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May 14, 1996
Project No. 94-71-2700

City of San Buenaventura
Water Department
Post Office Box 99
Ventura, California 93002

Attention: Ms. Betsy Cooper
Project Engineer

Subject: Calendar Year 1995 Annual Report, Mound Ground Water Basin, Ventura County,
California, Dated January 1996.

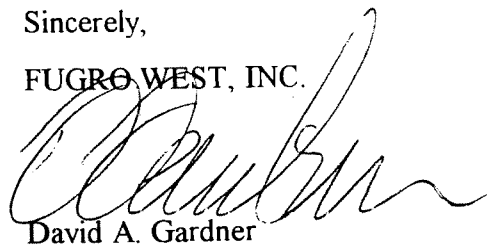
Dear Betsy:

Enclosed is the revised copy of the subject report. This final incorporates the comments
of both the City and United.

Should you have any questions, please do not hesitate to call.

Sincerely,

FUGRO WEST, INC.



David A. Gardner

Certified Hydrogeologist CHg 122



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EXECUTIVE SUMMARY

The Mound ground water basin continues to be an important source of ground water, both to the City of San Buenaventura and agricultural pumpers. This initial annual report provides information on the availability of the ground water resources, the current manner and distribution of extraction, variation in water levels and ground water quality as reflected in key designated study wells, and an opinion on the operational yield of the basin.

Ground water extractions from the Mound ground water basin have averaged about 4,300 acre-feet per year since 1980, and have ranged from as low as 1,000 acre-feet per year (1980) to about 7,200 acre-feet per year (1990). Extractions by the City of Buenaventura for municipal purposes are a significant percentage of total demand. When ground water extractions were at or near 7,000 acre-feet per year, several areas of depressed water levels developed in and around active wells; water level declines to below sea level occurred locally. However, as of early 1996, water levels have recovered to at or near historical high water levels.

Due to lack of data and analysis of the Mound Basin, defining the operational yield of the Basin is highly subjective. Data from the 1980s, particularly the drought from about 1987 through 1990, provide some evidence to support a basin yield of at least 8,000 acre-feet during dry cycles, providing pumping decreases during wet cycles to allow water levels to recover. It is anticipated that the Basin will be able to sustain a higher yield (at least 10,000 acre-feet during drought cycles), provided that future wells are located so as not to adversely impact the existing Victoria Well field. Continued collection of well data and analysis of the Basin will help to define acceptable pumping levels.

The planned utilization of the ground water resources of the Mound ground water basin is dependent on the continued collection of hydrogeologic data that are: 1) spatially distributed over the basin, and 2) collected with sufficient frequency to support a level of ground water extractions consistent with a reasonable range of water level fluctuations. The latter criteria must consider the basin's vulnerability to seawater intrusion, unreasonable water level declines in the eastern part of the basin, and avoidance of significant pumping troughs created by City wells. This report concludes by presenting a number of ground water management goals for the Mound ground water basin to be accomplished during calendar year 1996.

INTRODUCTION

GENERAL STATEMENT

Presented in this report is a summary of hydrogeologic conditions for the Mound ground water basin for calendar year 1995. This report constitutes the initial annual report documenting ground water supply and demand conditions for the Mound basin and is the third and final phase of a cooperative study of the basin undertaken by the City of San Buenaventura (City) and the United Water Conservation District (United). The first phase of work was to develop and populate a hydrogeologic database and management system for the basin to facilitate the ongoing interpretation of ground water conditions and to assist in the preparation of future annual reports. The second phase of work involved the construction of monitoring well clusters at two key locations in the basin for the collection of hydrogeologic data. Documentation of the construction of these monitoring wells has been provided under separate cover (Fugro, 1995). The third phase of work is the preparation of this annual report, which will serve as a basis for the planned development and management of the ground water resources of the basin.

PURPOSE AND SCOPE

The purpose of this annual report is to provide data and technical information needed to manage the ground water resources of the basin in order to maximize its long-term supply, protect the basin's ground water quality, and balance long-term average annual water replenishment and extractions.

The scope of this annual update of basin conditions included the following tasks:

- Tabulate precipitation, evaporation, and other related climatological data from stations located in and proximate to the Mound basin.
- Update water level hydrograph records and revise water level elevation contour maps using designated key water level wells based on water level data collected by the Ventura County Public Works Agency (VCPWA), United, and Fugro.
- Update water quality data for the basin and prepare charts of designated key study wells in the basin.
- Identify the locations of active wells in the basin, note sign and estimate ground water extractions from the basin during 1995.
- Address the manner, sources of, and quantities of water in 1995.

- Analyze ground water in storage in the basin, particularly the quantity of ground water above sea level, variations in pumping patterns, the status of seawater intrusion, the estimated volume and rate of ground water discharged offshore (if occurring), and provide an opinion of the operational yield (temporary surplus) of the basin.
- Identify and address additional operational concerns regarding the use of ground water in the basin and recommendations for the following year data collection and reporting program.

This report is intended to be a straightforward tool for the ongoing management of the ground water resources of the Mound basin. The report relies heavily on basic hydrogeologic data contained in the data management system (Microsoft Access 2.0 database software, customized by Calabash Software, for application to ground water data management) and ARC/INFO Geographic Information System (GIS) software. This report has extracted pertinent tables, graphs, and maps contained within both of these software systems. City staff have been trained to operate the system, load data, and extract information for the generation of future reports with minimal outside consultant assistance.

FINDINGS

PHYSICAL SETTING

The Mound ground water basin has been an important source of water supply to both agricultural and municipal users since at least the 1920s. The basin has generally been defined by past investigators (California Department of Water Resources [DWR], 1933 and 1953; Mann, 1959; County of Ventura, 1977 and 1992) as covering about 10,000 acres and extending from the Santa Clara River north to the Ventura foothills (northerly extent of the aquifer outcrop area) and from a surface topographic boundary with the easterly Santa Paula basin west to the Pacific Ocean. The basin thus forms an elongated east-west-trending ellipsoid with a maximum depth (aquifer thickness) along the syncline axis that generally parallels and is in the vicinity of State Highway 126 (Santa Paula Freeway).

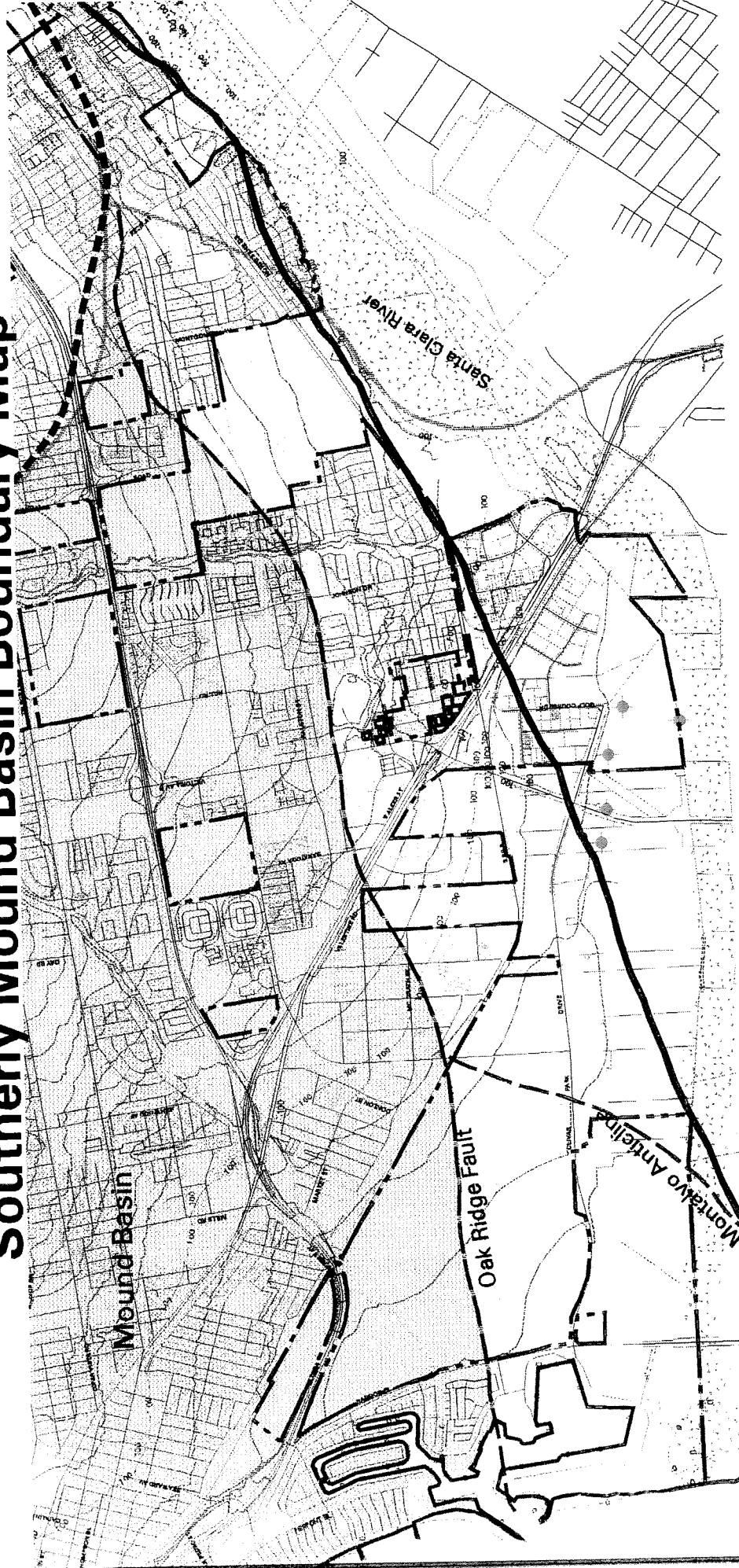
For the purposes of this study and as shown on Plate 1 - Mound Basin Study Area Map, the basin boundaries consist of a topographic divide formed by the Harmon alluvial fan immediately east of Kimball Road, the projected surface trace of the Oak Ridge fault to the south, the Pacific Ocean to the west (including the subsea aquifer area), and the aquifer outcrop area in the Ventura foothills to the north. Only the northerly and southerly boundaries have, strictly speaking, a hydrogeologic basis that considers faulting or folding of the major aquifers and therefore disruption in flow, or stratigraphic continuity (i.e., the surface outcrop area).

Ground water elevation contours support underflow from the easterly Santa Paula basin, although controversy exists regarding the significance of a ground water gradient steepening near Wells Road, perhaps related to a so-called Country Club fault of Mann (1959). To the west, the data support extension of the Ventura syncline of Weber (1973, California Division of Mines and Geology, Preliminary Report No. 14) offshore into Pierpont Bay. Ground water in the Mound aquifer is presumed to eventually discharge at some unknown distance offshore, although Greene, et al. (1971) speculates that such a point, if it exists, is many miles offshore.

The southerly basin boundary deserves some additional discussion because both a jurisdictional and adjudicated boundary exist south of the Oak Ridge fault (refer to Figure 1 - Southerly Mound Basin Boundary Map). As discussed by Mann (1959), the boundary line as chosen along the Santa Clara River is a rather arbitrary one. The southern boundary might also be defined as the approximate northerly extent of the Oxnard aquifer. Within the San Pedro Formation itself (i.e., Hueneme zone aquifers), however, the boundary may have greater physical significance. Approximately under the course of the Santa Clara River, especially west of Montalvo, is a sharp line of folding called the Montalvo anticline (Weber, et al., 1973). This structure appears to be the westerly expression of the Oak Ridge fault, along which the north side of South Mountain has been lifted. The top of the Montalvo anticline has been eroded (refer to Appendix D), and the truncated edges of the Hueneme zone aquifers may be in hydraulic communication with the Oxnard aquifer. Such a contact might serve a source of recharge to aquifers in the Mound basin under certain water level conditions. It is unlikely that the Montalvo anticline is a simple fold; the available evidence indicates that considerable faulting is involved (Yeats, 1987). Generally speaking, the more faulting, the less hydraulic communication there is within the San Pedro Formation between the Mound basin and the Montalvo basin.

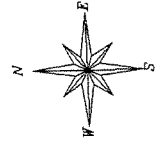
As Figure 1 shows, the Fox Canyon Groundwater Management Agency boundary (FCGMA) is based in part on Turner (1977) and is generally coincident with the Santa Clara River. This boundary is believed to represent the effective northerly outcrop area of the Oxnard aquifer which, due to various structural geologic controls (folding and uplift along the Oak Ridge fault), does not extend into the Mound basin. In our opinion, the FCGMA boundary is somewhat mislocated with respect to the presence of the Oxnard aquifer, which appears to extend farther north based on shallow well control (c.f., State well No. T2N/R22W-11C2). Also shown on Figure 1 is a so-called adjudicated Zone C Assessment Edge stipulated as a result of determination of benefit from United's Improved Vern Freeman Project in the early 1980s. Both boundaries are inferred to be coincident and have implications with respect to pump tax (extraction) charges levied by United. In our opinion, the geologic boundary of the Oak Ridge fault has merit as the most appropriate southerly boundary, particularly given the limited distribution of active wells, extractions, and remaining agricultural land use south of the Oak Ridge fault.

City of San Buenaventura Southerly Mound Basin Boundary Map



Legend

- | | | | |
|--|--|--|------------------------|
| | Approximate Boundary of Mound Basin | | Road Centerlines |
| | 3500' Buffer Around Basin | | Coastline |
| | Fault | | Parcel Lines |
| | Location of Fox Canyon GMA and Approximate Zone C Boundary | | Surface Topography |
| | Santa Paula Basin Boundary as per Settlement | | Zone "C" Well Location |
| | Ventura City Limits | | |





HYDROGEOLOGIC FEATURES

The Mound ground water basin is an elongated structural depression consisting of a generally symmetric synclinal fold whose axis parallels State Highway 126. The syncline plunges (gets deeper) gradually to the west and is offset to the south by the Oak Ridge fault. Fugro (previously Staal, Gardner & Dunne, Inc.[SGD]) prepared a series of hydrogeologic cross-sections of the Mound basin using available water well and oil well control for the area (refer to Plate 2 - Hydrogeologic Cross-Section Location Map). The sections delineate the continuity of major aquifers using nomenclature adopted by Turner (1977). These hydrogeologic cross-sections A-A' through E-E', and a portion of a longitudinal profile that extends along the axis of the Santa Clara River Valley into the easterly Santa Paula basin, Section L-L', are included for reference in this first annual report as Plates 3 through 8.

Aquifers in the basin containing fresh water are found at depths to at least 3,000 feet, although wells in the basin historically have ranged from depths of only about 300 to 700 feet. The aquifers consist of alluvial sediments derived from the Ventura foothills and Santa Clara River valley and are, in part, correlable with aquifers found in the Oxnard Plain. Notable differences for the Mound basin are the absence of the Oxnard aquifer (hence, the rationale for the northerly extent of the FCGMA boundary), a weakly defined presence of the Mugu aquifer, and comparable, although structurally disrupted and offset by the Oak Ridge fault, aquifers of the Hueneme and Fox Canyon units.

In general, aquifers in the Mound basin are confined by an approximate 300-foot-thick layer of low permeability, aquiclude materials. Aquifers display significant artesian characteristics, with the predominant direction of ground water flow from east to west. Recharge occurs as subsurface underflow from the Santa Paula basin and as local recharge from the Ventura foothills. The deeper, lower aquifer system (LAS) units of the Hueneme and Fox Canyon become unconfined only in the aquifer outcrop area in the Ventura foothills. Unfortunately, there are no wells or monitoring wells in this area to document changes in water levels and, hence, storage changes. This issue will be addressed later in the report.

BASIC DATA

In addition to Mann (1959), the draft report prepared by Geotechnical Consultants, Inc. ([GTC], 1972) provides important information on the hydrogeology of the Mound basin. That study resulted in a formal text and specifications for the construction of the City-owned Victoria Well No. 1. The study systematically compiled historical basic hydrogeologic data (well logs, water level, water quality) for the area. Considerable emphasis in this study was placed on an analysis of depth-dependent water quality variations such as total dissolved solids (TDS), sulfate, and iron and manganese ion concentrations. These data, together with data on file with the



VCPWA, United, and the City, were used to populate the data management system for this project.

The data gathered to populate the database ranges in age from the early 1900s to the present. Well logs provide record of original well owners and drillers, drill dates, depths, usage, and lithology. Water level records provided by VCPWA show hydrogeologic trends on key wells varying from 1922 through 1995. Water quality records from VCPWA begin in 1952 and continue sporadically through 1994, with no records available for much of the 1960s. Additional data was obtained from work previously performed on the Mound basin by Fugro. Wells from which hydrogeological data are available and that were used to populate the database are shown on Plate 1.

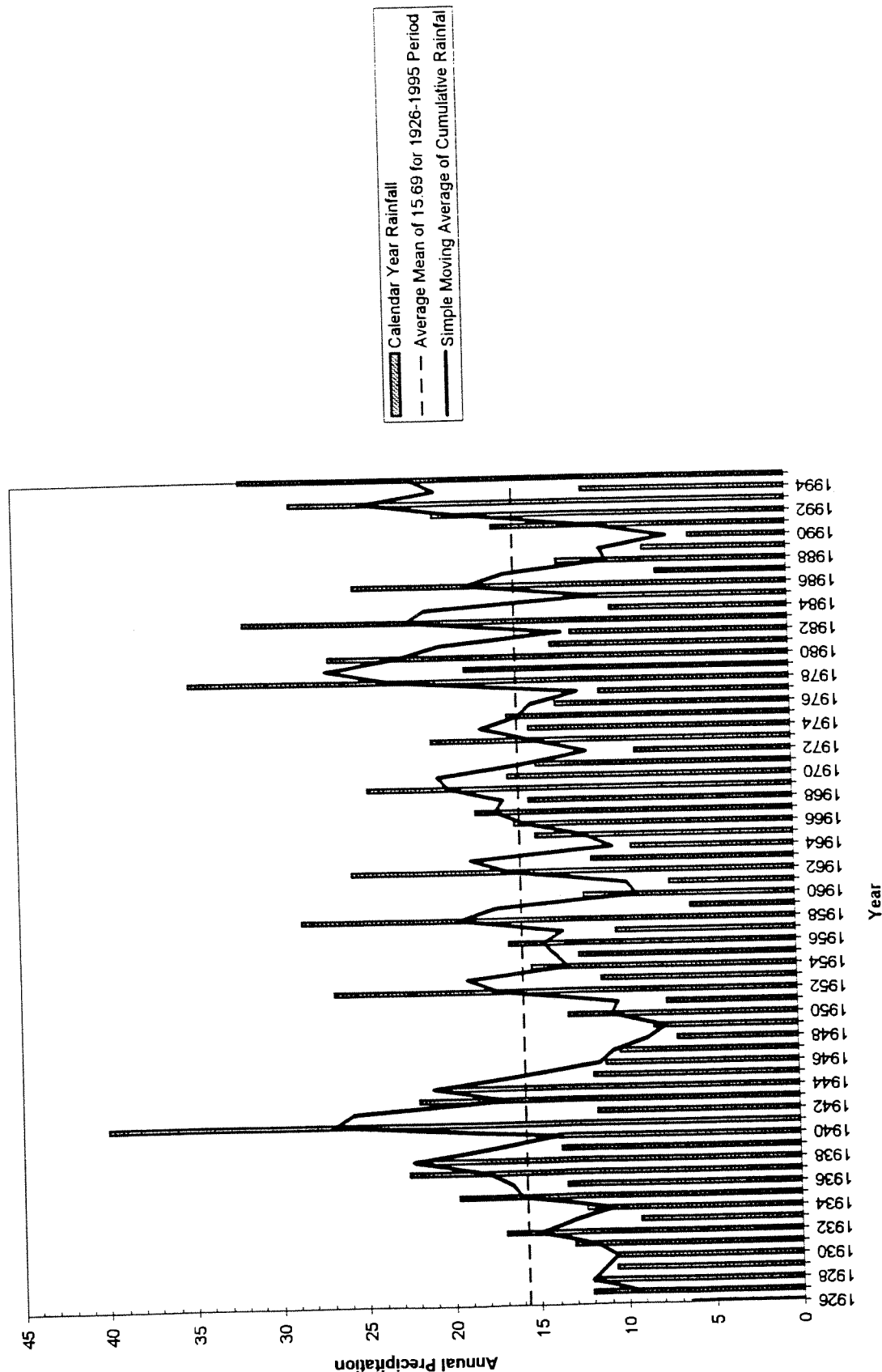
CLIMATOLOGICAL DATA

The VCPWA, Flood Control Division, maintains precipitation records from six rainfall stations in and near the Mound basin. For purposes of this data management program, data for Station No. 222, located at the County Government Center, was used for comparison of basin water level responses. Water year totals from 1926 to the present are shown on Figure 2 - Ventura County Government Center Annual Precipitation, together with a period moving average (similar to a cumulative departure from the mean). The location of the precipitation station is shown on Plate 1.

Rainfall that occurred during calendar year 1994-95 represents about twice the mean annual rainfall for the Ventura area. For the 67-year period 1928 to 1995, an average of 15.69 inches of rain per year was received at Station No. 222. During this period, Station No. 222 vicinity experienced annual precipitation extremes ranging from 5.62 inches in 1990 to 39.95 inches in 1941. Periods of notably deficient rainfall in the area occurred from about 1945 to 1951, 1974 to 1977, and 1987 to 1990.

In addition to precipitation data, since 1988 the California Irrigation Management Information System (CIMIS) has provided evapotranspiration and other related crop irrigation data for the area. The closest weather station for the Mound basin is located at Huntsinger Park (east Ventura), which provides daily climate data in the form of relative humidity, wind velocity, solar radiation, rainfall, temperature, and adjusted evapotranspiration. These data, together with a tabulation of rainfall data, are provided in Appendix A - Climatological Data.

ANNUAL PRECIPITATION
VENTURA COUNTY GOVERNMENT CENTER
STATION NO. 222



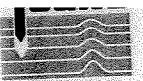
GROUND WATER LEVELS

General Conditions. Ground water levels in the Mound basin have in the past been monitored as frequently as bimonthly by the VCPWA and United at about seven key wells within the basin (refer to Table 1 - Summary of Key Monitoring Well Data). Plate 9 - Mound Basin Key Water Level Monitoring Wells, shows the locations of these wells, the monitoring well clusters constructed at Camino Real and Marina Park, and other wells in adjacent basins. Historical water level data for all wells in the basin for which data exist are contained in the data management system. Designated study wells shown on Plate 9 are those wells for which information are available on well depth or perforated interval, wellhead elevation, that provide a long-term history of valid measurements, and provide some spatial distribution within the basin. Hydrographs and data for these key study wells are found in Appendix B - Mound Basin Key Well Hydrographs. The middle cluster completions at the Camino Real Park, and the deep sampling at the Marina Park cluster, are designated as key wells, although water level data from all wells in each cluster will be routinely collected.

Table 1. Summary of Key Monitoring Well Data

State Well Number	Basin	Aquifer	Well Depth (feet)	Depth of Perforations (feet)	Period of Record
2N/22W-2C1	Santa Paula	Hueneme	Unknown	Unknown	1973-1995
2N/22W-11A1	Montalvo	Oxnard	Unknown	Unknown	1972-1995
2N/22W-3K2	Santa Paula	Hueneme	164	Unknown	1927-1995
2N-22W-3M2	Santa Paula	Hueneme	Unknown	Unknown	1972-1995
2N/22W-9K3	Mound	Hueneme	545	Unknown	1930-1995
2N-22W-8P1	Mound	Hueneme	364	Unknown	1932-1995
2N-22W-8N1	Mound	Hueneme	756	Unknown	1948-1995
2N-22W-8L1	Mound	Hueneme	1,000	460-1,000	1981-1995
2N-22W-7M2	Mound	Hueneme	1,280	710-780	1995
2N/22W-16K1	Montalvo	Oxnard	354	292-345	1947-1995
2N/23W-13K4	Mound	Oxnard (?)	1,200	800-1,200	1983-1995
2N/23W-15J1	Mound	Hueneme	660	970-1,070	1995

As the hydrographs illustrate, seasonal water level variations in the basin are relatively subdued, consistent with the artesian or confined nature of the aquifer system. Water levels in the Mound basin have fluctuated by as much as 100 feet in individual wells, with the most significant changes occurring in the central part of the basin (Sections 8 and 9 of T2N/R22W) during the late 1980s. The magnitude and rate of declines evident in State Well No. 2N/22W-8P1 and -9K3 are related to below average rainfall from about 1987 through 1990 and near-continuous pumpage



from the City-owned Victoria Well. Recovery of water levels in the early 1990s to preexisting levels was, however, pronounced and rapid.

Also evident in the historical record are short-term, typically seasonal, variations in water levels in individual wells in response to local pumping. These seasonal variations are typically on the order of 10 feet or less, superimposed over long-term variations in precipitation patterns that, in turn, influence regional pumping patterns and the volume of subsurface underflow (recharge) to the Mound basin. Particularly apparent in the hydrograph records are the droughts of the 1940s, the mid-1970s, and the late 1980s. The water levels, however, appear to recover essentially completely and proportionately to the rainfall received in a period of wet years (the early 1990s being an example), supporting a level of historical pumpage at least equal to recharge received to the basin as underflow. Early 1996 water level data for the City-owned Victoria Well No. 1 (08L01) support this conclusion.

1995 Conditions. The predominate direction of ground water flow in the basin (based on 1994 water level data), as shown on Plate 9, is from northeast to southwest. Due to funding cutbacks, the County of Ventura did not collect any water level measurements for wells in the Mound basin during calendar year 1995. United, however, did continue their monitoring of State Well No. 2N/22W-9K4 as well as measurements of water levels in State Well Nos. 2N/22W-2C1, -3K2, and -3M2 in the west Santa Paula basin.

As shown on Plate 9, the shape of the contours and spacing, given the availability of data, support a source of recharge to the basin in the San Pedro Formation as underflow from the Santa Paula basin. Recharge also occurs in older alluvial channels dissecting the Ventura foothills and, perhaps, under high water level conditions in the Montalvo basin, as underflow from the southeast. The contour map reflects a somewhat steeper gradient in the east portion of the basin, possibly due to aquifer geometry, permeability variations, the quality of well control (water level data obtained from wells perforated at somewhat different depths), and pumping influences. Near Victoria Avenue, the contours are aligned more nearly east-west, the gradient flattens (from about 0.005 to 0.001), and persists with this slope to the Pacific Ocean. Water level data from the Marina Park monitoring well cluster support the flatter gradient and reflect a piezometric surface in the Fall of 1995 at about 15 feet above sea level.

Long-term trends in potentiometric head (water levels) as reflected in the hydrograph records are a good indicator of changes in the hydrologic system. However, the basinwide distribution of water level information is difficult to analyze because of the number of wells available from which measurements are made is limited and because of local and transient factors affecting measurements such as pumping wells. Also presented are elevation contours based on data available from 1990 (refer to Plate 10), a period of low water levels in the basin. Pumping influences are clearly apparent, with water levels below sea level in the southwest part of the basin.



Also presented for comparative purposes are several hydrographs for key wells in the Montalvo forebay basin to the south and in the upgradient Santa Paula basin. The former basin is unconfined and presents a pattern of much greater variability in water levels, particularly during drought periods. Santa Paula basin wells reflect a pattern similar to the Mound basin wells. Variations in well depths, the regional hydraulic gradient, the extent of ground water pumpage, and regional recharge (underflow) are the major influencing factors in the magnitude of the seasonal ground water fluctuations in the basin. Of particular interest is the apparent uniformity of the ground water gradient to the west and the maintenance of water levels (artesian pressure) above sea level at the Pacific Ocean (Marina Park monitoring well cluster).

WATER QUALITY

Ground water quality data from wells in the Mound basin are random with respect to date of analysis, location, and constituents analyzed. The quality of ground water in aquifers in the San Pedro Formation has been consistently described as poor (Mann, 1958; GTC, 1972), demerited by relatively high concentrations of TDS, sulfate ions, and iron and manganese ions. GTC attempted to distinguish depth-dependent variations in water quality in the basin for wells with depths less than 300 feet versus those drilled to depths from 300 to 700 feet. The results were inconclusive, but tend to suggest poor water quality with depth. Data obtained from the Camino Real and Marina Park monitoring wells (refer to Table 2 - Summary of Monitoring Well Water Quality Data) suggest relatively better water quality from depths of 500 to 1,000 feet. Data obtained from the construction of Victoria Well No. 2 in 1994 (Fugro, 1994; USGS, 1995) are supportive of this conclusion.

Probably the most comprehensive analysis of time-dependent water quality variations in a single well in the basin was provided by SGD (1991) for the City-owned Victoria Well. Quality variations, with particular emphasis on water level, specific capacity, and monthly production, were evaluated in an attempt to assess an apparent trend in water quality deterioration and the success of past well rehabilitation efforts. These data, together with graphs of TDS for two other wells in the Mound basin, are presented in Appendix C - Mound Basin Water Quality Data. The data reflect a distinctly calcium sulfate water, with TDS concentrations from 1,000 to 1,500 mg/l.

Unfortunately, other than analysis performed by the City for the Victoria Well No. 1 and the Camino and Marina Park Monitoring Well clusters, no other water quality analysis for wells in the Mound basin were performed during calendar year 1995. Data obtained for the monitoring wells (Fugro, 1995) is reproduced as Table 2.



Table 2. Summary of Monitoring Well Water Quality

	Camino Real Park			Marina Park		
	Shallow	Middle	Deep	Shallow	Middle	Deep
	10/30/95	10/31/95	10/26/95	11/8/95	11/10/95	11/8/95
Sample Date:	10/30/95	10/31/95	10/26/95	11/8/95	11/10/95	11/8/95
Conductance (EC), umhos/cm	3,610	1,250	1,510	3,700	1,270	1,760
Field EC, umhos/cm	2,700	1,120	NA	3,900	1,190	1,300
pH, pH Units	7.6	8.3	8.3	7.7	8.2	8.2
Total Dissolved Solids (residue)	2,990	860	1,100	3160	925	1,320
Calcium	324	119	137	257	126	166
Magnesium	204	41	43	228	35	46
Sodium	303	102	141	362	102	167
Potassium	13.2	5.9	4.8	17.7	5.1	5.6
Bicarbonate	670	343	374	929	257	390
Sulfate	1,460	316	430	1,390	383	520
Chloride	144	48	73	87	45	74
Nitrate, as NO3	5.3	<0.4	<0.4	<0.4	<0.4	<0.4
Iron	0.53	0.49	0.35	0.08	0.74	2.13
Manganese	1.11	0.23	0.21	0.43	0.08	0.28
Depth of Perforations, feet	210-280	710-780	1,200-1,280	170-240	480-660	970-1,070
Water Level Elevations on 11/95 (feet, MSL)	144.36	23.18	12.31	30.32*	15.51	7.67

Note: Concentrations reported in milligrams per liter, unless noted otherwise.
* Indicates monitoring well flowing under artesian pressure

BASIN WATER DEMAND

Water demand in the Mound basin historically has been met through both ground water extractions and importation of water from a combination of sources including surface water from the Casitas Municipal Water District (Casitas), City-owned wells located outside the basin (Golf Course and Saticoy wells), from the Farmers Ditch Irrigation Company (Santa Paula basin), and from the Alta Mutual Water Company (Montalvo and Santa Paula basins).

Previous investigations (DWR, 1953; Mann, 1958; GTC, 1972) have provided a gross estimate of ground water extractions from the Mound basin using information from the City extraction and annual filings of ground water pumpage (wells that extracted greater than 25 acre-feet annually) reported to the State Division of Water Rights. The past tabulations have, however, considered some wells located outside the boundaries of the basin (GTC, 1972, Table 2). Moreover, information as to which specific wells were used to determine "Mound basin" pumpage is unclear. GTC provides a range of extractions from 1967 through 1971 of about 6,500 to 7,300 acre-feet per year.

Since 1979, declarations of extractions from the basin have been reported to United for about eight wells in the Mound basin (using the boundaries as defined in this report). The declared pumpage is presumably validated by United based on, in the case of irrigated agriculture,



the acreage irrigated, crops grown, and an annual water duty factor that considers adjusted evapotranspiration and effective rainfall. Most active wells in the basin that report extractions to United have flow meters. The accuracy of the declared pumpage is, therefore, considered good. Annual extractions since 1979 (both 1979 and 1995 are 6-month totals only) are shown on Table 3 - Mound Basin Water Demand. Municipal pumpage (exclusively for the City's Victoria Well No. 1) has been separated from the agricultural pumpage.

Table 3. Mound Basin Water Demand
(all values in acre-feet)

Year	Imported/ Delivered Water	Ground Water Extraction for Irrigation	Ground Water Extraction for Municipal and Industrial	Total Ground Water Extraction
1979	-	548	0	548
1980	-	1,068	0	1,066
1981	-	1,112	95	1,207
1982	-	1,080	2,025	3,104
1983	440	1,259	309	1,567
1984	811	2,059	3,003	5,062
1985	747	2,428	2,381	4,809
1986	774	1,727	2,755	4,483
1987	1,074	1,979	2,721	4,700
1988	939	1,889	3,920	5,809
1989	1,093	3,028	4,102	7,129
1990	1,259	2,905	4,366	7,270
1991	1,089	2,424	2,838	5,261
1992	741	1,681	3,007	4,689
1993	810	1,846	1,254	3,100
1994	821	2,189	3,175	5,364
1995	-	702	1,138	1,840
Period Annual Average (excluding half-year data for 1979 and 1995)		1,911	2,397	4,308

Of the seven existing active agricultural wells in the basin, each generally can be assigned to various categories of nearly contiguous blocks of agricultural land. These agricultural groupings are specifically as noted on Plate 11 - Mound Basin Active Well Locations-1995. It can be surmised that, for example, State Well Nos. T2N/R23W-13E1, -13F2, and -13K4 are used, at least in part, to irrigate Parcel Groups 1 and 2. While State Well No. T2N/R22W-8N1 supplies water to Parcel Group 3, State Well Nos. T2N/R22W-9K3 and -9K5 supply water to Parcel Group 6, and State Well No. T2N/R22W-9K1 supplies water to Parcel Group 5. This latter



group apparently also receives some delivered or imported water from wells operated by the Alta Mutual Water Company located in the Montalvo forebay basin (personal communication, Mr. Frank Brommenschenkel, 1996).

Several relatively large parcels of land shown as Parcel Group 4 (about 400 acres in aggregate) receive delivered water from the Farmers Irrigation Company. This water is imported from wells located in the Santa Paula basin, the annual amounts since 1983 also being shown on Table 3 based on information provided by Mr. Brommenschenkel. Various other imported water deliveries to the basin are provided by the Alta Mutual Water Company to parcels located north of Foothill Boulevard between Kimball Road east to the basin boundary. The magnitude of these deliveries is unknown but, based on irrigated acreage, is considered to be less than several hundred acre-feet per year.

As indicated on Table 3, extractions in the basin from about 1980 to 1994 have ranged from about 1,000 acre-feet to over 7,000 acre-feet and are significantly influenced by City pumpage. Also apparent are wet year versus dry year period variations in pumpage to meet agricultural demand. Considerable agricultural acreage in the basin is for row crops, which may or may not be grown (i.e., remain fallow) in any given year. In general, agricultural extractions appear to be on the order of 2,000 acre-feet per year for periods of normal to above normal rainfall and increase to about 3,000 acre-feet per year during periods of deficient precipitation. Pumpage from the City-owned Victoria Well No. 1 was at a maximum of about 4,000 acre-feet per year during 1988, 1989, and 1990, and represents the maximum possible output capacity of the well (about 2,500 gallons per minute).

SEAWATER INTRUSION

Mann (1958) in his preliminary report on the Mound basin provides a general overview of the physical possibility of seawater intrusion into the Mound basin. He noted that aquifers within the San Pedro formation extend offshore and that the probable pattern of seawater intrusion would occur via submarine outcrops westerly of the mouth of the Ventura River. Outcrops in the Pierpont Bay area are surmised to occur many miles offshore, although it is possible that folding and faulting associated with the Montalvo anticline or Oak Ridge fault could provide a pathway closer to the shoreline. Mann surmised that such a pathway would still likely be several miles offshore, a conclusion supported by offshore seismic work performed by the USGS (Greene, 1971).

In any event, the Marina Park monitoring well cluster now provides the opportunity for evaluating water level and water quality variations at the coastline and in aquifers known to be subject to the greatest pumping stress in the basin. Previous indications of seawater intrusion in the basin (elevated chloride ion concentrations in Section 5, T2N/R23W) in the early 1950s were inconclusive. No evidence of water quality deterioration has been noted in wells located further



south near the mouth of the Santa Clara River. No such quality deterioration is evident in the deeper monitoring wells located at Camino Real and Marina Park.

ACTIVE WELL LOCATIONS

Plate 11 identifies only eight active wells (or standby wells) in the Mound basin with extractions that were documented during calendar year 1995. There were no permits issued by the VCPWA, Water Resources Division, for construction of new (or replacement) wells in the Mound basin during calendar year 1995.

GROUND WATER IN STORAGE

Ground water in storage in the Mound basin can be grossly estimated based on the elevation of the piezometric surface (artesian head) recorded at the designated key wells in the basin and by considering several arbitrary datums such as effective base of fresh water (total storage), a datum consistent with a range of historical water level variations that considers well depths, pump settings, and drought cycles (usable storage), or a datum taken at sea level. This latter storage condition could be considered a prudent volume of basin temporary surplus for planning, considering the difficulty in assessing usable storage based on a pressure surface rather than in an unconfined basin, such as the adjacent Montalvo basin. Concerns of seawater intrusion in the Mound basin and the ability to readily detect a decline in this pressure surface to below sea level at, for example, the Marina Park monitoring well location, make this an appropriate storage condition to monitor.

Calculation of the amount of ground water stored within the Mound basin is a difficult task. Throughout the majority of the basin where ground water is extracted, aquifer materials are below sea level, and ground water exists under confined conditions. The amount of the ground water in storage is indirectly represented by the piezometric surface as measured in wells throughout the basin. The pressure surface is generated both in the northerly foothills, where ground water exists under unconfined conditions, and as hydraulic head created in the easterly Santa Paula basin.

A rough estimate of usable storage within the entire basin (rather than simply at the Marina Park monitoring well location) can be derived by considering a datum equivalent to the base of historical water level variations in the confined portion of the basin, and extrapolation of known water level data in the pressure area to the unconfined regions of the basin. To accomplish this, the boundary between the confined and unconfined areas was plotted (using previously prepared hydrogeologic cross sections A-A' through E-E' [SGD, 1991]) and the basin divided into nine storage cells as shown on Plate 12 - Mound Basin Storage Cell Map. An average ground water elevation for each of the cells was derived from the ground water surface contour map. For the unconfined region, the saturated thickness was taken to be the amount of saturated materials above sea level. Throughout the six cells in the confined region, key well hydrographs



were reviewed, and the amount of saturation for each cell was assumed to be the maximum historical water level fluctuation in the vicinity of each cell. Well logs throughout the basin were then reviewed, and the saturated thickness for each cell was multiplied by a factor of 0.5 to compensate for the presence of aquitards as opposed to aquifer materials in each cell. The final step was to assign a specific yield or porosity value for each of the cells. For the unconfined region, this value was assumed to be 25 percent, and for the confined region, a value of 15 percent was adopted (Freeze and Cherry, 1979). The results of this analysis is presented in Table 4 - Mound Basin 1994 Ground Water Storage Calculations.

Table 4. Mound Basin 1994 Ground Water Storage Calculations

UNCONFINED PORTION OF BASIN					
Storage Unit (see Plate 12)	Surface Area (Acres)	Saturated Thickness Above Sea Level (Feet)	Thickness Of Permeable Materials Above Sea Level (Feet)	Specific Yield (Percent)	Ground Water in Storage (Acre-Feet)
I	1,540	40	20	25	7,700
II	1,250	65	32.5	25	10,156
III	1,240	145	72.5	25	22,457
Subtotal Unconfined:					40,331
CONFINED PORTION OF BASIN					Ground Water In Storage (Acre-Feet)
Storage Unit	Surface Area (Acres)	Average Water Level Fluctuation (Feet)	Permeability (Percent)		
IV	1,470	74	15	16,317	
V	1,070	74	15	11,877	
VI	670	74	15	7,437	
VII	1,090	74	15	12,099	
VIII	1,180	74	15	13,098	
IX	920	74	15	10,212	
Subtotal Confined:					71,040
TOTAL:					111,371



CONCLUSIONS

BASIN OPERATIONAL YIELD

The planned utilization of the ground water resources of the Mound ground water basin is dependent on the continued collection of hydrogeologic data that are: 1) spatially distributed over the basin, and 2) collected with sufficient frequency to support a level of ground water extractions consistent with a reasonable range of water level fluctuations. The latter criteria must consider the basin's vulnerability to seawater intrusion, unreasonable water level declines in the eastern part of the basin, and avoidance of significant pumping troughs created by City wells. Ground water extractions in the basin from the period 1979 through 1994 have averaged about 4,300 acre-feet per year. The predominant pumpage (about 60 percent, although quite seasonally variable) has been by the City. The data suggest a trend of increasing reliance on the ground water resources of the basin by the City can be anticipated, particularly during periods of drought such as occurred from 1988 through 1990 when the yield of the Ventura River declined *

A "safe" or operational yield for the Mound basin has never formally been established, although the DWR (1953) and Mann (1958) have variously used a figure of from 8,000 to 10,000 acre-feet per year. This figure was applied, however, to a basin of somewhat larger dimensions (easterly and southerly extent) than considered in the present study. The DWR (1953) considered the basin yield as equivalent to the volume of underflow occurring from the Santa Paula basin. Although Mann (1958) does not cite an actual "yield" for the basin, he cites evidence of an apparent balance between extraction and water level declines. Extractions from the basin in the 1950s are, unfortunately, not cited by Mann other than that pumped by the City at the so-called "Beach" wells. Agricultural pumpage is not given. Extractions at that time were likely in the range of 6,000 to 8,000 acre-feet per year.

Due to lack of data and analysis of the Mound Basin, defining the operational yield of the Basin is highly subjective. Data from the 1980s, particularly the drought from about 1987 through 1990, provide some evidence to support a basin yield of at least 8,000 acre-feet during dry cycles, providing pumping decreases during wet cycles to allow water levels to recover. It is anticipated that the Basin will be able to sustain a higher yield (at least 10,000 acre-feet during drought cycles), provided that future wells are located so as not to adversely impact the existing Victoria Well field. Continued collection of well data and analysis of the Basin will help to define acceptable pumping levels.

Water level declines of as much as 100 feet occurred in the central part of the basin (Sections 8 and 9) as a result of City pumpage. Sharp recoveries in water levels were experienced in the same wells with the wet years of 1992 and 1993 (c.f., State Well No. T2N/22W-8N1 and -9K3). Comparison of the hydrograph data for these wells to earlier drought periods such as from

1945 to 1951 suggests a similar rate of progressive declines in water levels, although lower levels were achieved (below sea level) in the basin in the 1990s, the local occurrence of water levels below sea level likely relates to concentrated near-continuous pumpage by the City from a single well. Past extractions in the basin, when more wells were active, spread the demand somewhat more uniformly over the basin, and is considered a prudent basin management goal.

An average long-term yield from the Mound basin significantly greater than 10,000 acre-feet does not appear supportable at this time. An annual yield up to this amount during short-term droughts, say for 4 consecutive years is possible, but could likely only occur with increased pumpage by the City from the Victoria Well Nos. 1 and 2, or a third well. Any future City wells, such as the planned Mound Well No. 1, should be located so as not to adversely impact the existing Victoria well field. The actual well locations will be based on empirical data obtained from interference analyses from Victoria Well No. 2 or the idle Victoria Well No. 1. It should be noted that over the near term (next 5 years) the City-owned Victoria Well No. 1 is to serve as a standby well only, with Victoria Well No. 2 as the main production well. When the future Mound Well No. 1 is constructed and placed on line, Victoria Well No. 1 will likely be abandoned.

GROUND WATER MANAGEMENT

Suggested goals to be initiated or accomplished during calendar year 1996 include:

- Clarify the role and responsibilities of the agency(s) or individual(s) responsible for ongoing collection of water level, water quality, and extraction data. Key wells in the basin should be monitored at least quarterly for water level data and at least annually for water quality data. This task is considered a top priority.
- Develop a format for the simplified reporting of data for the calendar year 1996 annual report. The report format should, at a minimum, present water level, water quality, extraction, land use, well permit activity, and evapotranspiration data in appropriate tables and graphs. The text of the report should be streamlined considerably.
- Assess the significance, if any, of the southerly basin boundary vis a vis the Zone C Assessment Edge and FCGMA boundary.
- Delay preparation of calendar year 1996 report to the end of the first quarter to allow incorporation of complete extraction data reported to United.
- Assess the interrelationship of and optimal operational efficiency between the City-owned Victoria Well Nos. 1 and 2. Validate mutual drawdown interference between the two wells when Victoria Well No. 2 becomes operational this year.





- Initiate planning efforts for the siting and permitting for an additional well in the Mound basin, which has been referred to as Mound Well No. 1.
- Expand the data collection program through the construction of several shallow monitoring wells in the Ventura foothills (unconfined area) to assess changes of ground water in storage and the component of local recharge. Consider construction of a monitoring well in the lower Ventura River basin (West Park) as a supplemental source of supply from the lower San Pedro Formation (Fox Canyon equivalent aquifer).
- Identify and add any abandoned wells in the basin to the key well water level monitoring network.

CLOSURE

This report has been prepared for the City of San Buenaventura, the United Water Conservation District, and their agents with specific application of the ground water resources in the Mound basin, Ventura County, California. The report was prepared in accordance with generally accepted hydrogeologic practice, consistent with a standard of care, ordinary skill, and competence exercised by hydrogeologic professionals practicing in the area at this time. No other warranty, express or implied, is made.

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