CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

HYDROGEOLOGY OF THE OJAI GROUNDWATER BASIN: STORATIVITY AND CONFINEMENT, VENTURA COUNTY, CALIFORNIA

A thesis submitted in partial fulfillment of the requirements
For the degree of Master of Science in Geology

By

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DEDICATION

This work is dedicated to my patient wife, Heather Marie Naeve Kear, who has endured many nights and days of my absence in support of this thesis and degree.

ACKNOWLEDGEMENTS

It is with sincere appreciation that I would like to acknowledge, in chronological order of involvement, those who helped make this project a success. Dr. M. Ali Tabidian first introduced me to the idea of working with the Ojai Basin Groundwater Management Agency. Mr. David Panaro of Ventura County Watershed Protection District further offered his support and encouragement. Ms. Linda Richardson and Mr. Harry Bodell of the Ojai Basin Groundwater Management Agency met me for a luncheon wherein we determined that a basin-wide aquifer testing program would be a beneficial thesis project, and subsequently supported the project wholeheartedly.

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TABLE OF CONTENTS

West Ojai Basin

LIST OF FIGURES

LIST OF TABLES

Page

ABSTRACT

HYDROGEOLOGY OF THE OJAI GROUNDWATER BASIN:
STORATIVITY AND CONFINEMENT,
VENTURA COUNTY, CALIFORNIA

by

Jordan Leigh Kear

Master of Science in Geological Sciences

Located in western Ventura County, the Ojai Groundwater Basin underlies the intermontane lower Ojai Valley of the western Transverse Ranges geomorphic province of California. The basin is predominantly filled with Quaternary alluvial fan, floodplain and lacustrine deposits, which unconformably overlie older, folded and faulted sedimentary rocks of the Sespe, Vaqueros, and Rincon formations. Sand and gravel aquifer units appear to be thickest near the north and east portions of the basin (the alluvial fan heads) and thinnest to the south and west where lacustrine and floodplain deposits predominate as confining layers.

The Ojai Groundwater Basin is managed by the Ojai Basin Groundwater Management Agency, a special district of Ventura County responsible for basin management. Several agency/governmental-funded and privately-funded studies, conducted over the past 100 years, have revealed variable conclusions with respect to the basin's aquifer system degree of confinement (confined, semi-confined or unconfined).

For this study, and for the first time, a series of aquifer tests were conducted throughout the basin within a narrow (seven month) time frame to quantitatively

determine the local aquifer system's degree of confinement and its characteristics (hydraulic conductivity and storage coefficient values). Six aquifer tests were independently designed, managed and implemented with the assistance of well owners, pumpers, and local water purveyors. Detailed water level monitoring was also conducted to corroborate findings from previous tests. Available data from two aquifer tests, conducted by others in 1961 and 1996, were also evaluated. In total, over 20 data sets were evaluated for this project.

With respect to aquifer confinement conditions, it appears that water levels are imperative to the status of confined versus unconfined conditions observed in the basin both by aquifer testing and reported historical artesian conditions for the basin. During this investigation, the results of only one of the six aquifer tests, which was conducted during low groundwater level conditions, revealed a storage coefficient value, reflective of unconfined conditions (0.02). Previously conducted aquifer test results for the same portion of the basin revealed confined conditions during a period of higher groundwater levels. The results of the other five aquifer tests, conducted during a season of relatively higher precipitation, revealed storage coefficient values, reflective of confined conditions.

The results of this aquifer system characterization reveal that unconfined conditions (typified by a storage coefficient value of 0.02 at one tested area under low water level conditions) may only prevail in the areas such as alluvial fan head areas on the perimeter of the Ojai Valley to the east and north. On the valley floor itself in general and western end of the basin in particular, the aquifer system is under confined conditions at the tested areas and times (storativity values ranging from 0.0001 to 0.000001).

INTRODUCTION

The past century of groundwater production in the Ojai Valley was preceded by usage of spring water by native peoples. Two Chumash villages are known to have existed in the Ojai Valley, one on the Senior Canyon Alluvial Fan (Stoptopo) and another near what is today downtown Ojai (A'hwai), which relied upon hand dug wells and spring waters (Alam El Din, 1966). Groundwater resources have played a major role in development of agriculture and subsequent urban growth in the Ojai Valley from the late 1800s to the present.

Although many geologic and hydrogeologic investigations have been conducted in the valley, no comprehensive, basin-wide aquifer-test study had been undertaken to quantitatively characterize the Ojai Valley Groundwater Basin. Several studies have alluded to the necessity of such a study, including those of Turner (1971), the thesis of Manz (1988), and the Staal, Gardner, and Dunne report (1993).

The Ojai Basin Groundwater Management Agency (OBGMA), charged with protecting, managing, and studying the Ojai Basin, chose to initiate a series of graduate-level studies of the Basin in 2003 with the cooperation of academic institutions. The OBGMA, in consultation with the author of this thesis and other private and government agencies determined that a series of aquifer tests throughout the basin with the initial goal of determining if, and to what extent, the Ojai Basin is confined or unconfined, would contribute to the understanding of the Basin as a whole and facilitate its management. In addition to increasing the understanding of storage in the basin, such a study would help understand well pumping interference, the nature of recharge and discharge in the basin, contaminant fate and transport, and assist in providing additional framework for basin management.

Location

The study area, which lies in the western portion of Ventura County (Figure 1), is bordered by the Topa Topa Mountains and Santa Ynez Mountain Range on the north and east, Black Mountain on the south, and the Ventura River to the west.

Topographically, ground surface elevations across the study area range from over 396 meters (1,300 feet) above mean sea level (msl) at the northeastern portion of the basin near the alluvial fan heads, to approximately 213 meters (700 feet) above msl near the City of Ojai (Figure 2). Across the Ojai Basin (hillsides and valley floor), the ground surface elevations decrease generally to the southwest. Steeper slopes are associated with alluvial fans and gentler slopes are located on the valley floor near the City of Ojai.

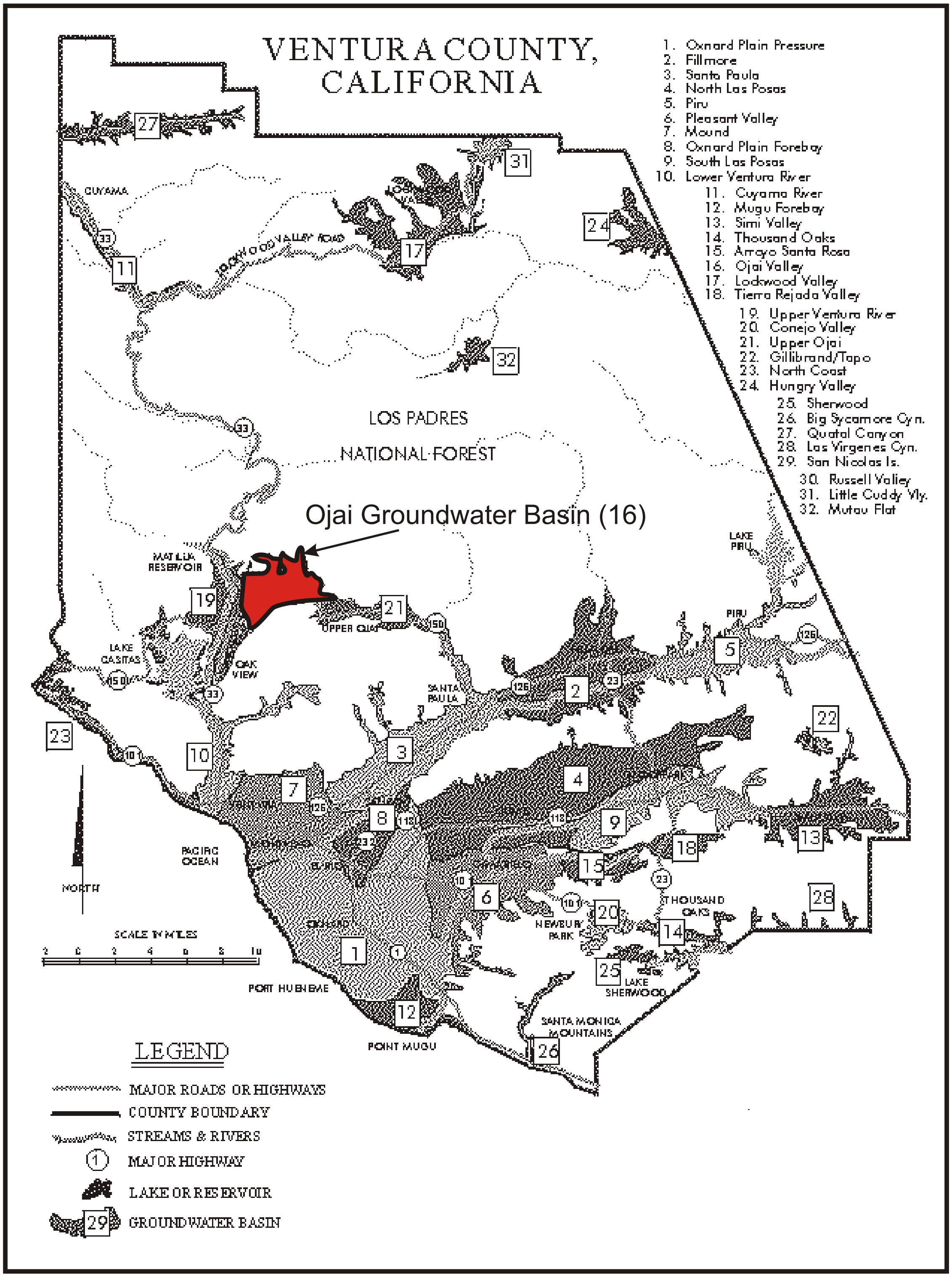


Figure 1. Location of the Ojai Basin, Ventura County, California.
Sources: County of Ventura, Water Resources Division, 2001; Panaro, 2000.

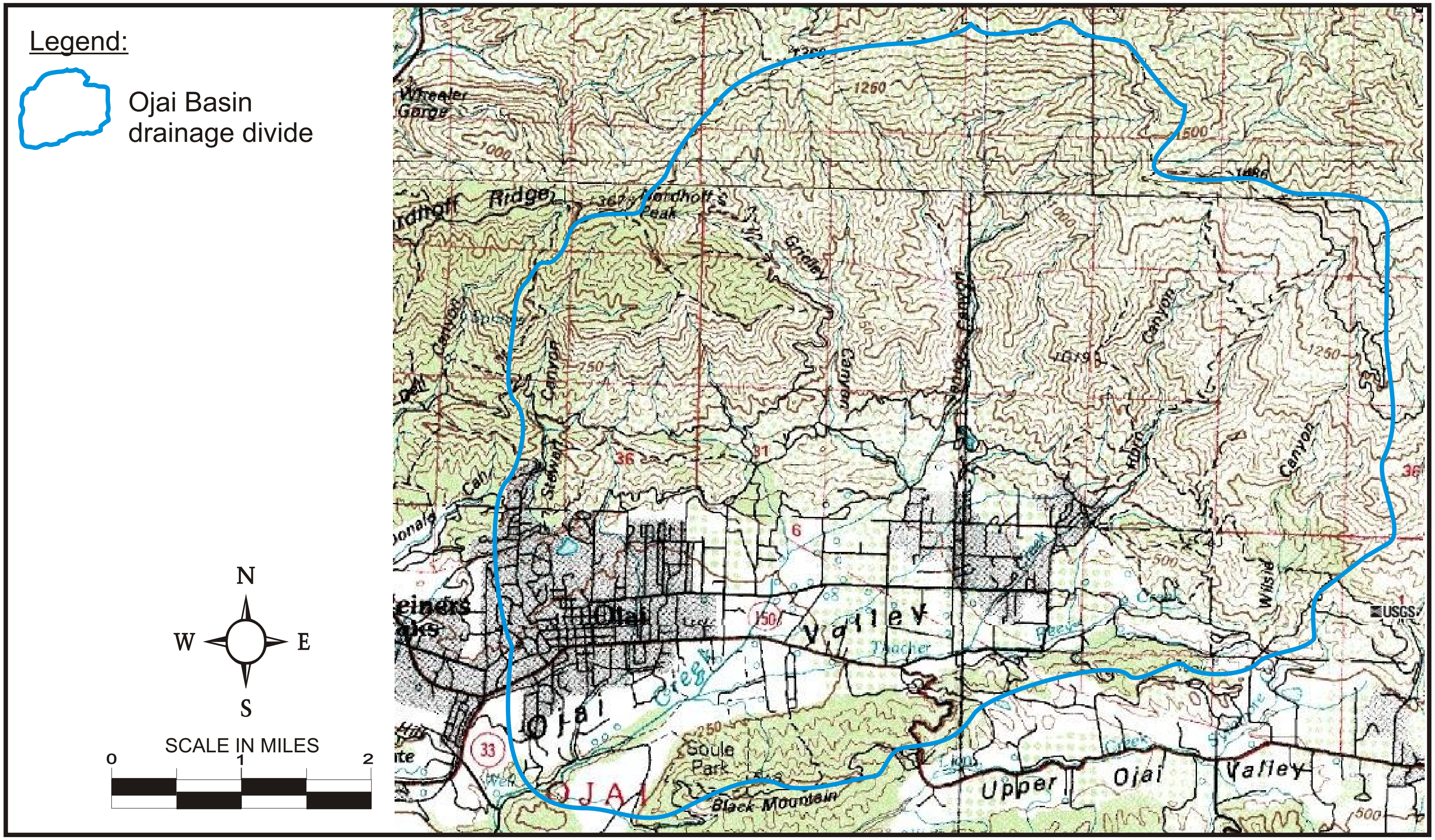


Figure 2. Drainage area of the Ojai Basin (approximately 36 square miles; up to 1,372 meters [4,500 feet]). Note alluvial surface area of 10.7 square miles. Source USGS, 1993.

The drainage area for the Ojai Basin comprises 36 square miles and rises to elevations of over 4,500 feet (1,372 m) msl. This compares with a 10.7-square mile surface area of the alluvial portion of the groundwater basin.

The ground surface across the groundwater basin comprises coalesced large and small southerly sloping alluvial fans. These fans were created by erosional and depositional activities associated with southerly-flowing creeks primarily from Gridley Canyon, Senior Canyon, and Horn Canyon (Figure 2). Several small, unnamed creeks and canyons drain the Black Mountain area along the southern side of the basin. Alluvium associated with these northerly-flowing creeks and landslide-related colluvium from the north flank of Black Mountain may contribute a small amount of sediment to the basin directly. These processes have likely had a profound effect on basin morphology, especially through blocking of free stream flows.

Previous Work

Hydrogeologic characteristics of the Ojai Basin groundwater system and its hydrogeologic setting, including its degree of confinement, have been documented in several publications, described below.

The State of California, Department of Water Resources (DWR [1933]) reported artesian conditions near the City of Ojai after the heavy rains of winter 1926-27, but also reported "…the same formation found above the lowest recorded water table exists below it…" (p. 197) which infers temporal unconfined conditions and also indicates that the basin was not completely dewatered during the historic time of minimum storage prior to 1933.

DWR (1953) reported that groundwater throughout the Ojai Basin is essentially unconfined, although lenses of clay result in localized confinement of portions of the groundwater body (p. 2-40).

Turner (1971) stated that the basin was unconfined based on large-amplitude fluctuations in long-term, groundwater-level hydrographs (1951-1970).

Manz (1988) generated a MODFLOW model of the Ojai Basin with limited data, and stated (p. 22) that the water-bearing rocks are primarily unconfined. Manz also stated that some small areas are overlain by a relatively impermeable clay layer and act as confined, but did not account for any confinement in his model calculations.

Fry (1991), while writing of the history of the Ojai Valley, described 118 flowing wells in the valley in the late 1800s, indicating confined conditions.

Jason (1993) and Staal, Gardner, and Dunne (1993) reported a general unconfinement of the Ojai Valley aquifer system, except in the western end of the basin where a semiconfining to confining layer is present.

Woods (2002), when reporting for the California Geological Survey on the liquefaction evaluation of the Ojai Quadrangle, reiterated Turner’s (1971) conclusions of unconfinement but also indicated that confined conditions exist.

In the 2003 edition of Bulletin 118, *California’s Groundwater,* the DWR reported that the Ojai Valley was generally unconfined but that confined conditions existed in the western portion of the basin.

Objectives and Methodology

Research consisted of collecting and reviewing extensive geologic data including previous work on the regional and local geology, hydrogeology, hydrology, stratigraphy, geomorphology, petroleum exploration and production, legal issues, and environmental and seismic studies. Collection of an extensive database of well logs, including geophysical logs, was critical to the understanding of the basin, and the correlations thereof are included as detailed cross sections. Climatological, precipitation, and barometric data were also key aspects of this study.

Ultimately, the study consisted of conducting six aquifer tests within the Ojai Valley, reviewing and analyzing over 20 aquifer test data sets from those tests and two previous tests, and compiling and interpreting all aquifer test data. Each aquifer test consisted of selecting target testing areas, interfacing with well owners and/or pumpers to coordinate pumping and irrigation schedules, monitoring pumping operations, collecting water level data from pumping and observation wells.

During the course of this study, six aquifer tests were designed, conducted, and analyzed by to evaluate hydrogeologic conditions in the Ojai Groundwater Basin. These tests commenced with a November 2003 test at the Ojai Mutual Well field of the Southern California Water Company; continued with the test pumping testing of a privately-owned well belonging to Mr. Jerry Conrow in January 2004; which was followed by the pumping of the Senior Canyon Mutual Water Company "Grant Well," in March 2004; another private orchard management company, Essick Farm Management, irrigation well was used in March 2004; followed by the testing of two residential/light agricultural well areas in April and May 2004. Over the course of seven months six aquifer tests were conducted, which resulted in nearly 30 data sets for analysis in addition to data from older tests that were available and described above.

The author, on behalf of the Ojai Basin Groundwater Management Agency, conducted the aquifer testing described herein. Pumping was conducted with the cooperation of the local well owners, operators, and pumpers. Field equipment consisted of a 500-foot-long electric tape "Powers Well Sounder," an In-Situ Hermit 2000 datalogger, and several pressure transducers, as well as ancillary cables, power cords, tape measures, tools, flashlights, and notebooks. For surveying lateral well point locations where direct tape measurements were not feasible, a Garmin GPS60C unit was utilized, with data loaded into the MapSource GIS application. In addition to manual solutions, the AQTESOLV for Windows application was utilized to assist in type-curve matching.

As part of the data analysis, geophysical well logs were collected from county records, individual well owners, and State agencies to graphically correlate aquifers, aquitards, and the effective base of fresh water/bedrock materials. Spontaneous potential, resistivity, acoustic, and gamma logs were utilized in the correlations, with cross sections presented as Figures 5, 6, and 7.

With respect to the original question of confinement, it appears that water levels and location are imperative to the status of confined versus unconfined conditions observed in the basin both by aquifer testing and historic artesian conditions reported in the basin. Excepting the highest areas of the alluvial fan heads, virtually all of the wells within the basin penetrate aquifers capable of being confined and there are certain water level elevations for each well which render the underlying aquifers confined or unconfined. Importantly, the presence of several aquifers and aquitards throughout much of the basin emphasize the significance of hydrologic conditions on the status of confinement.

Aquifer solution methodology

To evaluate aquifer test data, several published analytical solutions were employed and described in detail in sections detailing implementation and analysis of each individual aquifer test. Solution methods used during this study include those for: confined two-aquifer systems of Neuman and Witherspoon (1969); distance drawdown solutions; recovery analyses; type-curve solutions of Theis (1935); wedge-shaped confined aquifer solutions of Hantush (1962); well efficiency as presented by Driscoll (1986); type-curve solution for confined aquifers Hantush (1960); and the solution for a large-diameter pumping well in a confined aquifer of Papadopulos and Cooper (1967).

Significance

By this research, the hydrogeologic understanding of the Ojai groundwater basin is improved and the basin can be more effectively managed. Hydrogeologic parameters established by this study will form the basis for benefits to the basin including future groundwater models, detailed water quality analyses, locating and designs of future water supply wells and recharge facilities. Ultimately, this work coupled with previous and forthcoming work products, will be used as tools to improve the quality and quantity of water available to stakeholders of the Ojai groundwater basin.

GEOLOGY

Stratigraphy

Quaternary units

Quaternary surficial deposits cover the valley floor and margins of the Ojai Valley and extend up into the larger canyons that drain the Santa Ynez-Topa Topa Mountains and Black Mountain (Figures 3 and 4). These sediments consist of Pleistocene old alluvial fan, alluvial-valley, pediment gravel, and stream-terrace deposits; Pleistocene to Holocene young alluvial-fan, axial-valley, and stream terrace deposits; colluvium and active and historical stream-wash deposits. Pleistocene to Holocene landslide deposits (colluvium) are widespread in the southern half of the Ojai Quadrangle. In addition to naturally occurring deposits, artificial fill also exists within the Ojai Quadrangle (California Geological Survey, 2002).

One third of the Quaternary sedimentary deposits within the evaluation area are older, or Pleistocene age units. These include alluvial valley deposits, stream terrace deposits, alluvial fan deposits, and pediment gravel deposits. All of these deposits may contain a wide range of material, from gravel- to clay-size particles. The older units tend to be weakly to well consolidated and dense. These older units are well expressed chiefly in the area of the City of Ojai, in the east end of Ojai Valley, among the hillsides flanking Sisar Creek, and in the Lion Canyon area (Figures 3 and 4).

Active and historical stream-wash sediments (Figure 4), consisting of gravel, sand, and silt, mark the drainages of most of the named creeks that enter the Ojai Valley. Importantly, during the heavy rains of January 2005, large amounts of sediment were deposited over the much of the alluvial fan surfaces and creek channels. Boulders and cobbles filled portions of Reeves Creek and Thacher Creek (along the southern portion of the valley) level with the upper banks of these creeks.

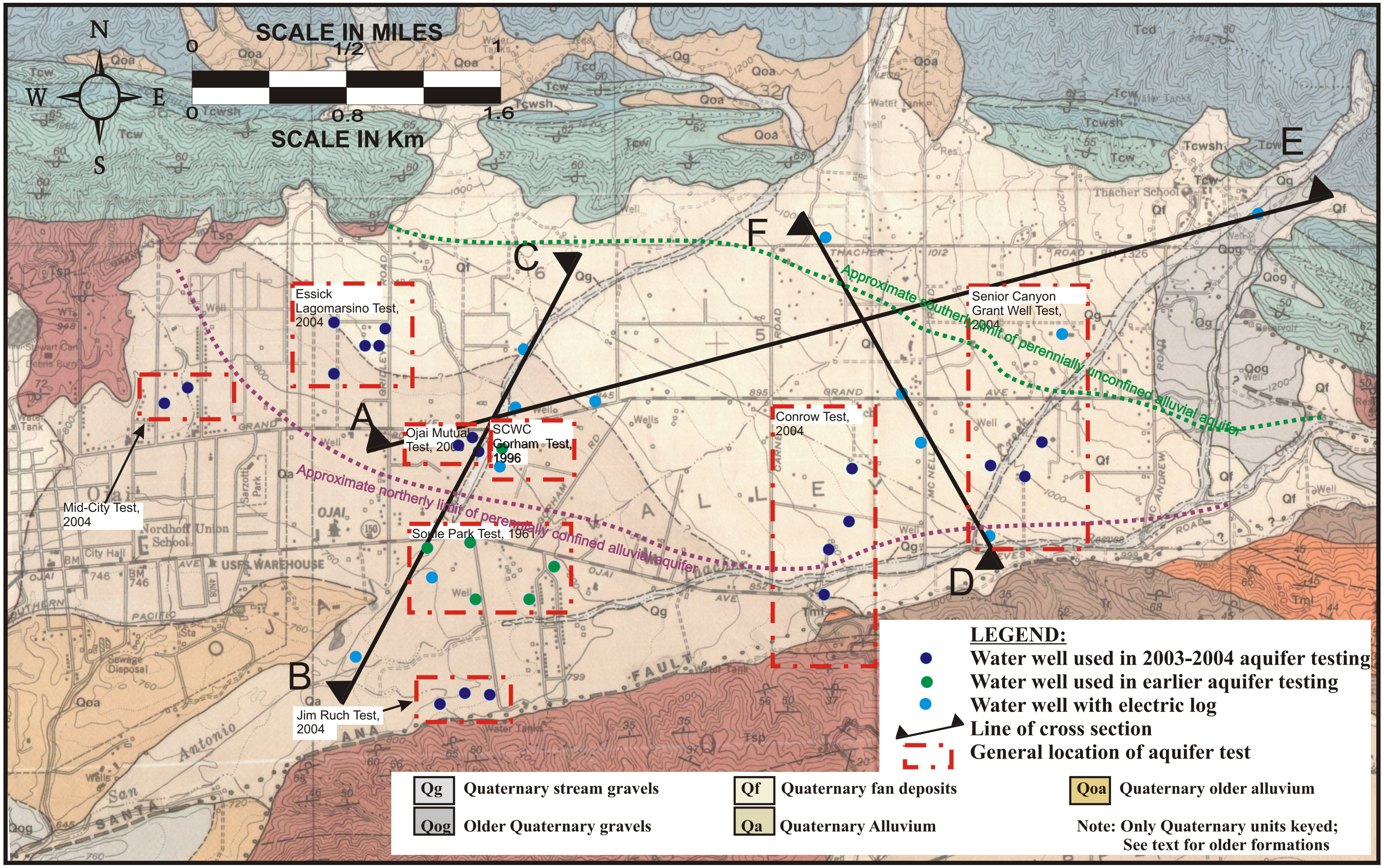


Figure 3. Location of aquifer tests (base map modified after Dibblee, 1991).

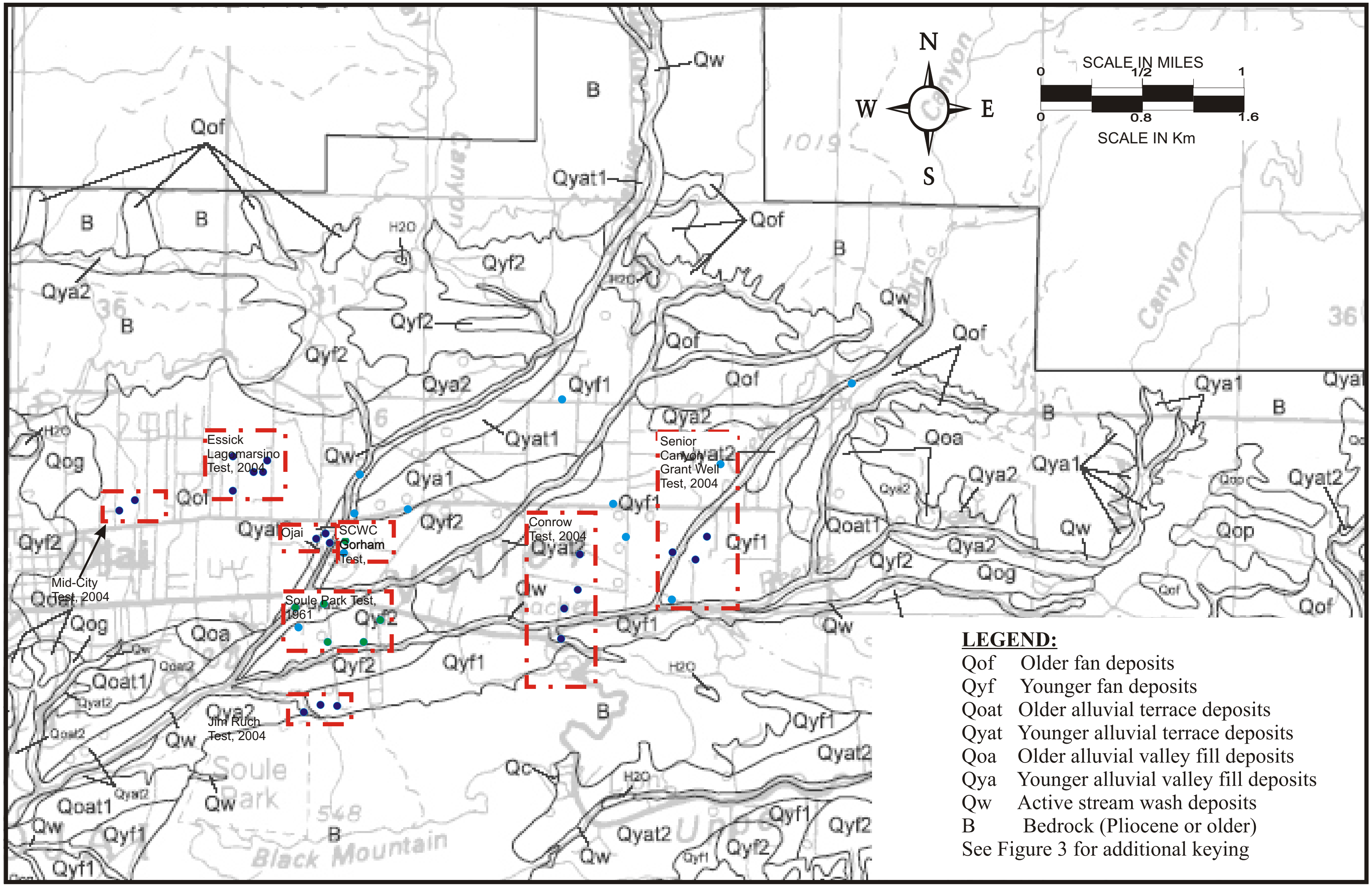


Figure 4. Quaternary geologic map of the Ojai Valley (Source: Calif. Div. of Mines and Geology, 2002).

Following the storms, where property owners and county officials had manually-excavated the creek channels, lower flows were observed to deposit finer-grained clasts with a thin (<5 cm), laterally-discontinuous veneer of silt and/or clay deposited where flows waned to nil.

Geologically young (Holocene to late Pleistocene) axial-valley deposits of gravel, sand, and silt occur within modern stream courses, in particular Reeves, Wilsie, Thacher, and San Antonio creeks of Ojai Valley (California Geological Survey, 2002). In all of these cases, the young axial-valley deposits flank historical stream-wash deposits. Both the axial-valley and stream-wash deposits tend to be loose and unconsolidated. Alluvial fan deposits of Holocene to late Pleistocene age are widespread throughout Ojai Valley, including the small upland valleys separated from the north side of Ojai Valley by Ladera Ridge. Young stream terrace deposits are well developed along San Antonio and Thacher creeks. These deposits also occur as small patches flanking younger stream, wash, or fan deposits within Wheeler, Senior, and Sisar canyons (California Geological Survey, 2002).

Cross-sectional, alluvial-fan morphology as presented by Fraser and Suttner (1986) in a compressional basin (as is the Ojai Valley) indicates a general thick package of sand and gravel units near the fan heads which thin toward the lower perimeters of the fans. Conversely, Fraser and Suttner (1986) presented that finer grain size lithologic units such as clays on the toes of alluvial fans are thickest at most distal locations from fan heads and thin headward.

Based on water well logs, a similar model can be generated for the Ojai Valley. Given the thickness (up to 15 meters [50 feet]), distribution, and lateral extent, these clay units are associated with lacustrine depositional environments. Since the only wells for which drill cuttings are available were drilled via rotary methods, no cores exist for the alluvial strata in the Ojai Valley to date; hence fossils that would further indicate a lacustrine environment of deposition for these clays have yet to be conclusively identified.

Figures 5, 6, and 7 (based on spontaneous potential and resistivity geophysical logs of water wells) present hydrogeologic cross sections that show a simple correlation of the fine grained units and the coarse grained units throughout the Ojai

Valley. These cross sections depict the locations and depths of aquifers and aquitards within the Ojai groundwater basin, similar to the Fraser and Suttner model of sediments in a compressional basin. Deeper aquifers appear to be perenially confined, while the upper aquifers may be either confined or unconfined based on water levels. The hydrostratigraphic environment described herein is clearly simplified and is based on aquifer testing and correlations using existing well data. As more data become available, including core samples, geophysical logs, basin-wide geophysical surveys, depth-discrete water quality and flow, and more hydrologic data, it is likely that a more complex hydrostratigraphic environment will be revealed.

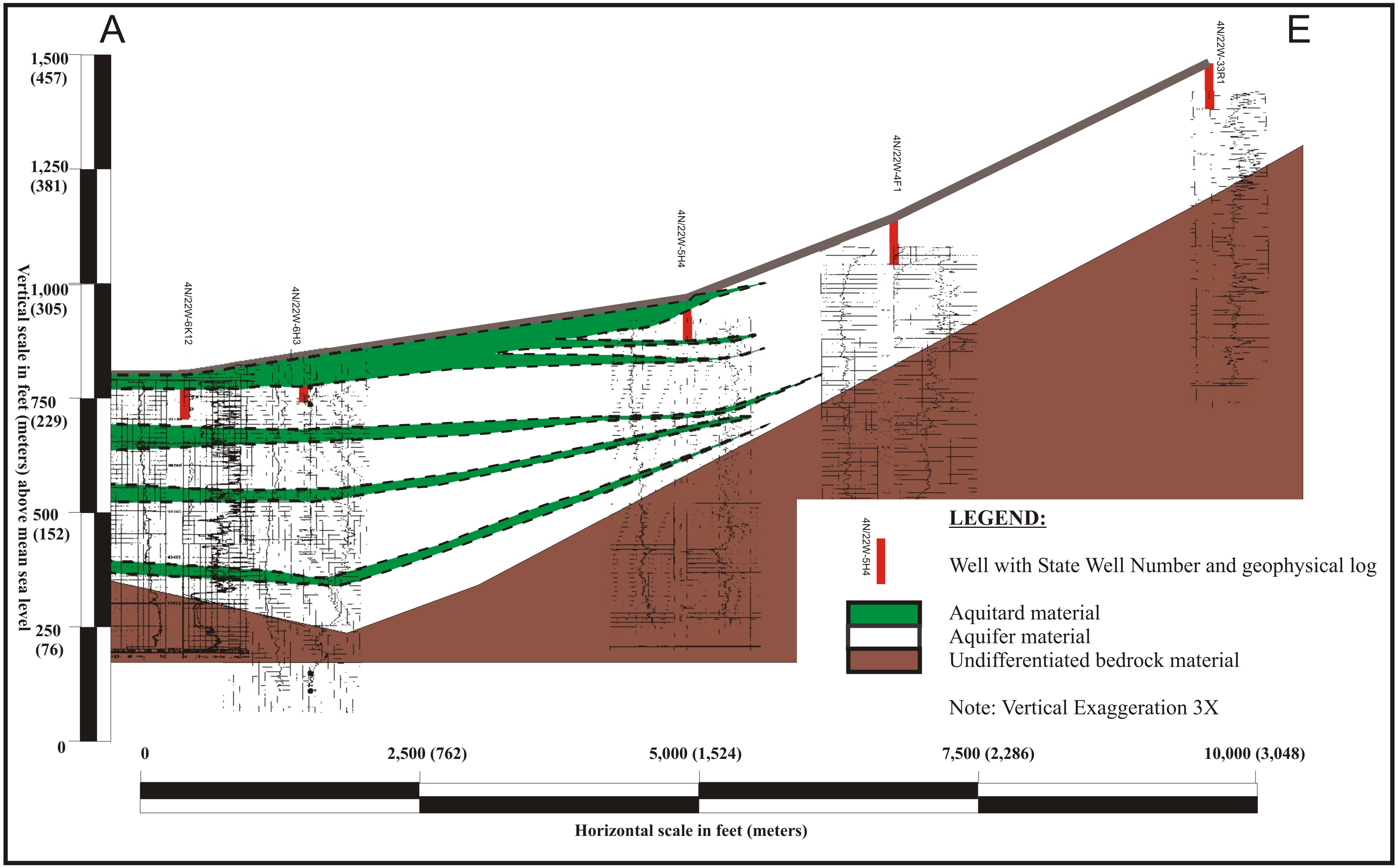


Figure 5. Hydrogeologic cross section along line A-E shown on Figure 3 (view looking north along central portion of Ojai Valley)

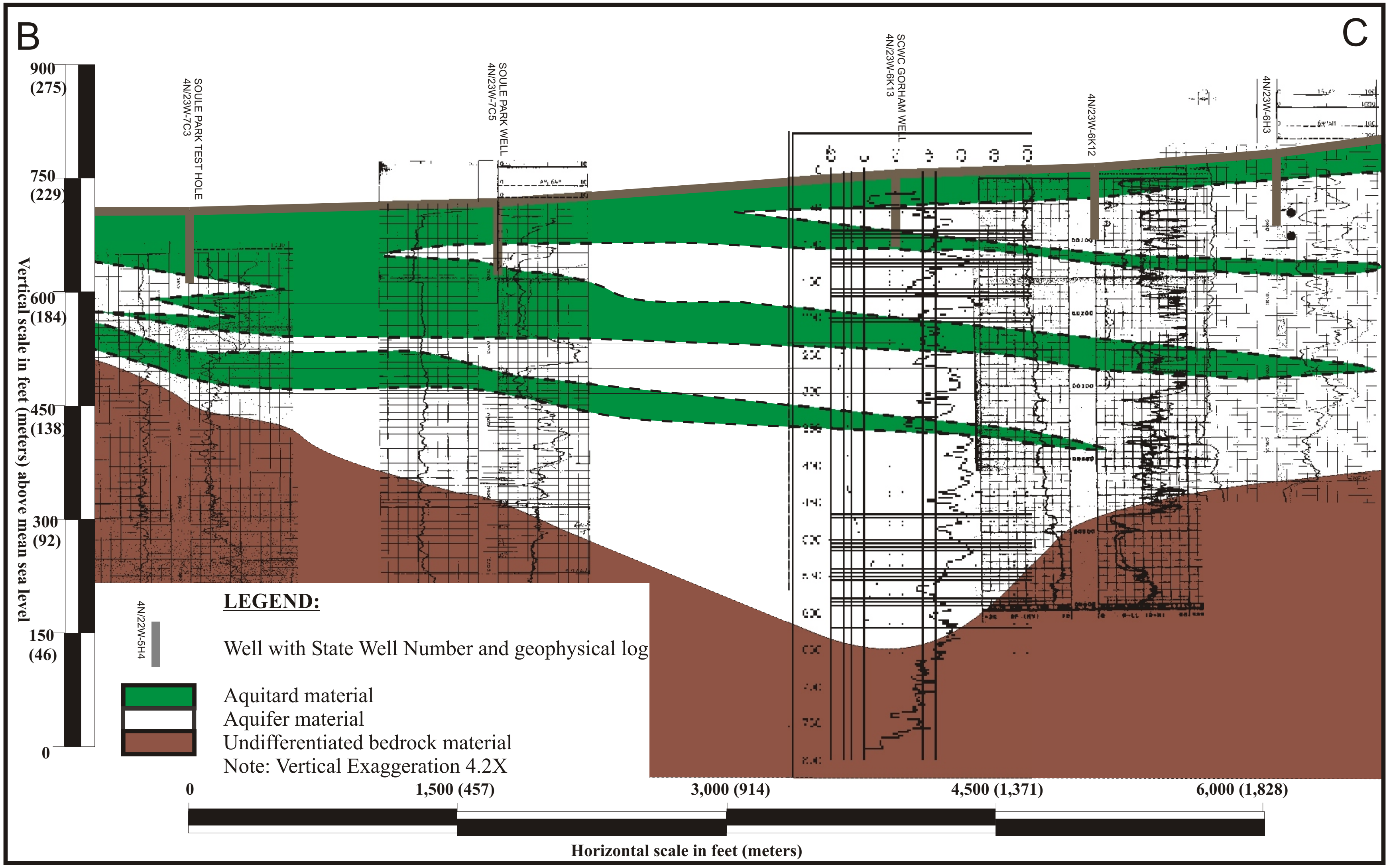


Figure 6. Hydrogeologic cross section along line B-C shown on Figure 3
(view looking west through western portion of the Ojai Basin)

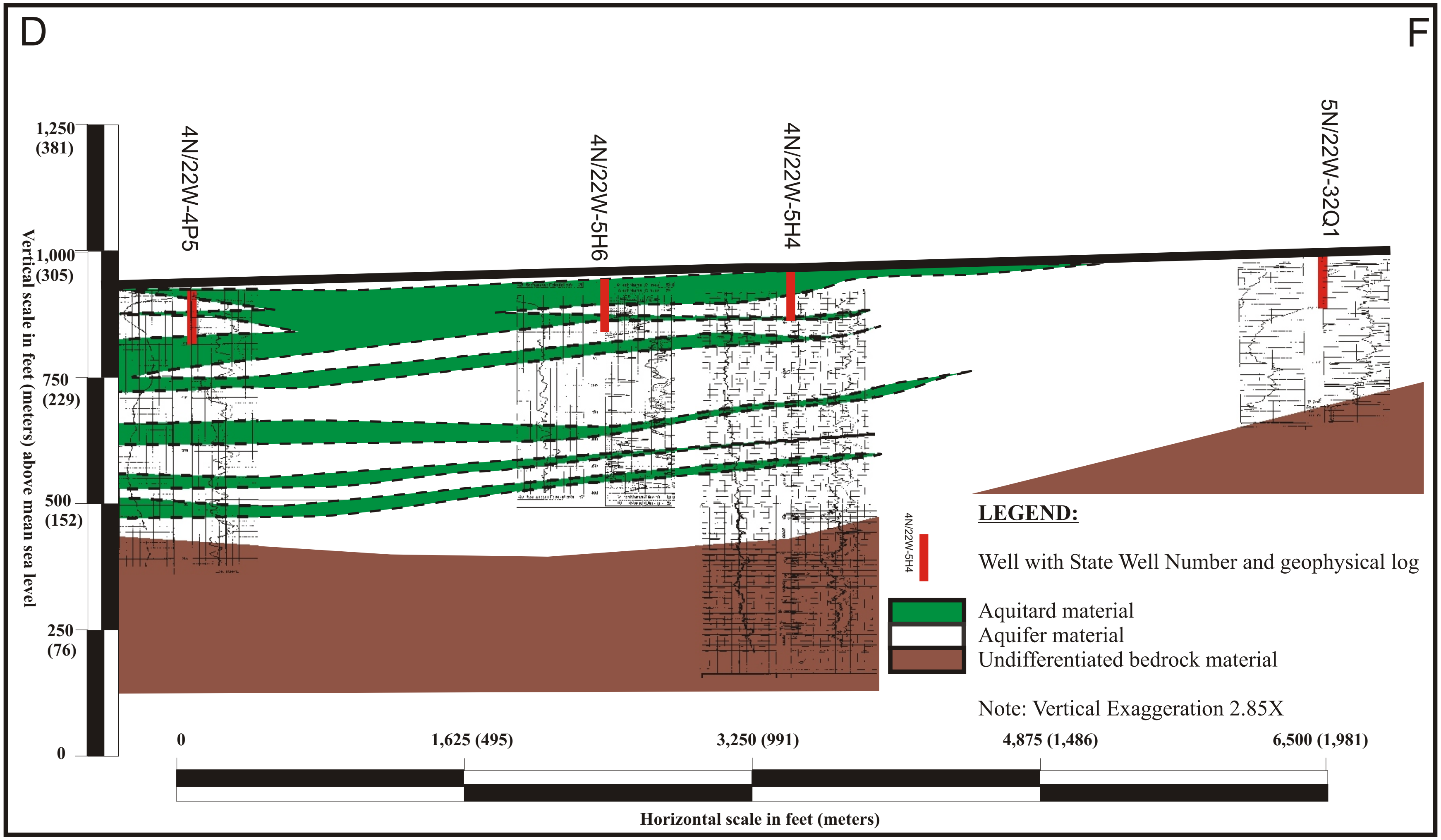


**Figure 7. Hydrogeologic cross section along line D-F shown on Figure 3
(view looking west along east portion of Ojai Valley)**

Pre-Quaternary Units

Pliocene and older rock units in the Ojai area form ridges, mountains and hillsides where exposed. Underlying the alluvium, these rocks effectively form the bottom of the fresh water within the groundwater basin. Some wells do extract groundwater from these older formations, which tend to yield water in low quantities and of relatively poor quality when compared to alluvial aquifers.

Bedrock units in the Ojai area range in age from early Eocene to Pleistocene. Clastic debris of all of these sedimentary formations are present and identifiable in drill cuttings of alluvial aquifers in water well bores. They have contributed sediment to the alluvial aquifers of the Ojai groundwater basin. A continuous sequence of Eocene clastic marine deposits is exposed in east-west trending bands across the northern third of the Ojai quadrangle; these rocks form the southern slopes of the Santa Ynez-Topa Topa Mountains (Dibblee, 1987) and are present within the drainage areas of upper portions of streams entering the Ojai Valley. Bedrock geology of the areas nearest the valley floor is presented on Figure 3.

The oldest geologic unit mapped in the Ojai Quadrangle is the early (?) to middle Eocene Juncal Formation, which crops out along the northern boundary of the Ojai quadrangle (Dibblee, 1987). The Juncal Formation primarily consists of olive gray to dark gray micaceous shale and siltstone with thin interbeds of light gray to light brown arkosic sandstone. Sandstones of the Juncal Formation are generally hard, light gray, fine- to medium-grained, and form prominent ledges, dip slopes, and strike ridges.

The middle to upper Eocene Matilija Sandstone conformably overlies the Juncal Formation and is composed of light brown to mottled pale green arkosic sandstone that is well-indurated, fine- to medium-grained, and thick-bedded to massive with thin partings and interbeds of gray micaceous shale. A separately mapped micaceous shale and siltstone unit with interbedded sandstone is also included in the Matilija Sandstone (California Geological Survey, 2002). Conformably overlying the Matilija Sandstone is the upper Eocene Cozy Dell Shale, which consists of dark gray, well-indurated, locally fissile, argillaceous to silty micaceous shale (Tcd, Figure 3) with minor interbedded sandstone, and separately mapped lenses of light-brown to gray-green arkosic sandstone with minor interbeds of micaceous shale (Tcdss, Figure 3).

The Cozy Dell Shale is conformably overlain by marine to transitional strata of the upper Eocene Coldwater Sandstone, which form a prominent white ledge along the northern margin of Ojai Valley at the base of the Santa Ynez-Topa Topa Mountains. The Coldwater Sandstone consists of hard, light brown and light gray to white, thick-bedded, well-indurated, fine- to coarse-grained, arkosic sandstone (Tcw, Figure 3) with minor interbeds of greenish gray siltstone and shale, and localized oyster-shell beds. Also included in the Coldwater Sandstone is a separately mapped unit (Tcwsh, Figure 3), which is composed of greenish-gray siltstone and shale with interbeds of light brown sandstone (Dibblee, 1987).

Eocene marine strata are overlain by upper Eocene to lower Miocene non-marine to transgressive marine deposits of the Sespe Formation (Tsp, Figure 3), Vaqueros Sandstone (Tvq, Figure 3), and Rincon Shale (Tr, Figure 3). Sespe strata are exposed discontinuously along the base of the Santa Ynez-Topa Topa Mountains and in the core of the Lion Mountain anticline that forms Black Mountain. The Sespe Formation consists of alluvial fan, floodplain, and deltaic deposits of maroon, red, and green silty shale and claystone interbedded with pale reddish gray, friable to poorly indurated sandstone and pebble-cobble conglomerate. Conformably overlying Sespe strata are the transitional to shallow marine deposits of the Vaqueros Sandstone, which are composed of light gray to light brown, massive to poorly bedded, fine-grained, locally calcareous sandstone. Limited exposures of Vaqueros Sandstone occur as narrow bands on the north side of Black Mountain. The marine Rincon Shale conformably overlies the Vaqueros Sandstone and is exposed in the hills north of Upper Ojai Valley. Rincon Shale consists of blue-gray to brown, argillaceous clay shale and siltstone that is characterized by ellipsoidal and spheroidal fracturing and commonly contains light brown to orange dolomitic concretions (California Geological Survey, 2002).

Rincon Shale is overlain by siliceous organic marine deposits of middle to upper Miocene Monterey (Modelo) Formation and upper Miocene Sisquoc Shale, which crop out along the crest, northern slopes, and uppermost southern slopes of Sulphur Mountain. Monterey Formation strata are divided into three members in the map area. These members include a lower shale unit composed of soft, fissile to punky clay shale with interbeds of hard siliceous shale and thin limestone beds, an upper shale unit (Tm, Figure 3) consisting of thinbedded, hard, platy to brittle siliceous shale, and a white-weathering diatomaceous shale. The Sisquoc Shale (Tsq) consists of light-gray to gray-brown, silty shale or claystone that is locally siliceous and diatomaceous (California Geological Survey, 2002).

The upper Ojai Valley is underlain by the non-marine Pleistocene Saugus Formation (Bush, 1956; Huftile, 1991a), and exposures of questionable Saugus Formation have been mapped along the Lion Fault at the southeast edge of Upper Ojai Valley. These outcrops consist of soft, massive, reddish yellow, medium-grained sandstone interbedded with boulder gravel and pebble conglomerate (Dibblee 1987).

Structural Geology

The importance of structural geology is relevant from a hydrogeologic standpoint for several reasons. Structures in the region define basin morphology, sedimentation rates and provenance. During aquifer testing, faults and onlapped bedrock folds provide no flow boundaries. Faults also can provide zones of fracture in consolidated rocks from which wells can extract groundwater. Faults can also provide conduits for poorer quality groundwater to migrate.

The Ojai Valley lies within the central Ventura Basin in the Transverse Ranges geomorphic province. Rocks in this region have been folded into a series of predominantly west-trending anticlines and synclines associated with thrust and reverse faults. This deformation was caused by regional north-south compression, which may have began during the late Pliocene (Yeats, 1989) or as late as 700,000 years ago (Jerome Treiman, personal communication) and continues today. Regional crustal shortening due to this compression is largely taken up locally by the San Cayetano Fault and associated folds in the vicinity of the eastern part of the Ojai quadrangle and by the Red Mountain Fault and associated folds west of the quadrangle. Between these two fault zones, in the Ojai Valley area, shortening is taken up on a blind thrust fault (Namson and Davis, 1988). The surface expression of the blind thrust is the south-dipping homocline south of Sulphur Mountain and the Lion Fault zone (Huftile, 1991b). The complex relationship between folding and faulting in the area is depicted in several cross sections (Huftile, 1991a, 1991b).

Major fold-related structures in the quadrangle include the Matilija Overturn, Ojai Syncline, Reeves Syncline, Lion Mountain Anticline, Big Canyon Syncline, Sulphur Mountain Anticlinorium, and Sulphur Mountain Homocline. The Matilija Overturn is the overturned south limb of an anticline in the Santa Ynez-Topa Topa Mountains involving competent Eocene clastic marine rocks. Non-marine Sespe Formation and older marine rocks form the Ojai syncline, which underlies Ojai Valley (Clark, 1982). The Reeves syncline underlies the hills north of Upper Ojai Valley and involves the more ductile middle to upper Miocene marine rocks. Sespe strata are exposed in the core of the Lion Mountain Anticline, which forms Black Mountain and continues to the east beneath Upper Ojai Valley. The Big Canyon syncline involves Miocene and younger rocks along the northeast side of Sulphur Mountain. The relatively ductile Rincon Formation forms the subsurface core of the Sulphur Mountain anticlinorium, which is complexly folded and has overturned limbs on both of its flanks.

Upper Miocene and Pliocene strata form the south-dipping Sulphur Mountain Homocline in the southern part of the Ojai quadrangle. Thrust and reverse faults associated with folding in the Ojai Quadrangle include the San Cayetano, Santa Ana, Lion, Big Mountain, Sisar, and South Sulphur Mountain faults. The San Cayetano fault is a major, active, north-dipping reverse fault, extending along the north flank of Ventura Basin from the east end of Ojai Valley to Piru. It displaces Tertiary and Quaternary rocks with as much as 9 km of stratigraphic separation (Rockwell, 1988), and its surface trace in the Ojai Quadrangle is included in the Official Earthquake Zone prepared by the California Geological Survey (Department of Conservation, 1986). The surface trace of the south-dipping (?) Santa Ana Fault has not been accurately located, but is tentatively mapped along the northern base of Black Mountain and is inferred to extend eastward under the San Cayetano Fault (Keller et al., 1982). During aquifer testing for this study, the Santa Ana Fault formed a no-flow boundary as described elsewhere in this report. The Lion, Big Mountain, and Sisar faults form a zone of south-dipping thrusts that extends across the Ojai Quadrangle along the north side of Sulphur Mountain. These faults formed as passive backthrusts above the main blind thrust fault (Huftile, 1991a).

HYDROLOGY

Climate and Rainfall

The climate of the area, which is known to be a Mediterranean-type climate, is characterized by long, dry summers and relatively short, mild winters. In this area, cyclic patterns emerge where deficient rainfall over several winters occurs (droughts) and occasional winters are replete with precipitation (El Niňo years).

Rainfall data for this project were obtained for the Ojai rain-gage stations, as available from the Western Regional Climate Center (WRCC), the Desert Research Institute (DRI) in Reno, Nevada, and the California DWR Data Exchange Center (CDEC). Key data are from 1931 to 2003 for the Ojai station that is located on the floor of the Ojai Valley, which is considered adequately representative of rainfall near the majority of the groundwater basin floor. Rainfall data (Figure 8) show that annual rainfall in the region has ranged from a low of 4.35 inches (11.05 cm) in 1947 to a high of 47.80 inches (121.41 cm) in 1978; average rainfall for the period of data record is 21.25 inches (53.98 cm). The highest rainfall totals (>35 inches) occurred during the years 1941, 1952, 1969, 1978, 1983, 1993, 1995, and 1998. Although still in progress, the 2005 year has been one of the wettest on record, with over 46 inches (116.84 cm) measured on the Ojai Valley floor.

Based on rainfall data obtained from the DRI, average annual rainfall is approximately 21 inches at the elevation of 745 feet above mean sea level at the Ojai ranger station. Information presented by the Department of Water Resources (2003) indicates that average rainfall is 24 inches per year on the valley floor near the upper reaches of the alluvial fans (1,250 feet, 381 m elevation), but exceeds 35 inches per year in the mountains to the north of the valley within the recharge areas (up to 4,500 feet, 1,372 m elevation). Based on monthly data available from the DRI, historically, approximately 80 percent of annual rainfall occurs during the months of December through March.

Accumulative Departure of Average Annual Rainfall

An accumulative departure curve for historical rainfall data is presented in Figure 9. The accumulative departure of rainfall is derived by comparing each year’s total rainfall to the average annual rainfall for each year within the period of record. These accumulative departure values are plotted relative to the long-term average of 21.25 inches (53.98 cm) for the 1931 through 2003 time period. The purpose of the accumulative departure graph is to illustrate temporal trends in rainfall data and create a theoretical, qualitative evaluation of water in underground storage. For example,

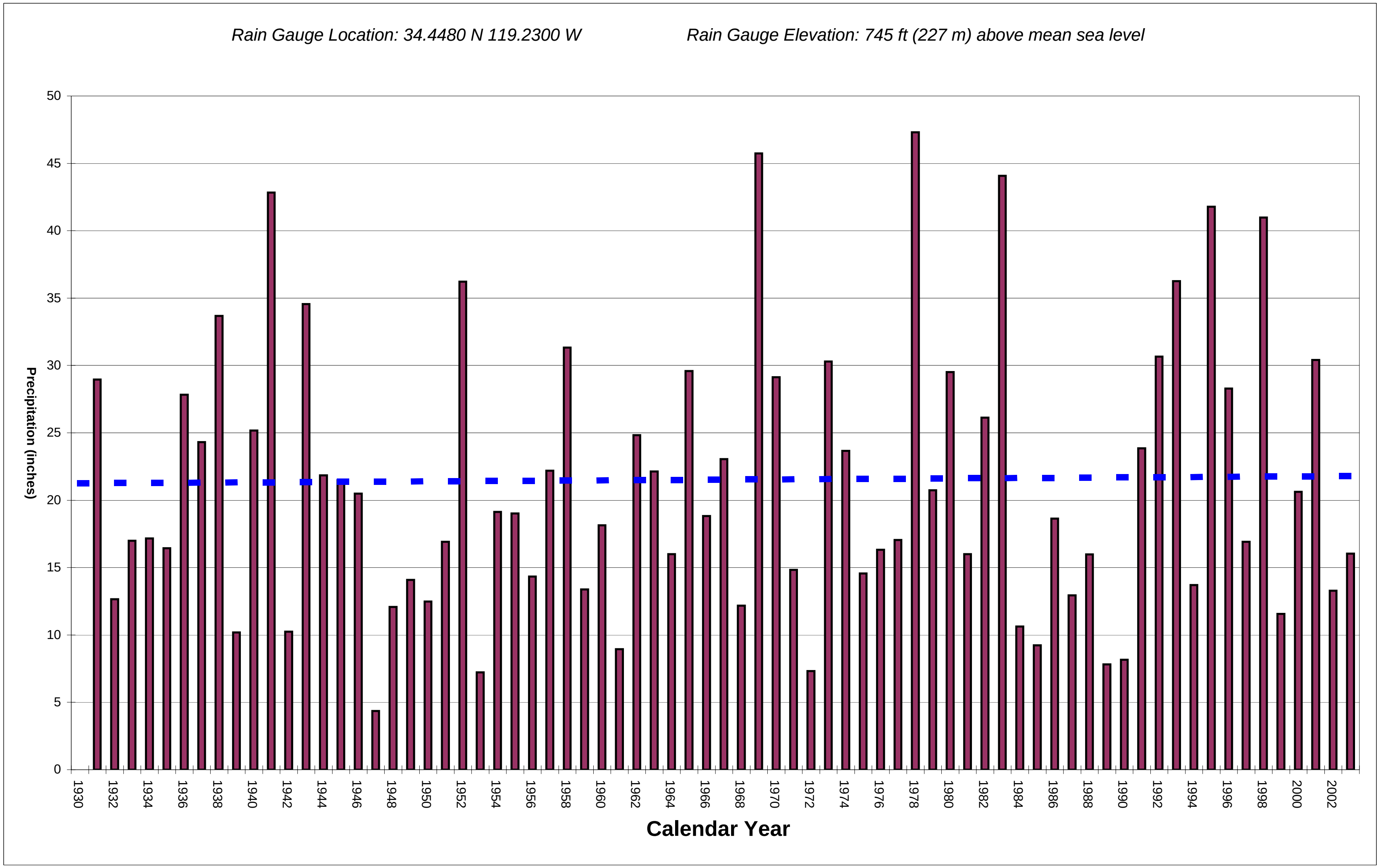


Figure 8. Annual Precipitation from 1930 to 2003, Ojai (source of data: Desert Research Institute).

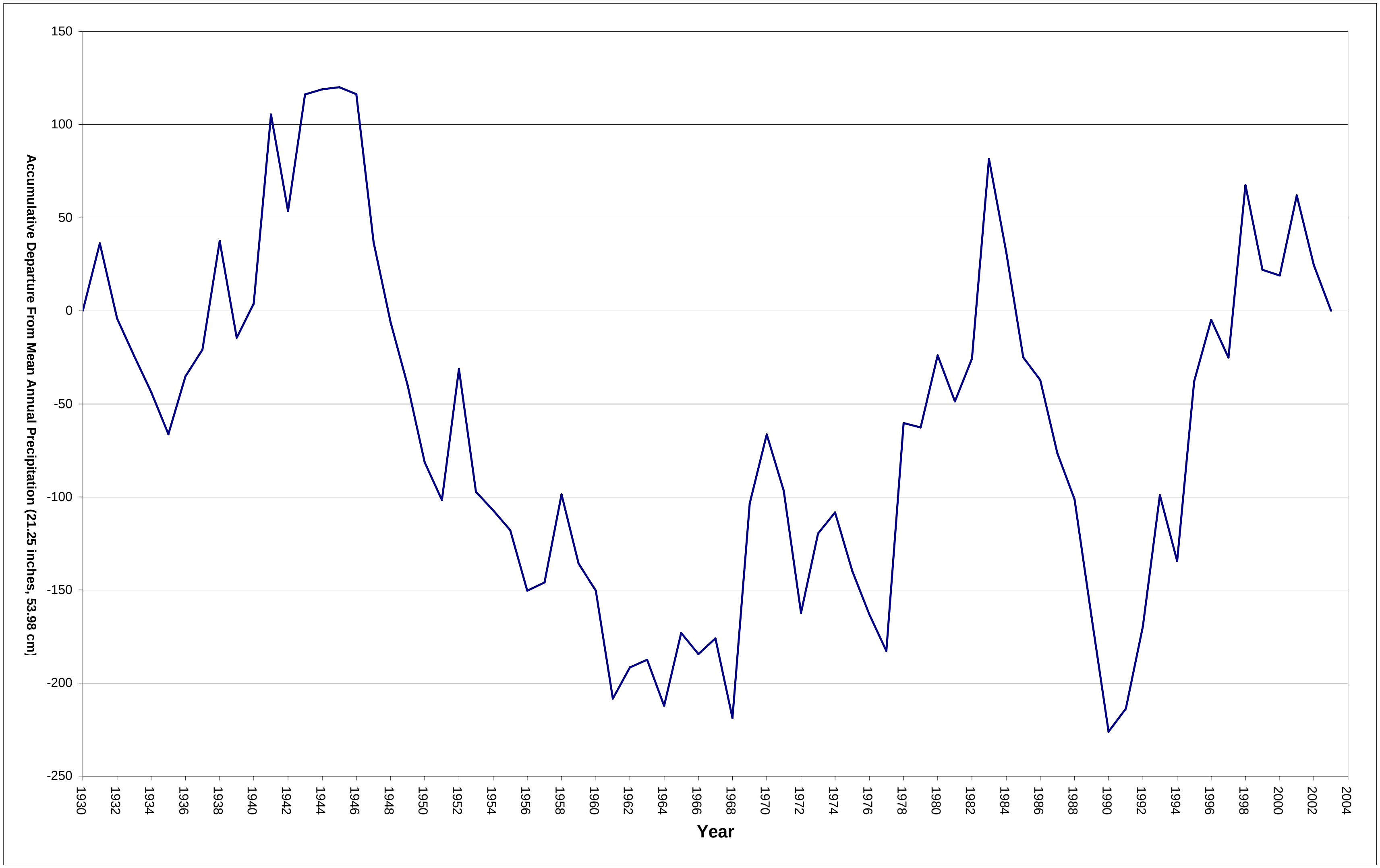


Figure 9. Accumulative departure curve, Ojai, California

during those years for which the graphed curve slopes downward to the right-hand side (negative slopes), conditions are indicative of a year that received less than the long-term average rainfall and less water is contributed to underground storage. Conversely, portions of the graph (Figure 9) which are ascending towards the right-hand side of the graph (positive slopes) indicate years where accumulative precipitation totals are generally increasing, relative to the long-term average and more water is contributed to storage within a theoretical system.

Some of the accumulative departure totals, calculated for those time periods showing deficient precipitation, may represent a year or two of well-above average precipitation. For example, the point at 1969 had an extremely high rainfall total (33.89 inches, 86.08 cm) for the entire period of record, even though it plots well below the zero line. The high amount of rainfall during that one year was not sufficient enough to raise the accumulative departure curve to a point above the zero line because accumulated departure totals prior to 1969 were significantly deficient relative to the long-term average. However, the high rainfall total in 1983 (at 44.07 inches, 111.94 cm) was enough to raise the total accumulated departure above the zero line on the graph.

Figure 9 shows that during most years, rainfall has been deficient relative to the long-term average and a series of historical periods (from 1947 to 1968 and from 1983 through 1990) where precipitation was declining relative to the long-term average. These years are considered relatively “dry” hydrologic periods, and indicate that drought conditions generally prevailed during those time periods in the area. In contrast, generally increasing amounts of rainfall occurred from 1935 to 1946, from 1977 to 1983, and from 1990 through 1998; these years indicate relatively “wet” hydrologic periods, during which rainfall in the majority of years was at or above the average annual value (Figure 9).

HYDROGEOLOGY

The Ojai Valley Groundwater Basin is bounded on the west and east by non-water-bearing Tertiary age rocks, on the south by the Santa Ana fault and Black Mountain, and on the north by the Santa Ynez Mountains, including the Topa Topa Mountains. The basin is drained by San Antonio Creek, a tributary to the Ventura River.

Groundwater is stored in alluvium and to some extent in fractures and interstices of the underlying older Tertiary sedimentary rocks (CSWRB, 1953). As documented herein, the primary storage units for groundwater are approximately four sand and gravel units on the order of up to 100 feet thick each, which are sourced, and thickest, near the alluvial fan heads near Horn and Senior Canyons in the northeast side of the Ojai Valley. Groundwater within these aquifers are, depending on the amount of water in storage and groundwater level position, predominantly under unconfined conditions near the fan heads and mostly confined to semiconfined in the central, southern, and western portions of the basin. The lateral range of confined versus unconfined conditions is northeasterly during wet periods and southwesterly during dry periods. Confining clay units are on the order of up to 40 to 100 feet thick and may be associated with ancient near-valley-wide lakes that formed due to the presence of damming by landslide debris from Black Mountain, blockage of the surface drainage by alluvial fan debris, and/or relative uplift of low-permeability units near the southwest boundary of the Ojai Valley. Figures 3, 5, 6, and 7 present the map and cross-sectional interpretations of the confining units (clay units) and aquifer materials (sand and gravel).

Depth to Groundwater Levels

In the Ojai Basin, the depth to groundwater varies greatly spatially and temporally. Geologic settings, climate and precipitation, pumpage, aquifer conditions (including storage coefficient) and topography are the main factors that influence groundwater fluctuations and depths to groundwater levels. Near the alluvial fan heads (recharge areas), depths to water can be on the order of 300 feet with seasonal variations between 50 and 90 feet. In the southern and western portions of the basin (discharge areas), however, the typical depths to water are less than 50 feet and show seasonal fluctuations on the order of 15 feet; these wells tend to exhibit flowing artesian conditions (an upward hydraulic gradient component) when the potentiometric surface is at a higher elevation than ground surface. More details of water levels are presented with discussions of aquifer testing (Section 5) within this thesis.

Recharge/Discharge and Groundwater Fluctuations

The primary sources of recharge water to the groundwater basin are infiltration and percolation of water from precipitation on the valley floor and water losses through stream beds and canyons emerging from the tributary area. The San Antonio Spreading Grounds, located just west of the point where San Antonio Creek enters the alluvium of the Ojai Valley, accepted diversion from near the confluence of Gridley Canyon and Senior Canyon and allowed off-stream infiltration intermittently. A minor amount of subsurface flow from surrounding bedrock aquifers is also a local contribution to groundwater (CSWRB, 1953).

Following approximately 11 inches (28 cm) of cumulative, intermittent precipitation between October and December 2004 to the valley floor, a December 30, 2004 reconnaissance of streams across the valley floor by the author indicated that surface flows were present throughout the Ojai Valley. Depths to groundwater remained relatively deep to that date, indicating that although the streams were "losing" streams, significant, but unquantified, surface flows exit the basin long before the basin is fully recharged.

Historically, imported water has been a very important component to the groundwater in storage within aquifer in Ojai Valley. Water diverted into the Ojai spreading grounds during the 1950s and 1960s from the Matilija conduit contributed water from Lake Matilija to the recharge of the Ojai Basin with the intent to augment basin recharge following drought years through the 1940s and 1950s. The first spreading of imported water reportedly occurred in 1952, with 1,200 acre-feet spread at the San Antonio Spreading Grounds (Al Din, 1962). From 1953 to 1958, no water was reportedly imported, but in 1959 659 acre-feet were spread.

Additional recharge occurs as a result of excess irrigation flow (including from the Matilija Conduit and Lake Casitas) and individual sewage disposal systems (whose source water is local groundwater and/or Lake Casitas, outside of the Ojai Basin).

Discharge from aquifers within the Ojai Basin is primarily through pumping activities for irrigation and municipal use. Evaporation and transpiration notwithstanding, relatively smaller amounts of groundwater exit from the local aquifer system via groundwater effluent streams (seasonally), artesian flowing wells that discharge to streams, and subsurface outflow to other adjacent groundwater systems.

Based on analysis of groundwater level hydrographs and groundwater fluctuation (Figures 10 through 15), the Ojai Basin is quickly recharged during wet periods, and it appears to be rapidly depleted during periods of drought. Years of drought and heavy precipitation appear to have a significant acute affect on the Ojai groundwater basin: one year of heavy rainfall, such as 1952, even though the region received deficient rainfall for the period of 1947 to 1968, resulted in a return to near maximum volume of groundwater in storage. Clearly, the importation of 1,200 acre feet coupled with natural recharge in 1952 assisted the recovery of water levels in the basin from historic lows and “dry” wells reported in 1951.

Compared to other southern California groundwater basins, Ojai is depleted quickly by pumping and recharged relatively quickly. The main reason for this is a large difference between the amount of drainage area (>36 square miles) feeding the streams which traverse the Ojai Basin relative to the surface area of the Ojai Basin itself (10.7 square miles), which is an intermontane basin draining via San Antonio Creek from the southwest portion of the basin. Other basins which may have a higher ratio of volume of available storage to recharge tributary area (Upper Santa Ana River Valley area), or be open to other groundwater basins or the ocean (Oxnard Plain), do not typically respond so quickly to precipitation trends.

Several hydrographs generated using key well data available from Ventura County (Figures 10 through 15) are presented for wells located throughout the Ojai valley. Due to the relatively rapid response of the water levels to precipitation, the hydrographs reflect a more horizontal graphed water level versus time when compared to the accumulative departure curve presented as Figure 9. For wells located in the central portion of the basin, the yearly high groundwater elevations and yearly low groundwater elevations are more widely separated than those values for wells near the basin margins. This phenomenon is due to heavy pumping near the center of the basin, which largely dewaters upper aquifer volumes between the months of June and September. Pumping demands for irrigation ease in accordance with a typical cooling of ambient air temperatures in October and hence less transpiration by irrigated crops, among other factors.

Over longer dry periods, such as the periods of dry years between 1947 to 1968 and 1984 through 1990, hydrographs generally indicate declining water levels overall. However, it should be noted that during any “wet year” within the longer-term rainfall-deficient periods (1952, as an example within the 1947 to 1968 period), the water levels within the Ojai Basin appear to recover to near-non-drought levels. This is attributed to a high ratio of recharge headwater area (36 mi^2) to alluvial aquifer surface area (10.7 mi^2), or a ratio 3.36 for the Ojai system. In alluvial basins where the areal extent of the aquifer system is large relative to the surface area of the recharge area (unlike Ojai), it is generally expected that groundwater in storage within the system may take a longer time to recover from droughts.

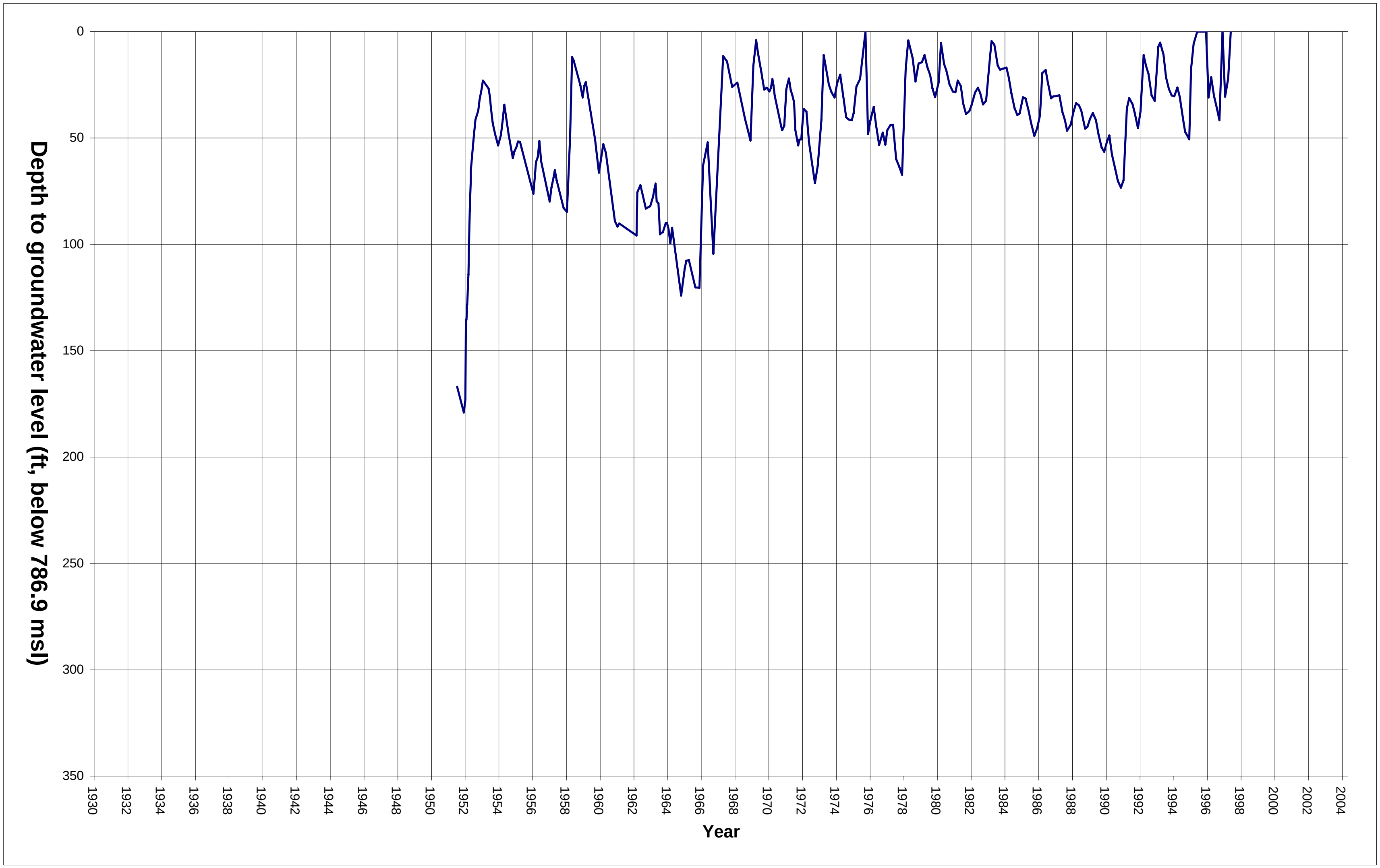


Figure 10. Groundwater level hydrograph for well 4N/22W-7B5 (source: Ventura County raw data records).

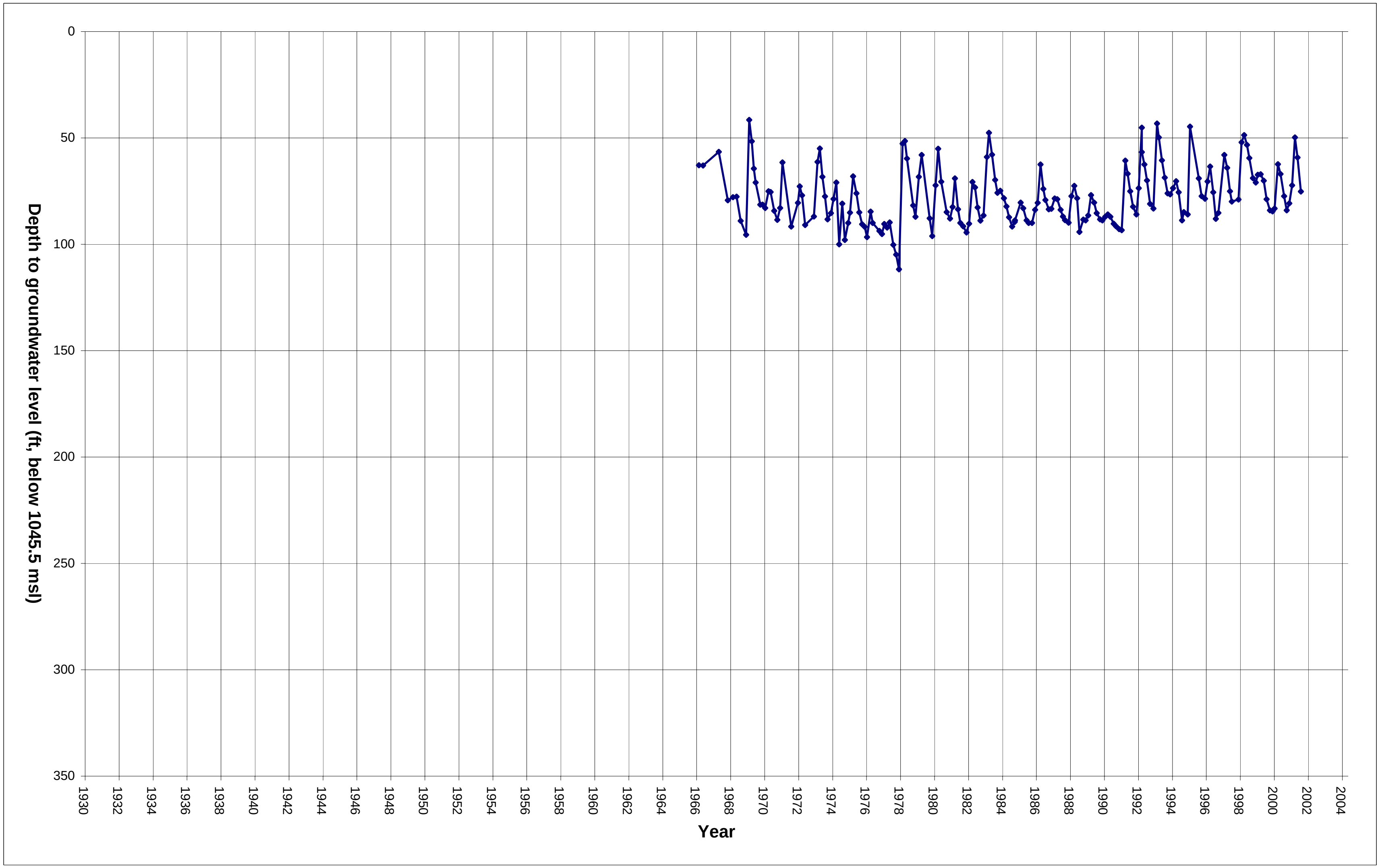


Figure 11. Water level hydrograph for well 4N/22W-4Q1 (source: Ventura County raw data records).

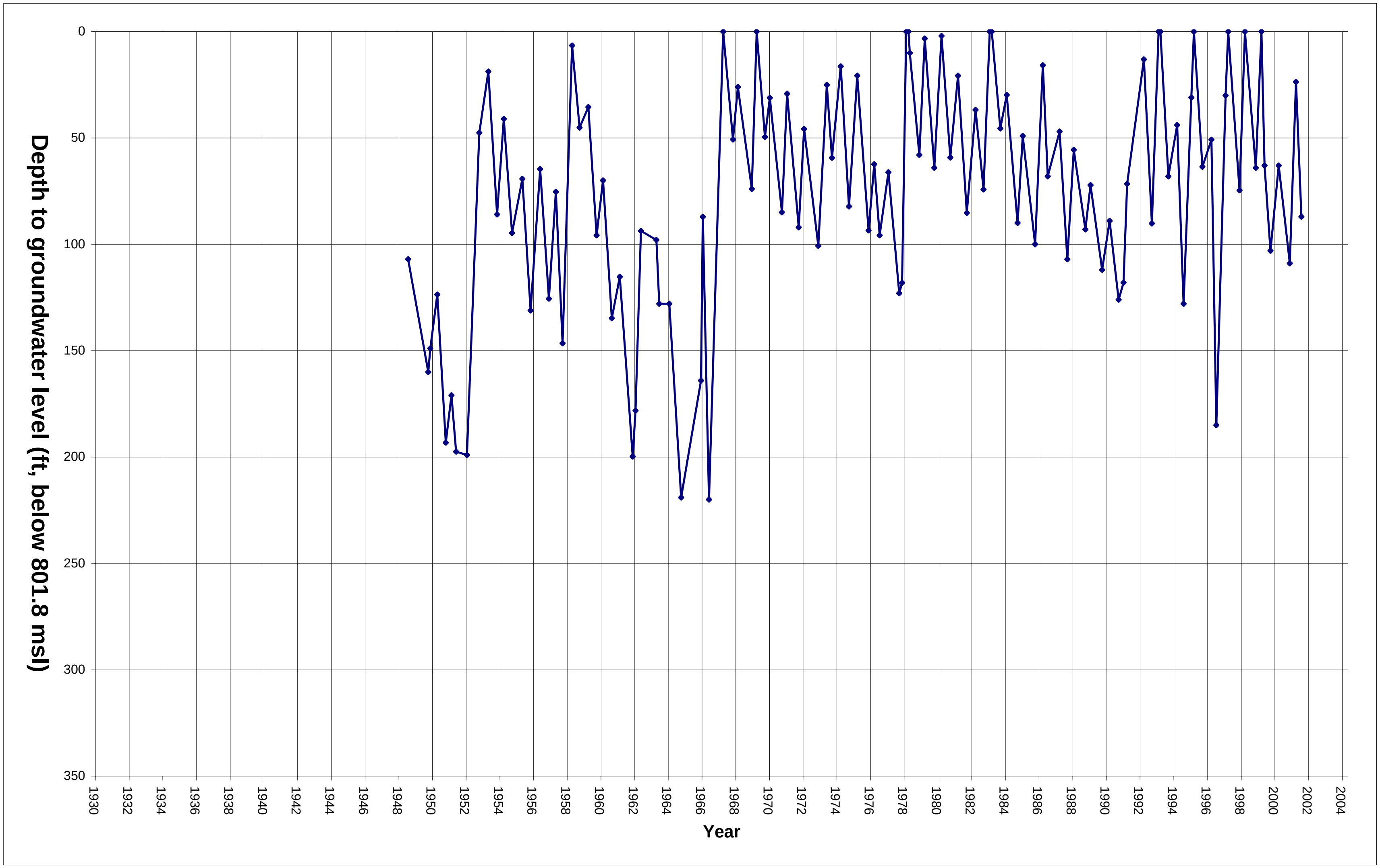


Figure 12. Water level hydrograph for well 4N/22W-6K3 (source: Ventura County raw data records)

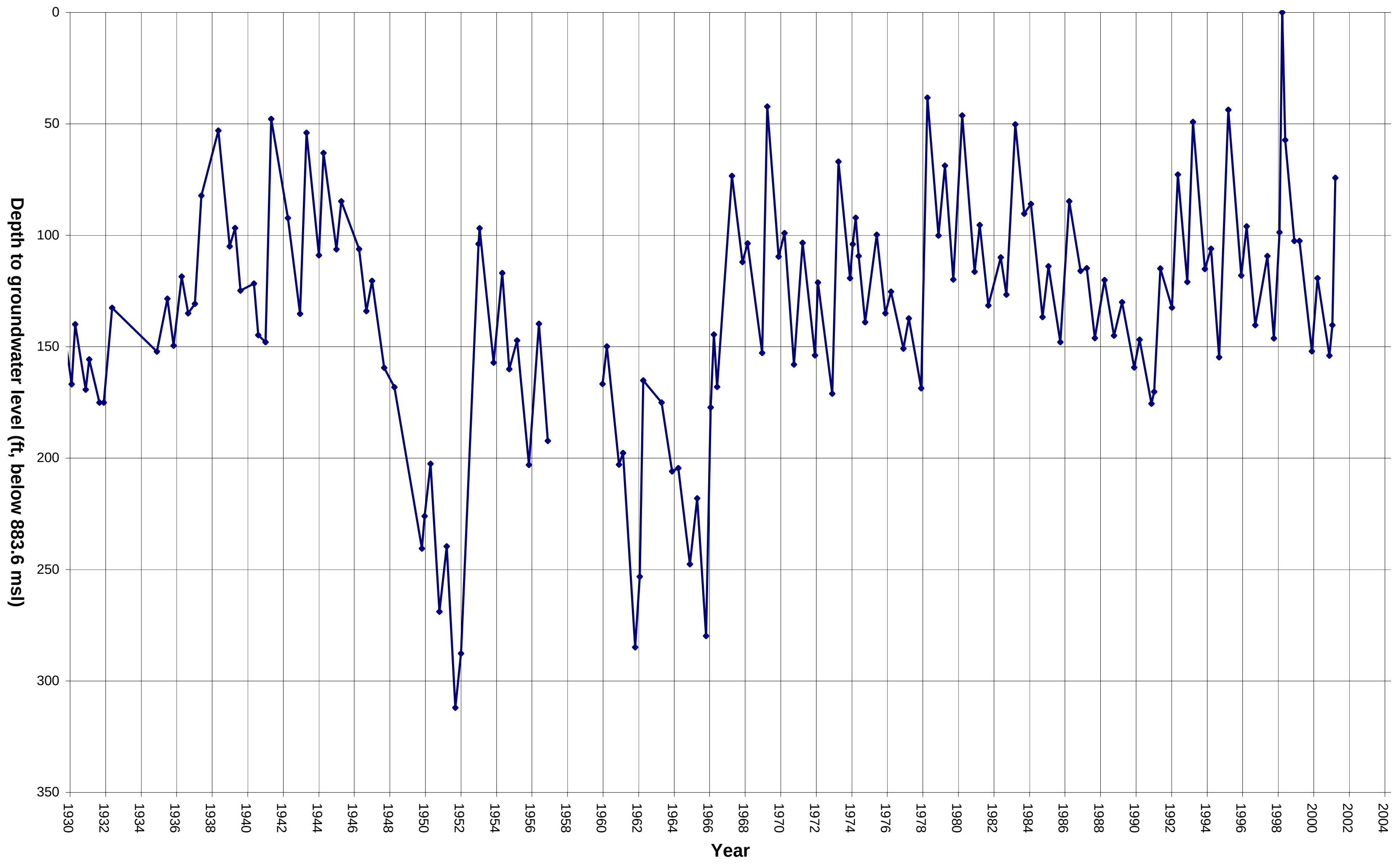


Figure 13. Water level hydrograph for well 4N/22W-5L8 (source: Ventura County raw data records).

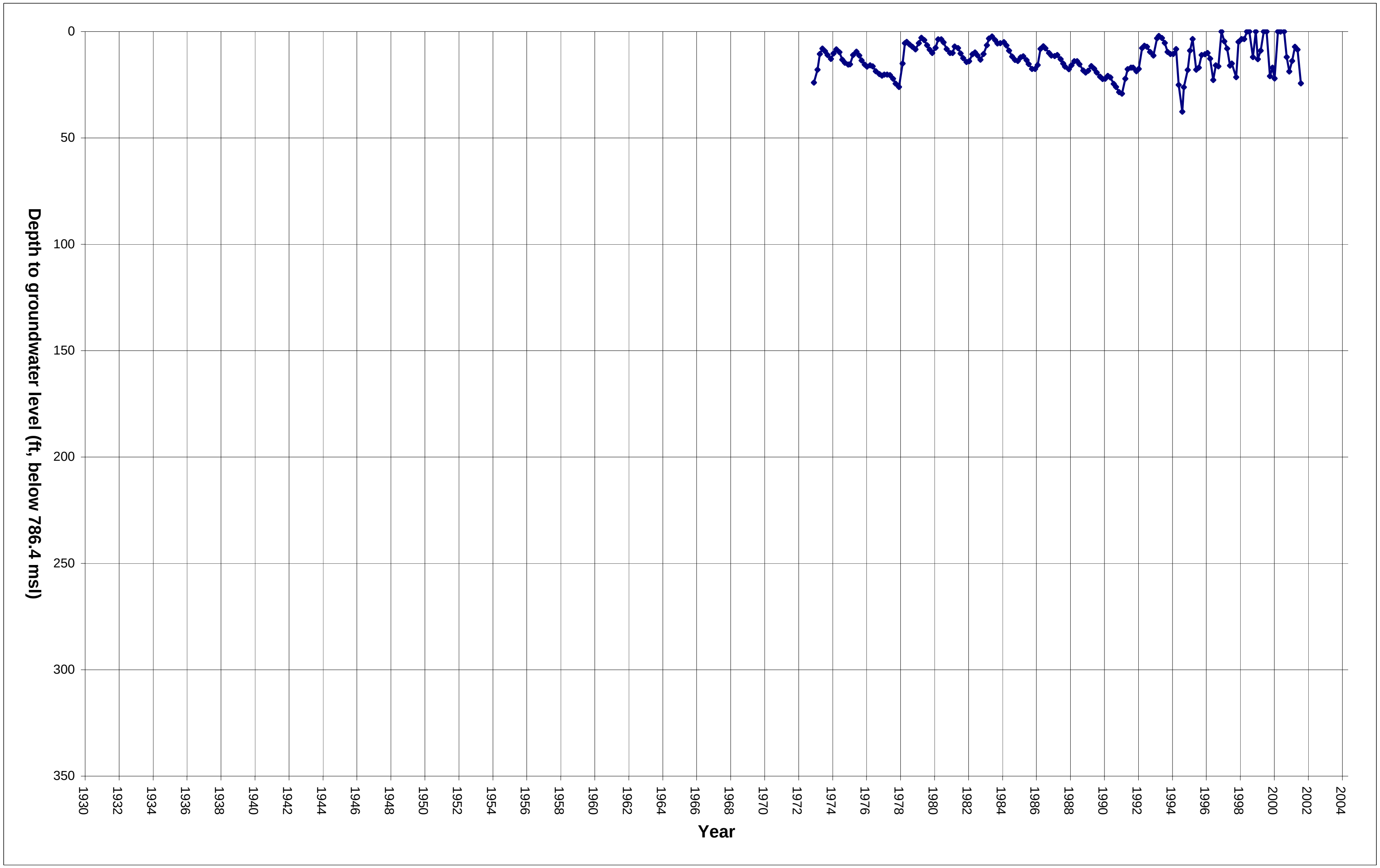


Figure 14. Water level hydrograph for well 4N/23W-1K2 (source: Ventura County raw data records)

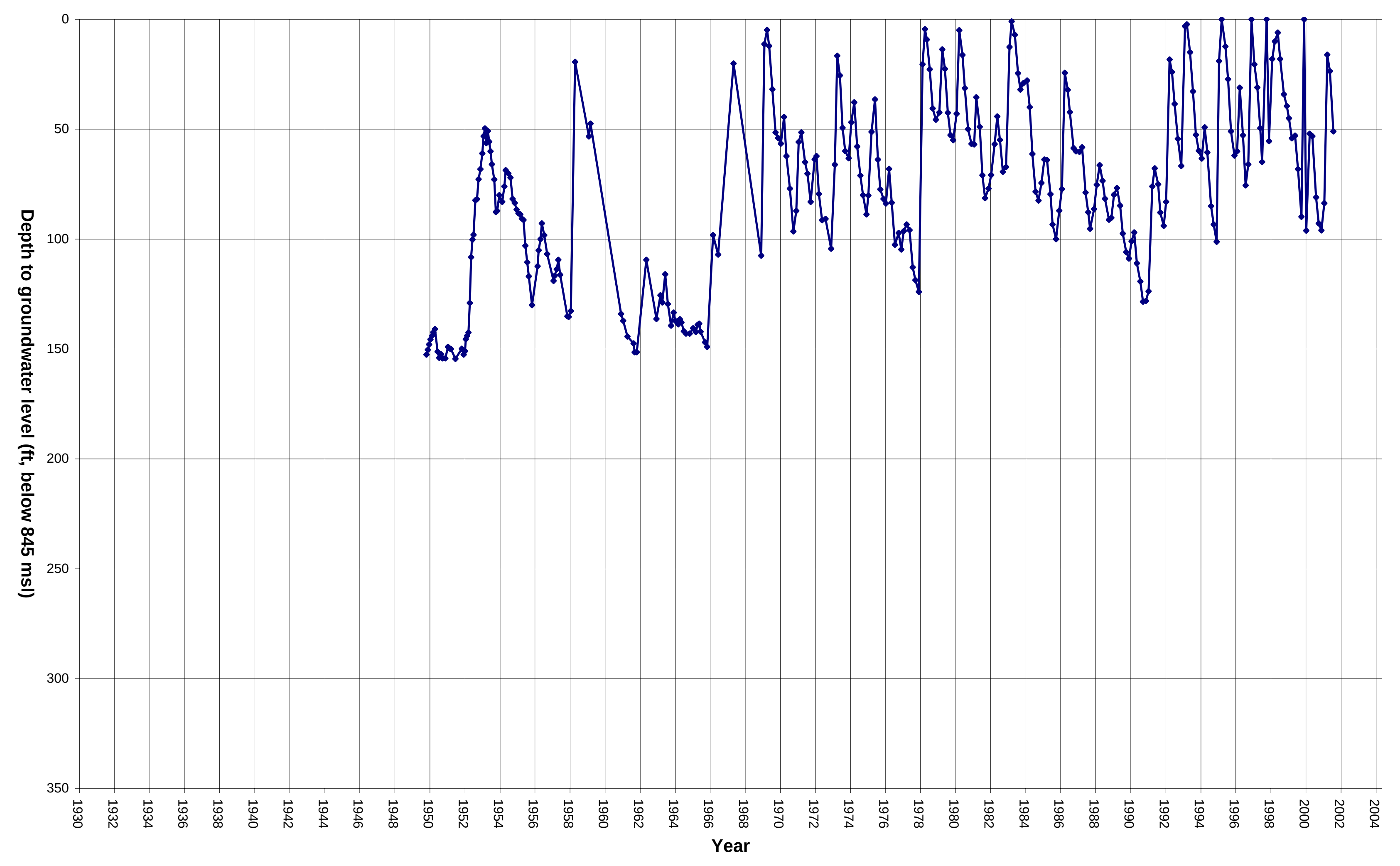


Figure 15. Water level hydrograph for well 4N/22W-6D1 (source: Ventura County raw data records).

Hydraulic Gradient

With the exception of local small scale anomalies as a result of geologic structures (such as faults) and pumping activities, hydraulic gradients in the Ojai Valley generally mimic topography, with groundwater flowing from basin margins to the central portion of the basin during pumping seasons and dry years. In wet years, the pumping depression often observed is less pronounced, and hydraulic gradients at those wet times indicate a general flow toward the southwest with discharge to streams and through the artesian flowing wells.

Groundwater in Storage

The total storage capacity of the Ojai Groundwater Basin has been estimated to be 70,000 acre-feet (af) (CSWRB, 1953), 84,000 af (VCPWA, 2002), and 85,000 af (DWR, 1975). The groundwater in storage was estimated to be 70 percent full in 2002 (OBGMA, 2003), or about 62,567 af. The OBGMA indicates that the groundwater in storage reached a nadir in 1951, when 43,731 acre-feet were estimated to be in storage. In 1983, the amount of groundwater in storage reached an historic high approaching 84,000 acre-feet, a value that was met again in 2005.

Estimated groundwater storage depletion during the seven-year drought period from 1944 to 1951 amounted to about 28,000 af (CSWRB, 1953). Total consumptive use of water on overlying lands, including precipitation, was estimated to have been about 71,000 af (CSWRB, 1953). Consumptive use of applied water from 1944 to 1951 was estimated to have been about 28,200 af (CSWRB, 1953). Underflow into the basin is estimated to range from 800 to 2,500 af/yr (Panaro, 2000). Recharge from percolation of excess irrigation is estimated to be 2,350 af/yr (Panaro, 2000).

Groundwater Quality

Groundwater in the Ojai basin is mainly calcium-bicarbonate to calcium-sulfate in character. Analyses of water from 19 wells sampled in 1952 showed an average total dissolved solids (TDS) content of 640 mg/L with a range from 450 to 1,140 mg/L (DWR, 1959). The average TDS content for analyses in 2000 was 665 mg/L, ranging from 568 to 790 mg/L (SCWC raw data records, 2001). Analyses of water from 6 public supply wells show TDS content ranging from 568 to 790 mg/L with an average of about 703 mg/L.

Comparison of water samples collected from 9 wells in 1933 with samples collected from the same wells in 1952 show that the average TDS content level increased about 150 mg/L (Department of Water Resources, 1959). The increase in average TDS content of water samples collected and analyzed in 1952 (Department of Water Resources, 1959) and 2000 (Southern California Water Company raw data records, 2001) suggests that this increasing trend may be continuing, though at a lower rate. High nitrate and sulfate concentrations have been reported in the basin (Panaro, 2000, personal communication). Twenty-one wells were sampled in the basin in 1994 to 1995. The samples were analyzed for a suite of constituents, including nitrate. The results indicated medium to high nitrate concentrations for many parts of the basin (VCPWA 1996) and revealed that the highest concentrations were in those unsewered areas in the east portion of the basin.

Water Supply Wells

It has been documented that there were 118 flowing artesian wells in the valley before the turn of the 20th century (Fry, 1991) and a total of over 300 water wells have been constructed since 1900. These wells are either active, destroyed, idle, or abandoned. Generally, depths of water wells drilled in the Ojai Valley have ranged from very shallow hand-dug wells to rotary-drilled water wells as deep as 700 feet. In some areas, oil exploration wells were converted to water wells when a lack of economically producible petroleum hydrocarbons was documented. The locations of many of the water supply wells known to have been drilled in the Ojai Valley are presented on Plate 1 (in pocket).

Details on well locations and construction details near areas of aquifer testing are presented elsewhere in this thesis.

AQUIFER TESTING

Previous Testing

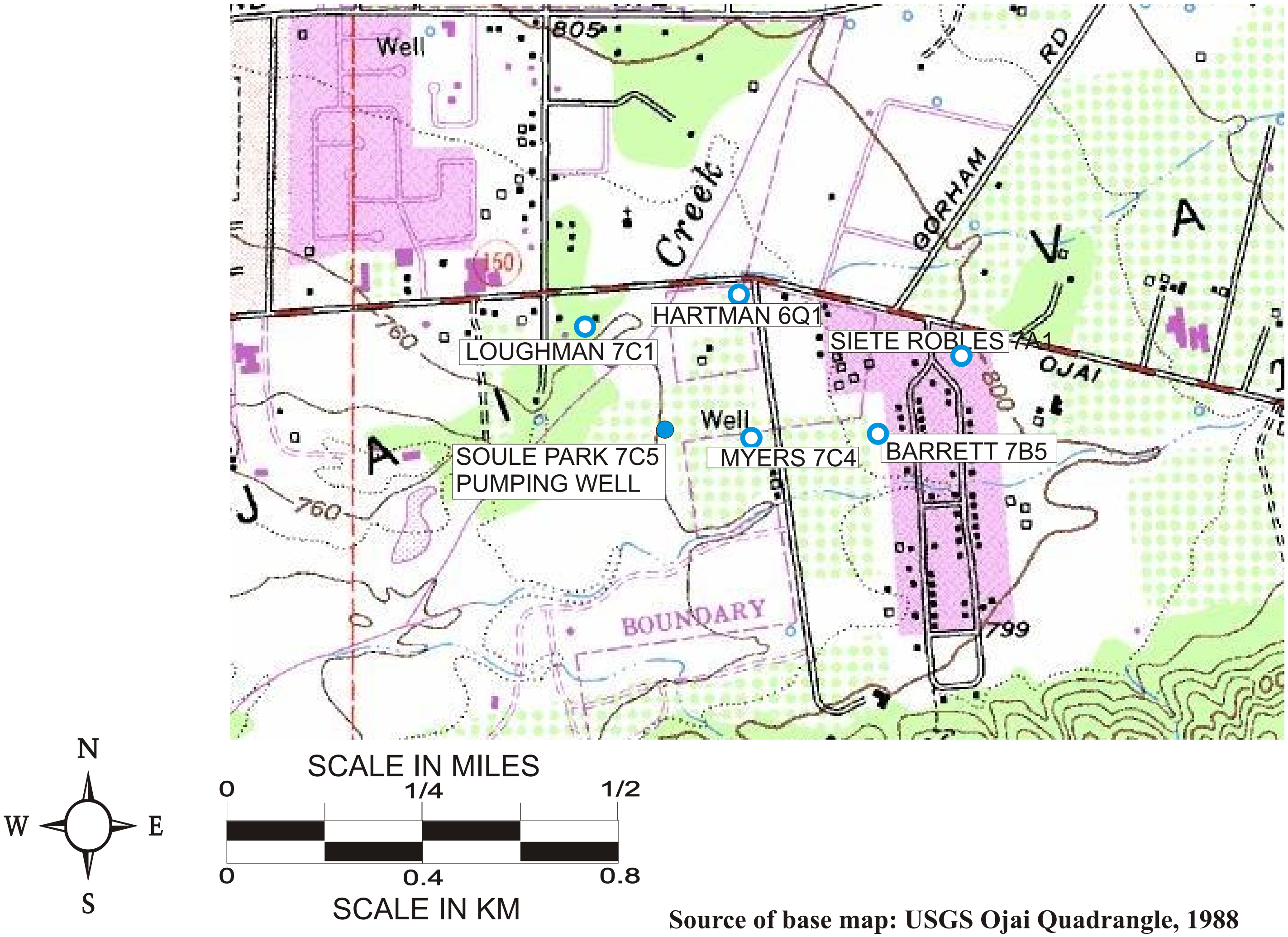
During the course of this study, data for two previously conducted aquifer tests in the Ojai Basin were analyzed. Results are documented in the following sections (5.1.1 and 5.1.2). Data from the 1961 Soule Park Golf Course aquifer test, conducted by county personnel and employees of Midway Pump and Drilling Company (who constructed and developed the wells) are sparse, but were recognized by others to be valid enough to be entered as evidence for the 1961 law suit of Barrett et al. v. Ventura County which resulted in the limitations of pumping quantities and pumping water level depths for the pumping well. Detailed data for the more recent of the two were documented in the SCWC Gorham Well completion report prepared by the consulting firm GSI/Water (1996).

Soule Park Golf Course 1961 (legal case)

Introduction

During development and step-drawdown testing of a newly-constructed production well (State Well No. 4N/22W-7C3) at Soule Park in 1961, water levels in several local groundwater wells were monitored. The known construction details of the wells involved in this 1961 testing are compiled in Table 1; well locations are presented on Figure 16 and a schematic geologic setting of the area is presented as Figure 17. Although the well was not fully developed, pumping for development was intermittent and details of recent or concurrent pumping in and near the observation wells were not reported, the depths to water in the observation wells were claimed (Barrett et al. v. Ventura County Retired Employees, Ventura County Superior Court Case Number 051216, 1961) to show a significant influence attributed to the groundwater extraction from the Soule Park Well.

The subsequent legal decision was based on these data, which constrained the amount of groundwater extraction and the extent of drawdown by the operation of the Soule Park well. Although these data are somewhat useful, it should be noted that this brief forensic analysis contains many data gaps. It is clear, however, that these data



Source of base map: USGS Ojai Quadrangle, 1988

Figure 16. Locations of wells monitored during 1961 Soule Park test.

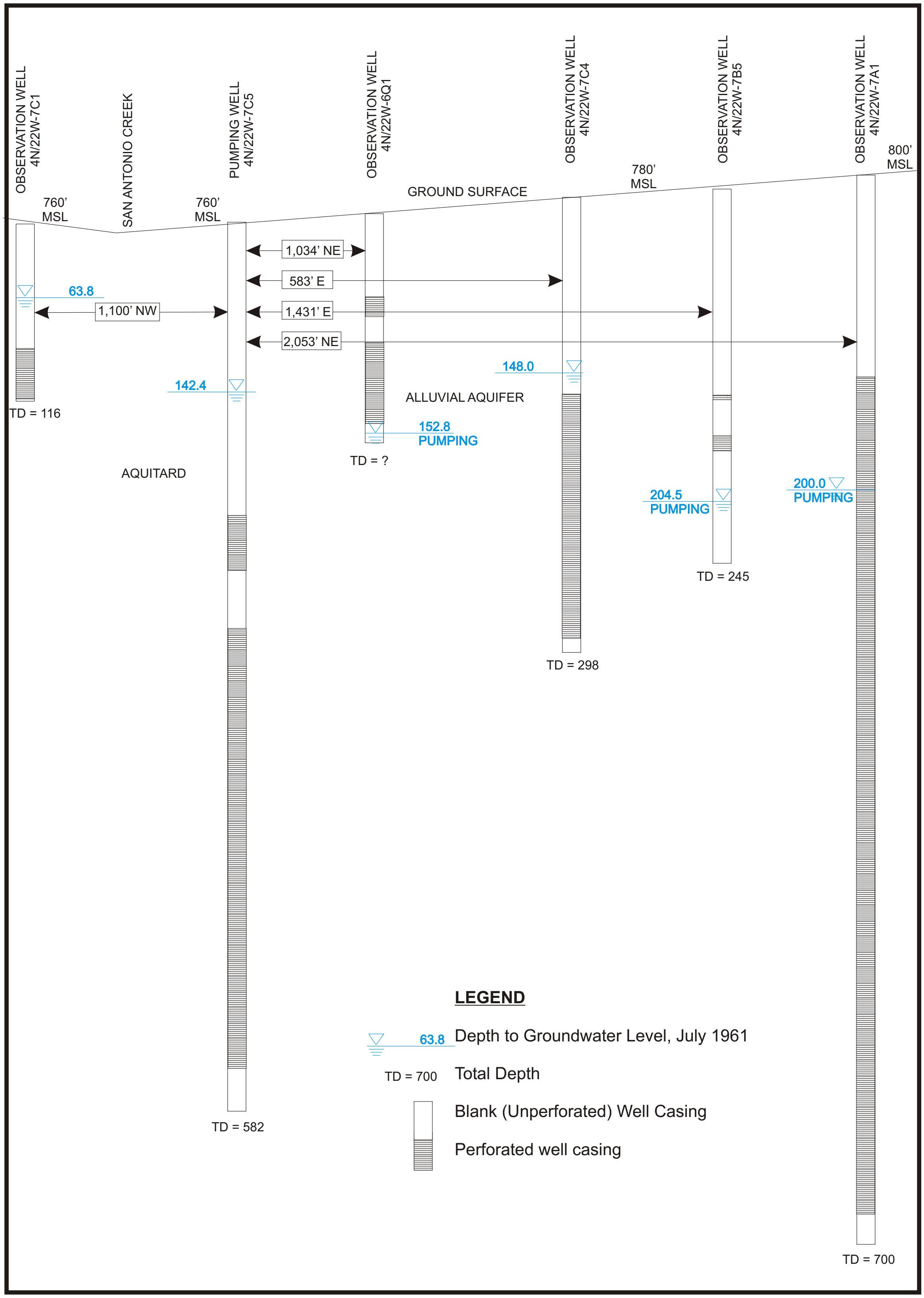


Figure 17. Schematic of pumping well 4N/22W-7C5 and observation wells 4N/22W-6Q1, -7A1, -7B5, -7C1 AND -7C4 (locations on Figure 16).

gaps and their interpretation in the 1960s likely affected the quantity of water that Soule Park is allowed to produce.

Table 1 -
Summary of drilling and well construction data for wells used in 1961 pumping testing (Source: Files of the Ventura County Public Works Agency, Water Resources Division)

State Well Number Owner/operator	Drill Date	Total Well Depth (ft)	Casing Diameter (in)	Distance from pumping well (ft), Direction	Perforation Depth Intervals (ft)	Well and pump status/information
4N/22W-7C5 Soule Park Well	1961	582	14	0	192-228 264-552	Pumping Well, Under development during data collection
4N/22W-7C1 Loughman	1940	116	6 5/8	876 NW	82-115	Irrigation well, not pumping
4N/22W-6Q1 Hartman	1939	150	12	1,034 NNE	52-65	Well deepened about 1950, pumping
4N/22W-7C4 Myers	1950	298	10	583 E	130-290	Domestic/irrigation well, not pumping
4N/22W-7A1 Siete Robles	1951	700	14,12,10	2,053 ENE	137-685	Mutual Water Company Well, Pumping
4N/22W-7B5 Barrett	1950	245	12	1,431 E	116-119 153-163	Domestic/irrigation well, pumping

Location

Soule Park Golf Course is south of Ojai Avenue, west of Boardman Road in the south-central portion of the Ojai Basin (Figure 16). The 1961 Soule Park Well aquifer test was conducted by extracting groundwater from aquifers underlying several properties, including the location of the Soule Park Golf Course, owned by the Ventura County Retired Employees Association at the time. Currently there are two wells on the course parcels, but only one was completed at the time of the aquifer test in 1961. Another test hole was drilled, but not completed as a water well, in 1961.

Data

On the morning of July 26, 1961, the depth to groundwater level in the Soule Park Well was reported by the pumping contractor to be 142.4 feet below the reference point. Based on Ventura County court documents, pumping for developmental phase and subsequently aquifer testing began at this location at noon on July 26, 1961. The developmental phase consisted of pumping the well for approximately 15 minutes and then shutting the pump off and allowing the water within the pump column to "surge" and flow out through the perforations. Reportedly, this effort was repeated for 29 hours, until 5:00 PM on July 27, 1961 at an average production rate of 600 gpm with a reported 40 minutes of pumping per hour. Hence, the net effect of developmental pumping on the hydrogeologic environment was approximately 29 hours of pumping continuously at 400 gpm.

Immediately after the developmental process (without a significant recovery period), the well was subject to step-drawdown testing. Each step was 3 hours in duration except for the final step, which was limited due to the well's capacity. The initial step was reported to be pumped at a rate of 200 gpm (pumping water level [PWL] = 241 ft, s=98.6 ft, Q/s=2.02 gpm/ft drawdown [ddn]), followed by 300 gpm (PWL=253, s=110.6, Q/s=2.7 gpm/ft ddn), 400 gpm (PWL=264, s=121.6, Q/s=3.29 gpm/ft ddn), 500 gpm (PWL=297, s=154.6, Q/s=3.23 gpm/ft ddn), and then 30 minutes of pumping at 600 gpm, two hours at 200 gpm, and ultimately 30 minutes at 550 gpm. Based on these data, over the 44 hours of well developmental pumping and test pumping at the Soule Park Well (from noon July 26 to 8:00 AM July 28, 1961) the net average pumping rate was 381 gpm. During the development and testing process, water levels were measured in nearby observation wells three times. The results of these measurements are compiled in Table 2.

Table 2 –
Summary of 1961 “Aquifer Test” Water Level and Drawdown Data

State Well Number Owner/Operator Radial Distance from pumping well	**Pre-test Static**	**4 hours after developmental pumping started, average discharge rate 400 gpm**		**15 Hours after developmental pumping started, average discharge rate 400 gpm**		**At completion of 44 hours testing and development, 8:00 AM July 28, 1961 Average discharge rate 381 gpm**	
	Depth to groundwater level (ft)	**Depth to groundwater level (ft)**	**s (ft)**	**Depth to groundwater level (ft)**	**s (ft)**	**Depth to groundwater level (ft)**	**s (ft)**
4N/22W-7C5 ***Soule Park Well*** ***0***	142.4	460 (?) (not fully developed)	317.6	264(?)	121.6	438 (may be representative of short-term higher rate	295.6
4N/22W-7C1 ***Loughman*** ***1100***	63.8	63.8	0	63.8	0	63.8	0
4N/22W-6Q1 ***Hartman*** ***875***	152.8 (pumping)	152.8	0	152.8	0	152.8	0
4N/22W-7C4 ***Myers*** ***375***	148.0	162	14	165	17	167	19
4N/22W-7A1 ***Siete Robles*** ***1,750***	200.0 (pumping)	200.5	0.5	205.5	5.5	207.8	7.8
4N/22W-7B5 ***Barrett*** ***1100***	204.5 (pumping)	205.5	1.0	208	3.5	209.3	4.8

Methods

Using the 1961 Soule Park test data, a graph of distance versus drawdown was prepared and analyzed (Figure 18). Based on the available 1961 data set, the key distance-drawdown solution is based on Jacob's (1946) approximation of the nonequilibrium equation. Transmissivity and storage coefficient were calculated by the equations: $T=2.303Q/2\pi\Delta s$ and $S=2.25Tt/ r_0$

where: T= transmissivity (ft^2/min)

Q = pumping rate (ft^3/min)

Δs = the difference in drawdown over one log cycle on Figure 18 (ft)

S = Storativity (unitless)

t = time since pumping began (min)

r_0 = projected zero drawdown point radially from pumping well (ft)

In the case of the Soule Park test of 1961, Q=381 gpm (50.9 ft^3/min), Δs is estimated to be 30 feet from Figure 18, and the r_0 is estimated to be 1,900 feet after a pumping time (t) of 44 hours (2,640 minutes). Hence, transmissivity is calculated by:

$T=2.303\ (50.9\ ft^3/min)\ /\ 2\pi\ (30\ ft) = 0.62\ ft^2/min$.

Storativity is calculated by:

$S=2.25\ (0.62\ ft^2/min)(2{,}640\ min)\ /\ (1{,}900\ ft)^2 = 0.00102$.

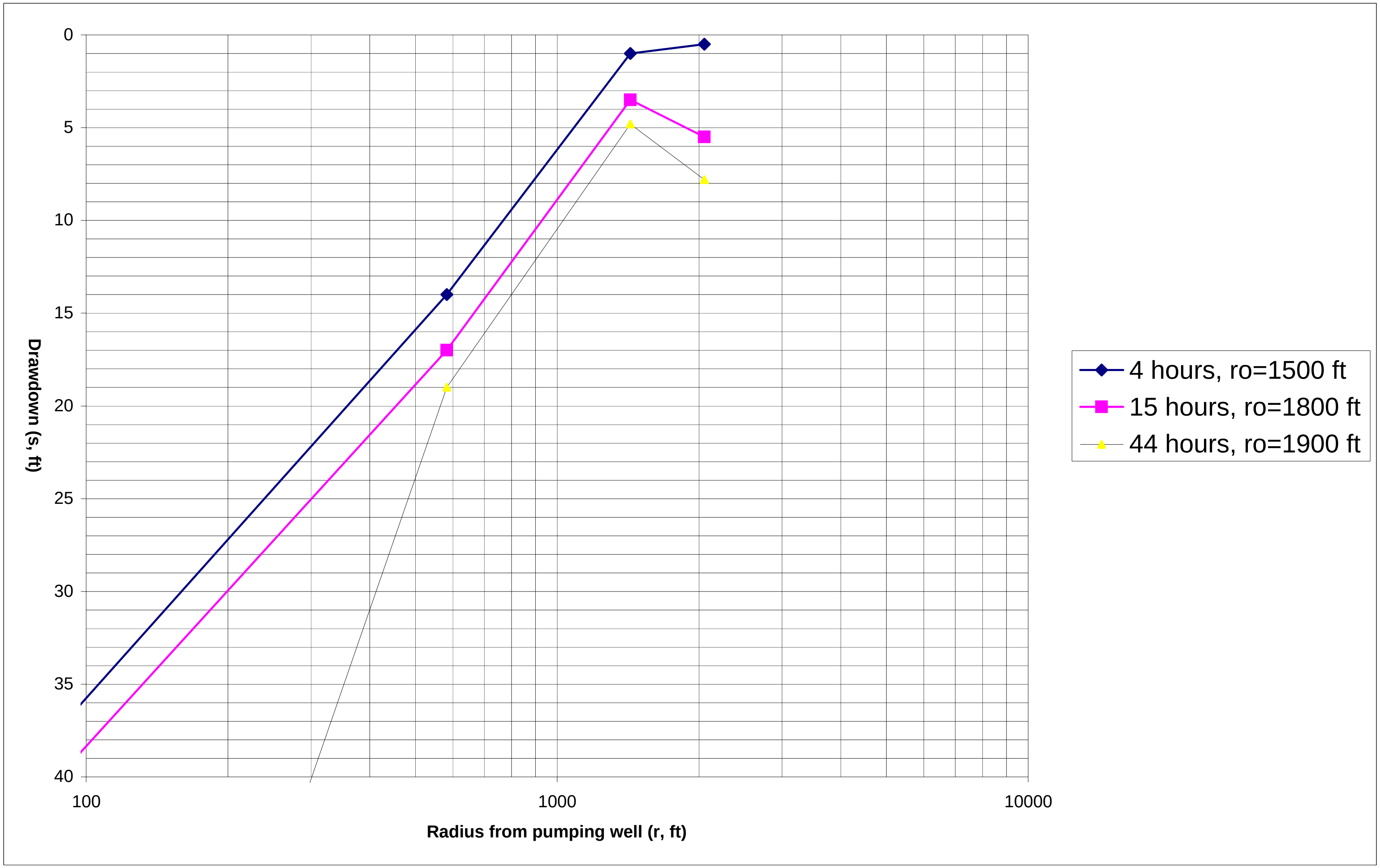


Figure 18. Distance drawdown curve, Soule Park 1961.

Results

Although the 1961 Soule Park data are recognized to be sparse and sporadic, several conclusions regarding the basin in the area may be drawn:

1. Based on the lack of drawdown in two of the observation wells, it appears that the shallow aquifers penetrated by the Loughman and Hartman wells are not in direct hydraulic continuity with the aquifers from which the Soule Park Well extracts groundwater.

2. Based on the higher drawdown values reported in the more distal Siete Robles Well and lower reported drawdown values in the more proximal Barrett Well (Table 2), coupled with the fact that the Siete Robles and Barrett Wells were reportedly (on Ventura County documents) pumping for the duration of the test, it appears that there was significant superposition of the water level drawdown during the observation period. Hence, perhaps not all data were considered when the judicial decision was rendered and drawdown from other wells may have been attributed to the Soule Park Well.

3. Based on the "Distance-drawdown graph," the "r_o" distance – that radial distance from a pumping well at which no effects of pumping are theoretically present – appears to be about 1,500 feet, 1,800 feet, and 1,900 feet for the pumping periods of 4 hours, 15 hours, and 44 hours, respectively, at averaged production rates (Figure 18).

4. Because in the 1961 legal case the drawdown data were apparently considered to include pumping development time and insufficient recovery periods (typically a period equal to pumping periods) elapsed between pumping development and test pumping, it is likely that the pumping water levels in the Soule Park Well were artificially low and not likely to be representative of a fully developed, efficient well. Additionally, pumping the well after full development, recovery, and at a constant rate for a 24-hour period during a low-demand period of the year, may have produced more scientific reliable results.

5. Historical flowing artesian wells and calculated low storativity values for the aquifer system in this area confirm that the deeper aquifer system exists under confined conditions.

6. The lack of drawdown apparent in the Loughman and Hartman wells may indicate that the aquifer units from which the Soule Park Well extracts groundwater were and are under confined conditions. Historical "dry" well conditions reported in the Loughman and Hartman wells suggest that unconfined conditions are prone to exist in the shallower aquifer(s) penetrated by these relatively shallow wells.

7. Because the 1961 test was conducted during a period of prevailing drought conditions, which started in 1946, the aquifers associated with the Soule Park Well appear to be under confined conditions and shallower aquifers which are up to about 150 feet deep may be under unconfined conditions, as there are such wells in this area that have reportedly been dry during drought periods.

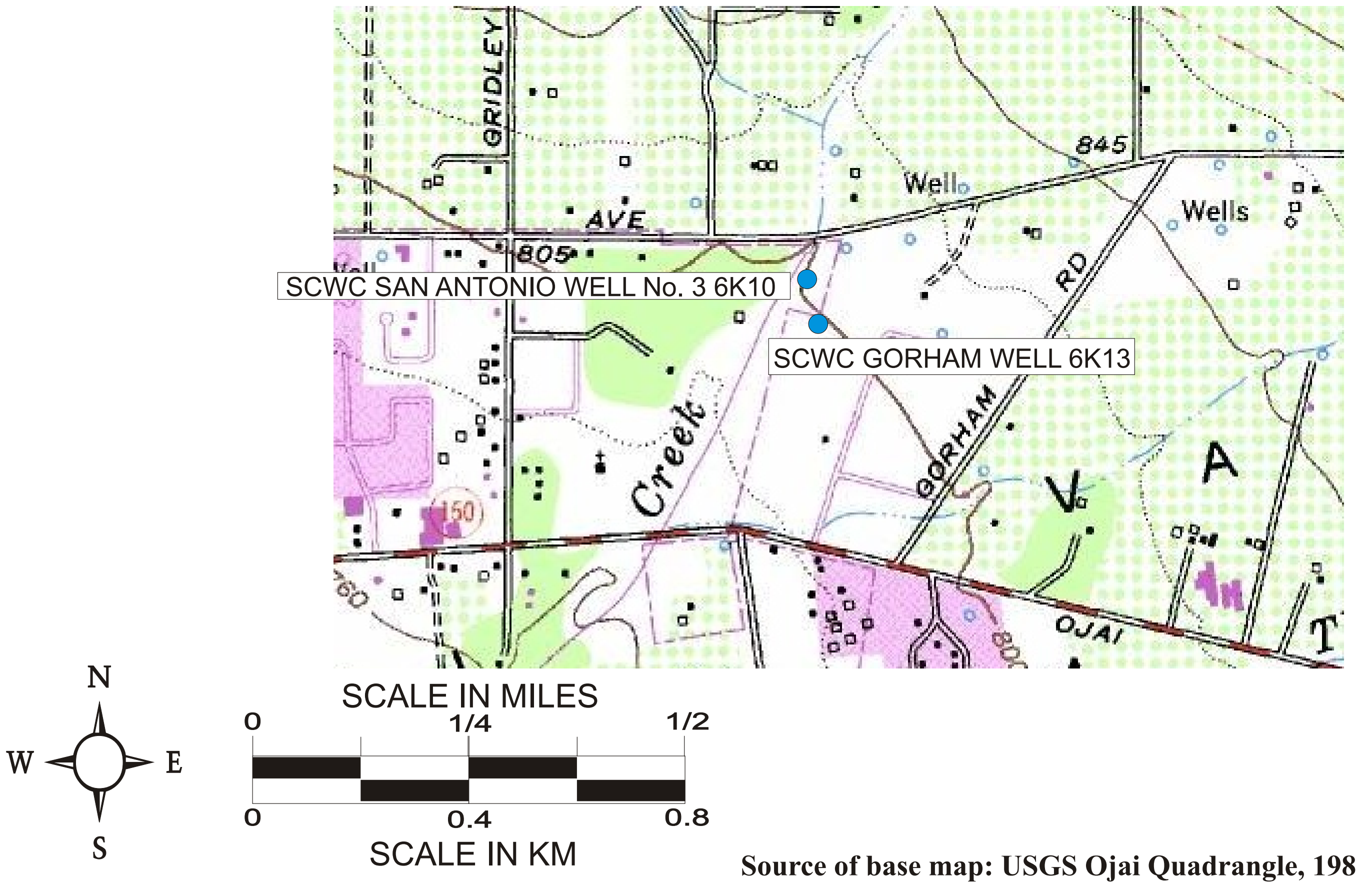
Southern California Water Company – Gorham Well 1996

Introduction

Following construction and development of Southern California Water Company Gorham Well (State Well No. 4N/22W-6K13), it was subjected to step-drawdown aquifer testing and an aquifer test with a constant rate of pumping. During the January 13, 1996 step-drawdown test, the well was pumped for five consecutive two-hour intervals at average production rates of 262 gpm, 527 gpm, 752 gpm, 997 gpm, and 1,247 gpm (Figure 21). Specific capacity values followed a relatively linear trend, ranging from about 17.5 gpm/ft drawdown at the lower pumping rate to about 7.1 gpm/ft drawdown at the highest pumping rate of the step test.

Location

The 1996 Gorham Well test was conducted within the Gorham Well Field, owned and operated by Southern California Water Company. In addition to the Gorham Well, San Antonio Well Nos. 2 and 3 are located on the parcel, which is east of San Antonio Creek and south of Grand Avenue in the central portion of the Ojai Basin (Figure 19).



Source of base map: USGS Ojai Quadrangle, 1988

Figure 19. Locations of wells monitored during 1996 SCWC Gorham test.

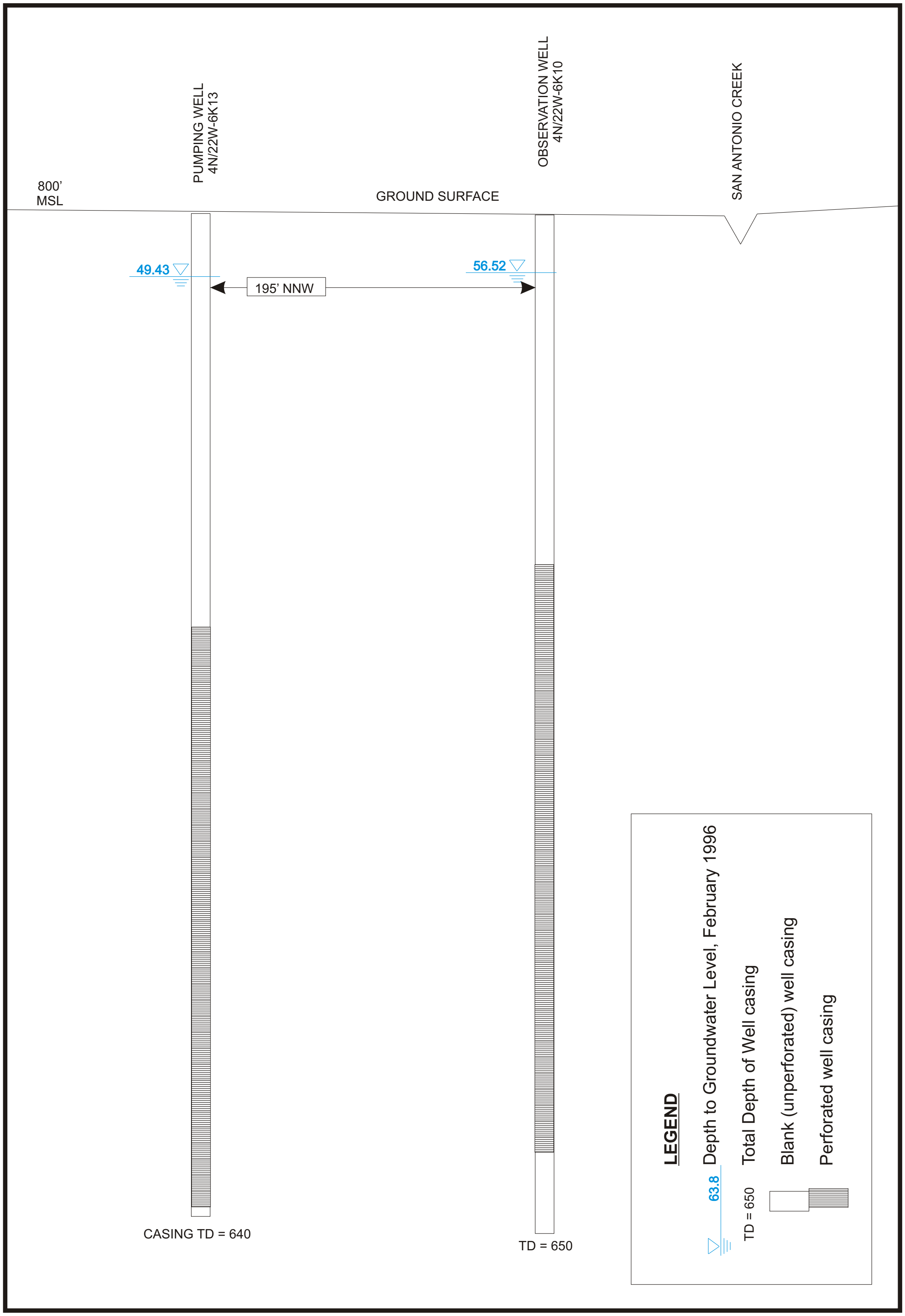


Figure 20. Schematic of pumping well 4N/22W-6K13 and observation well 4N/22W-6K10 (locations on Figure 19).

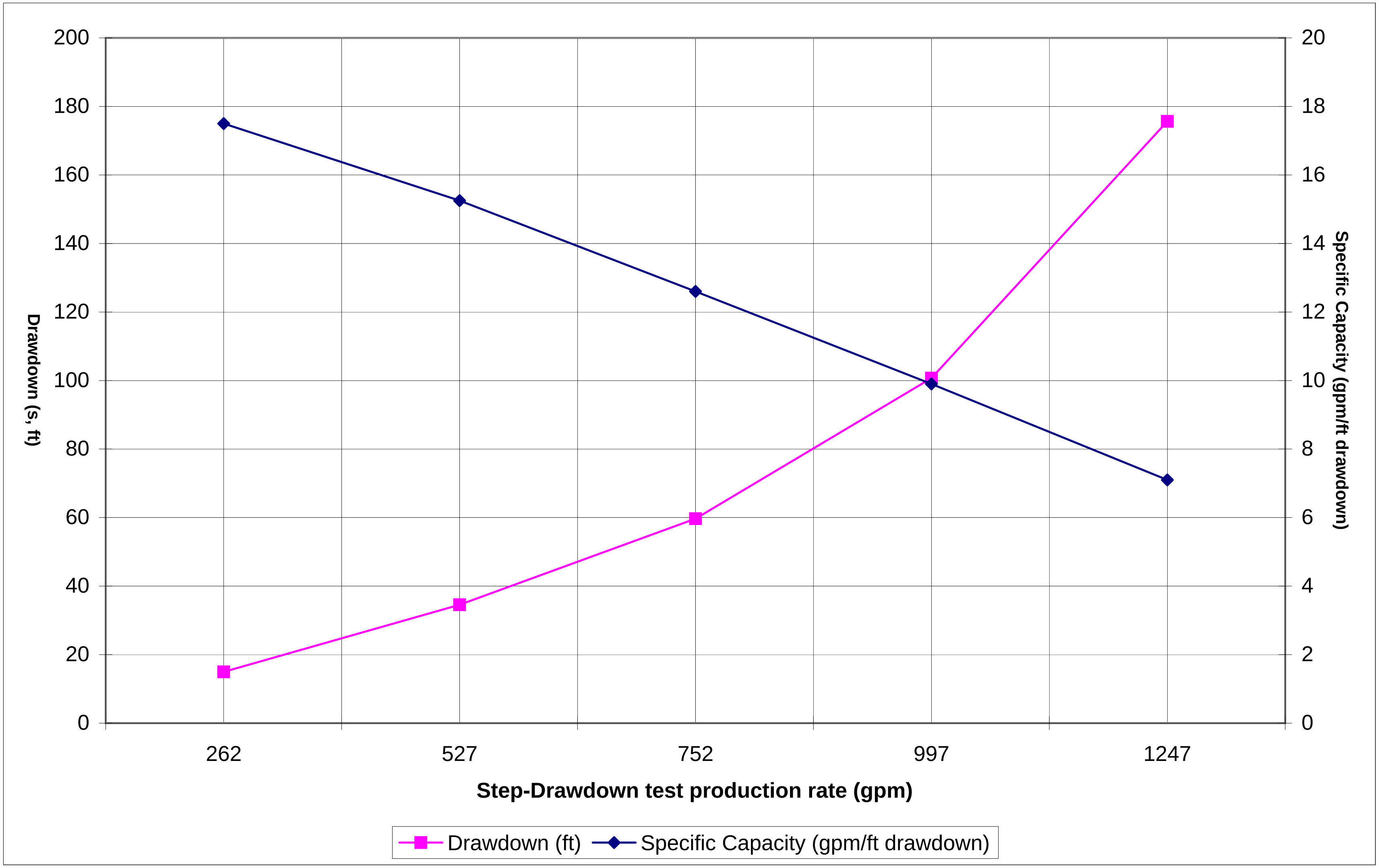


Figure 21. Step-drawdown test data and specific capacity, for Southern California Water Company Gorham Well, 1996.

Data

Based on the results of the step-drawdown testing, the well was test pumped for 71 hours at an average rate of 1,003 gpm; at the end of this period (January 17 to 20, 1996) the specific capacity was 6.8 gpm/ft drawdown.

The reported static water level at the time of the step test was 61.35 feet below the reference point and 49.43 feet at the beginning of the constant-rate test. It is likely that the apparent increase in groundwater elevation may be due to local recharge (only 1.17 inches of precipitation occurred during January 1996), a longer period of recovery following previous pumping in the Gorham Well (pumping development ceased on January 12, 1996 while at least four days of recovery separated the step and constant-rate test), and differential pumping patterns in other nearby wells.

Key data for evaluating storativity and confinement were obtained from SCWC's San Antonio Well No. 3 (State Well No. 4N/22W-6K10) located approximately 195 feet west-northwest of the Gorham Well as measured by the author using GPS technology. Table 3 presents well construction data, and Figure 20 presents a schematic cross-section of wells and general lithology.

Table 3 – Summary of Drilling and Well Construction Data: Gorham Well Test

State Well Number *Owner* Name	**Drill Date**	**Drill Depth (feet)**	**Casing Diameter (inches)**	**Distance from Pumping Well, Direction**	**Perforation Depth Intervals (feet)**	**Well and Pump Status/Information**
4N/22W-6K13 ***Southern California WC*** **Gorham Well**	1995	790	16	0	260–630	Pumping Well, equipped with test pump
4N/22W-6K10 ***Southern California WC*** **San Antonio Well No. 3**	1956	650	16	195 ft 335° NNW	225-600	Pump idle for duration of the test

Based on the data from the constant pumping-rate test GSI (1996) calculated an average storativity of 0.0015 for the aquifer units from which these wells extract groundwater. A radial distance of 250 feet was used for this calculation. Since the raw water level data were included in the well completion report possessed by SCWC, the author was able to review data and select data from the first 24 hours of pumping to subject to type curve analyses for aquifer parameter solutions. Because the complete data set revealed the effects of intermittent pumping of another well, only those data believed to be representative of influence from the Gorham Well were considered. Groundwater levels that are believed to have been influenced by intermittent pumping of other wells were not included in this forensic analysis. Further data adjustments were made based on GPS-based readings for the location of wells; based on this survey, a radial distance of 195 feet was used in aquifer parameter calculations. Water level data, reflecting these corrections, are presented in Appendix A.

Methods

Neuman-Witherspoon (1969) Solution for a Pumping Test in a Leaky Aquifer

Based on the geologic setting of the well locations and observed time-drawdown data, the type-curve solutions presented by Neuman-Witherspoon (1969) for a confined aquifer with leakage were used. Although not all assumptions of the solution are met, a type-curve analysis of the data by this method appears to yield the most consistent type-curve matching results (Figure 22).

Neuman and Witherspoon (1969) derived an analytical solution for the problem of flow to a well in a confined infinite radial system consisting of two aquifers separated by an aquitard. Although this solution is based on the well completely penetrating only one of the aquifers, the match of the type curve can be used to estimate an average of aquifer parameters for the aquifers penetrated by the wells. The solution considers storage in the aquitard and drawdown in the unpumped aquifer.

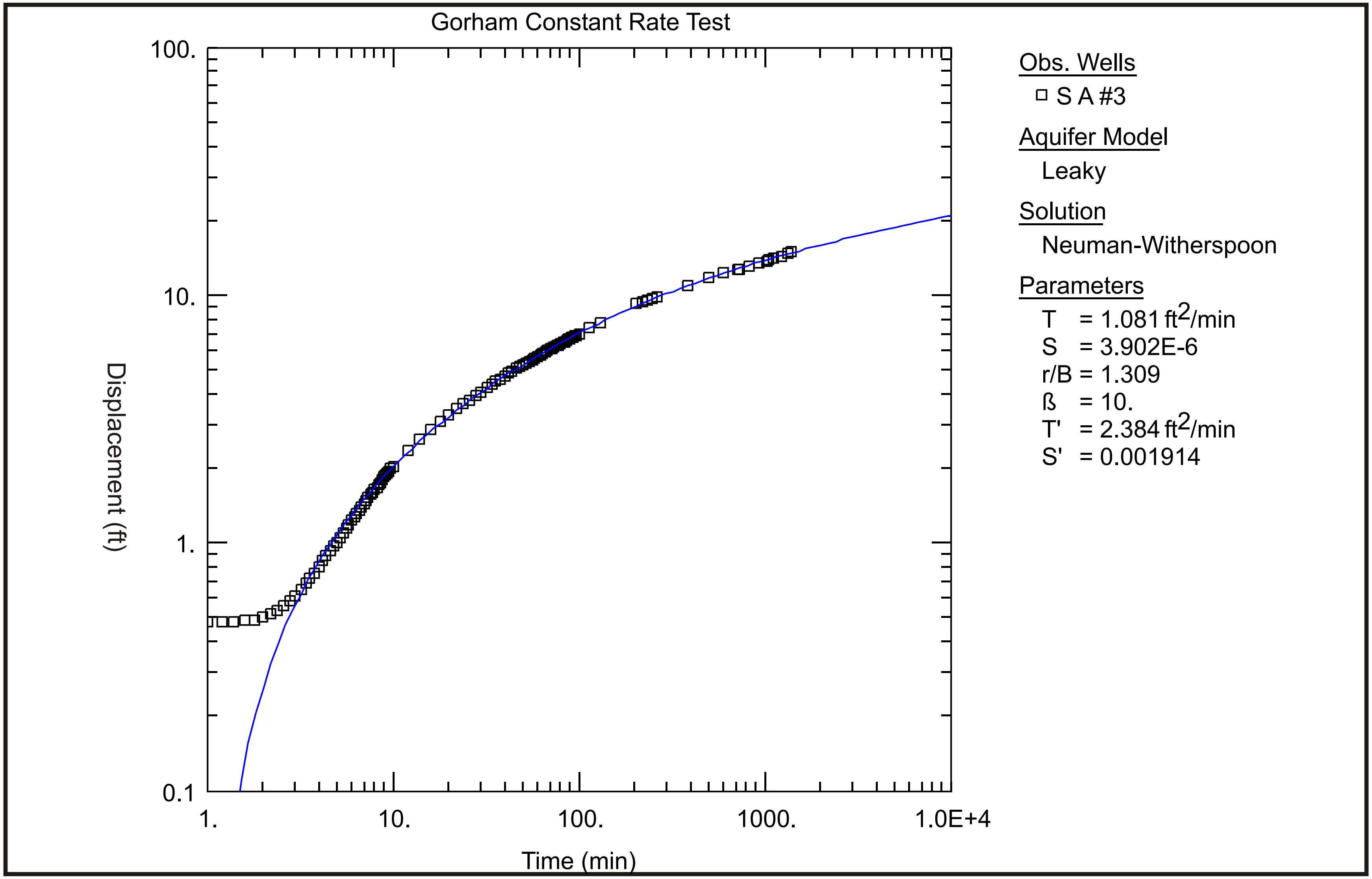


Figure 22. Neuman-Witherspoon solution, SCWC Gorham observation well 4N/22W-6K10.

Results

Based on the type-curve analyses, transmissivity values are determined to be on the order of 1.08 ft^2/min and storativity values are on the order of 3.9×10^{-6}. With these values, it appears that confined aquifer conditions, likely with leakage from overlying confining layers and aquifers, predominated during the period of testing of the Gorham Well.

Kear 2003-2004 Aquifer Tests

During the course of this study, six aquifer tests were designed, conducted, and analyzed by to evaluate hydrogeologic conditions in the Ojai Groundwater Basin. These tests commenced with a November 2003 test at the Ojai Mutual Well field of the Southern California Water Company; continued with the test pumping testing of a privately-owned well belonging to Mr. Jerry Conrow in January 2004; which was followed by the pumping of the Senior Canyon Mutual Water Company "Grant Well," in March 2004; another private orchard management company, Essick Farm Management, irrigation well was used in March 2004; followed by the testing of two residential/light agricultural well areas in April and May 2004. Over the course of seven months six aquifer tests were conducted, which resulted in nearly 30 data sets for analysis in addition to data from older tests that were available and described above.

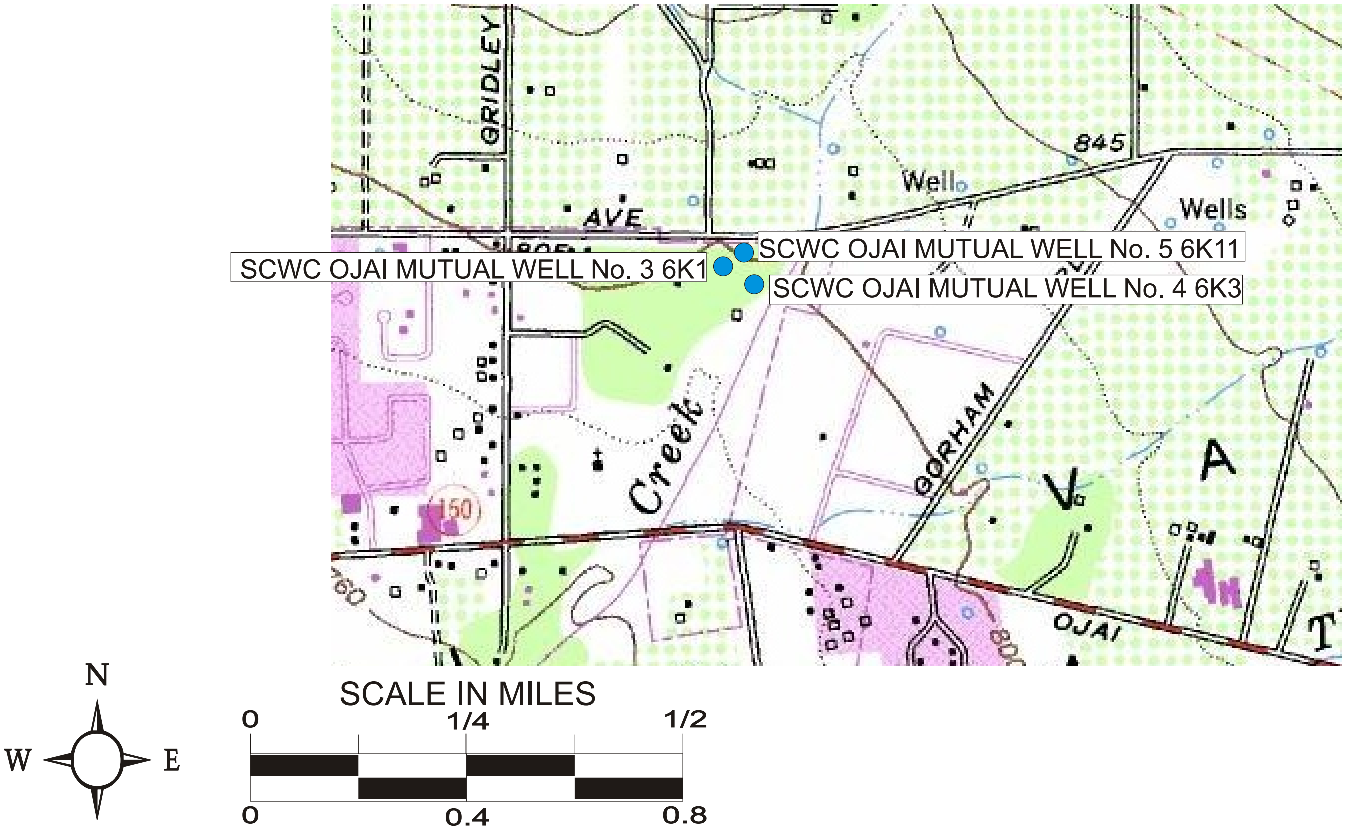
The author, on behalf of the Ojai Basin Groundwater Management Agency, conducted the aquifer testing described herein. Pumping was conducted with the cooperation of the local well owners, operators, and pumpers. Field equipment consisted of a 500-foot-long electric tape "Powers Well Sounder," an In-Situ Hermit 2000 datalogger, and several pressure transducers, as well as ancillary cables, power cords, tape measures, tools, flashlights, and notebooks. For surveying lateral well point locations where direct tape measurements were not feasible, a Garmin GPS60C unit was utilized, with data loaded into the MapSource GIS application. In addition to manual solutions, the AQTESOLV for Windows application was utilized to assist in type-curve matching.

Central Ojai Basin
(Southern California Water Company – Ojai Mutual Well Field)

Introduction

In November 2003, the first test for this study was conducted at the Southern California Water Company (SCWC) Ojai Mutual Well Field in the Central Portion of the Ojai Basin. Automatic and manual water level measurements in three SCWC-owned-and-operated Ojai Mutual Wells began on November 14, 2003 and continued until November 22, 2003. Controlled pumping of Ojai Mutual Well No. 5 began on November 21, 2003 while the other nearby wells (Ojai Mutual Well Nos. 3 and 4) were idle and monitored for water level changes. The average pumping rate was 383 gpm (51.3 cfm) for the 24-hour pumping test period. Based on analysis of drawdown data and aquifer test analytical solutions, the results are representative of unconfined conditions in the area of the Ojai Mutual Well Field at the time and importantly, prevailing hydrologic conditions of the November 2003 aquifer test.

This well field was selected for inclusion into the testing due to the proximity of potential observation wells, existing pump and power apparatus that need to be used for the City of Ojai water supply, a location for discharge waters, and ancillary access and pumping volume monitoring apparatus. Ojai Mutual Well No. 5 was selected as the pumping well because of its relative distal location compared to the actively pumping SCWC San Antonio well field (including the Gorham Well), the proximity of a relatively nearby dedicated observation well (52 feet away, Ojai Mutual Well No. 3) which could be locked and had no pump installed, and the more distal Ojai Mutual Well No. 4 which shares the parcel with the other two existing wells. (Ojai Mutual Well Nos. 1 and 2 were destroyed before implementation of this testing program.)



Source of base map: USGS Ojai Quadrangle, 1988

Figure 23. Locations of wells monitored during 2003 SCWC Ojai mutual test.

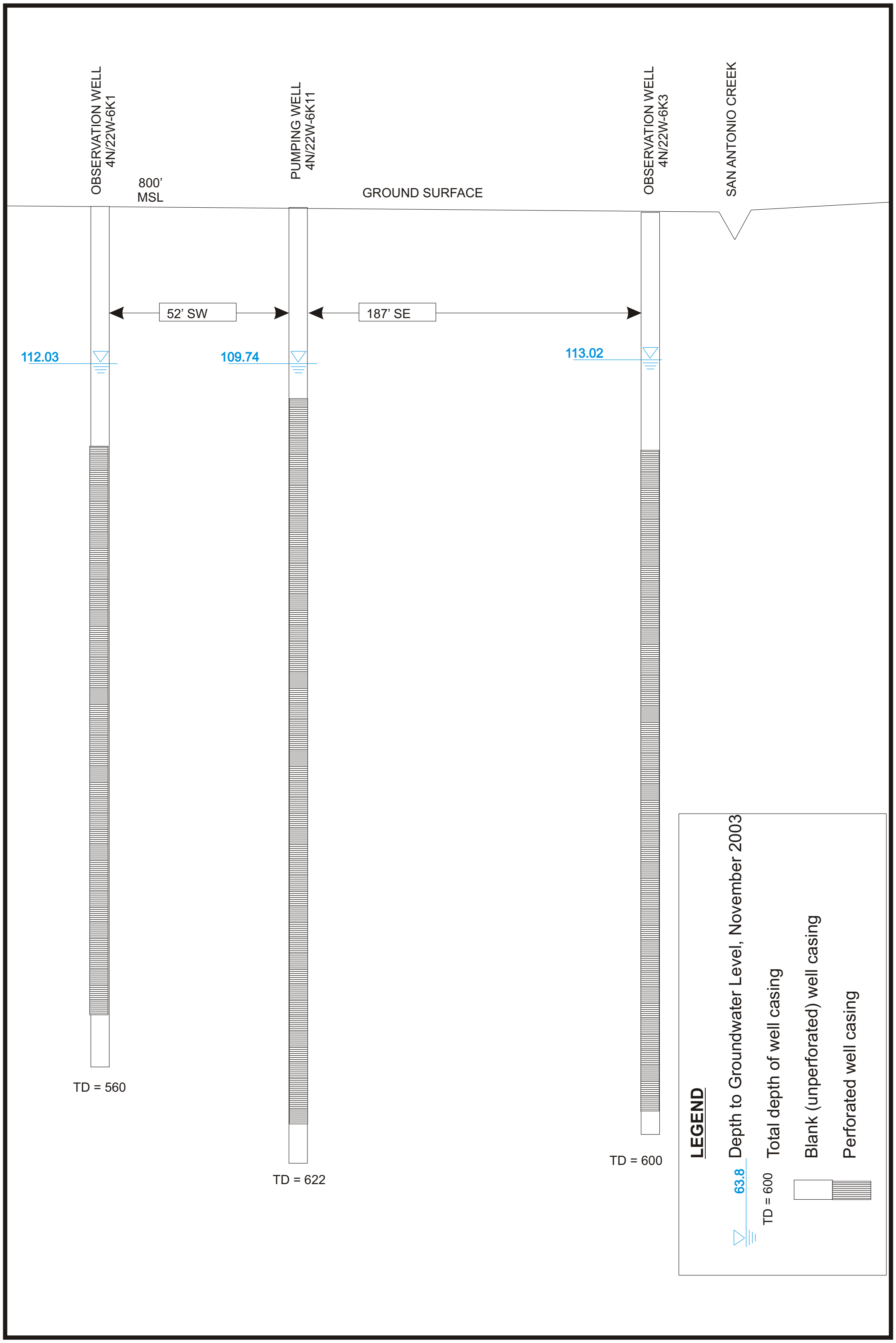


Figure 24. Schematic of pumping well 4N/22W-6K11 and observation wells 4N/22W-6K1 and -6K3 (locations on Figure 23).

Timing of this aquifer test was key in that it was the earliest period of the fall season wherein the wells could be shut off for a period of time to allow a maximum feasible water level recovery. Brief precipitation occurred in the Ojai Valley between October 31 and November 3, 2003, which relieved some of the delivery demands of the SCWC operation.

Location

The Ojai Mutual Well Field test was conducted within the SCWC-owned parcel opposite San Antonio Creek from the Gorham Well Field, also owned and operated by Southern California Water Company. In addition to the pumping and observation wells located on the parcel and utilized for this test, at least two destroyed wells exist on the property (Ojai Mutual Well Nos. 1 and 2). The Ojai Mutual Well Field is west of San Antonio Creek and south of Grand Avenue in the central portion of the Ojai Basin (Figure 23).

Data

Precipitation and barometric conditions

As measured at the OJA precipitation station, approximately 2.33 inches of rain had fallen since the 2003-2004 water year began. The most recent measurable precipitation prior to the commencement of the Ojai Mutual Well Field aquifer test was on the afternoon of November 15, 2003. This precipitation event brought a total of 0.05 inch of rain and preceded the pumping by 4 days.

The County of Ventura recorded hourly measurements of barometric pressure at the Simi Valley station. Relatively stable (within 5 millibars) atmospheric pressure conditions predominated prior to and during the testing period, so no barometric corrections to water level data were necessary. Moreover, automated water-level monitoring equipment are vented to the atmosphere and measure pressure directly, so a correction for barometry is inherent in water level data.

Pumping Well

The pumping well for this test was Ojai Mutual Well No. 5. Three years earlier (in 2000), the 16-inch-diameter well casing was equipped with a 10-inch-diameter liner. Access for water level monitoring was capable via a 2-inch-diameter steel sounding port on the south corner of the concrete pump base. Only a narrow, flexible electric sounder could fit down the sounding port, so only manual water levels were collected from this well. A totalizer reading in cubic feet exists in a buried vault along the discharge line from the vertical turbine well pump. Additional well information is presented in Table 4.

Observation Wells

Available observation wells for this test were SCWC-owned and operated Ojai Mutal Well Nos. 3 and 4. Ojai Mutual Well No. 4 is a high-capacity well used for municipal supply for the City of Ojai; it is equipped with a vertical turbine pump which was idle prior to and during the pumping portions of the test. A 4-inch-diameter sounding port provides access for water level monitoring, and in addition to electric tape sounders, a dedicated 1-inch-diameter steel pressure transducer was able to be inserted into the well for the pre-test monitoring and test data collection.

Ojai Mutual Well No. 3 was an idle well in the field. No pump existed in the well casing prior to and during the test, and a hinged, locking well lid limits access. Water level monitoring equipment, including pressure transducers and electric tape sounders were able to be lowered directly down the well casing. Additional well information is presented in Table 4 and Figure 24.

Aquifer test design

The aquifer test was designed to be conducted after allowing a maximum feasible water level recovery prior to pumping. Continuous automatic water level monitoring began at 10:00 AM on November 20, 2003 and continued through 7:00 PM on November 22, 2003. Ideally, no well would be pumping in the general area for an extended period prior to pumping, but the local water demands and routine maintenance of equipment such as filters and piping required occasional pumping during the pre-pumping water level monitoring period. Hence, pumping ceased in the Ojai Mutual Well Field 22 hours prior to the testing period, at approximately 6:00 PM on November 20, 2003. Limited pumping of Ojai Mutual Well Nos. 4 and 5 (about 4 ½ hours each) was conducted between 10:00 AM and 6:00 PM on November 20, 2003.

The final manually-collected water levels in the tested wells prior to beginning pumping were collected at approximately 4:00 PM on November 20, 2003. In Ojai Mutual Well No. 3, the depth to water from the reference point (top of casing) was 112.03 feet. In Ojai Mutual Well No. 4, where the reference point was the top of the sounding tube, the depth to water was 113.02 feet. In the planned pumping well, Ojai Mutual Well No. 5, the static water level was 109.74 feet below the top of the sounding tube reference point.

The pumping test was planned to allow the pumping well to produce at its normal rate continuously for 24 hours. Water was pumped into the municipal supply system.

Pumping commenced in Ojai Mutual Well No. 5 at 4:38 PM on November 21, 2003. The initial pumping rate was as high as 1498 gpm for the first few minutes, decreased to 613 gpm after the first hour, and eventually stabilized to a test-long average of 383 gpm. The total time of pumping for the test was 1,446 minutes. Initial drawdown in the pumping and observation wells was very high, correlative to the high initial pumping rate and the possible cycling effects of the nearby SCWC Gorham/San Antonio wells. Basin-wide recharge/local recovery may have also contributed to the higher (shallower) observed water levels near the end of pumping when compared to early raw drawdown data. Following pumping, recovery was measured in the pumping and observation wells for three hours.

Table 4 – SCWC Ojai Mutual Well Field: Summary of Drilling and Well Construction Data

State Well Number *Owner* Name	**Drill Date**	**Drill Depth (ft)**	**Casing Diameter (inches)**	**Distance from Pumping Well (ft), Direction**	**Perforation Depth Intervals (feet)**	**Well and Pump Status/Information**
4N/22W-6K11 *Southern California WC* Ojai Mutual Well No. 5	1951	622	16	0	120–592	Pumping Well, 10-inch-diameter liner (2000)
4N/22W-6K1 *Southern California WC* Ojai Mutual Well No. 3	1925	560	12	52 WSW	150-520	No pump, well capped
4N/22W-6K3 *Southern California WC* Ojai Mutual Well No. 4	1947	600	8	187 SSE	150-580	Pump off throughout test

Observed Drawdown

Owing primarily to the high initial rates of groundwater production from Ojai Mutual Well No. 5, which is common in high-capacity water wells in which water levels have been allowed to recover for a significant period, initial drawdown values were very high. For much of the observation period, water levels were actually rising from the initial maximum drawdown.

Pumping well

In the pumping well, the final depth to water taken during the pumping phase was 164.51 feet, representing a drawdown of 54.77 feet from the static (pre-test) water level of 109.74 feet.

Observation wells

In Ojai Mutual Well No. 3, located 52 feet southwest of the pumping well, the final depth to water taken during the pumping phase was 124.43 feet, representing a drawdown of 12.40 feet from the static (pre-test) water level of 112.03 feet. A drawdown of 12.22 feet was recorded via the automatic datalogger during near the conclusion of pumping, although a drawdown of 13.45 feet was recorded five hours into pumping and recovered thereafter.

In Ojai Mutual Well No. 4, located 187 feet southeast of the pumping well, the final depth to water taken during the pumping phase was 117.22 feet, representing a drawdown of 4.20 feet from the static (pre-test) water level of 113.02 feet. A drawdown of 3.08 feet was recorded via the automatic datalogger during near the conclusion of pumping, although a drawdown of 3.65 feet was recorded three hours into pumping and recovered thereafter.

A summary of water level data is presented as Table 5. A graphic presentation of selected water level data (Ojai Mutual Well No. 4) is presented as Figure 25. Raw water level data (in tabular form) are presented as Appendix B.

Table 5 – Summary of November 2003 Ojai Mutual Well Field Aquifer Test Water Level Data

State Well Number ***Owner*** **Radial Distance**	**Pre-test Static**	**16 hours after pumping started, Average pumping rate = 398 gpm**		**24 hours after pumping started, Average pumping rate = 383 gpm**		**After 2 ½ hours of recovery**	
	Depth to groundwater Level (ft)	**Depth to ground-water level (ft)**	**Draw-down (ft)**	**Depth to ground-water level (ft)**	**Draw-down (ft)**	**Depth to ground-water level (ft)**	**Residual Drawdown (ft)**
4N/22W-6K11 *SCWC* Ojai Mutual Well No. 5	109.74	168.55	58.81	164.51	54.77	108.99	-0.75
4N/22W-6K1 *SCWC* Ojai Mutual Well No. 3	112.03	124.92	12.89	124.43	12.40	110.47	-1.56
4N/22W-6K3 *SCWC* Ojai Mutual Well No. 4	113.02	117.53	4.51	117.22	4.20	110.44	-2.58

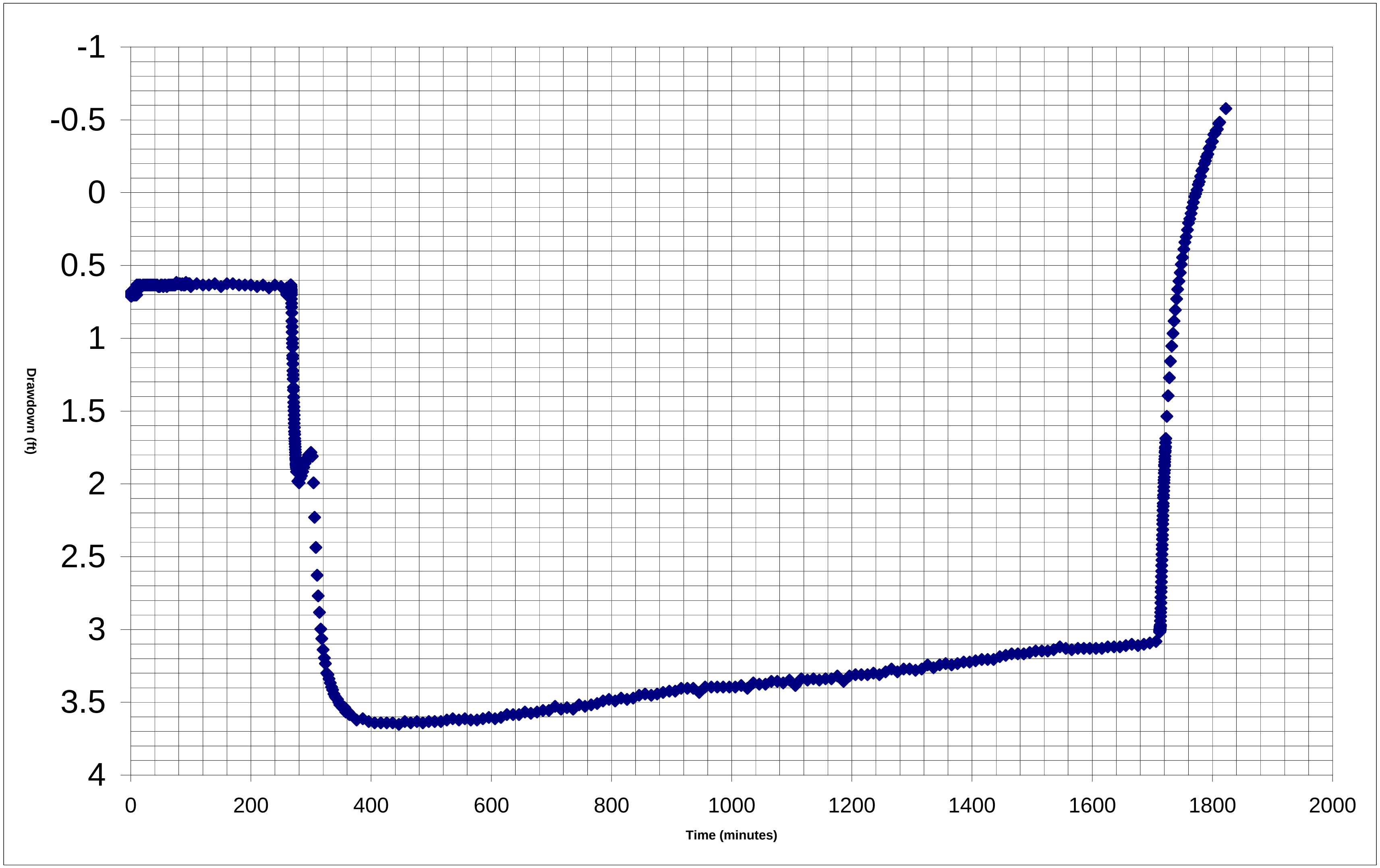


Figure 25. Summative water level observations, SCWC Ojai Mutual well no. 4.

Methods

Distance-drawdown, recovery analyses, and the Theis (1935) type-curve solution for unconfined aquifers via AQTESOLV (Geraghty and Miller, 2002) were used to determine aquifer characteristics. Driscoll's (1986) calculations for well efficiency were also considered.

Raw water level data from this aquifer test were used for all solutions due to the fact that pre-test monitoring indicated no identifiable water level trends, pumping data for SCWC San Antonio and Gorham Wells were wholly unavailable, barometric data indicated stable atmospheric conditions, and the pumping rate was not exactly constant throughout the pumping period.

Distance-drawdown

Distance drawdown analyses as presented by Cooper and Jacob (1946) were utilized for two pumping periods to identify aquifer parameters for this test. Both 15.5-hour and 24.1-hour test data are presented on Figure 26.

After approximately two-thirds of the test was complete (15.5 hours), the following data and solutions apply:

$Q = 398$ gpm $= 53.2$ cfm

$t = 930$ minutes

$\Delta s = 15.3$ ft

$r_o = 350$ ft

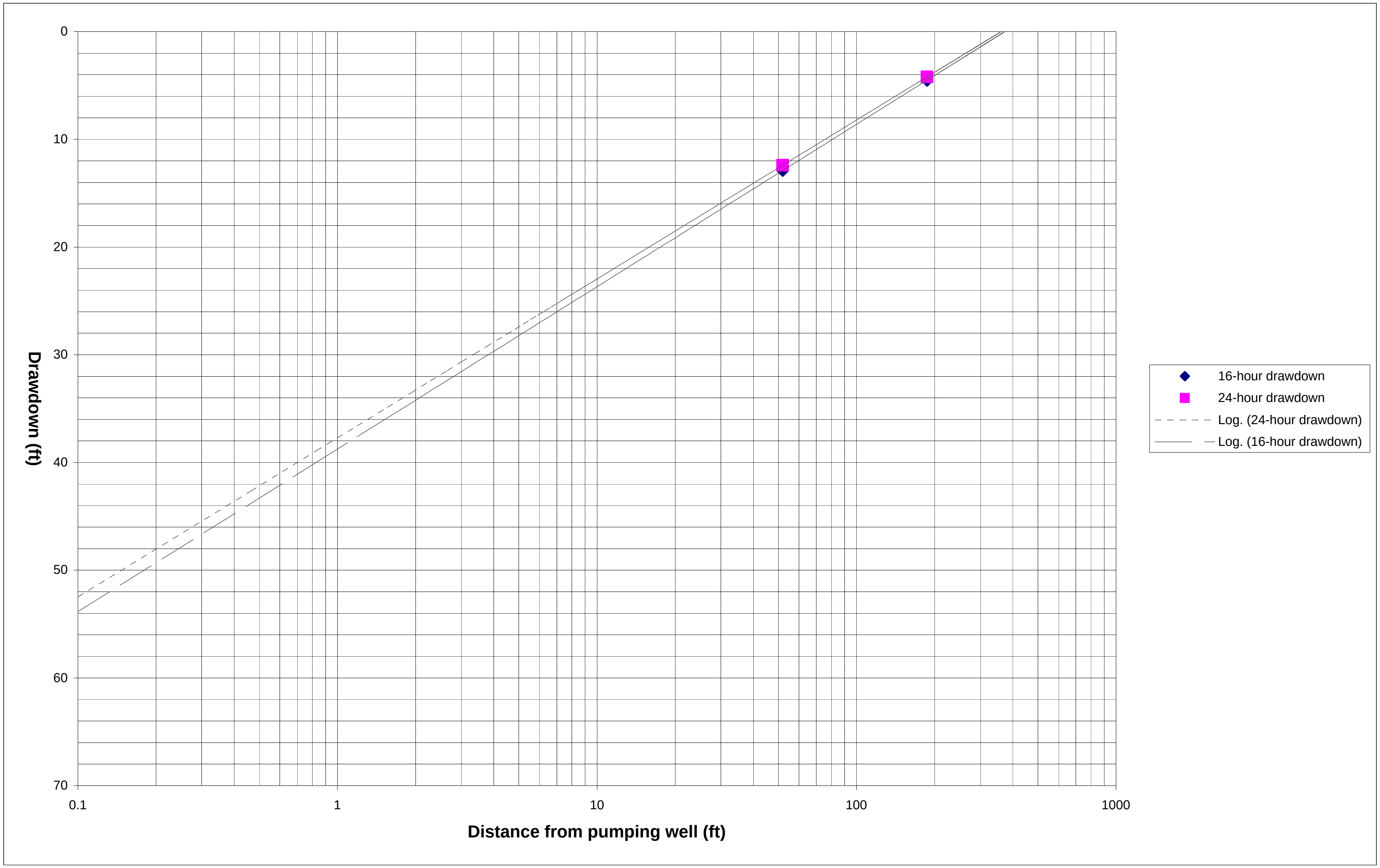


Figure 26. SCWC Ojai Mutual well field November 2003, distance drawdown analyses

and the Theis equation can be solved for transmissivity and storativity by:

$T = 2.303Q/2\pi\ \Delta s$

$T = 2.303\ (53.2\ \mathrm{ft}^3/\mathrm{min})/\ 2\ \pi\ (14.7\ \mathrm{ft})$

$T = 1.27\ \mathrm{ft}^2/\mathrm{min}$

$S = 2.25Tt/r_o^2$

$S = 2.25\ (1.27\ \mathrm{ft}^2/\mathrm{min})\ (930\ \mathrm{min})\ /\ (350)^2$

$S = 0.022$

At the end of pumping (24.1 hours), the following data and solutions apply:

Q = 383 gpm = 51.3 cfm

t = 1446 minutes

$\Delta s = 14.8$ ft

$r_o = 350$ ft

and the Theis equation can be solved for transmissivity and storativity by:

$T = 2.303Q/2\pi\ \Delta s$

$T = 2.303\ (51.3\ \mathrm{ft}^3/\mathrm{min})/\ 2\ \pi\ (14.8\ \mathrm{ft})$

$T = 1.27\ \mathrm{ft}^2/\mathrm{min}$ (13,687 gpd/ft)

$S = 2.25Tt/r_o^2$

$S = 2.25\ (1.27\ \mathrm{ft}^2/\mathrm{min})\ (1446\ \mathrm{min})\ /\ (350)^2$

$S = 0.034$

Recovery

Recovery analyses for a pumping well can be a valuable asset to compare with drawdown data. Because recovery levels rose to shallower depths than the original static water level, an assumed static level of 108 feet was used for these calculations. Figure 27 presents recovery data for the pumping well, Ojai Mutual Well No. 5.

$\Delta s' = 6$ ft

$t = 1446$ min

$Q = 51.3$ cfm

$T = 2.303Q/4\pi\Delta s'$

$T = 2.303\ (51.3\ \text{cfm})/4\pi\ (6\ \text{ft})$

$T = 1.57\ \text{ft}^2/\text{min}$

Theis type-curve matching

Although not all assumptions of the solution are met, type-curve analyses of the data by the Theis (1935) unconfined aquifer solution appears to yield the most consistent type-curve matching results (Figure 28). Based on the type-curve analyses, transmissivity values are on the order of 2.214 ft^2/min and storativity values are on the order of 0.01593.

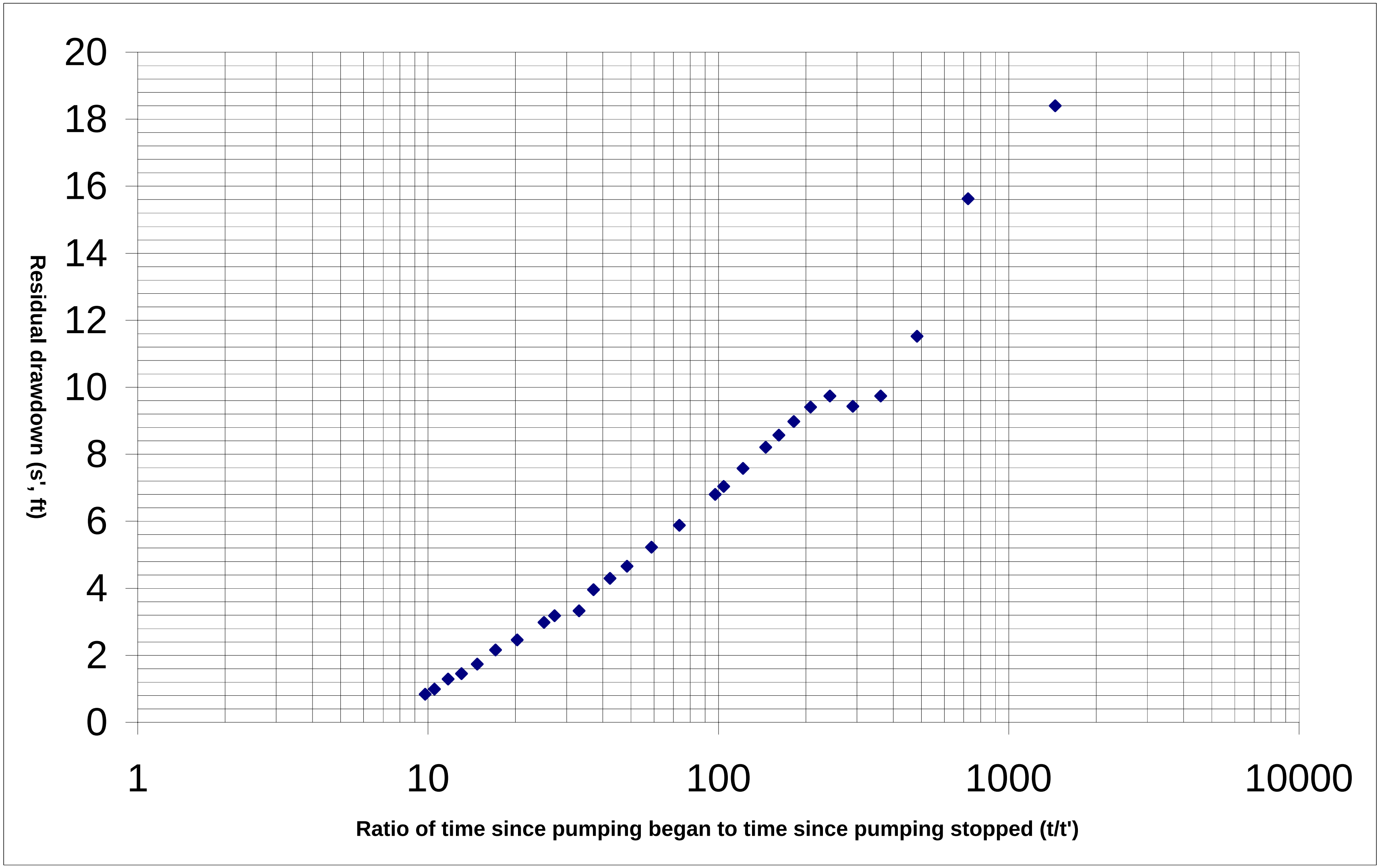


Figure 27. Recovery analyses, Ojai Mutual well no. 5, November 2003.

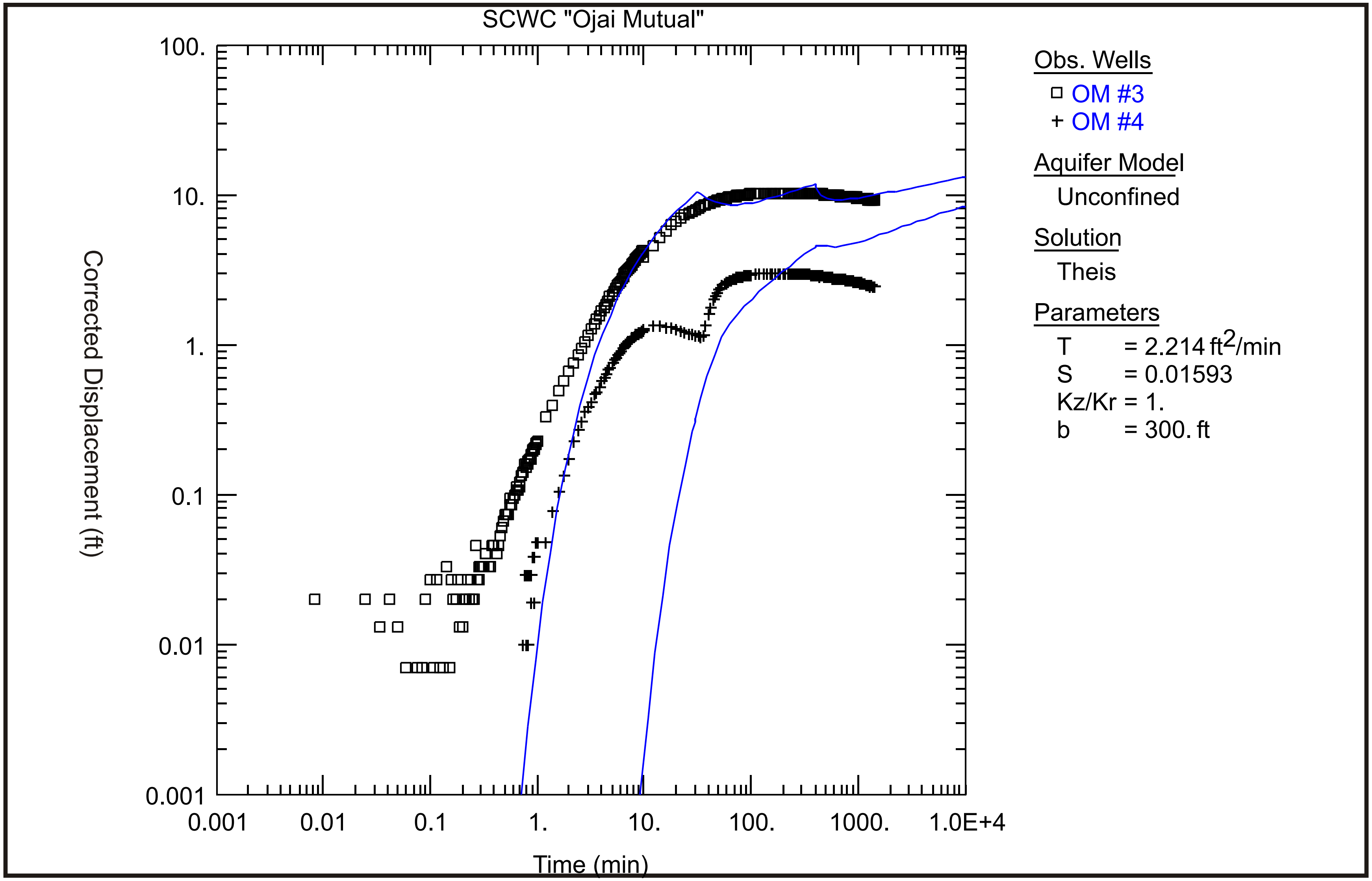


Figure 28. Theis solution, SCWC Ojai Mutual observation wells 4N/22W-6K3 and -6K1.

Well efficiency

The efficiency of the pumping well (Ojai Mutual Well No. 5) can be determined by comparing the theoretical specific capacity of the well, based on aquifer transmissivity and storativity, with the actual specific capacity of the well. The theoretical specific capacity can be estimated by the equation presented by Driscoll (1986):

Theoretical $Q/s = T / 264 (\log (0.3Tt/r^2S))$

For Ojai Mutual Well No. 5,

$T = 13{,}687$ gpd/ft

$t = 1$ day

$r = 0.6$ ft

$S = 0.034$

Theoretical $Q/s = 13{,}687$ gpd/ft $/ 264 (\log (0.3 (13{,}687$ gpd/ft $(1$ day$)/(0.6)^2$ $0.034))$

Theoretical $Q/s = 24.2$ gpm/ft

Measured specific capacity of the pumping well was 7 gpm/ft, calculated by dividing the pumping rate of 383 gpm by a drawdown of 54.77 ft. Hence, the efficiency for the well can be estimated by:

Well Efficiency = Measured Specific Capacity/Theoretical Specific Capacity X 100

Well Efficiency = 7 gpm/ft / 24.2 gpm/ft = 29%

Such a low well efficiency is common for older wells which have been equipped with well liners.

Results

Based on the SCWC Ojai Mutual aquifer test of November 2003, the following summary of aquifer data can be presented:

Table 6 –
Summary of November 2003 Ojai Mutual Well Field Aquifer Test Aquifer Characteristics

Parameter	Distance Drawdown (15-hour data)	Distance Drawdown (24-hour data)	Pumping Well Recovery	Theis type curve matching	Driscoll Well Efficiency
Transmissivity (ft^2/min)	1.27	1.27	1.57	2.214	--
Storativity	0.022	0.034	--	0.01593	--
Radius of influence	350 ft	350 ft	--	--	--
Well Efficiency	--	--	--	--	29%

Southeast Ojai Basin (Jerry Conrow Well)

Introduction

Aquifer testing in the southeast portion of the Ojai Basin was conducted in late January 2004. Monitoring of the observation and pumping wells began on January 19, 2004 and continued until January 31, 2004. The pumping schedule was designed to follow a relatively dry period such that citrus orchards could be irrigated during the pumping portions of the test.

Controlled pumping of Mr. Jerry Conrow's well (4N-22W-5Q1) began on January 27, 2004 while other nearby wells (4N/22W-5R2 and 5J7) were idle and monitored for water level changes. Although the pumping well was pumping for four days, after 22 hours of pumping Well 5J7 began pumping and began causing an increased water level drawdown interference. The average pumping rate was 266 gpm (51.3 cfm) for the 22 hour pumping period. Based on drawdown analyses and aquifer testing solutions, the data indicate confined conditions in the area of the aquifer test.

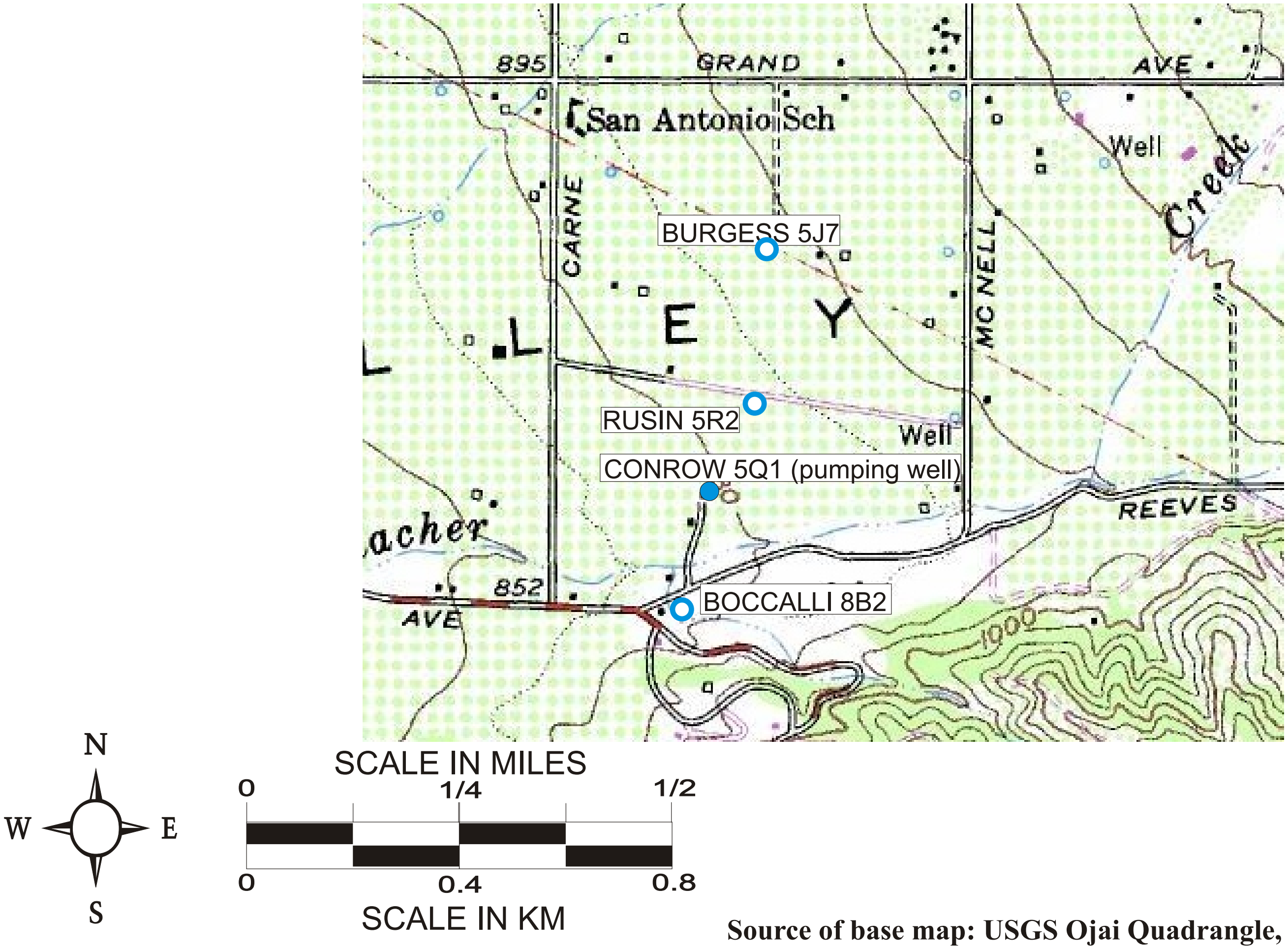
This well field was selected for inclusion into the testing due to the proximity of potential observation wells, existing pump and power apparatus that need to be used for the private orchard irrigation, a location for discharge waters, and ancillary access and pumping volume monitoring apparatus.

Timing of this aquifer test was key in that several well owners began pumping shortly following the test due to the hot and dry conditions prevailing during January 2004. Hence, only the first 22 hours of pumping data are considered reliable.

Location

As shown on Figure 29, the pumping and observation wells are located within one-half mile north of Reeves Road, between Carne Road to the west and McNell Road to the east. The aquifer testing area covers several privately-owned parcels, ground surface at the testing area is largely occupied by citrus groves, with limited roads, private drives, and residences. Pumping began on January 27, 2004 and continued for four days.

This area was selected for inclusion into the testing due to the proximity of potential observation wells, existing pump and power apparatus that need to be used for the private orchard irrigation, a location for discharge waters, and ancillary access and pumping volume monitoring apparatus. Moreover, the location of the pumping and observation wells provided a potential means to test the effects of a no-flow boundary (bedrock/Santa Ana Fault at the southern margin of the Ojai Basin) approximately 1/5 mile south of the pumping well and trending roughly east-northeast (Figure 3).



Source of base map: USGS Ojai Quadrangle, 1988

Figure 29. Locations of wells monitored during 2004 Conrow test.

Data

Precipitation and barometric conditions

As measured at the OJA precipitation station, approximately 5.13 inches of rain had fallen since the 2003-2004 water year began. The most recent measurable precipitation prior to the commencement of the Conrow aquifer test was on the evening of January 26, 2004. This precipitation event brought a total of 0.01 inch of rain and preceded the pumping by 16 hours; similar precipitation events (each of 0.01 inch) occurred three and seven days prior to the pumping test.

The County of Ventura recorded hourly measurements of barometric pressure at the Simi Valley station. Relatively stable (within 3 millibars) atmospheric pressure conditions predominated during the key 22 hours of the testing period, so no barometric corrections to water level data were necessary. Additionally, automated water level monitoring equipment are vented to the atmosphere and measure pressure directly, so a correction for barometry is inherent in water level data.

Pumping Well

The pumping well for this test was Well No. 4N/22W-5Q1, an irrigation well belonging to Mr. Jerry Conrow. At the time of the test, the well was relatively new, having been constructed between June and September 2003. Drilled via rotary methods, the well boring was advanced to 390 feet, and 385 feet of steel casing with interspersed perforations was installed. Access for water level monitoring was capable via a 2-inch-diameter steel sounding port on the northwest corner of the concrete pump base. Approximately 122 feet of electric sounder cable was stuck down the well, cut off near ground surface, and tied off through the sounding tube cap. This cable was reportedly abandoned when a representative of the pumping development company was unable to retrieve it. To allow access for functional sounding equipment, the author carefully removed the abandoned cable. With access available, manual water levels were collected from this well. A totalizer reading in acre feet exists on an elevated portion of the discharge line from the vertical turbine well pump. Additional well information is presented in Table 7

Observation Wells

Available observation wells for this test were privately-owned wells in the vicinity on adjacent or nearby parcels to that which was served by the pumping well. Well 4N/22W-5R2 is reportedly idle, but equipped with a vertical turbine pump which was idle prior to and during the pumping portions of the test. A narrow space between the pump base and the well casing allows for access for water level monitoring, and in addition to electric tape sounders, a dedicated 1-inch-diameter steel pressure transducer was able to be inserted into the well for the pre-test monitoring and test data collection.

Well 4N/22W-5J7 is an active irrigation well for the property to the north of Mr. Conrow's. A submersible pump existed in the well, and a narrow access port in the surface plate allowed only electric tape sounders to be lowered directly down the well casing for manual water level measurement. As mentioned above, this well began pumping 22 hours after Mr. Conrow's well began extracting groundwater during this test.

Located adjacent to a nearby restaurant, Well No. 4N/22W-8B2 would pump cyclically at low rates on demand for restaurant supply throughout the pumping period, so corrections to raw data were necessary.

Figure 30 presents a schematic diagram of known and assumed well and aquifer parameters for the aquifer test area.

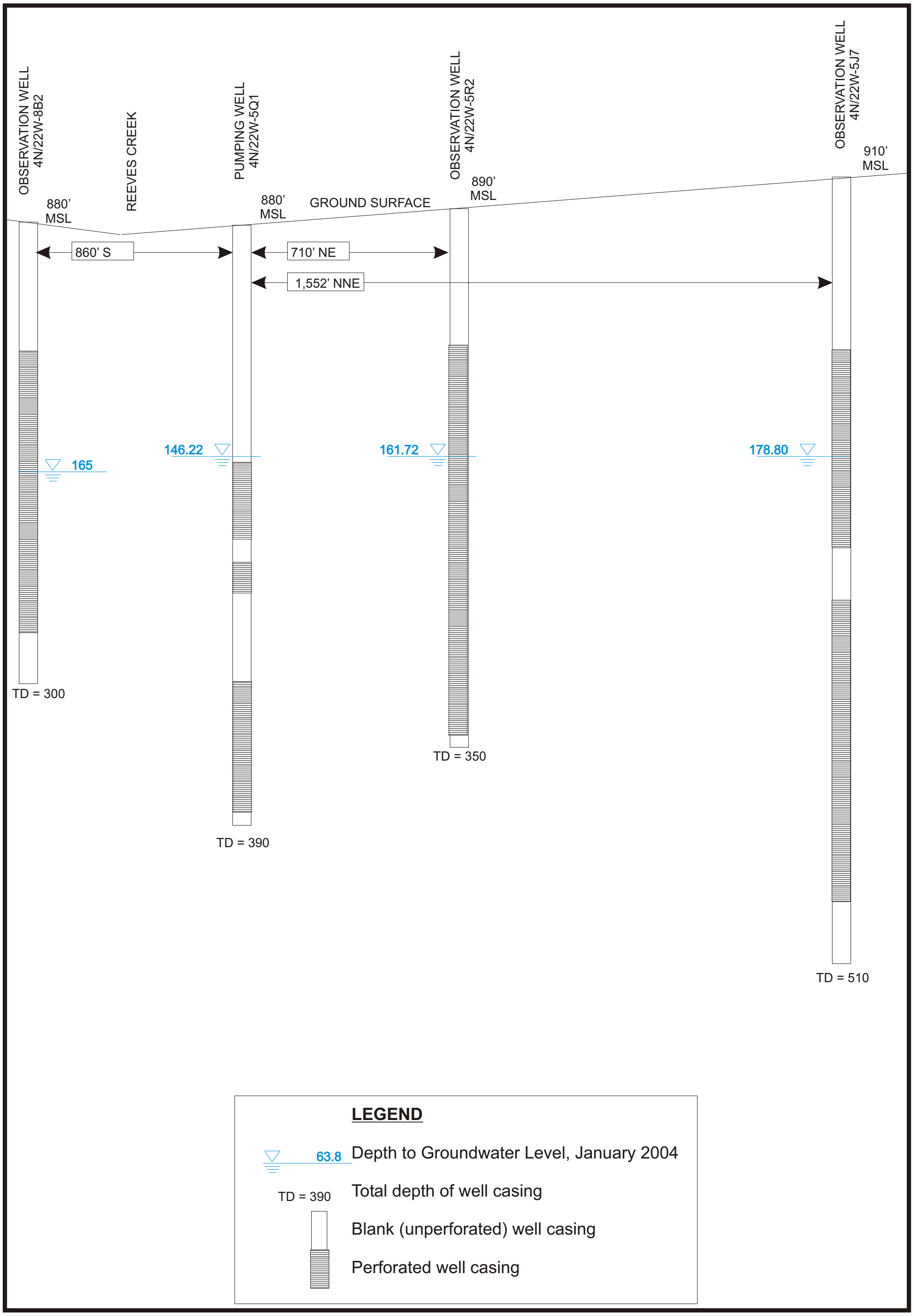


Figure 30. Schematic of pumping well 4N/22W-5Q1 and observation wells 4N/22W-5J7, -5R2, and -8B2 (locations shown on Figure 29).

Aquifer test design

The aquifer test was designed to be conducted after allowing a maximum feasible water level recovery prior to pumping. Continuous automatic water level monitoring began in Well 5R2 at 4:00 PM on January 19, 2004 and continued through 4:00 AM on January 30, 2004 when the datalogger ran out of memory. Ideally, no well would be pumping in the general area for an extended period prior to pumping, but the local water demands and required occasional pumping during the pre-pumping water level monitoring period. Hence, a brief 3-hour-pumping period was conducted on January 26, 2004 just over 24 hours prior to the testing period, at approximately 9:00 AM to noon. Other wells in the area may have been pumping intermittently, but automatic pre-test water level monitoring indicates that periods were likely brief and did not cause significant drawdown in Well 5R2.

The final manually collected water levels in the tested wells prior to beginning pumping were collected between approximately 11:30 AM and noon on January 27, 2004. In Conrow Well No. 5Q1, the depth to water from the reference point (top of sounding tube) was 146.22 feet. In Well No. 4N/22W-5R2, where the reference point was the top of the well casing, the depth to water was 161.72 feet. In the other observation wells, the depths to water were variable or not able to be measured. Well 8B2 reached a shallowest recovery depth to water of 165 feet between its own pumping cycles. In Well 5J7, the depth to water was approximately 178.80 feet.

The pumping test was planned to allow the pumping well to produce at its normal rate continuously for four days. Water was pumped into the orchard irrigation system.

Pumping commenced in the Conrow Well at 12:00 noon on January 27, 2004. The pumping rates were relatively constant, ranging between 255 and 280 gpm, with the initial 22 hours (1,333 minutes) bearing a 266 gpm average. Over the course of the 4 days of pumping the average rate was approximately 242 gpm. The total time of pumping for the test was 5,760 minutes. Following pumping, recovery was measured in the pumping well for 30 minutes.

Table 7 – Summary of Drilling and Well Construction Data

State Well Number *Owner* Name	**Drill Date**	**Drill Depth (feet)**	**Casing Diameter (inches)**	**Distance from Pumping Well (ft), Direction**	**Perforation Depth Intervals (feet)**	**Well and Pump Status/Information**
4N/22W-5Q1 ***Jerry Conrow*** **Well No. 2**	2003	390	14	0	150–200 220–240 300–385	Pumping Well, Casing installed to 385 feet
4N/22W-5R2 ***Barbara Rusin*** **Idle well**	1949*	350	12	710 ft 042° NE	?	Idle vertical turbine pump in well
4N/22W-5J7 ***James Burgess*** **Irrigation Well**	1930	510	9 5/8 (below 280)	1,552 018° NNE	"old well" 0-280; deepened and perforated 280-476	Well Began pumping 22 hours into test
4N/22W-8B2 ***Boccalli's Restaurant*** **Restaurant Well**	1948*	300	10	860 191° S	unknown	Restaurant Well cycled frequently at low pumping rates

* indicates earliest date of available data for well

Observed Drawdown

During the first 22 hours of pumping, the water levels decreased in the pumping and observation wells due to the groundwater extraction at the Conrow Well. For days two and three of pumping, production at Well J7 caused superposed drawdown in all observed wells.

Pumping well

In the pumping well, the 22-hour depth to water taken during the pumping phase was 162.42 feet, representing a drawdown of 16.20 feet from the static (pre-test) water level of 146.22 feet. After the complete 4-day irrigation period, the pumping water level was 160.47, representing a drawdown of 14.25 feet; note that the latter three days of the pumping period had a decreased pumping rate relative to the initial 22 hours.

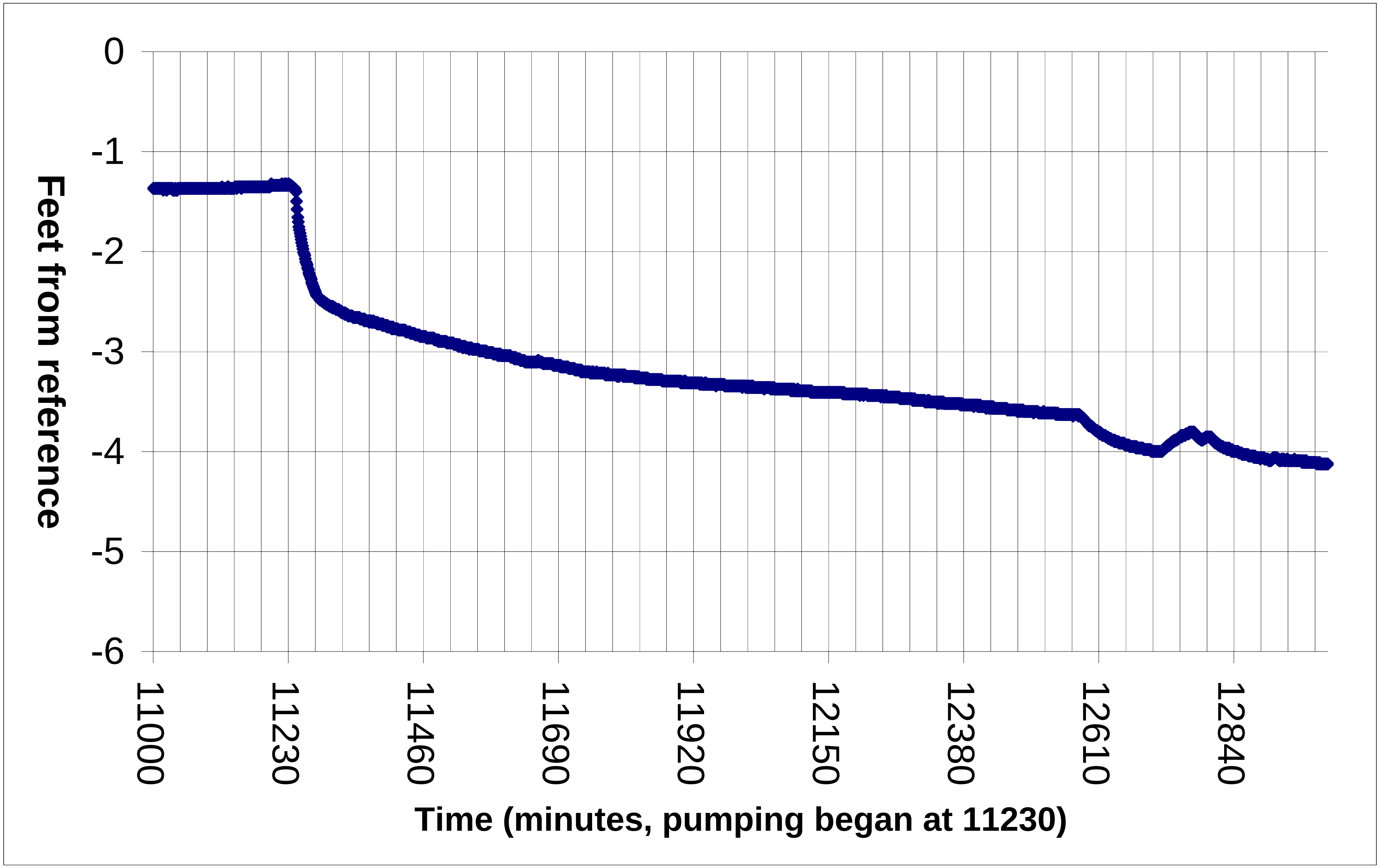


Figure 31: Summative water level observations, well 4N/22W-5R2.

Observation wells

In Well No. 5R2, located 710 feet northeast of the pumping well, the 22-hour depth to water taken during the pumping phase was 164.28 feet, representing a drawdown of 2.56 feet from the static (pre-test) water level of 161.72 feet. A drawdown of 2.30 feet was recorded via the automatic datalogger after 22 hours (1,333 minutes) before the effects of pumping of Well 5J7 were noticed. In Well No. 5J7, located 1,552 feet north-northeast of the pumping well, the final depth to water taken prior to its pumping was 180.17 feet, representing a drawdown of 1.37 feet from the static (pre-test) water level of 178.80 feet.

In Well No. 8B2, located 860 feet south of the pumping well, the assumed static water level was 165.00 feet, since the well was intermittently pumping. After 22 hours of pumping the Conrow Well, drawdown was 3.85 feet with an assumed water level of 168.85 feet. This higher drawdown for this well may be due to its own pumping effects, but the no-flow boundary of Tertiary rocks to the south would also likely increase the effects of the pumping of the Conrow Well. A summary of water level data is presented as Table 8. A graphic presentation of raw water level data for Observation Well 4N/22W-5R2 is presented as Figure 31. Data from the test are presented in table format as Appendix C.

Table 8 – Summary of January 2004 Southeast Ojai Basin Aquifer Test Water Level Data

State Well Number *Owner* Radial Distance	**Pre-test Static**	**22 hours into pumping, Average rate 266 gpm**	
	Depth to groundwater level (ft)	**Depth to groundwater level (ft)**	**Drawdown (ft)**
4N/22W-5Q1 ***Jerry Conrow*** **Well No. 2** **0**	146.22	162.42	16.20
4N/22W-5R2 ***Barbara Rusin*** **Idle well** **710**	161.72	164.28	2.56
4N/22W-5J7 ***James Burgess*** **Irrigation Well** **1,552**	178.80	180.17	1.37
4N/22W-8B2 ***Boccalli's Restaurant*** **Restaurant Well** **860**	165.00#	168.85	3.85

shallowest water level recovery between pumping cycles

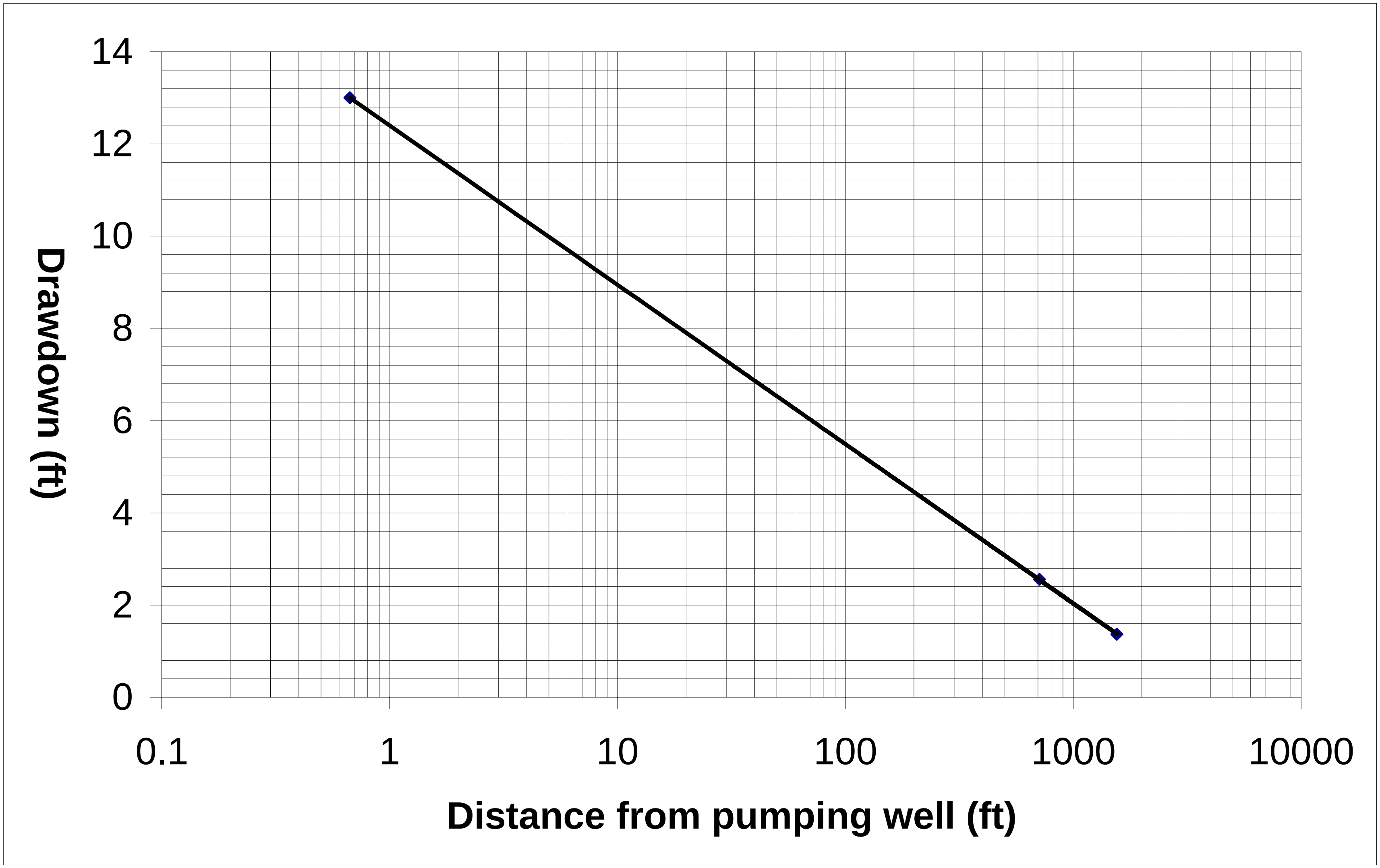


Figure 32. Distance-drawdown, Conrow Test, January 2004.

Methods

Distance-drawdown, recovery analyses, and the Theis (1935) type-curve solution for confined aquifers via AQTESOLV (Geraghty and Miller, 2002) were used to determine aquifer characteristics. Driscoll's (1986) calculations for well efficiency were also considered.

Raw water level data from this aquifer test were used for all solutions due to the fact that pre-test monitoring indicated no significant water level trends, barometric data indicated stable atmospheric conditions, and the pumping rate was not exactly constant throughout the pumping period. Note that manually-collected water levels were used for distance drawdown and recovery analyses, while automatically-collected data were used for type-curve analyses.

Distance-drawdown

Distance drawdown analyses as presented by Cooper and Jacob (1946) were utilized for the 22-hour pumping period to identify aquifer parameters for this test. A distance drawdown graph using test data are presented on Figure 32.

After the first day of pumping was nearly complete (22 hours), the following data and solutions apply:

$Q = 266$ gpm $= 35.5$ cfm

$t = 1{,}333$ minutes

$\Delta s = 4.5$ ft

$r_o = 3{,}800$ ft

and the Theis equation can be solved for transmissivity and storativity by:

$T = 2.303Q/2\pi\ \Delta s$

$T = 2.303\ (35.5\ ft^3/min)/\ 2\ \pi\ (4.5\ ft)$

$T = 2.89\ ft^2/min$

$S = 2.25Tt/r_o^2$

$S = 2.25\ (2.89\ ft^2/min)\ (1333\ min)\ /\ (3{,}800)^2$

$S = 0.0006$

Recovery

Recovery analyses for a pumping well can be a valuable asset to compare with drawdown data. Figure 33 presents recovery data for the pumping well.

$\Delta s' = 0.7$ ft

$t = 5760$ min

$Q = 32.3$ cfm

$T = 2.303Q/4\pi\Delta s'$

$T = 2.303\ (32.3\ cfm)/4\pi\ (0.7\ ft)$

$T = 8.46\ ft^2/min$

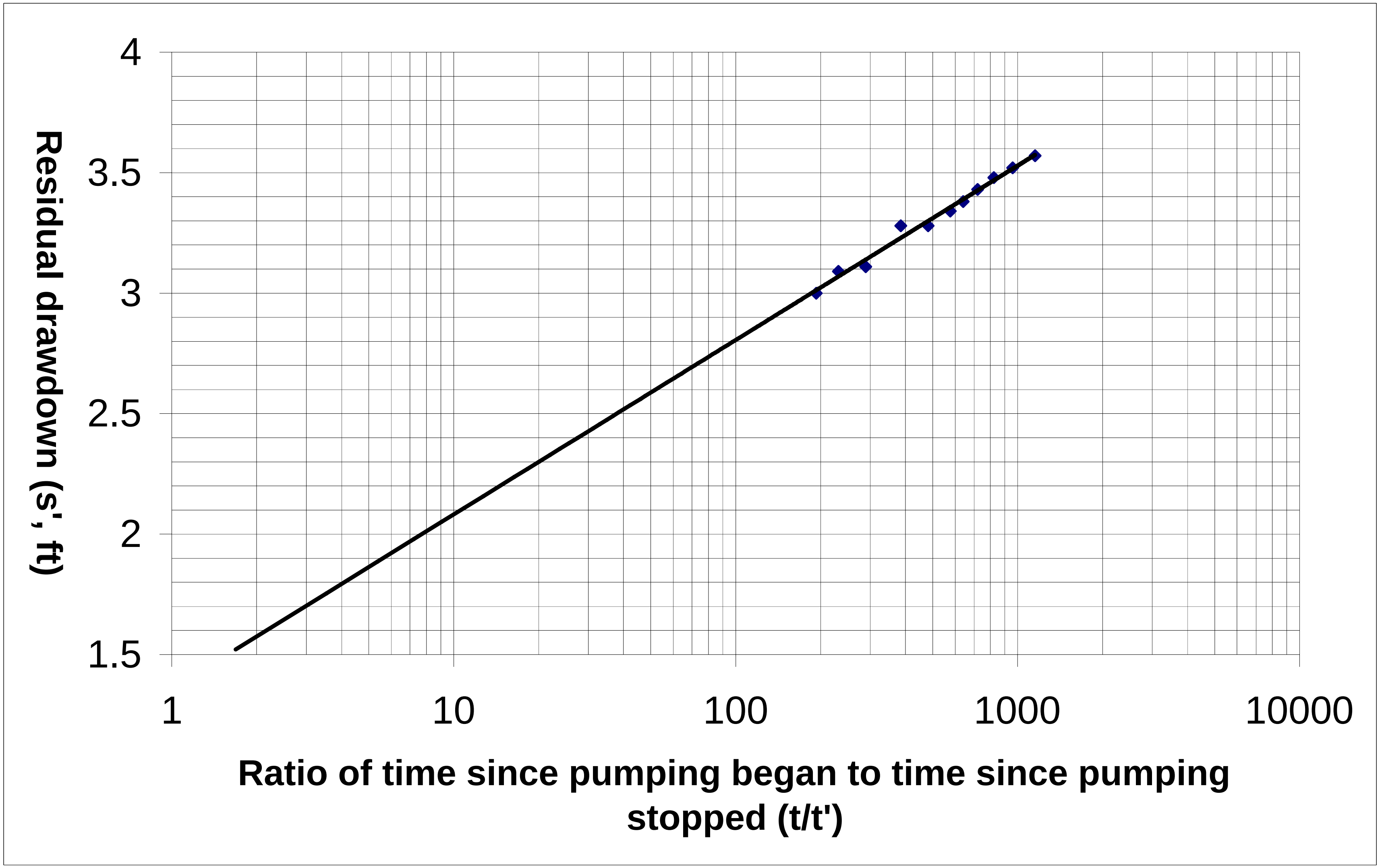


Figure 33. Recovery analyses, Conrow Well, January 2004.

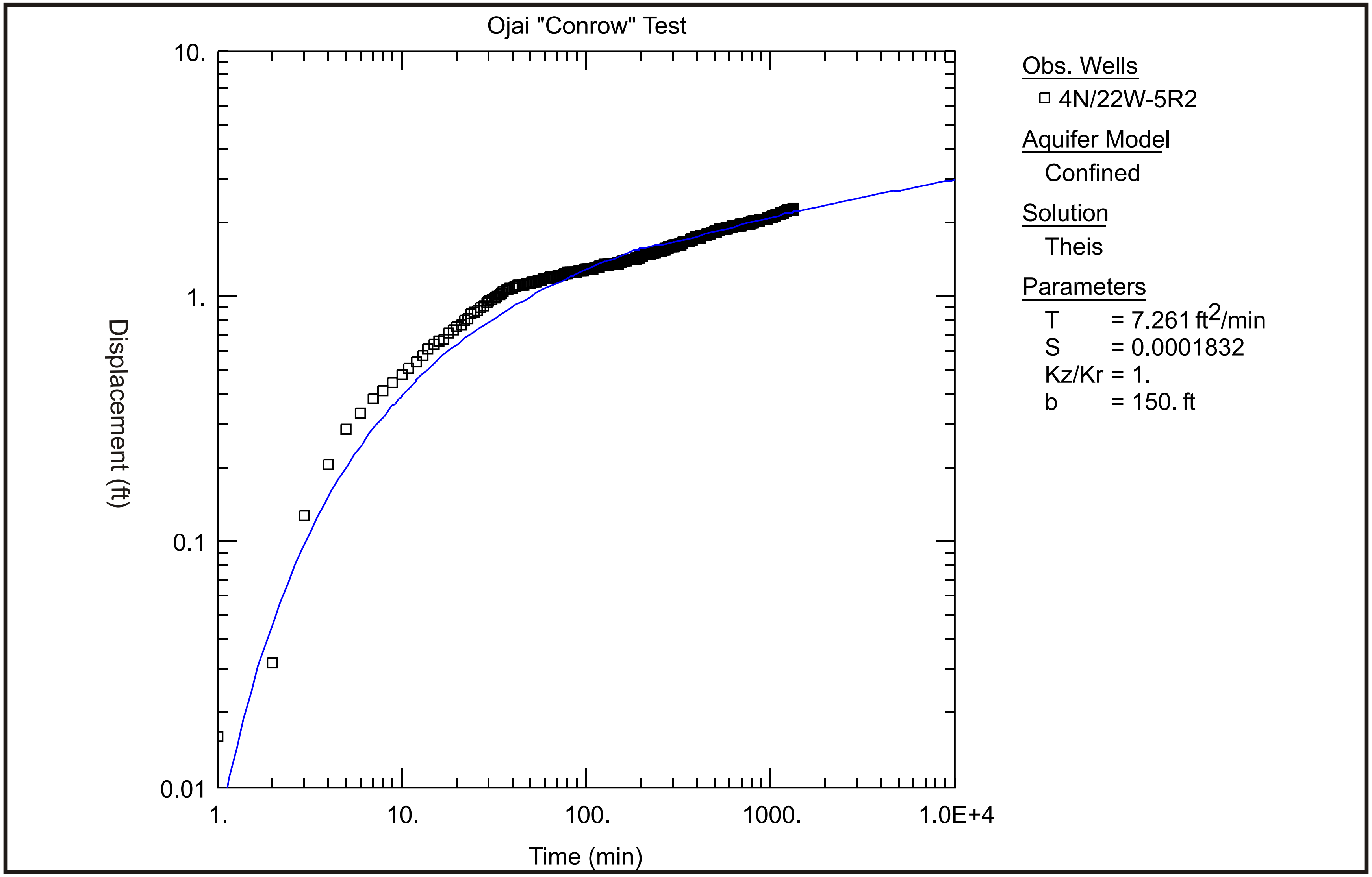


Figure 34. Theis solution, Conrow observation well 4N/22W-5R2.

Theis type-curve matching

Theis (1935) derived an equation which predicts water-level displacement in a confined aquifer in response to pumping. Although not all assumptions of the solution are met, type-curve analyses of the data by the Theis (1935) unconfined aquifer solution appears to yield the most consistent data and match the curves of displacement versus time to the greatest detail (Figure 34). Based on the type-curve analyses, transmissivity values are on the order of 7.261 ft^2/min and storativity values are on the order of 0.0001832.

Well efficiency

In confined aquifers, where no dewatering of the aquifer itself occurs, the efficiency of the well can be estimated by continuing the distance drawdown curve to the point on the outside of the well casing.

At 16 inches, the radial distance is 8 inches or 0.67 foot. The distance-drawdown curve projected to this point on the x-axis corresponds to a drawdown value of 13 feet.

For the Jerry Conrow Well No. 5Q1, at 22 hours of pumping, the actual drawdown in the pumping well was 16.20 feet. Measured specific capacity of the pumping well was 16.42 gpm/ft, calculated by dividing the pumping rate of 266 gpm by a drawdown of 16.20 ft. Hence, the efficiency for the well can be estimated by:

Well Efficiency = Measured drawdown in well/Theoretical Drawdown at edge of well casing X 100

Well Efficiency = 13 gpm/ft / 16.2 gpm/ft = 80.2%

Such a high well efficiency is to be expected for a relatively new well.

Results

Based on the southeast Ojai Basin aquifer test of January 2004, the following summary of aquifer data can be presented:

Table 9 – Summary of January 2004 Southeast Ojai Basin Well Field Aquifer Test Aquifer Characteristics

Parameter	Distance Drawdown (22-hour data)	Pumping Well Recovery (4 days pumping)	Theis type curve matching	Driscoll Well Efficiency
Transmissivity	2.89 ft^2/min	8.46 ft^2/min	7.261 ft^2/min	--
Storativity	0.0006	--	0.0001832	--
Radius of influence	3800 ft	--	--	--
Well Efficiency	--	--	--	80.2%

All methods of aquifer solutions employed appear to be in agreement to within an order of magnitude. Hence the confidence level of these values is moderate to high.

East Ojai Basin (Senior Canyon Water Company – Grant Well)

Introduction

Automatic and manual water level monitoring began on February 25, 2004 and continued until March 6, 2004 for the Senior Canyon Mutual Water Company (SCMWC) "Grant Well" aquifer test. During this time period, the region received significant precipitation and water levels within the basin were recovering during the test. Hence, data required some corrections to account for rising water levels and normalize accurate drawdown calculations. Pumping from the Grant Well began on March 2, 2004 and continued for exactly 24 hours, during which time the pumping rate averaged 325 gpm (43.5 cfm). Data from observation wells to the south indicate confined conditions but data from one well to the north indicated unconfined conditions.

With the concurrent precipitation and cooler prevailing temperatures, there was apparently no pumping in any of the wells in the area except for the Grant Well associated with this testing. Normalized testing data provided an excellent data set for aquifer analysis and interpretation. This hydrologic and logistic favorability rendered this test one of the most ideal during this study.

Location

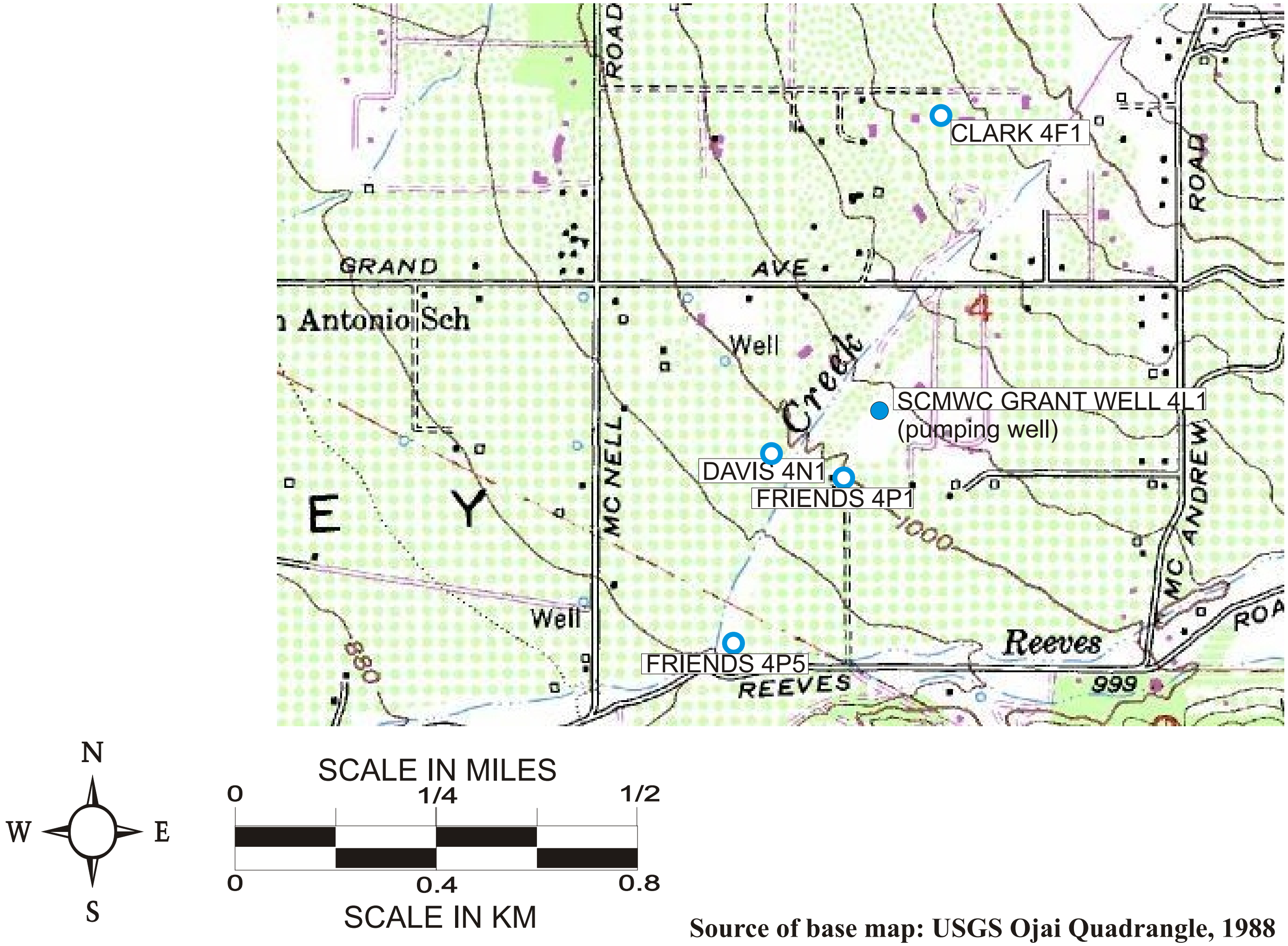
The SCMWC Grant Well was selected due to its location in the basin, logistical ability to be pumped by the water company, proximal potential observation wells, existing pump and power apparatus, a location for discharge waters, and ancillary access and pumping volume monitoring apparatus. The Grant Well is located in an area of low-density residential development and many citrus groves. Nearby active and inactive wells provided access to the aquifers for water level monitoring at the Friends Ranch and Bob Davis properties (Figure 35).

Data

Precipitation and barometric conditions

As measured at the OJA precipitation station, approximately 8.24 inches of rain had fallen between the beginning of the 2003-2004 water year and when monitoring for this aquifer test began. Between 10:00 AM on February 25, 2004 and 3:00 AM on February 26, 2004, 3.24 inches of rain fell at the OJA station and the year-to-date total was 11.48 inches. Near an observation well (4P1), a pot collected 3.75 inches of rain from this storm. Following this storm, many creeks in the valley area were noted to contain flowing water but the Thacher Creek channel near the Grant Well remained dry. Another storm system brought an additional inch of rain to the valley floor between March 1 and March 2, 2004. This storm event brought a total of 0.58 inch of rain and the most recent measurable precipitation preceded the pumping by 10 hours.

Hourly measurements of barometric pressure were recorded at the Simi Valley station by the County of Ventura. An approximate 7-millibar increase in atmospheric pressure conditions during the 24-hour pumping period was observed, and although the automatic data recording self-corrects for these changes, the manually-collected



Source of base map: USGS Ojai Quadrangle, 1988

Figure 35. Locations of wells monitored during 2004 SCMWC test.

water levels from key wells such as 4N1 requires barometric corrections to water level data.

Pumping Well

The pumping well for this test was the SCMWC Grant Well. In 1999, the 10-inch-diameter well casing was equipped with an 8-inch-diameter steel liner. Access for water level monitoring was capable via a ¼-inch-diameter flexible air line near the pump base. No access could be managed with an electric sounder or pressure transducer via orifices near the pump base. Only manual water levels obtained via air line measurements were collected from the pumping well during the pumping test. A totalizer reading in cubic feet exists in a control shed along the discharge line from the submersible well pump. Additional well information is presented in Table 10.

Observation Wells

Available key observation wells for this test were two wells on the Friends Ranch to the south of the pumping well (State well nos. 4N/22W-4P1 [idle] and -4P5 [active]), an irrigation well belonging to Bob Davis (State well no. 4N/22W-4N1), and the Stan Clark Well (State well no. 4N/22W-4F1). One of the Friends Ranch wells (4P1) was equipped with a low-capacity submersible pump but neither powered nor active; this well was fully accessible for electric tape sounder and pressure transducer water level measurement. Another Friends Ranch well (4P5) was equipped with a high-capacity pump but was not pumping during the time of the test; it was monitored manually. The active, but idle during the test, Bob Davis well (4N1), is an irrigation well equipped with a high-capacity vertical turbine pump, with water levels monitored manually. The Clark Well (4F1) was monitored during the test via an air line, and is a low-capacity well equipped with a submersible pump and used for domestic and irrigation purposes. Table 11 presents well data, while Figure 36 presents a schematic diagram of pumping well, observation well, and aquifer systems.

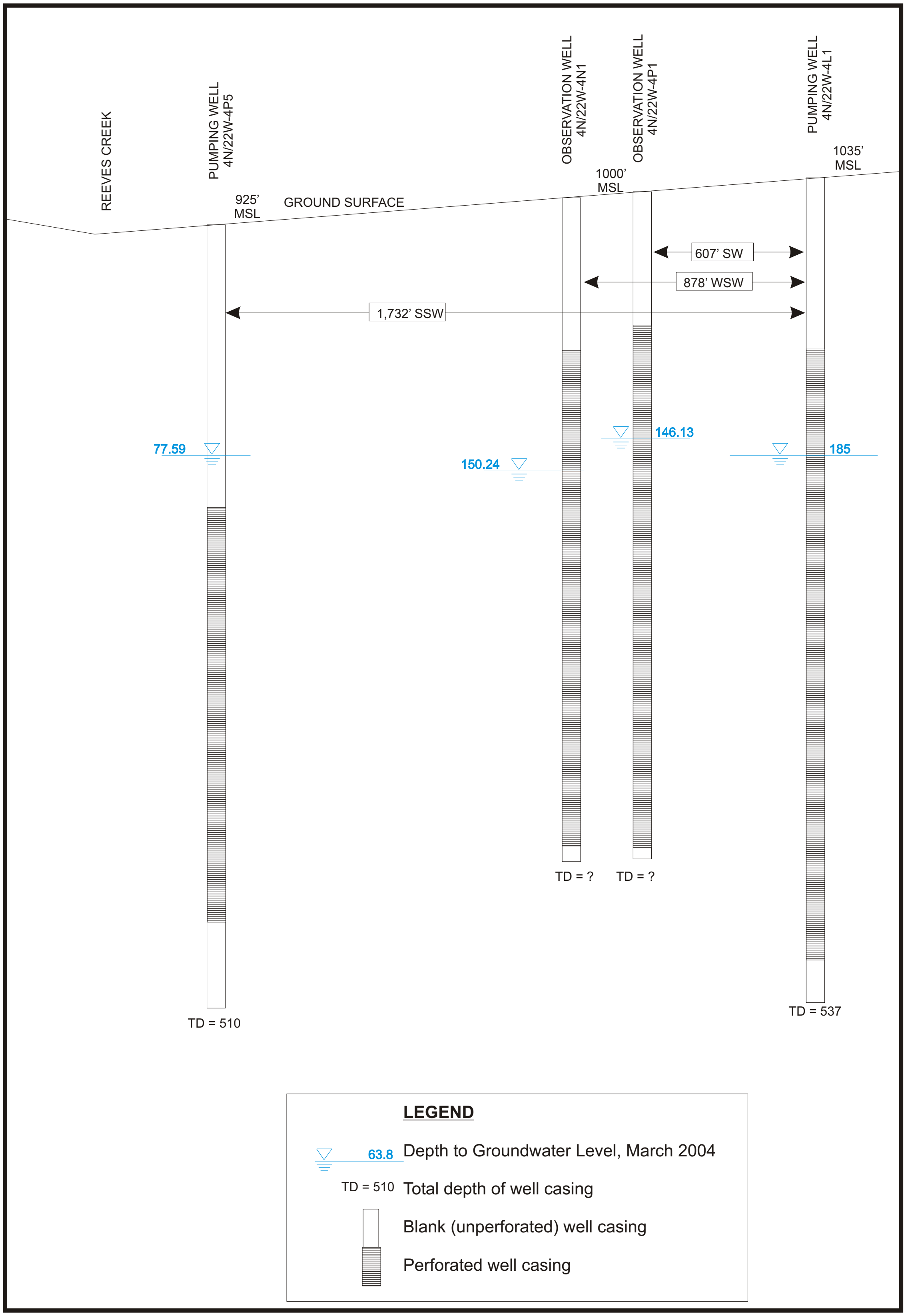


Figure 36. Schematic of pumping well 4N/22W-4L1 and observation wells 4N/22W-4P1, -4N1, and -4P5 (locations on Figure 35).

Aquifer test design

The aquifer test was designed to be conducted during a period of typically high precipitation to minimize the effects of nearby pumping wells. In Well 4N/22W-4P1, continuous (minutely) automatic water level monitoring began at 5:40 PM on February 26, 2004 and continued through 1:10 PM on March 6, 2004. Because of the recent and concurrent precipitation, no well was known to be pumping in the general area for an extended period prior to, during, or immediately following pumping of the Grant Well for the 24 hours of the aquifer test.

Importantly, pre-pumping and post-pumping monitoring of the water level in Well 4N/22W-4P1 indicated an average increase in groundwater elevation of 0.0005 ft/min. This correction factor is assumed to be representative of all wells in the area, and is used as discussed later.

The final manually-collected water levels in the tested wells prior to beginning pumping were collected between approximately 8:30 AM and 9:45 AM on March 2, 2004. In Well 4L1, the Grant Well, the depth to water level obtained via the air line was 185 feet. In Well 4P1, the depth to water was 146.13 feet from the reference point (top of casing). In Well 4P5, where the reference point was a hole in the well casing, the depth to water was 77.59 feet. In the Clark Well (4F1) the depth to water was 210 feet. In the Davis Well (4N1), the static water level was 150.24 feet below the reference point, a hole on the side of the well casing. The projected increase in water levels of 0.0005 ft/min (0.72 foot over 24 hours) is added to direct water level measurements before calculating drawdown.

The pumping test was planned to allow the pumping well to produce at its normal rate continuously for 24 hours. Water was discharged into the dry, permeable Thacher Creek bed and rapidly percolated into the subsurface. No effects of this percolation were observed or attributed to in observation well water level data.

Pumping commenced in the SCMWC Grant Well at 9:45 AM on March 2, 2004. The initial pumping rate was approximately 322 gpm and slowly increased to a 24-hour average of 325 gpm. The total time of pumping for the test was 1,440 minutes. The lack of changing demand head on the water discharge allowed for a relatively constant rate of discharge; however, the slight increase may be attributed to the increase in groundwater elevation in the area over the course of the test. Following pumping, recovery was measured in the pumping and observation wells for three hours.

Table 10 – Summary of Drilling and Well Construction Data

State Well Number *Owner* Name	**Drill Date**	**Drill Depth (feet)**	**Casing Diameter (inches)**	**Distance from Pumping Well, Direction**	**Perforation Depth Intervals (feet)**	**Well and Pump Status/Information**
4N/22W-4L1 ***Senior Canyon WC*** **Grant Well**	1946	540?	16	0	? (8-inch-diameter liner 190 to 540)	Liner installed in 1998
4N/22W-4P1 ***Friends Ranch***	1948*	?	12	607 235° SW		Old well, idle for years. Submersible pump exists in well, heavy sheet scale near surface.
4N/22W-4N1 ***Bob Davis*** **Irrigation Well**	1948*	?	12	878 249° WSW		
4N/22W-4P5 ***Friends Ranch*** **Irrigation Well**	2000	510	12	1732 201° SSW	290-460	
4N/22W-4F1 ***Clark Ranch*** **Irrigation Well**	1996	640	6	1505 1° N	300-460 500-600	Low producer, PVC casing to 600 feet
* indicates earliest date of available data for well						

Observed Drawdown

Pumping well

In the pumping well, the final depth to water taken during the pumping phase was 216 feet, representing a drawdown of 31 feet from the static (pre-test) water level of 185 feet. When corrected for water level increases of 0.0005 ft/min, the drawdown would be 31.72 feet.

Observation wells

In Well 4P1, located 607 feet southwest of the pumping well, the final depth to water taken during the pumping phase was 148.85 feet, representing a drawdown of 2.72 feet (3.44 feet corrected for recharge effects) from the static (pre-test) water level of 146.13 feet.

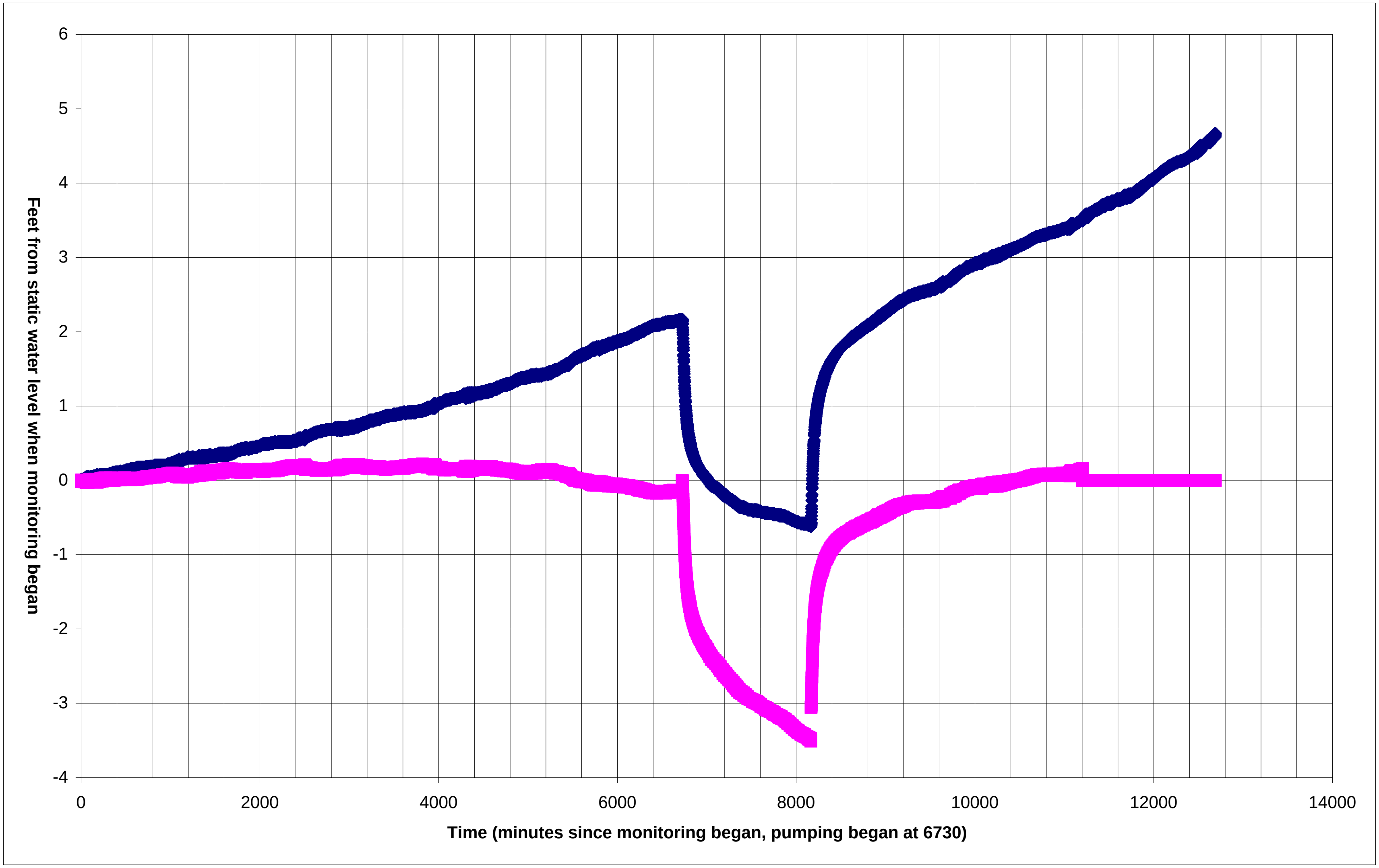


Figure 37. Summative raw and corrected water level data, SCMWC Grant well test, observation well 4N/22W-4P1.

In Well 4N1, located 867 feet west southwest of the pumping well, the final depth to water taken during the pumping phase was 153.00 feet (raw), representing a drawdown of 2.76 feet (3.48 feet corrected for recharge effects, 2.87 feet corrected for recharge and barometric effects) from the static (pre-test) water level of 150.24 feet.

A summary of water level data is presented as Table 11. A graphic presentation of raw water level data for observation well 4N/22W-4P1 is presented as Figure 37. Raw water level data are presented in tabular format in Appendix D.

Table 11 –
Summary of March 2004 SCMWC Grant Well Aquifer Test Water Level Data

State Well Number *Owner* Radial Distance	**Pre-test Static**	**200 minutes into pumping, Average rate 322 gpm**		**24 Hours into pumping, Average rate 325 gpm**	
	Depth to groundwater level (ft)	**Depth to groundwater level (ft)**	**Drawdown (ft, corrected)**	**Depth to groundwater level (ft)**	**Drawdown (ft, corrected)**
4N/22W-4L1 ***Senior Canyon WC*** **Grant Well** **0**	185	212	27 (27.1)	216	31 (31.72)
4N/22W-4P1 ***Friends Ranch*** **607**	146.13	148.14	2.01 (2.11)	148.85	2.72 (3.44)
4N/22W-4N1 ***Bob Davis*** **Irrigation Well** **827**	150.24	151.77	1.53 (1.63)	153.00	2.76 (2.87)

Methods

Distance-drawdown and the Hantush (1960) type-curve solution for confined aquifers via the software package AQTESOLV (Geraghty and Miller, 2002) were used to determine aquifer characteristics. Driscoll's (1986) calculations for well efficiency were also considered.

Corrected drawdown data from this aquifer test were used for all solutions due to the fact that pre-test and post-test monitoring indicated an increase in water levels averaging 0.0005 ft/min throughout the testing period. Further, an approximate 7-

millibar increase in atmospheric pressure over the 24-hour pumping period would require correction (decrease in observed drawdown) in manual water level measurements. A graphically-determined correction factor of approximately 0.63 foot was subtracted from observed drawdown in Well 4N1; this graphical determination was based on assuming parallel trends in drawdown of automated, self-barometric-correcting data from Well 4P1 and anticipated data from Well 4N1. The proximity of these two wells and lack of boundary condition effects should dictate sub-parallel drawdown trends.

Distance-drawdown

Distance drawdown analyses as presented by Cooper and Jacob (1946) were utilized for the 24-hour pumping period to identify aquifer parameters for this test.

At the end of pumping, after approximately 1440 minutes of the test was complete (24 hours), the following data and solutions apply:

$Q = 325$ gpm $= 43.45$ cfm

$t = 1440$ minutes

$\Delta s = 3.2$ ft

$r_o = 5{,}000$ ft

and the Theis equation can be solved for transmissivity and storativity by:

$T = 2.303Q/2\pi\ \Delta s$

$T = 2.303\ (43.45\ \text{ft}^3/\text{min})/\ 2\ \pi\ (3.2\ \text{ft})$

$T = 4.98\ \text{ft}^2/\text{min}$

$S = 2.25Tt/r_o^2$

$S = 2.25\ (7.98\ \text{ft}^2/\text{min})\ (1440\ \text{min})\ /\ (5000)^2$

$S = 0.000647$

Hantush Leaky Aquifer type-curve matching

Hantush (1960) derived an analytical solution for predicting water-level displacements in response to pumping in a leaky confined aquifer assuming storage in the aquitard(s). Although not all solution assumptions were met, to corroborate the solutions determined by other methods, the Hantush (1960) Leaky Confined Aquifer type-curve solutions were employed. Type-curve analyses of the data by the Hantush (1960) leaky confined aquifer solution appears to yield the most consistent data and visually matches the curves of displacement versus time to the greatest detail (Figure 38). Based on the type-curve analyses, transmissivity values are on the order of 4.349 ft^2/min and storativity values are on the order of 0.0003919.

Well efficiency

In confined aquifers, where no dewatering of the aquifer itself occurs, the efficiency of the well can be estimated by continuing the distance drawdown curve to the point on the outside of the well casing.

With a liner diameter of 8 inches, the radial distance is 4 inches or 0.33 foot. The distance-drawdown curve projected to this point on the x-axis corresponds to a drawdown value of 15 feet.

For the Grant Well No. 4L1, at 24 hours of pumping, the corrected drawdown in the pumping well was 31.72 feet. Measured specific capacity of the pumping well was 10.24 gpm/ft, calculated by dividing the pumping rate of 325 gpm by a drawdown of 31.72 ft. Hence, the efficiency for the well can be estimated by:

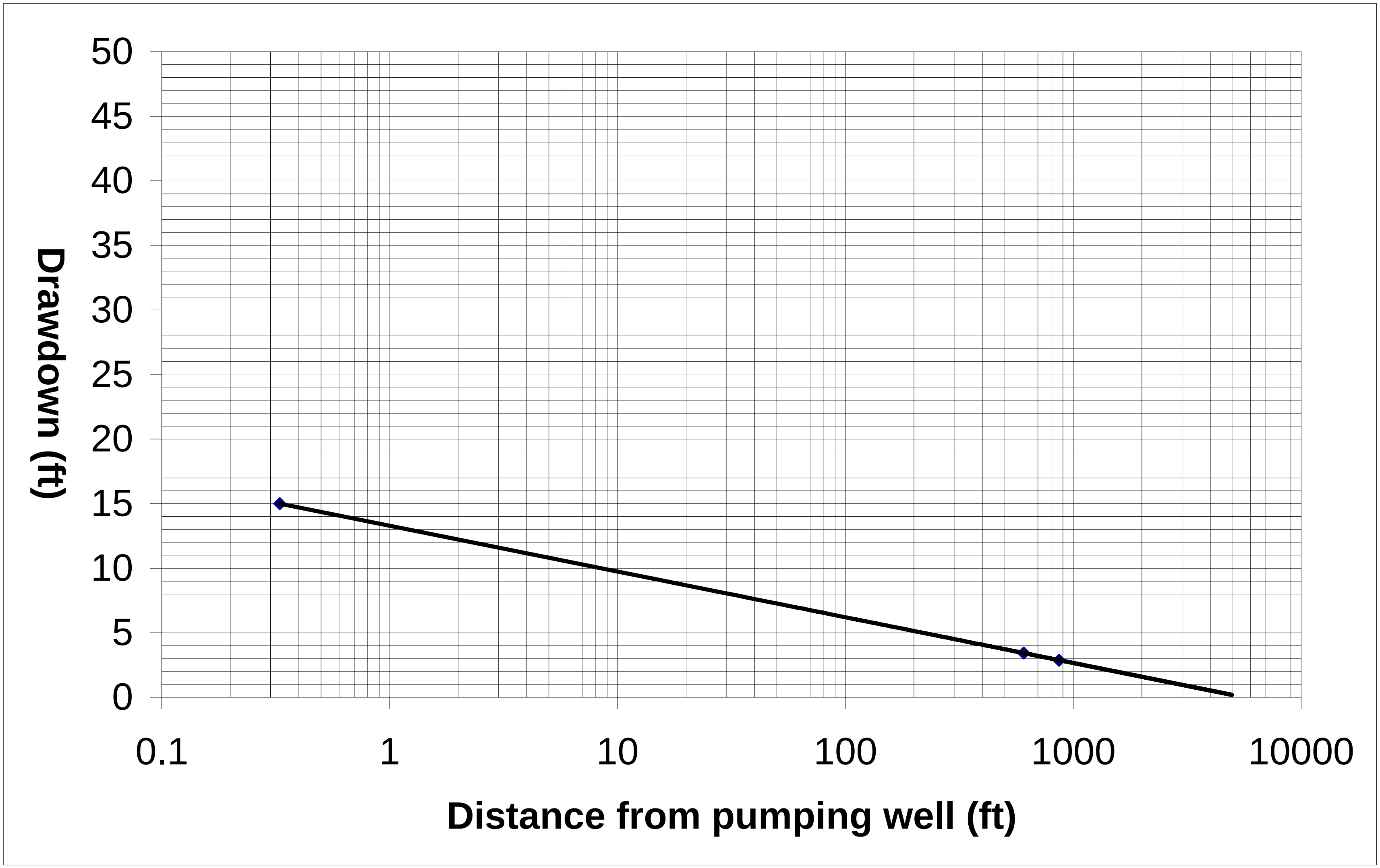


Figure 38: Distance drawdown, Senior Canyon Grant well test, March 2004.

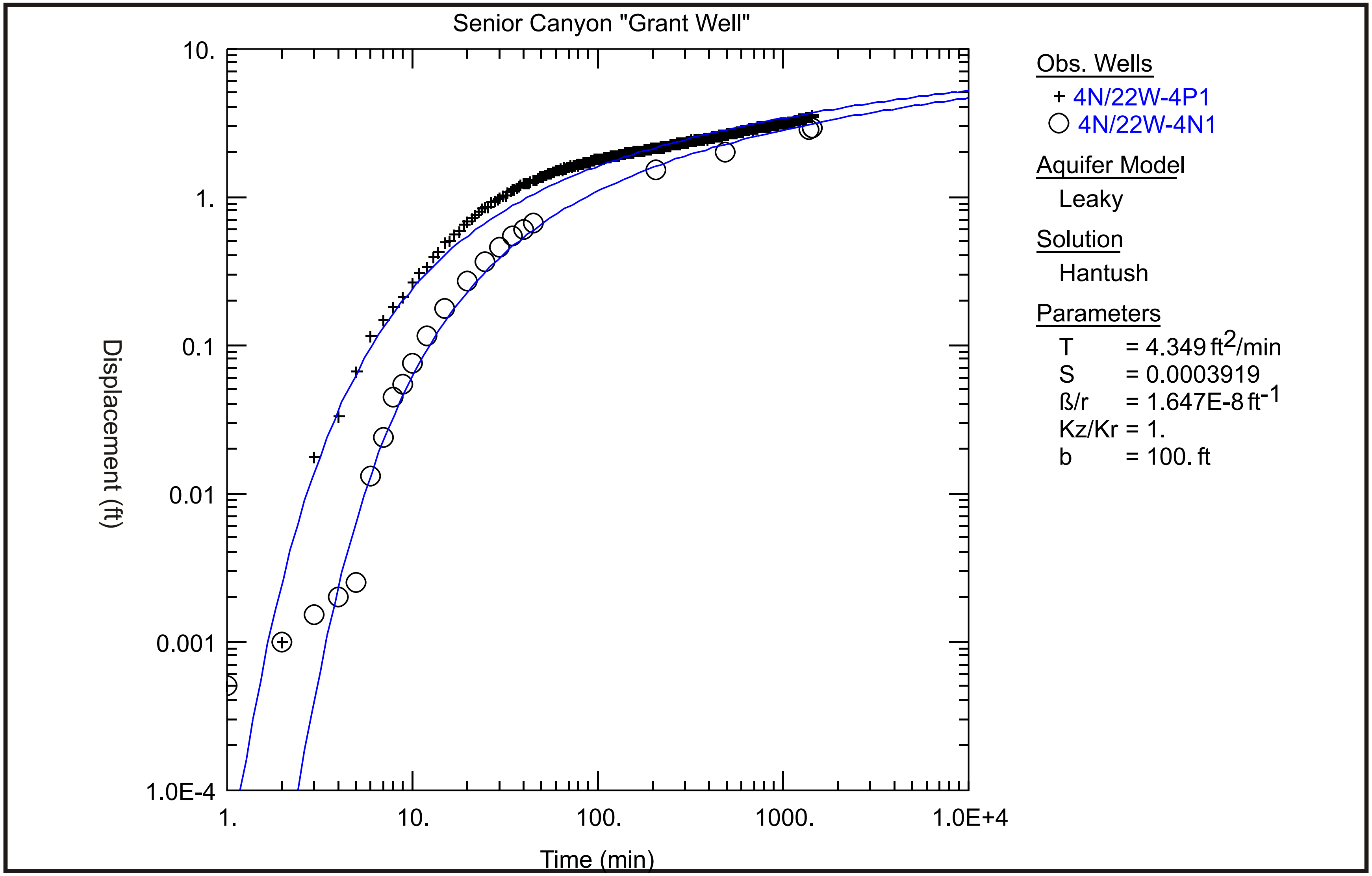


Figure 39. Hantush solution, SCMWC observation wells 4N/22W-4N1 and -4P1.

Well Efficiency = Measured drawdown in well/Theoretical Drawdown at edge of well casing X 100

Well Efficiency = 15 ft / 31.72 gpm/ft = 47.3%

Such a low well efficiency is common for older wells which have been equipped with well liners, have remained idle for long periods, and may be heavily encrusted with scale.

Results

Key results from this aquifer test include the determination of leaky-confined aquifer response to pumping. Additionally, the observation of recharge to the basin following a significant precipitation event indicates the value of short-interval, long-term water level monitoring data.

Based on the SCMWC Grant Well aquifer test of March 2004, the following summary of aquifer data can be presented:

Table 12 – Summary of March 2004 East Ojai Basin Well Field Aquifer Test Aquifer Characteristics

Parameter	Distance Drawdown (24-hour data)	Hantush type curve matching	Driscoll Well Efficiency
Transmissivity	4.98 ft^2/min	4.349 ft^2/min	--
Storativity	0.000647	0.0003919	--
Radius of influence	5000 ft	--	--
Well Efficiency	--	--	47.3%

Both methods of aquifer solutions employed appear to be in near agreement. Hence the confidence level of these values is high.

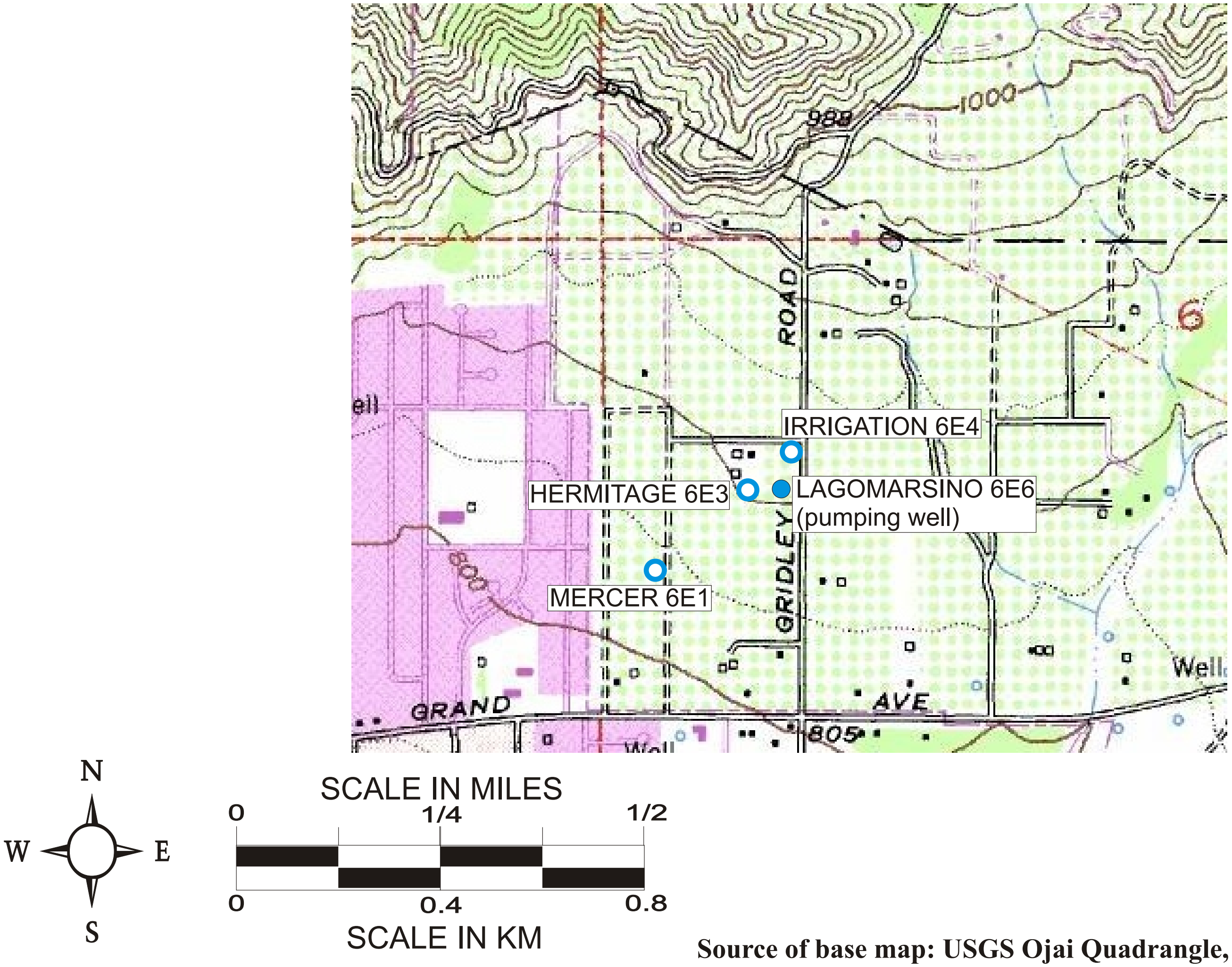
North Ojai Basin (Essick Lagomarsino Well)

Introduction

In mid-March 2004, the fourth test for this study was conducted in the northern portion of the Ojai Basin, using the Lagomarsino Ranch Well, operated by Essick Farm Management, as a pumping well. Strictly manual water level measurements in several nearby wells began on March 12, 2004 and continued to March 20, 2004. Pumping of the Lagomarsino Well began on March 16 and continued to March 20, 2004, at an average rate of approximately 213 gpm. Other nearby wells would cycle on and off but corrections to observation data were feasible and monitored for water level changes. Based on drawdown analyses and aquifer testing solutions, the data indicate confined conditions in the northern portion of the Ojai Basin at the time of the test.

Pumping of the Lagomarsino Well (4N/22W-6E6) commenced on March 16, 2004 while other nearby wells (4N/22W-6E4, -6D3, and 6E1) were idle, and the Hermitage Water Company well (4N/22W-6E3) was cycling under normal demands; all wells were monitored for water level changes. Influences of the wells that would pump simultaneously with the Lagomarsino Well were clearly identifiable and able to be filtered out of the data set as best as possible. Although the pumping well was pumping for four days, after about three hours of pumping Wells 6D3 and 6E1 began pumping at relatively low rates. Although the influence of these relatively distal wells was not observable at the three proximal wells, the ability to use those wells as data collection points ceased after they began pumping. Hermitage Water Company Well would cycle on and off for variable periods, depending on demands as it would fill the 7,000-gallon-capacity steel tank for water service. The maximum recovery measurements taken between pumping cycles are believed to be usable for data interpretation and solutions. Well 6E4 remained off for the entire period of testing.

Timing of this aquifer test was wholly dependent on irrigation demands. Because weather patterns affect the local orchards relatively equally, other irrigation wells are pumped at the same time as the Lagomarsino Well.



Source of base map: USGS Ojai Quadrangle, 1988

Figure 40. Locations of wells monitored during 2004 Essick Lagomarsino test.

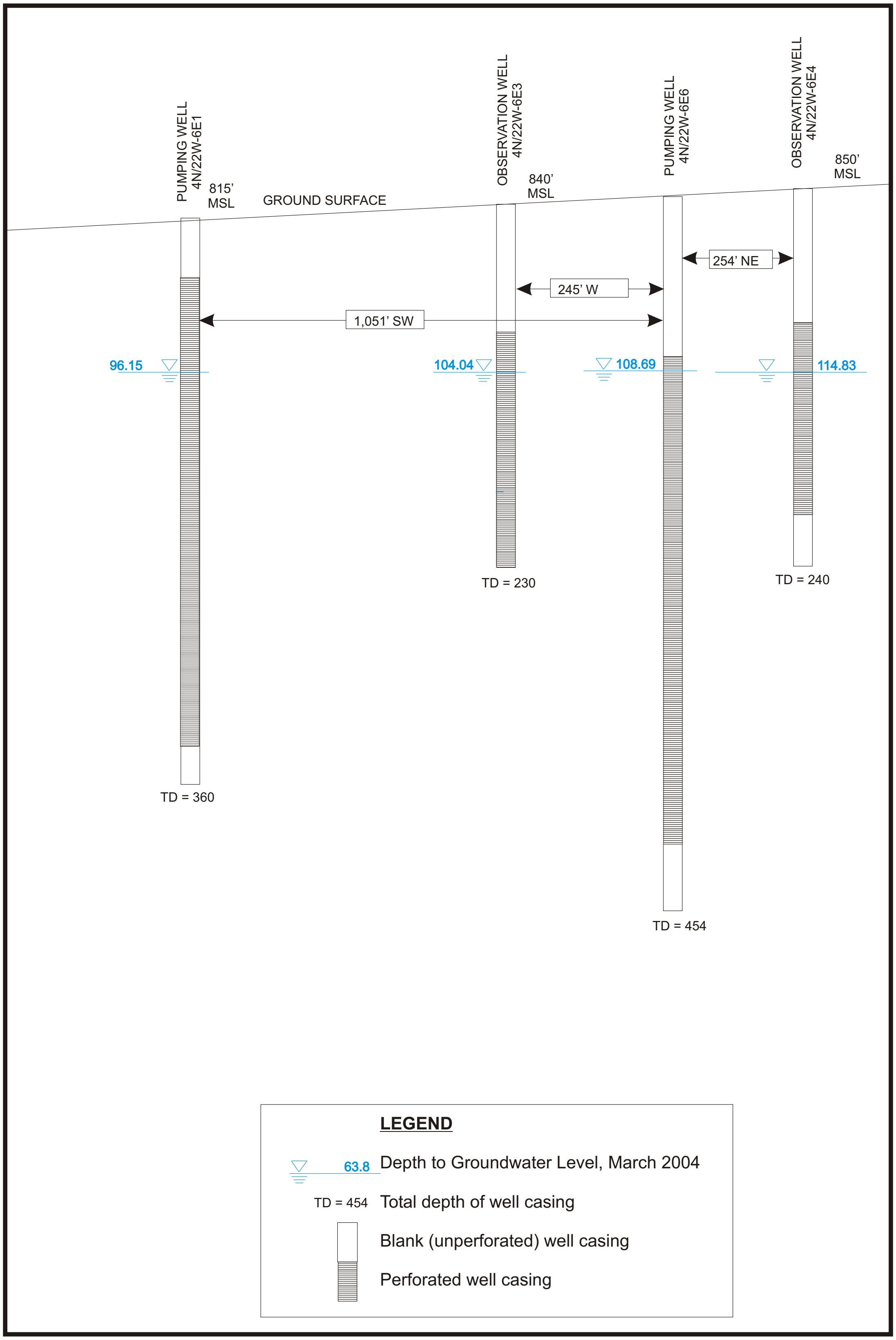


Figure 41. Schematic of pumping well 4N/22W-6E6 and observation wells 4N/22W-6E1, -6E3, and -6E4 (locations on Figure 40).

Location

As shown on Figure 40, the pumping and observation wells are located adjacent (west) to Gridley Road, north of Grand Avenue. This testing provided data for the north-central portion of the groundwater basin. Ground surface at the testing area slopes gently to the south and is largely occupied by citrus groves, with limited roads, private drives, and residences.

This well field was selected for inclusion into the testing due to the proximity of potential observation wells, existing pump and power apparatus that need to be used for the private orchard irrigation, a location for discharge waters, and ancillary access and pumping volume monitoring apparatus. All measurements were required to be obtained manually since no access to wells for transducers or power source for the automatic datalogger was available.

Data

Precipitation and barometric conditions

As measured at the OJA precipitation station, approximately 12.06 inches of rain fell since the 2003-2004 water year began. The most recent measurable precipitation prior to the commencement of the Lagomarsino Well aquifer test was associated with the storm of March 1, 2004. This precipitation event brought a total of 0.58 inch of rain and preceded the pumping by 15 days.

Hourly measurements of barometric pressure were recorded at the Simi Valley station by the County of Ventura. Variable (within 6.5 millibars) atmospheric pressure conditions predominated during the four days of the testing period. However, due to the likely errors in pumping water level data generated by pumping of the Hermitage Water Company well and variable pumping rate of the Lagomarsino Well, barometric corrections to water level data were assumed to be negligible and were not generated.

Pumping Well

The pumping well for this test was Well No. 4N/22W-6E6, an irrigation well belonging to the Lagomarsino Ranch and operated by Essick Farm Management Company. Drilled via rotary methods, the well boring was advanced to 454 feet, and 425 feet of steel casing with continuous (105-415) perforations was installed. Access for water level monitoring was capable via a 2-inch-diameter steel sounding port on the southwest corner of the concrete pump base. Only manual water levels were collected from this well. A totalizer reading in acre feet was present on the discharge line from the vertical turbine well pump. Additional well information is presented in Table 13.

Observation Wells

Available local observation wells for this test were privately-owned. Well 4N/22W-6E4 was reported by Mr. Don Essick to be idle but equipped with a vertical turbine pump which was idle prior to and during the pumping portions of the test. A steel sounding tube on the southeast corner of the concrete pump base allowed for access for water level monitoring; only an electric tape sounder was used for the pre-test monitoring and test data collection.

Well 4N/22W-6E3 is an active well for the services of the Gridley Road/Hermitage Water Company. A submersible pump exists in the well, and a narrow access port in the surface plate allows only electric tape sounders to be lowered directly down the well casing for manual water level measurement. As mentioned above, this well pumps intermittently based on demand and pumps to an approximate 7,000-gallon-capacity tank which then provides irrigation water to residences. No totalizer exists on the discharge line from the well; typical pumping periods were on the order of nine minutes, and non-pumping periods were on the order of 90 minutes during the testing period.

Located on a parcel west of the orchard irrigated by the Lagomarsino Well, the Mercer Ranch Wells 6E1 and 6D3 were monitored only prior to their own pumping, which commenced about three hours into the aquifer test. Cascading water and perhaps “breathing” conditions precluded the collection of reliable data from Well D3. Figure 41 presents a schematic view of the pumping and observation wells for this north basin test.

Aquifer test design

The aquifer test was designed to be conducted around the pumping demands of the irrigated orchards. Manual water level monitoring began on March 12, 2004 and continued sporadically through March 20, 2004 when the pumping ceased in the Lagomarsino Well. Ideally, no well would be pumping in the general area for an extended period prior to pumping for the aquifer test, but the local water demands required occasional pumping during the pre-pumping water level monitoring period. Hence, the initial water levels obtained from the wells were during a period of pumping on March 12. Moreover, intermittent pumping of the Hermitage Well (6E3) also had an effect. Other wells in the area may have also been pumping intermittently.

The final manually-collected water levels in the tested wells prior to pumping test commencement were collected between approximately 6:20 and 7:35 AM on March 16, 2004. In Lagomarsino Well No. 6E6, the depth to water from the reference point (top of sounding tube) was 108.69 feet. In Well No. 4N/22W-6E3, where the reference point was the top of the well casing, the depth to water was 104.04 feet. In Well No. 4N/22W-6E4, where the reference point was the top of the sounding tube, the depth to water was 114.83 feet. In Well No. 4N/22W-6E1, where the reference point was the top of the sounding tube, the depth to water was 96.15 feet.

The pumping test was planned to allow the pumping well to produce at its normal rate continuously for four days. Water was pumped into the orchard irrigation system.

Pumping commenced in the Lagomarsino Well at 7:35 AM on March 16, 2004. The pumping rates were variable, ranging between 26.8 and 38.2 cfm (~200 to 325 gpm), with the initial two hours (117 minutes) bearing a 229 gpm average. Over the course of the 4 days of pumping (5745 minutes) the average rate was approximately 211 gpm. Following pumping, recovery was measured in the pumping well for 40 minutes before pumping in nearby Well 6E3 created an influence on the Lagomarsino Well.

Table 13 – Summary of Drilling and Well Construction Data

State Well Number *Owner* Name	**Drill Date**	**Drill Depth (feet)**	**Casing Diameter (inches)**	**Distance from Pumping Well, Direction**	**Perforation Depth Intervals (feet)**	**Well and Pump Status/Information**
4N/22W-6E6 ***Ojai Land and Farming*** **Lagomarsino Well**	1957	454	12	0	105-415	Casing installed to 425 only
4N/22W-6E3 ***Gridley Road/Hermitage Water Company***	1924	230	10	245 270° W	?	Pumped intermittently throughout test at ~50gpm for up to 9 minutes per cycle
4N/22W-6E4 ***?*** **Irrigation Well**	1924	240	12	254 NNE	90-212	Idle Well, Vertical Turbine Pump in well
4N/22W-6D3 ***Mercer Ranch*** **Irrigation Well**	1938	250	12	840 288° WNW	40-250	Began pumping 3 hours into test, low constant rate
4N/22W-6E1 ***Mercer Ranch*** **Irrigation Well**	1945	360	12	1051 226°SW	40-46; 134-136; 168-170; 178-184; 244-250; 272-286; 318-338	Began pumping 3 hours into test, low constant rate

Observed Drawdown

Throughout the pumping period, water levels in all observed wells decreased due to the effects of the Lagomarsino Well pumpage. Superposed on this pattern were pumping effects from the intermittent pumping of Well 6E3 and the near-simultaneous pumping of Wells 6E1 and 6D3. Table 14 presents a summary of drawdown data, and Figure 42 graphically depicts a summary of water level observation.

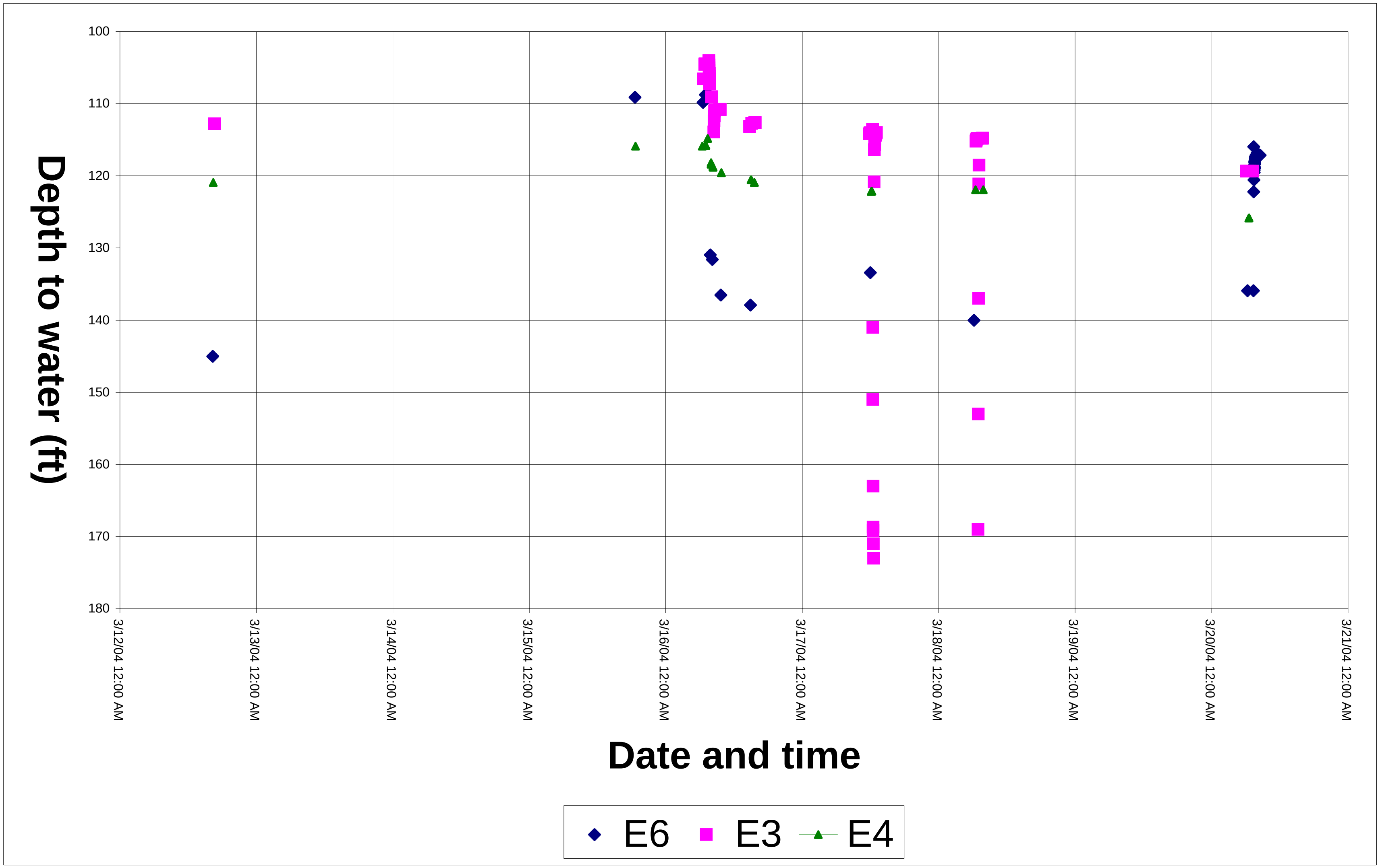


Figure 42. Essick Lagomarsino well test, water level summary.

Pumping well

In the pumping well, the 2-hour depth to water taken during the pumping phase was 136.52 feet, representing a drawdown of 27.83 feet from the static (pre-test) water level of 108.69 feet. After the complete 4-day irrigation period, the pumping water level was 135.90, representing a drawdown of 27.14 feet; note that the latter days of the pumping period had a decreased pumping rate relative to the initial 2 hours.

Observation wells

In Well No. 6E3, located 245 feet west of the pumping well, the 2-hour depth to water taken during the pumping phase was 110.81 feet, representing a drawdown of 6.77 feet from the static (pre-test) water level of 104.04 feet. After 4 days of pumping on Well 6E6, the water level in Well 6E3 was 119.36 feet, representing a drawdown of 15.32 feet.

In Well No. 6E4, located 254 feet north-northeast of the pumping well, the 2-hour and four-day depths to water were 119.57 and 125.80 feet, respectively, representing drawdowns of 4.74 and 10.97 feet from the static (pre-test) water level of 114.83 feet.

In Well No. 6E1, located 1,051 feet southwest of the pumping well, the static water level was 96.15 feet. After 2 hours of pumping the Lagomarsino Well, drawdown was 0.20 feet.

A summary of water level data is presented as Table 14. A graphic presentation of raw water level data is presented as Figure 42. Raw water level data in tabular format are presented as Appendix E.

Table 14 –
Summary of March 2004 Lagomarsino Well Aquifer Test Water Level Data

State Well Number *Owner* Radial Distance	**Pre-test Static**	**2 hours into pumping, Average rate 229 gpm**		**4 Days into pumping, Average rate 211 gpm**	
	Depth to groundwater level (ft)	**Depth to groundwater level (ft)**	**Drawdown (ft)**	**Depth to groundwater level (ft)**	**Drawdown (ft)**
4N/22W-6E6 ***Ojai Land and Farming*** **Lagomarsino Well** **0**	108.69	136.52	27.83	135.90	27.14
4N/22W-6E3 ***Gridley Road/Hermitage Water Company*** ***245***	104.04	110.81	6.77	119.36	15.32
4N/22W-6E4 ***?*** **Irrigation Well** **254**	114.83	119.57	4.74	125.80	10.97
4N/22W-6E1 ***Mercer Ranch*** **Irrigation Well** **1051**	96.15	96.35	0.20	140	pumping

[#] shallowest water level recovery between pumping cycles

Methods

Distance-drawdown, recovery analyses, and the Neuman-Witherspoon (1969) type-curve solution for leaky confined aquifers via AQTESOLV (Geraghty and Miller, 2002) were used to determine aquifer characteristics. Driscoll's (1986) calculations for well efficiency were also considered.

Raw water level data from this aquifer test, filtered to minimize the effects of local/observation well pumping, were used for all solutions due to the fact that pre-test monitoring indicated no significant water level trends, the pumping rate was not constant throughout the long pumping period, and a greater anticipated error based on the effects of local pumping. Note that only manually-collected water levels were used for distance drawdown, type-curve, and recovery analyses.

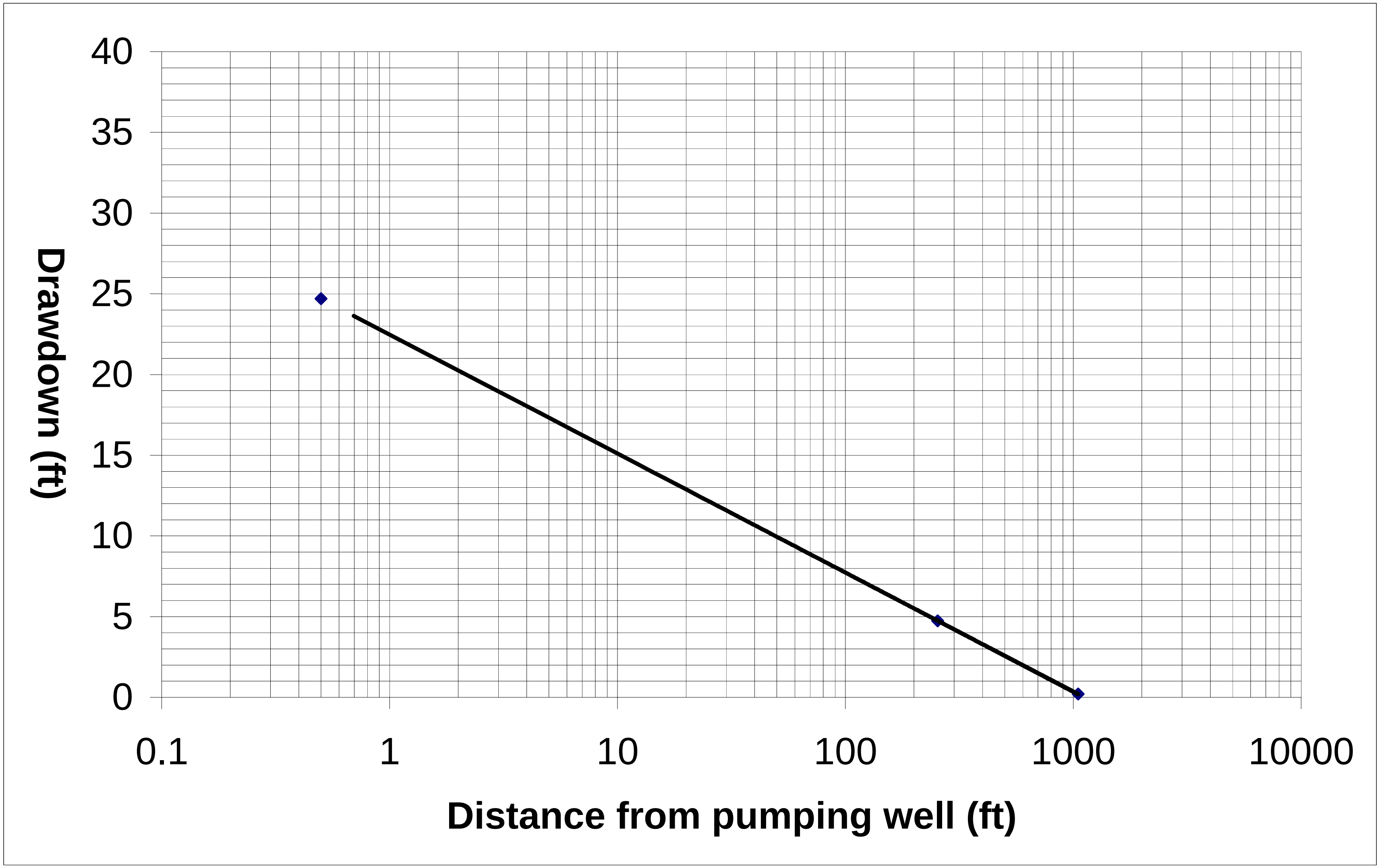


Figure 43. Distance drawdown, Lagomarsino test, March 2004.

Distance-drawdown

Distance drawdown analyses as presented by Cooper and Jacob (1946) were utilized for the 2-hour pumping period to identify aquifer parameters for this test. This time period was selected because the data set had not yet included pumping of the Mercer Ranch Wells. Well 6E4 was included because it was not pumping. Test data are presented as a distance-drawdown graph as Figure 43.

After the first two hours of pumping was complete (120 minutes), the following data and solutions apply:

$Q = 229$ gpm $= 30.6$ cfm

$t = 120$ minutes

$\Delta s = 7.1$ ft

$r_o = 1100$ ft

and the Theis equation can be solved for transmissivity and storativity by:

$T = 2.303Q/2\pi\ \Delta s$

$T = 2.303\ (30.6\ \text{ft}^3/\text{min})/\ 2\ \pi\ (7.1\ \text{ft})$

$T = 1.58\ \text{ft}^2/\text{min}$

$S = 2.25Tt/r_o^2$

$S = 2.25\ (1.58\ \text{ft}^2/\text{min})\ (120\ \text{min})\ /\ (1{,}100)^2$

$S = 0.000353$

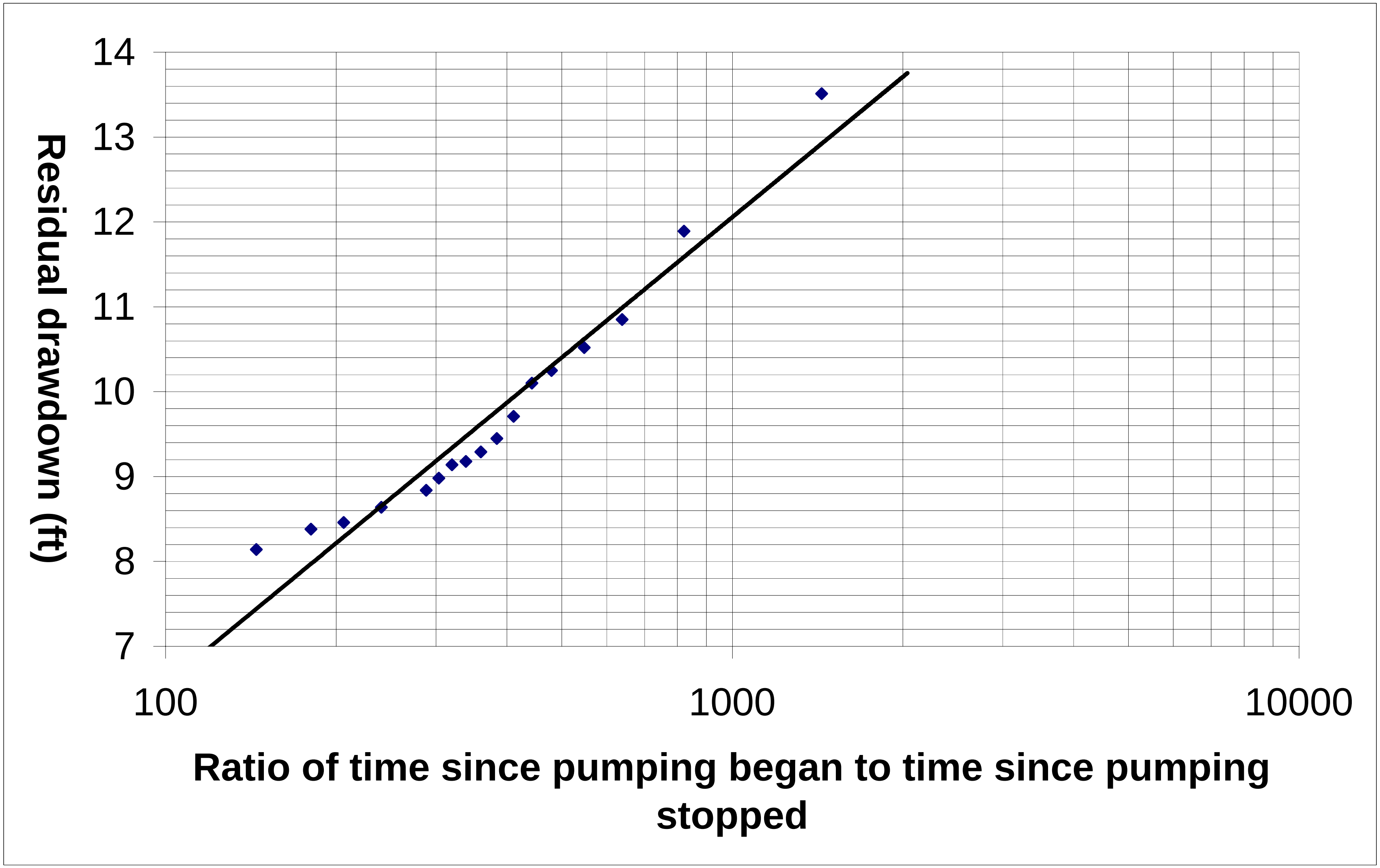


Figure 44. Recovery analyses Lagomarsino Well, March 2004.

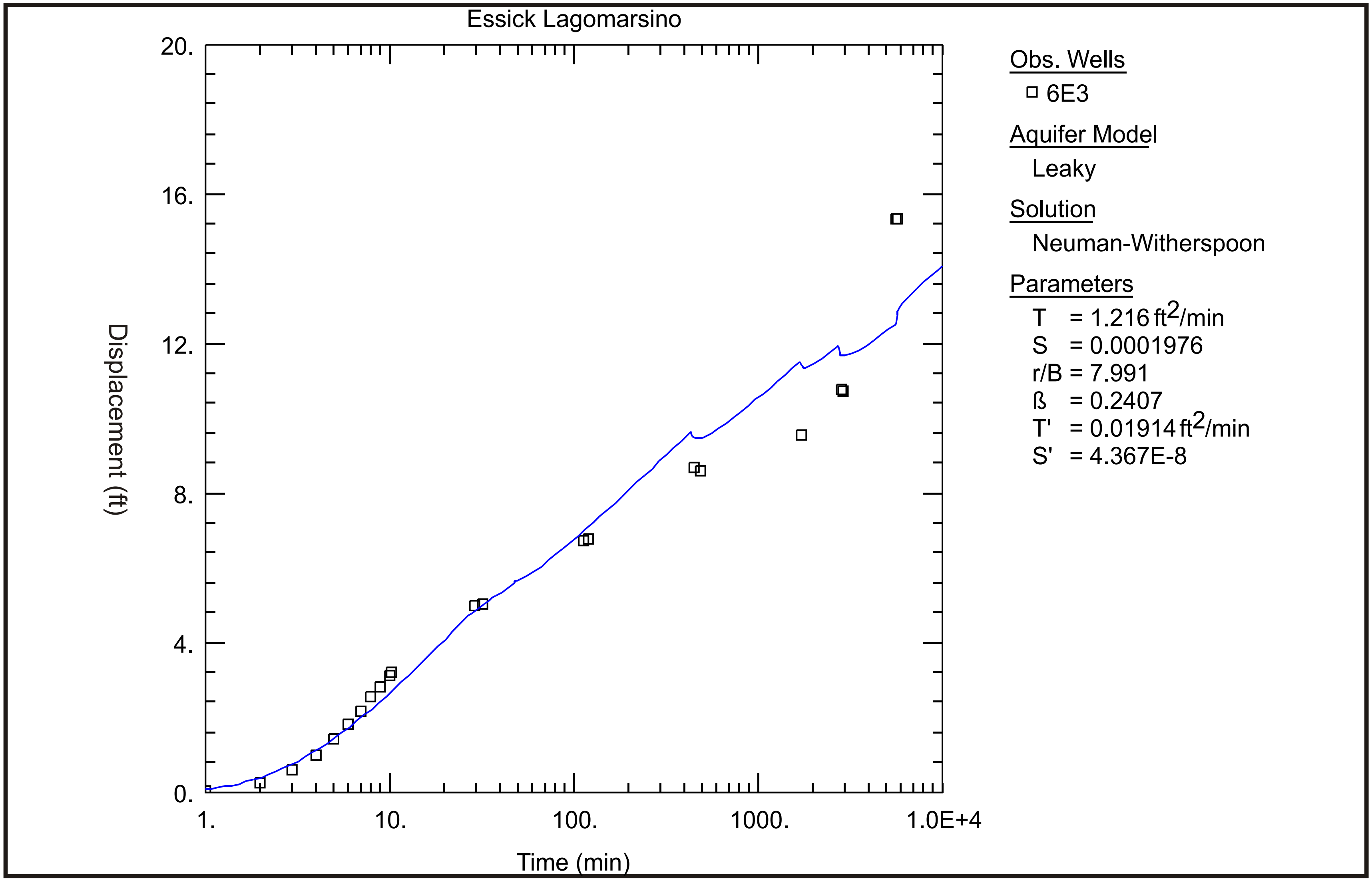


Figure 45. Neuman-Witherspoon solution, Essick-Lagomarsino observation well 4N/22W-6E3.

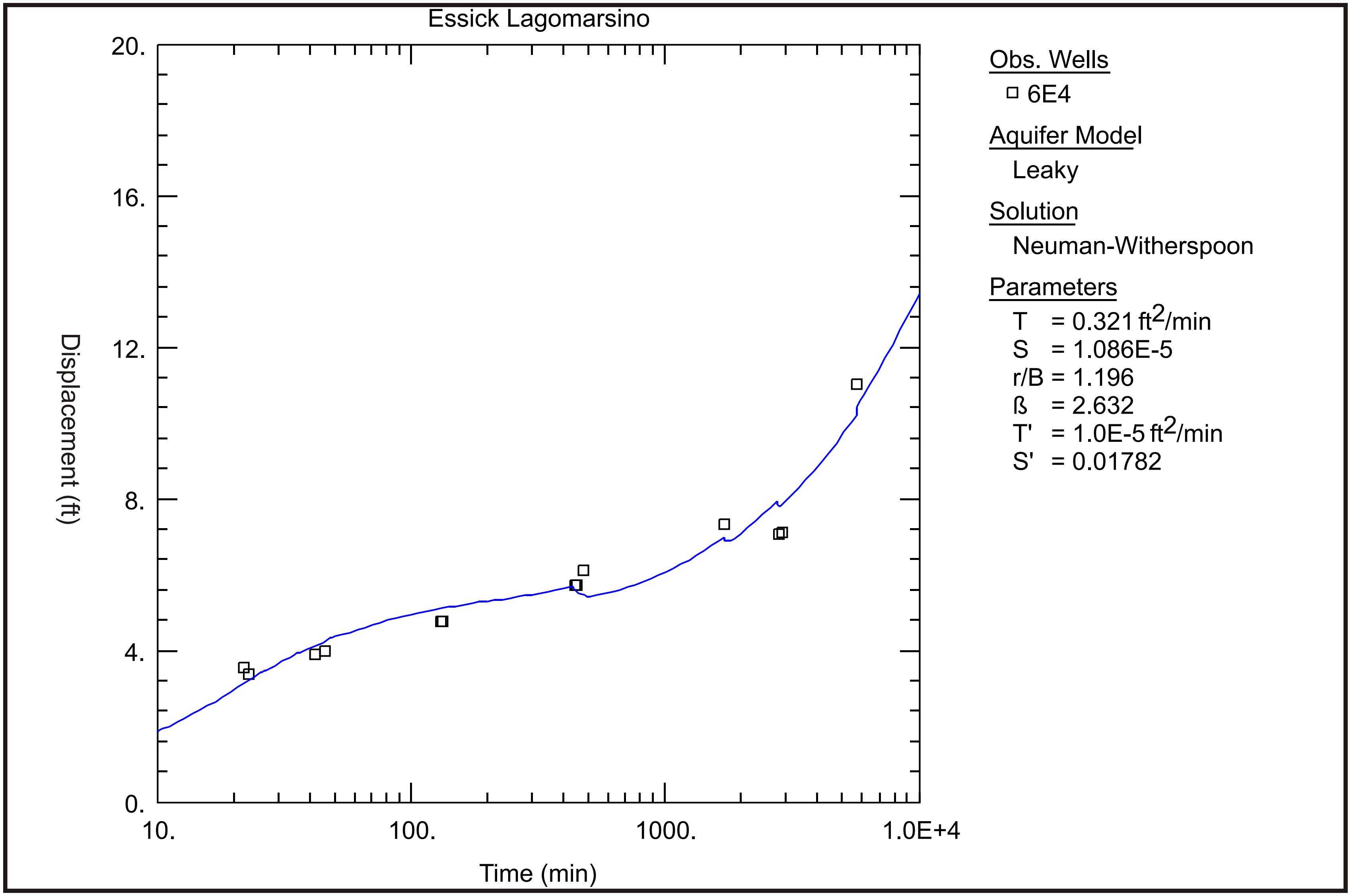


Figure 46. Neuman-Witherspoon solution, Essick-Lagomarsino observation well 4N/22W-6E4.

Recovery

Recovery analyses for a pumping well can be a valuable asset to compare with drawdown data. Figure 44 presents recovery data for the pumping well.

$\Delta s' = 5.5$ ft

$t = 5745$ min

$Q = 28.2$ cfm

$T = 2.303Q/4\pi\Delta s'$

$T = 2.303\ (28.2\ \text{cfm})/4\pi\ (5.5\ \text{ft})$

$T = 0.94\ \text{ft}^2/\text{min}$

Neuman-Witherspoon type-curve matching

Neuman and Witherspoon (1969) derived an analytical solution for the problem of flow to a well in a confined infinite radial system consisting of two aquifers separated by an aquitard. Although this solution is based on the well completely penetrating only one of the aquifers, the match of the type curve can be used to estimate an average of aquifer parameters for the aquifers penetrated by the wells. The solution considers storage in the aquitard and drawdown in the unpumped aquifer. Although not all assumptions of the solution are met, a type-curve analysis of the data by the Neuman-Witherspoon (1969) confined aquifer with leakage appears to yield the most consistent data and match the curve to the greatest detail (Figures 45 and 46). Based on the type-curve analyses, transmissivity values are on the order of 1.216 ft^2/min and storativity values are on the order of 0.00001086.

Well efficiency

In confined aquifers, where no dewatering of the aquifer itself occurs, the efficiency of the well can be estimated by continuing the distance drawdown curve to the point on the outside of the well casing.

At 12 inches, the radial distance is 6 inches or 0.5 foot. The distance-drawdown curve projected to this point on the x-axis corresponds to a drawdown value of 24.7 feet at 120 minutes.

For the Lagomarsino Well (6E6), at 2 hours of pumping, the actual drawdown in the pumping well was 27.83 feet. Measured specific capacity of the pumping well was 8.22 gpm/ft, calculated by dividing the pumping rate of 229 gpm by a drawdown of 27.83 ft. Hence, the efficiency for the well can be estimated by:

Well Efficiency = Measured drawdown in well/Theoretical Drawdown at edge of well casing X 100

Well Efficiency = 24.7 gpm/ft / 27.83 gpm/ft = 88.7%

Such a high well efficiency is quite unexpected for a relatively old well, but the time period of pumping is short and the water level drawdown in observation wells had not yet stabilized. However, this well is still quite efficient for its age and high efficiency values may reflect rehabilitation efforts and/or the frequent use by the owners.

Results

Based on the North Ojai Basin aquifer test of March 2004, leaky confined aquifer conditions appear to be present. Aquifer data are summarized on Table 15.

Table 15 – Summary of March 2004 North Ojai Basin Well Field Aquifer Test Aquifer Characteristics

Parameter	Distance Drawdown (2-hour data)	Pumping Well Recovery (4 days pumping)	Neuman-Witherspoon type curve matching (Well 6E3)	Neuman-Witherspoon type curve matching (Well 6E4)	Driscoll Well Efficiency
Transmissivity	1.58 ft^2/min	0.94 ft^2/min	1.216 ft^2/min	0.321 ft^2/min	--
Storativity	0.000353	--	0.0001976	0.00001086	--
Radius of influence	1100 ft	--	--		--
Well Efficiency	--	--	--		88.7%

Although the range of aquifer parameters generated by the various methods of aquifer solutions employed appear to be in agreement to within two orders of magnitude, the errors associated with unknown pumping decrease the confidence levels of these values. Hence the confidence level of these values is moderate.

The variability of aquifer data yielded by the two roughly equidistant observation wells likely reflects some aquifer heterogeneity. Alternatively, the differences could be an effect of local pumping. If heterogeneity is assumed, then the more transmissive materials along an east/west axis are present, with possible explanations being imbrication of clasts in a north-south fashion (impeding flow to the south), thickening of the aquifer material to the south, etc.

West Ojai Basin (Mid-City John Galaska Well and Dave Mollan Well)

Introduction

In April 2004, the test in the incorporated area of the City of Ojai was attempted. With the cooperation of the residential well owners, automatic and manual water level measurements in the two available wells began on April 12, 2004 and continued to April 16, 2004. Controlled pumping of John Galaska's well was attempted on April 14, 2004 at a rate of approximately 30 gpm but the pump began producing air and the test was aborted. However, the continuous monitoring of water levels, coupled with deduced pumping information, geology, and well construction information, confirmed confinement of the principal aquifer underlying this portion of the Ojai Basin.

Location

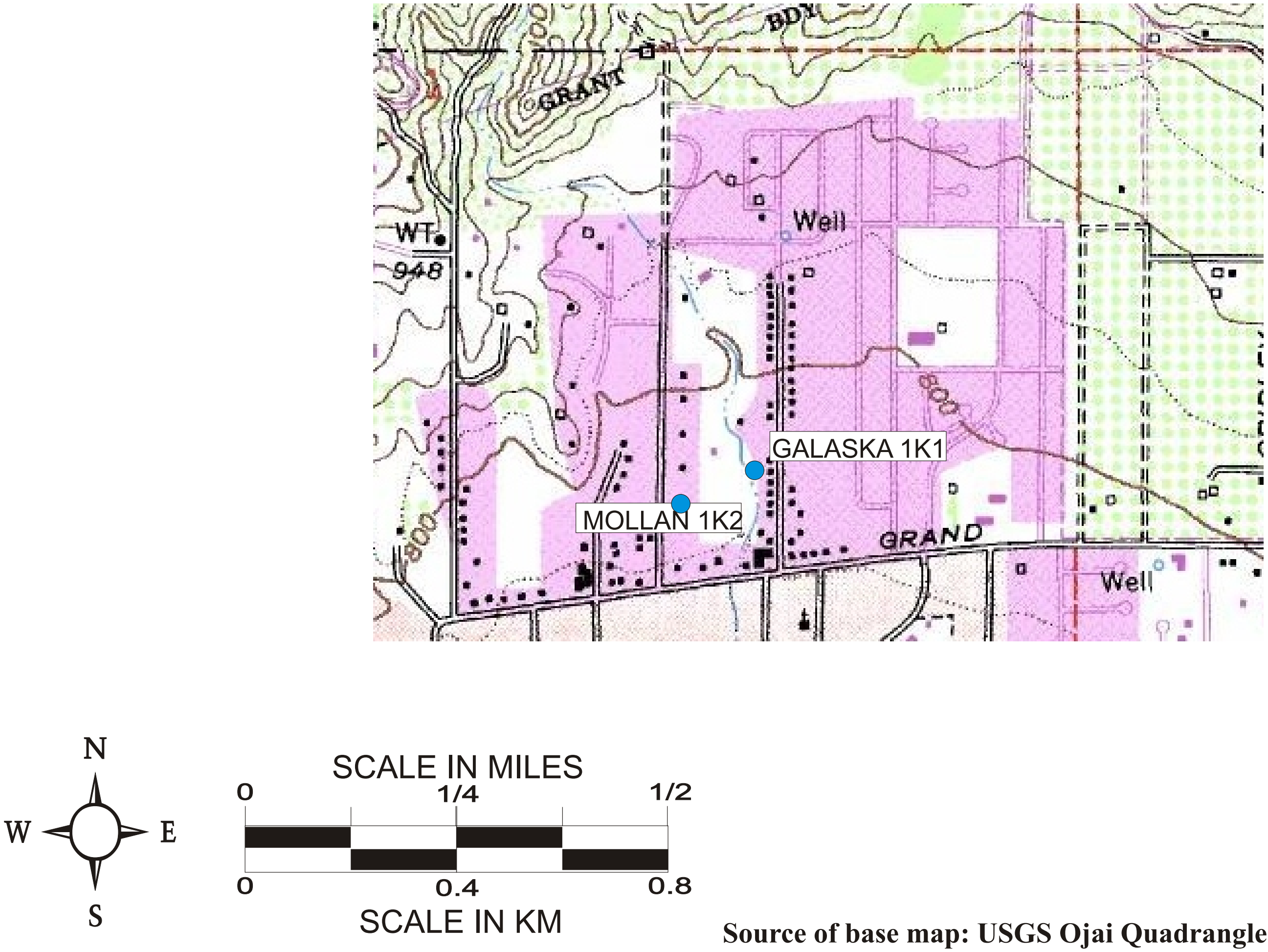
These residential wells were selected due to their locations in the basin, where previous investigators have indicated confined conditions exist (Figure 47). These old wells have been variably used over their 50-year life spans, with significant inefficiencies evident when pumping was attempted with maximum pumpage. The Galaska (4N/23W-1K1) Well was selected because it was believed able to be pumped at a greater rate than the Mollan (4N/23W-1K2) Well, access for a pressure transducer was feasible, and the well could be idle for a period prior to testing.

Data

Precipitation and barometric conditions

As measured at the OJA precipitation station, approximately 12.06 inches of rain had fallen between the beginning of the 2003-2004 water year and when monitoring for this aquifer test began. What would be the final precipitation event of the water year brought 0.43 inch of rain on April 17-18, the day following the last data collected for the test.

Hourly measurements of barometric pressure were recorded at the Simi Valley station by the County of Ventura. An approximate 4-millibar range of atmospheric pressure conditions occurred during the 4-day monitoring period, and no barometric corrections were implemented due to this relative stability and the fact that the automatic data recording self-corrects for barometric changes.



Source of base map: USGS Ojai Quadrangle, 1988

Figure 47. Locations of wells monitored during 2004 Galaska test.

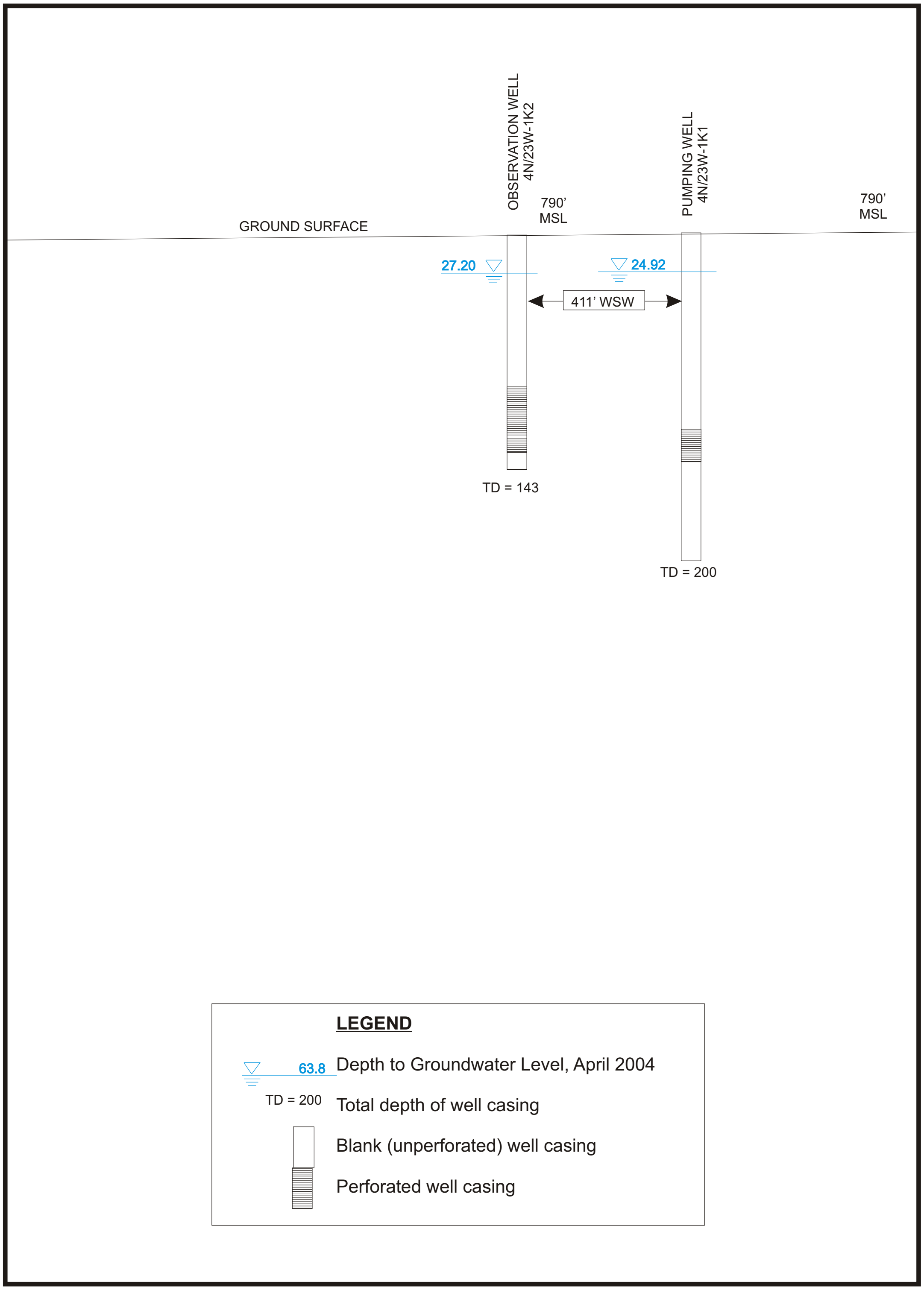


Figure 48. Schematic of pumping well 4N/23W-1K1
and observation well 4N/23W-1K2 (locations on Figure 47).

Pumping Well

The pumping well for this test was the Galaska Well. Access for water level monitoring was capable via an accessway through the seal in the 6-inch-diameter steel casing. Both automatic and manual water levels obtained via datalogger and pressure transducer and electric tape sounder. No totalizer exists on the 1-inch-diameter discharge line from the submersible well pump, so estimates of well yield are based on timing the filling of vessels. Additional well information is presented in Table 16, and a schematic cross-section is presented as Figure 48.

Observation Wells

Although the Mollan well was monitored during the planned pumping of the Galaska well, the water level in the Mollan well was recovering from an earlier pumping cycle. The Mollan Well (1K2) is equipped with a submersible pump and used for equestrian and irrigation purposes.

Aquifer test design

The aquifer test was designed to be conducted after several days of idle well conditions. However, the Mollan well was still recovering from a relatively recent pumping cycle on the date the test was scheduled. The Galaska well was also intermittently pumped for short durations, but the recovery was sufficiently quick to return static conditions. In the Galaska Well 4N/23W-1K1, continuous (minutely) automatic water level monitoring began at noon on April 12, 2004 and continued through 5:00 PM on April 16, 2004. Water levels relative to the reference point set at noon on April 12, 2004, 24.92 feet below the top of the well casing, are plotted for the four days on Figure 49.

The pumping test was planned to allow the pumping well (Galaska) to produce at its maximum rate continuously for 24 hours. Water was discharged into the corral for dust control, and into citrus orchards for irrigation.

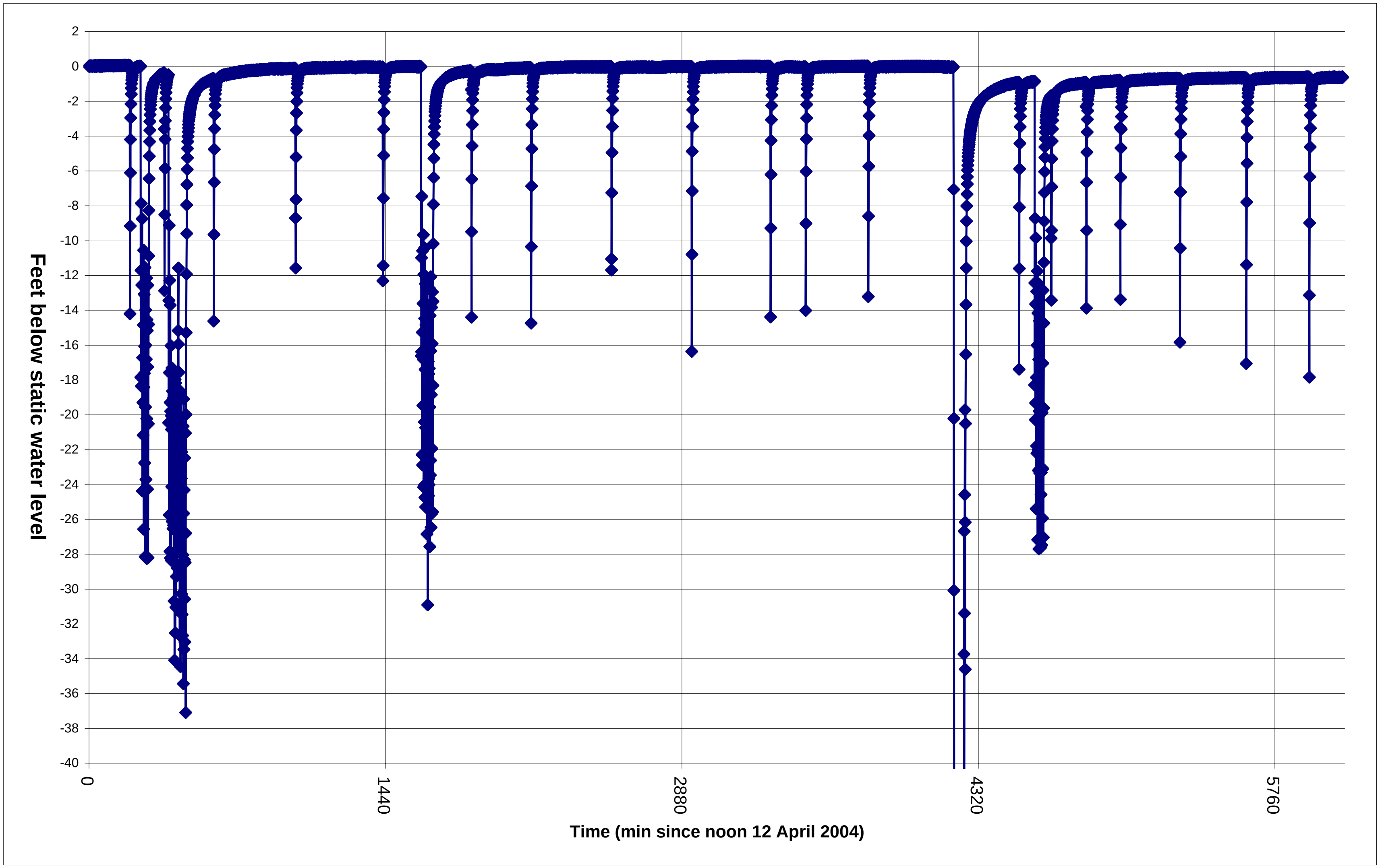


Figure 49: Summary of water level observations, Galaska well.

Pumping commenced in the Galaska Well at 9:48 AM on April 15, 2004. The pumping rate was approximately 22 gpm but the pump began producing air soon after commencing pumping. After 50 minutes, the test was aborted to avoid damage to the pump or casing. Following pumping, recovery was measured automatically in the pumping well.

Table 16 – Summary of Drilling and Well Construction Data

State Well Number *Owner* Name	**Drill Date**	**Drill Depth (feet)**	**Casing Diameter (inches)**	**Distance from Pumping Well, Direction**	**Perforation Depth Intervals (feet)**	**Well and Pump Status/ Information**
4N/23W-1K1 ***John Galaska*** **Equine/Irrigation Well**	1954	200	5	0	120-140	
4N/23W-1K2 ***Dave Mollan Company*** **Irrigation/Equine Well**	1953	143	5	411 242° WSW	90-130	Sander: pumped for several hours on days prior to test, other well monitored continuously.

Observed Drawdown

Pumping well

Although the planned test was aborted, more than 40 feet of drawdown were recorded as the pumping water level reached below the transducer to the pump intake. Also, four typical pumping periods (30 to 80 minutes) were recorded via the automatic datalogger and 19 short-term (~1 minute) pumping cycles were recorded. Between 28 and 37 feet of drawdown were recorded during each of these tests. Figure 49 presents a summary of water level data over the monitoring period.

Observation wells

During the planned and aborted test, the Mollan Well was recovering at a steady rate. No effect of the pumping well was evident in the data.

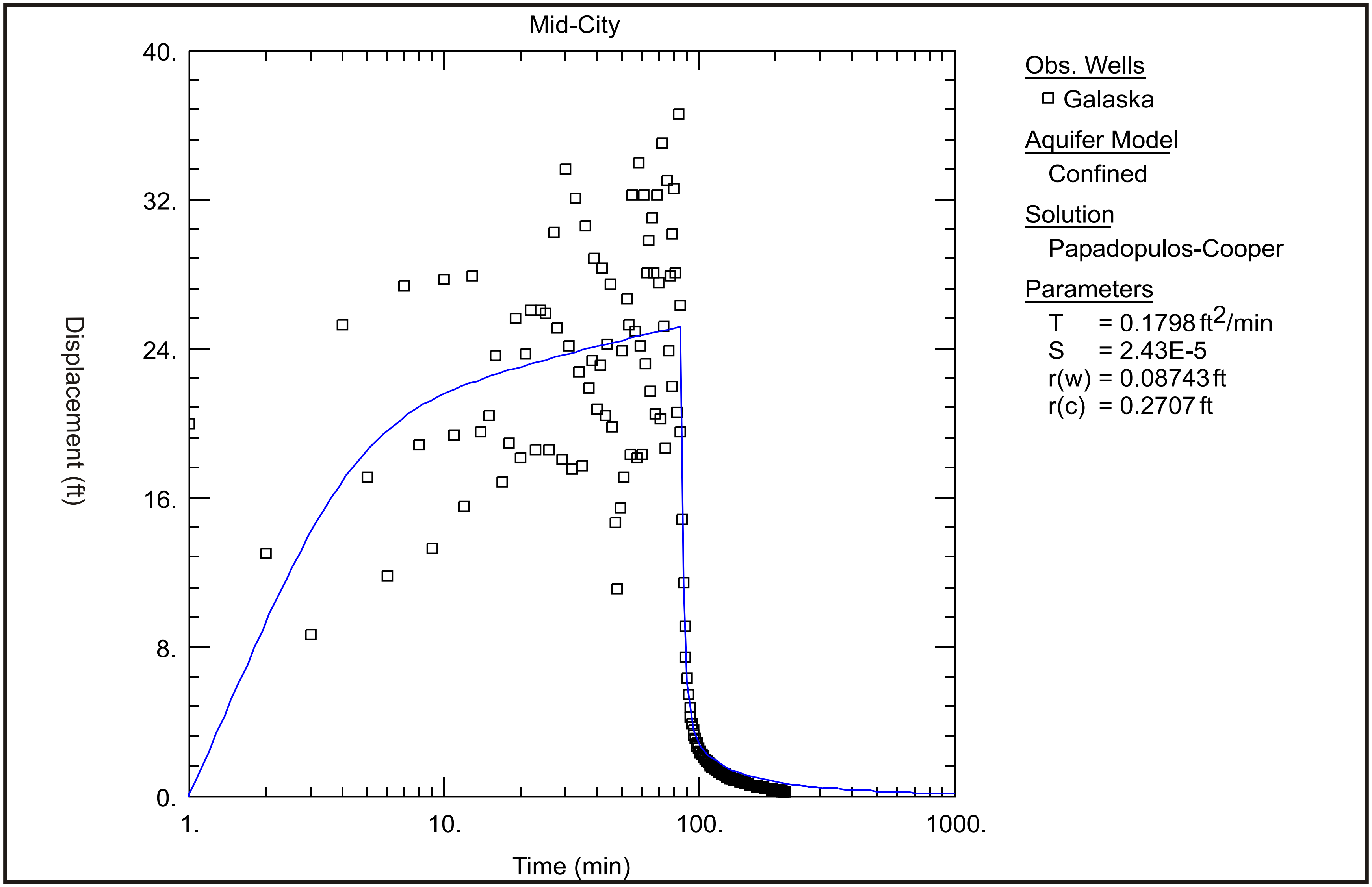


Figure 50. Papadopulos-Cooper solution, Galaska pumping well.

Methods/Results

Because of the lack of valuable observation well data, only pumping well data were utilized for this portion of the basin. The data used were from the longest period of pumping recorded by the datalogger, approximately 84 minutes on the afternoon of April 12, 2004, and subsequent recovery. A pumping rate of 22.4 gpm (3 cfm) is assumed based on average pumping rates for the well. Raw water level data, recorded minutely for the pumping period of April 12, 2004, are presented as Appendix F.

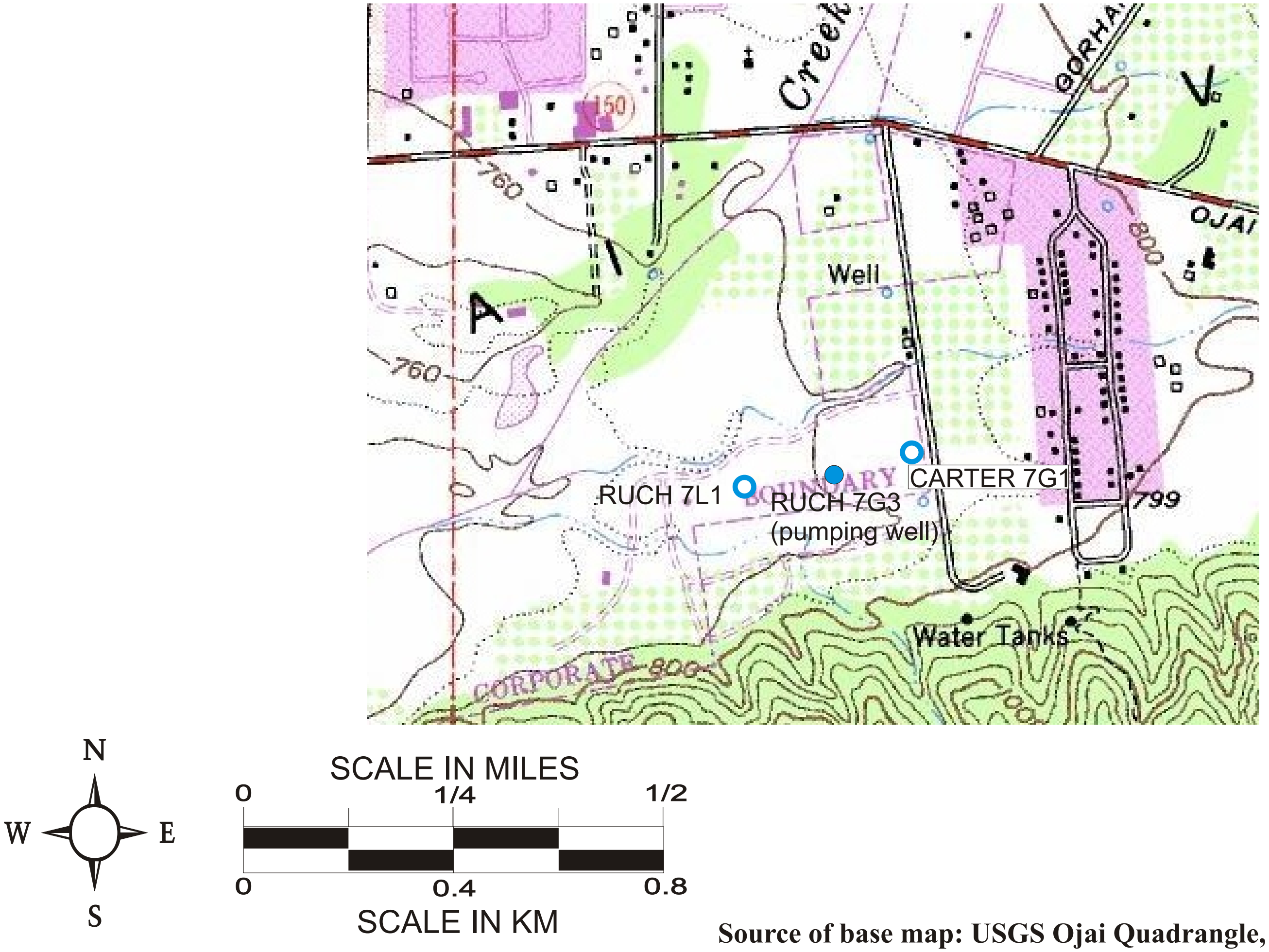
Papadopulos-Cooper type-curve matching

Papadopulos and Cooper (1967) derived a solution for a large-diameter pumping well in a confined aquifer. Type-curve analyses of the data by the Papadopulos-Cooper (1967) confined aquifer solution was chosen for its efficiency of use in aquifer tests for which there are only data from a pumping well. The type curve matches a best-fit curve to the data (Figure 50). Based on the type-curve analyses for data from the Galaska Well, transmissivity values are on the order of 0.1789 ft^2/min and storativity values are on the order of 0.0000243.

Southwest Basin (Jim Ruch Wells)

Introduction

In late April 2004, the final aquifer test for this study was conducted along the southern portion of the Ojai Basin. Automatic and manual water level measurements in the two wells on Mr. Jim Ruch's property began on April 21, 2004 and continued to May 3, 2004. Pumping of the primary irrigation well began on April 29, 2004 and intermittent pumping over the following several days was observed at rates averaging 31 gpm. Based on detailed observation data over selected periods of the test from nearby wells, the aquifers from which these wells extract groundwater appears to be confined.



Source of base map: USGS Ojai Quadrangle, 1988

Figure 51. Locations of wells monitored during 2004 Ruch test.

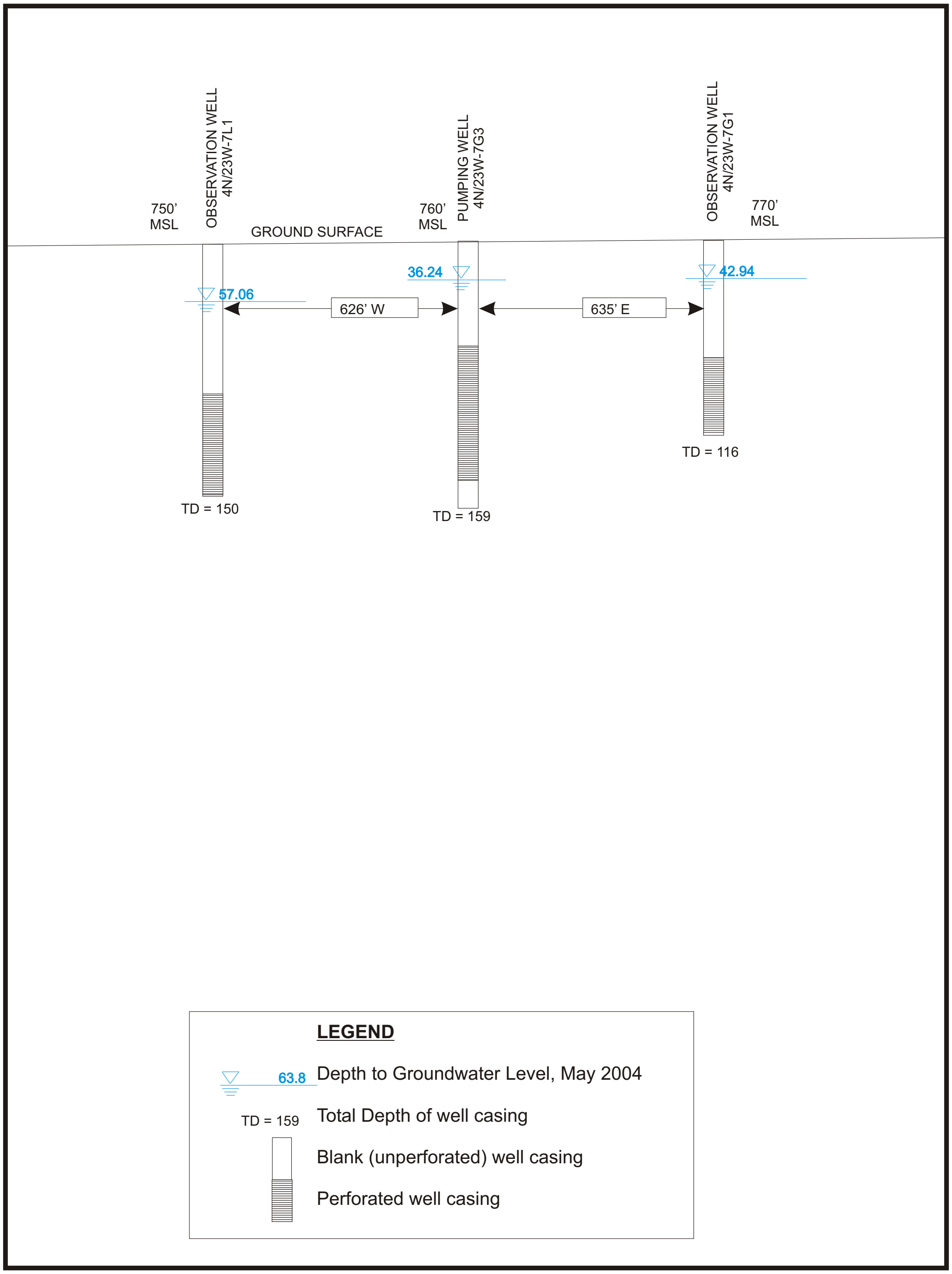


Figure 52. Schematic of pumping well 4N/23W-7G3 and observation wells 4N/23W-7G1 and -7L1.

Location

The Southwest Ojai Basin aquifer test was selected due to its location in the basin, logistical ability to be pumped by the well owner, proximal potential observation wells, existing pump and power apparatus, a location for discharge waters, and ancillary access and pumping volume monitoring apparatus (Figure 51). The key to this portion of the basin is that it has been mapped as being south of the fault mapped by Turner (1971) and aquifers appear to be much shallower than at locations more to the north in the basin. The pumping well (4N/23W-7G3) is located in an area of limited residential development and many citrus groves. Nearby active wells provided access to the aquifers for water level monitoring at Mr. Ruch's property (7L1) and the neighboring parcel to the east (7G1).

Few wells exist in the tested area, and there was apparently no pumping in any wells in the area except for the well associated with this testing.

Data

Precipitation and barometric conditions

As measured at the OJA precipitation station, approximately 12.49 inches of rain had fallen between the beginning of the 2003-2004 water year and when monitoring for this aquifer test began. The final precipitation event of the water year brought 0.43 inch of rain on April 17-18, which preceded data collection for this test by three days.

Hourly measurements of barometric pressure were recorded at the Simi Valley station by the County of Ventura. An approximate 11-millibar range of atmospheric pressure conditions were recorded during the monitoring period, but no barometric corrections were implemented due to the fact that the automatic data recording self-corrects for barometric changes.

Pumping Well

The pumping well for this test was the 4N/23W-7G3. This relatively new well was drilled in 1992. Access for water level monitoring was capable via a ½-inch-diameter port in the well seal on top of the well casing. Additional access for the pressure transducer was possible via the 3-inch-diameter discharge port where groundwater emerges from the well during periods of artesian conditions. Strictly automatic water levels were recorded from this well during the test. A totalizer reading in gallons exists on a discharge line from the submersible pump in the shed which also houses the well. Additional well information is presented in Table 17, and a schematic cross-section showing well and aquifer relationships is presented as Figure 52.

Observation Wells

Available key observation wells for this test were on the Ruch Property and the property to the east (State well nos. 4N/23W-7L1 [solar-powered pond well] and 4N/23W-7G1 [active]). Both wells are equipped with submersible pumps and remained idle for the duration of the pumping portions of the test. The pond well (7L1) was accessible to a pressure transducer via a port in the PVC slip cap covering the PVC casing. Only an electric tape sounder could access the water level through a ¼-inch-diameter port in the well cap of the domestic and irrigation Well 7G1, monitored manually during the initial portion of pumping.

Aquifer test design

The aquifer test was designed to be conducted during a period when limited water demand was occurring and the two properties could share a single well via existing cross-connection apparatus. In Well 4N/23W-7G3, continuous (10-minutely) automatic water level monitoring began on April 21, 2004; this frequency was increased to minutely on April 29, 2004 and the pond well (7L1) was added to the data logging schedule. This minutely monitoring continued through on May 4, 2004.

Importantly, pre-pumping and post-pumping monitoring of the water levels in Wells 4N/23W-7G3 and 7L1 indicated relatively stable groundwater levels.

The pumping test was planned to allow the pumping well to produce at its normal rate continuously for several days. However, the well produced on a variable time schedule with seven pumping periods over the six days between April 29 and

May 4, 2004. Water was discharged into the orchards and domestic facilities at the two residences.

Pumping commenced in the Ruch Well at 5:48 PM on April 29, 2004. The pumping rate was approximately 31 gpm, which appeared to be fairly constant rate when the well was pumping. Over the first 24 hours, the pump stopped two times for 10 minutes once and approximately 2 hours another time.

Table 17 – Summary of Drilling and Well Construction Data

State Well Number *Owner* Name	**Drill Date**	**Drill Depth (feet)**	**Casing Diameter (inches)**	**Distance from Pumping Well, Direction**	**Perforation Depth Intervals (feet)**	**Well and Pump Status/ Information**
4N/22W-7G3 ***Jim Ruch*** **Irrigation and Domestic Well**	1992	159	8	0	60-140	Pumping well
4N/22W-7L1 ***Jim Ruch*** ***Pond Supply Well***	1998	150	6	626 242° W	90-150	Solar powered pump
4N/22W-7G1 ***Duane Carter*** ***Domestic/*****Irrigation Well**	1924	116	15	635 73° E	?	Well underlies immobile pump rig.

Observed Drawdown

Pumping well

Although the pumping was not continuous, the automatic datalogger allowed for water level measurements to be collected continuously and record drawdown in the pumping well and one observation well during several pumping cycles. During a 109-minute pumping period on May 3, 2004, adequate data were collected to interpret drawdown and generate aquifer parameter solutions. During this period, a maximum pumping water level drawdown in the pumping well was 1.57 feet.

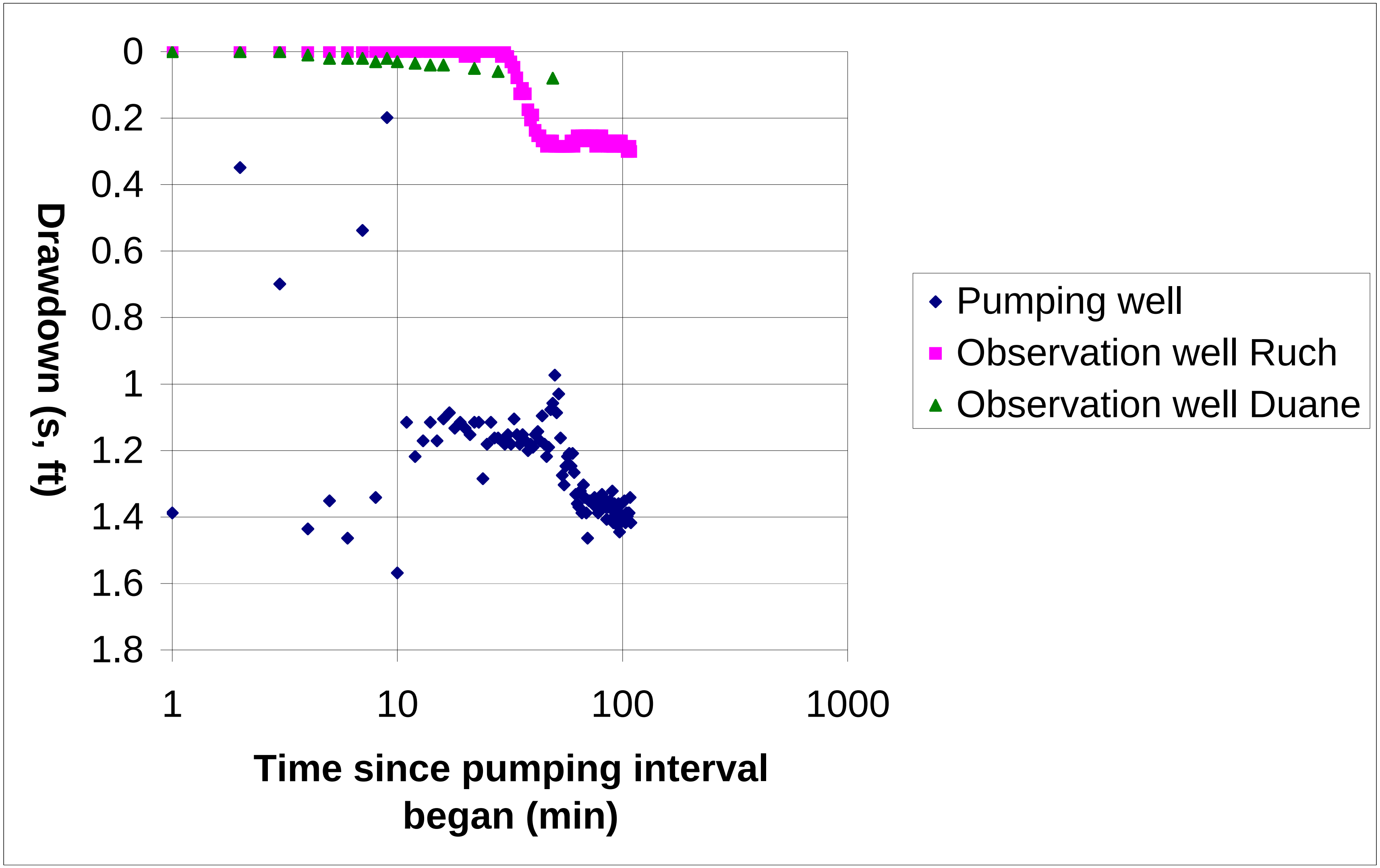


Figure 53. Water levels, selected portion of Ruch test.

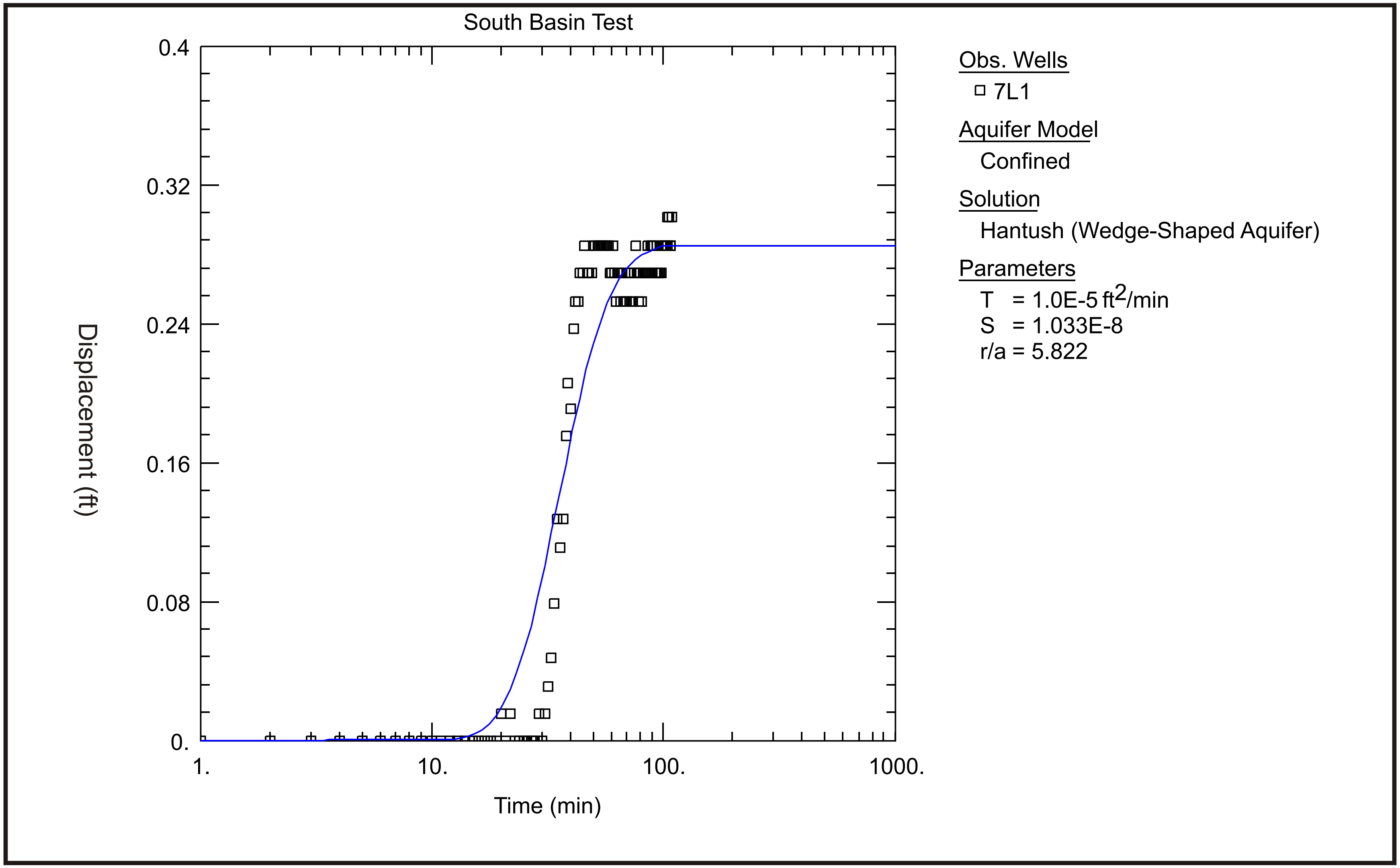


Figure 54. Hantush solution, Ruch observation well.

Observation wells

During the May 3, 2004 data set, a maximum drawdown of 0.30 foot was recorded in the pond well (7L1) located 623 feet west southwest of the pumping well. Effects of pumping were first observed approximately 30 minutes into pumping. This pattern is reflected in several other pumping cycles for which data were collected.

Figure 53 presents a summary of water levels for a selected portion of the south basin testing.

Methods/Results

Although the aquifer was not extensively stressed during this testing, the data from the 109-minute pumping interval on May 3, 2004 were subject to type curve analyses. A pumping rate of 31 gpm (4 cfm) is assumed based on average pumping rates for the well.

Hantush (wedge-shaped aquifer) type-curve matching

Hantush (1962) derived an equation which predicts water-level displacement in a wedge-shaped confined aquifer in response to pumping. Type-curve analyses of the data by the Hantush (1962) wedge-shaped confined aquifer solution were chosen due to the interpreted aquifer geometry in the area, narrowing to the north. The type curve matches a best-fit curve to the data (Figure 54), even though several assumptions are not met. Based on the type-curve analyses for data from the Pond Well, very low transmissivity values are on the order of 0.00001 ft^2/min and storativity values are on the order of 1.033×10^{-8}. These values, effectively zero, are likely due to the lack of significant stress applied to the pumped aquifers during the test.

CONCLUSIONS

This study was undertaken with the goal of determining the status of the Ojai Groundwater Basin with respect to degree of confinement and the determination of hydraulic conductivity and storativity. To accomplish this, aquifer tests were conducted at six locations throughout the basin under various hydrologic conditions. In addition, available data from two aquifer tests previously conducted by others were evaluated. Further research was conducted and included the generation of hydrographs, cross sections, and hydrogeologic maps.

Groundwater levels and basin recharge

Based on observed temporal changes in groundwater levels, it is clear that the Ojai Basin recharges quickly (on the order of weeks) with a rapid groundwater-level recovery following even average years of precipitation. As a result of these high recharge rates, impact of long term droughts on groundwater levels are minimized by intermittent years of above average precipitation. For example, between 1947 and 1968, although several consecutive years of prevailing below average rainfall occurred, intermittent years of above average precipitation (1952, etc.) brought water levels in the basin back to a status of sufficient storage. This is due to the fact that the basin has a relatively large drainage area, which increases the volume of water for potential infiltration, compared to its groundwater storage capacity. Other factors contributing to the relatively rapid emergence from drought conditions are: 1) the prevailing pumping of groundwater pumping is for irrigation and domestic use (of which a significant amount may be returned to the system); and 2) that the primary discharge mechanism for the basin is pumpage. It is also important to note that many "static" water levels measured during the irrigation season are influenced by nearby pumping wells; those measurements taken following major pumping but before seasonal precipitation indicate basin recovery from pumping, not necessarily basin recharge.

Aquifer testing

Based on interpretation of two previously-conducted (by other parties in 1961 and 1996) aquifer test data sets and six aquifer tests conducted during the course of this study and newly generated hydrogeologic maps and cross sections, aquifer units appear to be the most transmissive in the central, east-central, and southeast portions of the basin, where aquifer units are thick, deep, and composed of dominantly permeable and relatively well sorted Quaternary alluvial sand and gravel units. Near the basin boundaries aquifer units are thinner. Either a debris-flow depositional environment (typical of alluvial fans, with poorly-sorted sediments, mixed clay and gravel units, and indicative electric-log signatures) predominates, and/or aquifer units are relatively too high in elevation to maintain an adequate saturated thickness. The average aquifer transmissivity, therefore, appears to be lower in those peripheral areas than in the central portion of the basin. Table 18 and Figure 55 each present a summary of aquifer testing findings from this study.

Table 18 – Summary of Ojai Basin Aquifer Tests
Aquifer characteristics based on averaged data from all solutions

Aquifer Test	Transmissivity (ft^2/min)	Storativity	Aquifer characteristic at time of aquifer test
Soule Park (1961)	0.62	0.0010	Confined (based on low storativity and historic water levels)
SCWC Gorham Well (1996)	1.08	0.000004	Confined (based on low storativity and historic water levels)
SCWC Ojai Mutual (2003)	1.57	0.024	Unconfined (based on high storativity and historic water levels)
Conrow (2004)	6.20	0.0004	Confined (based on low storativity and historic water levels)
SCMWC Grant Well (2004)	4.66	0.00052	Confined (based on low storativity and historic water levels)
Essick Lagomarsino Well (2004)	1.01	0.0002	Confined (based on low storativity and historic water levels)
Galaska (2004)	0.1789	0.000024	Confined (based on low storativity and historic water levels)
Ruch (2004)	0.00001	0.00000001	Confined (based on low storativity and historic water levels)

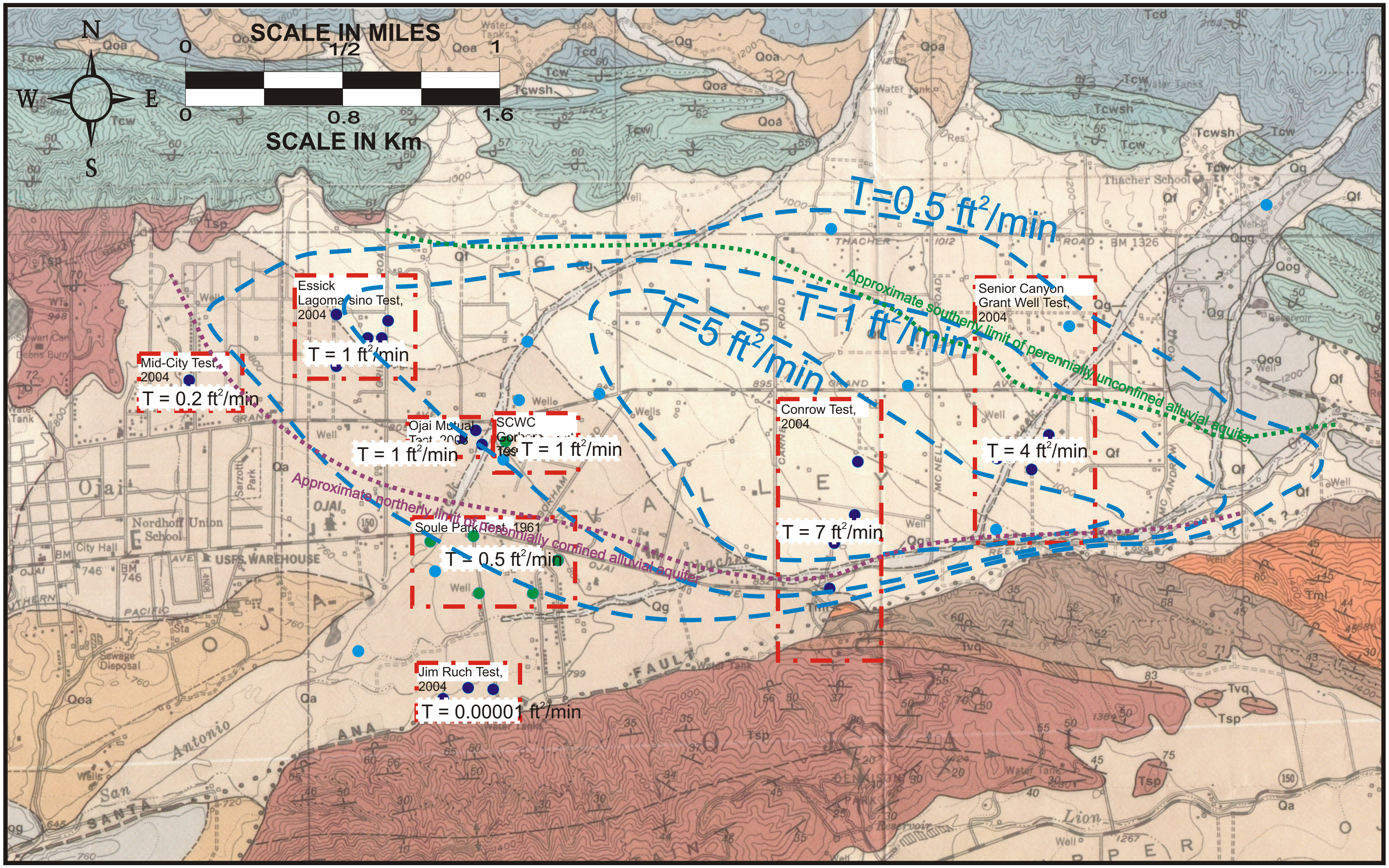


Figure 55. Approximate map of transmissivity based on aquifer test data and solutions.

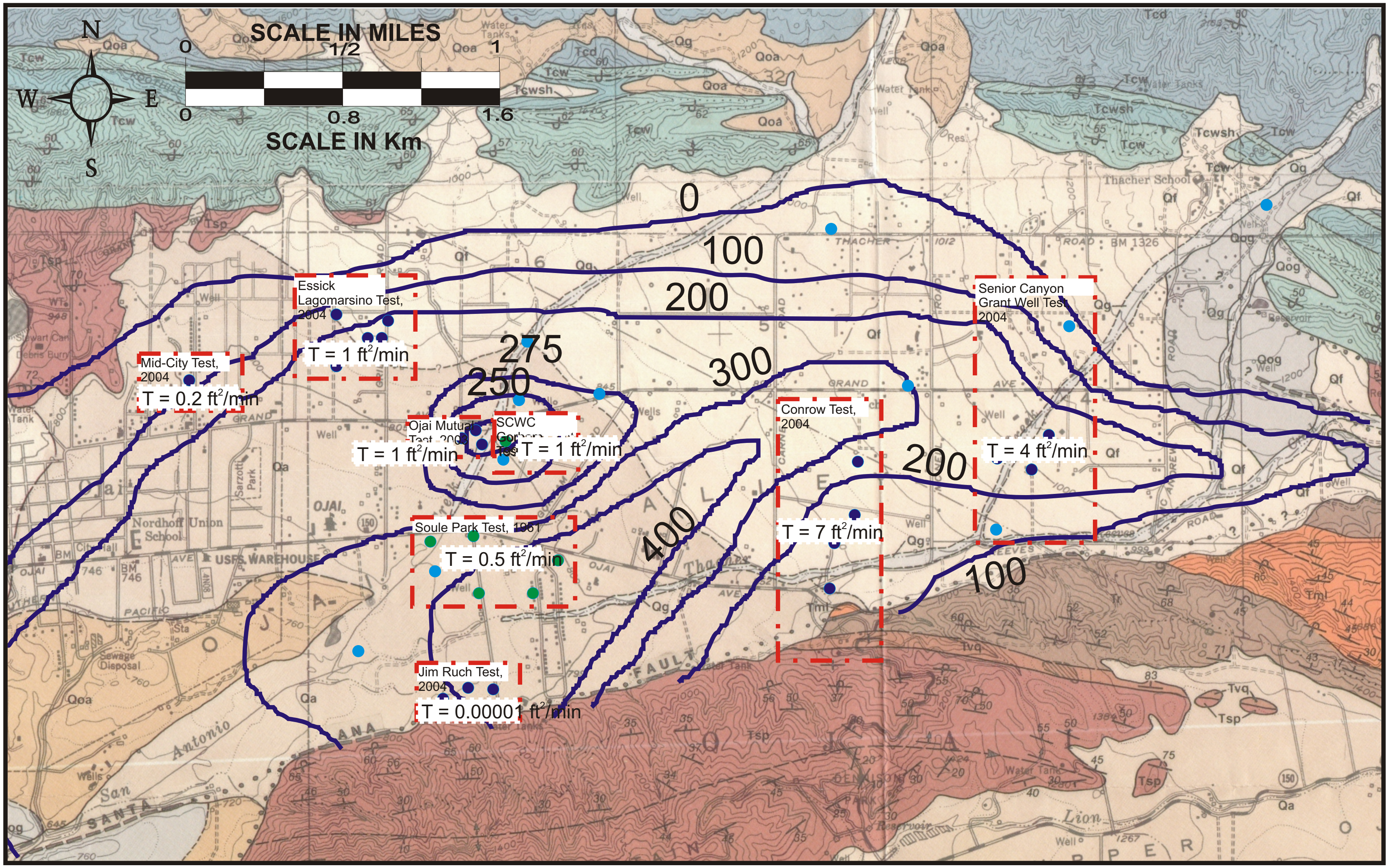


Figure 56. Approximate 1951 historic low saturated sand and gravel thickness map and transmissivity (T) values based on aquifer test data and solutions.

Alluvial aquifer and aquitard morphology

Cross sections, presented as Figures 5, 6, and 7, illustrate a correlation of aquifers, aquitards, and the top of bedrock which lies beneath the alluvium along planes where geophysical-log data are available for water wells in the basin. Most geophysical logs used for the correlations are resistivity and spontaneous potential logs are most commonly referred to as electric logs. From these sections (Figures 5 through 7), a depth-dimensional mechanism for confinement becomes apparent, and distinctly separate aquifers are presented within the Ojai Basin for the first time. Based on the interpretation of the three hydrogeologic cross sections and geophysical data, it is apparent that several clay units (aquiclude and aquitard) predominate and thicken in the southern and western portions of the Ojai Basin in the areas distal from the alluvial fan heads. Conversely, sand and gravel units become thicker and more predominant toward the fan heads. These several successive stratigraphic units represent a depositional environment wherein the Ojai Valley was subject to uplift and compression, predominantly from the upthrow of the San Cayetano Fault but also, to a lesser extent, the uplift of Black Mountain along what is mapped as the Santa Ana Fault. During certain historic periods, discharge out of the basin might have been slowed or even dammed by geologic activities such as local uplift of older rocks near the surface water outfall of the basin or landslides near the surface water discharge areas of the basin. Under this scenario, the basin would have been filled locally with standing bodies of water allowed for low energy clay deposits (aquitards). Thinner paleosol clays are also likely present, but these are not likely as thick nor laterally contiguous as the lacustrine-type clay deposits. These aquitard/aquiclude units might have a dominant impact on local groundwater hydraulics in such a way to affect the degree of confinement, well productivity, and groundwater quality. For reference, Figure 56 provides an approximate saturated sand-and-gravel thickness map during the historic low water level period of fall 1951. This map is intended to show the minimal historic saturated thickness in the basin and is constructed from historic low water level contours and effective base of fresh water maps prepared by Staal, Gardner, & Dunne, 1992.

Confinement versus unconfinement

Based on the aquifer-test results determined by this study, it appears that water levels are imperative to the status of confined versus unconfined conditions observed in the basin. With the exception of higher elevation areas associated with the alluvial-fan heads, the aquifer system is or is capable of being under confined conditions in the areas where the aquifer tests were conducted. As such, there are key water levels for most wells in the Ojai Basin that render the underlying aquifers targeted for groundwater extraction "confined" or "unconfined."

The number of aquifers penetrated by any given well may also provide information between confinement versus unconfinement. Over the course of a given year with typical seasonal fluctuations, hydrologic conditions may create confinement in all aquifers, confinement in lower aquifers only, with unconfined conditions prevalent in successively shallower aquifers depending on water levels and thicknesses of aquifer/aquitard units.

Other key hydrogeologic mapping features are the apparent extents of perennially confined aquifers in the Ojai Basin and the perennially unconfined aquifers therein (Figure 3). In confined aquifer systems, there is less likelihood for vertical migration of contaminants, wells can be more efficient if properly designed, and storage/basin management practices differ when compared to unconfined aquifers.

Importantly, the great number of wells historically constructed in the Ojai Valley may create conduits of inter-aquifer transmission of water, as many wells were perforated through what are now recognized to be aquitards.

RECOMMENDATIONS

This research provides a major contribution to the understanding of the hydrogeology of the Ojai groundwater basin area.

It is recommended that the OBGMA, as lead agency involved in the management and study of the Ojai Basin, pursue grant funding from various sources to implement the recommendations presented herein.

Depth-discrete water-quality assessment

Based on the delineation of isolated aquifers in the basin, it is likely that each zone may have its own unique water quality characteristics. Whereas shallow zones may be more susceptible to contamination by chemicals such as nitrate, deeper aquifer units may be contributing high concentrations of iron, manganese, or other ions to the well blends. It is therefore recommended that in order to improve the quality of extracted groundwater in the future, depth-specific water quality in the Ojai Basin be investigated. This may be accomplished by converting older water supply wells into depth-discrete monitoring wells, conducting down-well sampling in active wells when feasible, or drilling new wells dedicated to depth-discrete groundwater monitoring. Additionally, these data points may provide information on vertically-differential heads within individual aquifers, provide insight to spreading operations, cross-aquitard flow and allow for future aquifer testing to determine individual aquifer characteristics rather than integrated values as found by this study.

Fault analyses

The presence of faults and other geologic structures in a groundwater basin pose significant issues with respect to boundary conditions, water quality, groundwater hydraulics, and aquifer geometry. Previous investigators mapped faults bounding the northeast portion of the Ojai Basin (San Cayetano Fault), the south portion of the basin (Santa Ana Fault), and the fault separating the Ojai Basin subparallel to the Santa Ana Fault presented by Turner (1971). Confirmation and detailed mapping of these faults and their specific hydraulic characteristics might provide extensive results that can be utilized by hydrogeologists, geomorphologists, engineering geologists, or geotechnical engineers.

Geophysical surveys

Recent work in small intermontane basins similar to Ojai has been conducted with funding by grants from the State of California, Department of Water Resources. For example, Crescenta Valley Water District, near Glendale, California, recently received a grant to conduct a seismic refraction study within the basin to map the base of alluvium and top of underlying granitic bedrock.

A similar geophysical study in Ojai would help determine depth to bedrock. A complete alluvial thickness map could be generated, allowing for the maximum thickness of potentially water bearing alluvium to be penetrated by new water supply wells, as well as the morphology of the contact between the alluvium and bedrock.

Down-well geophysical investigations

Owing to the large amount of viable wells in the Ojai valley, it is recommended that down-well geophysical investigations be conducted in existing wells. Although rare within the existing well-log database, dual-induction and gamma-gamma logging can be conducted in PVC-cased wells to establish correlation points where they may be lacking, and provide information on depths to aquifers, aquitards, water quality, and depths to bedrock.

When vertical turbine or submersible pumps are removed for maintenance, it is recommended that down-well flowmeter (spinner) testing be conducted. This will establish the points of entry for pumped groundwater, and provide information on which aquifers in the basin are most productive under normal pumping conditions. Groundwater sampling down-well can be conducted on the same mobilization, contributing to depth-specific understanding of water quality (see Section 7.1).

Generation of groundwater model

As additional data become available, a detailed numerical groundwater model of the Ojai Basin will undoubtedly be generated. Manz (1988) created a numerical groundwater model for the Ojai Basin which used relatively large grid spacing for the model and relatively homogeneous cells. In a future groundwater model, cells could be modified from the polygons presented in the 1970- and 1980-vintage models, vertical layers could reflect aquifers and aquitards presented herein, various pumping and precipitation scenarios could be modeled, and water quality issues could be explored.

New well locations and pumpage

Based on the results of this study, the Ojai Basin can likely support several properly located, designed, and pumped-high-capacity water supply wells. Their key location issues are: 1) to be as distal as possible from other high capacity wells; 2) be located in the deeper and more transmissive portions of the basin; as well as 3) meet typical logistical issues such as property ownership, offsets/setbacks, drill rig access, discharge issues, etc. Key well design issues include the penetration of a maximum thickness of aquifer material, the targeting of production zones which may remain saturated (confined) perennially, the proper sizing perforations and gravel packs, and provision of proper sanitary seal(s), ancillary tubing, and other items. Pumpage issues include proper development, pump sizing, pump-depth setting, and operation rates, periods, and durations.

During drilling of new wells in the valley, the OBGMA should be aware and involved in the monitoring of pilot hole drilling, geologic and geophysical logging, and any water quantity or water quality findings from pilot borehole discharges.

Monitoring

The continued monitoring of the quantity and quality of groundwater in the Ojai Basin is tremendously important to continue the maintenance of the local database, provide data for future studies, calibrate models, assess and remediate groundwater problems, and monitor the effects of agriculture. Precipitation, amounts of water in storage, any artificial recharge and pumpage are also key monitoring parameters. Equally important is the monitoring of new water supply wells as they are constructed, to maintain an updated database and modify the understanding of the basin as new data become available.

Artificial recharge efforts

Because the Ojai Basin experiences acute effects of deficient rainfall, including annually low water levels which can render upper aquifers unsaturated, it is recommended that artificial recharge efforts be implemented. At ground surface, several options exist, including the rehabilitation of the San Antonio Spreading Grounds or construction of new spreading grounds. If intrusive recharge efforts are pursued, new aquifer storage/recovery (ASR) wells may be constructed or, where feasible, existing wells can be converted to serve an ASR function.

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APPENDIX A:

Raw data from 1996 SCWC Gorham Aquifer Test

SCWC Gorham Well Aquifer Test, 1996
Data from San Antonio Well No. 3

Time (min)	Drawdown	Time (min)	Drawdown	Time (min)	Drawdown
1	0.48	16	2.88	250	9.65
1.2	0.48	18	3.11	265	9.784
1.4	0.48	20	3.302	385	10.914
1.6	0.489	22	3.475	505	11.748
1.8	0.489	24	3.638	595	12.265
2	0.499	26	3.773	715	12.724
2.2	0.518	28	3.955	730	12.734
2.4	0.537	30	4.08	820	13.069
2.6	0.557	32	4.224	940	13.451
2.8	0.585	34	4.377	1030	13.758
3	0.614	36	4.483	1045	13.873
3.2	0.653	38	4.598	1120	14.083
3.4	0.691	40	4.713	1225	14.399
3.6	0.72	42	4.847	1330	14.676
3.8	0.758	44	4.943	1405	14.906
4	0.806	46	5.039		
4.2	0.845	48	5.135		
4.4	0.883	50	5.24		
4.6	0.931	52	5.327		
4.8	0.97	54	5.413		
5	1.008	56	5.499		
5.2	1.056	58	5.586		
5.4	1.104	60	5.672		
5.6	1.142	62	5.749		
5.8	1.19	64	5.825		
6	1.229	66	5.893		
6.2	1.277	68	5.969		
6.4	1.315	70	6.036		
6.6	1.354	72	6.104		
6.8	1.402	74	6.171		
7	1.44	76	6.238		
7.2	1.488	78	6.295		
7.4	1.526	80	6.362		
7.6	1.565	82	6.42		
7.8	1.603	84	6.478		
8	1.642	86	6.545		
8.2	1.68	88	6.602		
8.4	1.718	90	6.669		
8.6	1.757	92	6.708		
8.8	1.795	94	6.775		
9	1.843	96	6.832		
9.2	1.872	98	6.88		
9.4	1.911	100	6.947		
9.6	1.949	115	7.34		
9.8	1.987	130	7.686		
10	2.016	205	9.257		
12	2.343	220	9.391		
14	2.621	235	9.516		

APPENDIX B:

Raw data from November 2003 SCWC Ojai Mutual Aquifer Test

SCWC Ojai Mutual Aquifer Test, November 2003
Data from Ojai Mutual Well No. 3

Time (min)	Drawdown	Time (min)	Drawdown	Time (min)	Drawdown
0.0083	0.02	0.5333	0.073	5.2	2.291
0.025	0.02	0.55	0.086	5.4	2.384
0.0333	0.013	0.5666	0.093	5.6	2.477
0.0416	0.02	0.5833	0.086	5.8	2.564
0.05	0.013	0.6	0.093	6	2.657
0.0583	0.007	0.6166	0.1	6.2	2.75
0.075	0.007	0.6333	0.106	6.4	2.85
0.0833	0.007	0.65	0.113	6.6	2.95
0.0916	0.02	0.6666	0.106	6.8	3.043
0.1	0.027	0.6833	0.113	7	3.136
0.1083	0.007	0.7	0.12	7.2	3.229
0.1166	0.027	0.7166	0.133	7.4	3.316
0.125	0.007	0.7333	0.14	7.6	3.389
0.1333	0.007	0.75	0.14	7.8	3.482
0.1416	0.033	0.7666	0.16	8	3.562
0.15	0.007	0.7833	0.16	8.2	3.642
0.1583	0.027	0.8	0.153	8.4	3.735
0.1666	0.02	0.8166	0.16	8.6	3.821
0.175	0.02	0.8333	0.166	8.8	3.901
0.1833	0.027	0.85	0.173	9	3.981
0.1916	0.013	0.8666	0.173	9.2	4.061
0.2	0.013	0.8833	0.186	9.4	4.134
0.2083	0.02	0.9	0.2	9.6	4.214
0.2166	0.02	0.9166	0.193	9.8	4.294
0.225	0.027	0.9333	0.2	10	3.861
0.2333	0.02	0.95	0.206	12	4.613
0.2416	0.027	0.9666	0.213	14	5.252
0.25	0.02	0.9833	0.22	16	5.804
0.2583	0.02	1	0.226	18	6.283
0.2666	0.046	1.2	0.326	20	6.695
0.275	0.027	1.4	0.393	22	7.06
0.2833	0.027	1.6	0.493	24	7.38
0.2916	0.033	1.8	0.573	26	7.626
0.3	0.033	2	0.659	28	7.865
0.3083	0.033	2.2	0.759	30	8.091
0.3166	0.033	2.4	0.852	32	8.257
0.325	0.04	2.6	0.952	34	8.41
0.3333	0.04	2.8	1.052	36	8.563
0.35	0.033	3	1.152	38	8.682
0.3666	0.033	3.2	1.272	40	8.795
0.3833	0.046	3.4	1.378	42	8.921
0.4	0.046	3.6	1.485	44	9.021
0.4166	0.04	3.8	1.565	46	9.114
0.4333	0.046	4	1.665	48	9.194
0.45	0.053	4.2	1.765	50	9.26
0.4666	0.06	4.4	1.865	52	9.34
0.4833	0.066	4.6	1.964	54	9.433
0.5	0.073	4.8	2.091	56	9.493
0.5166	0.073	5	2.177	58	9.579

SCWC Ojai Mutual Aquifer Test, November 2003 (continued)
Data from Ojai Mutual Well No. 3

Time (min)	Drawdown	Time (min)	Drawdown	Time (min)	Drawdown
60	9.639	390	10.237	880	9.759
62	9.686	400	10.257	890	9.772
64	9.725	410	10.244	900	9.752
66	9.779	420	10.224	910	9.739
68	9.818	430	10.21	920	9.699
70	9.858	440	10.197	930	9.732
72	9.891	450	10.19	940	9.719
74	9.918	460	10.184	950	9.699
76	9.958	470	10.19	960	9.686
78	9.984	480	10.17	970	9.666
80	10.011	490	10.144	980	9.699
82	10.031	500	10.131	990	9.692
84	10.071	510	10.117	1000	9.666
86	10.084	520	10.111	1010	9.646
88	10.104	530	10.111	1020	9.659
90	10.117	540	10.097	1030	9.659
92	10.144	550	10.091	1040	9.632
94	10.164	560	10.064	1050	9.626
96	10.177	570	10.044	1060	9.632
98	10.19	580	10.031	1070	9.639
100	10.204	590	10.018	1080	9.612
110	10.27	600	10.004	1090	9.599
120	10.29	610	10.024	1100	9.579
130	10.27	620	9.998	1110	9.599
140	10.257	630	9.958	1120	9.593
150	10.25	640	9.951	1130	9.566
160	10.27	650	9.931	1140	9.566
170	10.29	660	9.938	1150	9.546
180	10.27	670	9.951	1160	9.513
190	10.277	680	9.885	1170	9.506
200	10.27	690	9.905	1180	9.48
210	10.27	700	9.891	1190	9.46
220	10.283	710	9.872	1200	9.46
230	10.263	720	9.885	1210	9.44
240	10.263	730	9.891	1220	9.44
250	10.257	740	9.878	1230	9.433
260	10.244	750	9.865	1240	9.42
270	10.25	760	9.825	1250	9.413
280	10.29	770	9.832	1260	9.4
290	10.29	780	9.838	1270	9.413
300	10.297	790	9.832	1280	9.387
310	10.297	800	9.825	1290	9.4
320	10.29	810	9.818	1300	9.367
330	10.283	820	9.792		
340	10.29	830	9.792		
350	10.303	840	9.779		
360	10.283	850	9.792		
370	10.277	860	9.779		
380	10.263	870	9.759		

SCWC Ojai Mutual Aquifer Test, November 2003 (continued)
Data from Ojai Mutual Well No. 3

Time (min)	Drawdown
390	10.237
1310	9.347
1320	9.38
1330	9.387
1340	9.34
1350	9.34
1360	9.347
1370	9.34
1380	9.32
1390	9.28
1400	9.32
1410	9.307
1420	9.327
1430	9.3
1440	9.287

SCWC Ojai Mutual Aquifer Test, November 2003 (continued)
Data from Ojai Mutual Well No. 4

Time (min)	Drawdown	Time (min)	Drawdown	Time (min)	Drawdown
0.7333	0.01	7.6	1.091	84	2.864
0.75	0.01	7.8	1.11	86	2.883
0.7666	0.029	8	1.129	88	2.883
0.7833	0.01	8.2	1.148	90	2.883
0.8	0.029	8.4	1.167	92	2.912
0.8166	0.01	8.6	1.176	94	2.912
0.8333	0.029	8.8	1.186	96	2.912
0.85	0.029	9	1.205	98	2.931
0.8666	0.019	9.2	1.214	100	2.931
0.8833	0.029	9.4	1.224	110	2.968
0.9	0.038	9.6	1.233	120	2.959
0.9166	0.038	9.8	1.243	130	2.978
0.9333	0.038	10	1.262	140	2.987
0.95	0.019	12	1.328	150	2.987
0.9666	0.048	14	1.338	160	2.987
0.9833	0.048	16	1.309	170	2.987
1	0.048	18	1.29	180	2.997
1.2	0.048	20	1.262	190	2.978
1.4	0.076	22	1.233	200	2.987
1.6	0.105	24	1.205	210	2.978
1.8	0.133	26	1.186	220	2.987
2	0.171	28	1.167	230	2.978
2.2	0.228	30	1.148	240	2.978
2.4	0.266	32	1.138	250	2.978
2.6	0.304	34	1.129	260	2.968
2.8	0.351	36	1.157	270	2.959
3	0.38	38	1.338	280	2.968
3.2	0.408	40	1.575	290	2.959
3.4	0.465	42	1.783	300	2.968
3.6	0.484	44	1.973	310	2.968
3.8	0.522	46	2.115	320	2.959
4	0.569	48	2.229	330	2.95
4.2	0.598	50	2.343	340	2.959
4.4	0.626	52	2.409	350	2.95
4.6	0.683	54	2.485	360	2.931
4.8	0.702	56	2.542	370	2.931
5	0.75	58	2.58	380	2.931
5.2	0.787	60	2.646	390	2.912
5.4	0.816	62	2.656	400	2.921
5.6	0.844	64	2.684	410	2.912
5.8	0.873	66	2.713	420	2.902
6	0.901	68	2.741	430	2.902
6.2	0.93	70	2.76	440	2.874
6.4	0.958	72	2.788	450	2.893
6.6	0.987	74	2.807	460	2.883
6.8	1.006	76	2.817	470	2.893
7	1.034	78	2.826	480	2.864
7.2	1.053	80	2.845	490	2.874
7.4	1.072	82	2.864	500	2.864

SCWC Ojai Mutual Aquifer Test, November 2003 (continued)
Data from Ojai Mutual Well No. 4

Time (min)	Drawdown	Time (min)	Drawdown
510	2.855	1000	2.618
520	2.836	1010	2.637
530	2.826	1020	2.618
540	2.836	1030	2.618
550	2.817	1040	2.627
560	2.826	1050	2.618
570	2.817	1060	2.589
580	2.798	1070	2.608
590	2.788	1080	2.589
600	2.798	1090	2.58
610	2.788	1100	2.589
620	2.779	1110	2.58
630	2.769	1120	2.57
640	2.769	1130	2.57
650	2.75	1140	2.561
660	2.75	1150	2.551
670	2.75	1160	2.551
680	2.779	1170	2.551
690	2.741	1180	2.532
700	2.741	1190	2.523
710	2.741	1200	2.513
720	2.741	1210	2.513
730	2.741	1220	2.513
740	2.741	1230	2.504
750	2.731	1240	2.494
760	2.75	1250	2.494
770	2.713	1260	2.494
780	2.722	1270	2.485
790	2.722	1280	2.466
800	2.703	1290	2.475
810	2.703	1300	2.485
820	2.713	1310	2.475
830	2.694	1320	2.475
840	2.731	1330	2.475
850	2.684	1340	2.475
860	2.694	1350	2.475
870	2.684	1360	2.466
880	2.694	1370	2.466
890	2.684	1380	2.466
900	2.684	1390	2.457
910	2.665	1400	2.447
920	2.703	1410	2.457
930	2.665	1420	2.447
940	2.656	1430	2.438
950	2.656	1440	2.428
960	2.656		
970	2.646		
980	2.656		
990	2.637		

APPENDIX C:

Raw data from January 2004 Conrow Aquifer Test

Conrow Aquifer Test, January 2004
Data from State Well No. 4N/22W-5R2

Time (min)	Drawdown	Time (min)	Drawdown	Time (min)	Drawdown
1	0.016	50	1.131	99	1.29
2	0.032	51	1.147	100	1.29
3	0.128	52	1.147	101	1.29
4	0.207	53	1.147	102	1.29
5	0.287	54	1.147	103	1.29
6	0.335	55	1.163	104	1.29
7	0.382	56	1.163	105	1.29
8	0.414	57	1.163	106	1.29
9	0.446	58	1.163	107	1.29
10	0.478	59	1.179	108	1.29
11	0.51	60	1.179	109	1.29
12	0.542	61	1.179	110	1.29
13	0.573	62	1.179	111	1.306
14	0.605	63	1.179	112	1.306
15	0.637	64	1.195	113	1.306
16	0.653	65	1.179	114	1.306
17	0.669	66	1.195	115	1.306
18	0.701	67	1.195	116	1.306
19	0.733	68	1.195	117	1.306
20	0.749	69	1.195	118	1.322
21	0.765	70	1.21	119	1.306
22	0.796	71	1.21	120	1.322
23	0.812	72	1.21	121	1.322
24	0.844	73	1.21	122	1.322
25	0.86	74	1.21	123	1.322
26	0.876	75	1.21	124	1.322
27	0.892	76	1.226	125	1.322
28	0.908	77	1.226	126	1.322
29	0.94	78	1.226	127	1.338
30	0.956	79	1.226	128	1.322
31	0.972	80	1.242	129	1.322
32	0.987	81	1.242	130	1.322
33	1.003	82	1.242	131	1.338
34	1.019	83	1.242	132	1.338
35	1.035	84	1.242	133	1.338
36	1.051	85	1.258	134	1.322
37	1.067	86	1.242	135	1.338
38	1.067	87	1.258	136	1.338
39	1.083	88	1.258	137	1.338
40	1.083	89	1.258	138	1.338
41	1.099	90	1.258	139	1.338
42	1.099	91	1.274	140	1.354
43	1.115	92	1.274	141	1.338
44	1.115	93	1.274	142	1.354
45	1.115	94	1.274	143	1.354
46	1.115	95	1.274	144	1.354
47	1.131	96	1.274	145	1.354
48	1.131	97	1.274	146	1.354
49	1.131	98	1.274	147	1.354

Conrow Aquifer Test, January 2004 (continued)
Data from State Well No. 4N/22W-5R2

Time (min)	Drawdown	Time (min)	Drawdown	Time (min)	Drawdown
147	1.354	196	1.433	245	1.513
148	1.354	197	1.449	246	1.529
149	1.37	198	1.449	247	1.529
150	1.354	199	1.449	248	1.529
151	1.37	200	1.449	249	1.529
152	1.37	201	1.449	250	1.529
153	1.37	202	1.449	251	1.529
154	1.37	203	1.449	252	1.529
155	1.37	204	1.449	253	1.529
156	1.37	205	1.465	254	1.529
157	1.386	206	1.465	255	1.529
158	1.37	207	1.465	256	1.529
159	1.386	208	1.465	257	1.529
160	1.386	209	1.465	258	1.529
161	1.386	210	1.465	259	1.545
162	1.386	211	1.465	260	1.545
163	1.386	212	1.465	261	1.545
164	1.386	213	1.481	262	1.545
165	1.402	214	1.481	263	1.545
166	1.402	215	1.481	264	1.545
167	1.386	216	1.481	265	1.545
168	1.402	217	1.481	266	1.545
169	1.402	218	1.481	267	1.545
170	1.402	219	1.481	268	1.545
171	1.402	220	1.481	269	1.545
172	1.402	221	1.481	270	1.545
173	1.402	222	1.481	271	1.561
174	1.402	223	1.481	272	1.561
175	1.402	224	1.497	273	1.561
176	1.417	225	1.497	274	1.561
177	1.417	226	1.497	275	1.561
178	1.417	227	1.497	276	1.561
179	1.417	228	1.497	277	1.561
180	1.417	229	1.497	278	1.577
181	1.417	230	1.497	279	1.577
182	1.417	231	1.497	280	1.561
183	1.417	232	1.497	281	1.577
184	1.417	233	1.497	282	1.577
185	1.417	234	1.497	283	1.577
186	1.417	235	1.497	284	1.577
187	1.417	236	1.497	285	1.577
188	1.417	237	1.497	286	1.593
189	1.433	238	1.513	287	1.577
190	1.433	239	1.513	288	1.577
191	1.433	240	1.513	289	1.577
192	1.433	241	1.513	290	1.577
193	1.433	242	1.513	291	1.593
194	1.433	243	1.513	292	1.593
195	1.433	244	1.529	293	1.593

Conrow Aquifer Test, January 2004 (continued)
Data from State Well No. 4N/22W-5R2

Time (min)	Drawdown	Time (min)	Drawdown	Time (min)	Drawdown
294	1.593	342	1.656	391	1.72
295	1.593	343	1.656	392	1.736
296	1.593	344	1.656	393	1.736
297	1.609	345	1.656	394	1.736
298	1.593	346	1.672	395	1.736
299	1.593	347	1.656	396	1.736
300	1.593	348	1.672	397	1.736
301	1.593	349	1.656	398	1.736
302	1.609	350	1.656	399	1.736
303	1.609	351	1.672	400	1.736
304	1.609	352	1.672	401	1.736
305	1.609	353	1.672	402	1.736
306	1.609	354	1.672	403	1.736
307	1.609	355	1.672	404	1.736
308	1.609	356	1.672	405	1.736
309	1.609	357	1.672	406	1.736
310	1.609	358	1.672	407	1.736
311	1.609	359	1.672	408	1.736
312	1.609	360	1.672	409	1.736
313	1.609	361	1.672	410	1.736
314	1.624	362	1.672	411	1.736
315	1.624	363	1.672	412	1.736
316	1.624	364	1.672	413	1.736
317	1.624	365	1.672	414	1.72
318	1.624	366	1.672	415	1.72
319	1.624	367	1.672	416	1.736
320	1.624	368	1.688	417	1.736
321	1.624	369	1.688	418	1.736
322	1.624	370	1.688	419	1.736
323	1.624	371	1.688	420	1.736
324	1.624	372	1.688	421	1.736
325	1.64	373	1.688	422	1.752
326	1.624	374	1.704	423	1.752
327	1.64	375	1.688	424	1.752
328	1.64	376	1.688	425	1.752
329	1.64	377	1.704	426	1.752
330	1.64	378	1.704	427	1.752
331	1.64	379	1.704	428	1.752
332	1.64	380	1.704	429	1.752
333	1.64	381	1.704	430	1.752
334	1.64	382	1.704	431	1.752
335	1.64	383	1.704	432	1.752
336	1.64	384	1.72	433	1.752
337	1.64	385	1.72	434	1.752
338	1.656	386	1.72	435	1.752
339	1.656	387	1.72	436	1.752
340	1.656	388	1.72	437	1.752
341	1.656	389	1.72	438	1.752
		390	1.72	439	1.752

Conrow Aquifer Test, January 2004 (continued)
Data from State Well No. 4N/22W-5R2

Time (min)	Drawdown	Time (min)	Drawdown	Time (min)	Drawdown
440	1.768	489	1.832	538	1.863
441	1.768	490	1.832	539	1.863
442	1.768	491	1.832	540	1.863
443	1.768	492	1.832	541	1.863
444	1.768	493	1.832	542	1.863
445	1.768	494	1.832	543	1.863
446	1.768	495	1.832	544	1.863
447	1.768	496	1.832	545	1.863
448	1.768	497	1.832	546	1.863
449	1.768	498	1.832	547	1.863
450	1.768	499	1.832	548	1.863
451	1.768	500	1.832	549	1.879
452	1.784	501	1.832	550	1.863
453	1.768	502	1.832	551	1.863
454	1.784	503	1.847	552	1.879
455	1.784	504	1.847	553	1.863
456	1.784	505	1.847	554	1.863
457	1.784	506	1.832	555	1.863
458	1.784	507	1.847	556	1.863
459	1.784	508	1.832	557	1.863
460	1.784	509	1.847	558	1.863
461	1.784	510	1.847	559	1.879
462	1.784	511	1.847	560	1.863
463	1.784	512	1.847	561	1.879
464	1.784	513	1.847	562	1.863
465	1.784	514	1.832	563	1.879
466	1.8	515	1.847	564	1.879
467	1.8	516	1.847	565	1.879
468	1.8	517	1.847	566	1.879
469	1.8	518	1.847	567	1.879
470	1.8	519	1.847	568	1.879
471	1.8	520	1.847	569	1.879
472	1.8	521	1.847	570	1.879
473	1.8	522	1.847	571	1.879
474	1.8	523	1.847	572	1.879
475	1.8	524	1.847	573	1.879
476	1.8	525	1.847	574	1.879
477	1.816	526	1.847	575	1.879
478	1.816	527	1.847	576	1.879
479	1.816	528	1.847	577	1.879
480	1.816	529	1.863	578	1.879
481	1.816	530	1.863	579	1.895
482	1.816	531	1.863	580	1.879
483	1.816	532	1.863	581	1.879
484	1.816	533	1.847	582	1.895
485	1.816	534	1.863	583	1.895
486	1.816	535	1.863	584	1.895
487	1.832	536	1.863	585	1.879
488	1.816	537	1.863	586	1.895

Conrow Aquifer Test, January 2004 (continued)
Data from State Well No. 4N/22W-5R2

Time (min)	Drawdown	Time (min)	Drawdown	Time (min)	Drawdown
587	1.895	636	1.927	685	1.943
588	1.895	637	1.927	686	1.943
589	1.895	638	1.927	687	1.943
590	1.895	639	1.927	688	1.943
591	1.895	640	1.927	689	1.943
592	1.895	641	1.927	690	1.959
593	1.895	642	1.927	691	1.943
594	1.895	643	1.927	692	1.943
595	1.895	644	1.927	693	1.943
596	1.895	645	1.927	694	1.959
597	1.895	646	1.927	695	1.959
598	1.895	647	1.927	696	1.959
599	1.911	648	1.927	697	1.959
600	1.895	649	1.927	698	1.943
601	1.895	650	1.927	699	1.959
602	1.911	651	1.927	700	1.943
603	1.911	652	1.927	701	1.959
604	1.911	653	1.927	702	1.959
605	1.911	654	1.927	703	1.959
606	1.911	655	1.927	704	1.959
607	1.911	656	1.927	705	1.959
608	1.911	657	1.943	706	1.959
609	1.911	658	1.927	707	1.959
610	1.911	659	1.943	708	1.959
611	1.911	660	1.943	709	1.959
612	1.911	661	1.943	710	1.959
613	1.911	662	1.943	711	1.959
614	1.911	663	1.927	712	1.959
615	1.911	664	1.943	713	1.959
616	1.911	665	1.927	714	1.959
617	1.911	666	1.943	715	1.959
618	1.911	667	1.943	716	1.959
619	1.911	668	1.943	717	1.975
620	1.911	669	1.943	718	1.959
621	1.911	670	1.943	719	1.959
622	1.911	671	1.943	720	1.959
623	1.911	672	1.943	721	1.959
624	1.911	673	1.943	722	1.959
625	1.911	674	1.943	723	1.959
626	1.927	675	1.943	724	1.959
627	1.927	676	1.943	725	1.959
628	1.927	677	1.943	726	1.959
629	1.927	678	1.943	727	1.959
630	1.927	679	1.943	728	1.959
631	1.927	680	1.943	729	1.959
632	1.927	681	1.943	730	1.959
633	1.927	682	1.943	731	1.959
634	1.927	683	1.943	732	1.975
635	1.927	684	1.943	733	1.975

Conrow Aquifer Test, January 2004 (continued)
Data from State Well No. 4N/22W-5R2

Time (min)	Drawdown	Time (min)	Drawdown	Time (min)	Drawdown
734	1.975	783	1.991	832	2.007
735	1.975	784	1.991	833	2.007
736	1.975	785	1.991	834	2.007
737	1.975	786	1.991	835	2.007
738	1.975	787	1.991	836	2.007
739	1.975	788	1.991	837	2.007
740	1.975	789	1.991	838	2.007
741	1.975	790	1.991	839	2.007
742	1.975	791	1.991	840	2.007
743	1.975	792	1.991	841	2.007
744	1.975	793	1.991	842	2.007
745	1.975	794	1.991	843	2.007
746	1.975	795	1.991	844	2.007
747	1.975	796	1.991	845	2.023
748	1.975	797	1.991	846	2.007
749	1.975	798	1.991	847	2.007
750	1.975	799	2.007	848	2.023
751	1.975	800	1.991	849	2.007
752	1.975	801	1.991	850	2.007
753	1.975	802	1.991	851	2.023
754	1.975	803	1.991	852	2.023
755	1.975	804	1.991	853	2.023
756	1.975	805	1.991	854	2.023
757	1.975	806	1.991	855	2.023
758	1.975	807	1.991	856	2.007
759	1.975	808	1.991	857	2.023
760	1.975	809	1.991	858	2.023
761	1.975	810	2.007	859	2.023
762	1.991	811	1.991	860	2.023
763	1.975	812	1.991	861	2.023
764	1.975	813	2.007	862	2.023
765	1.975	814	2.007	863	2.023
766	1.975	815	1.991	864	2.023
767	1.975	816	1.991	865	2.023
768	1.991	817	2.007	866	2.023
769	1.975	818	2.007	867	2.023
770	1.991	819	2.007	868	2.023
771	1.991	820	2.007	869	2.023
772	1.975	821	2.007	870	2.023
773	1.991	822	2.007	871	2.023
774	1.991	823	2.007	872	2.023
775	1.975	824	2.007	873	2.023
776	1.991	825	2.007	874	2.023
777	1.991	826	2.007	875	2.023
778	1.975	827	2.007	876	2.023
779	1.991	828	2.007	877	2.023
780	1.975	829	2.007	878	2.039
781	1.991	830	2.007	879	2.023
782	1.991	831	2.007	880	2.023

Conrow Aquifer Test, January 2004 (continued)
Data from State Well No. 4N/22W-5R2

Time (min)	Drawdown	Time (min)	Drawdown	Time (min)	Drawdown
881	2.039	930	2.039	979	2.07
882	2.039	931	2.039	980	2.07
883	2.039	932	2.039	981	2.07
884	2.039	933	2.054	982	2.07
885	2.039	934	2.039	983	2.07
886	2.039	935	2.039	984	2.07
887	2.039	936	2.054	985	2.07
888	2.039	937	2.054	986	2.07
889	2.039	938	2.054	987	2.07
890	2.039	939	2.054	988	2.07
891	2.039	940	2.054	989	2.07
892	2.039	941	2.054	990	2.07
893	2.039	942	2.054	991	2.07
894	2.039	943	2.054	992	2.07
895	2.039	944	2.054	993	2.07
896	2.039	945	2.054	994	2.07
897	2.039	946	2.054	995	2.07
898	2.039	947	2.054	996	2.07
899	2.039	948	2.054	997	2.07
900	2.039	949	2.054	998	2.086
901	2.039	950	2.054	999	2.07
902	2.039	951	2.054	1000	2.07
903	2.039	952	2.054	1001	2.07
904	2.039	953	2.054	1002	2.07
905	2.039	954	2.054	1003	2.086
906	2.039	955	2.054	1004	2.086
907	2.039	956	2.054	1005	2.086
908	2.039	957	2.054	1006	2.07
909	2.039	958	2.054	1007	2.07
910	2.039	959	2.054	1008	2.086
911	2.039	960	2.054	1009	2.086
912	2.039	961	2.054	1010	2.086
913	2.039	962	2.07	1011	2.086
914	2.039	963	2.054	1012	2.086
915	2.039	964	2.054	1013	2.086
916	2.039	965	2.054	1014	2.086
917	2.039	966	2.054	1015	2.086
918	2.039	967	2.054	1016	2.086
919	2.039	968	2.07	1017	2.086
920	2.039	969	2.054	1018	2.086
921	2.039	970	2.054	1019	2.086
922	2.039	971	2.054	1020	2.086
923	2.039	972	2.054	1021	2.086
924	2.039	973	2.054	1022	2.086
925	2.039	974	2.054	1023	2.086
926	2.039	975	2.07	1024	2.086
927	2.039	976	2.07	1025	2.086
928	2.039	977	2.07	1026	2.086
929	2.039	978	2.07	1027	2.086

Conrow Aquifer Test, January 2004 (continued)
Data from State Well No. 4N/22W-5R2

Time (min)	Drawdown	Time (min)	Drawdown	Time (min)	Drawdown
1028	2.086	1077	2.134	1126	2.15
1029	2.086	1078	2.118	1127	2.15
1030	2.102	1079	2.134	1128	2.15
1031	2.102	1080	2.118	1129	2.15
1032	2.102	1081	2.134	1130	2.15
1033	2.102	1082	2.134	1131	2.15
1034	2.102	1083	2.134	1132	2.15
1035	2.102	1084	2.134	1133	2.166
1036	2.102	1085	2.134	1134	2.15
1037	2.102	1086	2.134	1135	2.166
1038	2.102	1087	2.134	1136	2.15
1039	2.102	1088	2.134	1137	2.166
1040	2.102	1089	2.134	1138	2.166
1041	2.102	1090	2.134	1139	2.166
1042	2.102	1091	2.134	1140	2.166
1043	2.102	1092	2.134	1141	2.166
1044	2.102	1093	2.134	1142	2.166
1045	2.102	1094	2.15	1143	2.166
1046	2.102	1095	2.134	1144	2.166
1047	2.102	1096	2.134	1145	2.166
1048	2.102	1097	2.15	1146	2.166
1049	2.102	1098	2.134	1147	2.166
1050	2.102	1099	2.134	1148	2.166
1051	2.102	1100	2.134	1149	2.166
1052	2.118	1101	2.134	1150	2.166
1053	2.118	1102	2.15	1151	2.166
1054	2.118	1103	2.134	1152	2.166
1055	2.102	1104	2.134	1153	2.166
1056	2.118	1105	2.15	1154	2.166
1057	2.118	1106	2.15	1155	2.166
1058	2.118	1107	2.15	1156	2.182
1059	2.118	1108	2.15	1157	2.166
1060	2.118	1109	2.15	1158	2.166
1061	2.118	1110	2.15	1159	2.166
1062	2.118	1111	2.15	1160	2.166
1063	2.118	1112	2.15	1161	2.166
1064	2.118	1113	2.15	1162	2.166
1065	2.118	1114	2.15	1163	2.182
1066	2.118	1115	2.15	1164	2.166
1067	2.118	1116	2.15	1165	2.182
1068	2.118	1117	2.15	1166	2.182
1069	2.118	1118	2.15	1167	2.166
1070	2.118	1119	2.15	1168	2.182
1071	2.118	1120	2.15	1169	2.182
1072	2.118	1121	2.15	1170	2.182
1073	2.134	1122	2.15	1171	2.182
1074	2.134	1123	2.15	1172	2.182
1075	2.134	1124	2.15	1173	2.182
1076	2.134	1125	2.15	1174	2.182

Conrow Aquifer Test, January 2004 (continued)
Data from State Well No. 4N/22W-5R2

Time (min)	Drawdown	Time (min)	Drawdown	Time (min)	Drawdown
1175	2.182	1224	2.214	1273	2.246
1176	2.182	1225	2.214	1274	2.246
1177	2.198	1226	2.214	1275	2.23
1178	2.182	1227	2.214	1276	2.246
1179	2.182	1228	2.214	1277	2.246
1180	2.182	1229	2.214	1278	2.246
1181	2.182	1230	2.23	1279	2.246
1182	2.198	1231	2.214	1280	2.246
1183	2.182	1232	2.23	1281	2.246
1184	2.182	1233	2.23	1282	2.246
1185	2.198	1234	2.214	1283	2.246
1186	2.182	1235	2.214	1284	2.246
1187	2.198	1236	2.23	1285	2.246
1188	2.198	1237	2.214	1286	2.246
1189	2.182	1238	2.214	1287	2.246
1190	2.198	1239	2.23	1288	2.246
1191	2.198	1240	2.214	1289	2.246
1192	2.198	1241	2.23	1290	2.246
1193	2.198	1242	2.23	1291	2.246
1194	2.198	1243	2.23	1292	2.246
1195	2.198	1244	2.23	1293	2.246
1196	2.198	1245	2.23	1294	2.246
1197	2.198	1246	2.23	1295	2.246
1198	2.198	1247	2.23	1296	2.261
1199	2.198	1248	2.23	1297	2.261
1200	2.198	1249	2.23	1298	2.246
1201	2.198	1250	2.23	1299	2.246
1202	2.198	1251	2.23	1300	2.261
1203	2.198	1252	2.23	1301	2.261
1204	2.198	1253	2.23	1302	2.261
1205	2.198	1254	2.23	1303	2.261
1206	2.198	1255	2.23	1304	2.261
1207	2.198	1256	2.23	1305	2.261
1208	2.198	1257	2.23	1306	2.261
1209	2.198	1258	2.246	1307	2.261
1210	2.198	1259	2.23	1308	2.261
1211	2.198	1260	2.23	1309	2.261
1212	2.198	1261	2.23	1310	2.261
1213	2.214	1262	2.23	1311	2.261
1214	2.214	1263	2.23	1312	2.261
1215	2.214	1264	2.23	1313	2.261
1216	2.214	1265	2.23	1314	2.261
1217	2.214	1266	2.246	1315	2.261
1218	2.214	1267	2.246	1316	2.261
1219	2.214	1268	2.246	1317	2.261
1220	2.214	1269	2.246	1318	2.261
1221	2.214	1270	2.246	1319	2.261
1222	2.214	1271	2.246	1320	2.261
1223	2.214	1272	2.246	1321	2.261

Conrow Aquifer Test, January 2004 (continued)
Data from State Well No. 4N/22W-5R2

Time (min)	Drawdown
1322	2.261
1323	2.261
1324	2.261
1325	2.277
1326	2.261
1327	2.261
1328	2.261
1329	2.261
1330	2.261
1331	2.261
1332	2.261
1333	2.261

APPENDIX D:

Raw Data from March 2004 SCMWC Grant Well Aquifer Test

SCMWC Grant Well Aquifer Test, March 2004
Data from State Well No. 4N/22W-4N1

Time (min)	Drawdown
1	0.0005
2	0.001
3	0.0015
4	0.002
5	0.0025
6	0.013
7	0.0235
8	0.044
9	0.0545
10	0.075
12	0.116
15	0.1775
20	0.27
25	0.3625
30	0.455
35	0.5375
40	0.6
45	0.6625
208	1.5
495	2
1396	2.82
1439	2.87
1440	2.87

SCMWC Grant Well Aquifer Test, March 2004
(continued)
Data from State Well No. 4N/22W-4P1

Time (min)	Drawdown
1	0.0005
2	0.001
3	0.0175
4	0.033
5	0.0655
6	0.114
7	0.1465
8	0.179
9	0.2115
10	0.26
11	0.3075
12	0.34
13	0.3885
14	0.421
15	0.4855
16	0.502
17	0.5495
18	0.582
19	0.6465
20	0.679
21	0.7115
22	0.744
23	0.7915
24	0.824
25	0.8405
26	0.857
27	0.9055
28	0.938
29	0.9545
30	0.987
31	1.0185
32	1.019
33	1.0515
34	1.1
35	1.1165
36	1.133
37	1.1335
38	1.182
39	1.1985
40	1.231
41	1.2315
42	1.247
43	1.2475
44	1.28
45	1.2965
46	1.313
47	1.3135
48	1.33
49	1.3625
50	1.363
51	1.3795
52	1.396
53	1.4125
54	1.429
55	1.4295
56	1.446
57	1.4465
58	1.463
59	1.4795
60	1.495
61	1.5115
62	1.496
63	1.5125
64	1.545
65	1.5295
66	1.562
67	1.5785
68	1.563
69	1.5795
70	1.58
71	1.5805
72	1.613
73	1.5975
74	1.598
75	1.6145
76	1.631
77	1.6155
78	1.664
79	1.6325
80	1.665
81	1.6655
82	1.666
83	1.6825
84	1.683
85	1.6995
86	1.7
87	1.7005
88	1.717
89	1.7335
90	1.702
91	1.7185
92	1.719
93	1.7505
94	1.736
95	1.7365
96	1.752
97	1.7845
98	1.769
99	1.7855
100	1.786
101	1.7865
102	1.787
103	1.8035
104	1.804
105	1.8045
106	1.821
107	1.8215
108	1.822
109	1.8225
110	1.839
111	1.8395
112	1.84
113	1.8405
114	1.841
115	1.8575
116	1.858
117	1.8585
118	1.859
119	1.8755
120	1.876
121	1.8765
122	1.893
123	1.8935
124	1.894
125	1.8945
126	1.895
127	1.9115
128	1.912
129	1.9125
130	1.913
131	1.9295
132	1.914
133	1.9305
134	1.931
135	1.9315
136	1.932
137	1.9485
138	1.949
139	1.9495
140	1.95
141	1.9505
142	1.967
143	1.9675
144	1.968
145	1.9685
146	1.969
147	1.9855

SCMWC Grant Well Aquifer Test, March 2004
(continued)
Data from State Well No. 4N/22W-4P1

Time (min)	Drawdown
148	1.986
149	1.9865
150	1.987
151	1.9875
152	2.004
153	2.0045
154	2.005
155	2.0055
156	2.006
157	2.0065
158	2.022
159	2.0225
160	2.023
161	2.0235
162	2.024
163	2.0245
164	2.025
165	2.0415
166	2.042
167	2.0425
168	2.043
169	2.0435
170	2.044
171	2.0605
172	2.061
173	2.0615
174	2.062
175	2.0625
176	2.063
177	2.0635
178	2.064
179	2.0645
180	2.081
181	2.0815
182	2.082
183	2.0825
184	2.083
185	2.0835
186	2.1
187	2.1005
188	2.101
189	2.1015
190	2.102
191	2.1025
192	2.103
193	2.1035
194	2.104
195	2.1205
196	2.105
197	2.1215
198	2.122
199	2.1225
200	2.123
201	2.1235
202	2.124
203	2.1405
204	2.125
205	2.1415
206	2.142
207	2.1425
208	2.143
209	2.1435
210	2.144
211	2.1445
212	2.145
213	2.1455
214	2.162
215	2.1625
216	2.163
217	2.1635
218	2.164
219	2.1645
220	2.165
221	2.1655
222	2.182
223	2.1665
224	2.183
225	2.1675
226	2.2
227	2.1845
228	2.185
229	2.1695
230	2.202
231	2.1865
232	2.187
233	2.1875
234	2.188
235	2.1885
236	2.205
237	2.2215
238	2.206
239	2.2065
240	2.207
241	2.2075
242	2.224
243	2.2245
244	2.225
245	2.2255
246	2.226
247	2.2265
248	2.243
249	2.2275
250	2.244
251	2.2285
252	2.245
253	2.2295
254	2.246
255	2.2465
256	2.231
257	2.2475
258	2.248
259	2.2645
260	2.249
261	2.2495
262	2.25
263	2.2345
264	2.267
265	2.2675
266	2.268
267	2.2525
268	2.269
269	2.2855
270	2.27
271	2.2705
272	2.271
273	2.2715
274	2.272
275	2.2725
276	2.289
277	2.2895
278	2.29
279	2.2905
280	2.275
281	2.2915
282	2.276
283	2.2925
284	2.308
285	2.2935
286	2.309
287	2.2945
288	2.31
289	2.2955
290	2.326
291	2.3115
292	2.312
293	2.3125
294	2.328

SCMWC Grant Well Aquifer Test, March 2004
(continued)
Data from State Well No. 4N/22W-4P1

Time (min)	Drawdown	Time (min)	Drawdown	Time (min)	Drawdown
295	2.3135	344	2.417	393	2.4895
296	2.314	345	2.4015	394	2.474
297	2.3295	346	2.402	395	2.4905
298	2.33	347	2.4025	396	2.491
299	2.3305	348	2.419	397	2.4755
300	2.331	349	2.4195	398	2.476
301	2.3315	350	2.42	399	2.4925
302	2.332	351	2.4205	400	2.493
303	2.3325	352	2.421	401	2.4775
304	2.333	353	2.4215	402	2.51
305	2.3495	354	2.438	403	2.4785
306	2.334	355	2.4385	404	2.495
307	2.3345	356	2.423	405	2.4955
308	2.335	357	2.4235	406	2.496
309	2.3675	358	2.424	407	2.4965
310	2.352	359	2.4405	408	2.497
311	2.3525	360	2.425	409	2.4975
312	2.353	361	2.4415	410	2.482
313	2.3535	362	2.426	411	2.4985
314	2.354	363	2.4425	412	2.499
315	2.3545	364	2.443	413	2.4995
316	2.371	365	2.4275	414	2.5
317	2.3555	366	2.444	415	2.5165
318	2.356	367	2.4445	416	2.517
319	2.3725	368	2.429	417	2.5335
320	2.357	369	2.4295	418	2.518
321	2.3575	370	2.446	419	2.5185
322	2.374	371	2.4465	420	2.519
323	2.3745	372	2.447	421	2.5035
324	2.375	373	2.4475	422	2.52
325	2.4075	374	2.448	423	2.5365
326	2.376	375	2.4485	424	2.521
327	2.3765	376	2.465	425	2.5055
328	2.393	377	2.4495	426	2.538
329	2.3775	378	2.466	427	2.5225
330	2.394	379	2.4505	428	2.523
331	2.3945	380	2.467	429	2.5235
332	2.379	381	2.4515	430	2.556
333	2.4115	382	2.468	431	2.5245
334	2.412	383	2.4685	432	2.541
335	2.4125	384	2.469	433	2.5415
336	2.397	385	2.4695	434	2.542
337	2.3975	386	2.47	435	2.5585
338	2.398	387	2.4705	436	2.543
339	2.3985	388	2.471	437	2.5435
340	2.399	389	2.4715	438	2.544
341	2.3995	390	2.472	439	2.5605
342	2.4	391	2.4725	440	2.561
343	2.4165	392	2.457	441	2.5615

SCMWC Grant Well Aquifer Test, March 2004
(continued)
Data from State Well No. 4N/22W-4P1

Time (min)	Drawdown	Time (min)	Drawdown	Time (min)	Drawdown
442	2.562	491	2.6185	540	2.69
443	2.5465	492	2.619	541	2.7065
444	2.563	493	2.6195	542	2.691
445	2.5635	494	2.636	543	2.7075
446	2.548	495	2.6365	544	2.708
447	2.5645	496	2.637	545	2.7085
448	2.565	497	2.6215	546	2.709
449	2.5655	498	2.638	547	2.7095
450	2.55	499	2.6225	548	2.71
451	2.5665	500	2.639	549	2.6945
452	2.567	501	2.6545	550	2.695
453	2.5515	502	2.64	551	2.6955
454	2.568	503	2.6405	552	2.696
455	2.5525	504	2.641	553	2.7125
456	2.601	505	2.6415	554	2.697
457	2.5695	506	2.642	555	2.6975
458	2.57	507	2.6425	556	2.698
459	2.5705	508	2.643	557	2.7145
460	2.587	509	2.6435	558	2.715
461	2.5715	510	2.644	559	2.7155
462	2.588	511	2.6445	560	2.732
463	2.5725	512	2.645	561	2.7325
464	2.589	513	2.6455	562	2.733
465	2.5895	514	2.661	563	2.7175
466	2.574	515	2.6615	564	2.734
467	2.5905	516	2.662	565	2.7185
468	2.575	517	2.6625	566	2.719
469	2.5915	518	2.663	567	2.7355
470	2.608	519	2.6635	568	2.72
471	2.6085	520	2.664	569	2.7365
472	2.593	521	2.6645	570	2.753
473	2.5935	522	2.681	571	2.7215
474	2.594	523	2.6815	572	2.754
475	2.5945	524	2.666	573	2.7385
476	2.627	525	2.6825	574	2.739
477	2.5955	526	2.667	575	2.7555
478	2.596	527	2.6835	576	2.756
479	2.6125	528	2.668	577	2.7405
480	2.597	529	2.6685	578	2.757
481	2.5975	530	2.669	579	2.7575
482	2.614	531	2.6855	580	2.742
483	2.5985	532	2.686	581	2.7585
484	2.615	533	2.6705	582	2.759
485	2.6155	534	2.687	583	2.7595
486	2.616	535	2.6875	584	2.76
487	2.6165	536	2.688	585	2.7605
488	2.617	537	2.6885	586	2.745
489	2.6015	538	2.705	587	2.7615
490	2.618	539	2.7055	588	2.762

SCMWC Grant Well Aquifer Test, March 2004
(continued)
Data from State Well No. 4N/22W-4P1

Time (min)	Drawdown
589	2.7465
590	2.779
591	2.7475
592	2.78
593	2.7805
594	2.781
595	2.7655
596	2.766
597	2.7665
598	2.767
599	2.7675
600	2.784
601	2.7685
602	2.785
603	2.7855
604	2.802
605	2.7705
606	2.787
607	2.7715
608	2.804
609	2.7885
610	2.773
611	2.8055
612	2.79
613	2.7905
614	2.807
615	2.7915
616	2.792
617	2.8085
618	2.809
619	2.7935
620	2.826
621	2.8105
622	2.795
623	2.7955
624	2.812
625	2.8125
626	2.813
627	2.8135
628	2.814
629	2.8145
630	2.815
631	2.8155
632	2.816
633	2.8325
634	2.817
635	2.8335
636	2.818
637	2.8345
638	2.835
639	2.8355
640	2.82
641	2.8525
642	2.837
643	2.8375
644	2.838
645	2.8385
646	2.839
647	2.8395
648	2.84
649	2.8405
650	2.841
651	2.8575
652	2.842
653	2.8425
654	2.843
655	2.8595
656	2.844
657	2.8445
658	2.845
659	2.8615
660	2.846
661	2.8465
662	2.847
663	2.8635
664	2.848
665	2.8645
666	2.849
667	2.8495
668	2.866
669	2.8665
670	2.867
671	2.8675
672	2.868
673	2.8685
674	2.869
675	2.8695
676	2.87
677	2.8705
678	2.871
679	2.8715
680	2.872
681	2.8725
682	2.873
683	2.8735
684	2.874
685	2.8745
686	2.859
687	2.8755
688	2.876
689	2.8925
690	2.877
691	2.8775
692	2.878
693	2.8785
694	2.879
695	2.8795
696	2.88
697	2.8805
698	2.881
699	2.8815
700	2.898
701	2.8825
702	2.883
703	2.8835
704	2.9
705	2.8845
706	2.885
707	2.9015
708	2.902
709	2.9025
710	2.903
711	2.9035
712	2.904
713	2.8885
714	2.905
715	2.9055
716	2.906
717	2.9065
718	2.907
719	2.9075
720	2.908
721	2.9085
722	2.909
723	2.9095
724	2.91
725	2.9105
726	2.911
727	2.9115
728	2.912
729	2.9125
730	2.913
731	2.9135
732	2.914
733	2.9305
734	2.931
735	2.9315

SCMWC Grant Well Aquifer Test, March 2004
(continued)
Data from State Well No. 4N/22W-4P1

Time (min)	Drawdown
736	2.932
737	2.9325
738	2.933
739	2.9335
740	2.934
741	2.9345
742	2.935
743	2.9355
744	2.936
745	2.9365
746	2.937
747	2.9375
748	2.938
749	2.9385
750	2.939
751	2.9395
752	2.94
753	2.9405
754	2.941
755	2.9415
756	2.942
757	2.9425
758	2.943
759	2.9435
760	2.944
761	2.9445
762	2.945
763	2.9455
764	2.946
765	2.9465
766	2.947
767	2.9475
768	2.948
769	2.9485
770	2.949
771	2.9495
772	2.95
773	2.9505
774	2.951
775	2.9515
776	2.952
777	2.9525
778	2.953
779	2.9535
780	2.954
781	2.9545
782	2.955
783	2.9555
784	2.956
785	2.9565
786	2.957
787	2.9575
788	2.974
789	2.9745
790	2.975
791	2.9595
792	2.976
793	2.9605
794	2.977
795	2.9775
796	2.978
797	2.9785
798	2.963
799	2.9635
800	2.98
801	2.9645
802	2.981
803	2.9655
804	2.966
805	2.9665
806	2.983
807	2.9675
808	2.968
809	2.9685
810	2.969
811	2.9695
812	2.97
813	2.9865
814	2.971
815	2.9715
816	2.972
817	2.9725
818	2.973
819	2.9735
820	2.974
821	2.9745
822	2.991
823	2.9755
824	2.976
825	2.9925
826	2.977
827	2.9775
828	2.978
829	2.9785
830	2.979
831	2.9955
832	2.98
833	2.9965
834	2.997
835	2.9815
836	2.982
837	2.9985
838	2.999
839	2.9995
840	2.984
841	3.0005
842	2.985
843	3.0015
844	3.002
845	3.0025
846	3.003
847	3.0035
848	2.988
849	3.0045
850	3.005
851	3.0055
852	3.006
853	3.0065
854	3.007
855	3.0075
856	3.008
857	3.0085
858	3.009
859	3.0095
860	3.01
861	3.0105
862	3.011
863	3.0115
864	3.012
865	3.0125
866	3.013
867	3.0135
868	3.014
869	3.0145
870	3.015
871	3.0155
872	3.016
873	3.0165
874	3.017
875	3.0175
876	3.018
877	3.0185
878	3.019
879	3.0355
880	3.036
881	3.0365
882	3.037

SCMWC Grant Well Aquifer Test, March 2004
(continued)
Data from State Well No. 4N/22W-4P1

Time (min)	Drawdown	Time (min)	Drawdown	Time (min)	Drawdown
883	3.0375	932	3.078	981	3.1025
884	3.038	933	3.0625	982	3.103
885	3.0385	934	3.079	983	3.1035
886	3.039	935	3.0795	984	3.104
887	3.0395	936	3.08	985	3.1045
888	3.04	937	3.0645	986	3.105
889	3.0405	938	3.081	987	3.1055
890	3.041	939	3.0815	988	3.106
891	3.0415	940	3.082	989	3.1065
892	3.042	941	3.0825	990	3.107
893	3.0425	942	3.083	991	3.1075
894	3.043	943	3.0835	992	3.108
895	3.0435	944	3.084	993	3.1085
896	3.044	945	3.0845	994	3.109
897	3.0445	946	3.085	995	3.1095
898	3.045	947	3.0855	996	3.11
899	3.0455	948	3.086	997	3.1105
900	3.046	949	3.0865	998	3.111
901	3.0465	950	3.071	999	3.1115
902	3.047	951	3.0715	1000	3.112
903	3.0475	952	3.072	1001	3.1125
904	3.048	953	3.0885	1002	3.113
905	3.0485	954	3.089	1003	3.1135
906	3.049	955	3.0895	1004	3.114
907	3.0495	956	3.09	1005	3.1145
908	3.05	957	3.0905	1006	3.115
909	3.0505	958	3.091	1007	3.1155
910	3.051	959	3.0915	1008	3.116
911	3.0515	960	3.092	1009	3.1165
912	3.052	961	3.0925	1010	3.117
913	3.0525	962	3.093	1011	3.1175
914	3.053	963	3.0935	1012	3.118
915	3.0535	964	3.094	1013	3.1185
916	3.054	965	3.0945	1014	3.119
917	3.0545	966	3.095	1015	3.1355
918	3.055	967	3.0955	1016	3.12
919	3.0555	968	3.096	1017	3.1365
920	3.056	969	3.0965	1018	3.121
921	3.0565	970	3.097	1019	3.1215
922	3.057	971	3.0975	1020	3.138
923	3.0575	972	3.098	1021	3.1225
924	3.058	973	3.0985	1022	3.139
925	3.0585	974	3.099	1023	3.1235
926	3.075	975	3.0995	1024	3.14
927	3.0595	976	3.1	1025	3.1405
928	3.06	977	3.1005	1026	3.141
929	3.0605	978	3.101	1027	3.1255
930	3.061	979	3.1015	1028	3.142
931	3.0615	980	3.102	1029	3.1425

SCMWC Grant Well Aquifer Test, March 2004 (continued)
Data from State Well No. 4N/22W-4P1

Time (min)	Drawdown	Time (min)	Drawdown	Time (min)	Drawdown
1030	3.127	1079	3.1675	1128	3.207
1031	3.1435	1080	3.168	1129	3.2075
1032	3.144	1081	3.1685	1130	3.208
1033	3.1445	1082	3.169	1131	3.2085
1034	3.145	1083	3.1695	1132	3.209
1035	3.1455	1084	3.17	1133	3.2095
1036	3.146	1085	3.1705	1134	3.21
1037	3.1465	1086	3.186	1135	3.2105
1038	3.147	1087	3.1715	1136	3.211
1039	3.1475	1088	3.187	1137	3.2115
1040	3.148	1089	3.1875	1138	3.212
1041	3.1485	1090	3.188	1139	3.2125
1042	3.149	1091	3.1885	1140	3.213
1043	3.1495	1092	3.189	1141	3.2135
1044	3.15	1093	3.1745	1142	3.214
1045	3.1505	1094	3.19	1143	3.2145
1046	3.151	1095	3.1905	1144	3.215
1047	3.1515	1096	3.191	1145	3.2155
1048	3.152	1097	3.1915	1146	3.216
1049	3.1525	1098	3.192	1147	3.2165
1050	3.153	1099	3.1925	1148	3.217
1051	3.1535	1100	3.178	1149	3.2335
1052	3.154	1101	3.1785	1150	3.218
1053	3.1545	1102	3.194	1151	3.2185
1054	3.155	1103	3.1945	1152	3.235
1055	3.1555	1104	3.195	1153	3.2355
1056	3.156	1105	3.1805	1154	3.22
1057	3.1565	1106	3.196	1155	3.2365
1058	3.157	1107	3.1815	1156	3.237
1059	3.1575	1108	3.197	1157	3.2375
1060	3.158	1109	3.1975	1158	3.238
1061	3.1585	1110	3.183	1159	3.2385
1062	3.159	1111	3.1985	1160	3.239
1063	3.1595	1112	3.199	1161	3.2395
1064	3.16	1113	3.1995	1162	3.24
1065	3.1605	1114	3.2	1163	3.2405
1066	3.161	1115	3.2005	1164	3.241
1067	3.1615	1116	3.201	1165	3.2415
1068	3.162	1117	3.2015	1166	3.242
1069	3.1625	1118	3.202	1167	3.2425
1070	3.163	1119	3.2025	1168	3.243
1071	3.1635	1120	3.203	1169	3.2435
1072	3.164	1121	3.2035	1170	3.244
1073	3.1645	1122	3.204	1171	3.2445
1074	3.165	1123	3.2045	1172	3.245
1075	3.1655	1124	3.205	1173	3.2455
1076	3.166	1125	3.2055	1174	3.262
1077	3.1665	1126	3.206	1175	3.2625
1078	3.182	1127	3.2065	1176	3.247

SCMWC Grant Well Aquifer Test, March 2004
(continued)
Data from State Well No. 4N/22W-4P1

Time (min)	Drawdown	Time (min)	Drawdown	Time (min)	Drawdown
1177	3.2475	1226	3.304	1275	3.3605
1178	3.248	1227	3.3045	1276	3.361
1179	3.2485	1228	3.321	1277	3.3615
1180	3.265	1229	3.3055	1278	3.362
1181	3.2655	1230	3.306	1279	3.3625
1182	3.25	1231	3.3065	1280	3.363
1183	3.2505	1232	3.307	1281	3.3635
1184	3.251	1233	3.3075	1282	3.364
1185	3.2675	1234	3.308	1283	3.3645
1186	3.268	1235	3.3245	1284	3.365
1187	3.2685	1236	3.309	1285	3.3655
1188	3.253	1237	3.3255	1286	3.366
1189	3.2695	1238	3.326	1287	3.3665
1190	3.27	1239	3.3265	1288	3.383
1191	3.2705	1240	3.327	1289	3.3675
1192	3.271	1241	3.3275	1290	3.368
1193	3.2715	1242	3.328	1291	3.3845
1194	3.272	1243	3.3285	1292	3.385
1195	3.2725	1244	3.329	1293	3.3695
1196	3.273	1245	3.3295	1294	3.37
1197	3.2735	1246	3.33	1295	3.3865
1198	3.274	1247	3.3305	1296	3.387
1199	3.2745	1248	3.331	1297	3.3875
1200	3.275	1249	3.3315	1298	3.388
1201	3.2755	1250	3.332	1299	3.3885
1202	3.276	1251	3.3325	1300	3.373
1203	3.2765	1252	3.333	1301	3.3895
1204	3.277	1253	3.3335	1302	3.39
1205	3.2775	1254	3.334	1303	3.3905
1206	3.278	1255	3.3345	1304	3.391
1207	3.2945	1256	3.335	1305	3.3915
1208	3.295	1257	3.3355	1306	3.392
1209	3.2795	1258	3.336	1307	3.3925
1210	3.28	1259	3.3365	1308	3.393
1211	3.2965	1260	3.353	1309	3.3935
1212	3.297	1261	3.3375	1310	3.394
1213	3.2975	1262	3.354	1311	3.3945
1214	3.298	1263	3.3545	1312	3.395
1215	3.2985	1264	3.355	1313	3.3955
1216	3.299	1265	3.3555	1314	3.396
1217	3.2995	1266	3.356	1315	3.3965
1218	3.3	1267	3.3565	1316	3.397
1219	3.3005	1268	3.357	1317	3.3975
1220	3.301	1269	3.3575	1318	3.398
1221	3.3015	1270	3.358	1319	3.3985
1222	3.302	1271	3.3585	1320	3.399
1223	3.3025	1272	3.359	1321	3.3995
1224	3.303	1273	3.3595	1322	3.4
1225	3.3035	1274	3.36	1323	3.4005

SCMWC Grant Well Aquifer Test, March 2004 (continued)

Data from State Well No. 4N/22W-4P1

Time (min)	Drawdown
1324	3.401
1325	3.4015
1326	3.402
1327	3.4025
1328	3.403
1329	3.4035
1330	3.42
1331	3.4045
1332	3.405
1333	3.4055
1334	3.406
1335	3.4065
1336	3.407
1337	3.4075
1338	3.408
1339	3.4085
1340	3.409
1341	3.4095
1342	3.41
1343	3.4105
1344	3.411
1345	3.4115
1346	3.412
1347	3.4125
1348	3.413
1349	3.4135
1350	3.414
1351	3.4145
1352	3.431
1353	3.4155
1354	3.416
1355	3.4325
1356	3.433
1357	3.4335
1358	3.434
1359	3.4185
1360	3.435
1361	3.4355
1362	3.436
1363	3.4365
1364	3.437
1365	3.4215
1366	3.438
1367	3.4385
1368	3.439
1369	3.4395
1370	3.44
1371	3.4245
1372	3.425
1373	3.4415
1374	3.442
1375	3.4425
1376	3.443
1377	3.4435
1378	3.444
1379	3.4445
1380	3.445
1381	3.4455
1382	3.446
1383	3.4465
1384	3.447
1385	3.4475
1386	3.448
1387	3.4485
1388	3.449
1389	3.4495
1390	3.45
1391	3.4505
1392	3.451
1393	3.4515
1394	3.452
1395	3.4525
1396	3.453
1397	3.4535
1398	3.454
1399	3.4545
1400	3.455
1401	3.4555
1402	3.456
1403	3.4565
1404	3.457
1405	3.4575
1406	3.458
1407	3.4585
1408	3.475
1409	3.4595
1410	3.46
1411	3.4605
1412	3.477
1413	3.4615
1414	3.462
1415	3.4785
1416	3.463
1417	3.4795
1418	3.48
1419	3.4805
1420	3.481
1421	3.4815
1422	3.482
1423	3.4825
1424	3.483
1425	3.4675
1426	3.484
1427	3.4845
1428	3.485
1429	3.4855
1430	3.486
1431	3.4865
1432	3.471
1433	3.4875
1434	3.472
1435	3.4725
1436	3.489
1437	3.4895
1438	3.49
1439	3.5065
1440	3.507

APPENDIX E:

Raw data from March 2004 Essick Lagomarsino Aquifer Test

Essick Lagomarsino Well Aquifer Test, March 2004
Data from State Well No. 4N/22W-6E3

Time (min)	Drawdown
1	0.04
2	0.23
3	0.59
4	0.99
5	1.4
6	1.79
7	2.14
8	2.53
9	2.8
10	3.09
10.3	3.18
29	5
32	5.04
115	6.73
120	6.76
121	6.77
452	8.69
487	8.59
488	8.6
1731	9.54
2836	10.76
2891	10.73
5683	15.32
5745	15.32

Essick Lagomarsino Well Aquifer Test, March 2004
Data from State Well No. 4N/22W-6E4

Time (min)	Drawdown
22	3.54
23	3.35
42	3.88
46	4
131	4.74
133	4.75
445	5.7
447	5.73
480	6.09
1722	7.32
2815	7.08
2897	7.1
5701	11.02

APPENDIX F:

Raw data from April 2004 Galaska Aquifer test

Galaska Well Aquifer Test, April 2004
Data from State Well No. 4N/23W-1K1

Time (min)	Drawdown	Time (min)	Drawdown	Time (min)	Drawdown
1	19.977	50	23.835	99	2.668
2	12.961	51	17.083	100	2.544
3	8.646	52	26.648	101	2.43
4	25.275	53	25.294	102	2.316
5	17.102	54	18.307	103	2.211
6	11.802	55	32.183	104	2.125
7	27.358	56	24.934	105	2.039
8	18.819	57	18.165	106	1.954
9	13.227	58	33.979	107	1.896
10	27.737	59	24.166	108	1.839
11	19.313	60	18.345	109	1.744
12	15.564	61	32.25	110	1.706
13	27.869	62	23.171	111	1.649
14	19.559	63	28.011	112	1.592
15	20.365	64	29.79	113	1.563
16	23.645	65	21.655	114	1.496
17	16.826	66	30.973	115	1.487
18	18.924	67	28.059	116	1.43
19	25.644	68	20.508	117	1.391
20	18.165	69	32.193	118	1.363
21	23.712	70	27.557	119	1.296
22	26.051	71	20.176	120	1.268
23	18.582	72	34.962	121	1.229
24	26.061	73	25.18	122	1.239
25	25.862	74	18.62	123	1.201
26	18.525	75	32.987	124	1.191
27	30.216	76	23.835	125	1.163
28	25.114	77	27.85	126	1.144
29	18.06	78	30.103	127	1.077
30	33.611	79	21.987	128	1.058
31	24.138	80	32.562	129	1.039
32	17.491	81	28.011	130	1.01
33	32.042	82	20.574	131	1.001
34	22.754	83	36.606	132	0.982
35	17.7	84	26.326	133	0.944
36	30.566	85	19.502	134	0.934
37	21.835	86	14.804	135	0.934
38	23.38	87	11.45	136	0.896
39	28.806	88	9.112	137	0.858
40	20.735	89	7.476	138	0.886
41	23.048	90	6.305	139	0.839
42	28.324	91	5.429	140	0.82
43	20.403	92	4.773	141	0.829
44	24.176	93	4.23	142	0.81
45	27.405	94	3.83	143	0.801
46	19.815	95	3.535	144	0.791
47	14.69	96	3.278	145	0.782
48	11.089	97	3.049	146	0.744
49	15.478	98	2.859	147	0.724

Galaska Well Aquifer Test, April 2004
Data from State Well No. 4N/23W-1K1

Time (min)	Drawdown	Time (min)	Drawdown	Time (min)	Drawdown
148	0.724	197	0.334		
149	0.734	198	0.324		
150	0.705	199	0.324		
151	0.696	200	0.315		
152	0.696	201	0.315		
153	0.686	202	0.305		
154	0.677	203	0.296		
155	0.639	204	0.277		
156	0.648	205	0.286		
157	0.639	206	0.277		
158	0.601	207	0.277		
159	0.572	208	0.277		
160	0.601	209	0.267		
161	0.591	210	0.267		
162	0.572	211	0.257		
163	0.581	212	0.257		
164	0.562	213	0.248		
165	0.562	214	0.219		
166	0.553	215	0.238		
167	0.534	216	0.238		
168	0.486	217	0.229		
169	0.524	218	0.21		
170	0.515	219	0.21		
171	0.486				
172	0.496				
173	0.486				
174	0.486				
175	0.477				
176	0.477				
177	0.458				
178	0.448				
179	0.448				
180	0.439				
181	0.429				
182	0.429				
183	0.41				
184	0.419				
185	0.41				
186	0.4				
187	0.4				
188	0.391				
189	0.381				
190	0.381				
191	0.372				
192	0.362				
193	0.362				
194	0.334				
195	0.343				
196	0.334				

APPENDIX G:

Raw data from April 2004 Ruch Aquifer Test

Ruch Well Aquifer Test, April 2004
Data from State Well No. 4N/23W-7L1

Time (min)	Drawdown
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0
16	0
17	0
18	0
19	0
20	0.015
21	0
22	0.015
23	0
24	0
25	0
26	0
27	0
28	0
29	0.015
30	0
31	0.015
32	0.031
33	0.047
34	0.079
35	0.127
36	0.111
37	0.127
38	0.175
39	0.206
40	0.191
41	0.237
42	0.253
43	0.253
44	0.269
45	0.269
46	0.285
47	0.269
48	0.269
49	0.269
50	0.285
51	0.285
52	0.285
53	0.285
54	0.285
55	0.285
56	0.285
57	0.285
58	0.285
59	0.269
60	0.269
61	0.285
62	0.269
63	0.253
64	0.269
65	0.269
66	0.253
67	0.269
68	0.253
69	0.253
70	0.253
71	0.269
72	0.269
73	0.253
74	0.253
75	0.269
76	0.285
77	0.269
78	0.269
79	0.253
80	0.269
81	0.253
82	0.269
83	0.269
84	0.269
85	0.269
86	0.285
87	0.269
88	0.285
89	0.269
90	0.285
91	0.285
92	0.269
93	0.269
94	0.269
95	0.269
96	0.269
97	0.269
98	0.285
99	0.269
100	0.285
101	0.285
102	0.285
103	0.285
104	0.285
105	0.301
106	0.301
107	0.285
108	0.285
109	0.301