SURFACE WATER-GROUNDWATER INTERACTION REPORT

VENTURA RIVER HABITAT CONSERVATION PLAN VENTURA RIVER, CALIFORNIA

Prepared for:

CASITAS MUNICIPAL WATER AGENCY
CITY OF SAN BUENAVENTURA
COUNTY OF VENTURA
VENTURA COUNTY FLOOD CONTROL DISTRICT
OJAI VALLEY SANITARY DISTRICT
MEINERS OAKS COUNTY WATER DISTRICT
VENTURA RIVER COUNTY WATER DISTRICT
SOUTHERN CALIFORNIA WATER COMPANY
OJAI BASIN GROUNDWATER MANAGEMENT AGENCY

Prepared by:

ENTRIX, INC.
Ventura, California

Project No. 351003

February 12, 2001

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1.0
STUDY PURPOSE

ENTRIX, Inc. was contracted by the Cooperating Agencies to perform an analysis of surface water and groundwater hydrology in the Ventura River basin as part of the Habitat Conservation Plan (HCP) for the Ventura River in Ventura County, California. The Cooperating Agencies consist of the County of Ventura, the Ventura County Flood Control District (VCFCD), the City of San Buenaventura, the Casitas Municipal Water District (Casitas), the Meiners Oaks County Water District (MOCWD), the Ojai Valley Sanitary District (OVSD), the Ojai Basin Groundwater Management Agency, the Southern California Water Company (SCWC), the Ventura County Water Agency, and the City of Ojai. These agencies all operate and maintain facilities that may affect sensitive biological resources along the Ventura River. To comply with the Endangered Species Act (ESA), the agencies are developing a HCP in consultation with the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) to serve as the basis for an Incidental Take Permit.

The objectives of the surface water-groundwater interaction evaluation, outlined in *The Ventura River Habitat Conservation Plan Technical Approach* dated March 30, 2000, are to develop an improved understanding of the hydrologic system dynamics and determine the likelihood of groundwater pumping impacts on surface flows, based on available empirical data. The scope of work involved collecting and evaluating available surface flow and groundwater data and prior analyses of the surface and groundwater system. The focus of the evaluation was on the river reaches where the Cooperating Agencies can affect flow. The availability of concurrent surface flow and groundwater data determined the study period(s) and specific reaches analyzed. The study is focused on the Upper Ventura River and San Antonio Creek basins, and a brief discussion is also included for the Ojai Valley groundwater basin. The data reviewed as part of the evaluation included seasonal changes in groundwater levels and groundwater storage, groundwater flow relationships, and estimated contributions from groundwater to surface water.

The remainder of this report is organized as follows:

- Section 2.0 provides an overview of the environmental setting;
- Section 3.0 outlines the approach and methods description;
- Section 4.0 presents the results; and,
- Section 5.0 summarizes findings and recommendations.

A brief description of the environmental setting of the Ventura River system is provided below in order to understand the physical setting and characteristics of the system. This is not intended to provide a comprehensive description of the environmental conditions, rather a summary of the characteristics most pertinent to the surface and groundwater interaction study.

2.1 WATERSHED SETTING

The Ventura River drains a 228 square mile area of coastal Southern California in the Transverse Range. The headwaters are located in the San Rafael and Topatopa Mountains to the north, the Santa Ynez Mountains to the west, and Sulphur Mountain to the east. The mainstem of the river flows southward approximately 16.2 miles from the confluence of the Matilija Creek and North Fork Matilija Creek to the river mouth at Emma Wood State Beach in the City of San Buenaventura (**Figure 1**).

The Ventura River basin has a Mediterranean climate with a distinct seasonal pattern of wet-cool from November through March and dry-warm from April through October. Since the Ventura River watershed includes both steep mountains and coastal plains the spatial variation in average rainfall ranges between 16 inches near the river mouth to 40 inches at the headwaters (ENTRIX/WCC 1997). Rainfall records indicate that dramatic and rapid shifts in precipitation can occur from year-to-year, and that repeated cycles of dry and wet periods occur on approximately 20 to 30 year intervals (USBR 1954; Casitas 1993).

The Ventura River watershed has 3 distinct sections that differ in topography, geology, surface and groundwater hydrology, and roles in water resource management (Keller and Capelli 1992; Fugro West 1996a):

- Mountainous upland areas above the confluence of the Matilija and the North Fork of the Matilija which are comprised of steep, rugged topography with narrow valleys and steep streambed gradients;
- Alluvial channel and floodplain areas along the mainstem of the Ventura River below the confluence; and,
- The Lagoon at the river mouth along the coastline.

The mountainous uplands are the primary water and sediment production areas and the site of the water supply and flood control facilities. The alluvial valley is the area of water and sediment transport. The upper Ventura River mainstem valley (upstream of Foster Park) is also the river reach with groundwater production and surface diversions. **Figure 2** presents a profile of this section of the Ventura River.

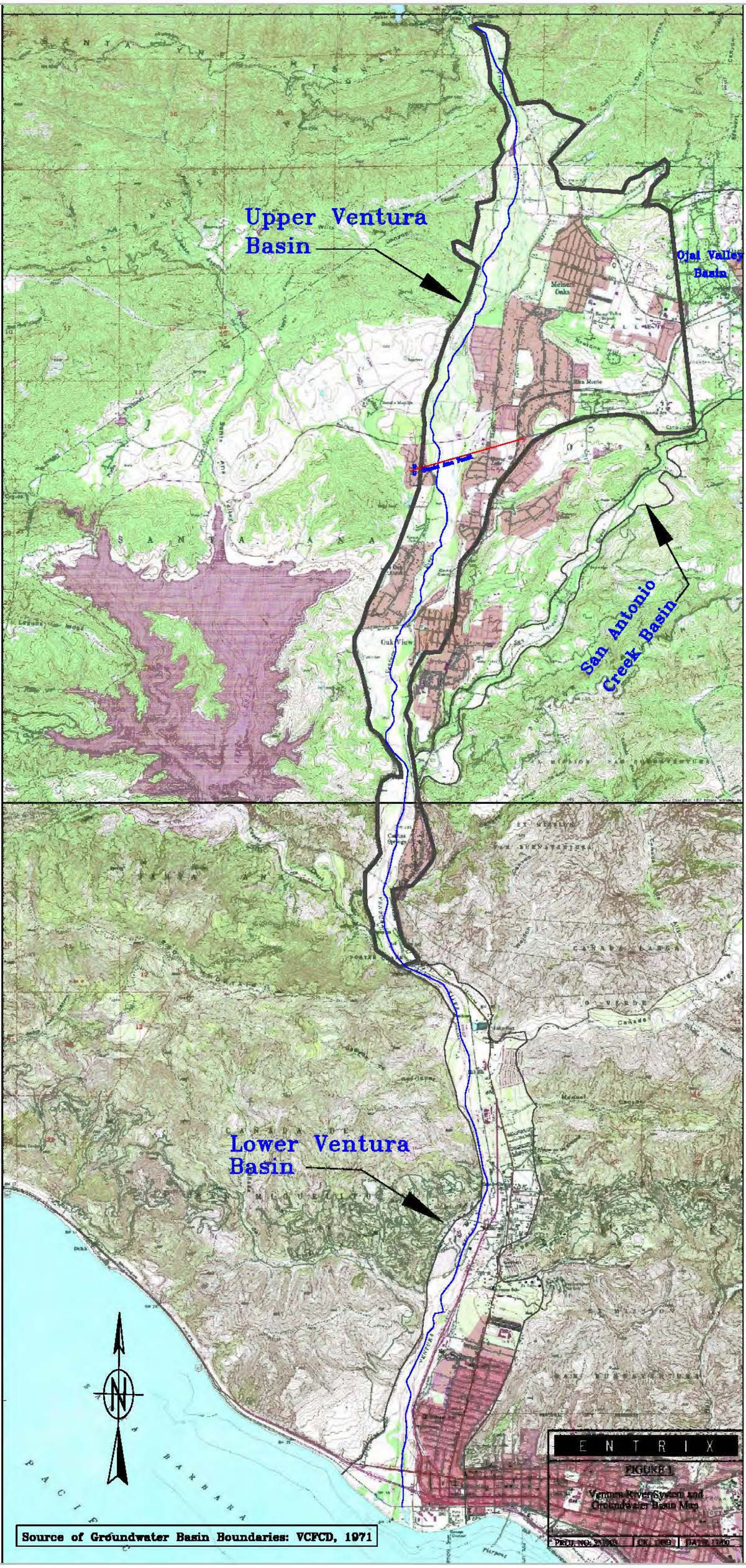

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FIGURE 1

Ventura River System and Groundwater Basin Map

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Source of Groundwater Basin Boundaries: VCFCD, 1971

Temporarily Unavailable

Figure 2. **Profile of the Upper Ventura River**

2.2 GEOLOGY

The Ventura River basin is located in the Transverse Ranges geomorphic province of California and is underlain by Tertiary-age marine and continental deposits, primarily sandstone, clay/siltstone, and shale (Dibblee 1988). These deposits have been deformed by tectonism, resulting in east-west trending fold and fault structures and geologic units inclined toward the north and south.

Two significant faults are located in the Ventura River system (Dibblee 1988; Jennings 1994). The Santa Ana/Arroyo Parida fault is an east-west trending structure that runs from the south central portion of the Ojai Valley across the Ventura River near the Highway 150 bridge to the west. The relative displacement along this fault is such that the northerly fault block has been lowered relative to the southerly fault block. The other fault is the San Cayetano fault, a steep, north-dipping thrust fault that runs over a distance of 30 miles from the Ojai Valley to northeast of Piru.

Additionally, there are several flexural-slip faults in the vicinity of Oak View that have produced tilted terrace surfaces south of the Santa Ana fault within the Ayers Creek syncline (Rockwell and Others 1984). The Red Mountain anticline and thrust fault dominates the reach from Oak View to Foster Park.

2.3 SEDIMENT CHARACTERISTICS

The Ventura River basin is considered to have some of the highest sediment yields recorded in the United States, with steep headwater slopes in the watershed producing most of the sediment supplied to the river through mass wasting processes (US Bureau of Reclamation [Reclamation] 2000). Forest fires are also believed to have a large impact on sediment production in the watershed by increasing the erodibility of hillslopes. Previous studies have estimated sediment yields for the Ventura and Matilija basins. Estimates range from 4.2 to 5.0 acre-ft/mi^2/yr for the Ventura basin without the influence of Casitas and Matilija dams to 2.78 acre-ft/mi^2/yr with Matilija and Casitas dams in place (Reclamation 2000). Estimated sediment yields ranged between 1.6 to 6.8 acre-ft/mi^2/yr for headwater sub-basins of the Ventura River, with 2.5 acre-ft/mi^2/yr a best estimate for just the Matilija sub-basin (Reclamation 2000). This compares with 0.7 acre-ft/mi^2/yr average sediment yield and 3.0 acre-ft/mi^2/yr, considered a high sediment yield, compiled from various drainage basins of 100 square miles or less in California (Leopold 1994).

Most of the total sediment load, 98%, is carried as suspended sediment (Reclamation 2000), which is typical of coastal California streams. The suspended sediment is comprised primarily of sand sized particles (0.062 to 2 mm). Bedload comprises only about 2% of the total sediment load, but the coarser bed materials exert a much greater influence on channel form. Bed particle sizes sampled on the mainstem near the Coyote Creek confluence indicate that the D_{50} (median diameter particle) is greater than 64mm (Reclamation 2000), which is generally described as cobble size material. Less than 1% of the sampled bed particle sizes were smaller than 0.062mm (silts and clays). Most of the mainstem Ventura River is dominated by cobble size material, with smaller sized gravels and larger sized boulders as sub-dominant.

2.4 HYDROGEOLOGY

The Ventura River system is comprised of five major groundwater basins: the Upper Ojai basin; the Ojai basin; the Upper Ventura River basin; the Lower Ventura River basin; and, the San Antonio Creek basin (VCFCD 1971).

The Upper Ventura River basin extends from the confluence of the Matilija Creek and the North Fork Matilija Creek (River Mile 16.2) to Foster Park (River Mile 5.9), at which an underground dam delineates the boundary between the Upper and Lower Ventura River groundwater basins. The boundary between the Ojai basin and the Upper Ventura River Basin is approximately situated between Camp Comfort to the south and Arbolada to the north. The depth to bedrock decreases in the vicinity of this boundary which results in a decrease in thickness of the aquifer materials.

The water bearing units within the Ventura River system consist of unconsolidated to semi-consolidated sediments of Recent and Pleistocene age. The aquifer materials overlie lower permeability consolidated Tertiary age marine and continental deposits, representing the effective base of the groundwater reservoir (Figure 2). The thickness of aquifer materials is generally shallow, but varies along the river due to the geologic structure of the basin (variations in the depth to bedrock and faulting). Along the Upper Ventura River, the water bearing units increase in thickness downstream of the confluence of Matilija and North Fork Matilija Creeks, attaining a maximum thickness of about 200 feet on the north (down dropped) side of the Arroyo Parida-Santa Ana Fault (Figure 2). Downstream of the Santa Ana fault, alluvium thickness is controlled by the folded bedrock surfaces and ranges from about 65 feet in the Mira Monte area, to 45 to 60 feet in the Foster Park area.

The water bearing units within the Ojai Groundwater Basin consist of undifferentiated and poorly consolidated sediments of Recent and Pleistocene age. These materials are generally interstratified and include clay, sand, gravel, and boulders which are derived from stream channel and alluvial fan deposits. The thickness of aquifer materials varies within the basin due the geologic structure of the basin (variations in the depth to bedrock and faulting). The water bearing units attain a thickness of approximately 700 feet in the vicinity of San Antonio School in the eastern portion of the basin to approximately 80 feet in the vicinity of Ojai Valley School in the western portion of the basin (VCFCD 1971). A confining clay layer is located in the southwest corner of the basin along San Antonio Creek. The layer reaches an approximate thickness of 200 feet, and wells in the vicinity of this area are reported to become artesian during periods of high groundwater levels. (ENTRIX/WCC 1997)

The water bearing materials underlying San Antonio Creek consist of alluvial sediments of Recent age. The average thickness of the sediment ranges between approximately 20 to 30 feet. The aquifer is generally unconfined and has a limited storage capacity.

As is typical for alluvial deposits, the aquifer is comprised of sand, gravel, cobbles, boulders, silt, and clay, often with interstratified, lenticular, and discontinuous sediment units. Sedimentary structures include channel fill deposits, point bars, and overbank deposits. As a result of these complex depositional features, aquifer parameters can vary greatly over short distances.

In general, groundwater in the Ventura River system occurs under unconfined conditions. However, some localized areas exhibit semi-confined characteristics. The primary source of recharge to the alluvial aquifer system is direct infiltration of surface flows. Other sources of recharge include direct infiltration of precipitation and downvalley underflow through alluvial sediments.

2.5 HYDROLOGY

Surface water flows in the Ventura river watershed are primarily dependent upon runoff from local and regional rainstorms, with a seasonal flow regime that mimics the rainfall seasonality. During the wet season, the surface flows are "flashy" with sudden rises in discharge immediately following the onset of precipitation and relatively rapid declines in streamflow after precipitation decreases. On the mainstem, flows can range from near zero to thousands of cubic feet per second within a few hours during major storms.

Under summer low flow conditions, surface streamflow at various locations in the watershed is governed by a complex interaction of precipitation input, discharge from springs, groundwater levels, the effects of water diversions, water storage, water supply releases, treated wastewater discharge, and groundwater extraction. Along the mainstem, surface flows dry up in locations between the Robles Diversion and the confluence of San Antonio Creek, but small summer flows are maintained upstream of Robles, in the "live reach" between Foster Park and the confluence of San Antonio Creek, and downstream of the Ojai Valley Sanitation District wastewater treatment plant (ENTRIX/WCC 1997).

2.6 SURFACE WATER DIVERSIONS

Surface water and groundwater have been developed for use along the Ventura River for over 200 years. As of 1981, approximately 45 known entities withdrew water from the Ventura River system (EDAW 1981). These entities include irrigators, domestic users, industrial users, and water purveyors or suppliers.

The most significant surface water diversion facilities are Matilija Dam on Matilija Creek, the Robles Diversion Dam on the mainstem Ventura River, Casitas Dam on Coyote and Santa Ana Creeks, and the subsurface dam and groundwater extraction wells (Nye wells) at Foster Park which are used to divert surface and subsurface flow, respectively.

Matilija Dam was constructed by the VCFCD in 1947. The dam is located approximately 0.6 miles upstream of the confluence of Matilija Creek and North Fork Matilija Creek, and was constructed as a flood control and water supply facility. The original storage capacity of dam and reservoir was 7,020 AF, but structural modifications to address concrete deterioration and siltation have reduced the water storage capacity to less than 500 AF at present (Reclamation 2000). Matilija's current operations are primarily for the purpose of optimizing diversions at Robles, using a release valve with a maximum capacity of 250 cfs (Reclamation 2000).

The Robles Diversion is located approximately 1.5 miles downstream of the confluence of Matilija Creek and North Fork Matilija Creek (River Mile 14). Since 1960, the diversion has been used to transfer water to Casitas Reservoir via a canal. The surface water diversions are primarily restricted to January, February, and March, and the mean monthly diversions during these months range from 2,183 to 3,489 AF (ENTRIX/WCC 1997). The annual total diversion volume varies with available runoff and storage capacity remaining in Casitas Reservoir, averaging 13,095 AF/year, with a median diversion volume of 6,335 AF/year (ENTRIX/WCC 1997).

Casitas Dam was constructed in 1959, and is located approximately 2.5 miles upstream of the Ventura River on Coyote and Santa Ana Creeks (near River Mile 6.2). Casitas Reservoir has a maximum storage capacity of 254,000 AF, and is supplied by inflow from the Robles Diversion via the Robles-Casitas canal in addition to watershed runoff from the Coyote and Santa Ana basins. (ENTRIX/WCC 1997)

The City of Ventura water supply facilities at Foster Park consist of a surface and subsurface water collection system. These facilities operate in conjunction with an underground dam constructed between 1906 and 1908 at the confluence of Coyote Creek and the Ventura River. The underground dam and confining bedrock surfaces increase groundwater levels in the vicinity of Foster Park produce enhanced surface flows for captured by a surface diversion and a subsurface collector system consisting of 2 perforated concrete pipes situated on the upstream side of the dam. An average of approximately 2,500 AF of surface water and 3,900 AF of groundwater is diverted at the Foster Park facilities annually. (ENTRIX/WCC 1997)

2.7 GROUNDWATER SUPPLY WELLS

Several public and private groundwater supply wells are located within the Upper Ventura River basin in the vicinity of the mainstem of the river. The most substantial groundwater extraction entities are the Meiners Oaks County Water District (MOCWD), the Ventura River County Water District (VRCWD), and the City of San Buenaventura.

The MOCWD operates 2 wells located approximately 1 mile downstream of Matilija Dam and 2 wells in the vicinity of Meiners Oaks adjacent to Rice Road. The MOCWD produces approximately 1,300 AF of water per year from these wells. The VRCWD operates 3 wells located between Meiners Oaks and the Highway 150 crossing. The VRCWD produces approximately 1,200 AF of water per year from these wells. The City of San Buenaventura operates 4 wells located in the Foster Park area. The City produces approximately 3,900 AF of water per year from these wells. (ENTRIX/WCC 1997; Ventura County Water Purveyors' database 2000).

3.0
HYDROLOGIC ANALYSIS METHODS

3.1 APPROACH

The groundwater and surface water interaction study included two phases of analysis: an initial phase of data gathering and review to refine the approach and methods applicable for the data set, followed by a qualitative and quantitative empirical-based assessment.

A thorough evaluation of groundwater pumping impacts on surface water flow requires concurrent groundwater pumping and water level data, surface water flow data, and field observations of the change in wetted length of the "live reach". Unfortunately, certain key elements of this data set are not available, specifically pumping data and observations of the 'live reach'.

Therefore, the hydrologic analysis relied on available data which included United States Geological Survey (USGS) stream gauge data, an evaluation of the Ventura River groundwater basin including structural and physical properties, groundwater elevation information, and water diversion information. These data were used to assess the dynamics of the Upper Ventura River basin groundwater system, and specify key areas within the system that may act to control or limit groundwater contributions to surface flows. Due to the limited available data, the objective of the evaluation was modified to focus on describing the system dynamics and developing recommendations for future work to address data gaps. The scope of the evaluation was determined by the available surface flow and groundwater data, and, therefore, focused on the Upper Ventura River and San Antonio Creek basins. A brief discussion is also included for the Ojai Valley groundwater basin based on the available information.

3.2 DATA COLLECTION AND REVIEW

Available surface flow and groundwater data were obtained from several resources including the City of San Buenaventura, the County of Ventura, the USGS, the California Department of Water Resources (DWR), and Casitas. The Ventura County Water Purveyors information database on well information was used to update information on the location and extraction volumes for active wells.

The surface hydrology information primarily included USGS stream gauge data, and water facilities and operations information from Casitas and the City. Typical or average data, as well as available detailed daily data were requested and reviewed. No specific field-verified, dated observations of the location, extent, duration of live flow versus discontinuous flow or dry back were available.

The critical groundwater hydrology information included structural and physical properties of the groundwater basins and aquifer system, and dated observations of ground water elevations within the basin. The primary source of these data is the

Ventura County Water Resources Management Study, Geohydrology of the Ventura River System: Groundwater Hydrology prepared by the Ventura County Flood Control District (VCFCD) in May 1971. While there have been a few other studies regarding groundwater along the Ventura River and there is considerable information about the Ojai Valley groundwater basin, the 1971 report is the only source identified during this review that had the geographic scope, range of groundwater characteristics, and surface hydrology information appropriate for further analysis.

Hydrographs of water levels in numerous groundwater monitoring wells within the basin from more recent years were also reviewed from DWR web database sources and Ventura County records. However, the usefulness of interpreting additional, specific hydrographs was limited by the lack of concurrent groundwater extraction pumping rates, volume, and/or level data without pumping rates and or volumes associated with specific wells or groups of wells for the years of observations, it is not possible to sort out the relative or absolute effect of natural hydrologic variability, surface water operations, and groundwater extraction on groundwater levels and patterns.

3.2.1 GROUNDWATER BASIN AND STREAM PROFILES

Scaled profiles of the base of the groundwater basin and the ground surface along the Ventura River were created from the data available in the VCFCD (1971) report and the USGS Matilija and Ventura 7.5-minute Quadrangle maps (1967, 1988).

Ground surface elevations along the stream alignment on the topographic maps were recorded for the corresponding river miles upstream of the mouth to produce the river profile (see Figure 2). The stream alignment was overlain on the 1971 report's maps to create profiles of various mapped groundwater characteristics. The effective base of the groundwater reservoir and groundwater elevations on the contour maps were thus interpreted to describe groundwater profiles along the river profile.

3.2.2 SEASONAL GROUNDWATER LEVELS

Groundwater levels in the Upper Ventura River Basin, the Ojai Basin, and the Lower San Antonio Creek Basin fluctuate seasonally with the highest water levels occurring in the winter and early spring and the lowest levels occurring in the late summer and early fall. In general, groundwater levels in these basins recover rapidly following periods of precipitation and decline slowly under natural conditions which is characteristic of unconfined groundwater basins (VCFCD, 1971). In the Upper Ventura River basin, groundwater levels in the vicinity of Meiners Oaks appear to fluctuate less than groundwater levels in the vicinity of Casitas Springs which may be related to differences in groundwater extraction and/or potentially related to a threshold-response relationship for groundwater flow across the Santa Ana/Arroyo Parida fault.

Seasonal and annual changes in groundwater levels could be described using various long-term monitoring well hydrographs within the basin. However, interpreting these patterns during the range of water year types and under the undocumented pumping rates for the specific years of observed water levels would be inappropriate.

Our description of the seasonal groundwater regime focuses on data from water years that indicate the recharge process during two wet seasons that have different preceding conditions. The first data set are groundwater levels from fall of 1957 and spring of 1958 (Water Year 1958). These data represent a wet year that was preceded by a dry runoff year in WY 1957, and also had dry conditions in WY 1955 and only normal runoff in WY 1956 (ENTRIX/WCC 1997). The second data set are groundwater levels from fall of 1968 and spring of 1969 (WY 1969). These data represent an even higher volume runoff wet year that was directly preceded by a below normal year (WY 1968), but the next two previous years had been above normal (WY 1966 and 1967). Groundwater profiles for each season of the two data sets were created from the contour maps (VCFCD 1971) to provide a basis for comparison.

3.2.3 SEASONAL GROUNDWATER STORAGE

As part of the 1971 VCFCD study, the Upper Ventura River and Lower San Antonio Creek basins were divided into several nodal areas and the physical properties of each node were used to estimate the total aquifer storage capacity (theoretical maximum) for each node. The report also indicated observed groundwater storage by node for Spring 1970, which likely represents a fully recharged aquifer following the major runoff year in 1969.

ENTRIX used the Spring 1970 storage capacity information to develop a storage coefficient for each node. This allows the groundwater level changes during the season to be expressed in terms of volume changes. The storage coefficient for each node was calculated by dividing the calculated storage by the average groundwater thickness (storage capacity/average thickness of groundwater). The storage coefficient was used to make an estimate the volume of water represented per unit change in head for each node, given the 1970 groundwater levels.

The derived storage coefficient was used to estimate the seasonal change in groundwater storage volume for the nodes situated along the Upper Ventura River and Lower San Antonio Creek between the Fall of 1968 and Spring of 1969, and calculate the percent change in groundwater storage versus the groundwater storage capacity for 1970 (a normal rainfall year that followed a major wet year).

3.2.4 GROUNDWATER FLOW PATTERNS

A simplified groundwater flow evaluation was made using the empirical data from the 1971 VCFCD study. A spreadsheet was developed using the groundwater elevation and groundwater storage information provided for the nodes along the Upper Ventura River.

The model was used to estimate the monthly change in storage in each node area (**Figure 3**), over a 3-month period, based on the physical properties of each node.

The following assumptions were used:

- The groundwater levels in the spring of 1970 were the starting conditions, indicative of a full aquifer for storage and head assumptions;
- No additional surface water recharge was assumed over the study months, a conservative representation of the typical late spring conditions; and,
- Each node's physical properties were represented by a single, typical or average cross section.

Darcy's law (Q = (K*i*A)/n) was used to calculate groundwater flow in and out of each node using the average specific yield provided in the 1971 VCFCD study report (n), calculated gradients from the potentiometric surface maps in the 1971 VCFCD study (i), calculated cross-sectional discharge areas estimated from the average groundwater thickness and width of each node in the 1971 VCFCD study (A), and a literature-derived hydraulic conductivity value (K) based on the average specific yield for each node.

The model produced a representation of seasonal groundwater flow downvalley through the identified nodes, creating a quantitative basis for describing the spatial pattern of flow behavior.

3.2.5 GROUNDWATER AND SURFACE WATER RELATIONSHIPS

The initial field and groundwater well locations, well ground surface elevations, and well distances from the active Ventura River channel indicated a potential for localized pumping impacts on surface flow. However, the potential impacts from a specific well or group of wells appeared secondary to the overall seasonal fluctuations in groundwater elevations throughout the Upper Ventura River basin. Therefore, the study focused on determining the system-wide relationship between groundwater and surface water.

The 1981 *Final Environmental Impact Report Ventura River Conjunctive Use Agreement* prepared by EDAW, Inc. provided some site-specific assessment of groundwater and surface water relationships in the "live reach" between San Antonio Creek and Foster Park. EDAW (1981) examined groundwater levels in two existing groundwater extraction wells, 4N23W16C4, located in the vicinity of Meiners Oaks, and 3N23W5B1, in the vicinity of Casitas Springs. Their study concluded that when the groundwater levels in 4N23W16C4 and 3N23W5B1 fall below approximately 495 and 250 feet msl, respectively, then surface flow in much of the "live reach" stops. This relationship indicates that there may be a threshold response, but without detailed surface water observations under various groundwater levels, the ability to describe the groundwater and surface water mechanisms remains limited. ENTRIX did review groundwater level records from 1949 to 2000 for these wells to determine the frequency at which groundwater levels fell below these threshold levels.

ENTRIX reviewed all the available streamflow and diversion data throughout the project area and identified a study period (WY 1970-1982) for which there are concurrent records for several of the key surface water points along the main stem and tributaries. A simple water-budget was identified that could account for nearly all inputs and losses aside from groundwater. Thus, an estimate of groundwater contributions to surface flow in the vicinity of Foster Park could be calculated by examining the difference between the volume of surface water ‘expected’ at Foster Park (all upstream mainstem and tributary inputs minus surface diversions) and the surface water that was realized at Foster Park (surface flow plus Foster Park diversion). A positive difference between the surface water expected and realized at Foster Park indicates that additional water has been provided from (1) the groundwater system, (2) overland flow, and/or (3) some other non-channelized surface water input. If the difference is negative, this indicates that surface water is likely undergoing a net loss to the groundwater system (i.e., recharging).

The following equation was used to estimate the ‘expected’ volume of surface water at Foster Park:

> Foster Park (expected) = Ventura River upstream of Robles (Matilija and NF Matilija) + San Antonio Creek + Coyote Creek (Casitas spill) – Robles Diversion

The value was compared with observed flow at Foster Park:

> Foster Park (realized) = Ventura River near Ventura + City diversion at Foster Park

4.1 UPPER VENTURA RIVER

Geologic controls, primarily folding, faulting, and rapid uplifting have produced a shallow alluvial aquifer along the Upper Ventura River that has small storage capacity relative to average annual runoff and water demand. While the aquifer can recharge quickly when runoff is available, the small storage capacity reduces carry-over storage from year to year. The largely unconfined aquifer is aligned along a moderately sloping valley profile and has a persistent downvalley flow direction. However, the rate of downvalley flow is not uniform through the various river reaches and groundwater nodes. Differential depths to bedrock and bedrock controls on valley width along the river reaches create varied aquifer storage and transmission rates that affect groundwater and surface water interactions. The Santa Ana fault configuration has a fundamental influence on downvalley movement of groundwater. North of the fault, on the down-dropped side, the thicker aquifer has a relatively large storage capacity while the south side of the fault has a much thinner alluvial veneer over bedrock (Figure 2). When groundwater levels on the upvalley (north) side of the fault fall below certain elevations, downvalley movement of groundwater can be reduced or eliminated. This situation is likely to have a fundamental effect on groundwater support to surface water flows downstream of the fault.

4.2 SEASONAL GROUNDWATER LEVELS

Groundwater levels within the Upper Ventura River basin fluctuate seasonally as is typical for shallow, unconfined, alluvial systems in the region. Groundwater levels rise during winter and spring in response to the precipitation, runoff, and recharge, then decline during summer and fall. The summer and fall decrease in groundwater levels results from several natural factors including: downvalley transfer within the aquifer, diminishing surface recharge during the low streamflow season, and increased evapotranspiration losses. The potential effects of groundwater extraction would likely exacerbate the seasonal pattern, since the peak groundwater pumping is typically during the summer.

The maximum groundwater elevation and the duration of high groundwater during winter and spring varies based on the water year conditions, runoff timing and volume, and the antecedent groundwater elevation at the beginning of the recharge season. In a few areas, those with shallow bedrock control, groundwater levels may reach and remain near the channel bed elevation perennially, such as the vicinity of Casitas Springs. The potentiometric surface maps from the VCFCD (1971) study suggests that much of the Upper Ventura River groundwater basin has a persistent downvalley gradient, tending towards a ‘losing’ stream condition, rather than having groundwater gradients towards the channel that provide base flow support.

Groundwater level data for WY 1958 (fall 1957- spring 1958) (Figure 3), WY 1969 (fall 1968 –spring 1969) and spring WY 1970 (**Figure 4**) indicates that although groundwater levels were low at the beginning of the each WY, a single wet year's runoff recharged the aquifer to levels reaching the channel bed in several locations by spring. These spring-time 'gaining' locations include the entire reach downstream of Hwy 150 to Foster Park, and a small section downstream of Robles diversion near River Mile 13. The remaining sections of the Upper Ventura River have 'losing' stream conditions despite the wet years' recharge effects. Since the spring 1958, 1969, and 1970 conditions are from wet water years, it is likely that other wet years and possibly some above normal years would create similar spatial patterns of groundwater support for surface flow.

The consistency of the two fall groundwater profiles (1957 and 1968), despite different antecedent water year conditions, suggests that when high groundwater levels occur, they do not have long duration. The fall of 1957 and 1968 groundwater levels depict seasonal minimum groundwater elevations during a dry water year and below normal water year, respectively, but 1957 was preceded by a relatively dry year while 1968 was preceded by an above normal water year. The lack of data regarding groundwater pumping volumes for these specific seasons and locations precludes a thorough assessment of the relative effect of pumping. However, the similar fall conditions produced from different antecedent water years, and some probable differences in local groundwater pumping in 1957 versus 1968 (pre-Robles/Casitas and very dry in 1957 versus post-Robles/Casitas and not dry in 1968), indicates that similar minimum groundwater levels may occur each year.

The seasonal profiles presented in Figures 3 and 4 demonstrate the impacts of the Santa Ana/Arroyo Parida fault zone on the groundwater profile for the Upper Ventura River groundwater basin. Groundwater levels downstream of the Highway 150 crossing may be impacted when the groundwater elevations north of the fault fall below the base of the downstream aquifer (approximately 495 feet msl) which results in a disconnection in groundwater flow across the fault. This disconnected condition may be of varied duration from year to year. However, it is likely that this condition occurs, at least briefly, in most water years, based on the examples from 1957 and 1968. The magnitude of impact of this disconnection on groundwater support to the downstream reaches (including the 'live stretch') cannot be assessed without considering the duration, rate, and total volume of downvalley groundwater discharge.

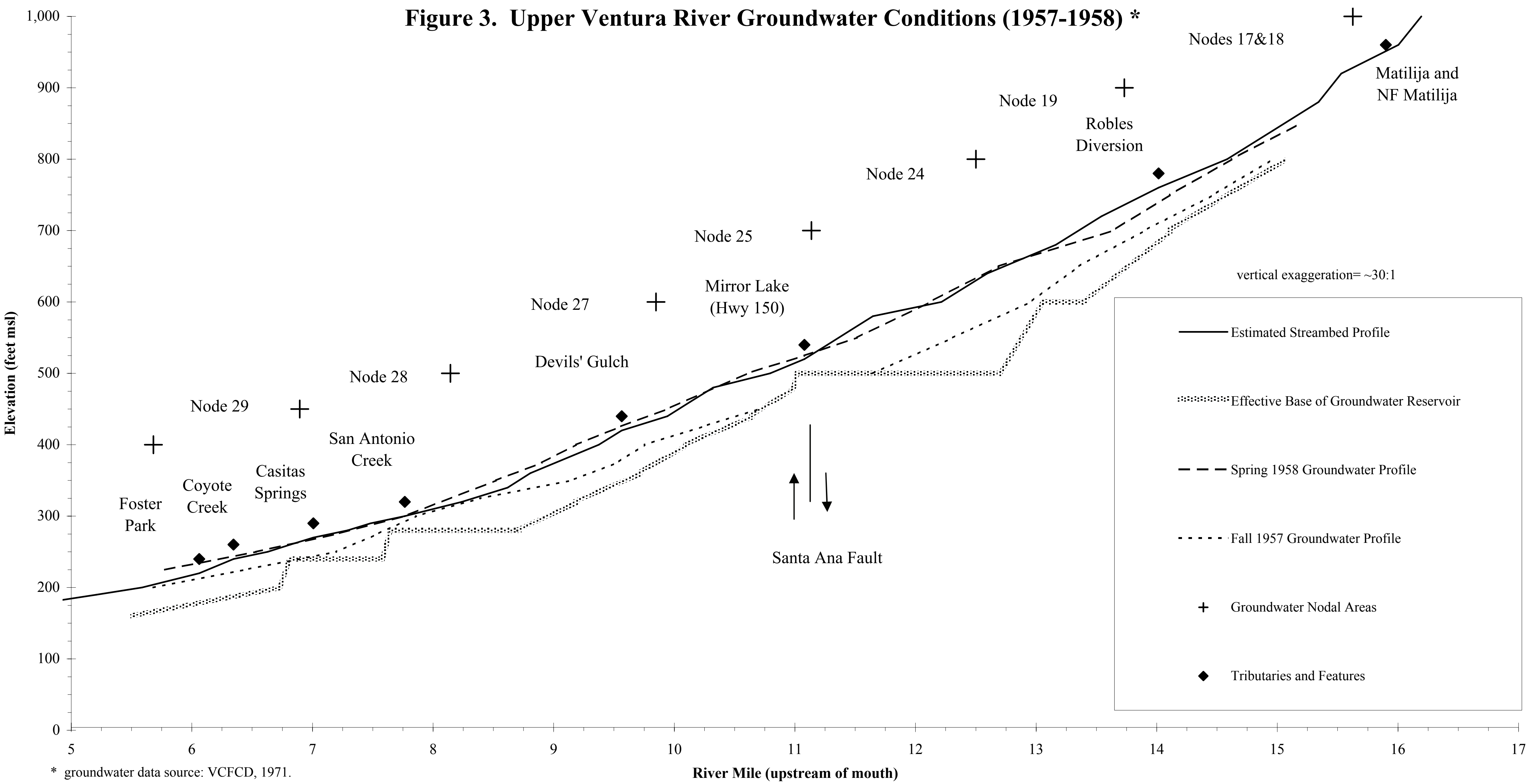
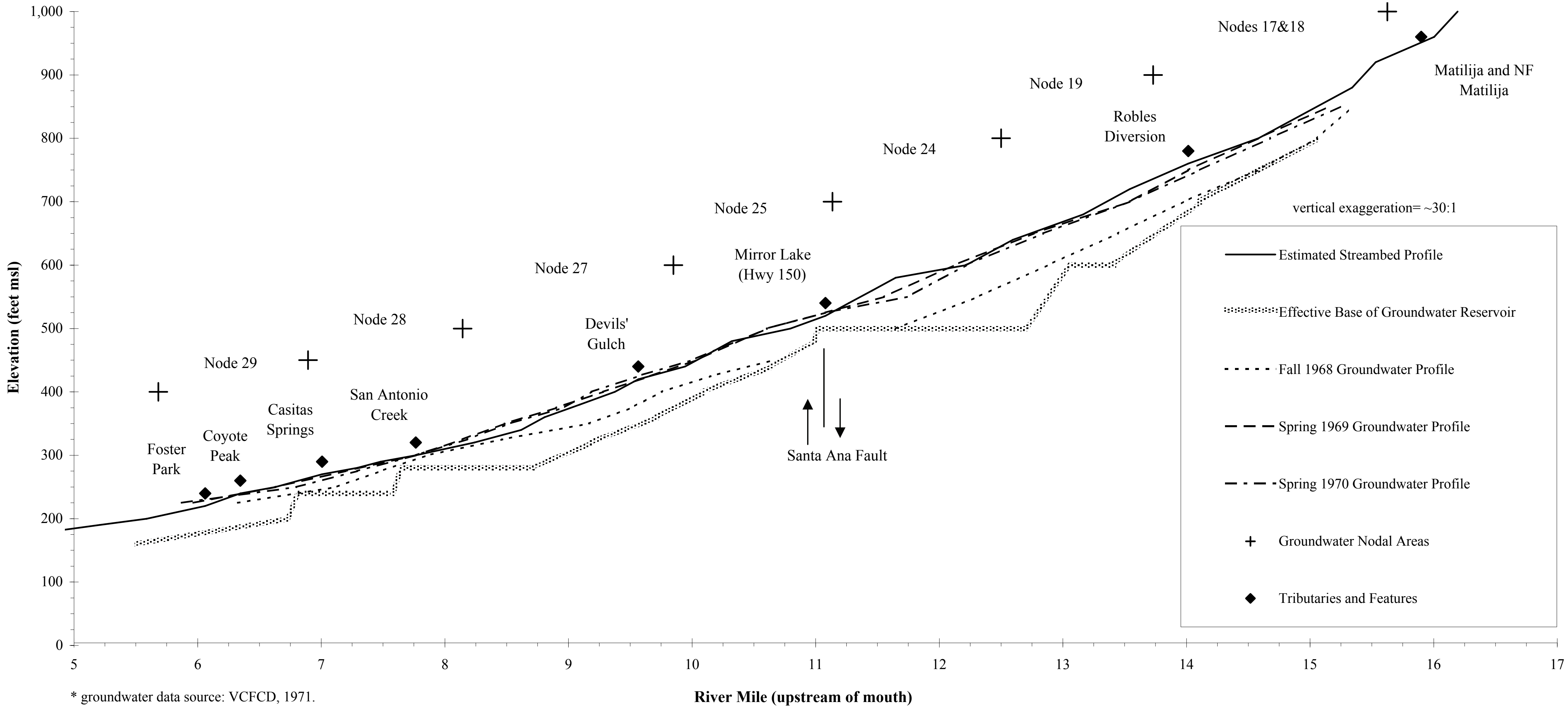


Figure 3. Upper Ventura River Groundwater Conditions (1957-1958) *

* groundwater data source: VCFCD, 1971.

Figure 4. Upper Ventura River Groundwater Conditions (1968-1970) *



* groundwater data source: VCFCD, 1971.

4.2.1 SEASONAL CHANGES IN GROUNDWATER STORAGE

Seasonal changes in groundwater storage were evaluated between the Fall of 1968 and the Spring of 1969 for the groundwater nodes along the Upper Ventura River, based on the 1971 VCFCD report using calculated storage coefficients to estimate changes in volume associated with changes in water levels.

In general, the groundwater storage capacity along the Upper Ventura River is small relative to annual surface water runoff. The VCFCD (1971) reports a total groundwater storage capacity for the Upper Ventura River groundwater basin of 35,118 AF, with about 18,645 AF (about 50%) of this storage capacity attributed to the nodes located along the river (Figure 3). The spring 1970 data show the storage levels during a normal water year that follows a major wet year. For the aquifer nodes along the river, the 1970 groundwater storage ranges from 66 to 100 percent of the estimated total storage capacity. Therefore, it is reasonable to assume that the 1970 conditions provide a representation of the Upper Ventura River groundwater basin at or near its fully recharged capacity.

The changes in groundwater storage volume during WY 1969 (Table 1) indicate that the increase in groundwater storage from that year’s recharge season averaged approximately 66% (8,268 AF) relative to the fully recharged condition (1970). The areas that showed the greatest increase were between the Highway 150 Bridge and Live Oak Acres (Node 25), near the confluence of San Antonio Creek (Node 28), near Rancho Matilija (Node 19), and above Robles Dam (Nodes 17&18). The rapid recharge of nearly all the nodes along the system and the similar seasonal response of groundwater profiles in WY 1958 and WY 1969 (Figures 3 and 4) may suggest that a large groundwater withdrawal is practical. However, the recharge rate and percentage of total storage recovered during seasonal recharge over a range of water year types has not been documented.

4.2.2 GROUNDWATER FLOW RELATIONSHIPS

The simple spreadsheet flow model (Appendix C) that represents seasonal down gradient flow volumes and rates, the physical aquifer properties (VCFCD 1971), and an understanding of the groundwater spatial patterns (Figures 3, 4 and 5) provide a basis for describing groundwater flow through the Upper Ventura River system (Table 2).

Groundwater flow along the Ventura River is generally downvalley toward the Pacific Ocean, and is influenced by several geologic features, primarily folding and the Santa Ana/Arroyo Parida Fault. These features impact the thickness and spatial distribution of water-bearing materials.

Each of the areas of shallow or narrow bedrock confinement are likely zones of high groundwater to provide support for surface flows (e.g., downstream end of Nodes 24, and in the middle of Nodes 28 and 29). For example, the “live reach” area between Foster Park and the confluence of San Antonio Creek (Node 29), have rising groundwater levels and significant groundwater contribution to surface flow due to a decrease in the depth to bedrock and a narrowing of the stream channel.

When aquifer storage capacity upstream of a bedrock control is large, but storage downstream of the control is small, the downstream nodes are vulnerable to reduced contributions from upstream if the upstream node experiences lowered water levels. For example, large volumes of groundwater could remain in storage upstream of the Santa Ana/Arroyo Parida Fault, but not flow downvalley when groundwater levels in Node 24 decline below the fault crest (approximately 495 feet msl). This condition, once it occurs, would not be reversed until the upstream groundwater node has recharged to establish sufficient head.

4.2.3 CONTRIBUTIONS FROM GROUNDWATER TO SURFACE WATER

4.2.3.1 Evaluation of Groundwater Levels in Wells 4N23W16C4 and 3N23W5B1

According to the information presented in the 1981 EDAW report, when the groundwater levels in 4N23W16C4 (in Node 24) and 3N23W5B1 (in Node 28) fall below approximately 495 and 250 feet msl, respectively, then surface flow in much of the "live reach" stops. Well 4N23W16C4 is located in the vicinity of Meiners Oaks and well 3N23W5B1 is located in the vicinity of Casitas Springs. Based on historic groundwater elevation data from 1949 to 1967 the groundwater levels demonstrate seasonal fluctuations relatively typical for the system (**Figure 5**). Groundwater levels change dramatically in the deeper alluvium areas (e.g., Node 24), with seasonal variations on the order of 20 to 50 feet. A similar seasonal fluctuation, but of smaller magnitude (in the range of 10 to 20 feet) occurs in the shallower alluvium areas (e.g., Node 28).

Based on the identified threshold elevations of 495 and 250 feet msl, respectively, for wells 4N23W16C4 and 3N23W5B1 (EDAW 1981), data for the period of record (Figure 5) indicates levels in the upstream well (4N23W16C4) dropped below the threshold in 6 of the years (12% of the years). Levels in the downstream well (3N23W5B1) dropped below the threshold in 13 of the years (26% of the years). The groundwater elevations fell below the threshold levels primarily during dry and below normal water years from late summer to early winter, for durations ranging between 2 weeks to 7 months. During some years, both wells experience low levels (e.g., 1961, 1977, 1990, 1991), which may reflect natural climatic conditions, the threshold-response relationship for groundwater flow across the Santa Ana/Arroyo Parida Fault, and similar groundwater use patterns. Each of the four years with low levels in both wells were the second of two relatively dry years in a row. Some years have low levels only in the downstream well, and these are not years following a low level in the upstream wells (e.g., 1949, 1951-52, 1957, 1972, 1986, 1993, 1994). This suggests that local influences in the vicinity of the downstream well might be the controlling factor in these years, not downvalley groundwater contributions. The 1949, 1950 –1952 low levels in the downstream well occur during a series of dry years (with 1952 a wet year that ended a drought), but during this same period, the upstream well does not fall below the threshold levels. Overall, the records for these two wells, in relationship to the thresholds identified by EDAW (1981) show that groundwater effects on the 'live stretch' are probably limited to conditions when a series of dry years occurs. Assessing the partial contribution of groundwater pumping to this natural response would require information on the pumping from individual wells and/or total volumes pumped in various nodes along the river.

4.2.3.2 Evaluation of Surface Water Flow Data

The relationship of groundwater and surface water can be described in terms of the physical processes and empirical data demonstrating certain conditions in groundwater levels and surface water flow. The water-budget approach to quantifying the contribution of groundwater to surface water flows provides an initial estimate of the importance of groundwater flow through the Upper Ventura River basin on surface water flows in the vicinity of Foster Park. However, without specific surface water observations (of flow amounts or presence/absence) and concurrent groundwater level and pumping volume data, the relative impact of groundwater pumping versus natural climatic and aquifer conditions cannot be discerned.

Of the available study period, water-budget information for 1970 and 1977 allow for examination of variations in the magnitude or season of groundwater contributions under conditions with a fully recharged condition in 1970 (Table 3) and a drought condition in 1977 (Table 4). The difference in ‘expected’ versus ‘recorded’ surface water at Foster Park in 1970 (Table 3) indicates that about 9,882 AF was realized at Foster Park that is not accounted for by the upstream surface water inputs. The monthly pattern with large excess flow in the rainy months suggests that some of this additional volume may have been a result of surface runoff from intervening areas (between gauges). Even if a portion of these peak month’s additional surface flow at Foster Park was not from groundwater contributions, the overall contribution of groundwater was about one-third of the total surface volume at Foster Park. The surface flow data for 1977 (Table 4) indicates that despite much lower total surface flow at Foster Park, groundwater may have contributed as much as 3,426 AF to surface flows or 52% of the total surface flow.

Table 1. Upper Ventura River Groundwater Storage Data for the Fall of 1968 and Spring of 1969

Groundwater Node(1)	**Average Groundwater Elevations(2) (feet msl)**		**Increase in Groundwater Elevation (Fall 1968 to Spring 1969)**	**Storage Coefficient(3)**	**Change in Groundwater Volume(4)**	**Groundwater Storage Spring 1970**	**Percent increase in Average Groundwater Storage (5)**
	Fall 1968	**Spring 1969**	**(feet)**	**(AF/ft.)**	**(AF)**	**(AF)**	
17&18	760	800	40	20.3	812	638	100%
19	625	675	50	30	1,500	3,122	48.1%
24	525	585	60	32.5	1,950	2,630	74.1%
25	442	488	46	37.1	1,707	1,559	100%
27	357	378	21	56.2	1,180	2,474	47.7%
28	275	290	15	44.4	666	1,199	55.6%
29	222	238	16	28.3	453	989	45.8%
				TOTAL =	**8,268**	**12,611**	**66%**

NOTES:

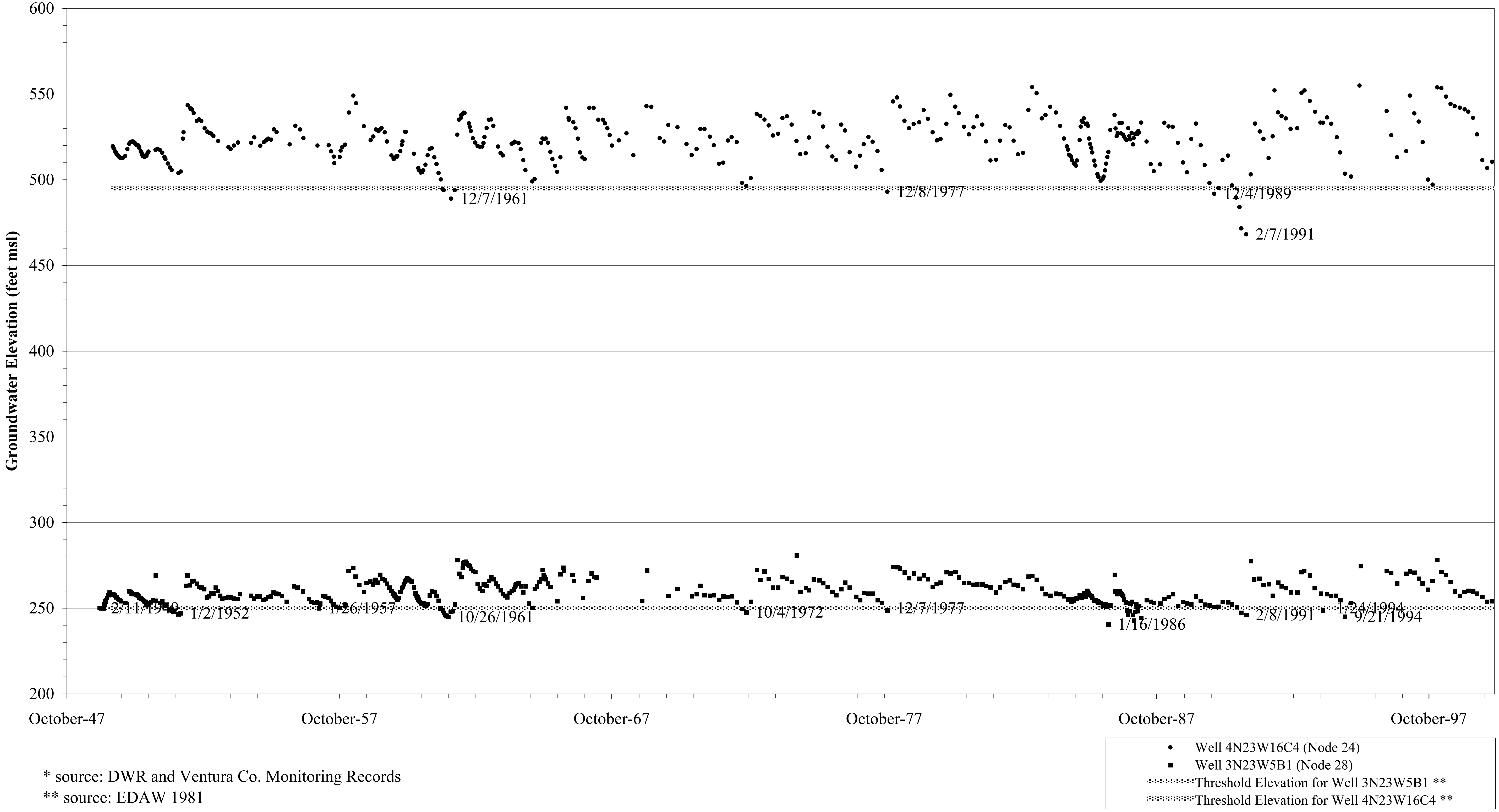
1) Groundwater nodes as outlined in the *Ventura County Water Resources Management Study, Geohydrology of the Ventura River System: Groundwater* (VCFCD 1971).
2) Calculated by subtracting the upstream groundwater elevation from the downstream groundwater elevation within each node as depicted in Plate 5a of the 1971 VCFCD study.
3) Calculated by dividing the storage capacity for each node by the average groundwater thickness in each node in Spring 1970 (storage capacity/average thickness of groundwater). The storage coefficient was used to estimate the volume of water that each node releases from storage per unit change in head under the fully recharged conditions.
4) Calculated by multiplying the change in groundwater elevation by the storage coefficient.
5) The percent change in groundwater storage was calculated by dividing the change in groundwater volume from Fall 1968 to Spring 1969 by the groundwater storage Spring 1970.

Table 2. Interpretation of Groundwater Flow Response from Aquifer Properties

River Reach	River Mile (US of Mouth)	Groundwater Node*	Aquifer Properties affecting Downvalley flow*	Estimated Groundwater Flow Response
Matilija Cr. & NF Matilija Cr. confluence to Kennedy Cyn	16.2 to 14.6	17	▪ Relatively high specific yield ▪ Low storage capacity ▪ Small cross-sectional discharge area ▪ High gradient	Transmits groundwater efficiently due to high gradient and high specific yield.
Kennedy Cyn to Rice Cyn (incl. Robles)	14.6 to 13.5	18	▪ Relatively high specific yield ▪ Moderate storage capacity ▪ Small cross-sectional discharge area ▪ High gradient	Transmits groundwater efficiently due to high gradient and high specific yield.
Meiners Oaks	13.5 to 12.4	19; (20,21 east of main river valley)	▪ Relatively low specific yield ▪ Large storage capacity ▪ Large cross-sectional discharge area ▪ Moderate gradient	Increase in groundwater elevations due to large storage capacity and decrease in gradient and specific yield relative to upstream Nodes 17 and 18.
Rancho Matilija (US of Hwy 150)	12.4 to 11.1	24; (23, 22 east of main river valley)	▪ Relatively low specific yield ▪ Large storage capacity ▪ Large cross-sectional discharge area ▪ Moderate gradient ▪ Santa Ana Fault US downdrop	Increase in groundwater elevations due to large storage capacity and decrease in gradient and specific yield relative to Nodes 17 and 18. Flow out of node controlled by Santa Ana fault.
Hwy 150 to Devil's Gulch	11.1 to 9.8	25	▪ Relatively moderate specific yield ▪ Moderate storage capacity ▪ Moderate cross-sectional discharge area ▪ Moderate gradient	Transmits water more efficiently than Node 24; groundwater levels may decrease, particularly if groundwater elevations in Node 24 are near/below the base of the alluvium in Node 25.
Live Oak Acres & Oak View	9.8 to 8.6	27	▪ Relatively high specific yield ▪ Large storage capacity ▪ Moderate cross-sectional discharge area ▪ Moderate gradient	Increase in groundwater elevations due to increase in storage capacity and increase in specific yield relative to Node 25.
San Antonio Creek to Casitas Springs	8.6 to 6.9	28	▪ Relatively high specific yield ▪ Moderate storage capacity ▪ Small cross-sectional discharge area ▪ Low gradient	Increase in groundwater elevations due to decrease in storage capacity, discharge area, and gradient relative to Node 27.
Casitas Springs to Foster Park	6.9 to 5.7	29	▪ Relatively moderate specific yield ▪ Moderate storage capacity ▪ Small cross-sectional discharge area ▪ Low gradient ▪ Foster Park subsurface dam	Increase in groundwater elevations due to decrease in specific yield and decrease in gradient. Flow out of this node regulated by the Foster Park dam (and underlying shallow bedrock).

- Identified by VCFCD (1971).

Figure 5. Groundwater Elevations for Selected Monitoring Wells (WY 1948-1998) *



* source: DWR and Ventura Co. Monitoring Records

** source: EDAW 1981

4.3 LOWER SAN ANTONIO CREEK

4.3.1 SEASONAL CHANGES IN GROUNDWATER LEVELS

Groundwater levels along lower San Antonio Creek for WY 1969 (VCFCD 1971) depict approximate seasonal changes in groundwater elevations from the fall of a below normal water year to the spring of a wet water year (**Figure 6**). During the year, ground water levels fluctuate about 30 feet, essentially the entire thickness of the aquifer. The fall 1968 profile indicates that much of lower San Antonio Creek has a groundwater table below the channel bed, except for the 1.5 miles immediately upstream of its confluence with the Ventura River. In contrast, the groundwater table reaches or exceeds the estimated channel bed surface along the entire 4.5 mile study area during the winter and spring.

4.3.2 SEASONAL CHANGES IN GROUNDWATER STORAGE

The groundwater storage capacity along Lower San Antonio Creek is very small relative to annual surface water runoff. The average annual runoff for Lower San Antonio Creek is approximately 11,206 AF (ENTRIX/WCC 1997). The total groundwater storage capacity along Lower San Antonio Creek is approximately 1,441 AF, and the groundwater storage in 1970 was approximately 838 AF (Table 5). Similar to the alluvial aquifer of the Upper Ventura River, the San Antonio Creek alluvial aquifer can recharge quickly in high runoff years. The groundwater storage changed approximately 200% (1,143 AF) compared to storage in 1970 between the Fall of 1968 and Spring of 1969.

Table 3. Surface Water Budget Estimate of Groundwater Contribution to Surface Flow at Foster Park (1970)

Month	Recorded Flow in the Upper Ventura River above the Robles Diversion[1]	Surface Water Diverted at the Robles Diversion	Recorded Flow below Robles Diversion in the Vicinity of Meiners Oaks[2]	Volume of Water Impounded by Robles Diversion or Infiltrated to Groundwater[3]	Recorded Flow from San Antonio Creek Near the Confluence with the Ventura River[4]	Recorded Flow from Coyote Creek Near the Confluence with the Ventura River[5]	Expected Flow at Foster Park Based on Upstream Recorded Surface Water Inputs[6]	Recorded Flow at Foster Park by USGS Gauge[7]	Estimated Surface Flow vs. Recorded Surface Flow at Foster Park[8]
	AF	AF	AF	AF	AF	AF	AF	AF	AF
Jan	1,057	312	210	534	495	13	718	1,449	732
Feb	2,084	988	392	704	1,343	31	1,766	3,265	1,499
Mar	7,659	7,347	584	-272	1,990	148	2,723	4,667	1,944
Apr	1,071	404	553	115	335	24	911	1,348	437
May	604	0	315	289	220	10	545	1,111	566
Jun	550	0	130	421	157	5	293	877	585
Jul	522	0	106	416	107	6	219	816	596
Aug	602	0	112	490	79	2	193	728	535
Sept	533	365	37	131	59	2	98	540	442
Oct	365	0	112	253	52	1	165	442	276
Nov	2,310	76	551	1,683	1,168	19	1,738	2,265	526
Dec	5,985	908	608	4,470	2,445	81	3,134	4,878	1,744
	23,343	10,400	3,710	9,233	8,450	343	12,503	22,385	9,882

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[1] Recorded by USGS stream gauges 11115500 and 11116000.

[2] Recorded by USGS stream gauge 11116550.

[3] The volume of water impounded by Robles Diversion or infiltrated to groundwater was calculated by subtracting the volume of water diverted by Robles and the recorded flow at Meiners Oaks from the recorded flow above the Robles Diversion.

[4] Recorded by USGS stream gauge 11117500.

[5] Recorded by USGS stream gauge 11118000.

[6] The expected flow at Foster Park was calculated by adding the recorded flow at Meiners Oaks, San Antonio Creek, and Coyote Creek.

[7] Recorded by USGS stream gauge 11118501.

[8] Groundwater contribution to surface flow is assumed to account for the majority of the difference between the estimated surface flow and the recorded flow at Foster Park.

Table 4. Surface Water Budget Estimate of Groundwater Contribution to Surface Flow at Foster Park (1977)

Month	Recorded Flow in the Upper Ventura River above the Robles Diversion[1]	Surface Water Diverted at the Robles Diversion	Recorded Flow below Robles Diversion in the Vicinity of Meiners Oaks[2]	Volume of Water Impounded by Robles Diversion or Infiltrated to Groundwater[3]	Recorded Flow from San Antonio Creek Near the Confluence with the Ventura River[4]	Recorded Flow from Coyote Creek Near the Confluence with the Ventura River[5]	Expected Flow at Foster Park Based on Upstream Recorded Surface Water Inputs[6]	Recorded Flow at Foster Park by USGS Gauge[7]	Estimated Surface Flow vs. Recorded Surface Flow at Foster Park[8]
	AF	AF	AF	AF	AF	AF	AF	AF	AF
Jan	1232	0	821	411	482	38	1340	1226	-114
Feb	437	0	170	267	45	9	224	553	329
Mar	422	0	93	329	78	10	181	638	457
Apr	294	0	20	275	30	8	57	568	511
May	595	50	372	173	147	5	524	674	150
Jun	400	0	113	287	11	2	125	536	410
Jul	134	0	0	134	0	0	0	452	452
Aug	78	0	0	78	0	0	0	403	403
Sept	63	0	0	63	0	0	0	337	337
Oct	74	0	0	74	0	0	0	290	290
Nov	87	0	0	87	0	0	0	188	188
Dec	1362	0	233	1129	426	8	667	681	14
	5,177	**50**	**1,821**	**3,306**	**1,218**	**80**	**3,119**	**6,545**	**3,426**

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[1] Recorded by USGS stream gauges 11115500 and 11116000.

[2] Recorded by USGS stream gauge 11116550.

[3] The volume of water impounded by Robles Diversion or infiltrated to groundwater was calculated by subtracting the volume of water diverted by Robles and the recorded flow at Meiners Oaks from the recorded flow above the Robles Diversion.

[4] Recorded by USGS stream gauge 11117500.

[5] Recorded by USGS stream gauge 11118000.

[6] The expected flow at Foster Park was calculated by adding the recorded flow at Meiners Oaks, San Antonio Creek, and Coyote Creek.

[7] Recorded by USGS stream gauge 11118501.

[8] Groundwater contribution to surface flow is assumed to account for the majority of the difference between the estimated surface flow and the recorded flow at Foster Park.

4.3.3 GROUNDWATER FLOW RELATIONSHIPS

Groundwater flow along Lower San Antonio Creek is downvalley toward the Ventura River with gradients controlled by the bedrock base of the aquifer, groundwater levels within the aquifer, and water levels in the Ventura River. Lower San Antonio Creek is effectively disconnected from the Ojai Valley Groundwater Basin due to a shallow bedrock barrier situated near Camp Comfort.

4.3.4 CONTRIBUTIONS FROM GROUNDWATER TO SURFACE WATER

Based on the physical properties and limited empirical data available, it can be concluded that the alluvial aquifer along San Antonio Creek probably supports surface flows each winter and spring, and may sustain perennial flow in the lower portion of the creek. However, limited observations of groundwater levels, surface flow conditions, and groundwater pumping volumes for this system hinder development of a quantitative assessment of groundwater contributions and potential impacts of pumping.

4.4 OJAI VALLEY GROUNDWATER BASIN

Geologic conditions provide for a broad, deep aquifer in the Ojai Valley with a large storage capacity relative to surface water runoff. The aquifer is likely slow to recharge, but it has a very large buffer for dry years. The total groundwater storage capacity for the Ojai Valley Groundwater Basin is approximately 83,493 AF (VCFCD 1971). The groundwater basin in the Ojai Valley is essentially distinct from that along the Ventura River or San Antonio Creek, and was not examined in relation to influences on surface flows. However, it should be noted that groundwater management of the Ojai basin is valuable for moderating year-to-year demands for surface water from the rest of the Ventura River basin.

Table 5. Lower San Antonio Creek Groundwater Storage Data for the Fall of 1968 and Spring of 1969

Groundwater Node[1]	Average Groundwater Elevations [2] (feet msl)		Increase in Groundwater Elevation (Fall 1968 to Spring 1969)	Storage Coefficient[3]	Change in Groundwater Volume[4]	Groundwater Storage Capacity Spring 1970[5]	Percent Change in Groundwater Storage [6]
	Spring 1969	**Fall 1968**	**(feet)**	**(AF/ft.)**	**(AF)**	**(AF)**	
30	460	490	30	15.2	456	479	95%
31	350	380	30	22.9	687	359	100%
				TOTAL=	1,143	838	100%

NOTES:

1) Groundwater nodes as outlined in the *Ventura County Water Resources Management Study, Geohydrology of the Ventura River System: Groundwater Hydrology* prepared by the Ventura County Flood Control District (VCFCD) in May 1971.
2) The average groundwater elevation was calculated by subtracting the upstream groundwater elevation from the downstream groundwater elevation within each node as depicted in Plate 5a of the 1971 VCFCD study.
3) The storage coefficient was calculated by dividing the calculated storage capacity for each node by the average groundwater thickness in each node in Spring 1970 storage capacity/average thickness of groundwater). The storage coefficient was used to estimate the volume of water that each node releases from storage per unit change in head under the assumed conditions.
4) The change in groundwater volume was calculated by multiplying the change in groundwater elevation by the storage coefficient.
5) The groundwater storage capacity of each node as specified in the 1971 VCFCD study.
6) The percent change in average groundwater storage capacity was calculated by dividing the change in groundwater volume from Fall 1968 to Spring 1969 by the groundwater storage capacity for Spring 1970.

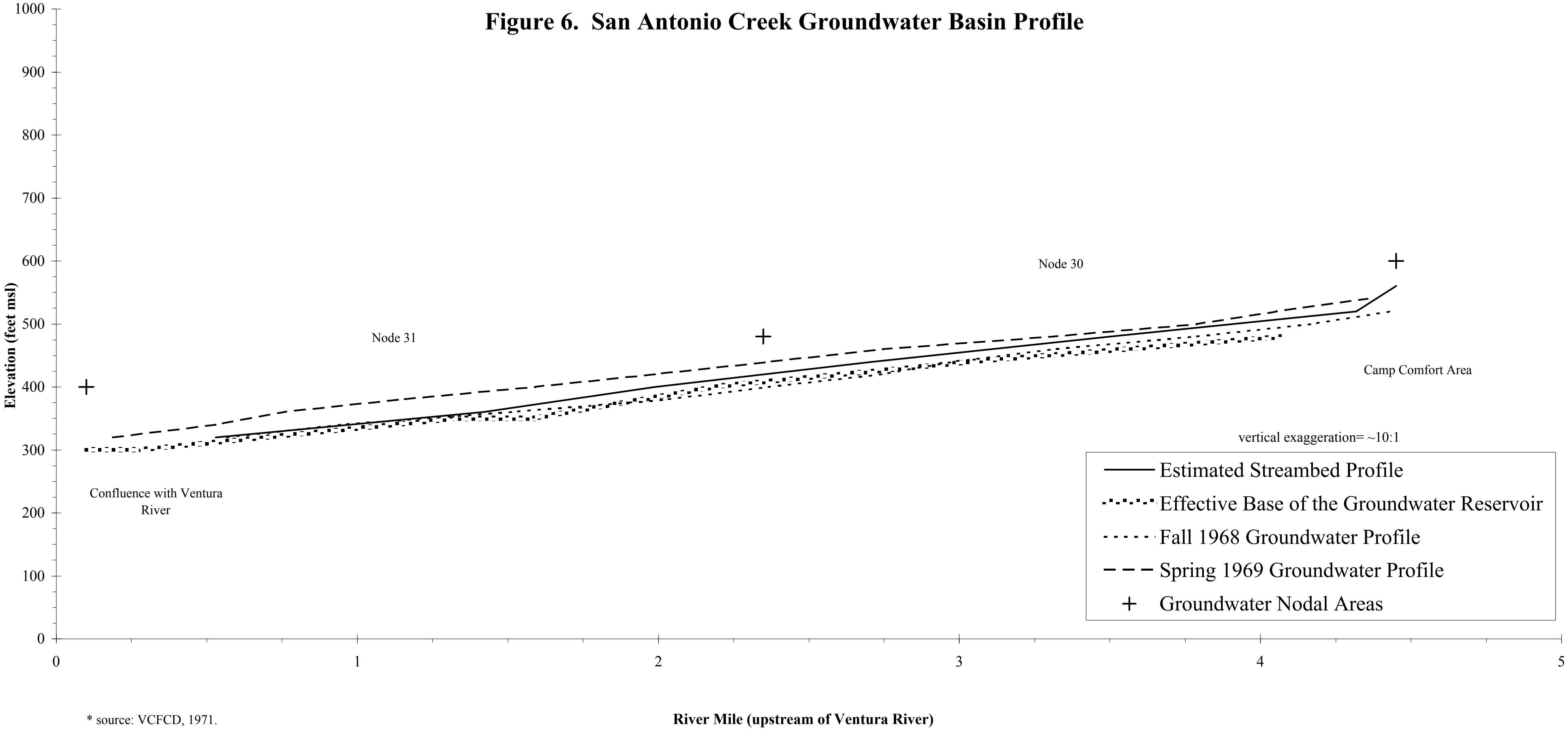

Figure 6. San Antonio Creek Groundwater Basin Profile

* source: VCFCD, 1971.

5.0

CONCLUSIONS AND RECOMMENDATIONS

The following summarizes the findings of the surface water-groundwater interaction study and presents recommendations for additional work to refine the understanding of the surface water-groundwater dynamics of the Upper Ventura River system:

- The Santa Ana/Arroyo Parida fault is likely a major influence on downvalley movement of groundwater. Improved knowledge of physical properties and flow processes of the groundwater aquifer in this critical area should form the basis for developing groundwater management for the upstream nodes that considers resultant water table impacts, not simply extraction volumes.

- The rate and ability of the groundwater system to recharge from surface water infiltration/percolation under water year types other than wet years should be evaluated as part of a 'safe-yield' assessment, due to the climatic cycles in the region.

- The surface flow in the vicinity of Foster Park does reflect augmentation from downvalley contribution of groundwater, over a wide range of water year types.

- Annual groundwater contributions from the Upper Ventura River basin to surface water flow at Foster Park are estimated to range between approximately 3,000 to 10,000 AF per year.

- Further quantification of groundwater pumping impacts on surface flows requires two critical data sets: (1) site-specific observations of the extent, duration, and magnitude of surface flows in the 'live-stretch' and other locations of concern; and, (2) concurrent information on groundwater pumping rates or volumes.

- An improved understanding of the historical water budget data, even without detailed historical observations of surface flows in the 'live-stretch' could be developed if groundwater pumping data for some of the dry and wet years in the water-budget study period (WY 1970-1982) can be obtained.

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