HOPKINS GROUNDWATER CONSULTANTS, INC.

PRELIMINARY HYDROGEOLOGICAL STUDY

CITY OF SOLVANG
SANTA YNEZ RIVER WELL FIELD
WELL SITE EVALUATION PROJECT
SOLVANG, CALIFORNIA

Prepared for:
CITY OF SOLVANG

February 2003

DRAFT

HOPKINS
GROUNDWATER
CONSULTANTS, INC.
THE WATER RESOURCE SPECIALISTS

February 7, 2003
Project No. 02-009-02

City of Solvang Public Works
1644 Oak Street
Post Office Box 107
Solvang, California 93464

Attention: Mr. Tom Rowe
Public Works Director

Subject: Preliminary Hydrogeological Study, City of Solvang Santa Ynez River Well Field Well Site Evaluation Project, Solvang, California.

Dear Mr. Rowe:

Hopkins Groundwater Consultants, Inc. (Hopkins) is pleased to submit this draft report which summarizes the subject study. Presented in this report are the findings, conclusions, and recommendations that were developed to assist the City of Solvang (City) in expanding the Santa Ynez River well field. This study provides a preliminary review of the existing hydrogeological conditions, existing well facilities, historical river flow patterns, and proposed well site locations. This study concludes that the City could construct new water well facilities that could physically produce up to the five (5) cubic feet per second permitted capacity; however, operation will likely require mitigation measures to minimize impacts to existing groundwater producers.

We trust this report is responsive to the needs of the City of Solvang. As always, Hopkins is pleased to have this opportunity to be of service. If you have questions or need any additional information, please give us a call.

Sincerely,

HOPKINS GROUNDWATER CONSULTANTS, INC.

DRAFT

Curtis J. Hopkins
Certified Engineering Geologist EG 1800
Certified Hydrogeologist HG 114

Wendy Read
Project Hydrogeologist

Draft Copies Delivered to Client: Three (3)

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INTRODUCTION

GENERAL STATEMENT

Presented in this report is a summary of the work performed, the study methods utilized, and principal findings and conclusions developed from a preliminary hydrogeological investigation that was conducted as part of the City of Solvang's (City) proposed expansion of the municipal well field located in the Santa Ynez River (River) groundwater basin. The purpose of this hydrogeological study is to assess the optimal placement and design of the new wells that are proposed for construction. The portion of the River that was examined by this study is depicted on Plate 1 – Study Area Location Map. The goals of this study are to determine well locations that will potentially: a) produce groundwater at sufficient rates, b) be protected from River flood flows, c) minimize potential interference with existing wells in the River, d) allow continued access for repair and maintenance of the well facilities, e) account for regulatory constraints on municipal supplies and allowed operation without additional filtration treatment, and f) be sensitive to the specific environmental issues of the River environment.

The City's Water System Master Plan Update concludes that the installation of new wells is essential for the City to increase the capacity and reliability of its historical supply from the River (Provost & Pritchard, 2002). The proposed well construction project is intended to benefit the City by ensuring the ability to meet peak daily flows and fire protection demands, improving the ability to conjunctively use both local and imported State Water Project water supplies, and developing the City's water rights by fixing beneficial use records at the permitted capacity.

BACKGROUND

The River has historically been a vital source of the City's groundwater supply and has been used in conjunction with the City's Santa Ynez Uplands well field and water deliveries from both the California State Water Project and the Santa Ynez River Water Conservation District Improvement District No. 1 (ID-1). The availability of the River basin groundwater supply has historically varied as a result of the seasonal and climatic changes that affect River flows and both the supply and demand within the basin. The river flows are augmented by spills and releases from Bradbury Dam at Lake Cachuma which is located approximately 10 miles upstream of the City.

Historical records indicate that at least 6 wells have been constructed for the City to extract from the River basin but only one is currently active. A second well is functional but because of recent changes in the location of the River channel, additional facilities for water filtration would be required before activation.

As part of an historical agreement, one well was transferred to the Alisal in the late 1980's. The Alisal is the single largest land owner in the study area and will likely be the owner of lands on which the City may wish to construct wells. The remaining wells in the City's River well field have reportedly been damaged or destroyed by flood waters.

The City Water Department, formerly the Solvang Municipal Improvement District (SMID), was granted Permit No. 15878 and amendments from the State Water Resources Control Board Division of Water Rights (SWRCB) to "extract water from the gravels of the River for use within the District." These extractions are to occur within a prescribed reach of the River, as described below. Other users, upstream, downstream, and within the same reach of the River, have rights to the underflow and surface water in the River which are currently being exercised. These users include, but are not limited to:

- The Santa Ynez River Water Conservation District Improvement District No. 1 (ID 1) which has an active well field upstream of Solvang within the reach of the River in which water diversion to the City is permitted;

- The Alisal River Golf Course and the Alisal Guest Ranch and Resort, which own much of the river bed and vicinity within the reach of City's water extraction rights, and has historically provided easements for water wells to the City and other users;

- Farms, ranches, and other communities downstream, such as the Cities of Buellton and Lompoc; and

- Flora and fauna of the riparian habitat, including the endangered steelhead trout, for which special releases from Lake Cachuma have been made since 1993.

SCOPE

Based on the City's Water System Master Plan Update (Provost & Pritchard, 2002), the scope of work for this study was developed through conversations with Mr. Alan DeHaai, of Provost & Pritchard, Inc., Fresno, California, and refined through discussions with Mr. Thomas Rowe, Public Works Director for the City of Solvang. This report completes work conducted for Task 1 of the City project services agreement number_____ dated November 2, 2002. As outlined in the agreement, the scope of work for this study includes:

- Studying hydrogeological conditions within the reach of the River where the City has rights to obtain groundwater;

- Developing recommendations for well placement, preliminary well design(s), and preferred construction methods; and

- Preparing and submitting this final report summarizing the findings of the well siting study.

To accomplish these goals, Hopkins conducted a review of available sources of information that pertain to the hydrogeology and production of groundwater from this portion of the Santa Ynez River Basin. Sources of information reviewed include previous geologic and hydrogeologic studies, historical aerial photographs, and Department of Public Works files provided by the City. Where available, boring logs and well construction reports were obtained and reviewed. Readily available documents and data obtained from government entities such as the United States Bureau of Reclamation (USBR), the United States Geological Survey (USGS), the SWRCB, the County of Santa Barbara Department of Public Works (County) Flood Control, the County Water Agency, the City, and the ID-1 were reviewed.

The various issues reviewed for this study include the limits of water extraction rights, present land ownership and existing easements, potential interference between proposed and existing wells in the study area, available drilling methods, access to well sites, and environmental and regulatory constraints.

FINDINGS

DESCRIPTION OF STUDY AREA

As shown on Plate 1, the Study Area consists of an approximately 2.25-mile-long reach of the Santa Ynez River. Elevations along the Study Area's reach of the River range from approximately 365 feet above mean sea level (MSL) at the Alisal Bridge to approximately 440 feet above MSL at the eastern boundary. The Study Area is bounded on the west by the Alisal Bridge in Solvang and on the east by the eastern limit of Section 23 in Township 6N and Range 31W (approximately 1200 feet west and downstream of the Refugio Bridge, [see Plate 1]) (Provost & Pritchard, 2002). The actual northern and southern boundaries of the Study Area (along the River) are irregularly defined by the limits of the River's water bearing alluvial deposits. The Study Area boundaries are consistent with those delineated in the City's SWRCB permit and the most recent permit amendment completed in 1981 (Aaron Miller, personal communication, November, 2002).

Discussions with City staff during initial project scoping meetings resulted in limiting the primary focus of this study to the western portion of the project study area. Factors that influenced this decision included; a) the proximity of the ID-1 well field, which is located in the central portion of the study area, b) the location of the Alisal irrigation supply wells, c) the potential environmental impacts, and d) the increased costs associated with extending infrastructure to produce and convey water from wells in the eastern portion of the study area.

Existing wells within the River basin are shown on Plate 2A – Well Location Map, Western Portion, and Plate 2B – Well Location Map, Eastern Portion. A major goal of this study is to find new well locations that do not significantly interfere with the production of these existing wells. For that reason, available information regarding the hydrogeological conditions within the ID-1 well field has been reviewed to develop an understanding of existing conditions, however, the area within and immediately adjacent the ID-1 well field easement is not considered a viable area for the potential siting of City wells.

HYDROGEOLOGY

Geologic Setting

The Study Area is located in the east-west-trending Santa Ynez Valley which is bounded by the Santa Ynez Mountains to the south, and the Purisima Hills and the San Rafael Foothills to the north. The mountains and hills are folded and faulted, coincidently with the physiographic features created by these structures and generally trend in a westerly and north-northwesterly direction. Regional folding in the bedrock formations that underlie the Lower Santa Ynez River Valley has formed the Santa Rita Syncline, which trends and plunges to the west/northwest and has an axis that has been mapped approximately 1 mile south of the City of Solvang (Dibblee, 1950).

Geologic structure in the Purisima Hills north of Solvang is dominated by a series of smaller anticlinal and synclinal structures that trend to the northwest. The evidence of normal faulting and folding in the Lower Santa Ynez Mountains south of Solvang predominantly indicate a west-northwestern structural trend with the southern fault blocks upthrown (Dibblee, 1950). As shown on Plate 3 – Geology and Cross-Section Location Map, the River alluvium in the Study Area unconformably rests on folded alluvial and marine sedimentary formations that are of Tertiary geological age. Plate 4 – Geologic Map Legend provides a brief description of the geological materials that are shown on the map. As indicated, the Vaqueros Formation consists of sandstone and siltstone beds, and the Rincon, Monterey, and Sisquoc Formations are predominantly comprised of claystone and shale materials. Outcrops located along the northern River bank indicate that the Quaternary age river deposits within the study area are mostly underlain by the non-water bearing Monterey Formation (Dibblee, 1988). The River channel deposits are predominantly interstratified gravels, sands, and silts.

North-south-trending tributary streams originate in the surrounding hills and flow into the Santa Ynez River. The 2 main stream channels in the Study Area are the Alamo Pintado Creek, on the north side of the River, and the Alisal Creek on the south side (see Plate 1). The Quaternary alluvium that has been deposited by these tributary streams consists of thin deposits of silt, sand, and gravel. To the north of the Study Area, streams incise geologic materials that comprise the Santa Ynez Uplands (Uplands) groundwater basin. All of the streams draining the south edge of the Uplands cross a relatively narrow barrier of consolidated rock along the north side of the River (Upson and Thomasson, 1951). The Uplands consist of weakly consolidated Quaternary Period deposits of stream terraces and alluvial fans that are identified as older alluvium (Dibblee, 1988).

Hydrogeologic Setting

Surface water and groundwater within the River flows westerly and drains the watershed down through the Lompoc Narrows (Narrows), which is located approximately 4 miles east of the City of Lompoc, and then northwesterly and westerly to the Pacific Ocean. The Bradbury Dam is located approximately 10 miles above the Study Area and was built on the River in the early 1950s to create the Lake Cachuma Reservoir (Cachuma). Cachuma is located downstream of the Gibralter and Juncal Reservoirs, which are also located on the River. All three reservoirs have historically provided water through tunnels in the Santa Ynez Mountains to the Santa Barbara coastal communities. Releases from the Bradbury dam are made as appropriate to balance flood flows and maintain a downstream supply of water for aquatic, riparian, and human demands along the River.

The Santa Barbara County Water Agency (SBCWA) has identified the portion of the River basin that extends from the Bradbury Dam to the Alisal Bridge as the Santa Ynez Riparian (Riparian) Sub Basin (Ahlroth, 1991). The Riparian sub basin primarily receives water via stream seepage from regulated releases, spills, and leakage from Cachuma Reservoir, and secondarily from direct precipitation and surface runoff percolation, and from river bank inflow. The SBCWA water budget model indicates that water is removed from the Riparian sub basin through minor bank outflow and mostly by municipal, industrial, agricultural, and phreatophyte consumptive uses.

The riparian basin has not been subject to overdraft because the average annual flow of the River has been greater than the volume of the basin. The United States Bureau of Reclamation (USBR) and the Cachuma Operations and Maintenance Board (COMB) are the operators of the Cachuma Project and control basin water levels (County of Santa Barbara Water Agency, 2000). Cachuma Reservoir releases occur in accord with SWRCB agreements with downstream users when surface and/or groundwater levels are low. The dam has overflowed in the past during storm events and controlled releases from the reservoir have occurred in anticipation of potential overflows.

The dominant source of recharge to this alluvial aquifer system is direct infiltration of surface flows. The groundwater in the alluvial aquifer has been determined to be in direct hydraulic communication with the River's surface flow. Because the River groundwater basin is narrow and shallow, it is filled relatively quickly during the wet season. Conversely, groundwater levels are significantly affected by pumping of River wells during the dry season.

The relatively small storage volume of the basin makes the River groundwater supply particularly vulnerable to prolonged droughts.

River Aquifer Geometry

In the study area the River aquifer is underlain primarily by bedrock comprised of non-water-bearing marine shale formations. Although a minor amount of water may be present within fractures and joints in the bedrock, the Tertiary rocks are considered to be the effective base of fresh water under the River basin. The shape of the aquifer boundaries (bottoms and sides) was developed as ancient paleochannels of the river scoured into the underlying bedrock. Subsequent uplifting and down-dropping that has occurred as Recent geological structures have formed has affected sedimentation and erosion rates and has also influenced the present shape and thickness of the aquifer.

The thickness of the River aquifer is variable along its course and is presently affected by the balance between sediment replenishment from the upstream tributaries and mass removal that occurs during large storm flows and high flow releases of water from Lake Cachuma. Alluvial mass movement through the River system is also affected by human activities which include the impoundment of sediment in the upstream reservoirs and the removal of material by the quarry activities downstream.

Variations in aquifer thicknesses and material types within the Study Area are available from a limited number of borings logs provided from historical well construction and from the geotechnical study conducted for replacement of the Alisal Bridge (Moore and Tabor, 1970). The lithological logs were obtained from consultant reports, City files, and ID-1 files. Available logs indicate that a majority of the existing wells were constructed from the late 1950s through the year 2002. The approximate location of the existing wells is shown on Plates 2A and 2B. Most of the existing wells in the Study Area are located in the western portion and owned by one of three entities: the City, ID-1, or the Alisal. Well 6N/31W-22F01, which is located just east of Alamo Pintado Creek, is believed to be owned by the Alisal (as the land owner) and monitored by the USBR to obtain routine water level measurements.

Using available information, which includes the approximate well locations provided by Plates 2A and 2B and the geological information provided by individual boring logs and the geological map on Plate 3 and 4, hydrogeolgical cross-sections were constructed to show inferred subsurface conditions (1 along the course of the river and 3 transverse). The location of the cross-sections are shown on Plate 3 and the individual sections are provided as Plates 5, 6, 7, and 8 – Hydrogeological Cross-Section A-A', B-B', C-C', and D-D', respectively. As shown on the hydrogeological cross-sections, the depth to bedrock from ground surface at the location of the City wells varied from approximately 42.5 feet to 68 feet. Plate 9 – Hydrogeological Cross-

Section Legend provides information that defines the symbols and notation that were used in the sections.

Well head elevation data are available for 7 of the ID-1 wells for which drilling logs are also available (SYRWCD, 2001). This provides a fair level of control for the elevation at the top of bedrock in their well field. The calculated elevations of the top of bedrock in the ID-1 well field vary from approximately 337 feet above MSL in Well 20 to approximately 363 feet above MSL in Well 22 (see Plate 2). Within the ID-1 well field available data indicate that the bedrock elevation reportedly varies about 25 feet and indicates that an extremely irregular surface defines the bottom of the alluvial aquifer.

Well field yield will ultimately be controlled by a number of factors which includes the aerial extent of the aquifer being produced and the sources of recharge relative to the sources of discharge. By comparing cross-sections B-B' and C-C' with D-D' (see Plates 6, 7, and 8) we can see that the cross-sectional area through which flow occurs within the River alluvium varies significantly along the course of the River. The width of alluvium in the area of the ID-1 well field is about twice as wide at the area down stream of Alamo Pintado Creek. This difference in aquifer geometry will have a significant affect in well performance, well interference, and planned well spacing.

Alluvial Aquifer System Dynamics

Deposition of sediment in fluvial environments produces a variety of interstratified, lenticular, and discontinuous structures, including coarse-grained channel deposits and point bars, and fine-grained floodplain deposits from over-bank flows. These fluvial deposits are reworked and buried as the river changes course. Because of this complex depositional environment, aquifer parameters can vary greatly over short distances and wells located fairly close to each other can have significantly different yields. Together the material types, aquifer thickness, and the proximity to flow boundary conditions at each well site will affect the ability to produce groundwater from an individual well facility.

The approximate thicknesses of channel deposits documented by boring logs within the reach of the River between the ID-1 well field and the Alisal Bridge ranges between 40 and 56 feet. The saturated thickness of alluvium at any given location defines the aquifer that is available for production. Based on historical static water level measurements, the documented aquifer thickness has ranged between 30 and 47 feet at various locations within the river. The aquifer thickness will also vary through time as a result of changes in local River supply and demand, and active channel migration.

The alluvial aquifer of the River system is also being affected by man-made processes that include impoundment of sediment behind upstream dams and mining of sediment from downstream quarries. The affect of these two activities is to diminish the sediment load within the River and contribute to the possible acceleration of erosion of the alluvial sediment within River channel. The result will likely be a reduction in aquifer thickness, aquifer storage capacity, and the productivity of wells within the River as this occurs. It is beyond the scope of this study to develop an understanding of the sediment transport mechanisms within the River and whether historical changes will have a significant affect in the near future.

REGULATORY CONSTRAINTS ON WELL LOCATIONS

Various requirements by governmental agencies must be considered in order to construct and extract water from new wells in the Study Area. To the extent practicable these considerations were made during review and selection of preliminary well site locations. To assist with identification and evaluation of these issues the City has contracted with an environmental consulting firm to prepare environmental documentation and assist with obtaining environmental permits from regulatory agencies. The preliminary governmental agency regulations considered in this study are described below.

United States Army Corps of Engineers

Correspondence located in the City files from Suzanne Elledge Permit Processing Services indicates that the United States Army Corps of Engineers (COE) Section 404 dredging/filling permit is required for dredging, filling, or discharge into the River. "Discharge" in this context refers to movement of dredged solids that could subsequently deposit and could alter the river flow. Project activities occurring within the high water mark of the River will have "considerable regulatory implications" for numerous agencies, particularly the COE (Helmer, 2001). It is our understanding that the COE regulates activities occurring below the ordinary high water mark as defined by the level of a 2 year flow event (John Gray, URS Corporation, personal communication, December 2002). To the extent feasible, well sites located below the ordinary high water mark in the River have been avoided.

National Marine Fisheries Service

The National Marine Fisheries Service (NMFS) will likely require the preparation of a Biological Opinion document pertaining to whether and how endangered species may be affected during well drilling and construction activities. In summary, NMFS is primarily concerned where there are standing or flowing surface waters. The well construction activities will need to avoid operation of equipment near or in surface waters to abate the concerns of NMFS.

State of California Department of Fish and Game

The California Department of Fish and Game (DFG) requires a Section 1601 Streambed Alteration Agreement for projects that impact the bed or bank of a river. A goal of this study is to propose well sites that will not require extensive impact to the River bed or banks, in an effort to protect the environment and to minimize potential mitigation efforts that might be required by the DFG. It is worth noting that although City Well 5 was located in a formerly active riverbed, evidenced by damage it received during the 1995-1996 storms, the DFG authorized a Streambed Alteration Agreement and filed a Notice of Exemption for CEQA requirements in July 2001 for work proposed for the City Well 5 Replacement Project (DFG, 2001).

Central Coast Regional Water Quality Control Board

The Central Coast Regional Water Quality Control Board (RWQCB) requires a Section 401 Clean Water Certification for water wells. In addition, if well discharge is to be released into the River a National Pollutant Discharge Elimination System (NPDES) permit will be required to satisfy RWQCB requirements for a point source discharge. It is likely that the conditions pertaining to water discharge certification will be the same for any of the well sites proposed, RWQCB certification requirements have not been considered during the evaluation of potential well sites in this study.

State of California Department of Health Services

The State of California Department of Health Services (DHS) requires a permit for well construction for facilities to be used for municipal supply. DHS regulates the distance from a well site to a potential source of contamination such as surface water bodies, sewers, and sewage disposal systems. In porous aquifers, the DHS requires a minimum horizontal distance of 600 feet from these features. Variances for sanitary seals less than the required 50 feet in length have been granted in the past for shallow River well construction where the total aquifer depth is only on the order of 50 feet. It is anticipated that DHS will likely grant a variance of this nature to the City of Solvang for this project.

In the case of existing and additional water wells for domestic purposes that extract water from the River underflow, DHS Surface Water Treatment Regulations (SWTR) apply if the nearest active River channel is less than 150 feet from the well (see Appendix A – State DHS Well Permit Information). Under the SWTR, turbidity, chlorine residual or microbial testing, and distance to the surface water must be monitored frequently and reported. If DHS criteria for these parameters are not met, or if the well is located less than 150 feet from surface water, then filtration and disinfection treatment must occur (Humayun [Mike] Ali, personal communication, November 2002).

County of Santa Barbara Department of Environmental Health Services

The County Department of Environmental Health Services (EHS) will require the City obtain a water well construction permit. EHS will review the proposed well locations when the well permit applications are filed and will place particular emphasis on the minimum distances from potential sources of contamination. The EHS will require a site inspection before the permit is granted and witnessing of the emplacement of the sanitary seal. If the City desires a variance from State or County standards for any of the proposed River wells (i.e., a below-ground vault, etc.), the EHS will likely permit the request if the State DHS will permit the changes (Davies, personal communication, December 2002).

Water Rights

In May of 1969, the SWRCB Division of Water Rights (Division) Decision #1338 approved the SMID Application #22423 for Permit #15878 to appropriate no more than 5 cubic feet per second (cfs) and 3,600 acre feet per year (AF/yr) of underflow from the Santa Ynez River to be put to beneficial use within the boundaries of the SMID. Since that time, the SMID, now the City Water Department has been granted various amendments to change the points of diversion and places of use. The most recently approved petition was granted in 1981 and changed the diversion area to that shown on Plate 1 (Aaron Miller, personal communication, November 2002). It is our understanding that the diversion area includes a triangular-shaped portion of land immediately west of the present-day Alisal Bridge. This is because the permitted westernmost diversion point was located at the former Alisal Bridge that was destroyed in the 1969-1970 flood event (Mr. Tom Rowe, personal communication, November 2002). As stated in the recently updated Water System Master Plan, "installation and use of additional [Santa Ynez River] wells is mandated to avoid reduction or loss of the supply altogether" (Provost & Pritchard, 2002). To obtain a current license for the maximum amount of River underflow diversion allowed in Permit #15878 (5 cfs, or 3,600 AF/yr), the City must establish the ability to extract more water than it currently does and demonstrate that the extracted water has been put to beneficial use.

In part, current extraction of water from the River underflow falls short of 3,600 AF/yr because the City has lost River wells to floods in previous years' storms. The Year 2001 annual production from River wells was 465 AF. At present, only City Wells 3 and 7A are functional. At this time, water is being pumped only from Well 7A because Well 3 is too close to the current active River channel to operate without an additional treatment and filtration program per DHS regulations. If both Well 7A and 3 were operating continuously, no more than approximately 1017 AF/yr (or 1.78 cfs) of water would be extracted (Provost & Pritchard, 2002). The capital cost estimates for additional River wells in updated Water System Master Plan are based on a projected yield of 300 gallons per minute (gpm) per well (Provost & Pritchard, 2002). Based upon this projection, at least 8 River wells would be required to maximize this source of water for City use.

CEQA Requirements

According to a letter to the SWRCB Division of Water Rights from the legal firm of Baker, Manock & Jensen (dated June 14, 2001), the City is committed to the preparation of a CEQA document to "analyze the potential impacts of its petition for extension of time for Permit 15878". The US Bureau of Reclamation is preparing or has prepared a comprehensive environmental review of the "Cachuma Project", involving studies of all species and users on the Santa Ynez River. A draft of this environmental report is reportedly considered a necessary precursor to a CEQA document pertaining to water diversion to be prepared by an environmental consultant to the City (Baker, 2001). The results of this well siting and hydrogeological study will provide information to the environmental consultant for the preparation of the CEQA-required environmental review.

PHYSICAL CONSTRAINTS

Easements and Property Ownership

Plate 10 – River Well Easements, indicates the locations of existing well easements that are located in the western half of the study area. The majority of the land in the Study Area is owned by the Alisal, however, a parcel of land adjacent to, and west of, the Alisal Bridge may actually be owned by the City (Mr. Thomas Rowe, personal communication, November 2002) (see Plate 10). Although readily available information from the City does not confirm the legal status of the identified easements or property ownership, this study has focused well siting efforts, where hydrogeologically feasible, on those areas where legal access appears to be facilitated. It is our understanding that existing easement agreements include provisions that restrict the operation of City wells in a manner that prevents the interference with existing production wells owned by the Alisal. It is likely that the City will need to consider similar arrangements to obtain additional property easements for the proposed new wells. Based on the findings of this study, additional land for access and well construction will be required for the City to space the wells appropriately and obtain the desired instantaneous and annual production rate.

Active River Channel Location

Historical aerial photographs were obtained and reviewed as part of this study to determine if the River had an established pattern or preferential flow path through the study area. This review was confined to the period after construction of the Bradbury Dam and after the cessation of levee construction (1969) which confined the natural migration of the active River channel. Photographs obtained for this study are provided in Appendix B - Photographic Survey Review of River Channel Migration. The photographs have been interpreted to identify the location of the primary active channels where perennial flow (base flow) continued after flood flows receded (see Appendix B). A compilation of the information from this series of photographs is presented on Plate 11 –Santa Ynez River Historical Active Channel Locations. These photographs show that under high flow conditions the river becomes a braded system where several major flow channels are formed. As flows recede, the River base flow is confined to the deepest channel which meanders through the valley and largely remains stable until reestablished by the high energy forces of a subsequent flood flow.

River channel migration is a dynamic process influenced by both natural and man-made conditions. Recent flooding events have been the result of a combination of large storm events and large release flows from Bradbury Dam. These events are not necessary coincidental. Large releases generally occur as Cachuma Reservoir is nearing a full level and flood capacity must be maintained. Flows from large storm events that occur during times when the reservoir is low are typically moderated by impoundment within the reservoir. These events may not result in significant flooding or migration of the active channel. As shown on Plate 11, west of the ID-1 well field the River has a tendency to establish its main flow channels along the southerly bank. However, this documentation also appears to show that the actual path of the active channel is unpredictable and has been reestablished at different locations throughout this reach of the River.

The aerial photographs do not represent a complete record nor do they show the complete extent of flood flows. However, this documentation is believed to provide sufficient information to demonstrate that it will be difficult to locate wells at any point in this reach of the river where surface flows will not encroach the DHS 150-foot set back distance. As shown by the flood flow photograph of 1969, all areas within this reach of the River are subject to flooding and future well sites should be protected accordingly (see Appendix B).

WELL SITE EVALUATION

Well Interference Analysis

Historical data provided by River well documentation were used to estimate potential well yields and aquifer parameters which were combined to study the operational interference affects between the proposed wells and existing wells. Our analysis utilized actual well data to estimate formation transmissivity values which ranged between 20,000 and 184,000 gallons per day per foot (gpd/ft) of aquifer. A summary of available data is included in Appendix C – Well Data and Aquifer Parameter Estimates. The available data indicate that historically wells have been produced at rates of up to 1,250 gpm for short periods of time but longer term production has been sustained by pumping at rates below 400 gpm. Transmissivity values greater than 35,000 gpd/ft were estimated based on short-term test data and are therefore invalid for use in estimating long-term production drawdown affects (see Appendix C). Transmissivity estimates where calculated from well specific capacity values which are affected by a number of factors including; a) the duration of the pumping period, b) the stress of the pumping rate, c) the location of the River recharge, d) local well interference, and e) no flow boundary affects.

For this study a review of potential well interference estimates is provided by using the Theis equation of groundwater flow, available data, and estimated and assumed aquifer parameters. A series of theoretical distance drawdown projections were generated and utilized to determine the relative affects when varying individual parameters that affect fluid flow. Four projections are provided in Appendix D – Theoretical Distance Drawdown Projections to demonstrate how changes in aquifer properties, pumping rates, and duration of pumping affect the pumping well and the water table at given distances from the point of extraction. When reviewing these results we must realize that the aquifer (total saturated thickness of alluvium) reportedly ranged between 30 and 47 feet thick (generally 30 to 35 feet) and that available drawdown is only equal to this amount.

Plate D1 shows how variations in formation transmissivity affect water levels in the aquifer. The affect of this parameter is far more significant at the well location than at distances of over 100 feet from the source of production. Based on available data, the value of 25,000 gpd/ft is believed representative for the River reach being studied and is used as the long-term transmissivity value in the other projections. Plate D2 indicates that variations in the pumping rate have a similar affect on water levels. The greatest affect is in the vicinity of the point of extraction. Historical information indicates that properly spaced wells can produce an average sustained production rate on the order of 300 gpm. For this reason, the production rate of 300 gpm is used in the subsequent two projections.

Plates D3 and D4 indicate that variations in the storage coefficient and the duration of pumping have an affect on aquifer water levels that is more pronounced at the greater distances from the pumping well. No available data are available to estimate an approximate aquifer storage coefficient. Based on the fine-grained nature of the matrix materials Hopkins has observed in the coarser sediment we estimate a storage coefficient of 0.03 (3 percent effective porosity) is a reasonable value to use for this interference analysis. The final projection over time uses a transmissivity of 25,000 gpd/ft, and storage coefficient of 0.03 and a discharge rate of 300 gpm (see Plate D4). A review of pumping after 90 days indicates that the drawdown a the pumping well is projected to be approximately 25 feet and the theoretical distance drawdown at a distance of 500 feet is approximately 6 feet. This indicates that the mutual interference of 2 pumping wells located approximately 500 feet apart would result in pumping water levels of 31 feet in each well. Because drawdown interference affects are additive, this method of analysis provides a rough estimate of well interference and thereby a gage of potentially achievable well extraction rates and potentially acceptable well spacing distances.

Proposed Well Locations

The proposed well sites are located along a reach of the River that spans from the Alisal Bridge eastward toward Alamo Pintado Creek. As shown on Plate 12 – Proposed Well Site Location Map, the sites are positioned along the north side of the River. These locations were selected because they are believed hydrgeologically advantageous for groundwater production, will allow for easier access, and will allow the City to connect to existing conveyance piping.

Although the proposed well sites are located within the 100-year floodplain the locations are believed to be above the ordinary high water mark of the active river channel. The present locations are at least 150 feet from any surface water flows in accordance with DHS requirements for extraction without additional filtration treatment. The proposed locations are spaced an approximate 500-foot distance from each other and from existing wells in the river. The spacing was based on available information and the well interference analysis conducted as part of this study which shows prolonged operation will result in mutual drawdown interference. Well locations are moderately clustered around Alamo Pintado Creek with the intended benefit of producing from the groundwater recharge mound provided by the year-round stream inflows and because the alluvial basin is believed to be wider in this area and conducive to higher well production rates.

The number of proposed well sites is based on considerations that include; a) the anticipated well production capabilities of individual facilities, b) the possible need to discontinue pumping of individual wells as the active River channel encroaches within the 150-foot-buffer zone, and c) the ability to develop operational strategies that can mitigate impacts to existing wells without discontinuing pumping. The 6 new locations would provide the City with a total of 8 actives wells that are believed will be capable of providing an average of 300 gpm each and will cumulatively satisfy the minimum extraction rate required to produce the desired diversion rate.

Access

During construction a pathway approximately 15 feet wide is required for a drill rig and auxiliary vehicles. The length of the access pathway varies by well site. A work area of approximately 50 by 50 feet (about 2,500 square feet) will be required for the proposed activities at each well site, including stockpiling of supplies. Because there is no improved access road along the proposed reach of the River, vehicles will access the well sites west of Alamo Pintado Creek using an entrance located west of the Alisal Bridge and then by using the historically established undeveloped access road that traverses the River terrace outside of the active channel. For well sites east of Alamo Pintado Creek, access will either require use of dirt roads through the ID-1 well field and then along the River terrace south of the Alisal River Golf Course, or through use of the golf course access road and bridge that crosses Alamo Pintado Creek then by establishing a new point of entry into the River course. Either route will require new access easements and permission from the property owner(s)

PRELIMINARY WELL DESIGN AND CONSTRUCTION METHODS

Historical Well Performance

Historical documentation of well performance for wells in this reach of the River indicate that the potential production capacity of wells has varied largely as a result of: a) well location (due to geological changes), b) the duration of pumping, c) the operational interference of proximate wells, d) available recharge provided by surface flows, and e) the location of the active River channel in relation to the well being pumped. Well discharge capacities have been documented to range between 200 gpm and 1,000 gpm. Long term operation of individual wells has generally resulted in reliable yields on the order of 200 gpm to 400 gpm. The higher well discharge capacities of 500 to 1,000 gpm have been documented for cyclical pumping patterns or during very short pumping periods of up to 2 hours (during variable rate well discharge testing). Our experiences indicates those wells with a suitable design and when located within 50 feet of surface flows have been capable of sustaining higher rates of sustained pumping (approximately 800 gpm). Based on these available data, we believe that the City should anticipate continuous (24-hour-per-day) operational yields that are on the order of 200 to 400 gpm (average 300 gpm). While this anticipated yield will require the construction of several more wells to meet the desired instantaneous discharge rate than if the individual well rates were higher, the well sizes can accordingly be smaller and the unit costs will be lower.

Preliminary Well Design

Well design considerations for this study have been based on Hopkins experience with well construction in alluvial aquifer systems and data that are available from wells in the area. Borehole depths for the proposed wells will likely not exceed 70 feet below ground surface and the proposed diameters will be up to 16 inches. The proposed wells will be constructed in the riverbed alluvium and will terminate at a depth of approximately 10 feet below the contact of the underlying bedrock materials which define the effective base of the aquifer. To maximize available drawdown, a pump chamber is designed to be constructed below the screen section at the bottom of the well and have a length of approximately 10 feet. If use of a submersible pump is desired, the pump chamber diameter should be sufficient to allow installation of a flow diverting pump shroud for proper motor cooling (minimum 8-inch-diameter). Plate 13 – Preliminary Well Design provides in concept the proposed well design for the new completions in the City well field.

At a minimum, wellhead protection should consist of a large diameter conductor casing (up to 18-inch-diameter) set to a depth of 20 feet and cemented in place. The conductor casing should be installed prior to pilot hole drilling and well construction. Additional protection should be appropriately designed for each specific location and may include 5-ton rip rap and or steel I-beam and steel cable gabions for flow diversion. Conveyance piping for produced water and conduits for pump electrical wiring will likely be located below-ground. These conduits should be protected at the wellhead by locating them on the downstream side of the well structure and buried to a minimum depth of 10 feet below ground surface (based on other proximate well designs) or below the depth of potential greatest scour as determined by the City's design engineer.

Based on available water quality data, well casing and well screen materials can be comprised of PVC plastic, low carbon steel, or stainless steel materials. Final selection of well materials should be based on the City's long term strategy for River water production. Low carbon steel wells have reportedly provided a 20- to 30-year-operational service life. However, Stainless steel or PVC may be preferable to improve the operational lifetime of the wells and allow for the use of more aggressive redevelopment methods that require the use of corrosive chemicals, (chlorine and acids).

A concrete sanitary seal will be emplaced in the upper 20 feet of the well annulus between the well casing and the conductor casing. This will add additional mass and wellhead protection. The well screen section should be encased with clean imported gravel that is emplaced in the annulus below the sanitary seal. The screen slot size will likely be in the range of a 0.060- to 0.090-inch-opening and based on formation materials observed. The gravel gradation will be selected according to the final screen slot size.

Preferred Drilling Methods

The different drilling methods available to the well construction industry provide individual advantages and disadvantages for any specific project. The benefits and drawbacks of each method are based on the specific application and the hydrogeological environment being drilled. Fluid rotary methods (direct and reverse rotary drilling) can cause significant formation damage through mud invasion. This occurrence may be irreversible and result in lower well yields and inefficient operation throughout the lifetime of the well. In addition, use of fluids requires additional drilling equipment, a large work site foot print, can be more costly for site clean up, and require more well development time. For these reasons we recommend using alternative drilling methods for the construction of the City wells.

Cable Tool Drilling

Unlike drilling methods that require the use of clay based drilling fluids and polymeric additives, the cable tool drilling method does not require the addition of a circulation fluid during the drilling process. Formation damage is not caused by fluid loss or mud invasion because hole stabilization is achieved using a steel drive casing. The result is that less fine material is required to be flushed from the borehole during development of the completed well. During well construction extraction of the temporary drive casings expose the permanent casing and screen to the surrounding formation. One potential drawback of this drilling method is that it can be relatively slow and labor intensive. However, competitive bidding will provide a means to weed out costly applications of this method.

Air Drilling

Direct air-rotary drilling using a down-hole air hammer can provide rapid penetration rates when drilling in hard-rock formations or formations with cobbles and boulder sized detritus. Limitations on air-rotary drilling include; relatively small borehole diameters, borehole stability in soft formation materials, and the common need to use foaming agents to help lift cutting from the well bore. Alone this method is not suitable for alluvial drilling. However, air-rotary drilling using a drive casing for borehole stabilization (as with the cable tool method) has proven effective. This method can provide for rapid penetration rates, minimal formation damage, and relatively quick well construction. The major drawbacks are the borehole diameter limitations and the common need for foam additives which can be problematic if drilling near surface waters. It is our experience that a modified version of this method combined with appropriate well design considerations can allow drilling without additives and make this method most beneficial under the right conditions.

Bucket and Conventional Auger Drilling

Auger well drilling methods are successful proven methods for drilling in loose to moderately consolidated formation materials. However, application of these methods for conventional production well construction projects is not common. When drilling below the water table, borehole stabilization can be a problem while trying to remove the cuttings. In addition, large diameter cobbles and boulders can be problematic to drill and cause unsuccessful attempts and borehole relocation. These types of methods have been most successfully applied on larger diameter well completions by using drilling mud or steel casing to help stabilize the borehole walls. It is likely not advantageous to incur the costs to drill larger diameter holes in the River environment available to the City. For these reasons these methods may be allowed, however, a cost competitive bidding process will likely eliminate them from being a successful application for this project.

Dual Rotary Drilling

The dual rotary drilling method is a relatively new method that provides an inner drill string which turns independently of the outer drill casing. The outer drill casing is equipped with a carbide button drill shoe that allows it to core through earth materials while it is turned by a set of casing jaws. The inner drill string is equipped with a drill bit that can fit inside the drill casing and be comprised of any number of drill bit designs (e.g., tricone roller bit, air hammer bit, etc). This type of drill rig can utilize a number of methods to remove drill cuttings including, direct air-rotary circulation, direct fluid-rotary circulation, or reverse fluid-rotary circulation. The benefit of this type of drilling method is that it can carve a larger diameter hole and successfully remove the drill cuttings with one of the circulation methods which are appropriate for the drilling conditions. The disadvantage of this method is the costs for drilling can be considerably greater than for the cost of other methods. This is because the drill rig and support equipment are relatively expensive and the method is far more capable than the challenge of the proposed drilling project.

Construction Duration and Schedule

It is anticipated that the well drilling, completion, and development will require the use of heavy equipment onsite for up to five working days or more at each well site, depending for the most part on difficulty of access. The entire well construction project duration will likely require about 6 weeks to complete and prepare for conveyance line connection, electrical power installation, well head protection measures, and project mitigation activities.

Because of the potential flood hazard, we recommend the City schedule the well construction work in the riverbed to be conducted during the dry season and avoid rainy season risks. We recommend the City obtain information from the U.S. Bureau of Reclamation regarding potential releases from Bradbury Dam throughout the duration of the drilling activities to avoid the possibility of site inundation during construction.

CONCLUSIONS AND RECOMMENDATIONS

The findings of this study indicate that it is highly probable that the City can expand its River well field and produce the permitted River diversion amount (5 cfs) within the reach of the River between the ID-1 well field and the Alisal Bridge. The proposed production of groundwater will likely require mitigation measures that can be implemented to minimize impacts on existing groundwater producers. This study concludes that extraction of groundwater downstream of the ID-1 well field will minimize impacts to ID-1 operations. In addition, an average well spacing of 500 feet will reduce mutual well interference affects and contribute to uninterrupted long-term operation of the proposed wells.

Distribution of wells over a larger section of the River will provide a higher reliability of maintaining well operation as the River active channel migrates. The historically sinuous nature of the River indicates there is the likelihood that any specific well site within this reach of the river may inevitably become located within 150 feet of flowing water as the channel shifts position. However, it is highly unlikely that the setback distance for all of the proposed well locations will be encroached by River base flows during the same year.

Long-term operational production capacities for individual well facilities can be anticipated to be on the order of 300 gpm. We conclude that construction of multiple smaller production wells will increase the likelihood of success by distributing groundwater extraction over a greater area. We recommend the City consider well designs and construction methods that can cost effectively establish the proposed well field with facilities that will produce the most probable long-term operational rates that are likely obtainable. Through establishment and operation of the well field the City will develop additional hydrogeological data that can be used to locate and design future wells that may be more productive and efficient, and that may reduce impacts observed during future operation.

This study concludes that mitigation measures to reduce impacts to existing users may require daily adjustments to production from wells nearest existing well facilities and seasonal adjustments to pumping in response to the availability of surface flows within the River system. We recommend the City initiate discussion with the appropriate land owners and permitting agencies to allow further development of the project plans and specifications and environmental documentation that incorporates site specific constraints.

CLOSURE

This report has been prepared for the exclusive use of the City of Solvang and its agents for specific application to the understanding of hydrogeolgical conditions and the proposed new well construction sites located within the City permitted diversion area of the Santa Ynez River that is located in Santa Barbara County, California. The findings, conclusions, and recommendations presented herein were prepared in accordance with generally accepted hydrogeologic engineering practices. No other warranty, express or implied, is made.

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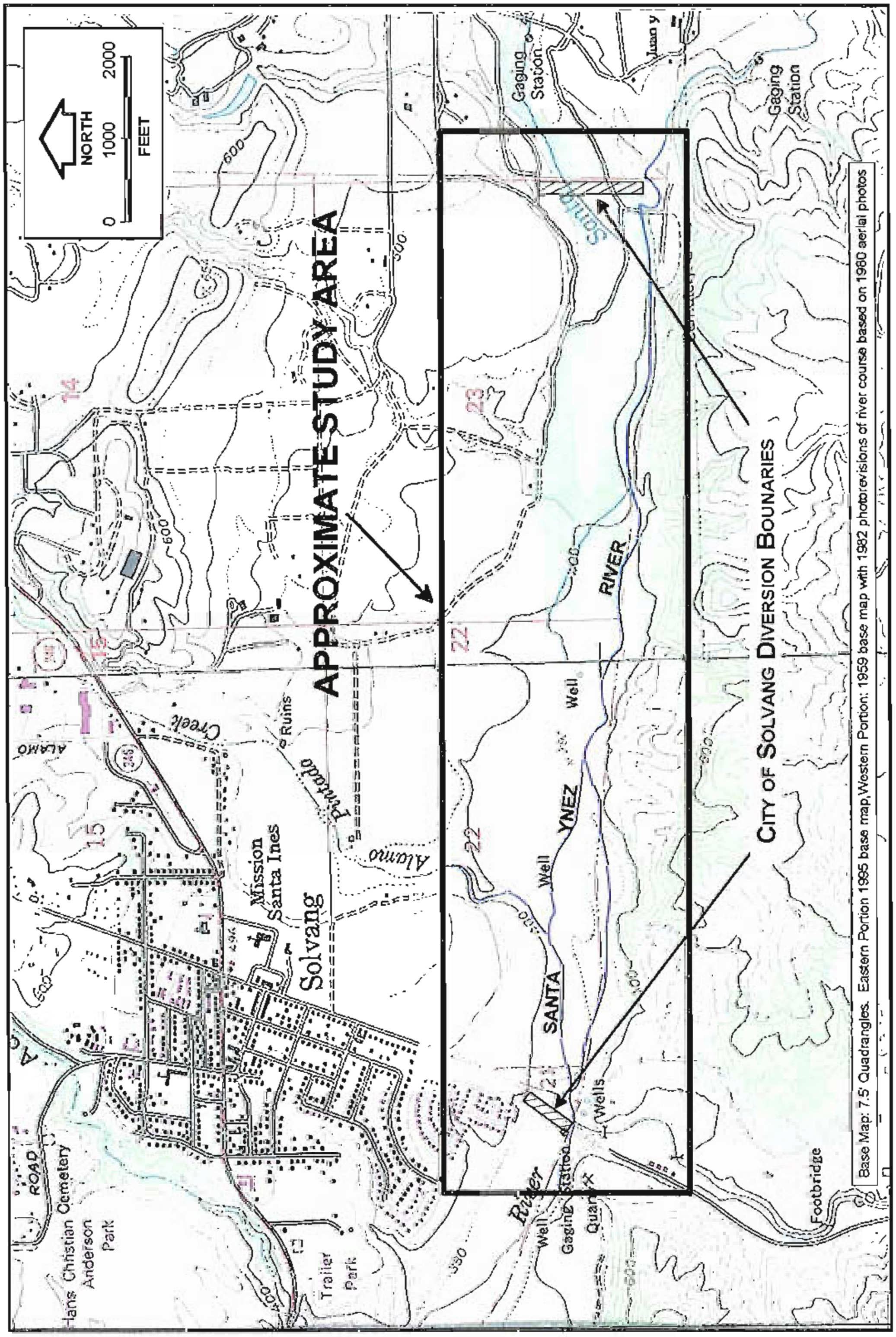
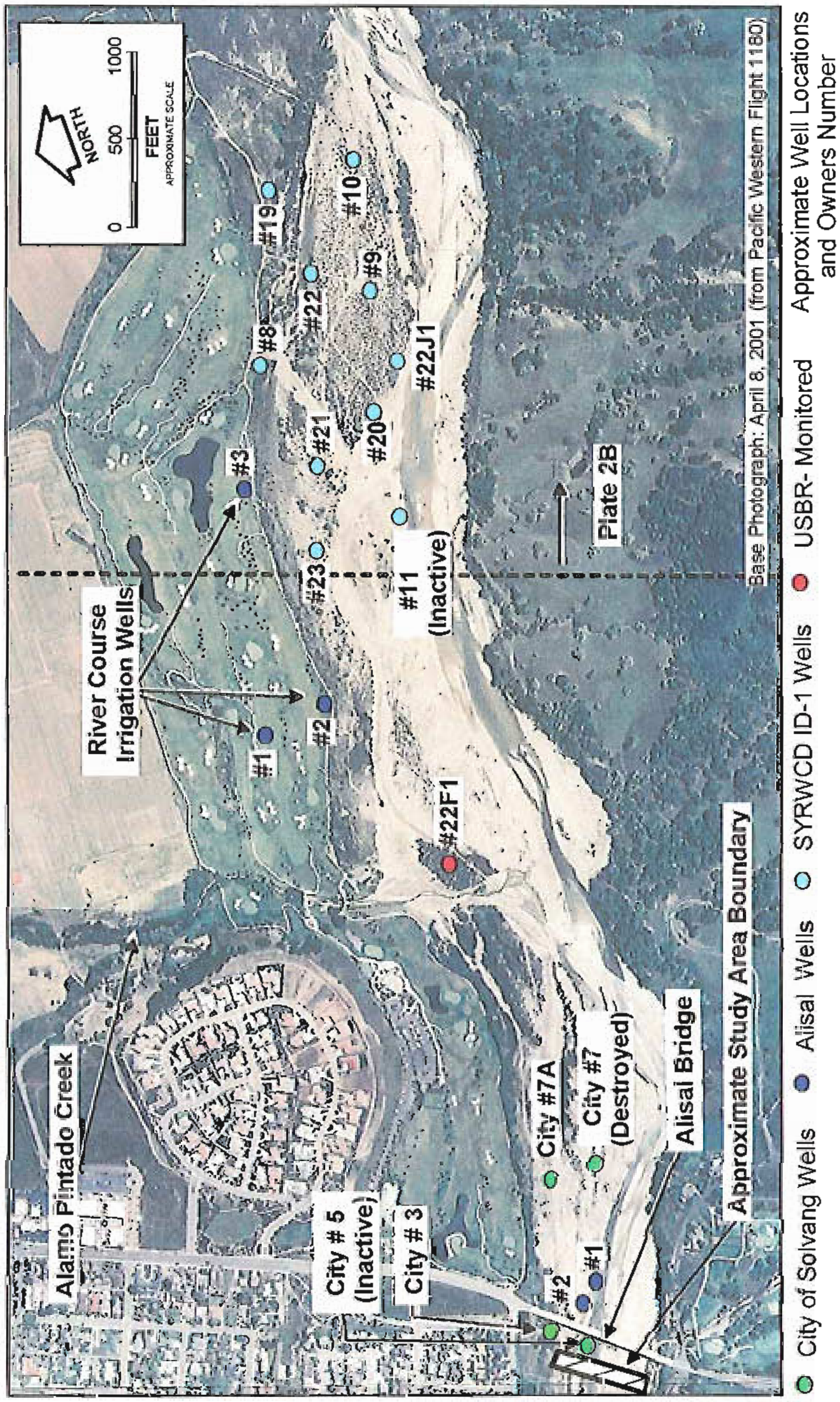
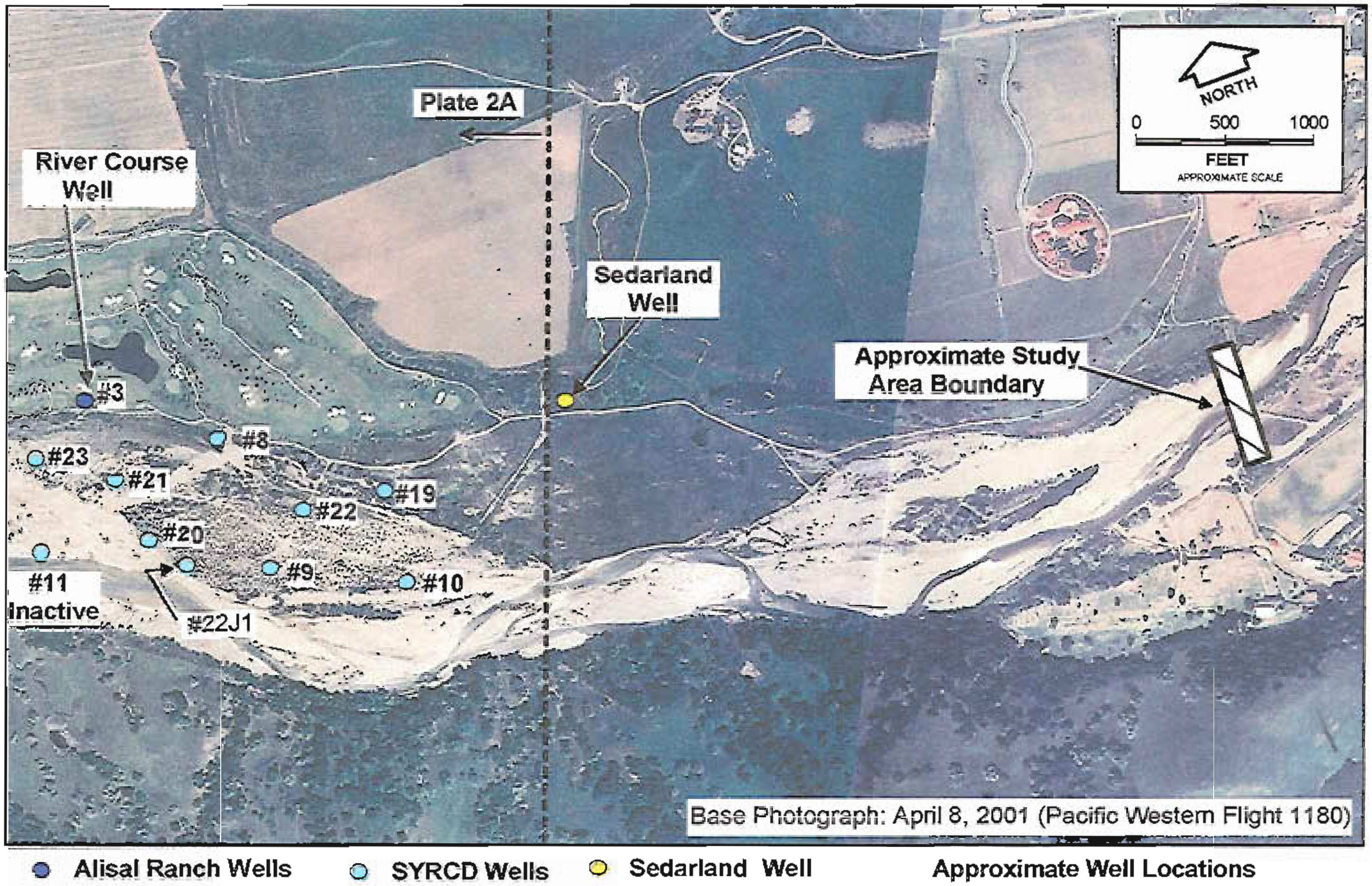
PLATES



STUDY AREA LOCATION MAP
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California

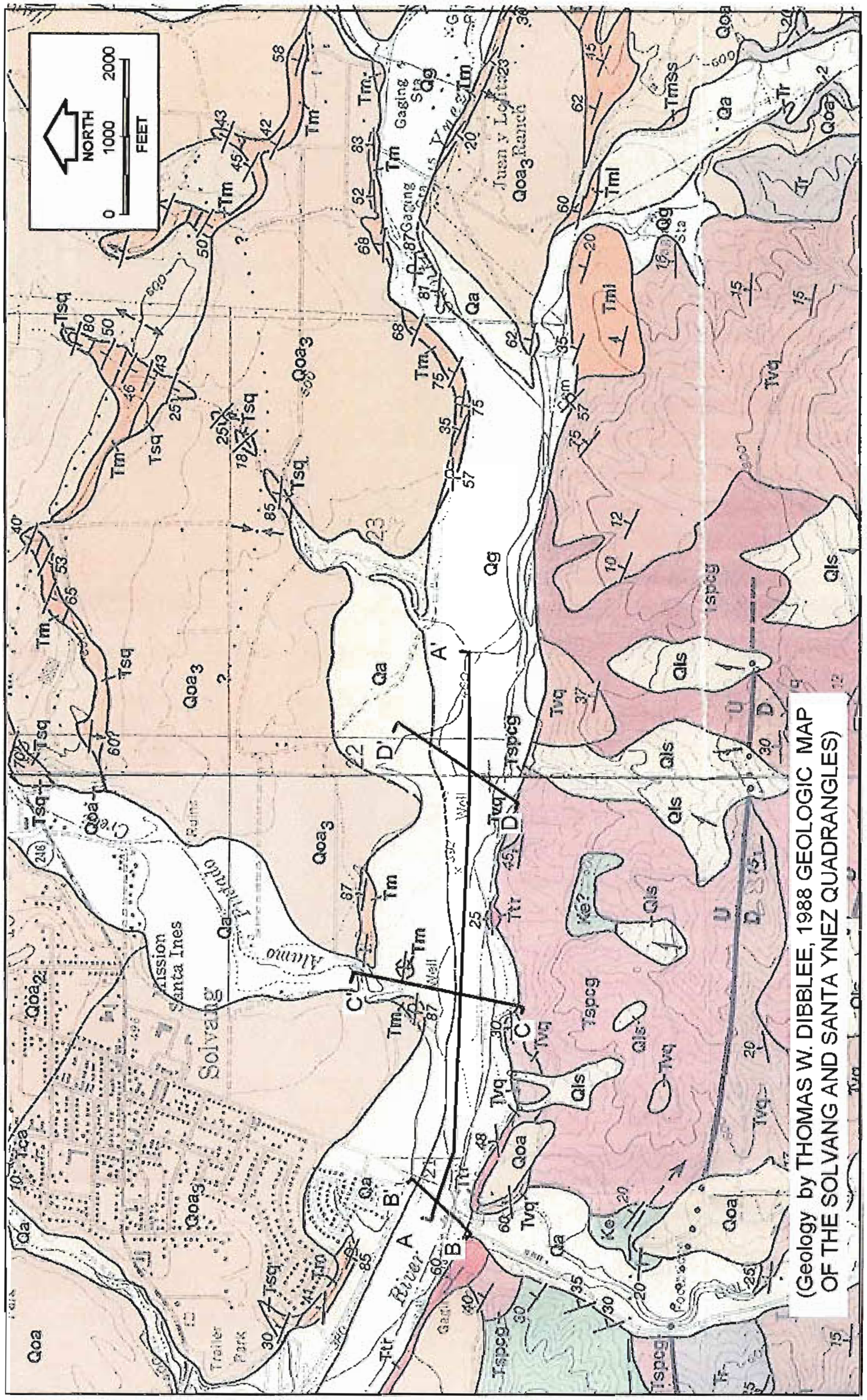


WELL LOCATION MAP, WESTERN PORTION
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California



WELL LOCATION MAP, EASTERN PORTION
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California

HOPKINS
GROUNDWATER
CONSULTANTS



GEOLOGY AND CROSS-SECTION LOCATION MAP
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California

Period	Epoch	Symbol	Description
QUATERNARY	HOLOCENE	Qa, Qg, Qls	**SURFICIAL SEDIMENTS** - **Qls** - landslide debris **Qa** - valley and floodplain deposits of silt, sand and gravel **Qg** - stream channel deposits of gravel, sand and silt
QUATERNARY	PLEISTOCENE	Qoa (Qoa3, Qoa2, Qoa1)	**OLDER DISSECTED SURFICIAL SEDIMENTS** - remnants of weakly consolidated stream terrace and alluvial fan depoists of silt, sand and gravel Qoa3 - lowest, youngest, **Qoa2** - intermediate, **Qoa1** - highest, oldest
TERTIARY	MIOCENE	Tsq	**SISQUOC SHALE** - soft white impure diatomite and diatomaceous shale
TERTIARY	MIOCENE	Tm	**MONTEREY SHALE** - upper shale unit, siliceous shale, thinly bedded, hard, brittle
TERTIARY	MIOCENE	Tml	**MONTEREY SHALE** - lower shale unit, semi-siliceous shale, thin calcareous strata, soft, punky
TERTIARY	MIOCENE	Tr	**RINCON SHALE** - clay shale or claystone, gray, poorly bedded
TERTIARY	OLIGOCENE	Tvq	**VAQUEROS SANDSTONE** - greenish-tan sandstone and interbedded greenish siltstone, with calcareous lenses
TERTIARY	OLIGOCENE	Tspcg	**SESPE FORMATION** - conglomerate, greenish-gray to reddish
CRETACEOUS		Ke	**ESPADA FORMATION** - micaceous shale, dark gray, hard, with hard olive-gray arkosic sandstone

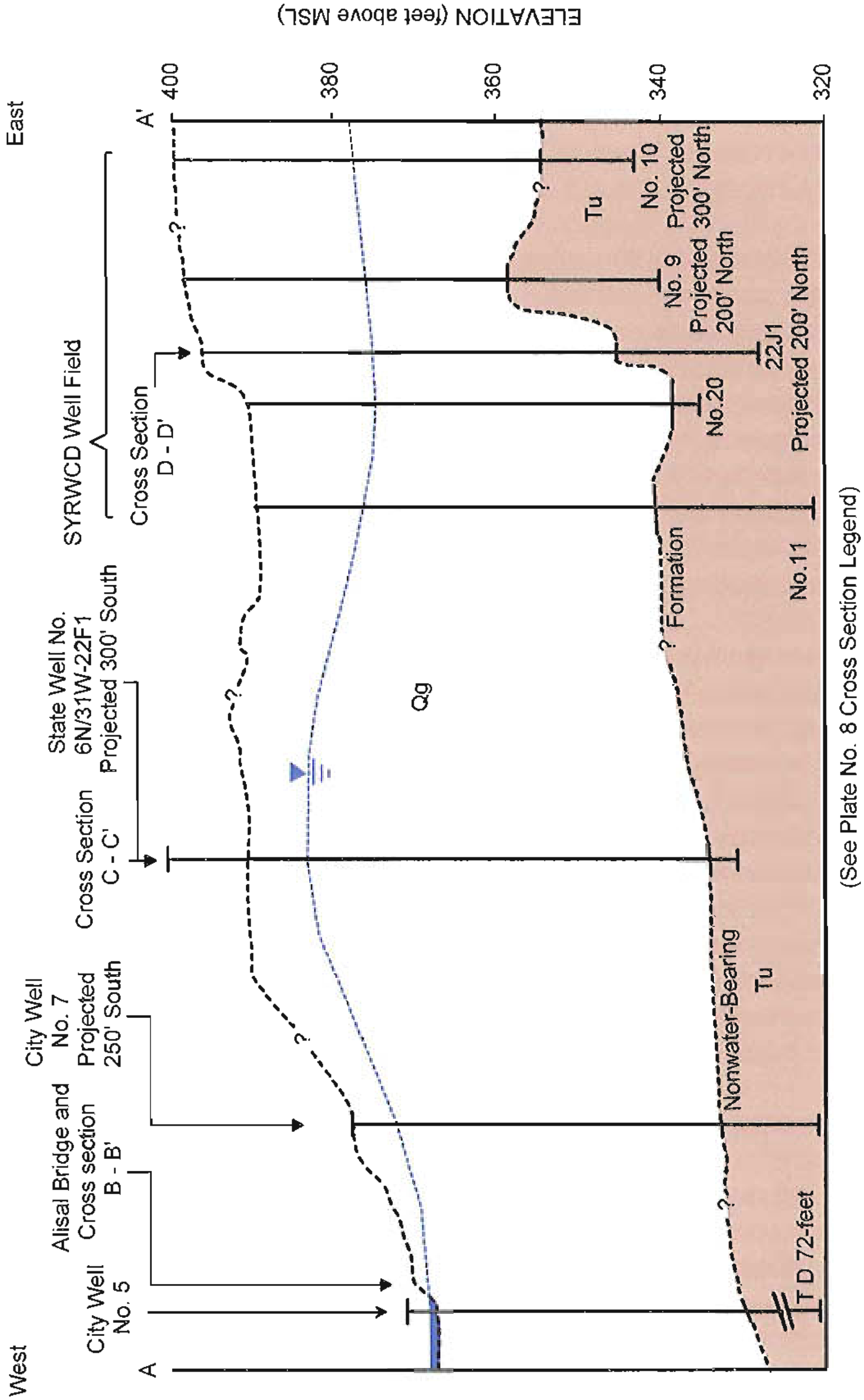
(Geology by THOMAS W. DIBBLEE, 1988 GEOLOGIC MAP OF THE SOLVANG AND SANTA YNEZ QUADRANGLES)

SYMBOLS

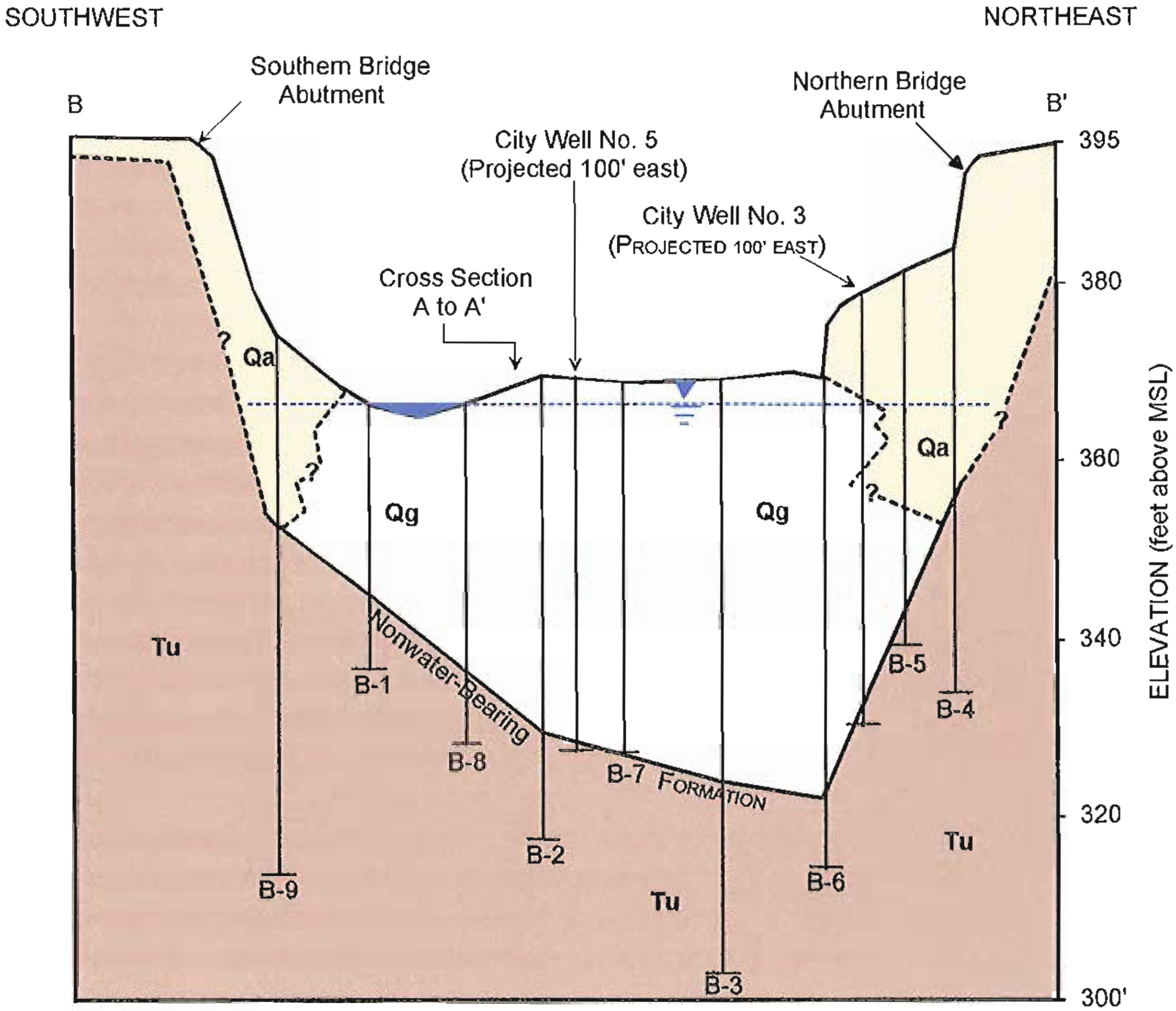
- Formation contact - dashed where inferred or indefinite
- Anticline - arrow on axis indicates direction of plunge
- Syncline - arrow on axis indicates direction of plunge
- Fault - dashed where indefinite or inferred, dotted where concealed

Strike and dip of stratified rocks:
- 45 — inclined (approximate)
- 25 — overturned
- 49 — vertical
- C C' — Cross section location

GEOLOGY MAP LEGEND
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California

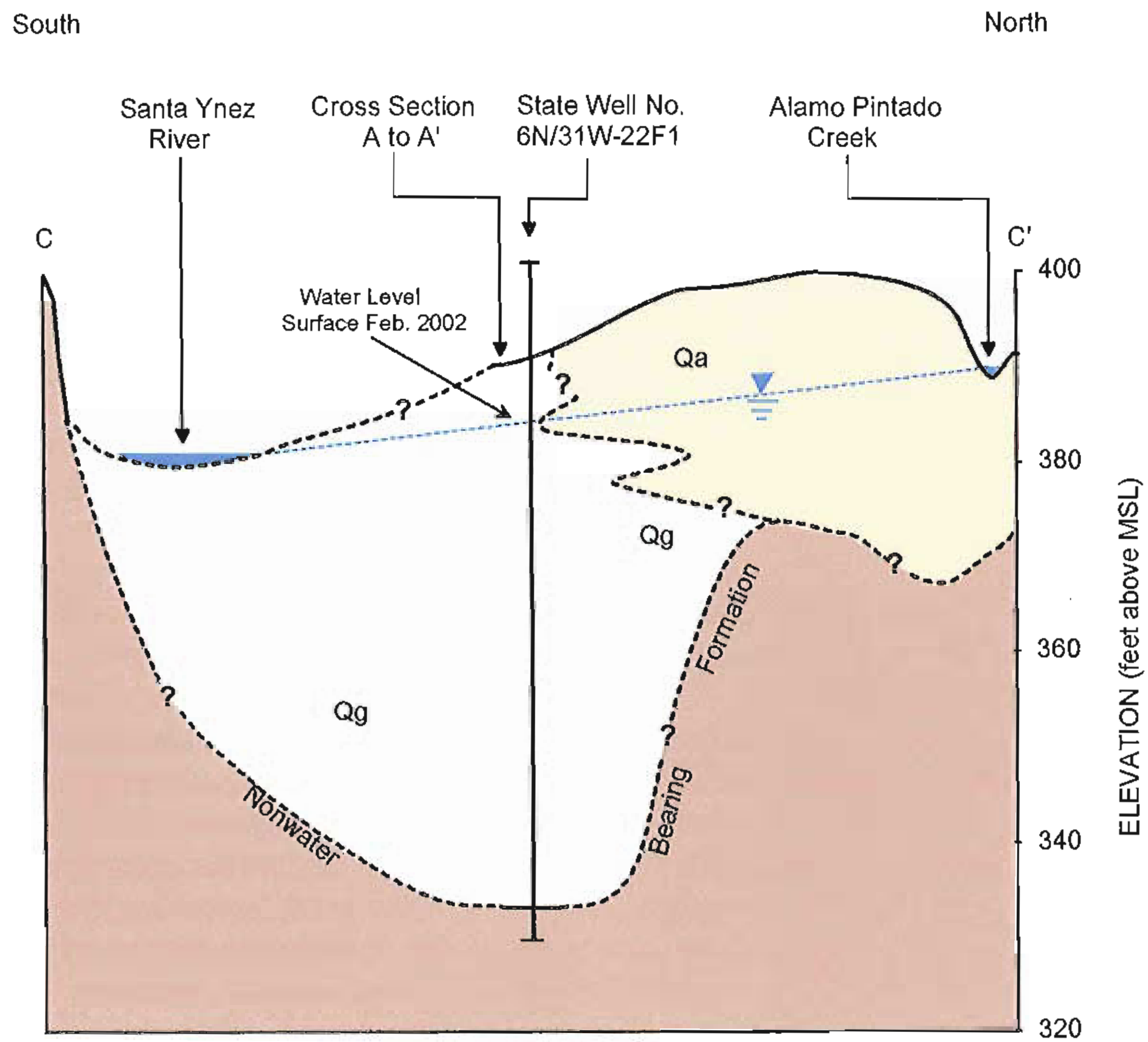


CROSS-SECTION A – A'
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California



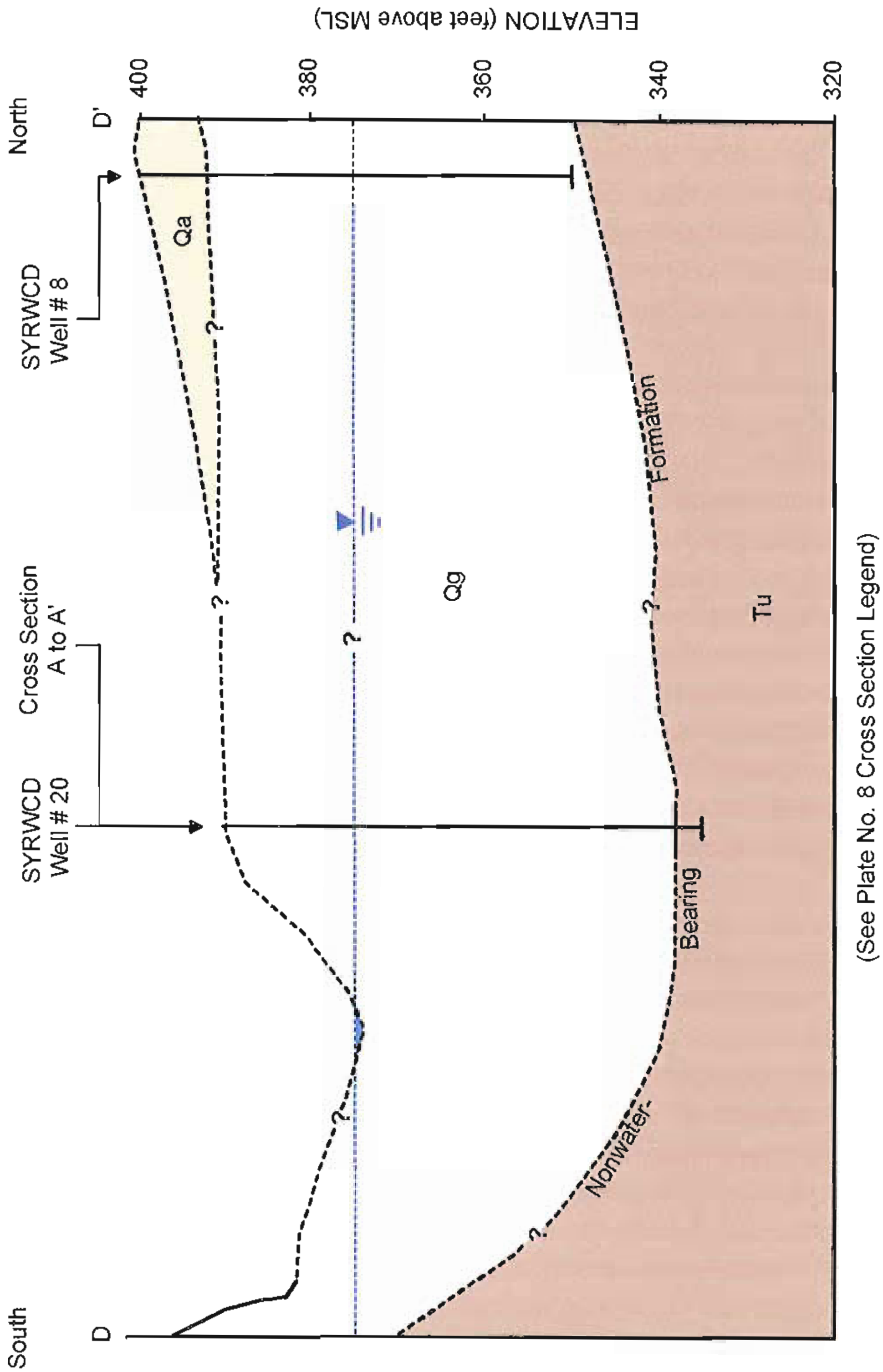
(See Plate No. 8 Cross Section Legend)

HYDROGEOLOGICAL CROSS-SECTION B - B'
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California



(See Plate No. 8 Cross Section Legend)

HYDROGEOLOGICAL CROSS-SECTION C - C'
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California

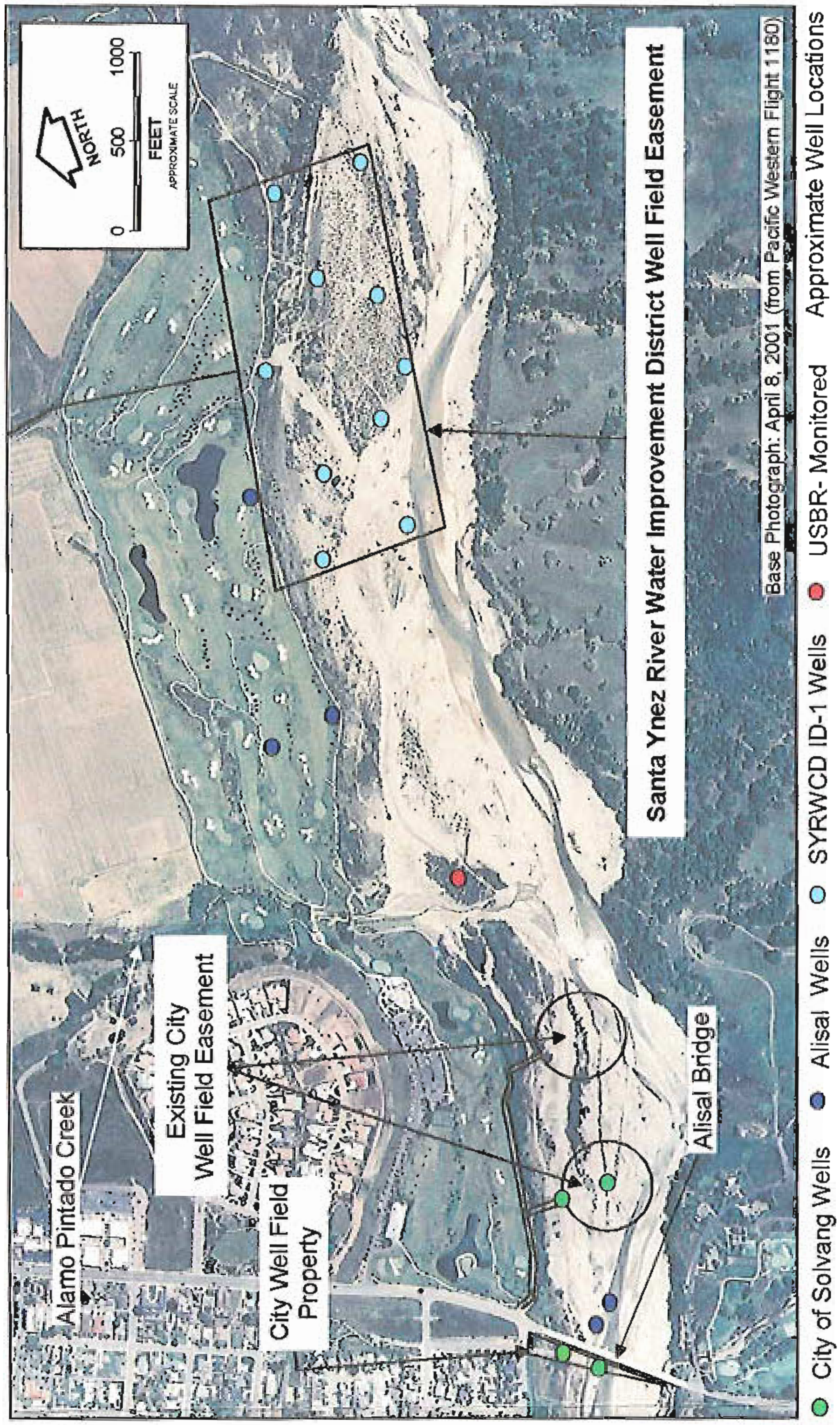


CROSS-SECTION D – D'
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California

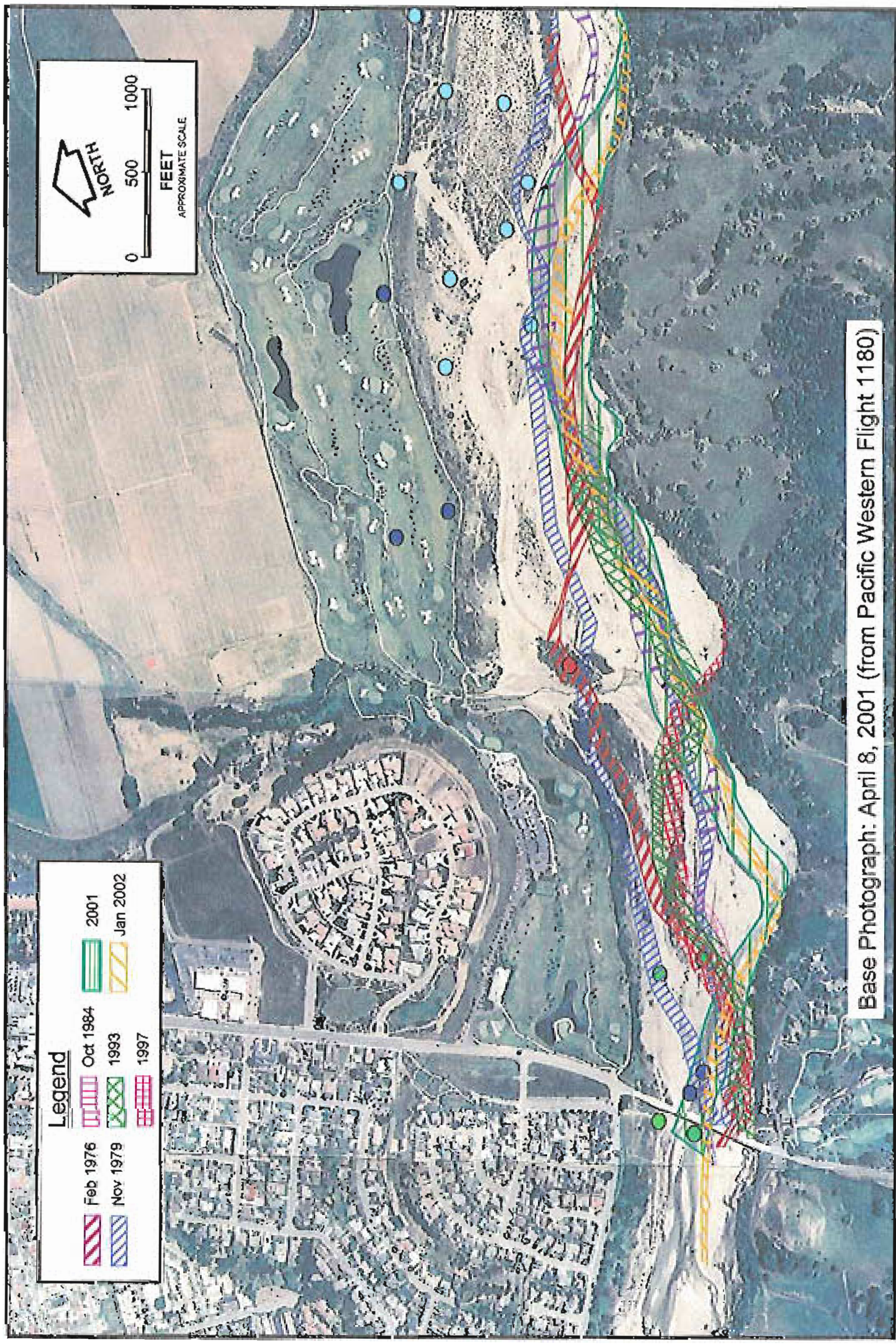
Qa	Valley Flood Plain Deposits of silt, sand and gravel
Qg	Stream Channel Deposits of gravel, sand and silt
Tu	Undifferentiated Tertiary Formations, nonwater-bearing Includes - Sisquoc, Monterey and Rincon Shales, Vaqueros Sandstone and Sespe Formation
B-9 ⊥	Name and Location of Geotechnical Borings for Alisal Bridge Design (Moore & Tabor, 1970)
City Well No. 3 ⊥	Name and Location of Water Supply Well
———	Formation contact - solid where observed
--------	Formation contact - dashed where inferred or indefinite
---? ---	Formation contact - queried where unknown

SCALE
Horizontal 1" = 200'
Vertical 1" =20'

HYDROGEOLOGICAL CROSS-SECTION LEGEND
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California



RIVER WELL EASEMENTS
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California



City of Solvang Wells · Alisal Wells · SYRWCD ID-1 Wells · USBR- Monitored

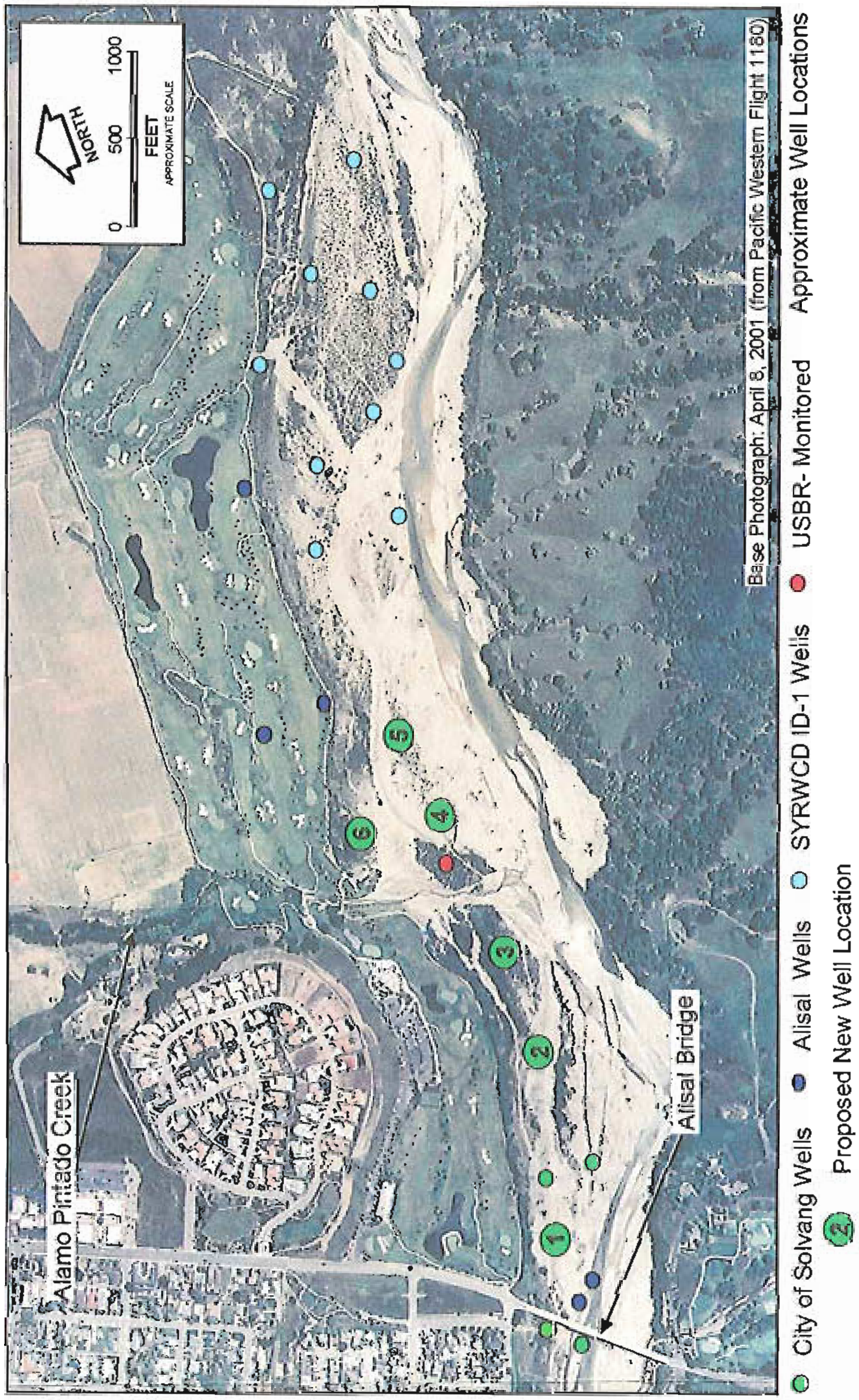
SANTA YNEZ RIVER HISTORICAL ACTIVE CHANNEL LOCATIONS

Preliminary Hydrogeolgical Study

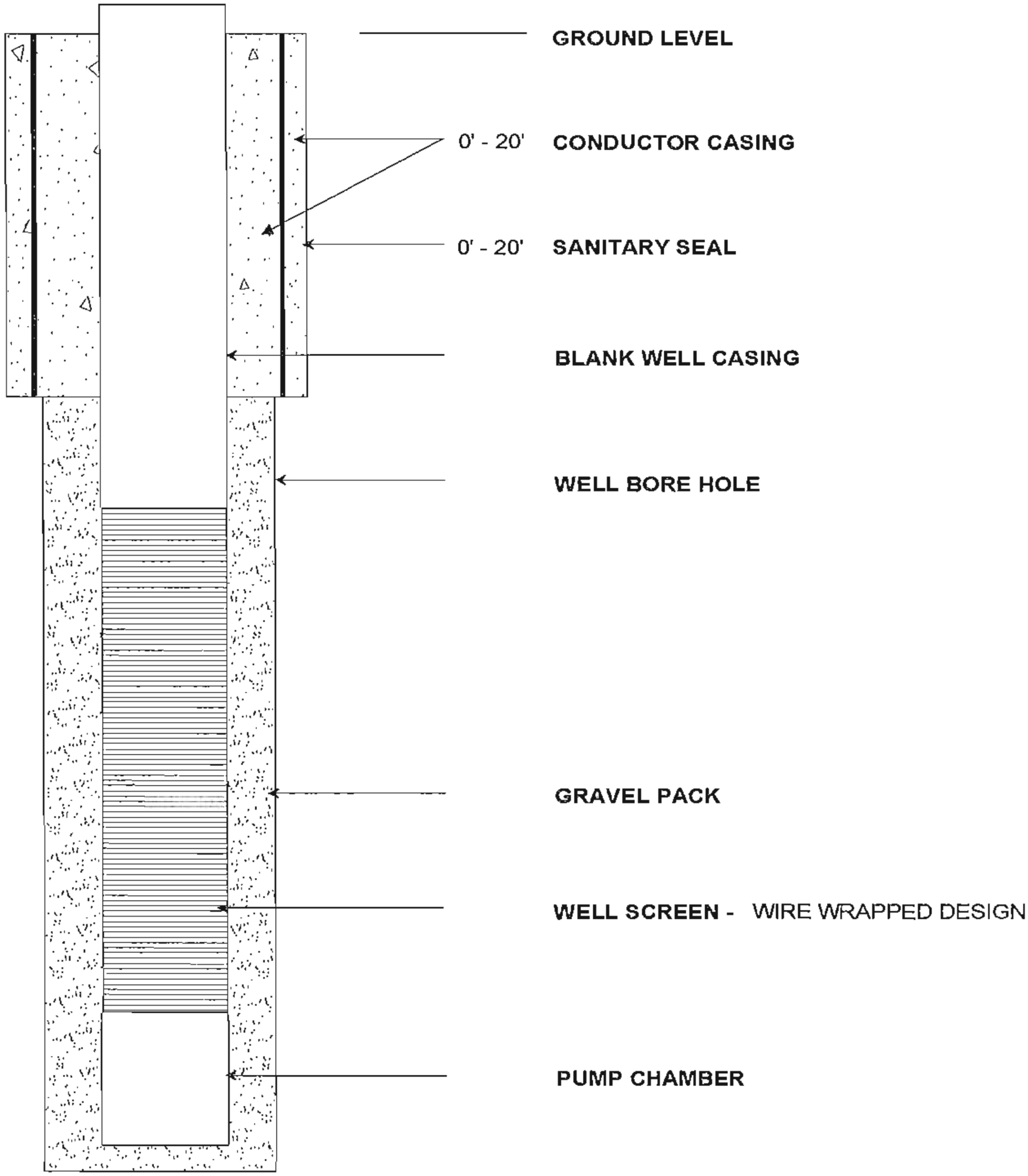
Santa Ynez River Well Construction Project

City of Solvang

Solvang, California



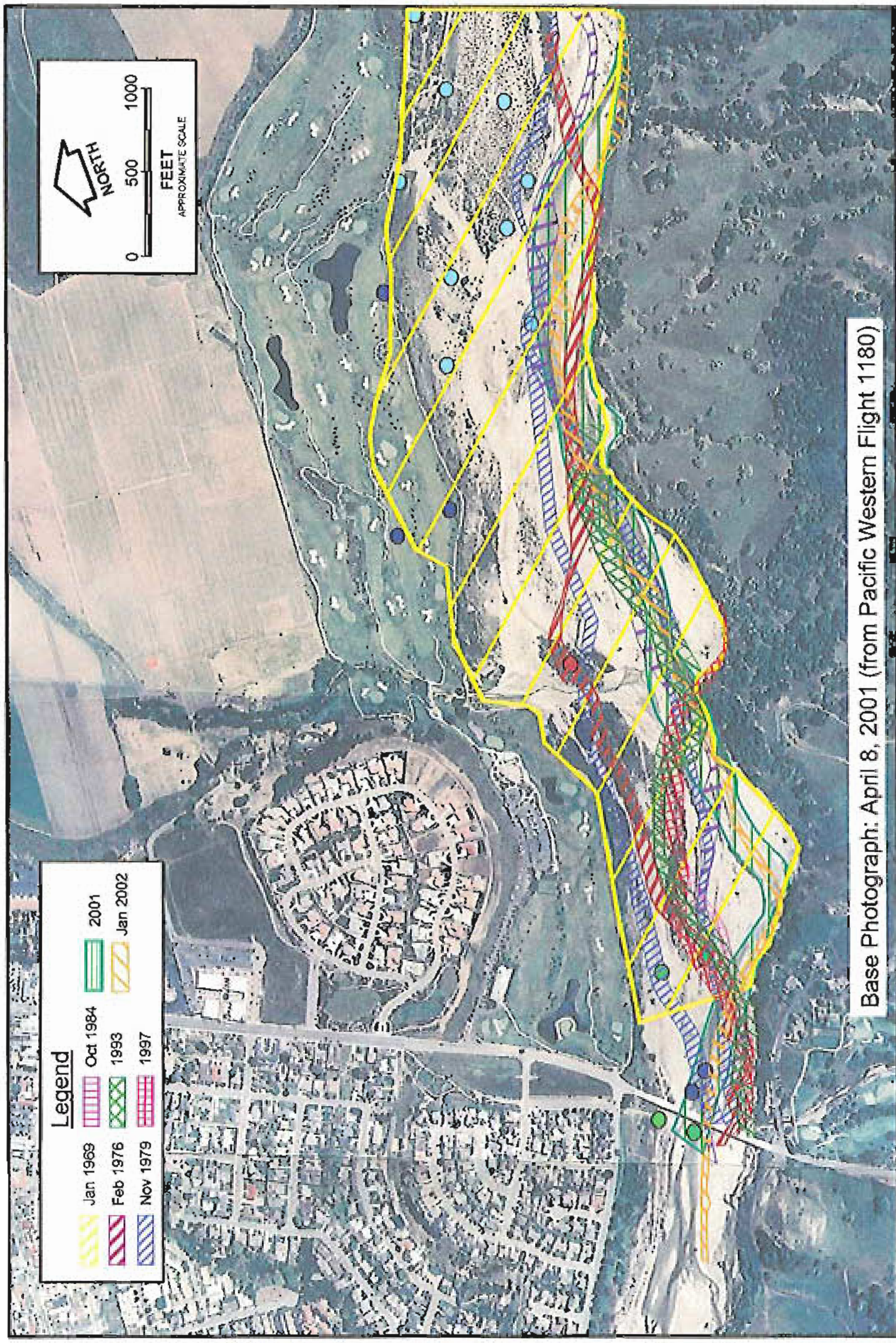
PROPOSED WELL SITE LOCATION MAP
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California



PRELIMINARY WELL DESIGN
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California

APPENDIX A
STATE DHS WELL PERMIT INFORMATION

APPENDIX B
PHOTOGRAPHIC SURVEY REVIEW OF RIVER CHANNEL MIGRATION



City of Solvang Wells · Alisal Wells · SYRWCD ID-1 Wells · USBR- Monitored

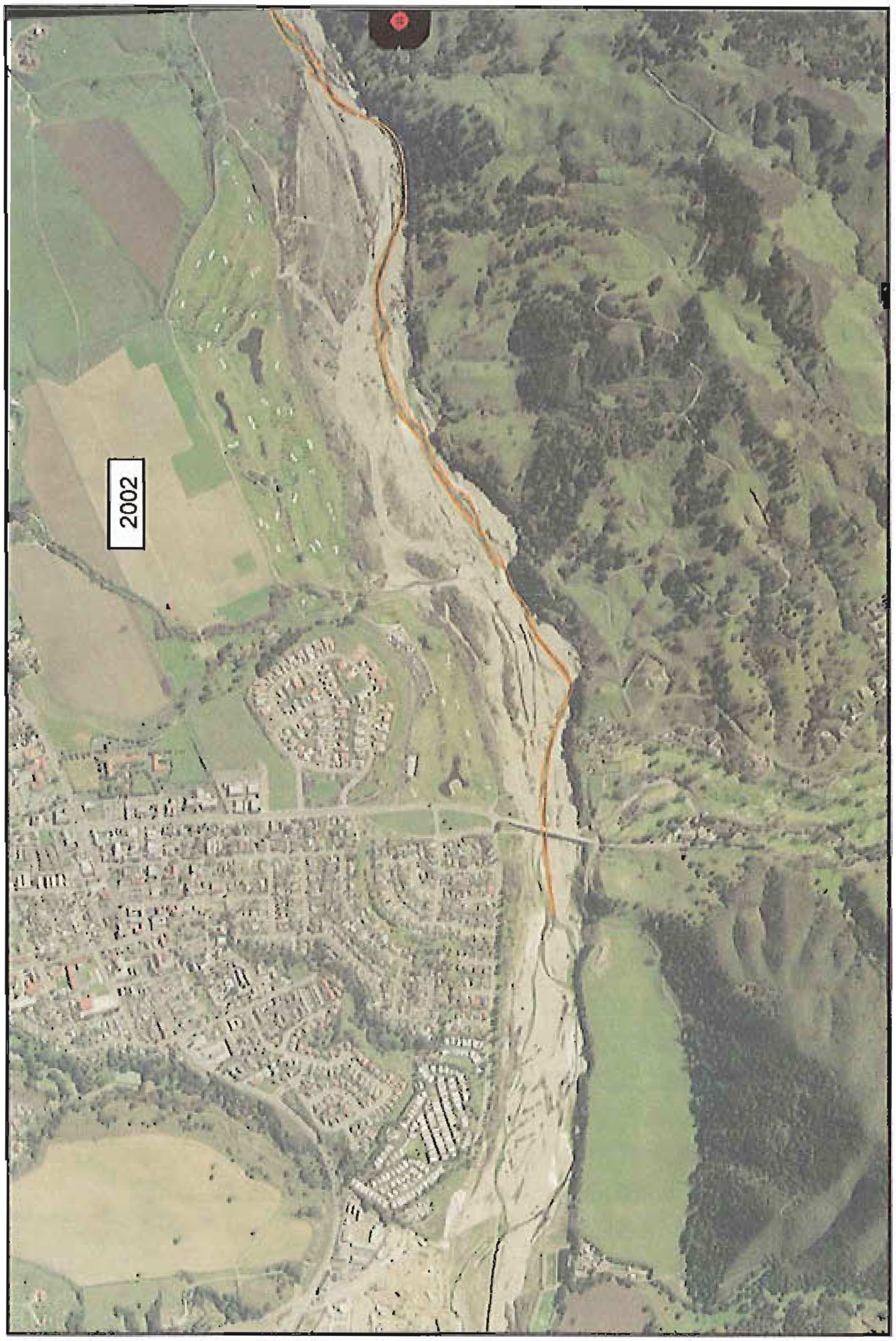
COMPILATION OF MAIN RIVER CHANNEL LOCATIONS

Preliminary Hydrogeolgical Study

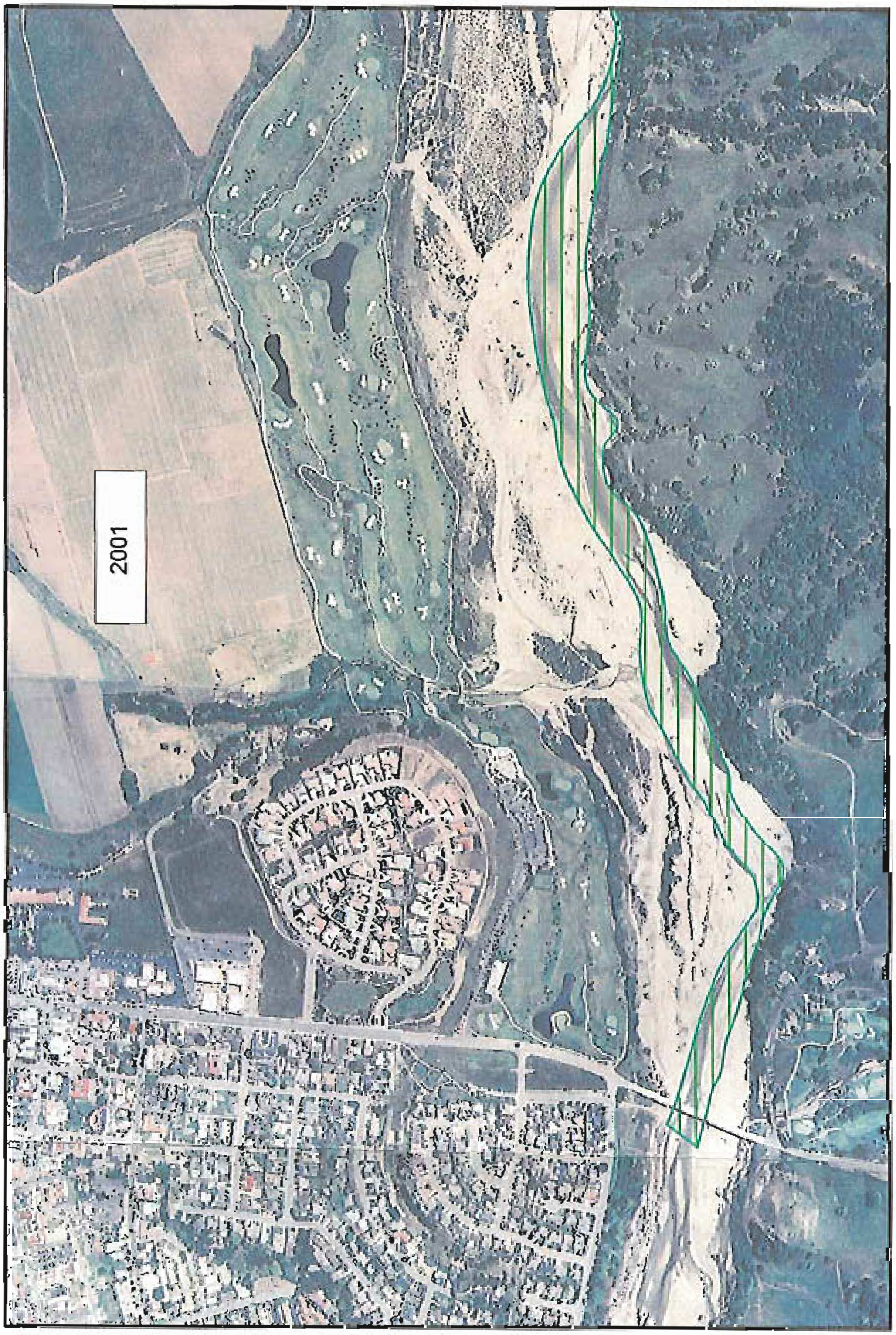
Santa Ynez River Well Construction Project

City of Solvang

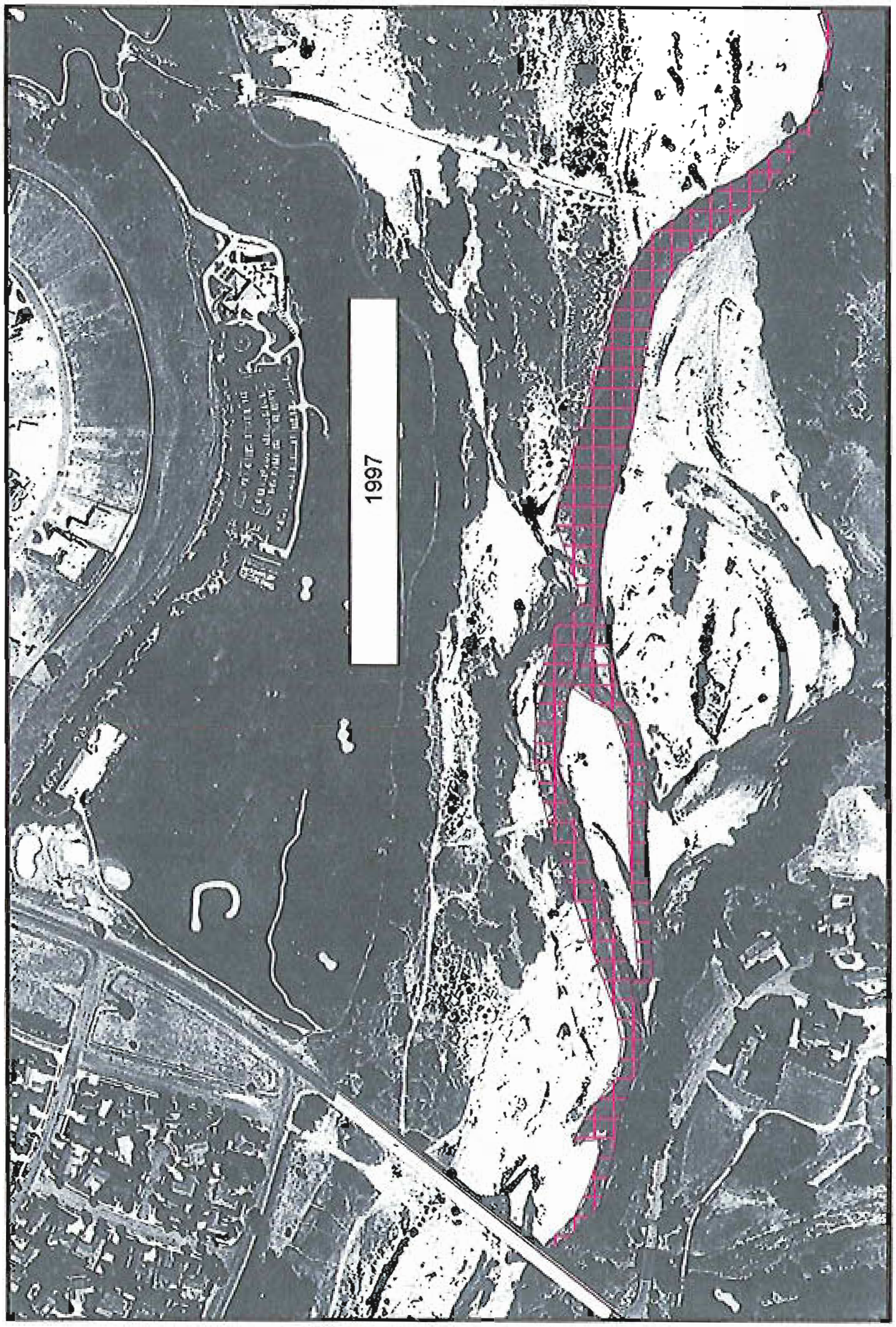
Solvang, California



RIVER CHANNEL LOCATION JANUARY 2002
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California

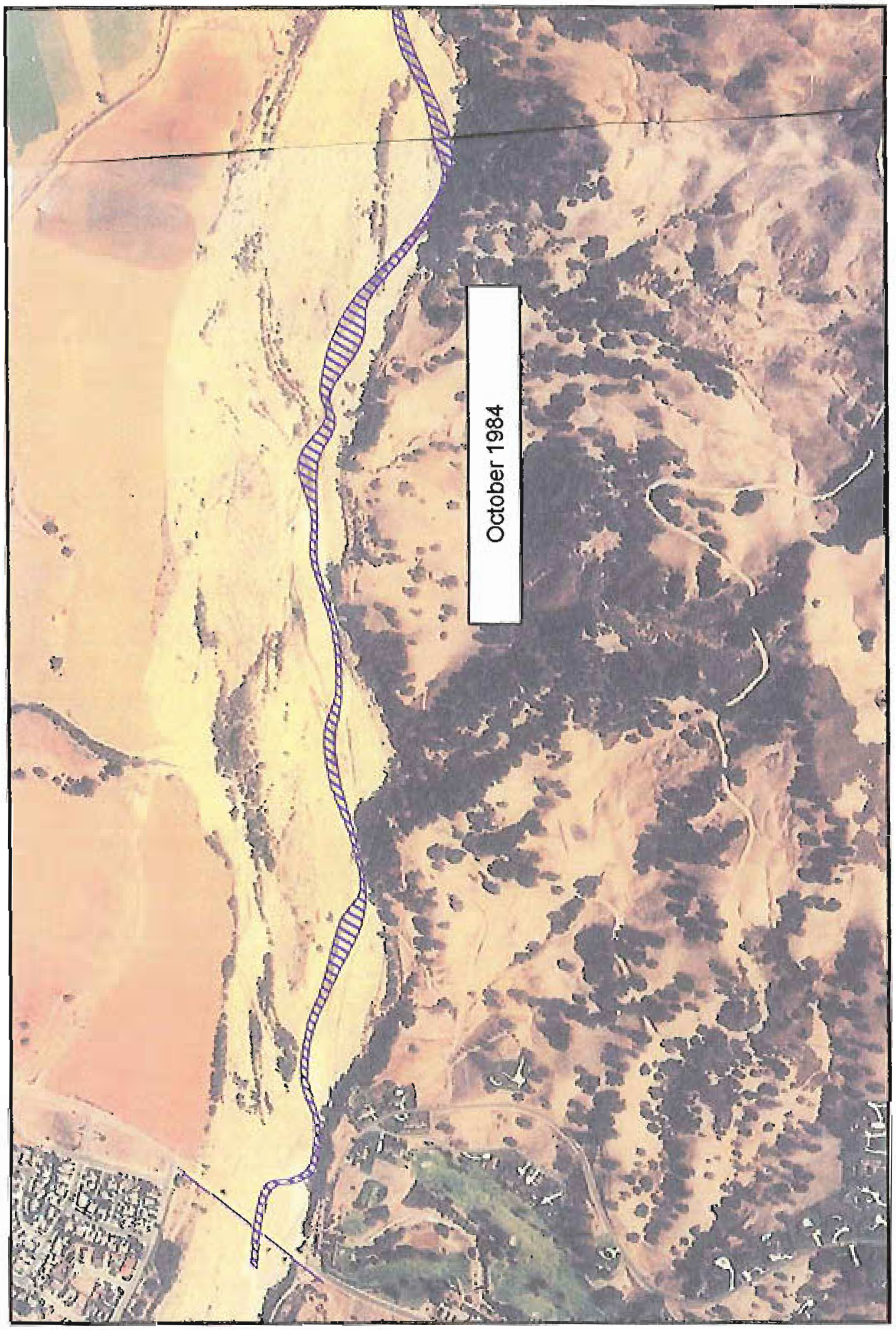


RIVER CHANNEL LOCATION APRIL 2001
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California

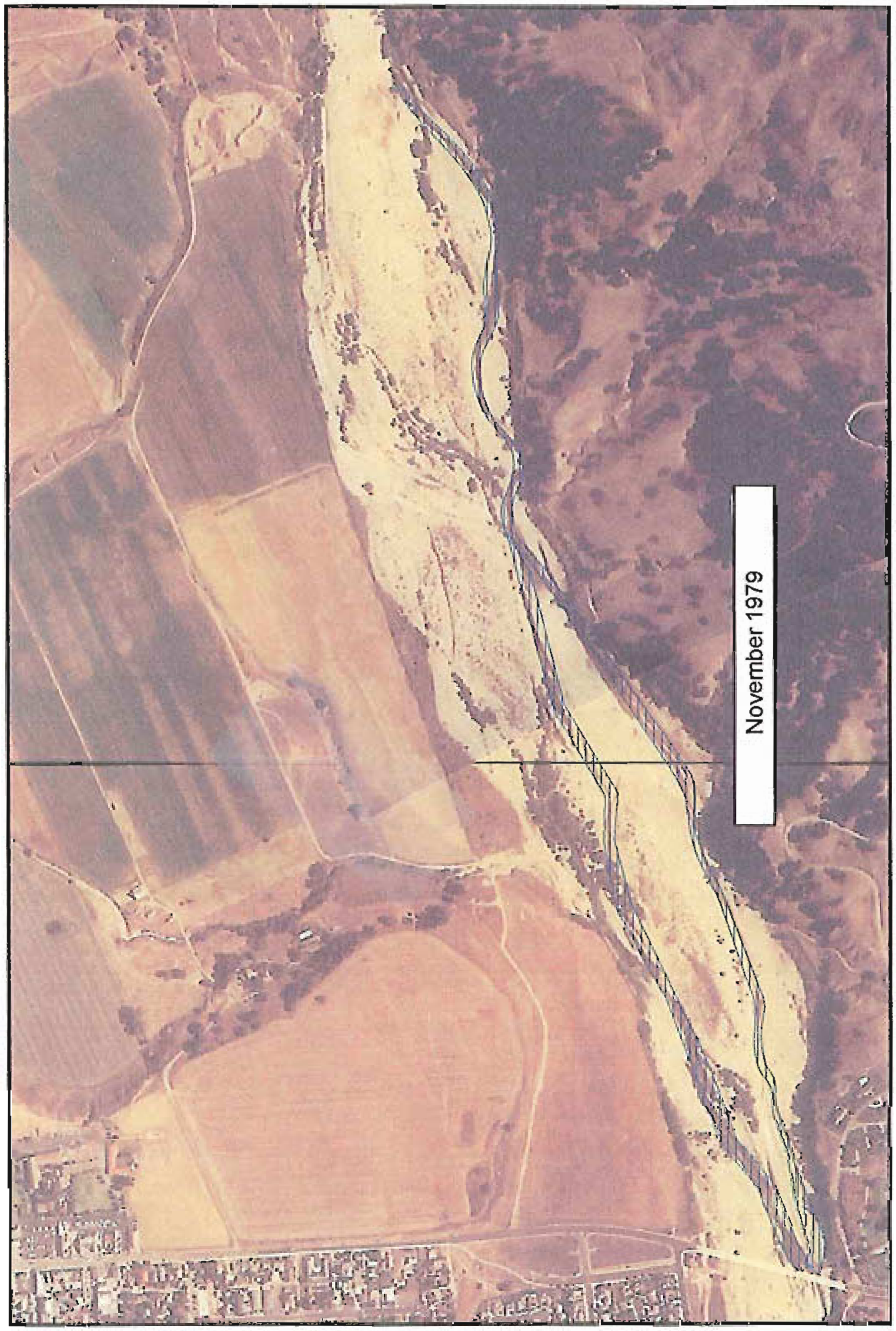


RIVER CHANNEL LOCATION AUGUST 1997
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California

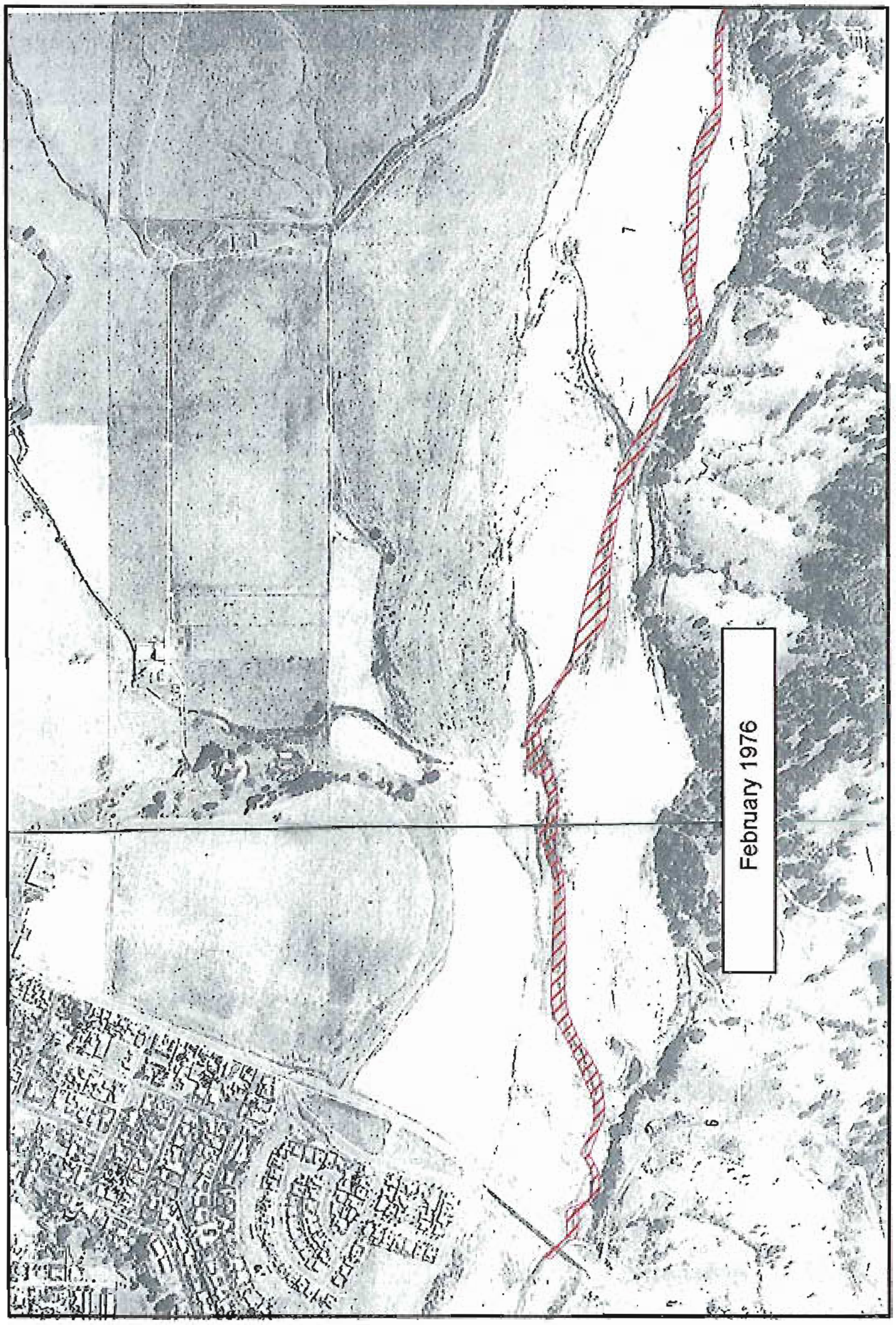
RIVER CHANNEL LOCATION OCTOBER 1993
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California



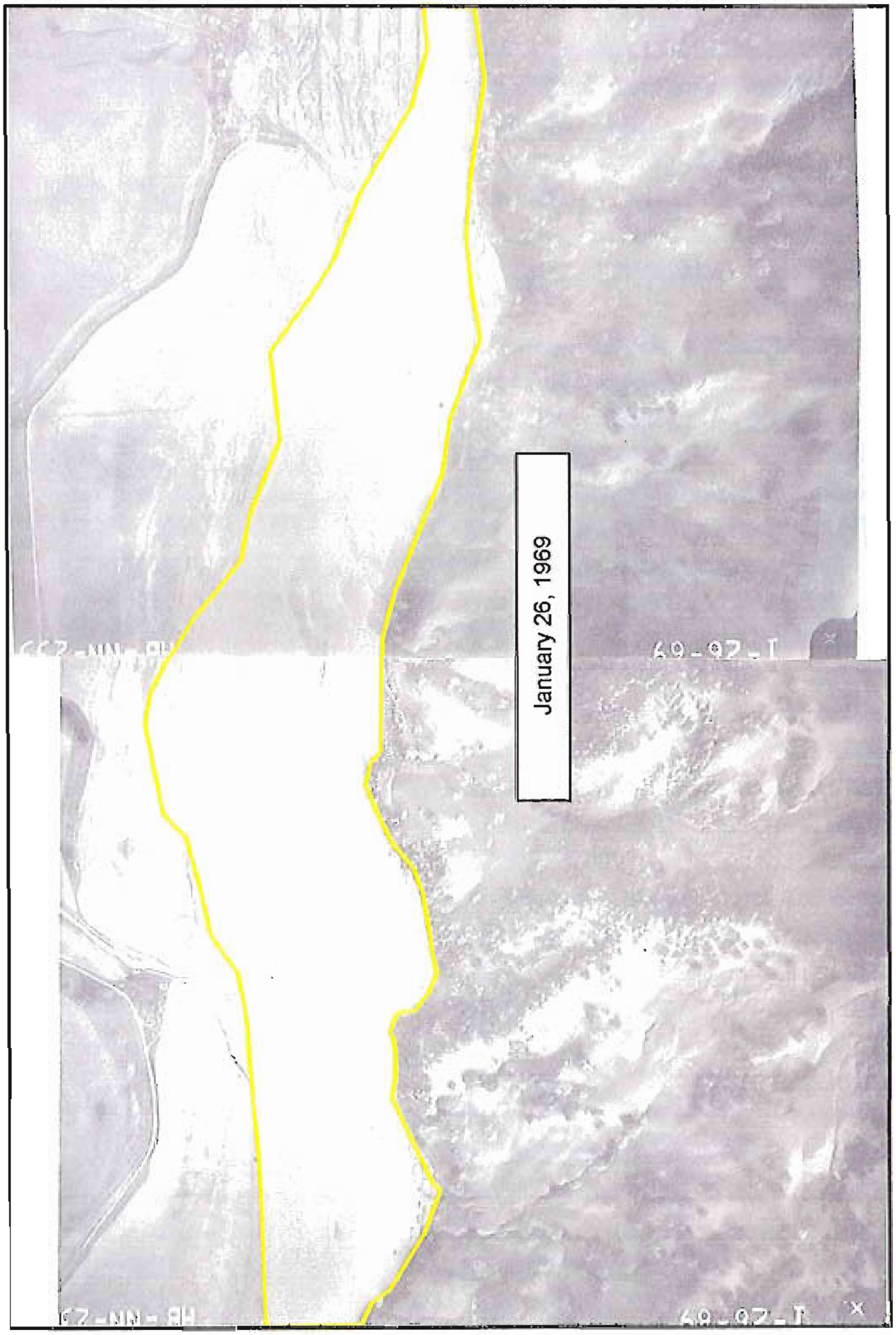
RIVER CHANNEL LOCATION OCTOBER 1984
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California



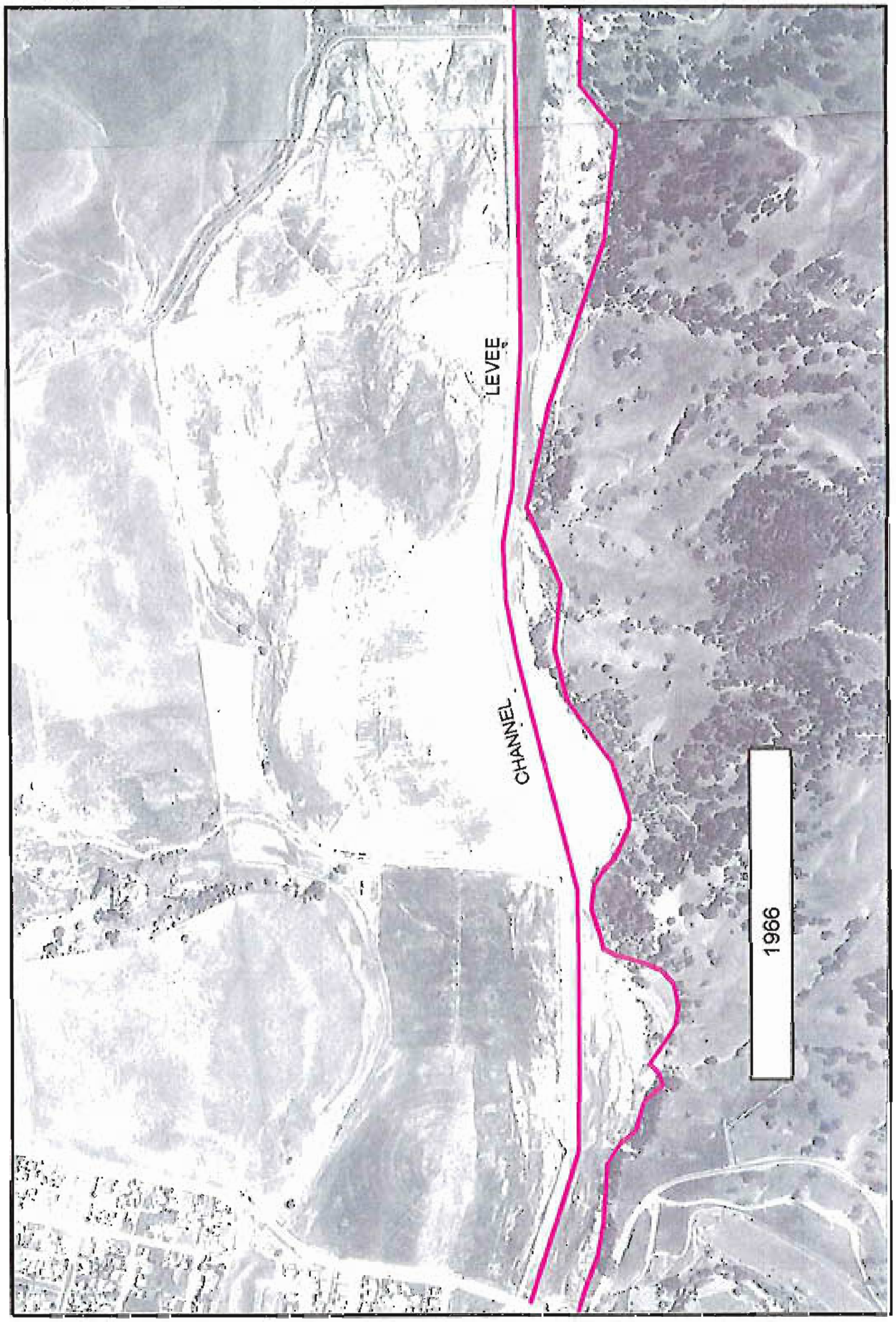
RIVER CHANNEL LOCATION NOVEMBER 1979
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California



RIVER CHANNEL LOCATION FEBRUARY 1976
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California



RIVER CHANNEL LOCATION JANUARY 1969
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California

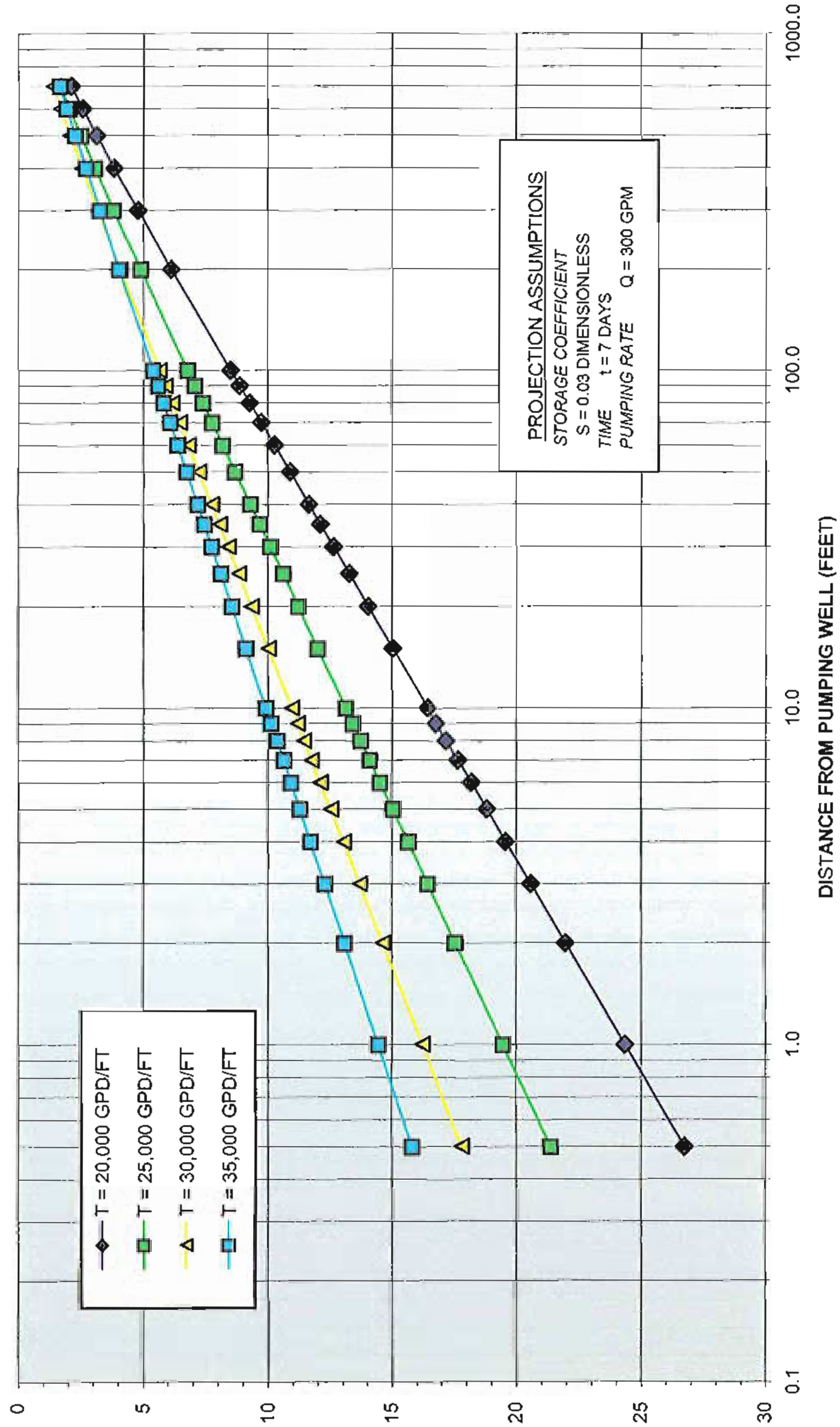


RIVER CHANNEL LOCATION APRIL 1966
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California

APPENDIX C
WELL DATA AND AQUIFER PARAMETER ESTIMATES

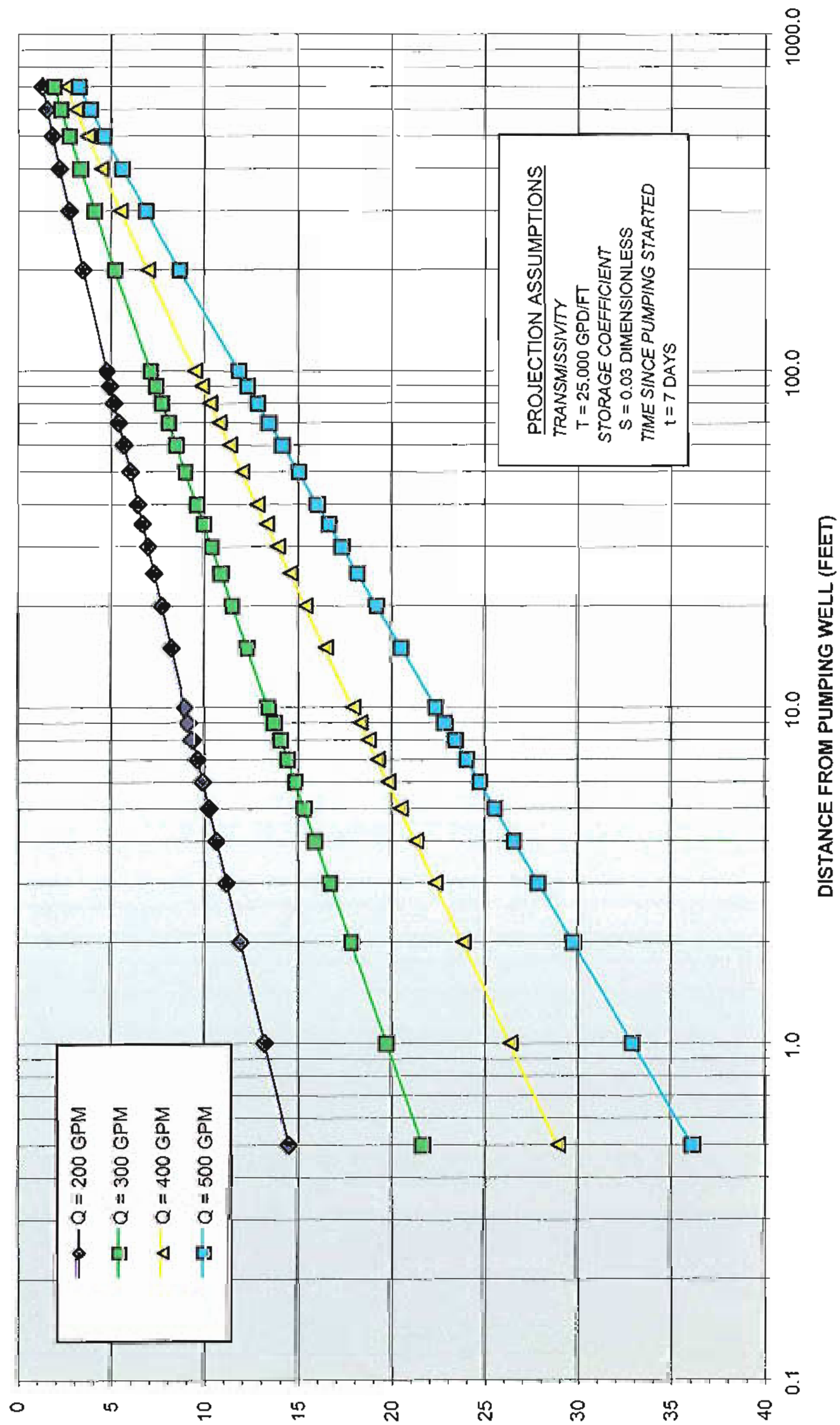
WELL NAME	DISCHARGE RATE (GPM)	DURATION OF TEST (MINUTES)	DEPTH TO STATIC WATER LEVEL (FEET)	DEPTH TO PUMPING WATER LEVEL (FEET)	DRAWDOWN (FEET)	SPECIFIC CAPACITY (GPM/FT)	ESTIMATED TRANSMISSIVITY (GPD/FT)	TOTAL DEPTH OF ALLUVIUM (FEET)	SATURATED THICKNESS (FEET)	ESTIMATED HYDRAULIC CONDUCTIVITY (FT/SEC)	ESTIMATED HYDRAULIC CONDUCTIVITY (FT/DAY)
City 3 (5A)	200	60	12.7	17.3	4.6	43.5	65,217	43	26	0.004	339
City 3 (5A)	400	60	12.7	24.2	11.5	34.8	52,174	43	19	0.004	371
City 3 (5A)	477	60	12.7	34.5	21.8	21.9	32,821	43	9	0.006	516
City 3 (5A)	423	60	12.7	33.5	20.8	20.3	30,505	43	10	0.005	429
City 3 (5A)	400	720	11.8	30	18.2	22.0	32,967	43	13	0.004	339
Orig. City #5 (in 1957)	1,250	unknown	1	36	35	35.7	53,571	40	4	0.021	1,791
Orig. City #5 (in 1957)	1,000	unknown	1	34	33	30.3	45,455	40	6	0.012	1,013
Orig. City #5 (in 1957)	750	unknown	1	25	24	31.3	46,875	40	15	0.005	418
Orig. City #5 (in 1957)	500	unknown	1	17	16	31.3	46,875	40	23	0.003	272
Orig. City #5 (in 1974)	677	unknown	0.5	13	12.5	54.2	81,240	40	27	0.005	402
Orig. City #7 (in 1985)	405	480	14.1	36.6	22.5	18.0	27,000	47.5	11	0.004	331
City 7A (7R)	500	unknown	7.7	40	32.3	15.5	23,220	55	15	0.002	207
City 7A (7R)	400	unknown	7.7	36.5	28.8	13.9	20,833	55	19	0.002	151
City 7A (7R)	300	unknown	7.7	30	22.3	13.5	20,179	55	25	0.001	108
Alisal Ranch Course #2	600	30	11.9	16.79	4.89	122.7	184,049	41.5	25	0.012	996
Alisal River Course #2	230	60	21.25	23.7	2.45	93.9	140,816	54	30	0.007	621
Alisal River Course #2	410	60	21.25	29.2	7.95	51.6	77,358	54	25	0.005	417
Alisal River Course #2	575	60	21.25	34.8	13.55	42.4	63,653	54	19	0.005	443
Alisal River Course #3	175	60	23.87	31.5	7.63	22.9	34,404	56	25	0.002	188
Alisal River Course #3	310	60	23.87	37.37	13.5	23.0	34,444	56	19	0.003	247
Alisal River Course #3	375	60	23.87	45.95	22.08	17.0	25,476	56	10	0.004	339

APPENDIX D
THEORETICAL DISTANCE DRAWDOWN PROJECTIONS

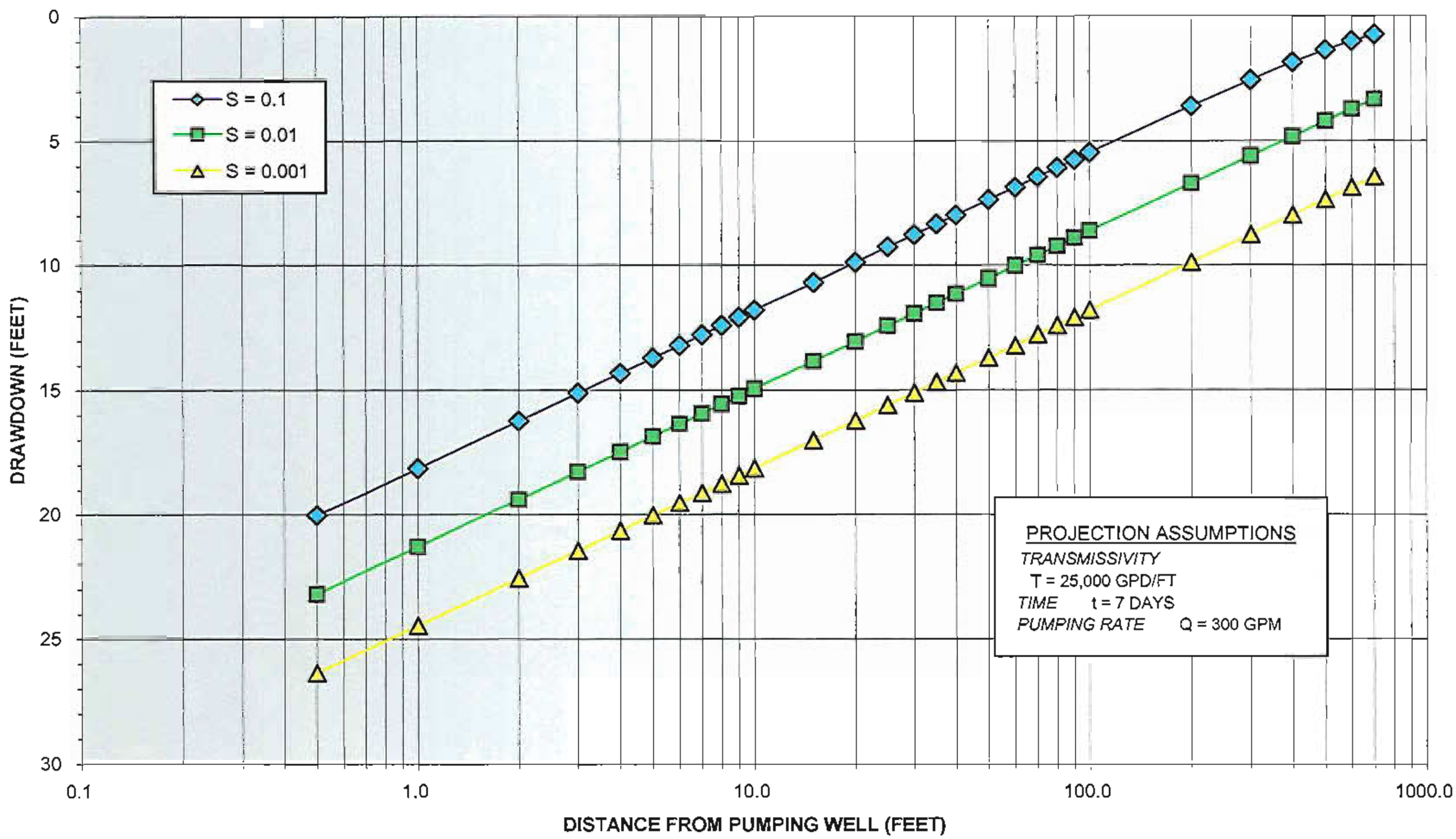


THEORETICAL DISTANCE DRAWDOWN PROJECTION
VARIABLE TRANSMISSIVITY VALUES
Preliminary Hydrogeological Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California

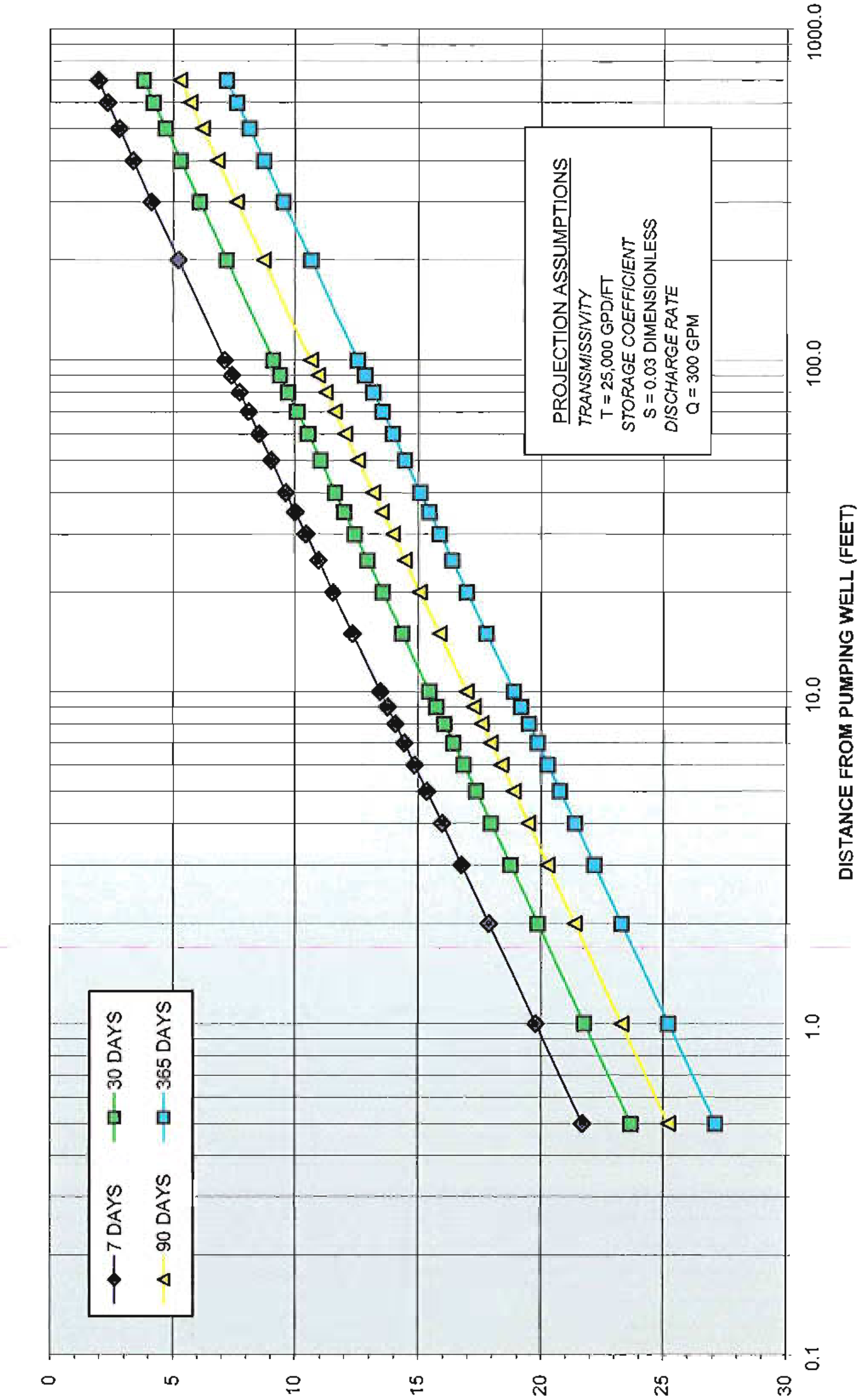
HOPKINS
GROUNDWATER
CONSULTANTS



THEORETICAL DISTANCE DRAWDOWN PROJECTION
VARIABLE DISCHARGE RATE
Preliminary Hydrogeological Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California



THEORETICAL DISTANCE DRAWDOWN PROJECTION
VARIABLE STORAGE COEFFICIENT VALUES
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California



THEORETICAL DISTANCE DRAWDOWN PROJECTION
VARIABLE PRODUCTION DURATION
Preliminary Hydrogeolgical Study
Santa Ynez River Well Construction Project
City of Solvang
Solvang, California