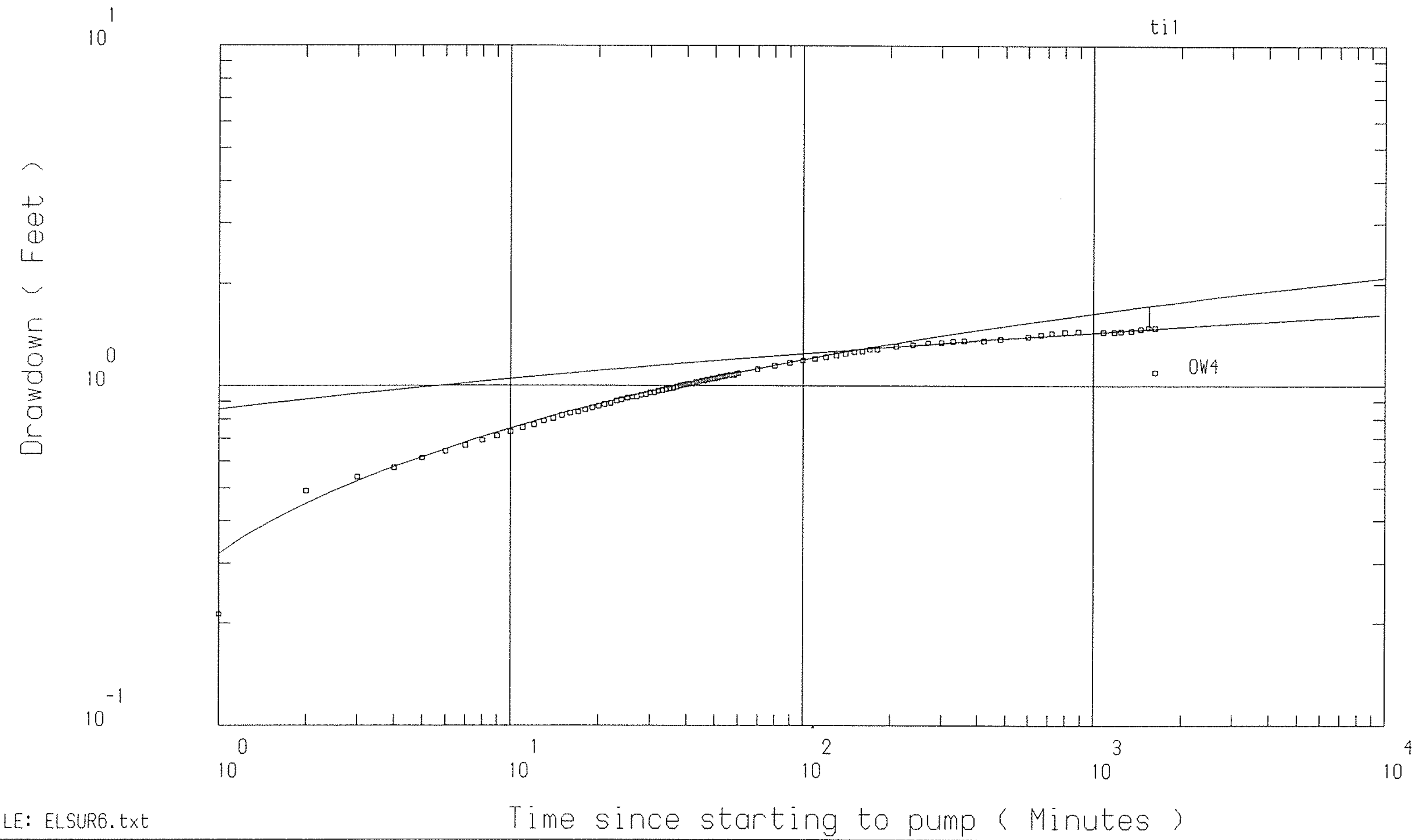
Cooper-Jacob Analysis - El Sur OW4

Figure D 3

[PUMPING TEST LOG-LOG ANALYSIS : Rtheis TYPE CURVE Confined]

Observation well : OW4
Distance r = 36.00 FT
Pumping well : EL SUR "NEW"
Pumping rate Q = 1150.00 USG/Min
BOUNDARY ANALYSIS :
tr1 = 0.6413 Min
ti1 = 1559.52 Min
ri1 = 1775.29 FT

Transmissivity T = 683658.638 USGPD/FT
Storativity S = 0.02258401
Drawdown [W(u)=1.0] s1 = 0.19277164 FT
Drawdown [W(u)=1.0] s2 = 0.08390545 FT

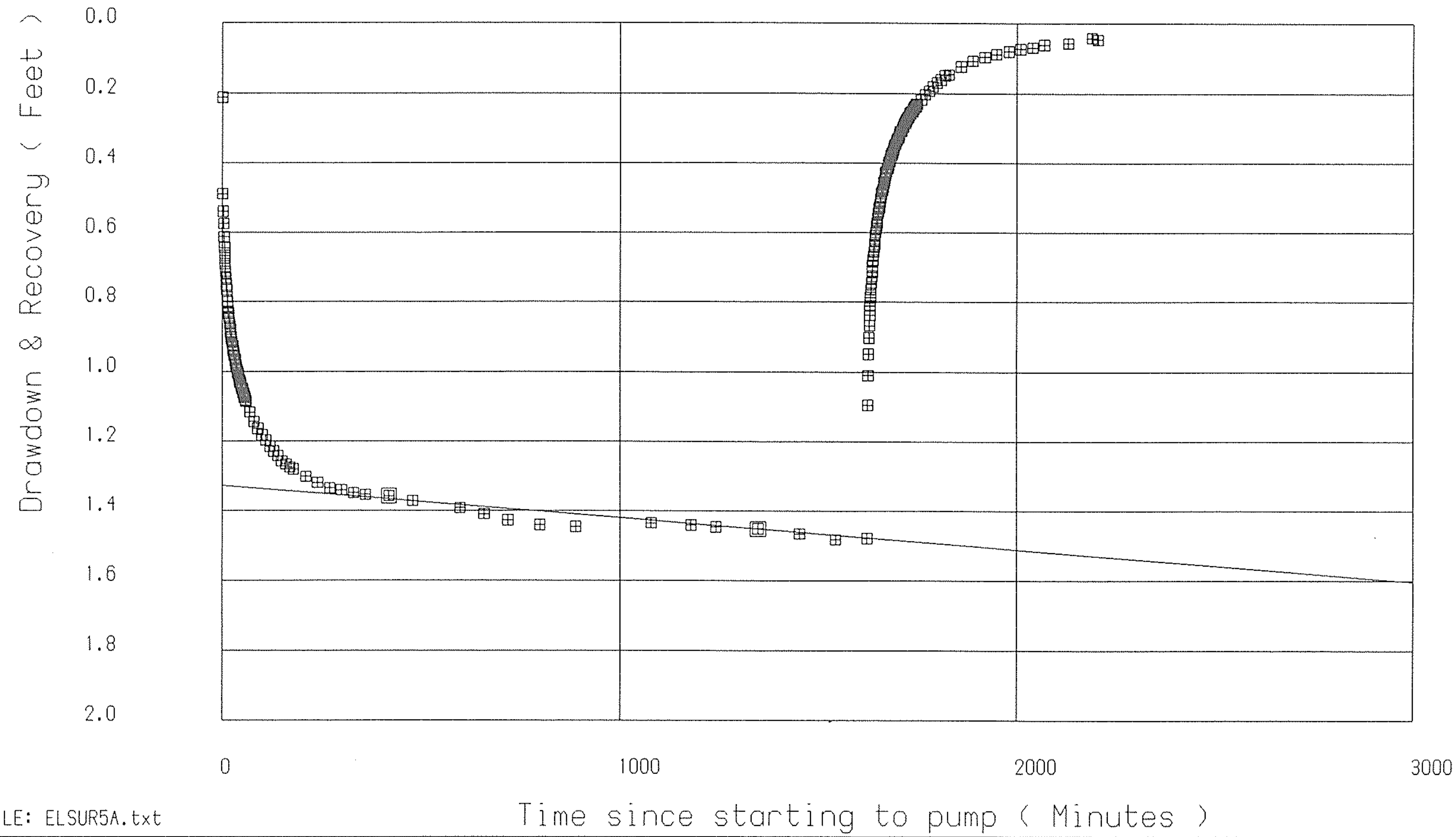


FILE: ELSUR6.txt

Evaluation of Recharge Boundary Conditions

Figure D 4

Observation well : OW4_REC5d
Distance r = 36.00 FT
Pumping well : EL SUR "NEW"
Pumping rate Q = 1150.00 USG/Min



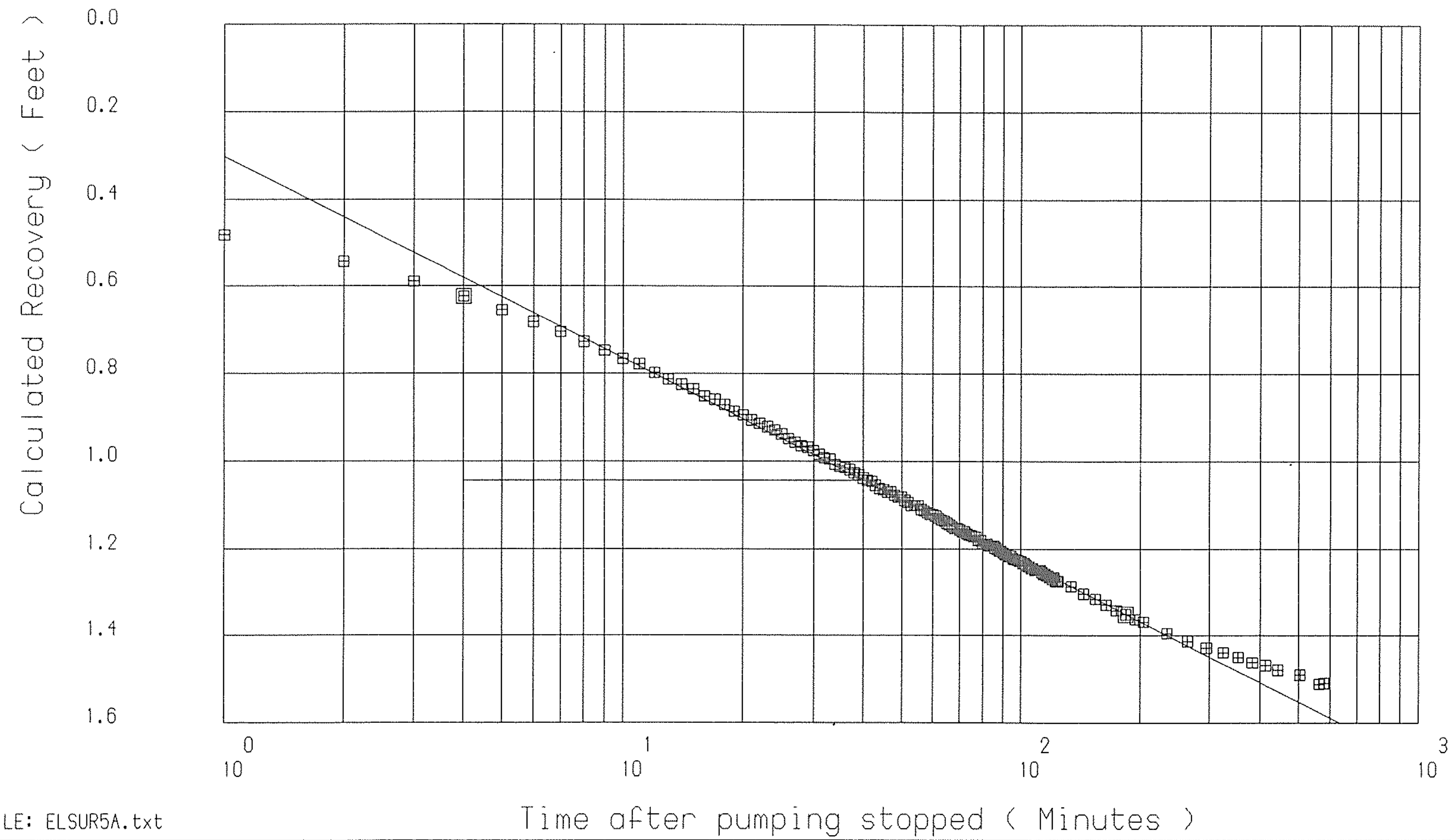
FILE: ELSUR5A.txt

Recovery Analysis of OW4

Figure D 5

[PUMPING TEST RECOVERY SEMI-LOG ANALYSIS : JACOB METHOD]

Observation well : OW4_REC5d		t0	=	0.22600325 Min
Distance	r = 36.00 FT	ds	=	0.46390127 FT
Pumping well	: EL SUR "NEW"	T	=	653361.323 USGPD/FT
Pumping rate	Q = 1150.00 USG/Min	S	=	0.0237367832



FILE: ELSUR5A.txt

Recovery Analysis of OW4- Part 2

Figure D 6

[PUMPING TEST RECOVERY SEMI-LOG ANALYSIS : JACOB METHOD]

Observation well : OW4_REC5d

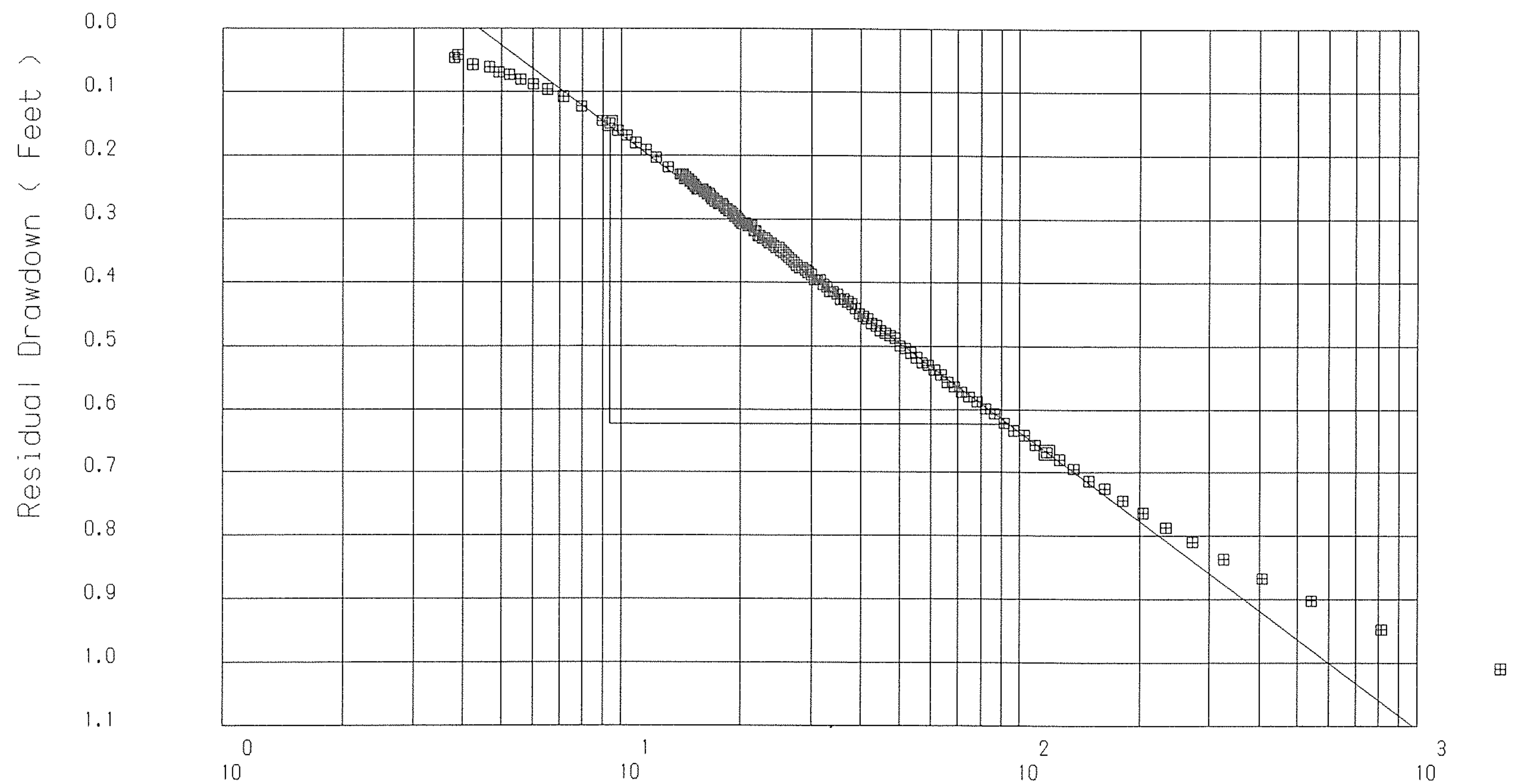
Distance r = 36.00 FT

Pumping well : EL SUR "NEW"

Pumping rate Q = 1150.00 USG/Min

ds = 0.46880969 FT

T = 646520.655 USGPD/FT



FILE: ELSUR5A.txt

Recovery Analysis of OW4 - Part 3

Figure D 7

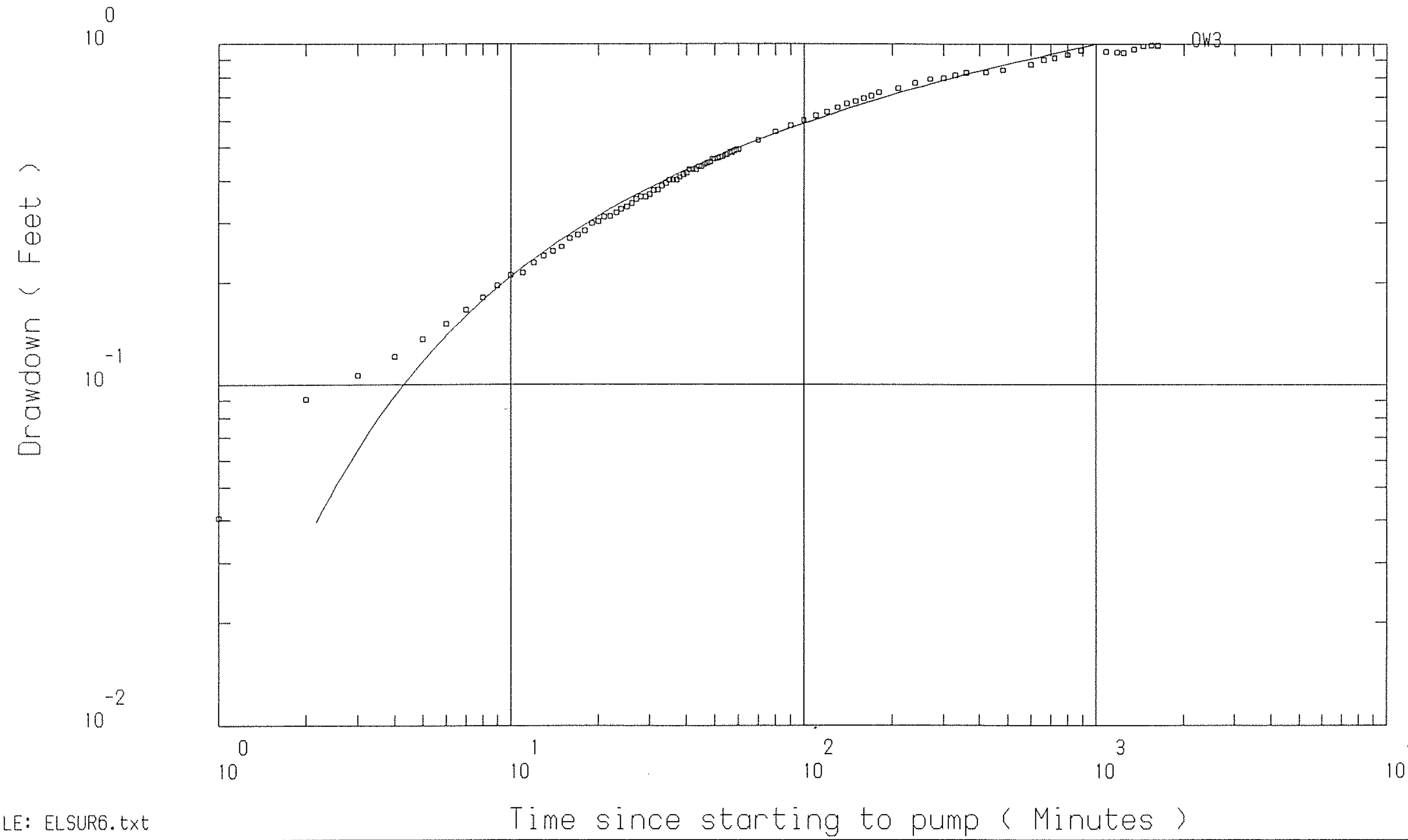
[PUMPING TEST LOG-LOG ANALYSIS : Boulton TYPE CURVE THEIS CURVE]

Observation well : OW3
Distance r = 100.00 FT
Pumping well : EL SUR "NEW"
Pumping rate Q = 1150.00 USG/Min
Transmissivity (early) T = 732508.485 USGPD/FT

Storativity (early) S = 0.00000588

MATCH POINT :

1/ua	=	4624.51	1.00
W(uay,r/M)	=	5.5581492	1.00
Time	=	1.00	0.0002162 Min
Drawdown	=	1.00	0.1799160 FT



FILE: ELSUR6.txt

Figure D 8

[PUMPING TEST LOG-LOG ANALYSIS : Boulton TYPE CURVE THEIS CURVE]

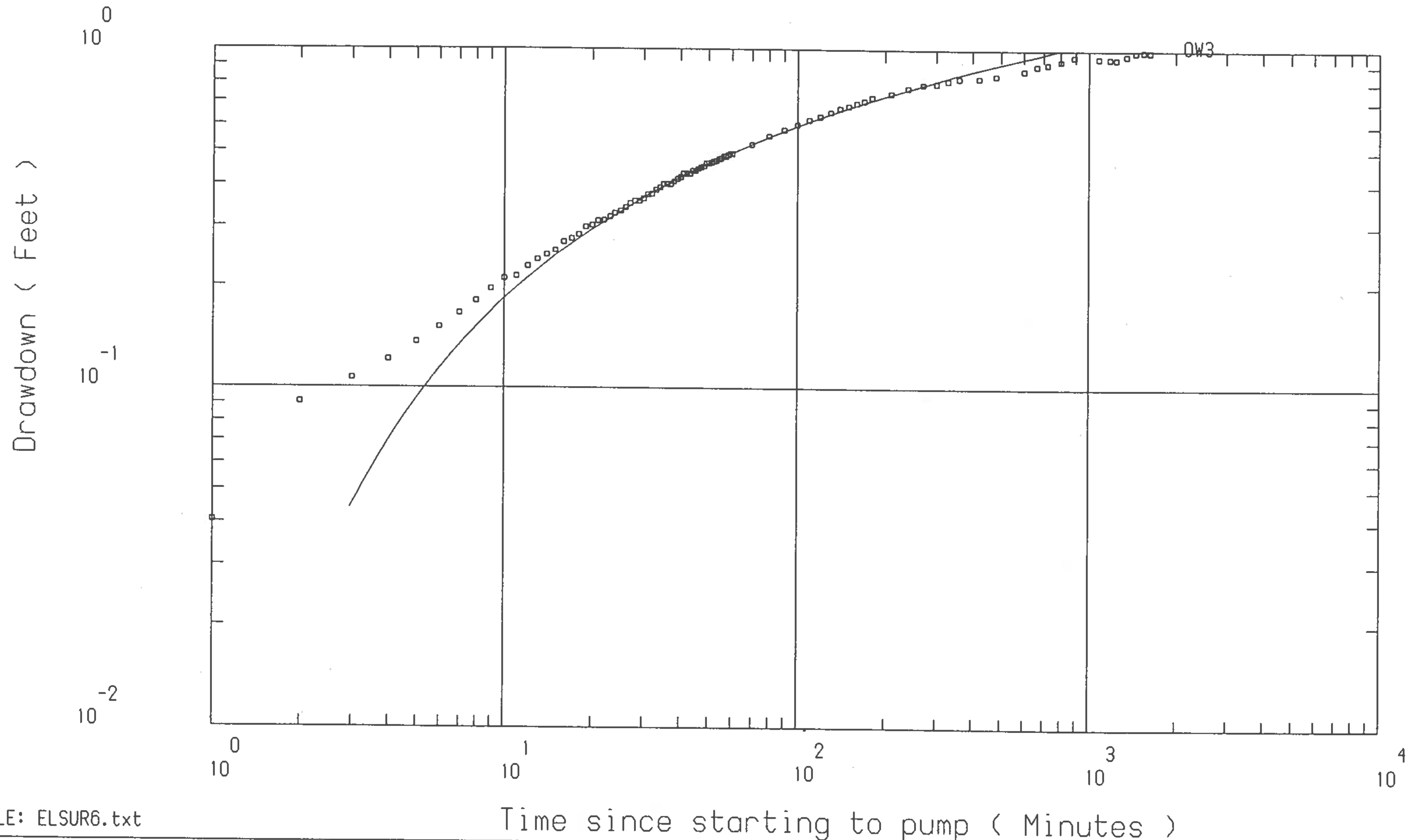
Observation well : OW3
Distance r = 100.00 FT
Pumping well : EL SUR "NEW"
Pumping rate Q = 1150.00 USG/Min

Transmissivity (late) T = 658083.803 USGPD/FT

Storativity (late) Sy = 0.00721705

MATCH POINT :

1/uy	=	3.3859859	1.00
W(uay,r/M)	=	4.9934274	1.00
Time	=	1.00	0.2953350 Min
Drawdown	=	1.00	0.2002632 FT



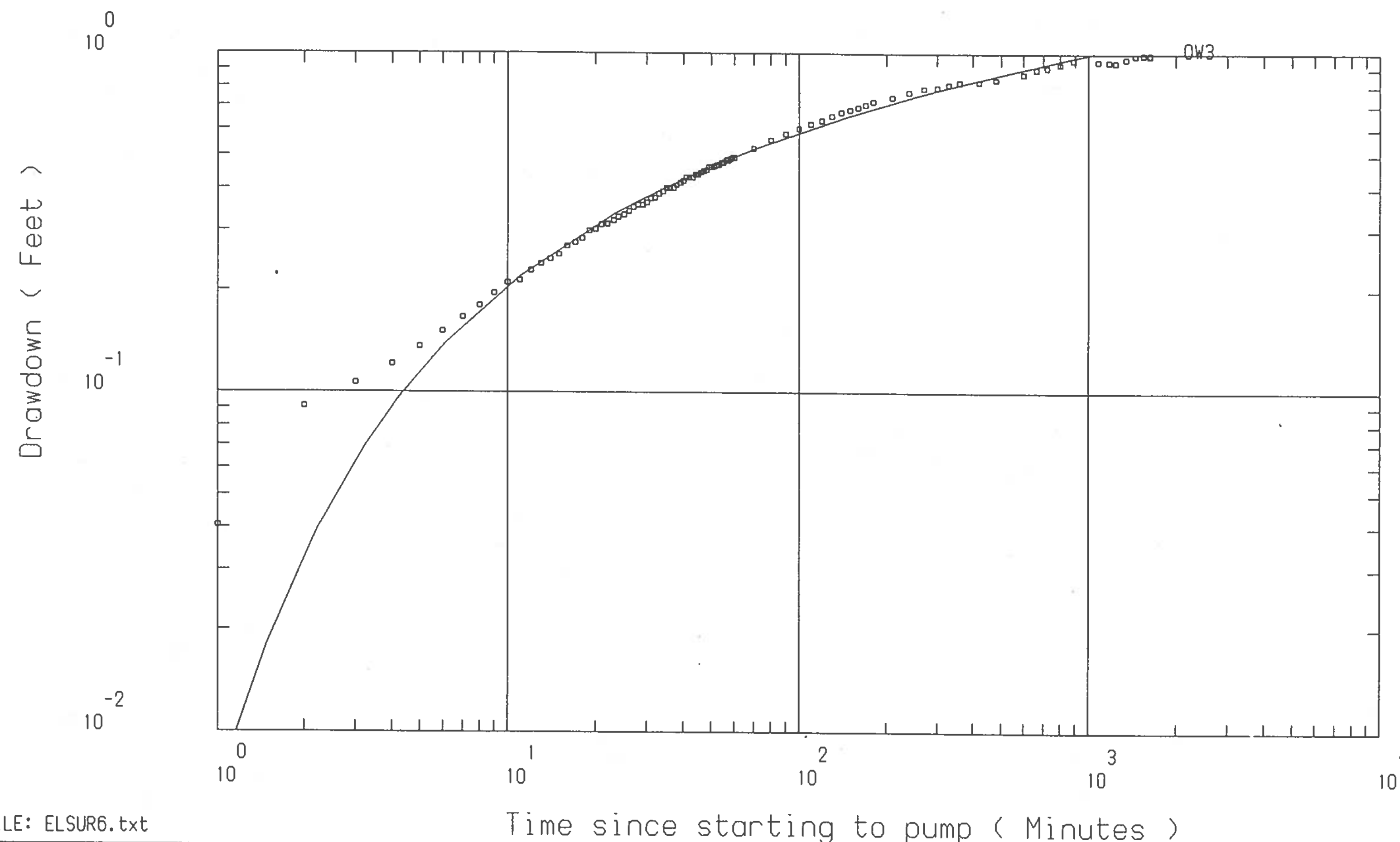
FILE: ELSUR6.txt

Figure D 9

[PUMPING TEST LOG-LOG ANALYSIS : Rtheis TYPE CURVE Confined]

Observation well	:	OW3
Distance	r =	100.00 FT
Pumping well	:	EL SUR "NEW"
Pumping rate	Q =	1150.00 USG/Min
Aquifer thickness	b =	30.0 FT

Transmissivity	T =	732508.485 USGPD/FT	
Storativity	S =	0.05999926	
Hydr. conductivity	K =	24416.950 USGPD/FT^2	
MATCH POINT :			
1/u	=	0.4533466	1.00
W(u)	=	5.5581492	1.00
Time	=	1.00	2.2058177 Min
Drawdown	=	1.00	0.1799160 FT



FILE: ELSUR6.txt

Figure D 10

[PUMPING TEST SEMI-LOG ANALYSIS : JACOB METHOD]

Observation well : OW3
Distance r = 100.00 FT
Pumping well : EL SUR "NEW"
Pumping rate Q = 1150.00 USG/Min

t0 = 4.40751228 Min
ds = 0.44237532 FT
T = 685153.845 USGPD/FT
S = 0.0629129997
t(sl) = 123.961 Min

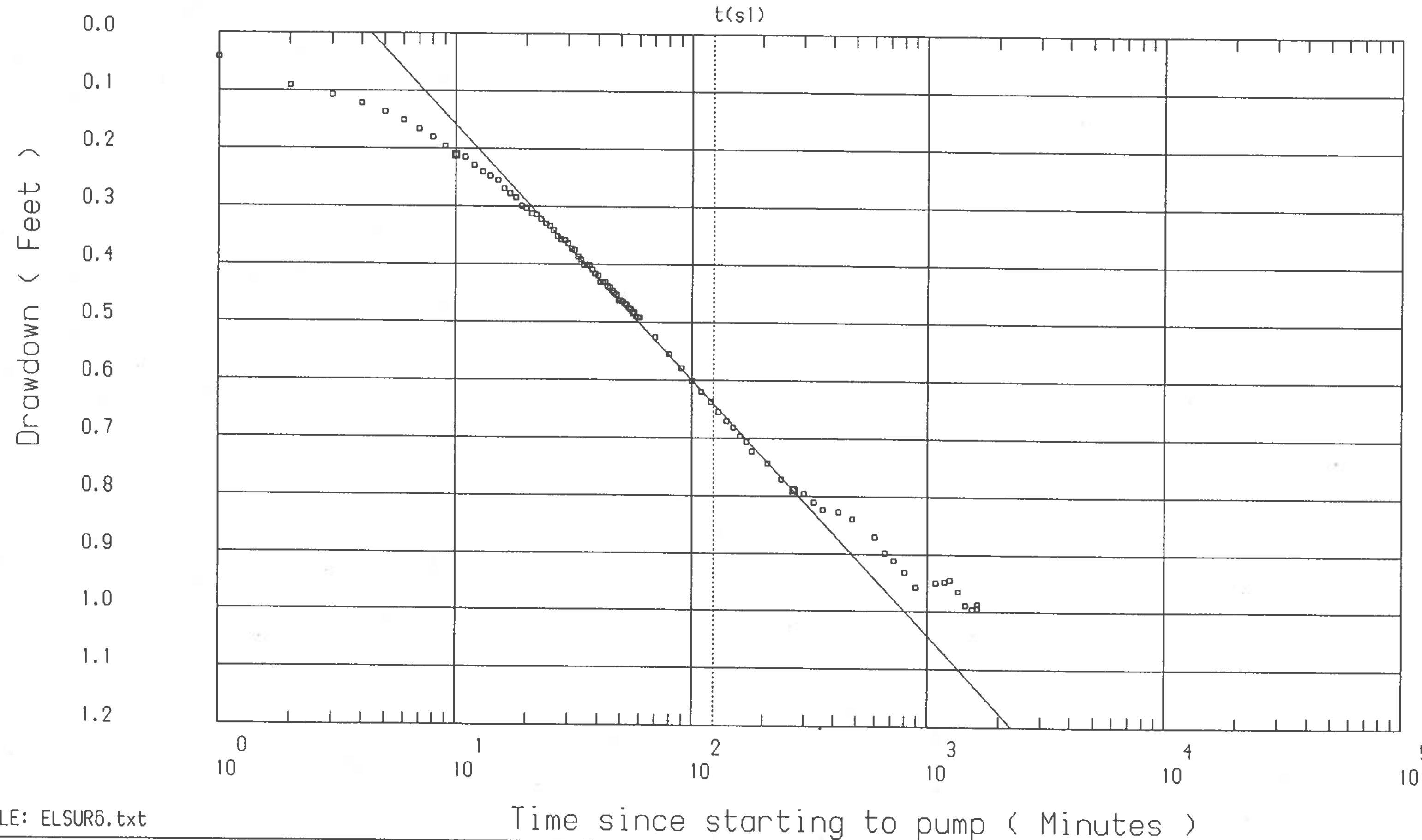


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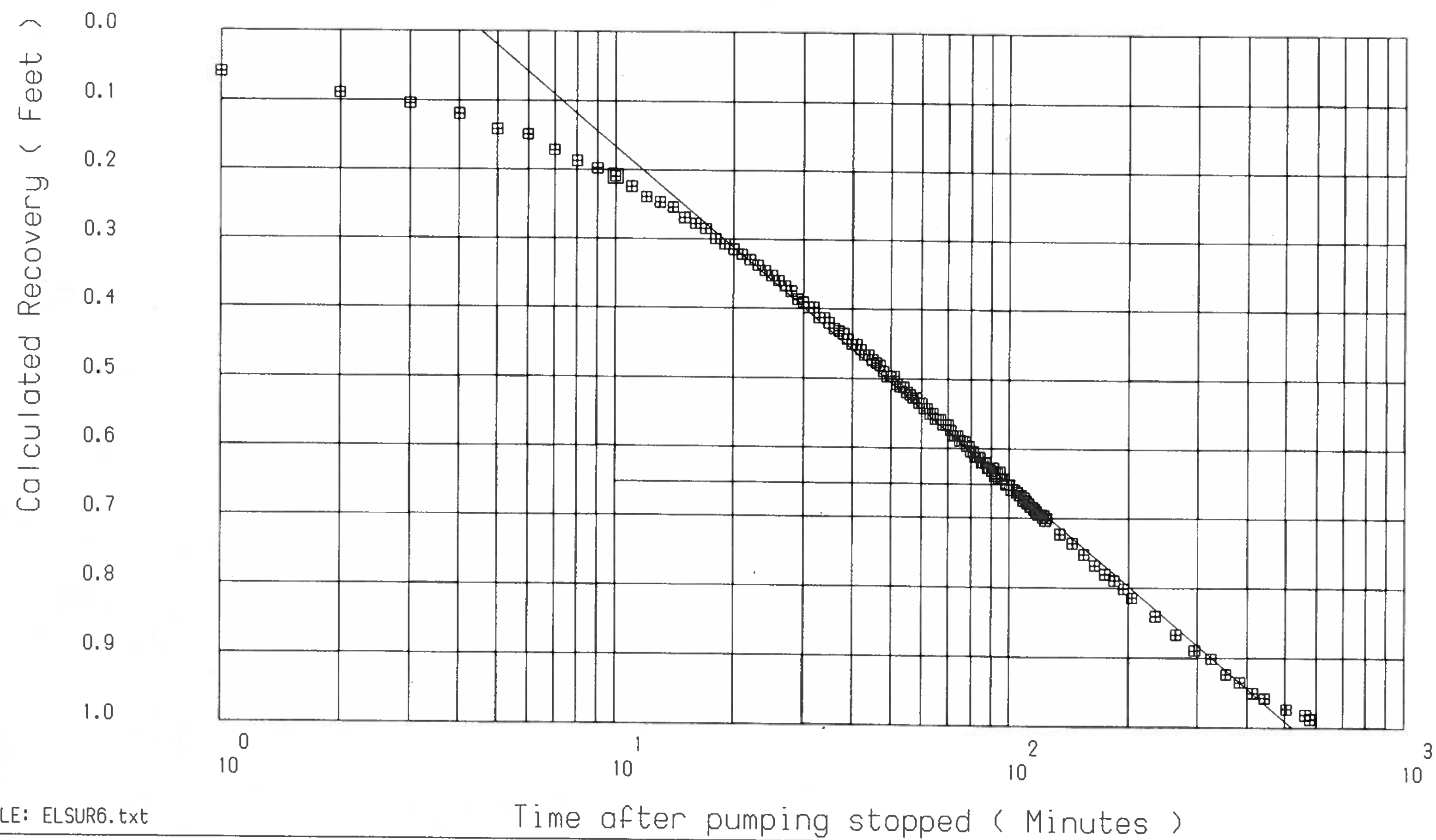
Figure D 11

[PUMPING TEST RECOVERY SEMI-LOG ANALYSIS : JACOB METHOD]

Observation well : OW3
Distance r = 100.00 FT
Pumping well : EL SUR "NEW"
Pumping rate Q = 1150.00 USG/Min

t0 = 4.57251565 Min
ds = 0.48608262 FT
T = 623546.568 USGPD/FT
S = 0.0593995092



FILE: ELSUR6.txt

Figure D 12

[PUMPING TEST RECOVERY SEMI-LOG ANALYSIS : JACOB METHOD]

Observation well : OW3

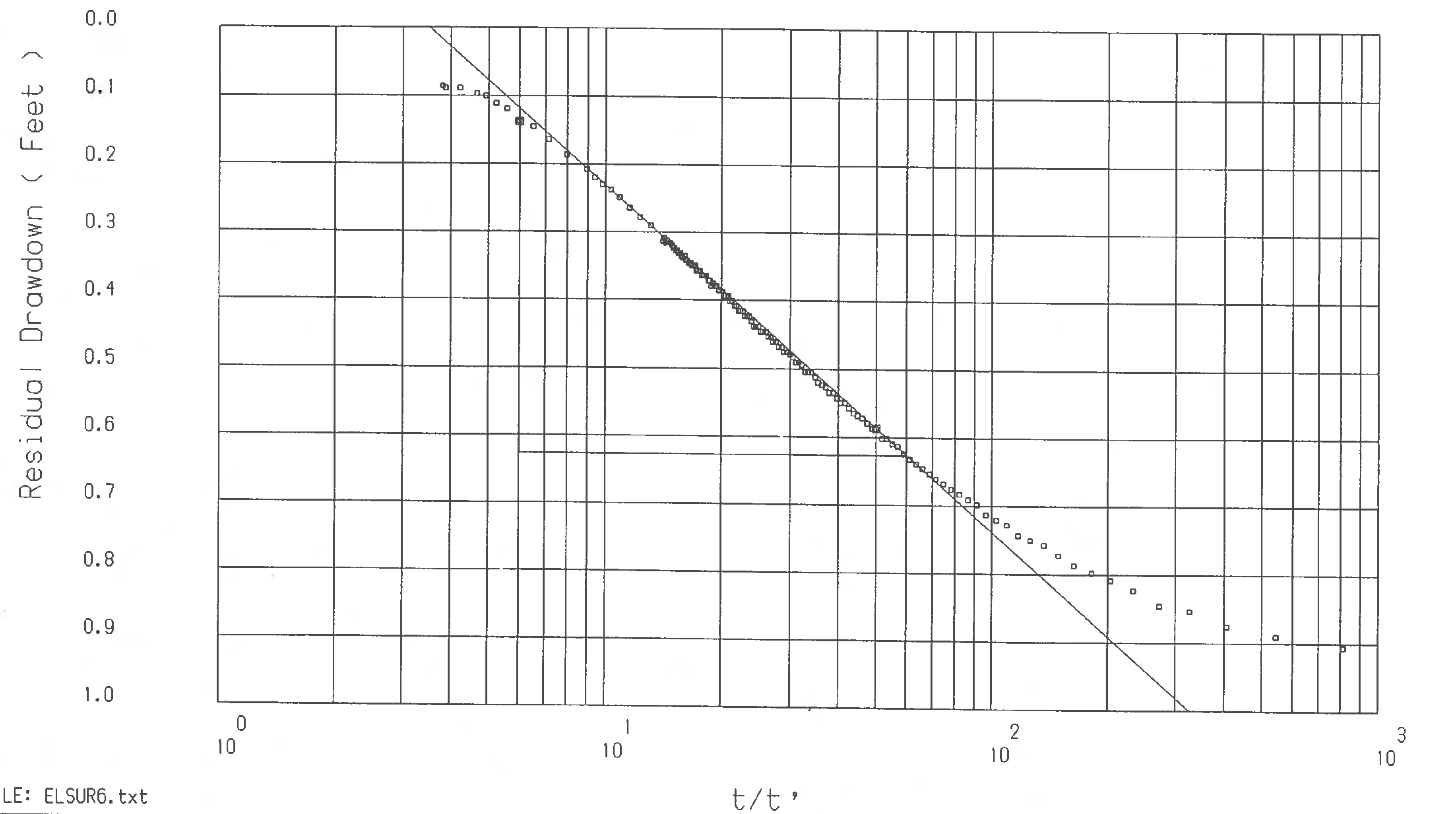
Distance r = 100.00 FT

Pumping well : EL SUR "NEW"

Pumping rate Q = 1150.00 USG/Min

ds = 0.50869819 FT

T = 595825.096 USGPD/FT



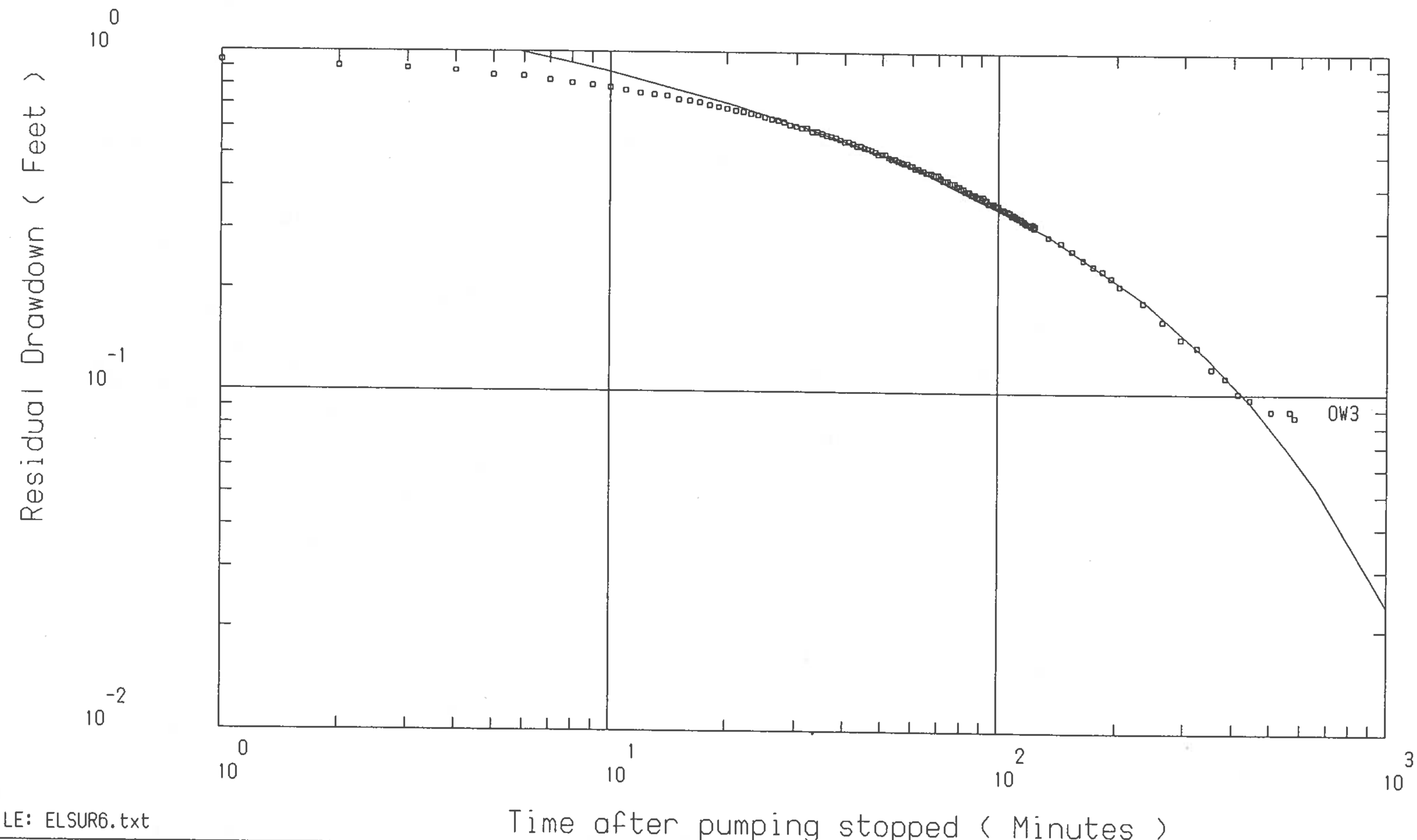
FILE: ELSUR6.txt

Figure D 13

[PUMPING TEST RECOVERY LOG-LOG ANALYSIS : Theis TYPE CURVE Confined]

Observation well	:	OW3
Distance	r =	100.00 FT
Pumping well	:	EL SUR "NEW"
Pumping rate	Q =	1150.00 USG/Min
Aquifer thickness	b =	30.0 FT

Transmissivity	T =	545068.848 USGPD/FT	
Storativity	S =	0.00003070	
Hydr. conductivity	K =	18168.962 USGPD/FT^2	
MATCH POINT :			
u	=	0.0015170	1.00
W(u)	=	4.1358893	1.00
Time	=	1.00	659.21 Min
Drawdown	=	1.00	0.2417860 FT



FILE: ELSUR6.txt

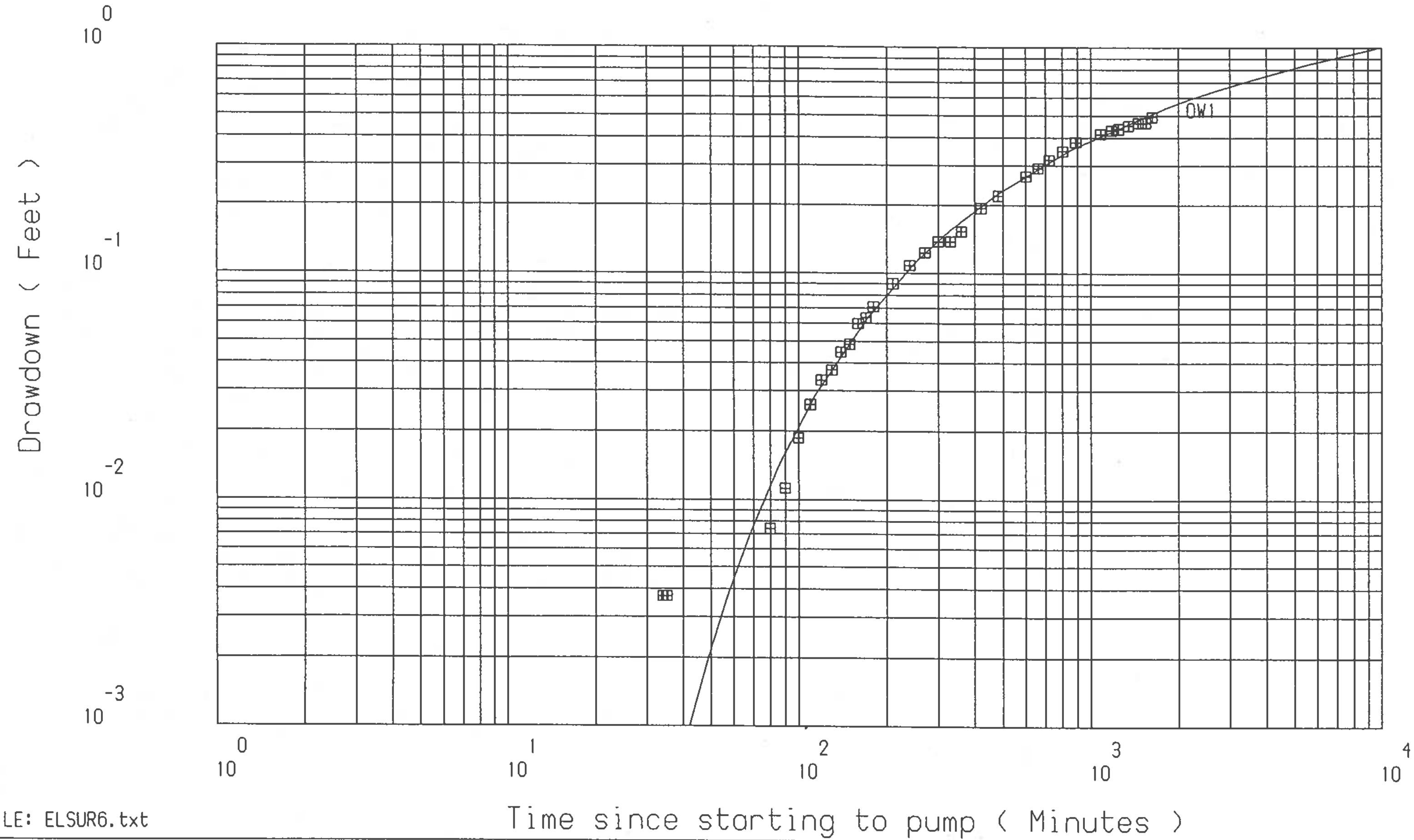
Figure D 14

[PUMPING TEST LOG-LOG ANALYSIS : Rtheis TYPE CURVE Confined]

Observation well : OW1
Distance r = 600.00 FT
Pumping well : EL SUR "NEW"
Pumping rate Q = 1150.00 USG/Min
Aquifer thickness b = 35.0 FT

Transmissivity T = 454974.823 USGPD/FT
Storativity S = 0.08065913
Hydr. conductivity K = 12999.281 USGPD/FT^2
MATCH POINT :

1/u	=	0.0058183	1.00
W(u)	=	3.4522712	1.00
Time	=	1.00	171.87 Min
Drawdown	=	1.00	0.2896644 FT



FILE: ELSUR6.txt

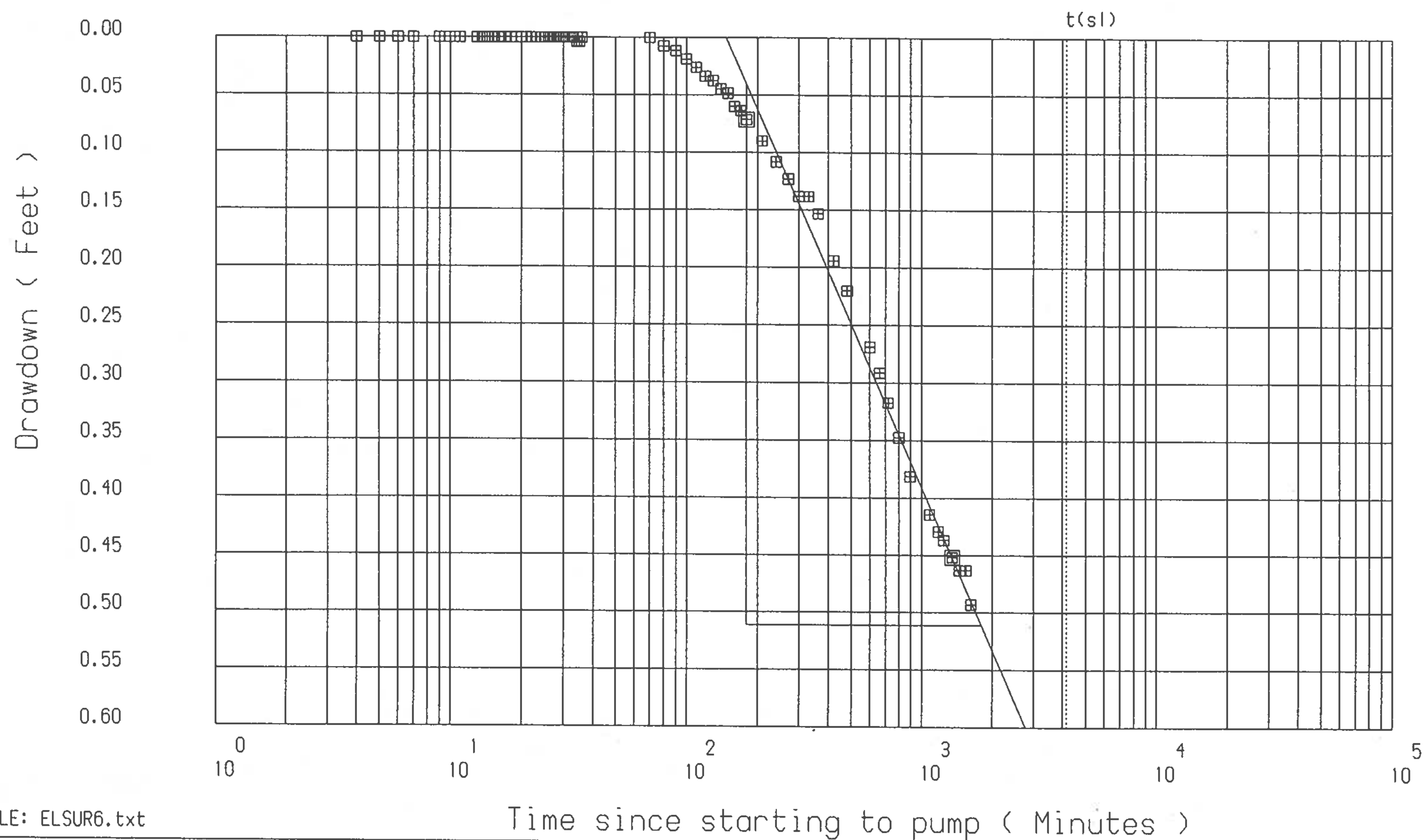
Rthies Analysis of OW1

Figure D 15

[PUMPING TEST SEMI-LOG ANALYSIS : JACOB METHOD]

Observation well : OW1
Distonce r = 600.00 FT
Pumping well : EL SUR "NEW"
Pumping rate Q = 1150.00 USG/Min

t0 = 148.207 Min
ds = 0.47154712 FT
T = 642767.472 USGPD/FT
S = 0.0551289397
t(sl) = 4168.329 Min



FILE: ELSUR6.txt

Jocob Method on OW1

Figure D 16

Input Data for Analysis of EL Sur Aquifer Test

Length unit : Feet
Time unit : Minutes
Pumping rate unit : Gallons
: Minutes
Start of test : 980922203200.0
Drawdown test duration : 0.0 Hours
: 1624.0000 Minutes
Recovery test duration : 0.0 Hours
: 580.0000 Minutes
Number of observation wells : 3

Pumping well I.D. : EL SUR "NEW"
Pumping rate : 1150.0000
X coordinate : 0.0
Y coordinate : 0.0
Type of water level data : Head
Initial depth : 0.0
Initial head : 13.0000
Initial water level : 0.0
Elevation of measuring point : 0.0
Number of data : 1

ELAPSED TIME	WATER LEVEL
1.0000	1.0000

Observation well # 1 : OW4
Radius from pumped well : 36.0000
Type of water level data : Head
Initial depth : 0.0
Initial head : 13.6850
Initial water level : 0.0
Elevation of measuring point : 0.0
Number of data : 236

ELAPSED TIME	WATER LEVEL
1.0000	13.4720
2.0000	13.1956
3.0000	13.1457
4.0000	13.1111

5.0000	13.0727
6.0000	13.0420
7.0000	13.0189
8.0000	12.9959
9.0000	12.9729
10.0000	12.9530
11.0000	12.9340
12.0000	12.9190
13.0000	12.8990
14.0000	12.8840
15.0000	12.8690
16.0000	12.8570
17.0000	12.8500
18.0000	12.8380
19.0000	12.8230
20.0000	12.8150
21.0000	12.8050
22.0000	12.7960
23.0000	12.7840
24.0000	12.7770
25.0000	12.7670
26.0000	12.7590
27.0000	12.7570
28.0000	12.7480
29.0000	12.7420
30.0000	12.7320
31.0000	12.7310
32.0000	12.7210
33.0000	12.7170
34.0000	12.7110
35.0000	12.7060
36.0000	12.7020
37.0000	12.6940
38.0000	12.6860
39.0000	12.6820
40.0000	12.6790
41.0000	12.6750
42.0000	12.6710
43.0000	12.6630
44.0000	12.6590
45.0000	12.6540
46.0000	12.6520
47.0000	12.6480

48.0000	12.6440
49.0000	12.6380
50.0000	12.6380
51.0000	12.6330
52.0000	12.6250
53.0000	12.6230
54.0000	12.6210
55.0000	12.6150
56.0000	12.6110
57.0000	12.6130
58.0000	12.6100
59.0000	12.6040
60.0000	12.6000
70.0000	12.5690
80.0000	12.5420
90.0000	12.5210
100.0000	12.5024
110.0000	12.4870
120.0000	12.4697
130.0000	12.4563
140.0000	12.4428
150.0000	12.4274
160.0000	12.4197
170.0000	12.4101
180.0000	12.4043
210.0000	12.3832
240.0000	12.3658
270.0000	12.3504
300.0000	12.3447
330.0000	12.3370
360.0000	12.3313
420.0000	12.3275
480.0000	12.3142
600.0000	12.2932
660.0000	12.2760
720.0000	12.2587
800.0000	12.2452
890.0000	12.2392
1080.0000	12.2505
1180.0000	12.2450
1243.0000	12.2394
1348.0000	12.2337
1453.0000	12.2185

1543.0000	12.2030
1623.0000	12.2068
1624.0000	12.5908
1625.0000	12.6753
1626.0000	12.7367
1627.0000	12.7828
1628.0000	12.8173
1629.0000	12.8481
1630.0000	12.8749
1631.0000	12.8980
1632.0000	12.9210
1633.0000	12.9402
1634.0000	12.9594
1635.0000	12.9709
1636.0000	12.9901
1637.0000	13.0055
1638.0000	13.0170
1639.0000	13.0285
1640.0000	13.0439
1641.0000	13.0516
1642.0000	13.0631
1643.0000	13.0784
1644.0000	13.0861
1645.0000	13.0976
1646.0000	13.1053
1647.0000	13.1130
1648.0000	13.1207
1649.0000	13.1284
1650.0000	13.1399
1651.0000	13.1476
1652.0000	13.1552
1653.0000	13.1591
1654.0000	13.1668
1655.0000	13.1744
1656.0000	13.1821
1657.0000	13.1860
1658.0000	13.1975
1659.0000	13.2013
1660.0000	13.2052
1661.0000	13.2090
1662.0000	13.2167
1663.0000	13.2205
1664.0000	13.2282

1665.0000	13.2320
1666.0000	13.2359
1667.0000	13.2436
1668.0000	13.2512
1669.0000	13.2551
1670.0000	13.2589
1671.0000	13.2589
1672.0000	13.2666
1673.0000	13.2704
1674.0000	13.2704
1675.0000	13.2781
1676.0000	13.2820
1677.0000	13.2896
1678.0000	13.2896
1679.0000	13.2896
1680.0000	13.2973
1681.0000	13.3012
1682.0000	13.3050
1683.0000	13.3088
1684.0000	13.3088
1685.0000	13.3127
1686.0000	13.3165
1687.0000	13.3204
1688.0000	13.3242
1689.0000	13.3280
1690.0000	13.3319
1691.0000	13.3357
1692.0000	13.3396
1693.0000	13.3396
1694.0000	13.3434
1695.0000	13.3472
1696.0000	13.3472
1697.0000	13.3511
1698.0000	13.3549
1699.0000	13.3549
1700.0000	13.3588
1701.0000	13.3588
1702.0000	13.3664
1703.0000	13.3664
1704.0000	13.3741
1705.0000	13.3741
1706.0000	13.3741
1707.0000	13.3780

1708.0000	13.3780
1709.0000	13.3780
1710.0000	13.3818
1711.0000	13.3856
1712.0000	13.3895
1713.0000	13.3895
1714.0000	13.3933
1715.0000	13.3972
1716.0000	13.3972
1717.0000	13.4010
1718.0000	13.4010
1719.0000	13.4048
1720.0000	13.4087
1721.0000	13.4087
1722.0000	13.4087
1723.0000	13.4125
1724.0000	13.4125
1725.0000	13.4164
1726.0000	13.4164
1727.0000	13.4202
1728.0000	13.4240
1729.0000	13.4240
1730.0000	13.4279
1731.0000	13.4279
1732.0000	13.4317
1733.0000	13.4317
1734.0000	13.4317
1735.0000	13.4317
1736.0000	13.4317
1737.0000	13.4355
1738.0000	13.4394
1739.0000	13.4394
1740.0000	13.4432
1741.0000	13.4432
1742.0000	13.4471
1743.0000	13.4471
1744.0000	13.4509
1745.0000	13.4471
1746.0000	13.4547
1747.0000	13.4547
1748.0000	13.4547
1758.0000	13.4663
1768.0000	13.4816

1778.0000	13.4931
1788.0000	13.5047
1798.0000	13.5162
1808.0000	13.5239
1818.0000	13.5354
1828.0000	13.5392
1858.0000	13.5623
1888.0000	13.5776
1918.0000	13.5891
1948.0000	13.5968
1978.0000	13.6045
2008.0000	13.6122
2038.0000	13.6160
2068.0000	13.6237
2128.0000	13.6275
2188.0000	13.6429
2203.0000	13.6391

Observation well # 2 : OW3
Radius from pumped well : 100.0000
Type of water level data : Head
Initial depth : 0.0
Initial head : 11.8870
Initial water level : 0.0
Elevation of measuring point : 0.0
Number of data : 236

ELAPSED TIME	WATER LEVEL
1.0000	11.8465
2.0000	11.7965
3.0000	11.7807
4.0000	11.7659
5.0000	11.7510
6.0000	11.7362
7.0000	11.7213
8.0000	11.7065
9.0000	11.6917
10.0000	11.6768
11.0000	11.6731
12.0000	11.6583
13.0000	11.6472
14.0000	11.6397

15.0000	11.6323
16.0000	11.6175
17.0000	11.6101
18.0000	11.6026
19.0000	11.5878
20.0000	11.5841
21.0000	11.5749
22.0000	11.5730
23.0000	11.5655
24.0000	11.5581
25.0000	11.5526
26.0000	11.5452
27.0000	11.5359
28.0000	11.5304
29.0000	11.5284
30.0000	11.5230
31.0000	11.5136
32.0000	11.5118
33.0000	11.5007
34.0000	11.4950
35.0000	11.4859
36.0000	11.4859
37.0000	11.4859
38.0000	11.4784
39.0000	11.4710
40.0000	11.4673
41.0000	11.4562
42.0000	11.4562
43.0000	11.4562
44.0000	11.4488
45.0000	11.4468
46.0000	11.4413
47.0000	11.4376
48.0000	11.4339
49.0000	11.4246
50.0000	11.4246
51.0000	11.4228
52.0000	11.4191
53.0000	11.4171
54.0000	11.4117
55.0000	11.4097
56.0000	11.4023
57.0000	11.4042

58.0000	11.3968
59.0000	11.3949
60.0000	11.3949
70.0000	11.3613
80.0000	11.3316
90.0000	11.3075
100.0000	11.2852
110.0000	11.2665
120.0000	11.2500
130.0000	11.2329
140.0000	11.2161
150.0000	11.2049
160.0000	11.1900
170.0000	11.1807
180.0000	11.1639
210.0000	11.1432
240.0000	11.1152
270.0000	11.0964
300.0000	11.0910
330.0000	11.0761
360.0000	11.0632
420.0000	11.0600
480.0000	11.0474
600.0000	11.0165
660.0000	10.9884
720.0000	10.9755
800.0000	10.9552
890.0000	10.9302
1080.0000	10.9366
1180.0000	10.9393
1243.0000	10.9419
1348.0000	10.9216
1453.0000	10.8990
1543.0000	10.8919
1623.0000	10.8923
1624.0000	10.8997
1625.0000	10.9516
1626.0000	10.9813
1627.0000	10.9961
1628.0000	11.0110
1629.0000	11.0332
1630.0000	11.0407
1631.0000	11.0629

1632.0000	11.0778
1633.0000	11.0889
1634.0000	11.1000
1635.0000	11.1149
1636.0000	11.1297
1637.0000	11.1371
1638.0000	11.1445
1639.0000	11.1594
1640.0000	11.1668
1641.0000	11.1742
1642.0000	11.1891
1643.0000	11.1965
1644.0000	11.2039
1645.0000	11.2113
1646.0000	11.2187
1647.0000	11.2262
1648.0000	11.2336
1649.0000	11.2410
1650.0000	11.2484
1651.0000	11.2558
1652.0000	11.2633
1653.0000	11.2744
1654.0000	11.2781
1655.0000	11.2855
1656.0000	11.2855
1657.0000	11.3004
1658.0000	11.3004
1659.0000	11.3078
1660.0000	11.3152
1661.0000	11.3189
1662.0000	11.3226
1663.0000	11.3300
1664.0000	11.3375
1665.0000	11.3375
1666.0000	11.3449
1667.0000	11.3523
1668.0000	11.3523
1669.0000	11.3597
1670.0000	11.3634
1671.0000	11.3671
1672.0000	11.3746
1673.0000	11.3820
1674.0000	11.3820

1675.0000	11.3820
1676.0000	11.3931
1677.0000	11.3968
1678.0000	11.3968
1679.0000	11.4042
1680.0000	11.4079
1681.0000	11.4117
1682.0000	11.4117
1683.0000	11.4191
1684.0000	11.4191
1685.0000	11.4265
1686.0000	11.4265
1687.0000	11.4339
1688.0000	11.4339
1689.0000	11.4413
1690.0000	11.4413
1691.0000	11.4413
1692.0000	11.4488
1693.0000	11.4488
1694.0000	11.4488
1695.0000	11.4562
1696.0000	11.4636
1697.0000	11.4636
1698.0000	11.4636
1699.0000	11.4710
1700.0000	11.4710
1701.0000	11.4710
1702.0000	11.4784
1703.0000	11.4784
1704.0000	11.4859
1705.0000	11.4859
1706.0000	11.4933
1707.0000	11.4933
1708.0000	11.4933
1709.0000	11.5007
1710.0000	11.5007
1711.0000	11.5007
1712.0000	11.5081
1713.0000	11.5081
1714.0000	11.5118
1715.0000	11.5081
1716.0000	11.5155
1717.0000	11.5155

1718.0000	11.5230
1719.0000	11.5230
1720.0000	11.5230
1721.0000	11.5230
1722.0000	11.5304
1723.0000	11.5304
1724.0000	11.5304
1725.0000	11.5378
1726.0000	11.5378
1727.0000	11.5378
1728.0000	11.5415
1729.0000	11.5415
1730.0000	11.5452
1731.0000	11.5452
1732.0000	11.5526
1733.0000	11.5489
1734.0000	11.5526
1735.0000	11.5563
1736.0000	11.5563
1737.0000	11.5601
1738.0000	11.5601
1739.0000	11.5638
1740.0000	11.5638
1741.0000	11.5675
1742.0000	11.5712
1743.0000	11.5712
1744.0000	11.5712
1745.0000	11.5749
1746.0000	11.5712
1747.0000	11.5786
1748.0000	11.5749
1758.0000	11.5972
1768.0000	11.6083
1778.0000	11.6231
1788.0000	11.6380
1798.0000	11.6491
1808.0000	11.6565
1818.0000	11.6676
1828.0000	11.6788
1858.0000	11.7010
1888.0000	11.7233
1918.0000	11.7418
1948.0000	11.7493

1978.0000	11.7678
2008.0000	11.7752
2038.0000	11.7864
2068.0000	11.7901
2128.0000	11.7975
2188.0000	11.7975
2203.0000	11.8012

Observation well # 3 : OW1
Radius from pumped well : 600.0000
Type of water level data : Head
Initial depth : 0.0
Initial head : 10.0749
Initial water level : 0.0
Elevation of measuring point : 0.0
Number of data : 221

ELAPSED TIME	WATER LEVEL
4.0000	10.0749
5.0000	10.0749
6.0000	10.0749
7.0000	10.0749
8.0000	10.0787
9.0000	10.0749
10.0000	10.0749
11.0000	10.0749
12.0000	10.0787
13.0000	10.0749
14.0000	10.0749
15.0000	10.0749
16.0000	10.0749
17.0000	10.0749
18.0000	10.0749
19.0000	10.0749
20.0000	10.0749
21.0000	10.0749
22.0000	10.0749
23.0000	10.0749
24.0000	10.0749
25.0000	10.0749
26.0000	10.0749
27.0000	10.0749

28.0000	10.0749
29.0000	10.0749
30.0000	10.0749
31.0000	10.0749
32.0000	10.0749
33.0000	10.0749
34.0000	10.0712
35.0000	10.0712
36.0000	10.0749
37.0000	10.0824
38.0000	10.0862
39.0000	10.0862
40.0000	10.0862
41.0000	10.0862
42.0000	10.0862
43.0000	10.0862
44.0000	10.0862
45.0000	10.0862
46.0000	10.0862
47.0000	10.0862
48.0000	10.0862
49.0000	10.0862
50.0000	10.0862
51.0000	10.0824
52.0000	10.0824
53.0000	10.0824
54.0000	10.0824
55.0000	10.0824
56.0000	10.0787
57.0000	10.0787
58.0000	10.0787
59.0000	10.0787
60.0000	10.0787
70.0000	10.0749
80.0000	10.0675
90.0000	10.0637
100.0000	10.0563
110.0000	10.0488
120.0000	10.0413
130.0000	10.0376
140.0000	10.0301
150.0000	10.0264
160.0000	10.0152

170.0000	10.0114
180.0000	10.0039
210.0000	9.98526
240.0000	9.966575
270.0000	9.951627
300.0000	9.936679
330.0000	9.936679
360.0000	9.921731
420.0000	9.880624
480.0000	9.854465
600.0000	9.805884
660.0000	9.783463
720.0000	9.757303
800.0000	9.727407
890.0000	9.693774
1080.0000	9.660141
1180.0000	9.645193
1243.0000	9.637719
1348.0000	9.622771
1453.0000	9.61156
1543.0000	9.61156
1623.0000	9.581664
1633.0000	9.581664
1637.0000	9.577928
1638.0000	9.581664
1639.0000	9.581664
1640.0000	9.581664
1641.0000	9.581664
1642.0000	9.581664
1643.0000	9.581664
1644.0000	9.581664
1645.0000	9.581664
1646.0000	9.581664
1647.0000	9.581664
1648.0000	9.581664
1649.0000	9.581664
1650.0000	9.581664
1651.0000	9.581664
1652.0000	9.581664
1653.0000	9.581664
1654.0000	9.581664
1655.0000	9.581664
1656.0000	9.581664

1657.0000	9.581664
1658.0000	9.581664
1659.0000	9.581664
1660.0000	9.581664
1661.0000	9.581664
1662.0000	9.585402
1663.0000	9.585402
1664.0000	9.585402
1665.0000	9.585402
1666.0000	9.585402
1667.0000	9.585402
1668.0000	9.585402
1669.0000	9.585402
1670.0000	9.585402
1671.0000	9.585402
1672.0000	9.585402
1673.0000	9.589138
1674.0000	9.585402
1675.0000	9.589138
1676.0000	9.589138
1677.0000	9.589138
1678.0000	9.589138
1679.0000	9.589138
1680.0000	9.589138
1681.0000	9.589138
1682.0000	9.589138
1683.0000	9.589138
1684.0000	9.589138
1685.0000	9.592875
1686.0000	9.592875
1687.0000	9.592875
1688.0000	9.589138
1689.0000	9.592875
1690.0000	9.589138
1691.0000	9.592875
1692.0000	9.592875
1693.0000	9.592875
1694.0000	9.592875
1695.0000	9.592875
1696.0000	9.596612
1697.0000	9.596612
1698.0000	9.596612
1699.0000	9.596612

1700.0000	9.596612
1701.0000	9.596612
1702.0000	9.596612
1703.0000	9.596612
1704.0000	9.596612
1705.0000	9.600349
1706.0000	9.600349
1707.0000	9.600349
1708.0000	9.600349
1709.0000	9.600349
1710.0000	9.600349
1711.0000	9.600349
1712.0000	9.604086
1713.0000	9.604086
1714.0000	9.604086
1715.0000	9.61156
1716.0000	9.61156
1717.0000	9.61156
1718.0000	9.61156
1719.0000	9.61156
1720.0000	9.61156
1721.0000	9.615297
1722.0000	9.615297
1723.0000	9.615297
1724.0000	9.615297
1725.0000	9.615297
1726.0000	9.615297
1727.0000	9.615297
1728.0000	9.619034
1729.0000	9.619034
1730.0000	9.619034
1731.0000	9.619034
1732.0000	9.622771
1733.0000	9.622771
1734.0000	9.622771
1735.0000	9.622771
1736.0000	9.622771
1737.0000	9.622771
1738.0000	9.622771
1739.0000	9.626508
1740.0000	9.626508
1741.0000	9.626508
1742.0000	9.626508

Appendix E. Mussetter Geomorphology Report

Mussetter Engineering Inc.

Consultants in
Water Resource Engineering &
Engineering Geomorphology

November 30, 1998

Mr. Matthew A. Zidar
Jones & Stokes Associates, Inc.
2600 V Street
Sacramento, California 95818-1914

Re: Geomorphic Evaluation of Big Sur River, Andrew Molera State Park

Dear Matt,

As requested by you I visited the lower reaches of the Big Sur River within the boundaries of Andrew Molera State Park to conduct a reconnaissance-level geomorphic evaluation of the river, and to assess the impacts of recent floods and man-made changes. The following is my report on the site visit that was conducted on October 1, 1998.

INTRODUCTION

Andrew Molera State Park is located 22 miles south of Carmel, California, on Highway 1. The Big Sur River, a gravel and cobble bed stream that drains the Santa Lucia Mountains traverses the park and flows into the Pacific Ocean on the south side of Molera Point. The reach of Big Sur River that is the subject of this evaluation is that portion from the State Park parking lot on the west side of Highway 1 to the lagoon formed by a transient sandbar at the ocean margin. The length of the reach of interest is about 0.8 miles, the average bed slope is about 0.4 percent, and the bed materials range in size from sand to small boulders (0.1 to 300 mm). One moderate size tributary enters the river on the right bank (looking downstream) within the reach of interest.

Geologically, the project reach is underlain and bounded laterally by the Cretaceous-Jurassic-age Fransiscan Melange that is composed primarily of extensively sheared sandstones, greywacke, metavolcavic rocks and schists (Hall, 1991). Franciscan Melange rocks are exposed at the coast at the mouth of the Big Sur River, and form the valley floor contraction that is responsible for the formation of the Creamery Meadow that is underlain by about 70 to 80 feet of alluvial sediments (Jones & Stokes Associates, 1997). The alluvial valley fill in the State Park is bounded to the south by Franciscan melange outcrop and by uplifted stream and marine terraces as well as Upper Cretaceous-age outcrop and colluvial deposits on the north.

The objective of this investigation is to evaluate the potential impacts of groundwater pumping from El Sur Ranch wells near the Big Sur lagoon on surface-water flows near the parking lot and the establishment and maintenance of riparian vegetation along the Creamery Meadow. In mid July 1990 the channel of the Big Sur River in the vicinity of the Parking lot was relocated to enable bank protection measures to be installed to protect the Bobcat Trail and ultimately Highway 1 at the point

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(970) 224-4612 • fax (970) 472-6062

where the Big Sur River turns to the west. It was during this timeframe when surficial flows in the localized reach of the Big Sur River ceased (M. Zidar, Jones & Stokes Associates, Inc., personal communication). At that time the discharge in the river was about 5 cfs.

HYDROLOGY

Peak flow and mean daily flow data were obtained for the USGS gage for the Big Sur River near Big Sur, California (Gage No. 11143000). **Figure 1** presents the average annual hydrograph derived from the mean daily flows. The data indicate that the highest mean daily flows (300 to 350 cfs) are likely to occur in January and February as a result of winter rains, and that on an average basis the flows in the river in July are likely to be less than 20 cfs. Flow duration curves based on the mean daily flows were developed for the months of June and July (**Figure 2**). The July curve on Figure 2 indicates that a discharge of 5 cfs is equaled or exceeded about 99 percent of the time. A peak flow frequency analysis was conducted with the gage records using Bulletin 17B procedures (**Figure 3**). **Table 1** presents the annual instantaneous peaks and their estimated recurrence intervals for the period from 1990 to 1998.

Table 1. Annual Instantaneous Peak Discharges and Associated Recurrence Intervals for Big Sur River, near Big Sur, California (USGS Gage No. 11143000), 1990-1998.

Year	Peak Discharge (cfs)	Recurrence Interval (years)
1990	1,360	1.25
1991	2,370	2.0
1992	2,090	1.75
1993	3,400	4.5
1994	1,100	1.0
1995	6,690	20
1996	3,000	3.5
1997	5,000	7.0
1998*	>5,000	7.0
* Provisional value		

The data in Table 1 demonstrate that the peak discharges in the last 4 years have been of relatively high magnitude, and therefore, should have been morphogenetically significant in the project reach (Wolman and Miller, 1960; Wolman and Gerson, 1978). The 1995 peak discharge (6,690 cfs) was the second highest peak of record for the gage (1950-1998).

GEOMORPHOLOGY

To evaluate the geomorphic conditions within the project reach, the channel was walked from the parking lot to the ocean. The upstream portion of the reach from the footbridge across the Big Sur River to the almost right angle bend where the river turns to the west (**Plate 1**) is characterized by the presence of a very coarse-grained backwater-induced bar on the left bank and the gabion-revetted parking lot on the right bank. Erosion of the bank and the Bobcat Trail is occurring at the bend (**Plate 2**). The backwater condition is caused by the sharp bend at the downstream end of the subreach during high flows when the coarse grained (gravel and cobble) bed material is entrained upstream of the backwater influence (Harvey et al., 1993). The net effect is deposition of a very coarse-grained bar upstream of the bend (**Plate 3**). Material deposited on the bar surface ranges from sand sized to about 300 mm (**Plate 4**), and obviously the bar has a very high permeability. Immediately downstream of the bend an un-named right bank tributary has delivered boulder-sized materials to the Big Sur River, most likely as the result of an in-channel debris flow (**Plate 5**). The debris flow deposits locally increase the size of the bed material in the Big Sur River because the boulders are too large for the river to transport downstream (**Plate 6**).

For a distance of about 1,000 feet downstream of the tributary confluence the Big Sur River is confined between terraces that are very heavily vegetated by red alders and willows (**Plate 7**). The combined effects of the heavily vegetated banks, confined flows, and upstream deposition of the coarser sediments in the backwater bar (Plates 3, 4) cause the channel to be laterally stable and have a high transport capacity for the range of bed material sizes (less than about 90 mm) that pass through the upstream bend. For the next approximately 2,000 feet where the river traverses the Creamery Meadow the channel is characterized by alternating bank attached sand and gravel bars on the inside of the bends and eroding banks on the outsides of the bends. The channel is bounded by a highly erodible floodplain surface located about 5 feet above the channel bed (**Plate 8**). The bank materials are composite with a sand and gravel toe that fines upwards to a silty-sand surface that has a low moisture holding capacity. Deposition of sands and gravels on the bars is accompanied by erosion and retreat of the opposing bank (**Plate 9**). Bank retreat on the order of more than 100 feet (**Plate 10**) has occurred over the last few years because of the frequency of high flows (Table 1). Backwater conditions and reduced hydraulic energies of the peak flows are caused by the lagoon that effectively controls the baselevel for the Big Sur River (**Plate 11**).

CONCLUSIONS

This reconnaissance of the Big Sur River within the boundaries of Andrew Molera State Park was conducted to primarily address two issues: (1) the potential impact of groundwater pumping on drying up of the river near the parking lot in July 1990, and (2) the lack of riparian revegetation along the river where it traverses the lower reaches of the Creamery Meadow. Based on the field observations and the review of the hydrological records for the Big Sur River the following is concluded:

1. The combined effects of very low flow in the river (about 5 cfs) which represents a flow that is exceeded about 99 percent of the time (Figure 2), and the relocation of the river onto the very coarse-grained and highly permeable backwater-induced bar deposits are the most likely cause of the local loss of surface flows in the river.

2. The recent peak flow hydrological record indicates that several morphogenetically significant flows have occurred since 1993 following a period of relatively low peak flows (Figure 3). Mobilization of the bed material during the high flows has caused deposition in areas where the shear stress is locally reduced, and this in turn has caused accelerated erosion of the opposite non-cohesive bank materials. Riparian species are in fact colonizing the bank-attached bars which suggests that riparian succession will occur as the floodplain of the Creamery Meadow is reworked by the river. Infrequent overtopping of the existing floodplain coupled with low moisture retention soils is the most likely reason that the meadow surface is colonized primarily by drought tolerant non-riparian plant species.

If I can provide you with further information, or if you need clarification of the information in this report, please do not hesitate to contact me.

Sincerely,

MUSSETTER ENGINEERING, INC.

Michael D. Harvey, Ph.D., P.G.
Principal Geomorphologist

MDH:bbv
Enclosures

REFERENCES

Hall, C.A., 1991. Geology of the Point Sur-Lopez Point region, Coast Ranges, California: A part of the southern California allochthon, California Bureau of Mines and Geology.

Harvey, M.D., Mussetter, R.A. and Wick, E.G., 1993. A physical process-biological response model for spawning habitat formation for the endangered Colorado Squawfish, Rivers, 4(2), 114-131.

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Wolman, M.G. and Miller, J.P., 1960. Magnitude and frequency of forces in geomorphic processes, Journal of Geology, 68, 54-74.

Wolman, M.G. and Gerson, R., 1978. Relative scales of time and effectiveness of climate in watershed geomorphology, Earth Surface Processes, 3, 189-208.

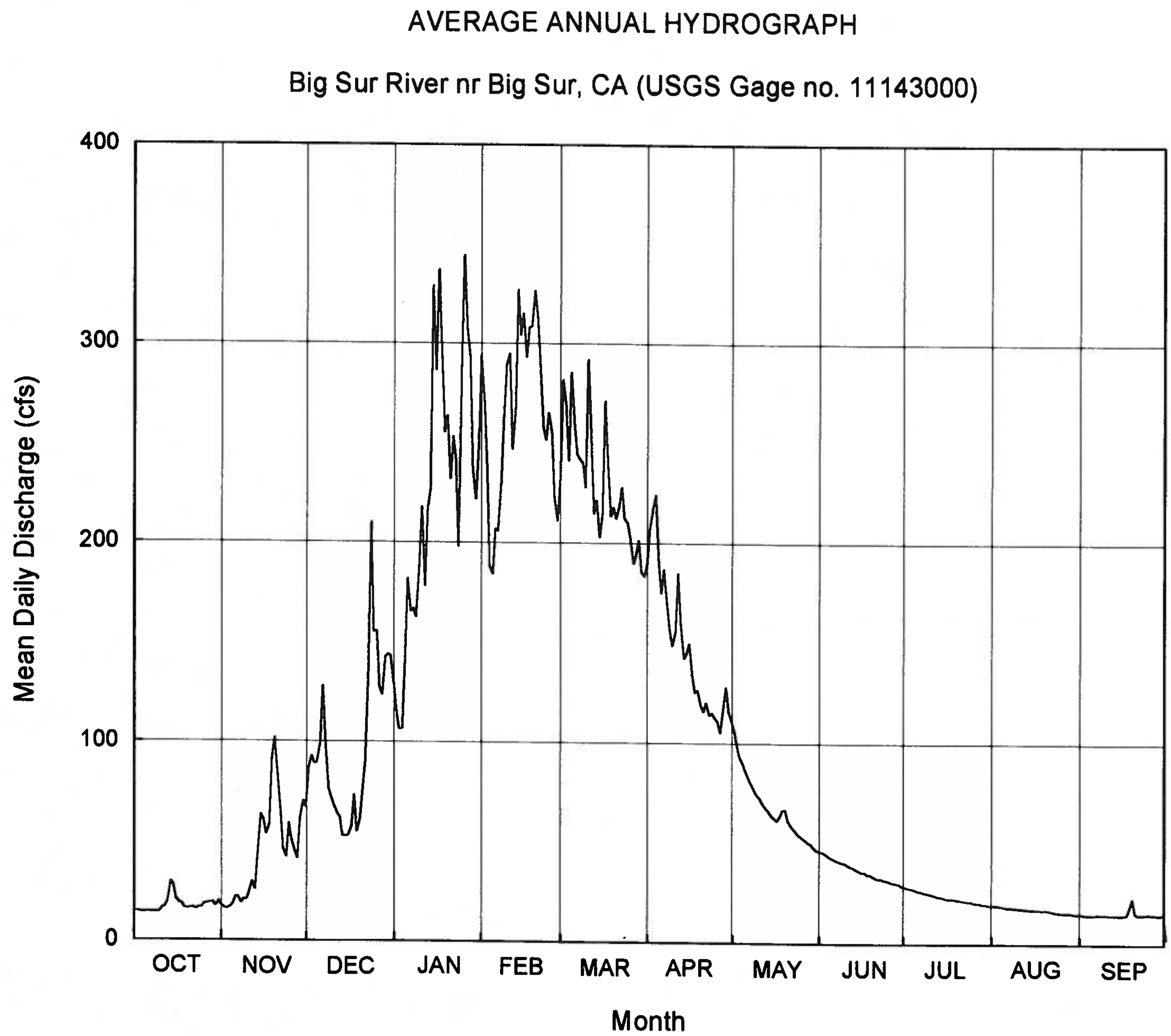
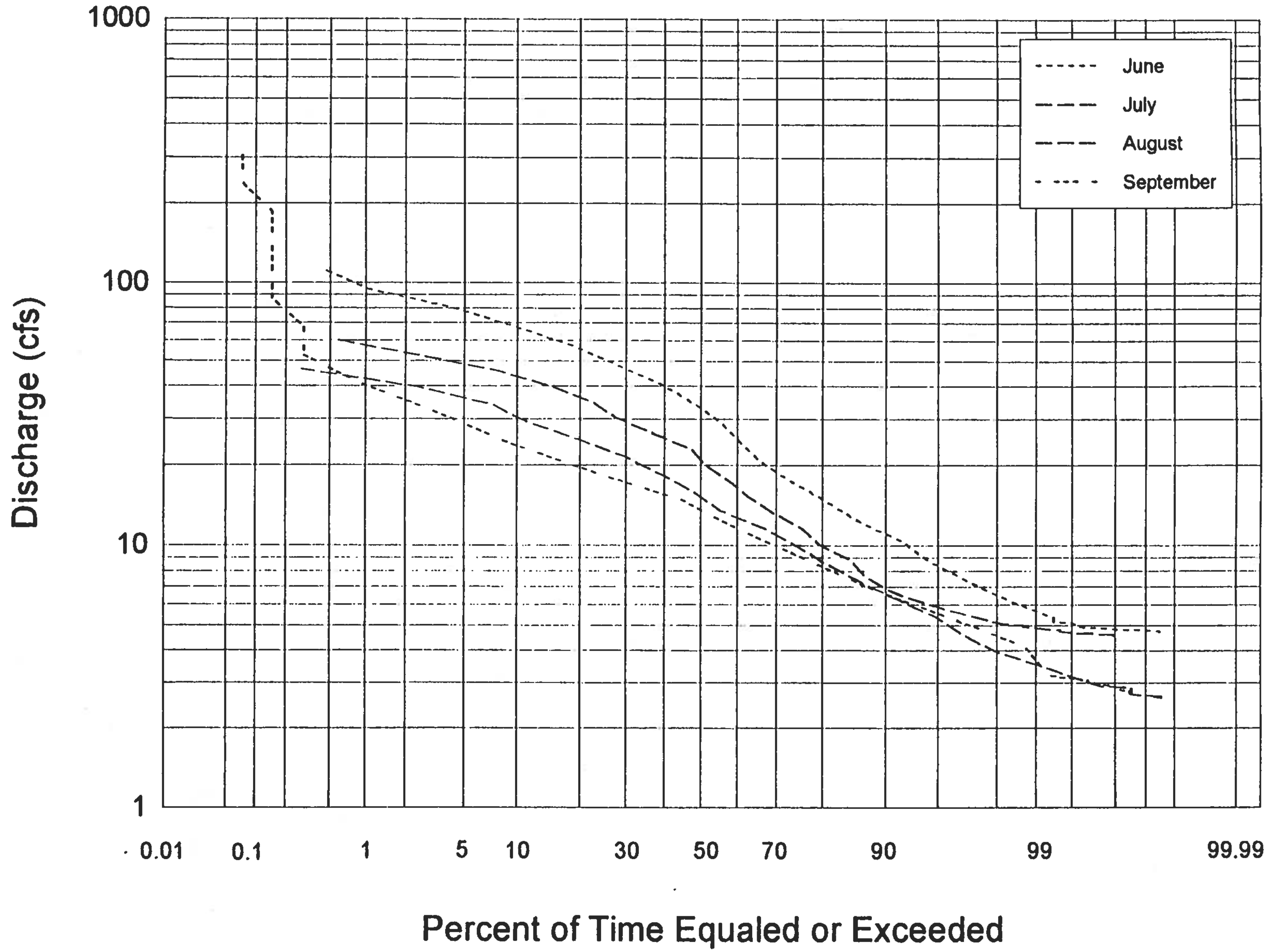


Figure 1. Average annual hydrograph for Big Sur River, near Big Sur, California (USGS Gage No. 11143000).



Big Sur River near Big Sur, CA (USGS Gage no. 1114300)
Flow Duration Curve

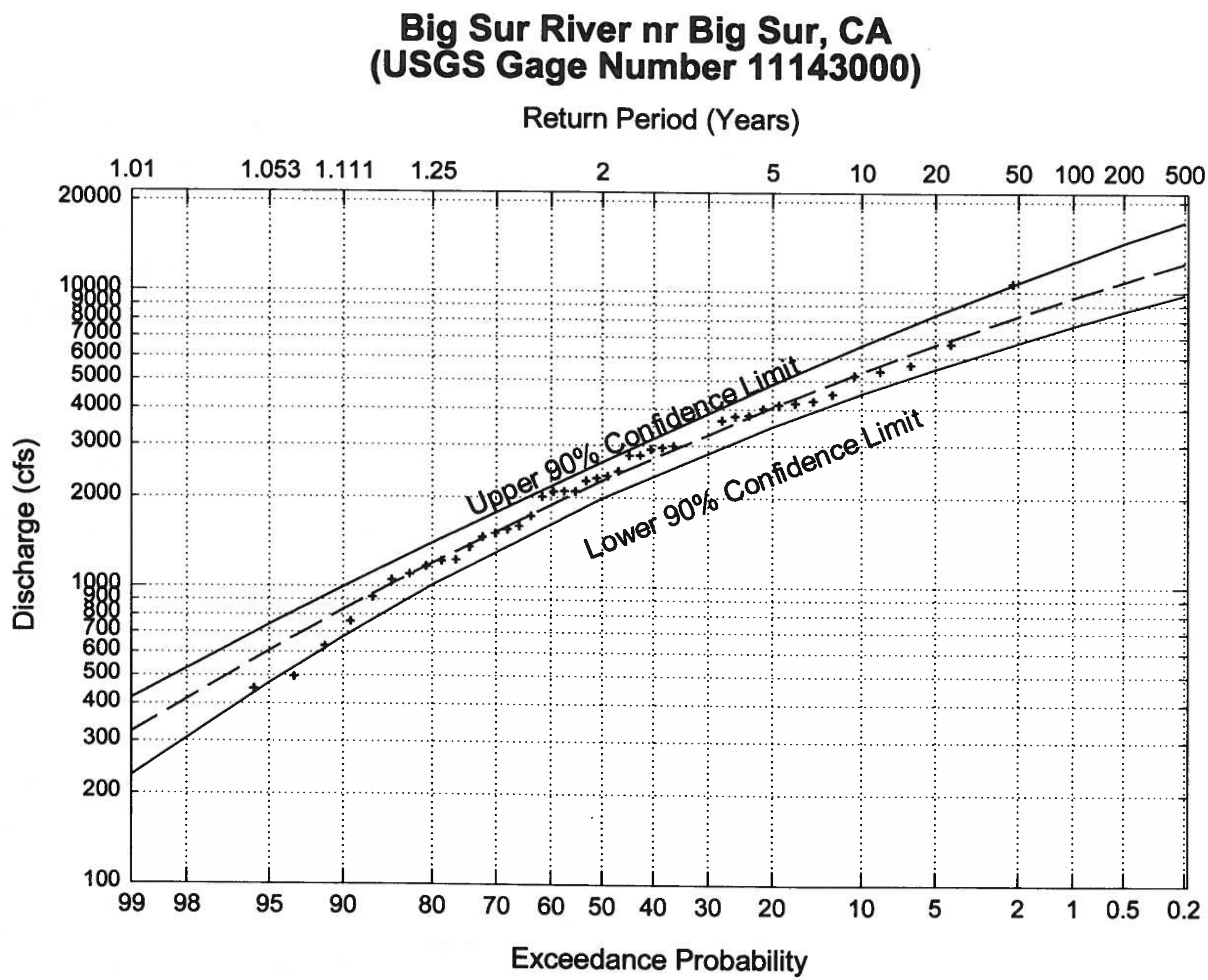


Figure 3. Peak flow frequency analysis for Big Sur River, near Big Sur, California (USGS Gage No. 11143000).

Plate 1. View downstream of Big Sur River from footbridge across Big Sur River near parking lot in Andrew Molera State Park. The remains of gabion revetments are located on the right side of the channel.

Plate 2. View upstream of the eroding right bank of the Big Sur River at the sharp turn to the west. The Bobcat Trail is being eroded by continuing retreat of the bank.

Plate 3. View upstream of the coarse-grained backwater-induced bar upstream of the sharp bend in the Big Sur River, Andrew Molera State Park. The footbridge is in the background at the upstream end of the riffle.

Plate 4. Bar surface sediments at the backwater-induced bar on the left side of the Big Sur River. The notebook is 7 ins. long (178 mm), and the largest deposited rock has an intermediate diameter of 300 mm.

Plate 5. View downstream of the confluence of the un-named right bank tributary and the Big Sur River. The large angular sandstone boulders were probably transported by a debris flow. Impact scars on the alders in the center of the photograph are about 6 feet above the bed of the channel.

Plate 6. View downstream of the Big Sur River just downstream of the right bank tributary confluence. Note the very large boulders derived from the tributary that can be seen amongst the clasts deposited by the river on the bar in the foreground.

Plate 7. View upstream of the Big Sur River about 1,000 feet downstream of the right bank tributary. The channel is confined between terraces that are heavily vegetated by red alders and willows.

Plate 8. View downstream of the Big Sur River about 1,500 feet downstream of the right bank tributary. The bank attached sand and gravel bar is causing erosion of the floodplain surface on the left bank of the river. Note the basal gravels and upwards fining of the bank materials that form the floodplain.

Plate 9. View upstream of the Big Sur River about 1,600 feet downstream of the right bank tributary. The bank attached bar on the left bank is causing erosion and retreat of the right bank. Note the colonization of the gravel bar by willows and alders.

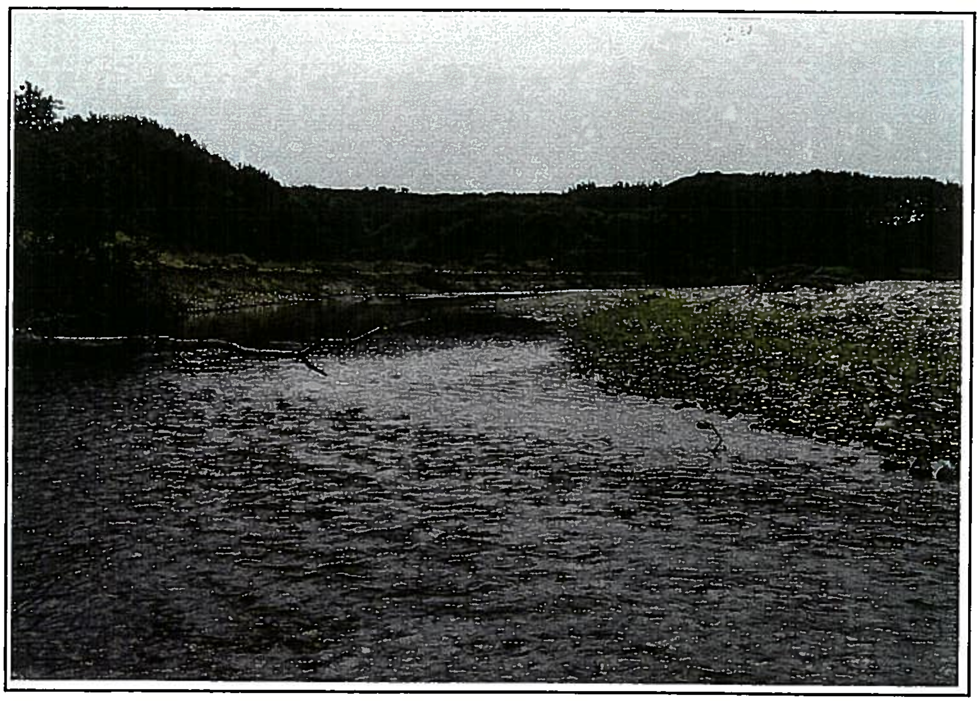


Plate 10. View downstream of the eroding left bank of the Big Sur River about 2,500 feet downstream of the right bank tributary. The highly erodible left bank has retreated over 100 feet in the last 3 years.

Appendix F. Water Quality Data

CLS Labs

Analysis Report: **General Mineral Analysis**

Client: **Jones & Stokes Associates, Inc**
2600 V Street STE 100
Sacramento, Ca 95818-1914

Project No.:
Contact: **Zidar**
Phone: **(916)737-3000**

Project: **EL SUR**

Lab Contact: **GEORGE HAMPTON**
Lab ID No.: **P7116-1A**
Job No.: **817116**
COC Log No.: **53037**
Batch No.: **W980925I**
Instrument ID: **INMIX**
Analyst ID: **PONGC**
Matrix: **WATER**

Date Sampled: **09/25/98**
Date Received: **09/25/98**
Date Extracted: **N/A**
Date Analyzed: **09/25/98**
Date Reported: **10/02/98**
Client ID No.: **STREAM**

STREAM

Analyte CAS No.	Results (mg/L)	Rep. Limit (mg/L)	Method	Dilution (factor)
Alkalinity as CaCO3 N/A	130	1.0	310.1	1.0
-Bicarbonate as CaCO3 N/A	130	1.0	310.1	1.0
-Carbonate as CaCO3 N/A	ND	1.0	310.1	1.0
-Hydroxide as CaCO3 N/A	ND	1.0	310.1	1.0
Ca (Calcium) 7440-70-2	52	1.0	200.7	1.0
Chloride N/A	6.2	0.50	300.0	1.0
Fluoride N/A	0.30	0.050	340.2	1.0
Hardness as CaCO3 N/A	170	1.0	200.7	1.0
K (Potassium) 7440-09-7	1.4	1.0	200.7	1.0
Methylene Blue Active Substances N/A	ND	0.50	425.1	1.0
Mg (Magnesium) 7439-95-4	9.0	1.0	200.7	1.0
Na (Sodium) 127-09-3	10	1.0	200.7	1.0
Nitrate (as NO3) N/A	ND	0.50	300.0	1.0
pH N/A	8.1	Note 1	150.1	1.0
Specific Conductance N/A	290	Note 2	120.1	1.0
Sulfate N/A	23	1.0	300.0	1.0
Total Dissolved Solids N/A	200	1.0	160.1	1.0

Note 1: Units for pH are standard pH units.
Note 2: Units for specific conductance are umho/cm @ 25 degrees Celsius.

ND = Not detected at or above indicated Reporting Limit

CLS Labs

Analysis Report: **General Mineral Analysis**

Client: Jones & Stokes Associates, Inc 2600 V Street STE 100 Sacramento, Ca 95818-1914	*Project No.:* *Contact:* Zidar *Phone:* (916)737-3000
Project: EL SUR	*Lab Contact:* GEORGE HAMPTON
Date Sampled: 09/25/98 *Date Received:* 09/25/98 *Date Extracted:* N/A *Date Analyzed:* 09/25/98 *Date Reported:* 10/02/98 *Client ID No.:* LAGOON	*Lab ID No.:* P7116-2A *Job No.:* 817116 *COC Log No.:* 53037 *Batch No.:* W980925I *Instrument ID:* INMIX *Analyst ID:* PONGC *Matrix:* WATER

LAGOON

Analyte CAS No.	Results (mg/L)	Rep. Limit (mg/L)	Method	Dilution (factor)
Alkalinity as CaCO3				
N/A	130	1.0	310.1	1.0
-Bicarbonate as CaCO3				
N/A	130	1.0	310.1	1.0
-Carbonate as CaCO3				
N/A	ND	1.0	310.1	1.0
-Hydroxide as CaCO3				
N/A	ND	1.0	310.1	1.0
Ca (Calcium)				
7440-70-2	52	1.0	200.7	1.0
Chloride				
N/A	6.3	0.50	300.0	1.0
Fluoride				
N/A	0.27	0.050	340.2	1.0
Hardness as CaCO3				
N/A	170	1.0	200.7	1.0
K (Potassium)				
7440-09-7	1.8	1.0	200.7	1.0
Methylene Blue Active Substances				
N/A	ND	0.50	425.1	1.0
Mg (Magnesium)				
7439-95-4	9.0	1.0	200.7	1.0
Na (Sodium)				
127-09-3	12	1.0	200.7	1.0
Nitrate (as NO3)				
N/A	ND	0.50	300.0	1.0
pH				
N/A	8.0	Note 1	150.1	1.0
Specific Conductance				
N/A	280	Note 2	120.1	1.0
Sulfate				
N/A	23	1.0	300.0	1.0
Total Dissolved Solids				
N/A	200	1.0	160.1	1.0

Note 1: Units for pH are standard pH units.
Note 2: Units for specific conductance are umho/cm @ 25 degrees Celsius.

ND = Not detected at or above indicated Reporting Limit

CA DOHS ELAP Accreditation/Registration Number 1233

CLS Labs

Analysis Report: **General Mineral Analysis**

Client: **Jones & Stokes Associates, Inc**
2600 V Street STE 100
Sacramento, Ca 95818-1914

Project No.:
Contact: **Zidar**
Phone: **(916)737-3000**

Project: **EL SUR**

Lab Contact: **GEORGE HAMPTON**
Lab ID No.: **P7116-3A**
Job No.: **817116**
COC Log No.: **53037**
Batch No.: **W980925I**
Instrument ID: **INMIX**
Analyst ID: **PONGC**
Matrix: **WATER**

Date Sampled: **09/25/98**
Date Received: **09/25/98**
Date Extracted: **N/A**
Date Analyzed: **09/25/98**
Date Reported: **10/02/98**
Client ID No.: **WELL-OLD**

WELL-OLD

Analyte CAS No.	Results (mg/L)	Rep. Limit (mg/L)	Method	Dilution (factor)
Alkalinity as CaCO3 N/A	130	1.0	310.1	1.0
-Bicarbonate as CaCO3 N/A	130	1.0	310.1	1.0
-Carbonate as CaCO3 N/A	ND	1.0	310.1	1.0
-Hydroxide as CaCO3 N/A	ND	1.0	310.1	1.0
Ca (Calcium) 7440-70-2	45	1.0	200.7	1.0
Chloride N/A	11	2.0	300.0	4.0
Fluoride N/A	0.24	0.050	340.2	1.0
Hardness as CaCO3 N/A	150	1.0	200.7	1.0
K (Potassium) 7440-09-7	1.8	1.0	200.7	1.0
Methylene Blue Active Substances N/A	ND	0.50	425.1	1.0
Mg (Magnesium) 7439-95-4	9.9	1.0	200.7	1.0
Na (Sodium) 127-09-3	18	1.0	200.7	1.0
Nitrate (as NO3) N/A	ND	0.50	300.0	1.0
pH N/A	7.2	Note 1	150.1	1.0
Specific Conductance N/A	290	Note 2	120.1	1.0
Sulfate N/A	22	1.0	300.0	1.0
Total Dissolved Solids N/A	200	1.0	160.1	1.0

Note 1: Units for pH are standard pH units.
Note 2: Units for specific conductance are umho/cm @ 25 degrees Celsius.

ND = Not detected at or above indicated Reporting Limit

CA DOHS ELAP Accreditation/Registration Number 1233

CLS Labs

Analysis Report: **General Mineral Analysis**

Client: **Jones & Stokes Associates, Inc**
2600 V Street STE 100
Sacramento, Ca 95818-1914

Project No.:
Contact: **Zidar**
Phone: **(916)737-3000**

Project: **EL SUR**

Lab Contact: **GEORGE HAMPTON**
Lab ID No.: **P7116-4A**
Job No.: **817116**
COC Log No.: **53037**
Batch No.: **W980925I**
Instrument ID: **INMIX**
Analyst ID: **PONGC**
Matrix: **WATER**

Date Sampled: **09/25/98**
Date Received: **09/25/98**
Date Extracted: **N/A**
Date Analyzed: **09/25/98**
Date Reported: **10/02/98**
Client ID No.: **NEW-WELL**

NEW-WELL

Analyte CAS No.	Results (mg/L)	Rep. Limit (mg/L)	Method	Dilution (factor)
Alkalinity as CaCO3 N/A	130	1.0	310.1	1.0
-Bicarbonate as CaCO3 N/A	130	1.0	310.1	1.0
-Carbonate as CaCO3 N/A	ND	1.0	310.1	1.0
-Hydroxide as CaCO3 N/A	ND	1.0	310.1	1.0
Ca (Calcium) 7440-70-2	51	1.0	200.7	1.0
Chloride N/A	6.8	0.50	300.0	1.0
Fluoride N/A	0.28	0.050	340.2	1.0
Hardness as CaCO3 N/A	160	1.0	200.7	1.0
K (Potassium) 7440-09-7	1.6	1.0	200.7	1.0
Methylene Blue Active Substances N/A	ND	0.50	425.1	1.0
Mg (Magnesium) 7439-95-4	8.9	1.0	200.7	1.0
Na (Sodium) 127-09-3	ND	1.0	200.7	1.0
Nitrate (as NO3) N/A	0.56	0.50	300.0	1.0
pH N/A	7.5	Note 1	150.1	1.0
Specific Conductance N/A	280	Note 2	120.1	1.0
Sulfate N/A	23	1.0	300.0	1.0
Total Dissolved Solids N/A	200	1.0	160.1	1.0

Note 1: Units for pH are standard pH units.
Note 2: Units for specific conductance are umho/cm @ 25 degrees Celsius.

ND = Not detected at or above indicated Reporting Limit

CA DOHS ELAP Accreditation/Registration Number 1233

CLS – Labs CHAIN OF CUSTODY

CLS ID No.: P7116 LOG NO. 53037

REPORT TO:

NAME AND ADDRESS: Jones + Stokes Assoc.
2600 V Street
Sacramento CA

PROJECT MANAGER: Adar PHONE#: 737-3000

PROJECT NAME: El Sur

SAMPLED BY: Babb

JOB DESCRIPTION:

SITE LOCATION:

CLIENT JOB NUMBER:

DESTINATION LABORATORY:
☐ CLS (916) 638-7301
3249 FITZGERALD RD.
RANCHO CORDOVA, CA 95742
☐ OTHER

FIELD CONDITIONS:

COMPOSITE:

DATE	TIME	SAMPLE IDENTIFICATION	MATRIX	CONTAINER NO.	CONTAINER TYPE	PRESERVATIVES	ANALYSIS REQUESTED: General Minerals	1 DAY	2 DAY	5 DAY	10 DAY	SPECIAL INSTRUCTIONS
9/25	9:30	STREAM		2	1LP		X				X	
9/25	9:30	LAGOON		2	1LP		X				X	
9/25	9:30	WELL-OLD		2	1LP		X				X	
9/25	9:30	NEW-WELL		2	1LP		X				X	

INVOICE TO:

P.O. #

QUOTE #

SUSPECTED CONSTITUENTS:

SAMPLE RETENTION TIME:

PRESERVATIVES: (1) HCL (2) HNO_3 (3) = COLD (4)

RELINQUISHED BY (SIGN)	PRINT NAME / COMPANY	DATE / TIME	RECEIVED BY (SIGN)	PRINT NAME / COMPANY
S Babb				

REC'D AT LAB BY: [signature] DATE / TIME: 9/25/98 16:30

CONDITIONS / COMMENTS:

SHIPPED VIA ☐ FED X ☐ UPS ☐ OTHER

AIR BILL #

ESR--27

CLS Labs

Jones & Stokes Associates, Inc
2600 V Street STE 100
Sacramento, Ca 95818-1914

10/05/98

Attention: Zidar

Reference: Analytical Results

Project Name: EL SUR
Project No.:
Date Received: 09/25/98
Chain Of Custody: 53037

CLS ID No.: P7116
CLS Job No.: 817116

The following analyses were performed on the above referenced project:

No. of Samples	*Turnaround Time*	*Analysis Description*
4	10 Days	General Mineral

These samples were received by CLS Labs in a chilled, intact state and accompanied by a valid chain of custody document.

Calibrations for analytical testing have been performed in accordance to and pass the EPA's criteria for acceptability.

Analytical results are attached to this letter. Please call if we can provide additional assistance.

Sincerely,

James Liang, Ph.D.
Laboratory Director

CLS Labs

Analysis Report: **General Mineral Analysis**

Client: **Jones & Stokes Associates, Inc**
2600 V Street STE 100
Sacramento, Ca 95818-1914

Project: **EL SUR**

Date Extracted: **N/A**
Date Analyzed: **09/25/98**
Date Reported: **10/02/98**

Project No.:
Contact: **Zidar**
Phone: **(916)737-3000**

Lab Contact: **GEORGE HAMPTON**
Lab ID No.: **P7116**
Job No.: **817116**
COC Log No.: **53037**
Batch No.: **W980925I**
Instrument ID: **INMIX**
Analyst ID: **PONGC**
Matrix: **WATER**

METHOD BLANK

Analyte	CAS No.	Results (mg/L)	Reporting Limit (mg/L)	Method
Alkalinity as CaCO3	N/A	ND	1.0	310.1
-Bicarbonate as CaCO3	N/A	ND	1.0	310.1
-Carbonate as CaCO3	N/A	ND	1.0	310.1
-Hydroxide as CaCO3	N/A	ND	1.0	310.1
Ca (Calcium)	7440-70-2	ND	1.0	200.7
Chloride	N/A	ND	0.50	300.0
Fluoride	N/A	ND	0.050	340.2
Hardness as CaCO3	N/A	ND	1.0	200.7
K (Potassium)	7440-09-7	ND	1.0	200.7
Methylene Blue Active Substances	N/A	ND	0.50	425.1
Mg (Magnesium)	7439-95-4	ND	1.0	200.7
Na (Sodium)	127-09-3	ND	1.0	200.7
Nitrate (as NO3)	N/A	ND	0.50	300.0
Specific Conductance	N/A	ND	Note 2	120.1
Sulfate	N/A	ND	1.0	300.0
Total Dissolved Solids	N/A	ND	1.0	160.1

Note 1: Units for pH are standard pH units.
Note 2: Units for specific conductance are umho/cm @ 25 degrees Celsius.

ND = Not detected at or above indicated Reporting Limit

CA DOHS ELAP Accreditation/Registration Number 1233

CLS Labs

Analysis Report: **General Mineral Analysis**

Client: **Jones & Stokes Associates, Inc**
2600 V Street STE 100
Sacramento, Ca 95818-1914

Project: **EL SUR**

Date Extracted: **N/A**
Date Analyzed: **09/25/98**
Date Reported: **10/02/98**

Project No.:
Contact: **Zidar**
Phone: **(916)737-3000**

Lab Contact: **GEORGE HAMPTON**
Lab ID No.: **P7116**
Job No.: **817116**
COC Log No.: **53037**
Batch No.: **W980925I**
Instrument ID: **INMIX**
Analyst ID: **PONGC**
Matrix: **WATER**

LAB CONTROL SAMPLE

Analyte	CAS No.	LCS Conc. (mg/L)	LCS Recovery (percent)
Ca (Calcium)	7440-70-2	10.0	99
Chloride	N/A	5.00	99
Fluoride	N/A	0.500	102
K (Potassium)	7440-09-7	10.0	100
Methylene Blue Active Substances	N/A	1.00	95
Mg (Magnesium)	7439-95-4	10.0	95
Na (Sodium)	127-09-3	10.0	103
Nitrate (as NO3)	N/A	5.00	97
Sulfate	N/A	5.00	96

LAB CONTROL SAMPLE DUPLICATE

Analyte	CAS No.	LCS Conc. (mg/L)	LCSD Recovery (percent)
Ca (Calcium)	7440-70-2	10.0	100
Chloride	N/A	5.00	98
Fluoride	N/A	0.500	103
K (Potassium)	7440-09-7	10.0	97
Methylene Blue Active Substances	N/A	1.00	97
Mg (Magnesium)	7439-95-4	10.0	96
Na (Sodium)	127-09-3	10.0	102
Nitrate (as NO3)	N/A	5.00	96
Sulfate	N/A	5.00	97

LCS RPD

Analyte	CAS No.	LCS Relative Percent Difference (percent)
Ca (Calcium)	7440-70-2	1
Chloride	N/A	1
Fluoride	N/A	1
K (Potassium)	7440-09-7	3
Methylene Blue Active Substances	N/A	2
Mg (Magnesium)	7439-95-4	1
Na (Sodium)	127-09-3	1
Nitrate (as NO3)	N/A	1

CA DOHS ELAP Accreditation/Registration Number 1233

CLS Labs

Analysis Report: **General Mineral Analysis**

Client: **Jones & Stokes Associates, Inc**
2600 V Street STE 100
Sacramento, Ca 95818-1914

Project: **EL SUR**

Date Extracted: **N/A**
Date Analyzed: **09/25/98**
Date Reported: **10/02/98**

Project No.:
Contact: **Zidar**
Phone: **(916)737-3000**

Lab Contact: **GEORGE HAMPTON**
Lab ID No.: **P7116**
Job No.: **817116**
COC Log No.: **53037**
Batch No.: **W980925I**
Instrument ID: **INMIX**
Analyst ID: **PONGC**
Matrix: **WATER**

LCS RPD(cont.)

Analyte	CAS No.	LCS Relative Percent Difference (percent)
Sulfate	N/A	1

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