DECLARATION OF PAUL D. HORTON, P.G., C.HG. REGARDING EL SUR RANCH WATER RIGHT PERMIT APPLICATION No. 30166

Big Sur River
Monterey County, California

01-ESR-007

Prepared For:

Applicant
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Monterey County, California

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EXECUTIVE SUMMARY

For the past seven years I have been the Principal Investigator for the extensive field studies and subsequent data analysis of the interaction of the hydrologic and hydrogeologic systems of the Big Sur River as it flows into the Ocean within AMSP. I have spent hundreds of hours actively participating in the field studies and data analysis, as well as directed the work of other personnel at the Source Group, Inc. (SGI) and have coordinated SGI's work with that of Dr. Charles Hanson who was investigating the potential impact of the irrigation pumping on the River's fish habitat.

These studies have measured the direct effects of El Sur Ranch (ESR) well pumping on the Big Sur River during the most critical low-flow months of a critically dry year, a dry year and a wet year. These studies focused largely on the lower reach of the River, from the AMSP parking lot through the lagoon at the mouth of the River (the "Study Area"). These studies have documented that:

i. The maximum zone of influence of the El Sur Ranch irrigation wells extends a radius of 1,000 feet from the New Well.

ii. It takes approximately four days after the start of pumping to reach a stable equilibrium, and approximately the same amount of time for recovery following pump shutdown. Approximately 90-percent (%) of both drawdown and recovery occur within 24 hours of onset of pumping or shut-off of the pump.

iii. The pumping of the ESR wells does not and cannot create a condition of overdraft of the alluvial aquifer system or impact upstream users.

iv. On average (based on usage data from 1975 through 2004), less than 1.1% of the water (both surface and underflow) that flows through the lower Big Sur River watershed each year has been utilized by the ESR ranching operation.

v. Intrusion of saline water into the alluvium correlates primarily to "spring" tides, and does not affect surface water quality in the Big Sur River or Lagoon.

vi. A "colmation" layer in the bed of the Big Sur River significantly retards water exchange between the surface flow and aquifer.

vii. At the highest extraction rate achieved during the 2007 critically dry year test with both wells pumping (5.02 cubic feet per second [cfs]), the maximum reduction of surface flow across the area of measured influence (Zones 2-4), which occurs at the downstream edge of the this area (the upstream edge of the lagoon), was calculated to be 0.4 cfs.

viii. No impact of irrigation pumping on river stage was discernible within the regular moment-to-moment river stage fluctuations that occur naturally. A theoretical impact to river stage induced by pumping was calculated to be a cumulative maximum of 0.04 feet during the 2007 study (at the downstream edge of the area of impact). For comparison purposes, daily stage fluctuations due to evapotranspiration (ET) and solar impacts on the River exceed this amount, up to 0.1 (1.2 inches) feet during the 2007 study season. In summary, during the critically dry years (the most sensitive time with ability to potentially impact the riverine habitat), the maximum potential pumping impact to river stage is a reduction of, at most, 0.04 feet (0.5 inches), at the downstream limit of the ZOI, with no measureable impact at the upper limit of the zone of influence (ZOI).

ix. Water quality parameters in the river and lagoon for electrical conductivity (salinity) and dissolved oxygen showed no impact or correlation of any kind to pumping of the ESR wells in any of the three study seasons.

x. Irrigation pumping of up to 5.02 cfs in 2007 did not significantly affect water temperature in the Big Sur River Hanson Environmental's (Hanson, 2008) statistical analysis of temperature data found a pumping-correlated temperature increase of less than 0.3 degrees Celsius in two areas of the river at which groundwater inflow contributes to surface flow of the river. Hanson's statistical analysis is consistent with the Source Group's (SGI) finding that pumping reduces the amount of cold temperature groundwater influx into the river along the Creamery Meadow side of the river. The temperature change found by Hanson appears insignificant when compared with approximately 3 degrees Celsius (5.5° F) natural daily temperature fluctuation of the river, documented over three summer pumping seasons.

xi. Excepting the special holiday conditions of high water use at the State Parks, river flows within the Study Area during the late summer through early fall time period can be estimated based on the continuously collected U.S. Geological Survey (USGS) flow gauge data.

1.0 BACKGROUND

1.1 Site Locale and Use

El Sur Ranch (ESR) is located immediately west and north of Andrew Molera State Park (AMSP) on California's Central Coast, a 30-minute drive south of Carmel, California on State Highway 1 (Figure 1-1). Marine terrace bench lands form the verdant pasture lands for ESR's cow and calving operations (Figure 1-2). Irrigation water for ESR pastures has been provided from wells located adjacent to the Big Sur River (River) since 1950.

1.2 Investigator Background

A description of relevant experience is included in my updated Curriculum Vitae in Appendix A.

1.3 Ranch Operations

There are three groundwater pumping wells within AMSP adjacent to the Big Sur River and in close proximity to the Ocean, on land that was previously owned and managed by ESR (Figure 1-3). As a condition of the land gift that added land to AMSP, ESR retained the ownership, access, and right to develop and use the 'New Well' and 'Old Well' which currently support ESR operations. The third well is a low yield water supply well called 'Navy Well' which is operated by the California Department of Parks and Recreation (DPR) though I understand it is currently not in use. The Old Well is located closer to the Ocean than the New Well and occasionally must be shut down due to elevated salinity making its water poorly suited for irrigation during specific periods of the normal summer season.

The irrigated pasture lands located on the Marine Terrace bench lands provide a steady supply of quality forage for the cow and calving operations through the summer and fall months of every year (Figure 1-2). Calving operations occur in the fall season. Most of the operation of the two El Sur Ranch irrigation wells occurs from May through October, the dry months of the year (Figure 1-4). Based on analysis of a thirty year period of record (1975 through 2004), the months with the highest pumping rates are June through September.

The pumping rate for each well is dependent on the elevation of the field that is being irrigated (Figure 1-5). Pumping rates for each well are highest when irrigating the fields at the lowest elevation, as there is less hydraulic head to push against (i.e. it is harder to push water further uphill). The pump in the New Well cannot be controlled to vary pumping capacity; it therefore runs at maximum capacity when it is in operation. Its pumping rate is limited by its physical ability to extract water and deliver it within the existing piping system against the hydraulic head conditions required to pump it to the irrigated fields whereby the elevation and number of open valves in the pasture being irrigated determine the rate of pumping possible. The pump in the Old Well can be valved back based on flow requirements. Pump tests of the two irrigation wells were conducted by SGI in 2004, at the beginning of our studies. The report of the pump tests is included as Exhibit ESR-4 to these proceedings. SGI was also furnished copies of a number of pump tests that had been conducted periodically since 1950 (Exhibit ESR-16) and pumping records (Exhibit ESR-17).

Based on the pump tests we examined, the highest combined average monthly pumping rate on record, 5.70 cubic feet per second (cfs), occurred in June of 1986 (this was anomalous in the pumping record and may have been associated with the testing of the New Well irrigation well). The average combined pumping rate of these irrigation wells has been 2.8 cfs during the summer irrigation season, June through September (based on 1975 through 2004 pumping records).

1.4 Study Problem/Questions Posed

The main question asked of all of the studies conducted by ESR on the mouth of the Big Sur River is:

> *What are the effects of pumping the El Sur Ranch irrigation wells on the Big Sur River as it relates to habitat for the riverine ecosystem?*

In my studies of the hydrologic system, I addressed the elements of the main question by answering four focused questions that related more directly on the hydrologic system as follows:

1. *Does and/or could pumping of the ESR wells in the future cause a reduction of flow in the Big Sur River, and if so, how much, when and where?*
2. *Does and/or could future pumping of the ESR wells cause a measureable reduction of stage in the Big Sur River, and if so, how much, when and where?*
3. *Does and/or could pumping of the ESR wells affect water quality of the Big Sur River in a negative way for the riverine ecosystem?*
4. *Does and/or could pumping of the ESR wells exacerbate and/or induce migration of the naturally present saline wedge located beneath the fresh water at the mouth of the River to the extent that it could affect water quality in the river or lagoon?*

To investigate these questions, SGI conducted intensive field studies covering a range of flow conditions (Wet, Dry and Critically Dry). The results of these studies have been documented in the following detailed reports and memoranda that have been included in the State Water Resources Control Board's Division of Water Rights files offered as exhibits as part of this proceeding; the documents are incorporated as part of this testimony:

Hydrogeologic Investigation and Conceptual Site Model Within the Lower Reach of the Big Sur River, May 2005 ("2004 Study"). (Exhibit ESR-5.)

Addendum to Hydrogeologic Investigation and Conceptual Site Model Within the Lower Reach of the Big Sur River, March 2007 ("2006 Study"). (Exhibit ESR-6.)

2007 Addendum to Hydrogeologic Investigation and Conceptual Site Model Within the Lower Reach of the Big Sur River, April 2008 ("2007 Study") (Exhibit ESR-7).

Pumping Zone of Influence Clarified Relative to DEIR Claims Memorandum, May 21, 2010. ("Zone of Influence memo") (Exhibit ESR-8.)

Surface Water Drawdown at 5 cfs Pumping Rate Memorandum, May 21, 2010. ("Surface Drawdown memo") (Exhibit ESR-9.)

My testimony summarizes the results of the extensive studies conducted during the summer and early fall of 2004, 2006, and 2007. These studies focused largely on the lower reach of the River, from the AMSP parking lot through the lagoon at the mouth of the River (the "Study Area"). These studies have provided definitive, data-based and scientifically supported answers to the aforementioned questions.

2.0 GENERALIZED GEOLOGIC AND HYDROGEOLOGIC SETTING

The Big Sur River Valley is an ancestral stream-carved canyon composed of nearly impermeable bedrock that has been filled with sand, gravel, cobble and boulder deposits over which flows the Big Sur River (Figure 2-1). In the eastern part of its watershed, the Big Sur River rushes at a steep grade through the hard, resistant crystalline rocks of the Sur series to form the narrow, rock-bound valley called the Gorge. As water emerges from the lower end of the Gorge, approximately five miles above the river's mouth, its velocity is slowed and it has built up a series of boulders, gravel, and sand deposits along the river channel. These deposits are several hundred feet to 2,000 feet wide. Where the river meets the ocean, these deposits of sand, gravel, cobbles and boulders have filled the ancestral canyon of the Big Sur River to depths of greater than 90 feet, both onshore and for some distance offshore.

These alluvial deposits make up a permeable aquifer allowing for significant transmission of underflow (groundwater in alluvial deposits flowing beneath the river channel) that, along with the Big Sur River, drains the 58.4 square mile watershed (Figure 2-2). Due to the permeable nature of the sand, gravel and cobble deposits over which the River flows, underflow moving within the alluvial aquifer is hydraulically connected through the river bed to surface flow in the River[1]. Flow on the Big Sur River is unimpeded (i.e., there are no artificial dams on the River).

The Study Area that has been the focus of the SGI studies stretches from the upstream end of the AMSP parking lot to the river's mouth, a distance of approximately one mile (Figure 2-2). Within the Study Area, the River turns south-west and runs along the northern edge of the River valley as it approaches the El Sur Ranch pumping wells. In the reach between the AMSP parking lot and the ESR wells, the River is naturally in a 'losing' condition, so that surface water flow in the River is slowly being lost through the river bed to the alluvial aquifer below. As the River approaches the ESR wells it jogs to the south, crossing the normal direction of groundwater flow within the aquifer. It is along this stretch that the River transitions to a 'gaining' condition, with surface flow in the River being augmented by inflow from the alluvial aquifer. Finally, the River turns back to the west and enters a large ponded area called the Lagoon before its final discharge into the Ocean. The ESR irrigation wells are located near the Big Sur River channel and are completed within the alluvial deposits that fill the ancestral river canyon carved into the Franciscan Bedrock.

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[1] For brevity, water occurring in the subsurface may be referred to in this testimony as "groundwater" or "underflow" and the alluvium may be referred to as the "groundwater basin". Such references are not meant to imply that the water is percolating groundwater in the legal sense. Similarly, references to the "Big Sur River," "river flow," "stream flow," or "river" are meant to refer to its surface flow, but should not be interpreted as suggesting that the Big Sur River consists only of its surface expression, in any legal sense.

3.0 SUMMARY OF STUDIES CONDUCTED

3.1 Previous Investigators

A significant amount of information regarding the hydrogeology of the lower portion of the Big Sur River basin and the area around the ESR irrigation wells had already been collected though several detailed investigations prior to SGI's work. Dames & Moore conducted an engineering and geologic investigation at the mouth of the Big Sur River in 1964 (Dames and Moore, 1964). That investigation consisted of driving test piles onshore, excavating test pits, numerous jet probings offshore, geologic mapping and a seismic refraction survey. The nature of the alluvial aquifer materials at the mouth of the River revealed by that investigation indicated a very coarse primary matrix of boulder and cobble deposits.

In the late '90s Jones and Stokes investigated the hydrologic connection between the surface flow of the river and the underlying alluvial material in the vicinity of the El Sur Ranch pumps. (Jones & Stokes 1997 and 1999). Jones and Stokes presented a hydrogeologic conceptual model for the Study Area based on work that included:

- Installation of three additional wells during 1997 and 1998 (JSA-03, JSA-04 and JSA-05) (Jones & Stokes, 1999);
- Two aquifer tests: one using New Well and the other using both New Well and Old Well (Jones & Stokes, 1999);
- Two geophysical surveys: one in July 1997 (Geoconsultants, 1997), and one in October 1998 (Geoconsultants, 1998);
- A reconnaissance-level geomorphology evaluation in October 1998 (Mussetter Engineering, 1998); and
- Continuous water level monitoring for two ESR wells conducted between August 1997 and June 1998, and one monitoring well from July through September 1998 (Jones & Stokes, 1999).

Jones and Stokes concluded that:

- The groundwater system is highly transmissive and hydraulically connected to the river;
- The irrigation pumping draws water both from aquifer storage and the river but does not significantly decrease the stage or flow of the river; and
- The irrigation pumping does not impact groundwater levels in Creamery Meadow.

In addition to these site-specific studies, the hydrology, hydrogeology, and geology of the general surrounding area has been studied by many investigators over the last 78 years as presented in several published documents that were obtained and reviewed as part of our work (See reference list).

3.2 SGI Studies

Under my direction, SGI conducted three main field studies of the Big Sur River Study Area. Each study was conducted during the lowest yearly flow conditions, which occur in late summer to early fall. These three studies took place in the years 2004, 2006, and 2007. Each of the studies was conducted in cooperation with the biological consulting firm Hanson Environmental (Hanson), which published companion reports to the SGI reports. A brief introduction to each of the three studies is found below.

3.2.1 2004 Study

The first SGI study was conducted in the summer of 2004 during “Dry” river flow conditions. During this study period, physical and chemical characteristics of the river were studied during a typical irrigation pumping season and a conceptual model of the river/ocean/groundwater interaction was developed. The 2004 Study included instrumentation of the river reach nearest the pumping wells and extensive data collection designed to define the relationships between pumping and river effects (Figure 3-1). The results of the 2004 field study were published in detail in our 2005 report titled:

Hydrogeologic Investigation and Conceptual Site Model within the Lower Reach of the Big Sur River, May 2005 (“2004 Study”).

Based on review and analysis of the information and data collected during the 2004 study year, and upon the input from outside reviewers for the California Department of Fish and Game (CDFG) and the State Water Resources Control Board (SWRCB), follow-on studies were developed to address specific questions of interest raised by the DFG and the SWRCB.

3.2.2 2006 Study

As a result of the aforementioned review process, a more focused study was undertaken during the late summer pumping season of 2006, which occurred during “Wet” river flow conditions (Figure 3-2). Unlike the 2004 Study, ESR irrigation pumping was controlled and scheduled to allow a more refined evaluation of potential pumping effects on river flow and water quality as a result of various pumping scenarios. The results of the 2006 field study were published in detail in our 2007 report titled:

Addendum to Hydrogeologic Investigation and Conceptual Site Model within the Lower Reach of the Big Sur River, March 2007 (“2006 Study”).

3.2.3 2007 Study

Based on the results of the 2004 and 2006 studies, and upon further consultation with DFG and SWRCB, a third follow-on study was initiated during the late summer of 2007. This Study was initiated upon realization that 2007 (the second driest year of record) would provide the opportunity to study the wells' effect on river flow and water quality during 'Critically Dry' river flow conditions. The 2007 study focused very specifically on those areas of the River where pumping effects were most likely to occur, and on the river characteristics most important to instream resources. Like the 2006 study, the 2007 study included control of ESR irrigation pumping schedules to compare the hydrologic system at maximum stress conditions with the conditions that are present with no irrigation pumping at all. The 2007 Study included instrumentation of the pumping area of influence and extensive data collection focused on refining answers and relationships discovered and defined in the earlier studies (Figure 3-3). The results of the 2007 field study were published in detail in our 2008 report titled:

2007 Addendum to Hydrogeologic Investigation and Conceptual Site Model Within the Lower Reach of the Big Sur River, April 2008 ("2007 Study").

3.3 Summary of Work Conducted

The SGI studies conducted at my direction resulted in the collection of a prodigious amount of physical and chemical monitoring data documenting the nature of the inter-relationships between the aquifer, the river, the pumping wells, the ocean and tides, the daily diurnal changes in the watershed, and the local changes caused by precipitation events. This data collection and study effort included over 100 research days directly walking the River and surrounding areas during the late summer/early fall of 2004, 2006 and 2007. During this time, the researchers were not only installing instrumentation and collecting data measurements, but also observing and recording (including pictures and video) the condition of the River by physically walking its course. Each study period included hourly recording of groundwater levels and twice-weekly water quality measurements in up to eleven monitoring wells and three pumping wells. Temporary flow gauging stations were established at three locations along the River during the 2004 and 2007 field seasons to measure river flow above and within the zone of the pumps' influence (ZOI). In conjunction with Hanson, eleven fish passage transects were established and data, including wetted width, depth profiles and water quality measurements, were recorded twice weekly (in 2004, water quality measurements and fish passage data were collected all the way up to the Molera parking lot). During the 2006 Study season, SGI directly measured the hydraulic conductivity of the River bed to determine the rate of percolation of surface water flow into the underlying aquifer. This was done using a falling head permeameter collecting 134 separate measurements during 36 individual tests within the area of the River nearest the pumping wells. During the 2006 and 2007 studies, there were respectively nine pairs and ten pairs of piezometers measuring water elevations (both River stage and groundwater elevation) at points along the River within the ZOI on an hourly basis (approximately 1,100 data points) for the duration of each study, yielding a high resolution data set of direct groundwater gradient measurements. Two weather stations were installed in 2004: one in the El Sur Ranch pastures and one at the New Well, to provide site specific meteorologic data. Data from other weather stations local to the Study Area, current and historical local tides, and current and historical U.S. Geological Survey (USGS) flow/stage, were obtained from internet sources.

4.0 SITE HYDROGEOLOGY DEFINED BY STUDIES

The Big Sur River drains a total watershed area of 58.4 square miles. The water shed is divided by the Sur Hill Fault into an upper and lower portion (Figure 4-1). The upper 46.5 square mile watershed provides the majority of the surface water and underflow that drains through the Big Sur River valley, all of which is forced to the surface by a change in geologic conditions at the Sur Hill Fault location before transitioning to the lower watershed. The USGS maintains the Big Sur River Gauging Station at this location, the measurements from which reflect the entire drainage of the upper watershed. The lower watershed drains an 11.9 square mile area extending from the Sur Hill Fault to the Pacific Ocean and includes the Study Area. Below the Sur Hill Fault transition, some of the water reenters the highly permeable alluvial aquifer deposits as underflow, with the remainder flowing as surface water in the Big Sur River.

Our Study Area boundary is defined by an approximately one-mile stretch of the Big Sur River terminating at the Pacific Ocean and includes the land area that contributes groundwater and surface water flow into and out of this stretch of the river. The generalized map of geologic units in the Study Area is depicted on Figure 4-2. Three principal geologic units occur in the Study Area including Franciscan Formation bedrock, terrace alluvial deposits, and Quaternary aged stream alluvium filling the Big Sur River valley as shown in photographs on Figures 4-3a through 4-3c.

The bedrock in the Study Area (i.e., in simple terms, the carved-out basin that holds the alluvial aquifer) has geologically been designated as the Franciscan Formation. The rocks of the Franciscan Formation (a varied formation consisting of several different rock types) underlie both the Quaternary alluvial deposits (the aquifer under the river) and the terrace deposits (where the irrigated pastures lie) throughout the Study Area. The Franciscan Formation bedrock (Figure 4-3a) that underlies the alluvium in the portion of the Study Area where all the wells are located consists of dark gray clay that grades into a weathered micro-graywacke at depth as confirmed in core samples collected during this investigation for the drilling of wells ESR-10A,B,C.

A series of alluvial terrace deposits occupy the indentations between the bedrock promontories along the Big Sur Coast. The best developed terrace deposit extends from the Point Sur lighthouse to the Big Sur River and is approximately 3,000 feet in width. These terrace deposits form the bench land that underlies the cow-calving pastures irrigated by El Sur Ranch (Figure 1-2). Due to continuing mountain uplift, the Big Sur River has cut a valley approximately 2,000 feet in width through these consolidated terrace deposits in the Study Area and sculpted the top of the rocks of the Franciscan Formation below. The terrace deposits documented in drilling cores and inspection of outcrops indicates that in the Study Area, the terrace deposits consist of semi to weakly consolidated (cemented) material made up of cobbles, gravel, sand, silt and some clay (Figure 4-3b).

The main subject of our studies was the aquifer in the Study Area, which is comprised of alluvium that is fairly coarse in nature due to the high energy of the regular winter floods. Point bar deposits observed in the Study Area consist of large cobbles roughly six to ten inches in diameter and are interspersed within a coarse gravel and sand matrix (Figure 4-3c). The subsurface nature of the relationship of these three geologic deposits is depicted graphically in cross section form on Figures 4-4 through 4-6.

In the Study Area, the base of the ancestral canyon has been carved into the Franciscan Formation bedrock. This bedrock has varying characteristics which have determined the morphology of the canyon and the current course of the Big Sur River. Immediately north of the Andrew Molera State Park parking lot, the River makes a right angle turn to the west and exposes a competent tan sandstone of the Franciscan Formation. Near the mouth of the river, drilling core results indicate that the underlying Franciscan Formation consists of a more easily eroded micro-graywacke that is weathered to gray clay at its surface. In the final 500 feet of river channel, the Franciscan bedrock gives way to meta-volcanic rocks that are hard and more resistant to weathering and erosion than the clay. These meta-volcanics have constricted the canyon width as the River makes its escape to the ocean.

Based on the compilation of data collected through multiple investigations, the surface of the ancestral canyon carved into the Franciscan Formation bedrock that makes up the bottom extent of the alluvial deposits has been fairly well defined throughout the Study Area. The interpreted bedrock surface indicates that a fairly deep and narrow canyon was cut through the area at the mouth of the river, hitting depths of 100 feet below sea level at the interface with the ocean. Inset 500 feet from the current ocean interface, the ancestral canyon is split into two channels by a subsurface knob of hard Franciscan rock that rises to approximately 15 feet below mean sea level (Figure 4-7). A deeper narrow channel was carved on the northwest side of this knob and a shallower and wider channel was cut on the southeast side of the knob (Figure 4-8). The alluvium deposited in the channels carved around this bedrock knob at depths lower than 20 feet below mean sea level is partially made up of very coarse material including boulders up to three feet in diameter. As mapped by Dames and Moore (1964), these deposits continue beyond the current mouth of the Big Sur River and extend into what is now the sub-marine portion of the ancestral canyon.

The alluvial deposits are bounded to the north by semi-consolidated terrace deposits that also overlie Franciscan bedrock. These terrace deposits consist of significantly older alluvial and colluvial material with estimated hydraulic conductivities of less than 100 feet per day (ft/day). Groundwater is present in these deposits, which discharge small amounts of water into the younger alluvium where the alluvial aquifer abuts the terrace deposits. Estimates for total discharge from the terrace deposits into the alluvial aquifer indicate likely discharge of less than 0.64 cubic feet per second (cfs). The southern boundary of alluvium in the ancestral canyon consists of Franciscan Formation bedrock that has extremely limited hydraulic conductivity. Due to the fact that the Franciscan deposits are highly sheared and generally mixed up, they are unable to transmit any significant amounts of groundwater into the overlying and adjacent alluvium.

4.1 Groundwater Movement

The predominant source of water moving within the alluvium in the Study Area is Big Sur River flow as it exits the Gorge in Pfeiffer-Big Sur State Park. Additional sources include tributary stream inflows and precipitation that falls on the alluvium below Pfeiffer-Big Sur State Park as well as the minor contribution from the terrace deposits to the north. Both geologic conditions and water balance evaluations indicate that there is no significant contribution of groundwater from adjacent bedrock (Franciscan Formation) in the reach of the river from the Andrew Molera State Park parking lot to the USGS flow gauge in Pfeiffer-Big Sur State Park.

The groundwater within the Big Sur River valley occurs within the alluvial aquifer material under unconfined conditions, meaning that the water table forms the upper boundary. Both the groundwater and the surface flow move down-stream parallel to the axis of the valley in the general direction of southeast to northwest, as depicted on Figure 4-9. In the vicinity of the ESR wells, however, the groundwater moves transverse to the direction of the River's surface flow. When the ESR wells are pumping, groundwater movement is modified such that within the zone of influence of the ESR wells, groundwater flow also moves towards the wells as shown on Figure 4-10.

4.2 Aquifer Hydraulic Conductivity

Constant-rate pumping tests to measure the aquifer properties of transmissivity and hydraulic conductivity have been conducted by previous investigators and SGI. The results of this testing indicate that aquifer transmissivity is on the order of 600,000 gallons per day per foot (gpd/ft). The aquifer hydraulic conductivity has been calculated to range from 3,389 to 3,918 ft/day, with an average of 3,623 ft/day.

5.0 BIG SUR RIVER HYDROLOGY

The USGS Big Sur River gauge, located within Pfeiffer State Park, has been recording river flows since 1950. Currently, a stage height measurement is taken every 15 minutes. Stage height is converted into flow via a stage/discharge relationship which is recalibrated by the USGS monthly. The Big Sur River remains completely un-controlled (i.e., there are no dams on the river, and only limited diversions above the USGS gauge), and river flows at the gauge can range from below 5 cfs to greater than 1,000 cfs within a single year.

Big Sur River flow consists of two components, runoff and baseflow. The runoff component occurs during and immediately after periods of precipitation. Within the majority of the watershed, only a relatively thin veneer of soil covers the bedrock (metamorphic rocks of the Sur Complex) which leads to rapid runoff and relatively high peak flows of short duration in response to precipitation. The baseflow component reflects discharge of groundwater to the Big Sur River, resulting from hydraulic head differences between the aquifer and the Big Sur River. During the dry season (May through October), when there is little or no precipitation, the River surface flow is almost entirely baseflow (i.e., surface flow originating from groundwater discharge).

The CDFG requested that SGI classify water flow conditions (which are sometimes referred to as 'water year types' though flow conditions can change dramatically within a given year), so that analysis could be focused on relatively dry conditions, when pumping the El Sur Ranch wells might have the greatest impact on Big Sur River flows. The analysis identified five different flow classifications, ranging from wet to critically dry. The classifications are based on how the average river flow for a given day compares to the range of historical average flows recorded for that day in each of the 55 years in the historical record (1950 through 2004).

CDFG asked that five different flow conditions be identified, based on the how the flow in a given time period compares to the range of historical flows:

- **Critically Dry Conditions**– Flow is less than (i.e., does not exceed) the 20th percentile of the historical annual flows;
- **Dry Conditions** – Flow is between 20th and 40th percentile of the historical annual flows;
- **Average Conditions** – Flow is between 40th and 60th percentile of the historical annual flows;
- **Above Normal Conditions** – Flow is between 60th and 80th percentile of the historical annual flows; and
- **Wet Conditions** – Flow is greater than the 80th percentile of the historical annual flows.

Flow conditions were characterized by comparing daily average flows at the USGS gauge obtained during our studies to 55 years (1950 through 2004) of historical daily average flows. Non-exceedance flow percentages were computed for each day of the year, by applying the Weibull plotting position formula to the historical data. For example, on July 22nd, 20-percent (%) of the historical flows (i.e., the daily average flow results on every July 22nd during the 55 years studied) do not exceed 10 cfs (i.e., 10 cfs is the 20% non-exceedance flow for that day). The daily average flow on July 22, 2007 was 8.9 cfs, thus, based on comparison to the 55 years of flows that occurred on July 22, the flow conditions for July 22, 2007 are classified as critically dry because the flow was less than 10 cfs.

Figure 5-1 presents a graph depicting daily mean flow statistics (i.e., showing the five flow conditions) on the Big Sur River for the 55 year period of record with validated (i.e., verified by the USGS) flow data (USGS, 2004). Figure 5-2 focuses on the drier period of time between late summer and early fall. The critically dry daily flows (20% non-exceedance frequency) reach a minimum of 8 cfs during September. The daily average flows during the 2004 Study generally reflected dry river flow conditions, while those for the 2006 Study generally reflected wet river flow conditions. Daily average river flows during the 2007 Study generally reflected critically dry flow conditions.

5.1 River Flows Measured at Temporary Gauging Stations

SGI established temporary river flow gauging stations within the Study Area during the 2004, 2006 and 2007 Studies, in order to better understand flows in the Big Sur River in proximity to the El Sur Ranch wells. Establishing temporary flow gauging stations involved defining the profile of the River at each gauge location, developing a means to measure the river stage at each location, and, at select locations, estimating the stage/discharge relationship so that the measured river stage could be used to estimate River discharge.

For the 2004 and 2006 studies, flow measurements were obtained at discrete locations (Figures 3-1 and 3-2) at least twice a week. A stage/discharge relationship was established at several points along the River during the 2004 and 2006 studies, though data collection frequency was low (twice weekly).

For the 2007 study, three temporary gauging stations were installed in the River along with stilling wells (Figure 3-3). Stilling wells ensure that stage readings do not reflect wave or ripple movement of the stream's flow. Improved stage discharge relationships were established at three locations along the River during the 2007 Study, and the frequency of data collection at each point was increased to hourly.

River flow data collected during the 2007 study year at the temporary gauges VT-1, VT-2 and -VT-3 revealed the varied influences on Big Sur River flows (Figure 5-3). Natural factors affecting river flow during the Study seasons included rainfall events in the watershed that occurred during these studies and are easy to interpret in the stream flow gauge data. Additional changes in flow are evidenced in response to variable water use in the areas up-gradient of the Study Area. Increases in use are most notable on holiday weekends when water use in the watershed peaks. Labor Day weekend flows exhibit this condition as shown on Figure 5-3. When reviewing river flow in detail throughout a typical day, the impacts of evapotranspiration (i.e., water use by plants along the River) and open water evaporation on river flow are exhibited by diurnal changes in river water level elevations measured at all gauging stations.

An estimate of the zone of pumping influence, or ZOI, was determined during the 2006 Study. For the 2007 Study, temporary gauges were established near the upstream end (VT-3) and near the downstream end (VT-2) of the ZOI (Figures 3-3 and 5-3). Data from both gauging locations showed natural factors affecting river flow similar to those seen in VT-1. Additionally, differences in river flow between VT-3 and VT-2 allowed for quantification of gains in flow during non-pumping situations and the reduction in flow gains or losses when the pumps are in use (Figure 5-3).

5.2 Flow Correlations Between USGS Gauge and Temporary Gauging Stations

The temporary flow gauge station (Figure 3-3) established at the VT-1 location during each of the SGI studies was designed, in part, to determine flow gains and losses between the USGS gauge and the Study Area. In general, the stream flow monitoring indicated that daily average river flow during the critically dry year study period of 2007 was reduced a maximum of 4.5 cfs between the USGS gauge and the upstream end of the Study Area with an average reduction of 2.8 cfs. The amount of flow reduction varies in response to variable water use conditions and weather conditions within the watershed as noted above.

Figure 5-4 presents a correlation analysis of flows at the USGS gauge to flows measured in the Study Area at location VT-3. The correlation is relatively good statistically (coefficient of determination of 0.78). In other words, flow within the Study Area has a strong relationship to flow at the USGS gauge. Except under special circumstances (holiday weekends) in the watershed, flows within the Study Area during the late summer through early fall time period can be estimated based on the continuously collected USGS flow gauge data.

6.0 GROUNDWATER – OCEAN RELATIONSHIP DEFINED BY STUDIES

The Big Sur River Valley alluvium is directly hydraulically connected with the Pacific Ocean. As generally described by Ghyben and Herzberg (Fetter, 1980), the interface between the fresh water flowing down the alluvium filled valley and the salt water of the ocean is approximately wedged shaped, with the more dense salty ocean water pushing inland underneath the less dense fresh water (Figure 6-1). Tidal fluctuations raise and lower the ocean surface water elevation, which in turn changes the hydraulic gradient between the ocean water and the fresh water in the alluvial aquifer. A rising tide increases the gradient and the effective elevation of sea level, which forces the salty ocean water, or 'saline wedge', further inland, while a falling tide causes the saline wedge to retreat toward the ocean.

The most significant landward migration of saline water occurs in response to 'spring' tide events, which are the extremely high tides that reoccur approximately once every 28 days. The 'spring' tides are highest during the summer months and are brought about by a particular alignment of the Sun, Moon and the Earth. The onset of 'spring' tides in the summer months pushes the saline wedge the furthest inland.

6.1 Tidal Influences

6.1.1 Direct Measurement

ESR occasionally has to curtail pumping of the Old Well during the summer pumping season due to elevated salinity levels. Data from the 2004 study showed that salinity concentrations in the Old Well did not correlate with the rate or frequency of pumping; indicating that pumping alone cannot induce saline water flow inland from the ocean. However, there is a correlation between elevated salinity in the Old Well and spring tide events (Figure 6-2). A spring tide forces the saline wedge further inland relative to an average high tide, allowing the saline wedge diffusion front to come into contact with the Old Well. When the Old Well is active, it can sample this higher saline content water. In response to the elevated saline concentrations, ESR ranch managers report that they routinely shutdown the well and do not reactivate it until the saline condition is gone (the saline wedge retreats toward the ocean).

6.1.2 Simulation Model

In order to further evaluate saline intrusion as a possible mechanism for observed water quality impacts to the Old Well, a density-dependent flow and transport model was developed using the U.S. Geological Survey SEAWAT-2000 model (Langevin et al., 2003). Study Area information gathered during the 2004 irrigation season was evaluated using that model, and the ability of the model to reproduce the observed groundwater quality supports the validity of a conceptual model based on density-dependent flow. The model took into account the shape and depth of the aquifer bottom, the high hydraulic conductivities associated with a boulder zone at depth in the alluvium, the high summer 'spring' tides combined with pumping stresses, and the density-driver flow of a saltwater wedge. The model confirmed that the observed groundwater quality distribution at the mouth of the Big Sur River and at the Navy and Old Wells is completely consistent with subsurface saltwater intrusion and the movement of its accompanying diffusion front. Additional model documentation is included as Appendix B to this testimony.

6.2 River Mouth Dynamics

On occasion, heavy wave action coupled with high tides can create a sand bar that closes the Lagoon, the large ponded area located at the mouth of the Big Sur River. This has the effect of trapping the river's surface flows in the Lagoon and generally increasing surface and groundwater levels within the Study Area close to the Lagoon. During the 2004 study, the Lagoon was closed for almost two months. During that time, water levels rose several feet, though water quality (dissolved oxygen, temperature and electro-conductivity) in the Lagoon remained consistent with the pre-closure period. The Lagoon also closed during the 2007 study, though only for a couple of days around the Labor Day holiday weekend. The Lagoon did not close during the 2006 Study.

6.3 Extent of Saline Wedge Intrusion Effects

Both the historical data and the SEAWAT model indicate that the New Well and Creamery Meadow are not threatened with seawater intrusion impacts due to pumping for the El Sur Ranch. While the Old Well is periodically affected by sea water intrusion, the New Well has never experienced a recorded instance of significantly elevated salinity, even though it has been pumped and monitored for several decades. Based on the physics of saline water intrusion as described by Ghyben and Herzberg (Fetter; 1980) combined with the knowledge of the elevations of the base of the aquifer, the furthest inland that the saline wedge can possibly migrate is to the location of the Old Well when it is pumping and tides are at their highest level. Migration of the natural saline wedge further inland is not possible due to the physics of saline water intrusion. A primary factor that limits the ability for further inland migration of a saline wedge is the rising elevation of the bedrock surface that makes up the bottom of the alluvial aquifer moving inland from the mouth of the river. Creamery Meadow is located easterly enough that due to the bottom elevation of the aquifer and the physics of saline intrusion, it cannot reasonably be expected to experience sea water intrusion.

Consistent with knowledge of the aquifer bottom elevation and the physics of saline water movement, the periodic advance of the saline wedge into the alluvium under the lagoon in response to spring tides has no measurable impact on surface water quality in the Lagoon or the River. Water quality studies carried out in the Lagoon have shown that the predominant mechanism for elevated saline content in the Lagoon is ocean wave overwash. During high tide events, wave action can temporarily push saline sea water directly into the Lagoon. When the tide retreats and the wave action overwash attenuates, river flow pushes the saline water out of the Lagoon restoring fresh water quality concentrations. Based on three seasons of measurement, pumping has not induced any measurable surface water quality changes in the Lagoon.

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7.0 AQUIFER RESPONSE TO PUMPING DEFINED BY STUDIES

The zone of influence of a pumping well is the area that is hydraulically affected by that well. The zone of influence is defined by the pumping cone of groundwater depression (i.e., the lowered groundwater levels, or "drawdown," that occurs in the area around a well as a result of pumping that well). A pumping well has no hydraulic effects outside its zone of influence. Please note, drawdown discussed in this section represents the impact of pumping on groundwater levels only. These reductions do not represent reductions in River stage, which I will discuss later.

7.1 Zone of Influence and Drawdown Effects

Groundwater drawdown within the zone of influence of a pumping well is roughly conical in shape, unless distorted by the effects of hydraulic barriers or replenishment sources. The greatest drawdown is experienced immediately adjacent to the pumping well, with effects decreasing as the distance from the pumping well increases. The cone of groundwater depression, and thus the zone of influence for the El Sur Ranch irrigation wells, was determined with the use of data logging pressure transducers in monitoring wells and piezometers installed around the pumping wells and along the Big Sur River. These transducers measured the groundwater elevation on an hourly basis, and provided a complete record of groundwater drawdown during various pumping tests including Old Well pumping by itself, New Well pumping by itself, and both wells pumping together. These data were collected during wet conditions in 2006 and critically dry conditions in 2007. Though specifically designed pumping tests were not conducted in 2004, transducers in the surrounding monitoring wells also recorded changes in groundwater conditions during ESR pumping operations that year.

A standard mathematical technique to determine the zone of influence for a pumping well is to graph groundwater drawdown at various distances from a pumping well, with the distances from the pumping well on a logarithmic scale. Based on the principles of groundwater hydraulics, the drawdown data plotted on such a graph should approximate a straight line. The boundary of the zone of influence from the pumping well is then derived from this graph as the point at which the line approximated by the data is projected to the intercept (intersection with the line of zero drawdown). This graphical technique based on empirically measured site data was utilized for water level drawdown data collected during both the 2006 and 2007 pumping seasons for all pumping conditions applied. The results of this data analysis have indicated that the maximum projected ZOI is 1,000 feet up gradient of the New Well location. Figure 4-10 depicts the maximum measured ZOI to be 1,000 feet that occurred during pumping the New Well at an average rate of 3.03 cfs during the 2006 study season. Analysis of all other pumping conditions, including those conditions when both wells were pumping, allowed determination of an empirically-derived ZOI of less than 1,000 feet up gradient from the New Well. Field data from all groundwater level monitoring points has validated this zone of influence and based on this data, it can be considered a conservative estimate, that is, the maximum potential ZOI based on the pumping rates El Sur Ranch can and does pump.

The ZOI includes parts of Creamery Meadow and extends to just upstream of the piezometer P4u location. Though there were no observation wells with transducers in Creamery Meadow to measure the groundwater drawdown induced by the irrigation wells, groundwater drawdown beneath the River was a maximum of 0.20 feet when both the Old and New Wells were pumped in 2006 (measured by transducers placed in piezometers that were installed in the River channel). Since drawdown decreases with increasing distance from the pumping well, the maximum drawdown experienced in Creamery Meadow must be less than 0.20 feet.

7.2 Aquifer Recovery Times

Following the start of pumping (assuming a constant or nearly constant rate), the groundwater cone of depression grows until it reaches a "stable equilibrium," at which time the groundwater drawdown levels stabilize. Until the stable equilibrium is established, the maximum pumping effects are not experienced by the surrounding aquifer. When a pumping well is shutdown, the recovery of groundwater levels (i.e., the rise in groundwater levels) mirrors the pumping drawdown and the cone of groundwater depression dissipates in a period of time nearly identical to the time it took to establish a stable equilibrium.

In the case of the El Sur Ranch pumping wells, it takes approximately four days after the start of pumping to reach a stable equilibrium, and approximately the same amount of time for recovery following pump shutdown. Approximately 90% of both drawdown and recovery occurs within 24 hours of onset. 98% of drawdown occurs in 3.2 to 3.5 days with total stabilization in a maximum of 4 days. The approximate four-day equilibrium time period has been consistently determined by direct measurements of groundwater levels from monitoring wells and piezometers within the ZOI of the two irrigation wells, during multi week-long pumping tests spanning three seasons of study (Figures 7-1 and 7-2).

7.3 Aquifer Overdraft Potential

Lowered groundwater levels and reduced water availability are effects that continue after pumping has ceased in an aquifer that has had a long history of overdraft. Aquifer overdraft, or over-use, refers to groundwater pumping in excess of natural aquifer recharge. This type of situation results in the lowering of groundwater levels and a reduction in the overall amount of water available. Another term for pumping more water from an aquifer than is being replenished is 'water mining'. It is a condition that occurs in many parts of the country, including California's Central Valley, but is not occurring in the alluvial aquifer in the Big Sur River gorge.

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In general, the amount of water that flows through the Lower Big Sur River watershed is two orders of magnitude greater than the amount of water used by ESR. Water balance calculations presented in the 2004 Study (Table 7-1) show that, on average (based on usage data from 1975 through 2004), less than 1.1% of the water (both surface and underflow) that flows out of the mouth of the lower Big Sur River watershed each year has been utilized by the ESR ranching operation (2004 study). This percentage of ESR flow usage is based on the average ESR extraction rate from 1975 through 2004 of 937 acre-feet per year and the average water-balance determined water flow, both surface and underflow, to the ocean of 85,442 acre-feet per year.

Data collected from three summers of water level monitoring data (2004, 2006, and 2007) indicate that any water pumped from the aquifer by ESR is replenished by aquifer recharge to the basin in the form of rain from winter storms. Water level monitoring data collected as part of these three years of studies indicate that the Big Sur River aquifer does not exhibit any indication of aquifer overdraft resulting from irrigation well pumping in the last 1,000 feet of its travel to the ocean and by extension, the upstream portions of the aquifer.

8.0 RIVER-AQUIFER DYNAMICS DEFINED BY STUDIES

8.1 Degree of River-Aquifer Connectivity

The transfer of water between the River and the underlying alluvial aquifer is important to understanding the potential impacts of pumping on River flow and stage. One of the key factors governing the movement of water between the River and the aquifer is the degree of resistance to flow through the riverbed. Therefore, I measured this resistance to flow as a part of my work.

The high volume flows that occur during the winter and spring months move silt, sand, pebbles, rocks and, in some cases, boulders down the River channel along with the flowing water. With the end of the rainy season, the flow of water in the River subsides and the entrained materials drop to the river bed. The smaller silt and sand particles are driven into the spaces between the rocks and cobbles in the river bed in a process known as 'colmation'. This filling or clogging of the spaces between the rocks and cobbles in the river bed makes it more difficult for water to flow between the River and the underlying aquifer.

During the 2006 study season, the ability of water to flow vertically through the bed of the River was directly measured and compared to the ability for water to flow horizontally through the underlying alluvial aquifer material. Using a falling head permeameter, 134 measurements of river bed hydraulic conductivity within the ZOI were collected at 36 separate locations. For the Big Sur River, it was determined that it is approximately 35 times easier for water to flow horizontally through the alluvial aquifer material than it is to flow vertically through the river bed to the underlying aquifer. To put this into perspective: this is analogous to the difference in speed between flying in a jet airliner and riding a bicycle. This river bed impedance to the exchange of water limits gains and losses of surface flow resulting from hydraulically 'gaining' or 'losing' river conditions. A literature search showed that these results found for the Big Sur River were similar to tests conducted in river environments with similar streambed composition and morphology (References highlighted in Section 11.0 relate to this statement).

8.2 Definition of Flux Zones

To quantify the actual flow of water through the river bed within the ZOI of the pumping wells, piezometer pairs were installed at select points along the River and within the upper part of the Lagoon. Each piezometer pair contained two transducers, one that measured the elevation of the water flowing in the River, and one that measured groundwater levels below the River bed. In order to estimate the rate of flow (Q) through the river bed, the simple Darcy's Law ($Q = K \times dh/dl \times A$) equation was utilized. The hydraulic conductivity (K) of the river bed was determined as described in Section 8.1 above. The gradient (dh/dl) through the river bed was determined for each piezometer pair location by comparing the difference between water levels in the River and water levels in the groundwater below the River. An area (A) of the river bed through which flow occurs, called a 'flux zone', was assigned to each piezometer pair. The boundaries of the flux zones (Zones) were based on the midpoint between piezometer pairs, which side of the River the piezometer pair was on, and/or on natural river transitions, such as the upstream end of the Lagoon. Six Zones were established based on the seven piezometer pair locations (i.e., piezometer pairs P1 through P6, see Figure 8-1). Zone 1 was the upper part of the Lagoon, while Zones 2 through 5 were found progressively further upstream. Figure 8-1 depicts the interpreted streambed Zones associated with the hydraulic gradients measured at each of the piezometer well pairs. The data indicate that the amount of flow through the river bed within the 2006 Study Area is variable between different Zones of the river and between different halves of the river within the same Zone. For the 2007 Study, the area for each Zone was modified based on an increased number of installed piezometer pairs (i.e., now inclusive of Zones P4u and P6) and calibrated based on river flow data derived from temporary gauging stations VT2 and VT3. Figure 8-1 shows the flux zones used in the 2007 Study.

8.3 Correlations of River Responses to Pumping

Piezometer data from both the 2006 and 2007 studies indicate that the only measurable impact to river flow of pumping the ESR irrigation wells occurs within River Zones 2 through 4. This section of the river gains flow from the inflow of groundwater from the underlying aquifer. This state of gaining flow continues in Zone 4 when pumping is active, though the amount of water gained by the River from the underlying aquifer is generally less.

A conservative correlation factor was developed which relates pumping to the reduction in rate of groundwater inflow to the River. The 2006 data showed that there was a maximum groundwater inflow reduction of 0.30 cfs for every 1.0 cfs (30% of the pumped rate) of groundwater extracted by pumping. That is, for every volume of water pumped, 30%, at most, comes from underflow that would have discharged into the River within the area of pumping influence (i.e., Zones 2 through 4). The remaining 70% of the water pumped is comprised of underflow that was destined to discharge to the Pacific Ocean without ever entering the River. This maximum inflow reduction of 30% of the pumped rate was measured during pumping of the New Well at an average rate of 3.03 cfs during the 2006 study year. When both wells were pumped during the 2007 study year, the inflow reduction correlation was 24% of the pumping rate (2007 study). The full effect of the groundwater inflow reduction occurs at the most down-gradient portion of zone 2 and approaches zero at the upper edge of the ZOI. The result of this groundwater inflow reduction resulted in a total loss in surface flow between zones 2 through 4 of 0.4 cfs.

The 2007 correlation factor reflects a lower total average pumping rate (5.02 cfs) and a lower New Well pumping rate (2.60 cfs) that were achieved during the 2007 study year. Maximum pumping rates during the 2007 study year were slightly lower compared to 2006 due to the mix of fields being irrigated (more higher elevation fields when studies were conducted) as compared to the 2006 study years.

9.0 IMPACTS OF PUMPING ON RIVER STAGE AND FLOW DEFINED BY STUDIES

Pumping impacts to the Big Sur River surface flows are limited by the area and degree of connection between the River and the underlying aquifer. Additionally, hydraulic considerations limit effects at the start of pumping and extend effects past pump shutdown. Through measurements of water levels in the river and underlying aquifer, river bed hydraulic conductivity and river bed area, gains and losses to river flow related to pumping can be quantified.

9.1 Flux Zones within ZOI and the Cumulative Nature of Impacts on the River

Irrigation well impacts to the River occur exclusively within the pumping ZOI. Within the River, the effects of pumping on surface flows are cumulative in the downstream direction away from the upgradient edge of the ZOI. Above the ZOI, the River is unaffected by well pumping – because there is no drawdown in the aquifer beyond the ZOI, there can be no increase in the gradient driving flow between the River and the aquifer. Thus, pumping effects on stage and flow are just beginning at a location just upstream of the piezometer P4u location (flux zone 4u), where impacts are minimal, and increasing cumulatively in the downstream direction. The maximum measurable effect on stage and flow is found at piezometer P2 (flux zone 2), which is located just upstream of the Lagoon (Figure 8-1). As determined during the 2006 study, the natural dynamic water level conditions present in the Lagoon prevent pumping from having an effect on riverine conditions within the lagoon area. Although technically within the ZOI of the pumping wells, our 2006 study determined that the Lagoon riverine environment is not impacted by pumping.

9.2 Measureable Impacts on Stage

Piezometer pairs along the river allowed measurements of river water stage (in shallow piezometers) and groundwater (in deep piezometers), and provided the basis for calculating the effect of pumping on the River. For the 2007 Study, the maximum groundwater drawdown, measured in a deeper piezometer along the River, was 0.17 feet which occurred when both irrigation wells were pumping at a combined rate of 5.02 cfs during Critically Dry conditions (Figure 9-1, see footnote[2]). By contrast to the obvious groundwater response, there was no clearly discernible surface water drawdown response in the shallow river flow piezometers during the 2006 or 2007 study years.

[2] In preparing this declaration, I reviewed my three study reports, their figures and the supporting data. In doing so, I discovered an inadvertent error in the preparation of Figure 3-1 of the 2007 study report (Exh. ESR-7). That figure indicates groundwater drawdown of 0.25 feet at the P1L location and a possible groundwater drawdown of 0.03 feet at P4uL location. My review of data and supporting text shows that there is no basis for those numbers posted on the map and that they represent an error in map production. Figure 9-1 to this declaration corrects the error showing no groundwater drawdown in these two locations

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Although there has been no discernible surface water drawdown measured as a result of the naturally dynamic fluctuations impacting river stage at all times, the measurement of flow losses from the River during pumping and the principles of mass balance indicate that some level of surface water drawdown must be inferred. Because of this, I conducted data analysis regarding pumping-related lowering of surface water levels in the river focused on the data collected during the 2007 study when both wells were pumping at a combined production rate of approximately 5 cfs and the River flow was experiencing Critically Dry conditions. Three methods were used to estimate the theoretical lowering of surface water levels as a result of the measured and calculated flow losses during the 2007 study: a simple regression analysis, a mass balance analysis using an established stage/discharge relationship, and a modified regression analysis that accounted for surface water stage trends prior to pumping (*Surface Drawdown Memo Exhibit ESR-9).*

Based on the results of these three analyses, I was able to quantify the effect of pumping at the combined rate of 5.02 cfs during Critically Dry summer flow conditions on surface water elevations within the ZOI of the irrigation wells. The reduction in surface water elevation due to pumping is not constant throughout the ZOI. It is greatest at the lower end, just above the lagoon, where cumulative surface water withdrawal is greatest and progressively smaller moving upstream, approaching zero at the upstream edge of the ZOI. The maximum estimated reduction in river surface water elevation due to irrigation pumping is approximately 0.03 to 0.04 feet (0.4 to 0.5 inches, slightly less than the diameter of a dime) at the head of the lagoon, the most downstream location of the ZOI that is of concern (Zones 2-4 on Figure 8-1). Using the methods detailed in my Surface Drawdown Memo (Exhibit ESR-9), I have estimated the potential surface water drawdown's induced by pumping at the permit maximum of 5.84 cfs during 2007 critically dry year conditions to range from 0.06 to 0.09 feet. In comparison, daily evapotranspiration (ET) of riparian vegetation causes river fluctuations of up to 0.1 feet (1.2 inches).

10.0 IMPACTS OF PUMPING ON RIVER WATER QUALITY DEFINED BY STUDIES

River water quality measurements consisting of temperature, electrical conductivity and dissolved oxygen data collected extensively in all three study years have indicated no significant correlation between irrigation pumping and changes in surface water quality. Based on the results of the 2004 study, the salinity (measured via the water's electrical conductivity) showed no real variation within the river or the groundwater entering the river. As such, the data collected indicates that there is no connection between ESR pumping and the salinity of the river and underflow system within the area of influence including the lagoon. These observations are consistent with the results of the salinity intrusion model discussed in Section 6.1. The 2006 and 2007 studies focused on evaluating potential impacts to river temperature and dissolved oxygen with the ZOI of the pumping wells.

River water quality background measurements have been collected during all three study years at locations upstream of the pumping well's ZOI. In comparison to the upstream water quality measurements (upstream surface water entering the Study Area that represents background), certain areas within the ZOI show a distinct reduction in both temperature and dissolved oxygen content, especially along the right bank (looking upstream) of the River adjacent to Creamery Meadow, providing direct evidence of the results of cold groundwater mixing with River water. River temperature profiles from the summer of 2004 clearly demonstrate this condition showing cold water in-flow occurring in flux zones 2-4 (Figure 10-1). Additionally, mass balance considerations suggest that the reduction in groundwater inflow must have an effect on the quality of the water in the River since the temperature and dissolved oxygen content of the groundwater is notably different than that of the surface water during the mid and late summer. The pumping-induced effects resulting from the reduction of groundwater inflow to the River on dissolved oxygen and daily average temperature were both explored during the 2006 and 2007 studies.

Twice weekly measurements of water quality were taken from 11 transects (PT1 through PT11) within the Study Area in 2006 and 2007. At each measuring transect, a water quality reading was obtained from near the left bank, near the right bank, and at center channel of the River. My analysis of the collected data from both the 2006 and 2007 studies showed no obvious or discernible link between the pumping of the ESR irrigation wells and water quality measurements (temperature and dissolved oxygen concentrations) in the River within the pumping ZOI. Hanson conducted an independent statistical analysis of the water quality data (Hanson, 2008). Hanson's statistical analysis of the same data indicated a statistical temperature increase of less than 0.3 degrees Celsius in response to pumping in two areas of the river that correlate with groundwater inflow. This statistical analysis correlates well with my analysis indicating that pumping has the effect of reducing the amount of cold temperature groundwater influx into the river along the Creamery Meadow side.

In summary, documented changes in the water quality of the Big Sur River do occur, however, it is the result of the influx of cool groundwater that has measurably lower levels of dissolved oxygen. The depletion of dissolved oxygen in the groundwater is most likely due to upstream use of septic tanks, leachfields, and fertilizers as discussed further in the following section of this report.

10.1 Studies Reveal That Impacts to Groundwater by Upstream Parties is Indicated

Investigation into potential causes of oxygen depletion in the subsurface portion of the Big Sur River suggests that the reason lies with the sewage disposal practices in the upstream portion of the Big Sur watershed within the populated region along Highway 1. The primary means of human waste disposal in the Big Sur River Valley is through the use of septic tanks and leach fields, which are located within the alluvial aquifer material. The nutrients and organic wastes encourage the growth of bacteria which, as they consume organic matter, metabolize oxygen resulting in low dissolved oxygen concentrations in the River water and especially within the underflow water. When underflow with low dissolved oxygen concentrations reenters the River, such as at the gaining section of the River within the pumping well ZOI, the dissolved oxygen concentration in surface water can be reduced.

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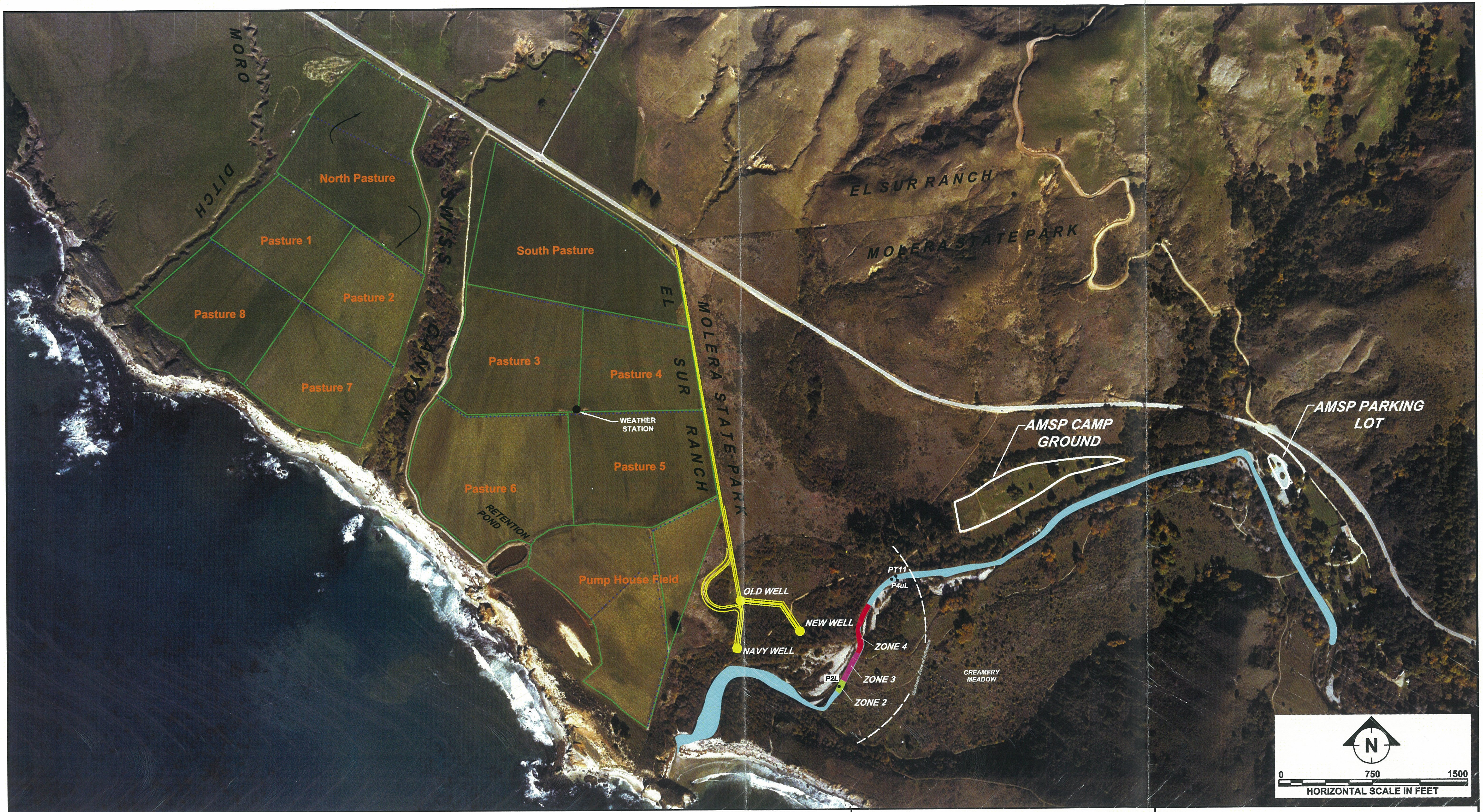
FIGURES

ESR--2

FIGURES



LEGEND

Irrigation Valves

Piping Runs (Easements)

Map provided by: Aerial Photomapping Services (photo date Dec-03)
Surveying provided by: Rasmussen Land Surveying, Inc.

EL SUR RANCH BIG SUR, CALIFORNIA			
PROJECT NO.	DATE	DRAWN BY:	APP. BY:
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EL SUR RANCH
AERIAL VIEW

SGI environmental THE SOURCE GROUP, INC.
3451-C VINCENT ROAD
PLEASANT HILL, CA 94523

FIGURE
1-1

ESR-2

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PLEASANT HILL, CA 94523

EL SUR RANCH
BIG SUR, CALIFORNIA

PROJECT NO.	DATE	DR.BY:	APP. BY:
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FIGURE 1-2
EL SUR RANCH BENCH LAND

ESR--2

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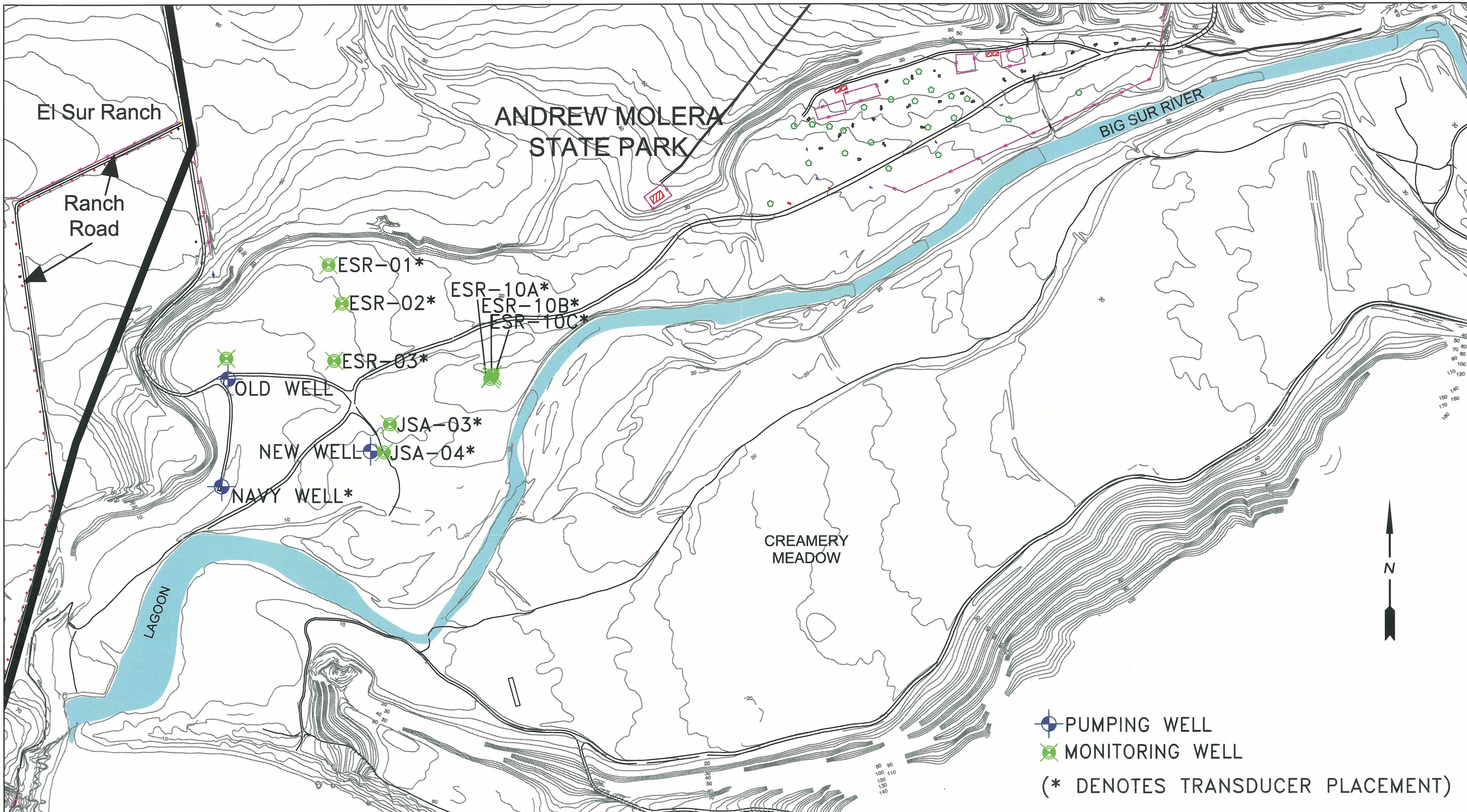

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EL SUR RANCH
BIG SUR, CALIFORNIA

SCALE 0 300 600 SCALE IN FEET

FIGURE 1-3
WELL LOCATION MAP

PROJECT NO.	DATE	DR. BY	APP. BY
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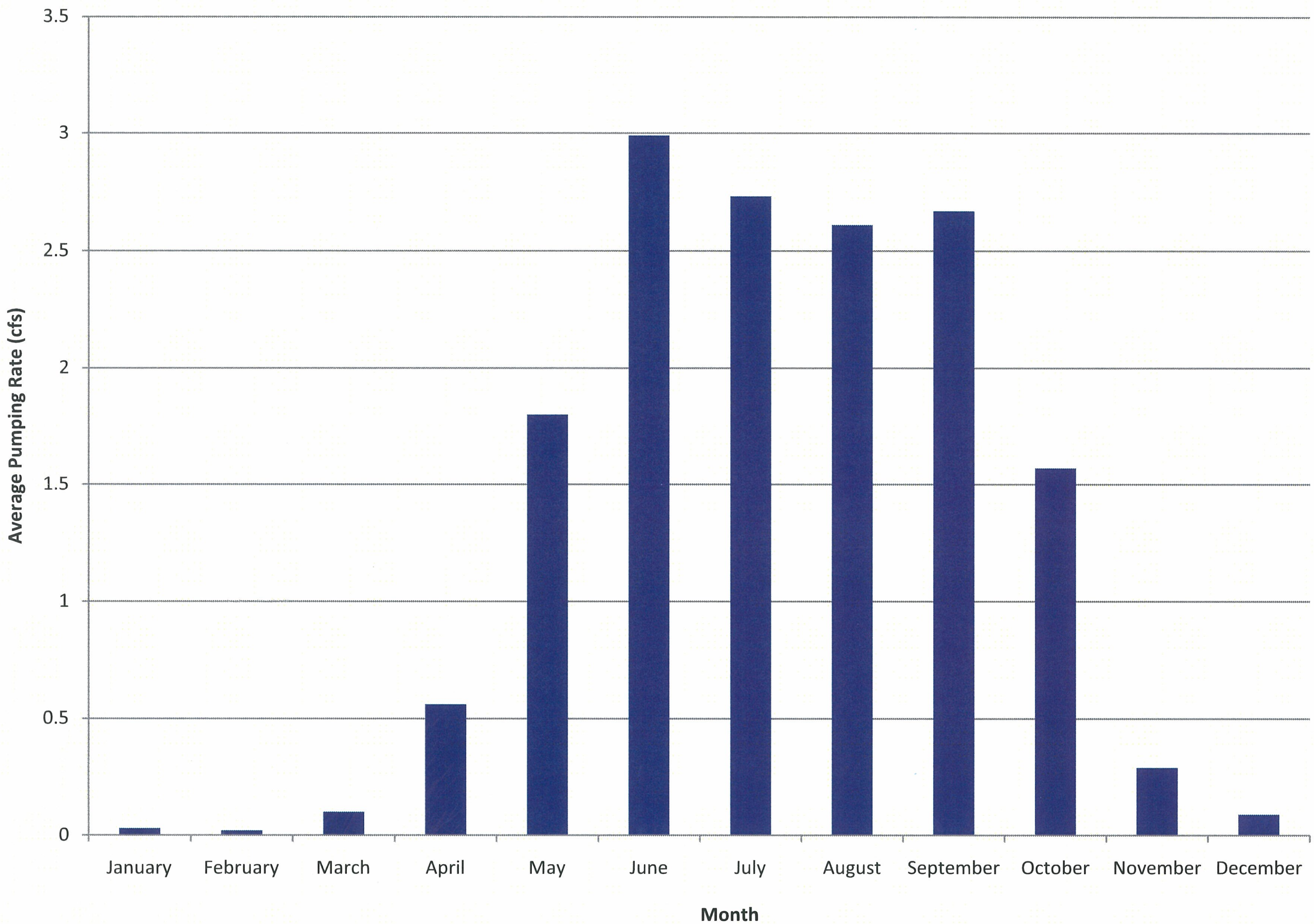
Figure 1-4
Average Monthly Irrigation Pumping
El Sur Ranch
Big Sur, California



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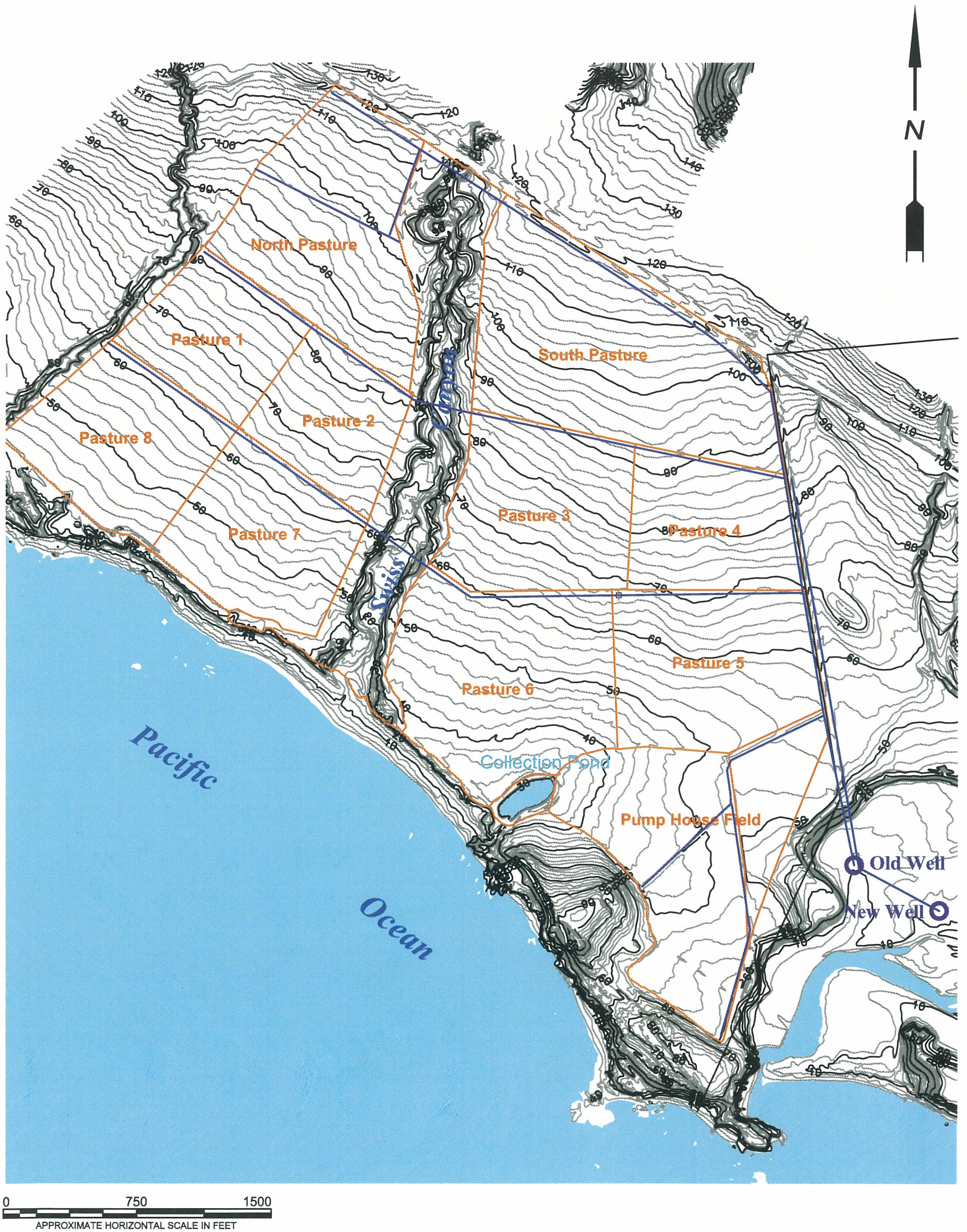
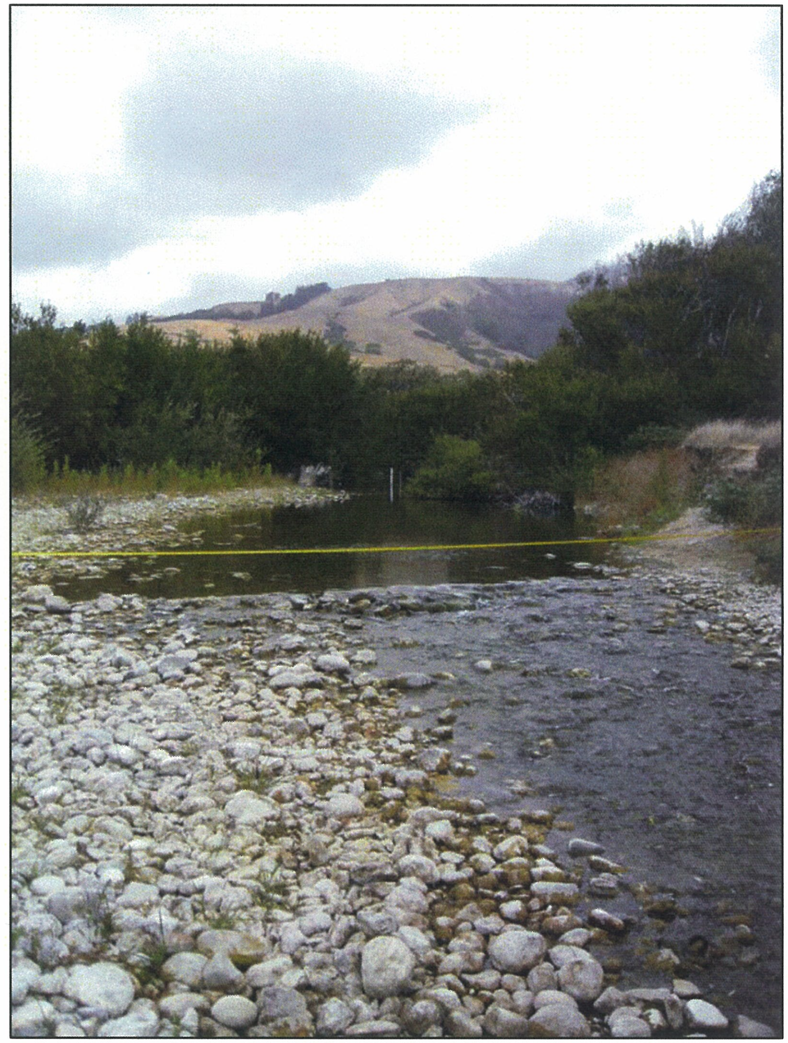


SGI environmental THE SOURCE GROUP, INC. 3451-C VINCENT ROAD PLEASANT HILL, CA 94523	EL SUR RANCH BIG SUR, CALIFORNIA				FIGURE 1-5 ESR PASTURE MAP
	PROJECT NO.	DATE	DR.BY:	APP. BY:	ESR--2
	01ESR-007	05/09/2011	ZA	PH	EXHIBIT ESR-2 Testimony of Paul D. Horton, PG., C.HG.

UPPER GORGE



STUDY AREA

ESR--2
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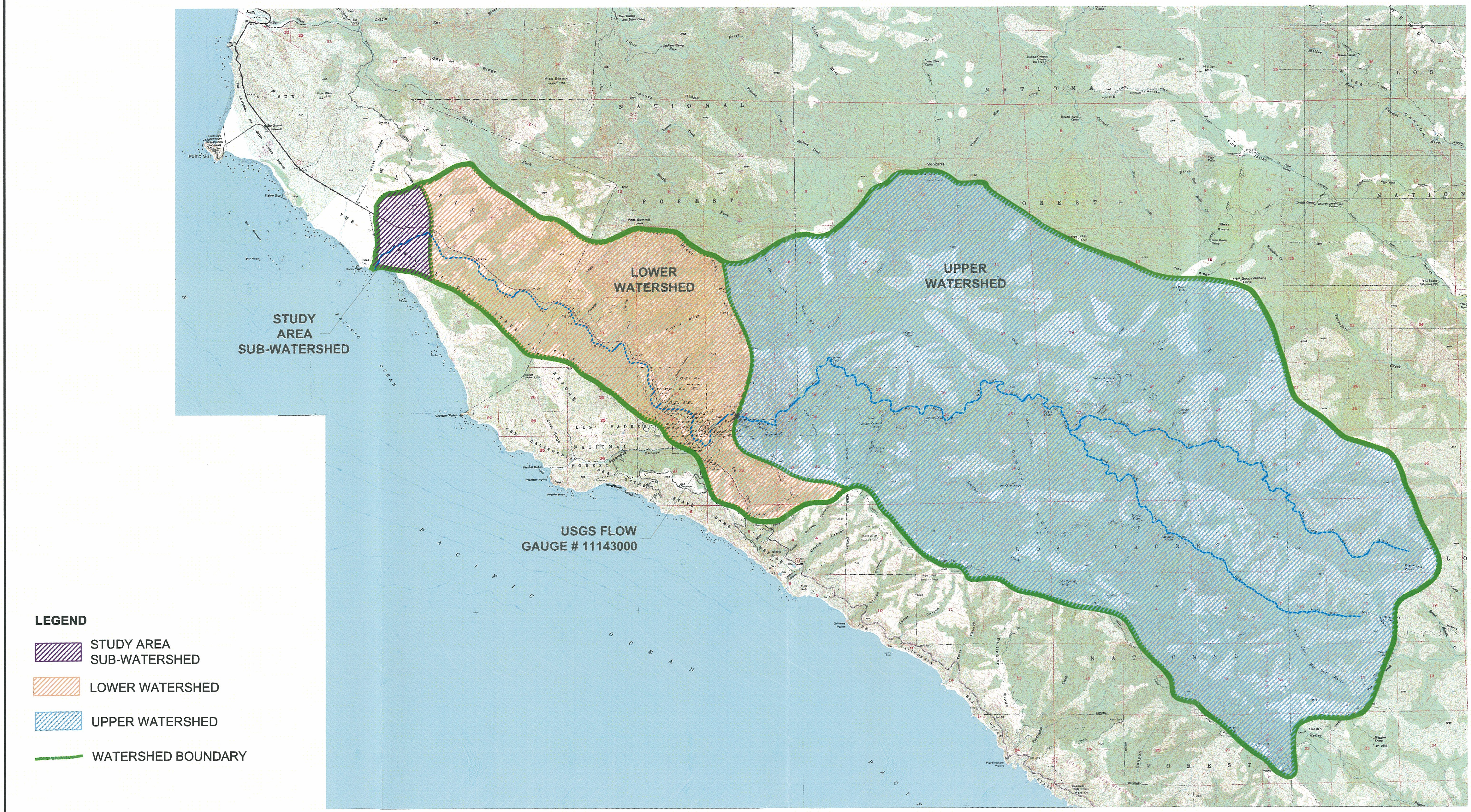
PLEASANT HILL, CA 94523

EL SUR RANCH
BIG SUR, CALIFORNIA

PROJECT NO.	DATE	DR.BY:	APP. BY:
01-ESR-007	05/09/2011	ZA	PH

FIGURE 2-1

BIG SUR RIVER DEPOSITS



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EL SUR RANCH
BIG SUR, CALIFORNIA

PROJECT NO.	DATE	DR. BY	APP. BY
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FIGURE 2-2

BIG SUR RIVER WATERSHED

ESR--2

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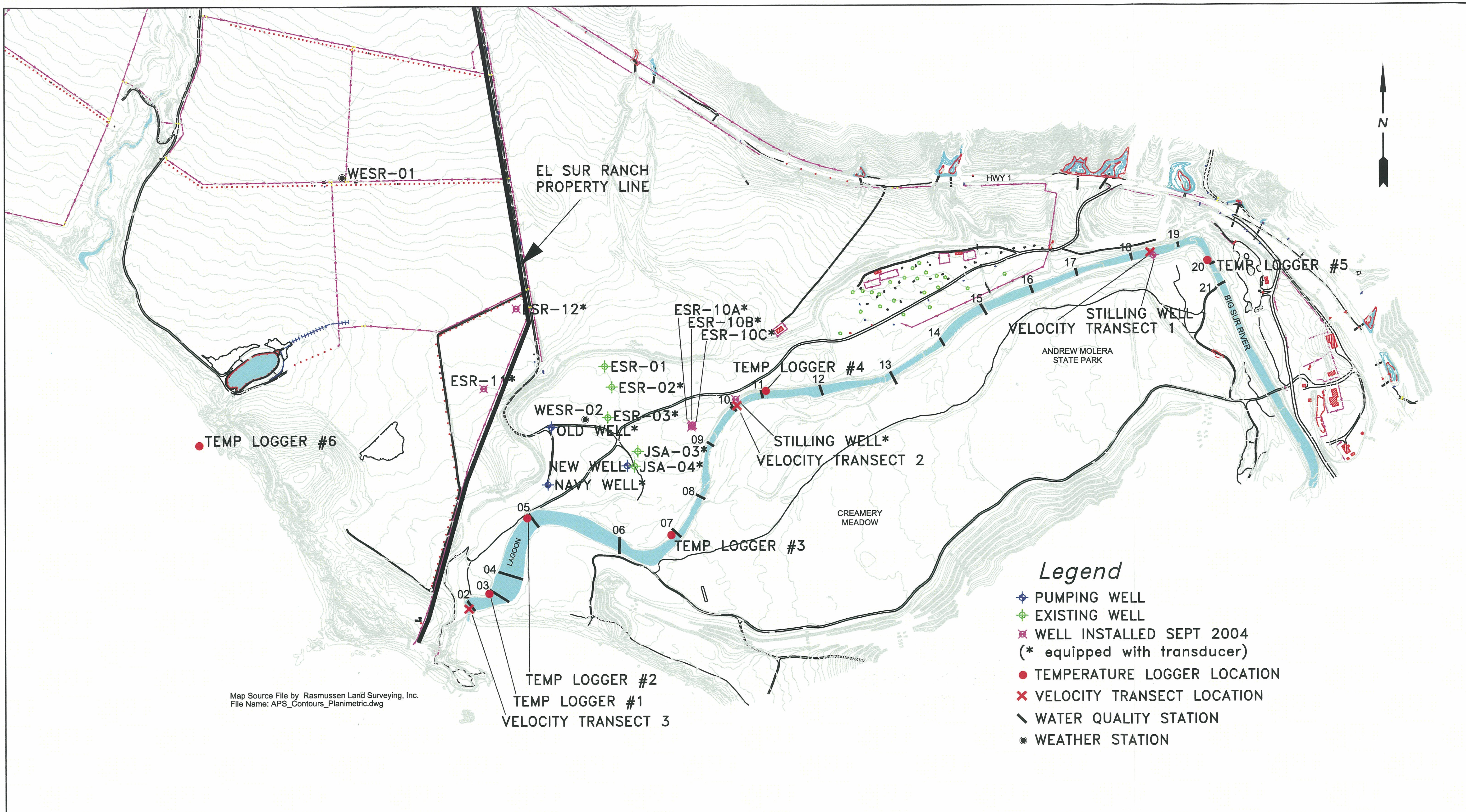

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PLEASANT HILL, CA 94523

EL SUR RANCH
BIG SUR, CALIFORNIA

SCALE
0 500 1000
SCALE IN FEET

FIGURE 3-1

2004 MONITORING STATION MAP

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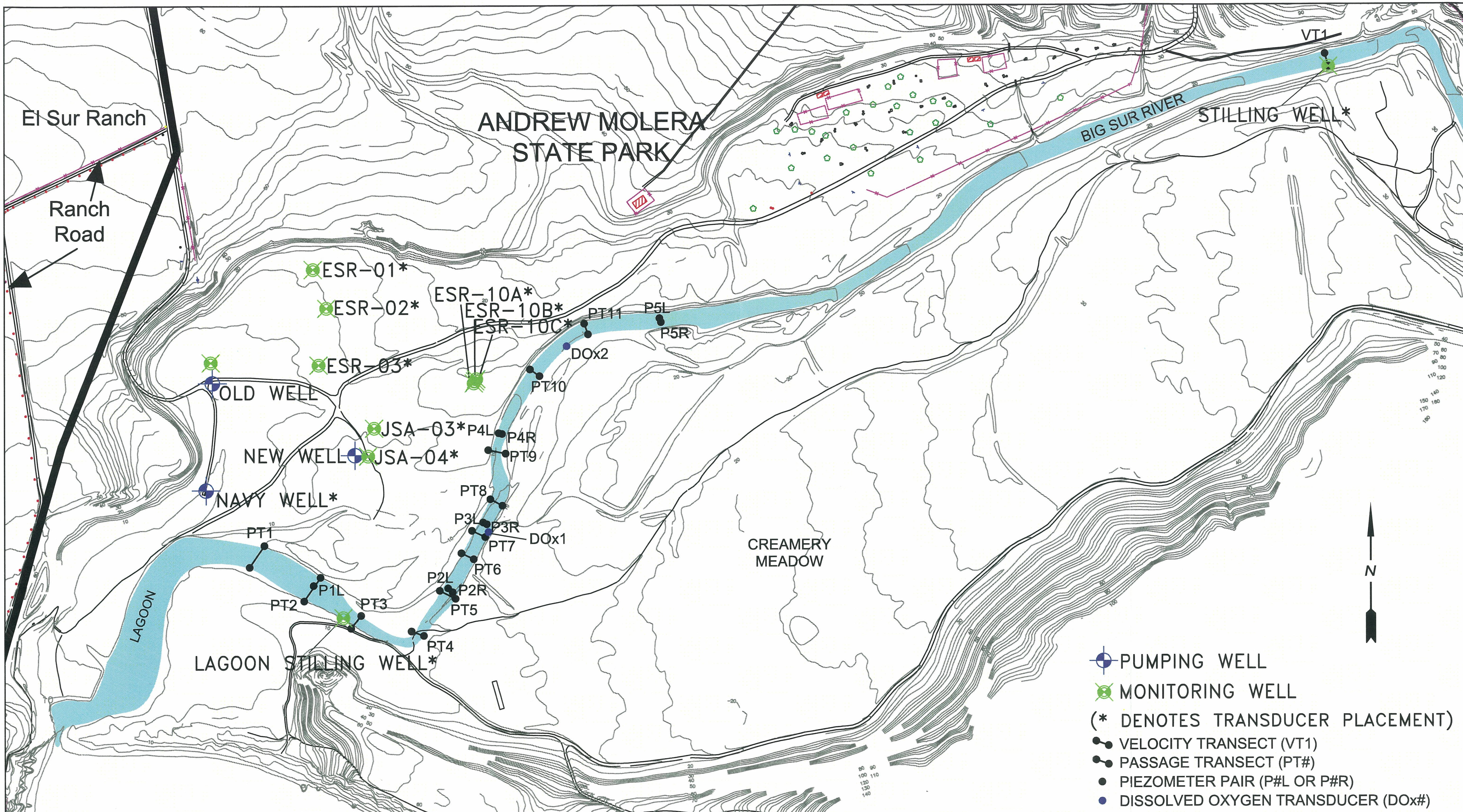
ESR-2



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PLEASANT HILL, CA 94523

EL SUR RANCH
BIG SUR, CALIFORNIA

SCALE
0 300 600
SCALE IN FEET

FIGURE 3-2
2006 STUDY AREA MONITORING STATION AND SENSOR LOCATION MAP

PROJECT NO.	DATE	DR. BY	APP. BY
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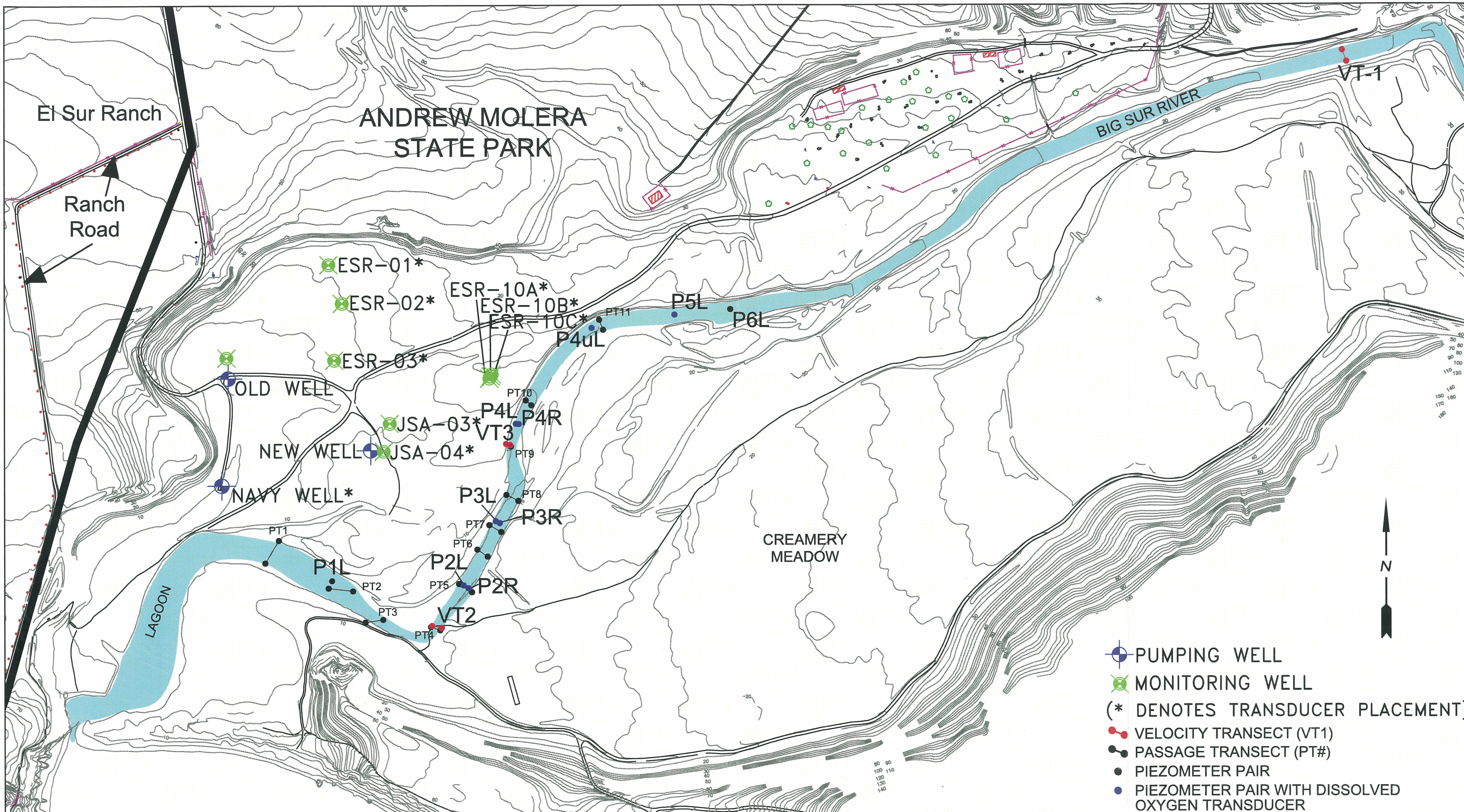
ESR-2



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EL SUR RANCH BIG SUR, CALIFORNIA		SCALE: 0 — 300 — 600 SCALE IN FEET		FIGURE 3-3 **2007** STUDY AREA MONITORING STATION AND SENSOR LOCATION MAP
PROJECT NO. 01-ESR-007	DATE 05/09/2011	DR. BY NC/JP	APP. BY PH	

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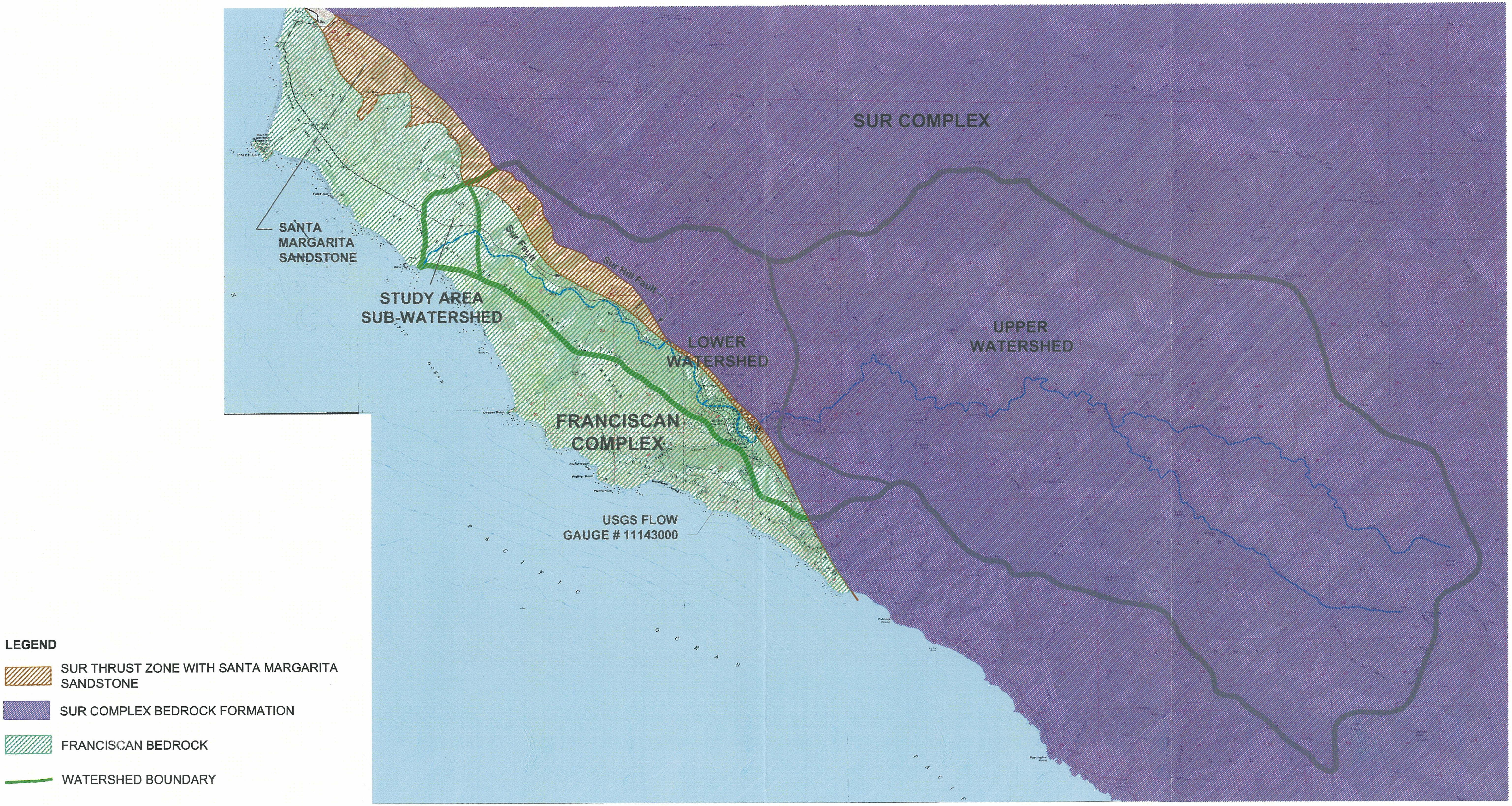
ESR-2



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EL SUR RANCH
BIG SUR, CALIFORNIA

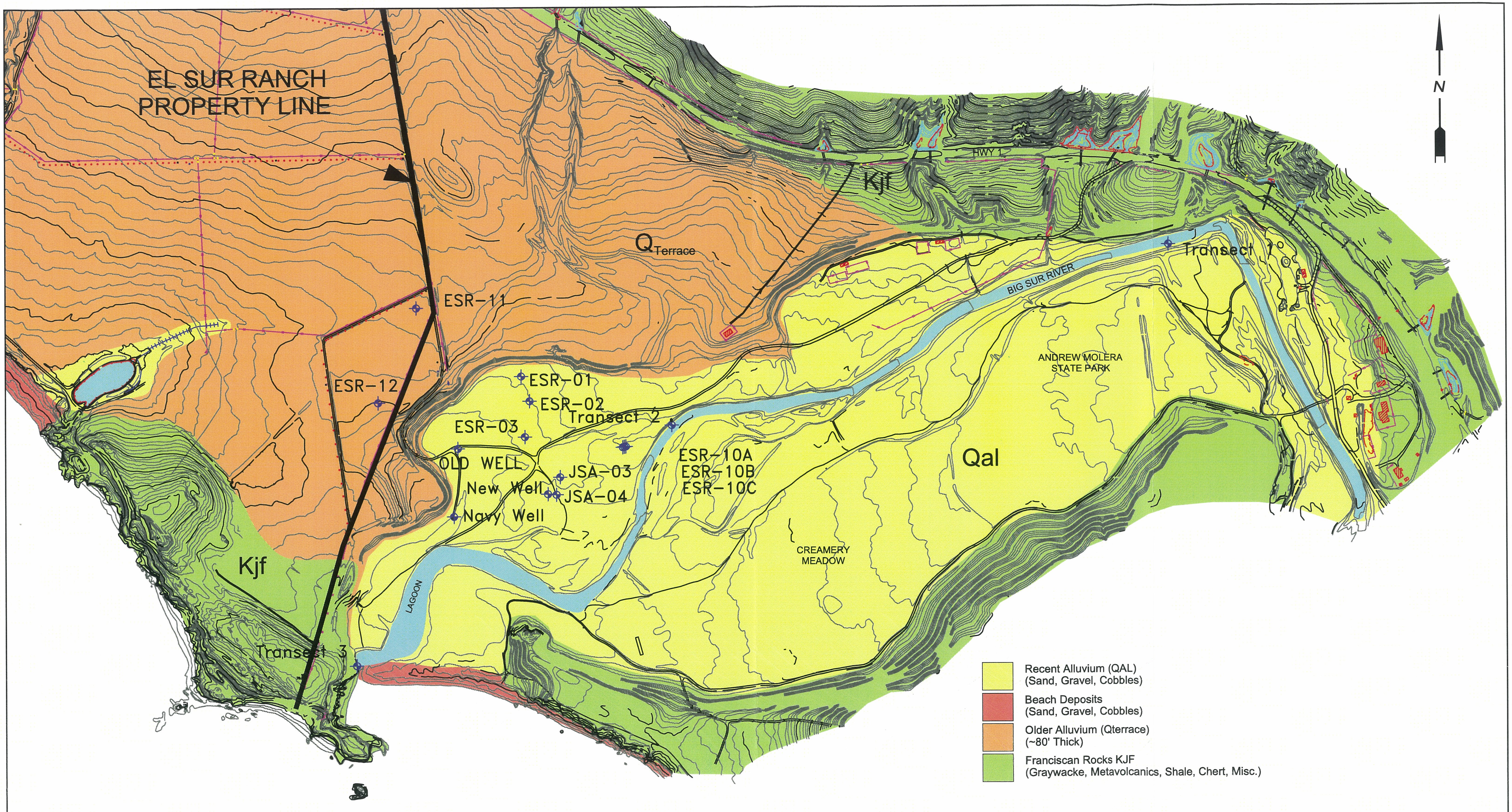
PROJECT NO.	DATE	DR. BY	APP. BY
01-ESR-007	05/09/2011	SB	PH

FIGURE 4-1

BIG SUR WATERSHED AND BEDROCK GEOLOGY

ESR--2

EXHIBIT ESR-2 Testimony of Paul D. Horton, PG., C.HG.



Map Source File by Rasmussen Land Surveying, Inc.
File Name: APS_Contours_Planimetric.dwg

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PLEASANT HILL, CA 94523

EL SUR RANCH
BIG SUR, CALIFORNIA

SCALE
0 500 1000
SCALE IN FEET

PROJECT NO.	DATE	DR. BY	APP. BY
01-ESR-007	05/09/2011	SB	SM

FIGURE 4-2

STUDY AREA GEOLOGIC MAP

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ESR-2

Micro-graywacke weathering to grey sandy Clay
Hwy 1 Roadcut Across from Andrew Molera State Park

SGI environmental THE SOURCE GROUP, INC. 3451-C VINCENT ROAD PLEASANT HILL, CA 94523	EL SUR RANCH BIG SUR, CALIFORNIA			WEATHERED FRANCISCAN FORMATION	
	DATE 05/09/2011	DR. BY ZA	APP. BY PH	PROJECT NO. 001-ESR-007	FIGURE NO. 4-3a

ESR--2

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Marine Terrace Deposit
El Sur Ranch Just North of the V–Notch

SGI environmental THE SOURCE GROUP, INC. 3451-C VINCENT ROAD PLEASANT HILL, CA 94523	EL SUR RANCH BIG SUR, CALIFORNIA			MARINE TERRACE DEPOSIT	
	DATE 05/09/2011	DR. BY ZA	APP. BY PH	PROJECT NO. 01–ESR–007	FIGURE NO. 4–3b

ESR--2
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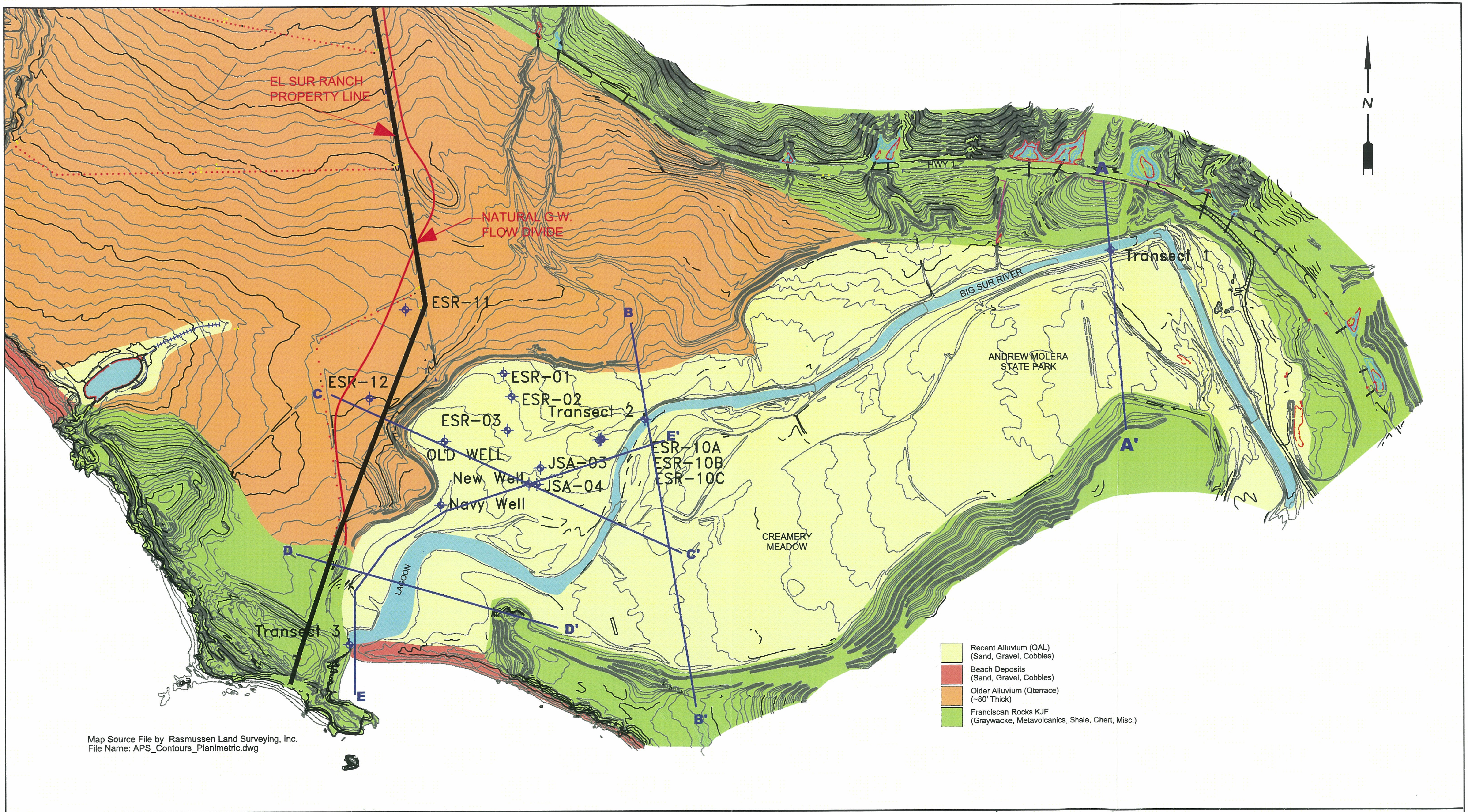
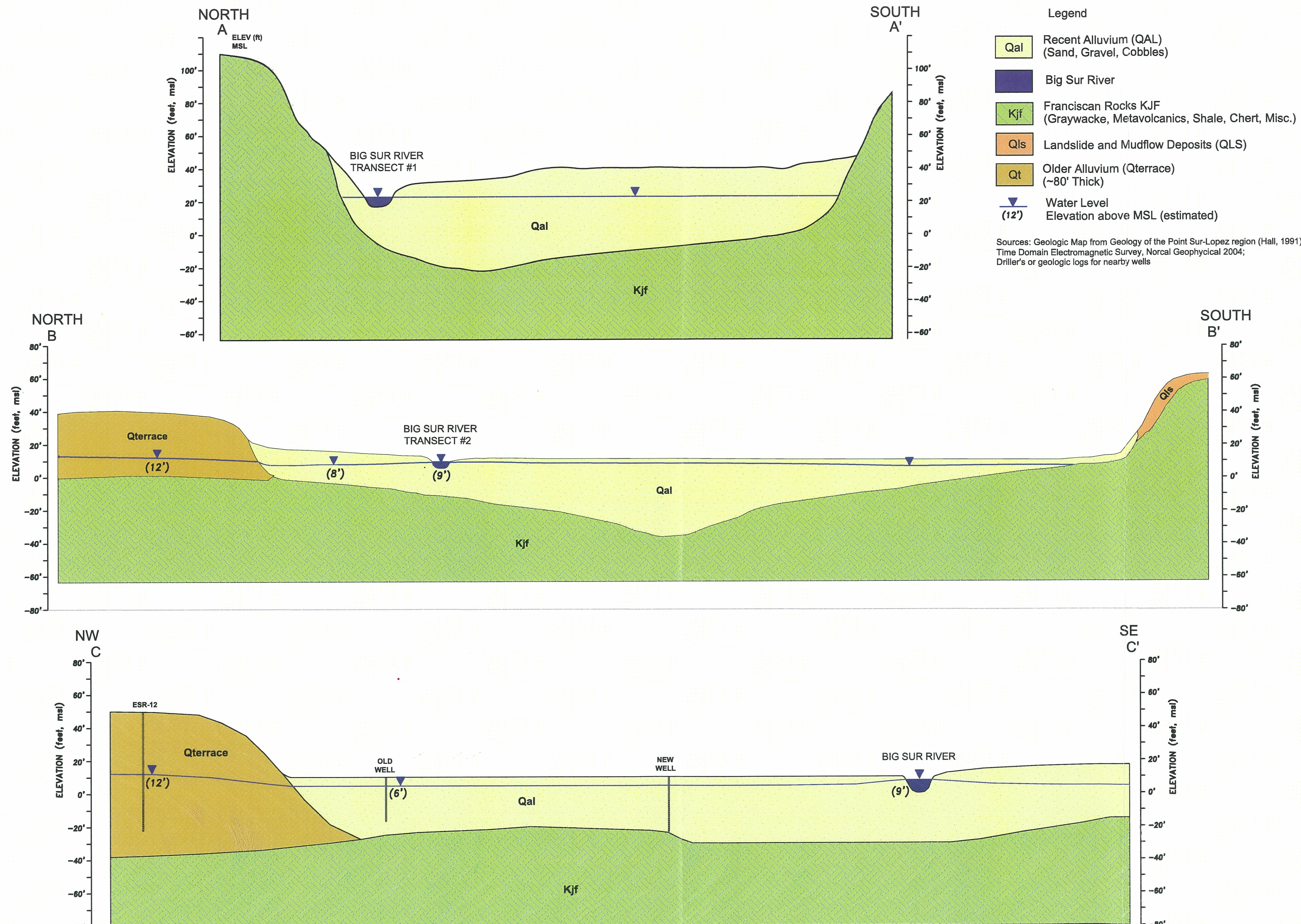
SGI environmental THE SOURCE GROUP, INC. 3451-C VINCENT ROAD PLEASANT HILL, CA 94523	EL SUR RANCH BIG SUR, CALIFORNIA			QUATERNARY ALLUVIUM IN STUDY AREA	
	DATE 05/09/2011	DR. BY ZA	APP. BY PH	PROJECT NO. 01-ESR-007	FIGURE NO. 4-3c

ESR--2

EXHIBIT ESR-2 Testimony of Paul D. Horton, PG., C.HG.



SGI environmental — THE SOURCE GROUP, INC. 3451-C VINCENT ROAD PLEASANT HILL, CA 94523	EL SUR RANCH BIG SUR, CALIFORNIA	SCALE 0 500 1000 SCALE IN FEET	FIGURE 4-4 CROSS SECTION LOCATION MAP
	PROJECT NO. 01-ESR-007 / DATE 05/09/2011	DR. BY SB / APP. BY SM	



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PLEASANT HILL, CA 94523

EL SUR RANCH
BIG SUR, CALIFORNIA

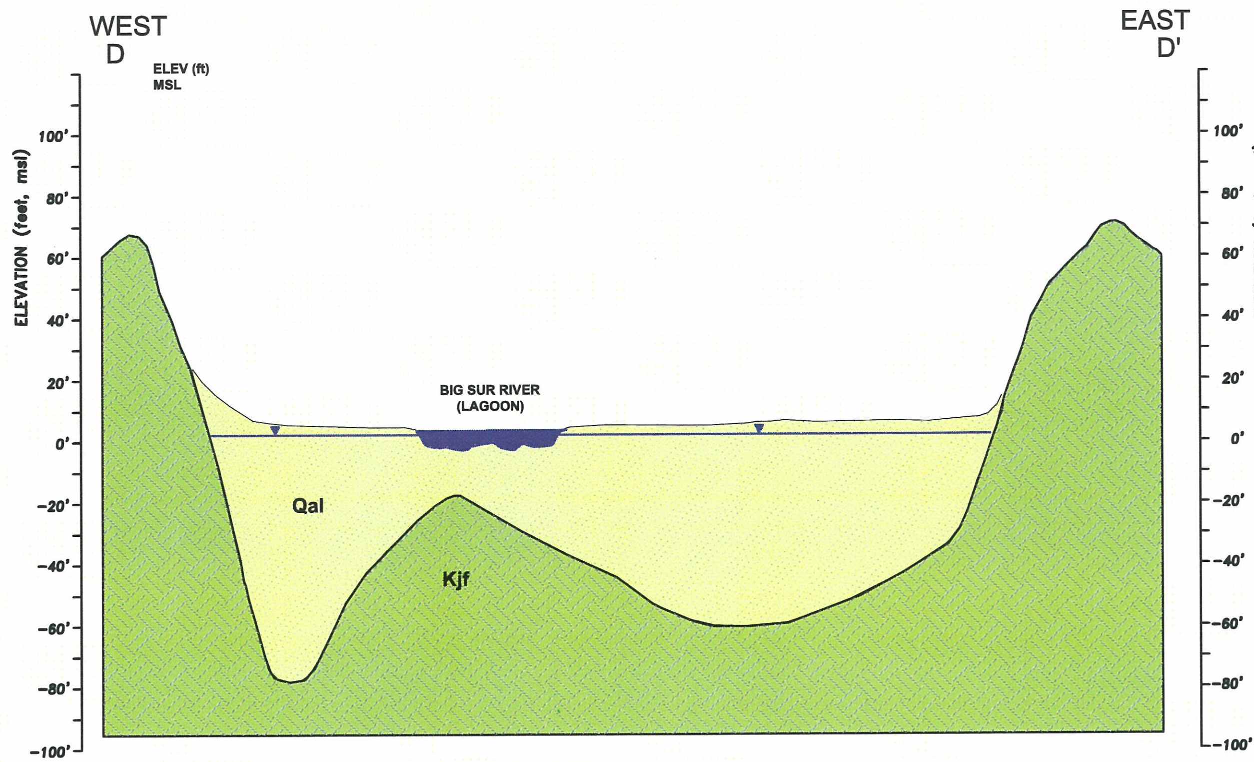
SCALE
0 200 400
SCALE IN FEET

PROJECT NO.	DATE	DR. BY	APP. BY
01-ESR-007	05/09/2011	SB	SM

FIGURE 4-5

CROSS SECTION A-A' THRU C-C'

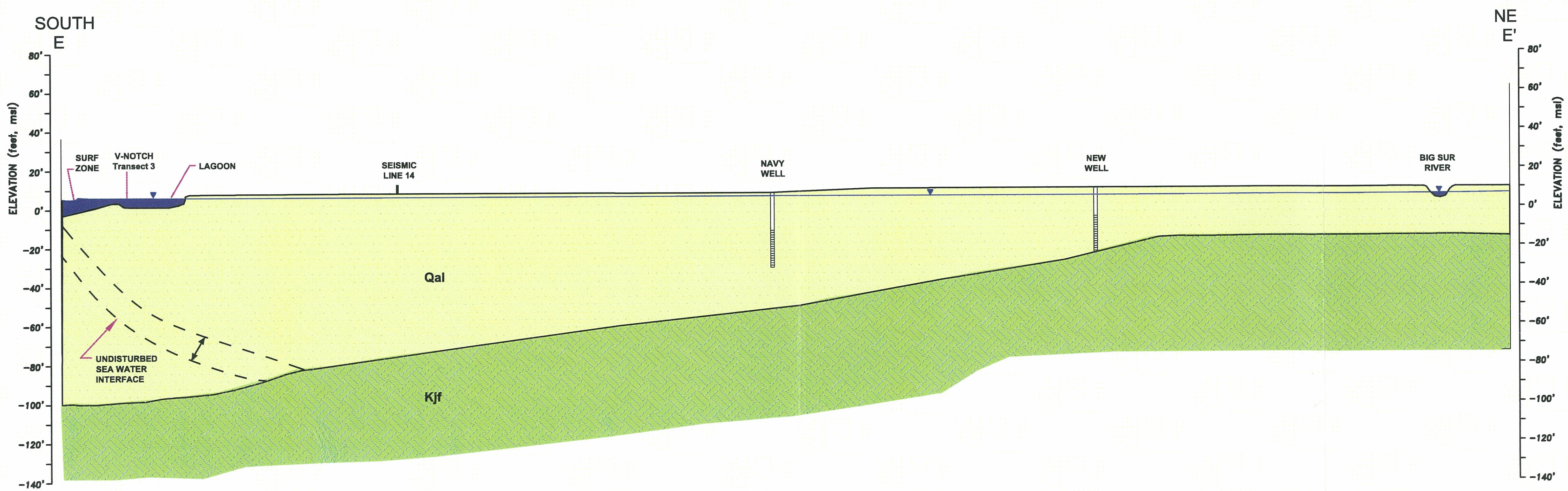
ESR--2



Legend

- Qal: Recent Alluvium (QAL) (Sand, Gravel, Cobbles)
- Big Sur River
- Kjf: Franciscan Rocks KJF (Graywacke, Metavolcanics, Shale, Chert, Misc.)
- Qt: Older Alluvium (Qterrace) (~80' Thick)
- Water Level

Sources: Geologic Map from Geology of the Point Sur-Lopez region (Hall, 1991); Time Domain Electromagnetic Survey, Norcal Geophyical 2004; Driller's or geologic logs for nearby wells



SGI environmental THE SOURCE GROUP, INC. 3451-C VINCENT ROAD PLEASANT HILL, CA 94523	EL SUR RANCH BIG SUR, CALIFORNIA	SCALE 0 200 400 SCALE IN FEET		FIGURE 4-6 CROSS SECTION D-D' THRU E-E'
		PROJECT NO. 01-ESR-007	DATE 05/09/2011	DR. BY SB / APP. BY SM

ESR--2

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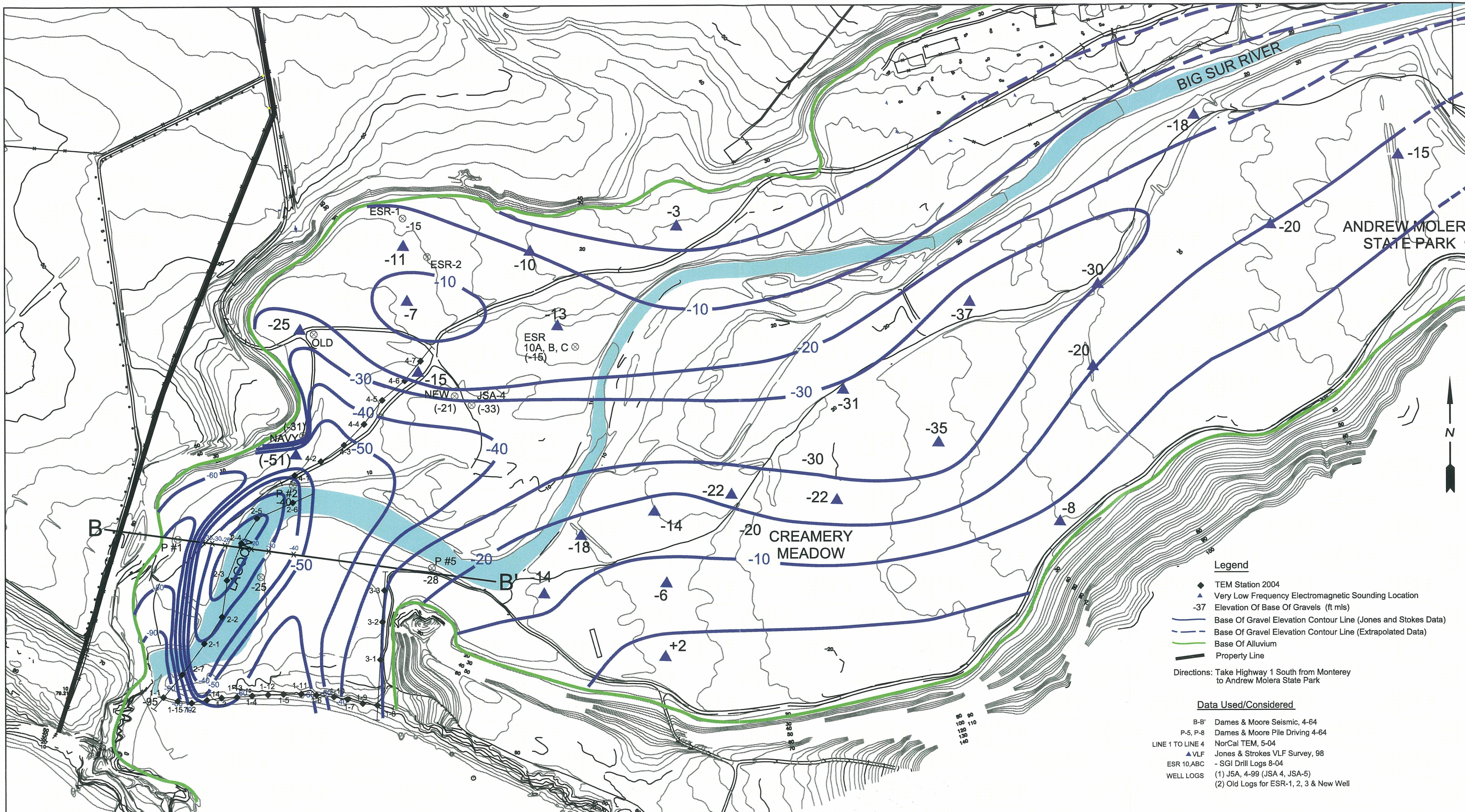

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3451-C VINCENT ROAD
PLEASANT HILL, CA 94523

EL SUR RANCH
BIG SUR, CALIFORNIA

SCALE 0 150 300 600 APPROXIMATE SCALE FEET

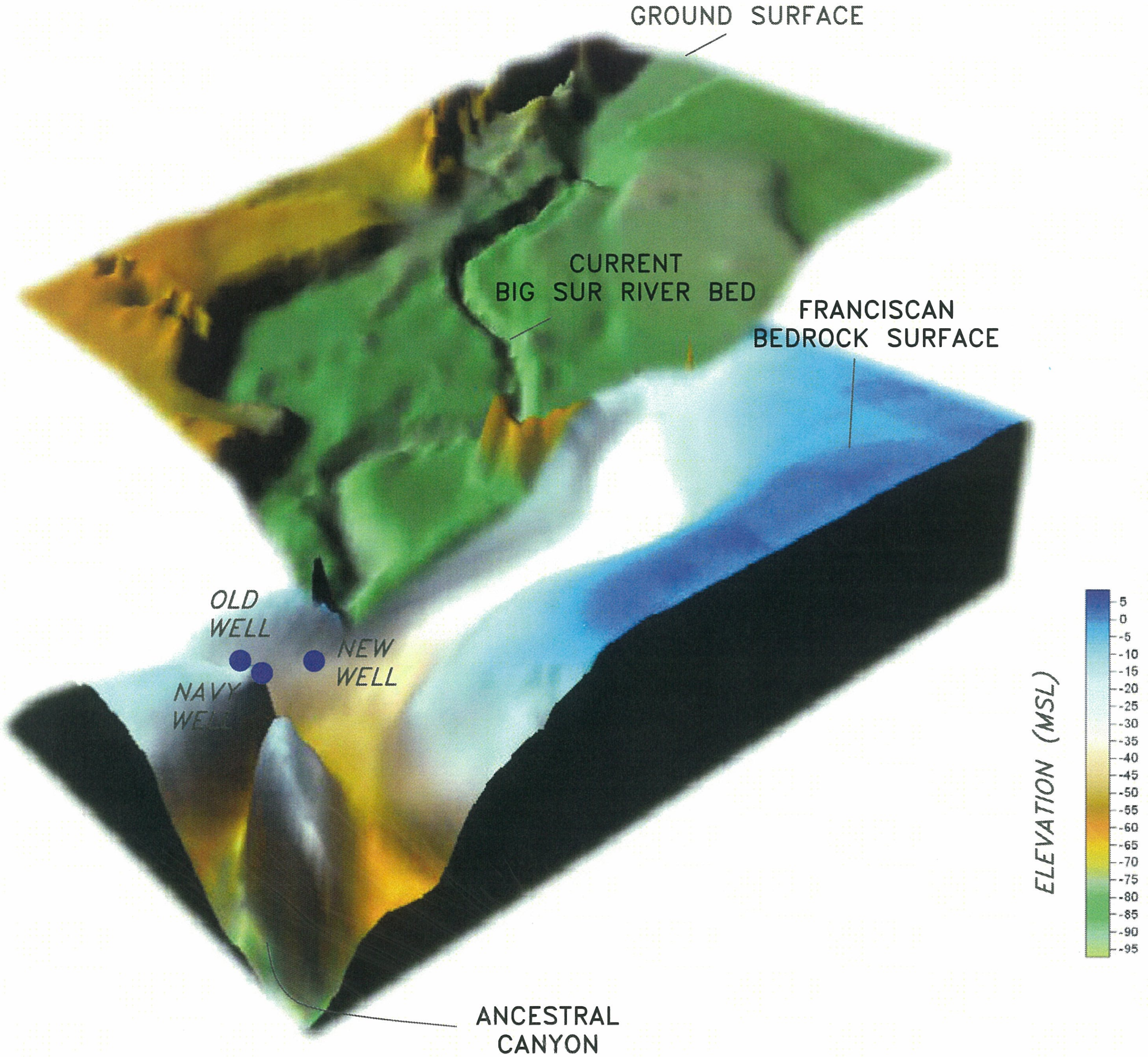
FIGURE 4-7

BASE OF AQUIFER ELEVATION MAP

PROJECT NO.	DATE	DR. BY	APP. BY
01-ESR-007	05/09/2011	MM	KT

EXHIBIT ESR-2 Testimony of David Horton, PG., C.HG.

ESR-2



Vertical Exaggeration (ground surface) approx. 5X

Vertical Exaggeration (bedrock surface) approx. 10X

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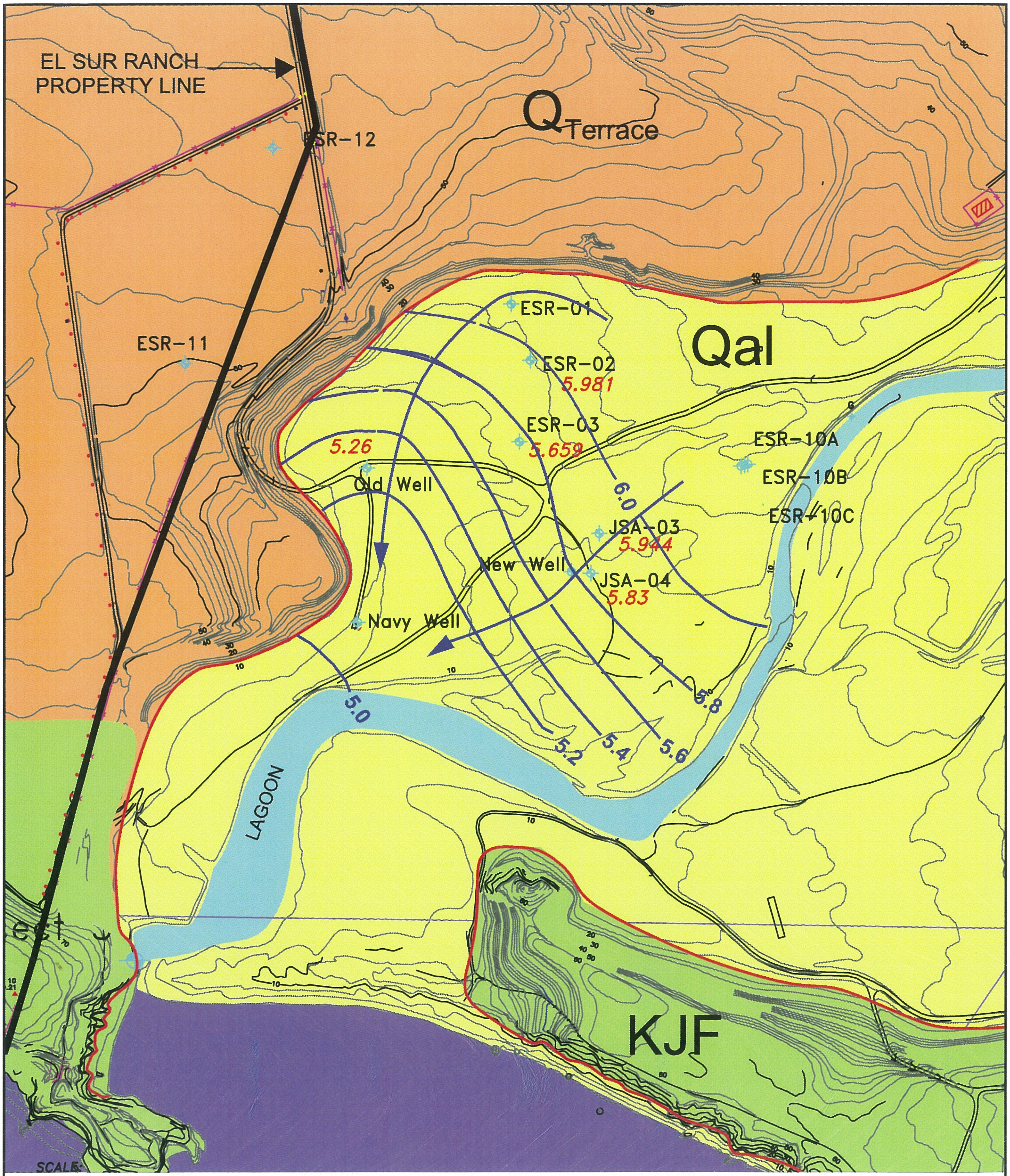
PLEASANT HILL, CA 94523

EL SUR RANCH
BIG SUR, CALIFORNIA

3D REPRESENTATION OF BEDROCK & GROUND SURFACES

DATE	DR. BY	APP. BY	PROJECT NO.	FIGURE NO.
05/09/2011	SB	PH	01-ESR-001	4-8



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PLEASANT HILL, CA 94523

EL SUR RANCH BIG SUR, CALIFORNIA			GROUNDWATER ELEVATION MAP APRIL 15, 2004 PRE-PUMPING	
DATE 05/09/2011	DR. BY SB	APP. BY PH	PROJECT NO. 01-ESR-007	FIGURE NO. 2-9

ESR--2

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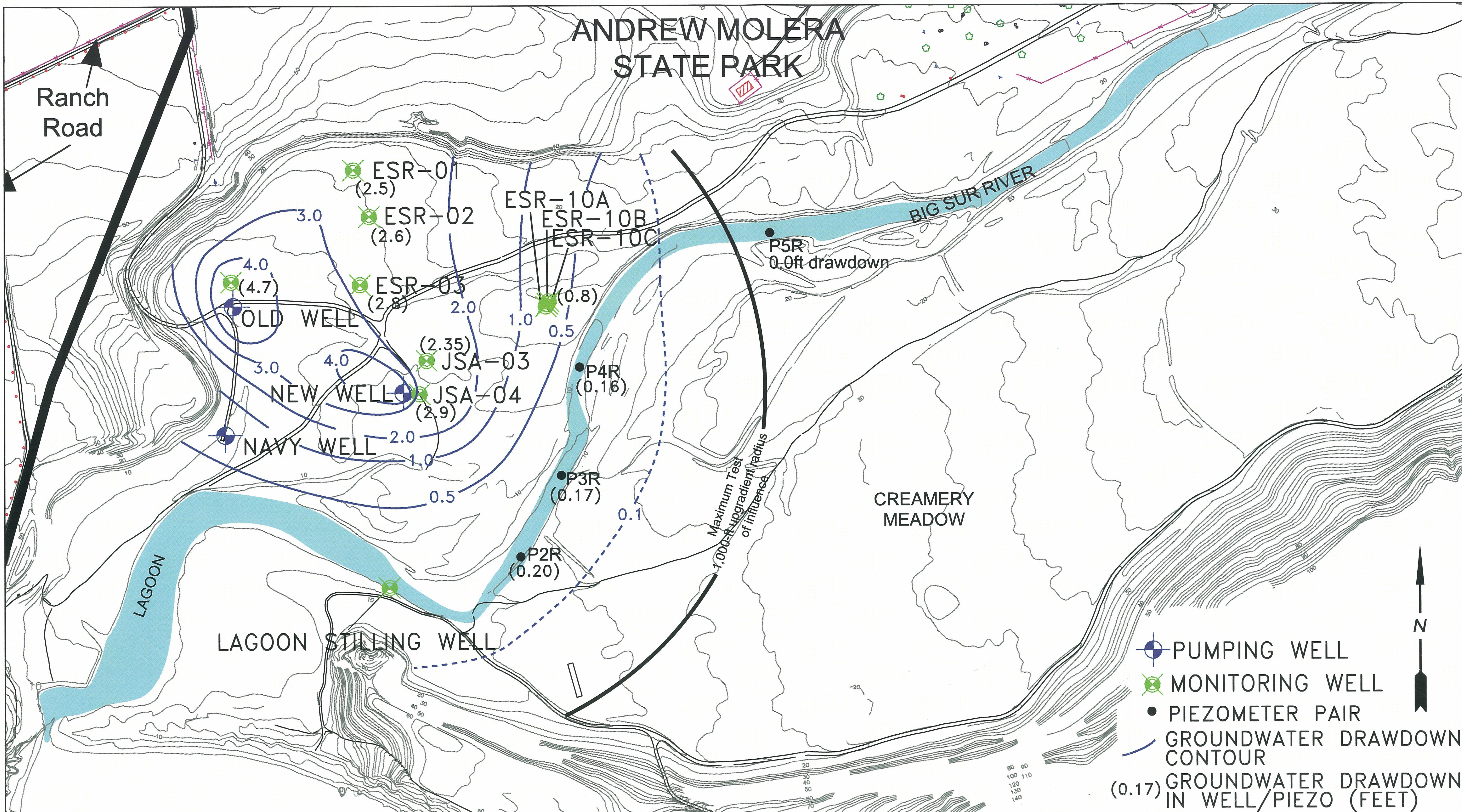

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PLEASANT HILL, CA 94523

EL SUR RANCH
BIG SUR, CALIFORNIA

SCALE
0 250 500
SCALE IN FEET

PROJECT NO.	DATE	DR. BY	APP. BY
01-ESR-007	05/09/2010	ML/JP	PH

FIGURE 4-10

2006 IRRIGATION WELL RADIUS OF INFLUENCE AND GROUNDWATER DRAWDOWN MAP (MAXIMUM PUMPING CONDITIONS DEPICTED)

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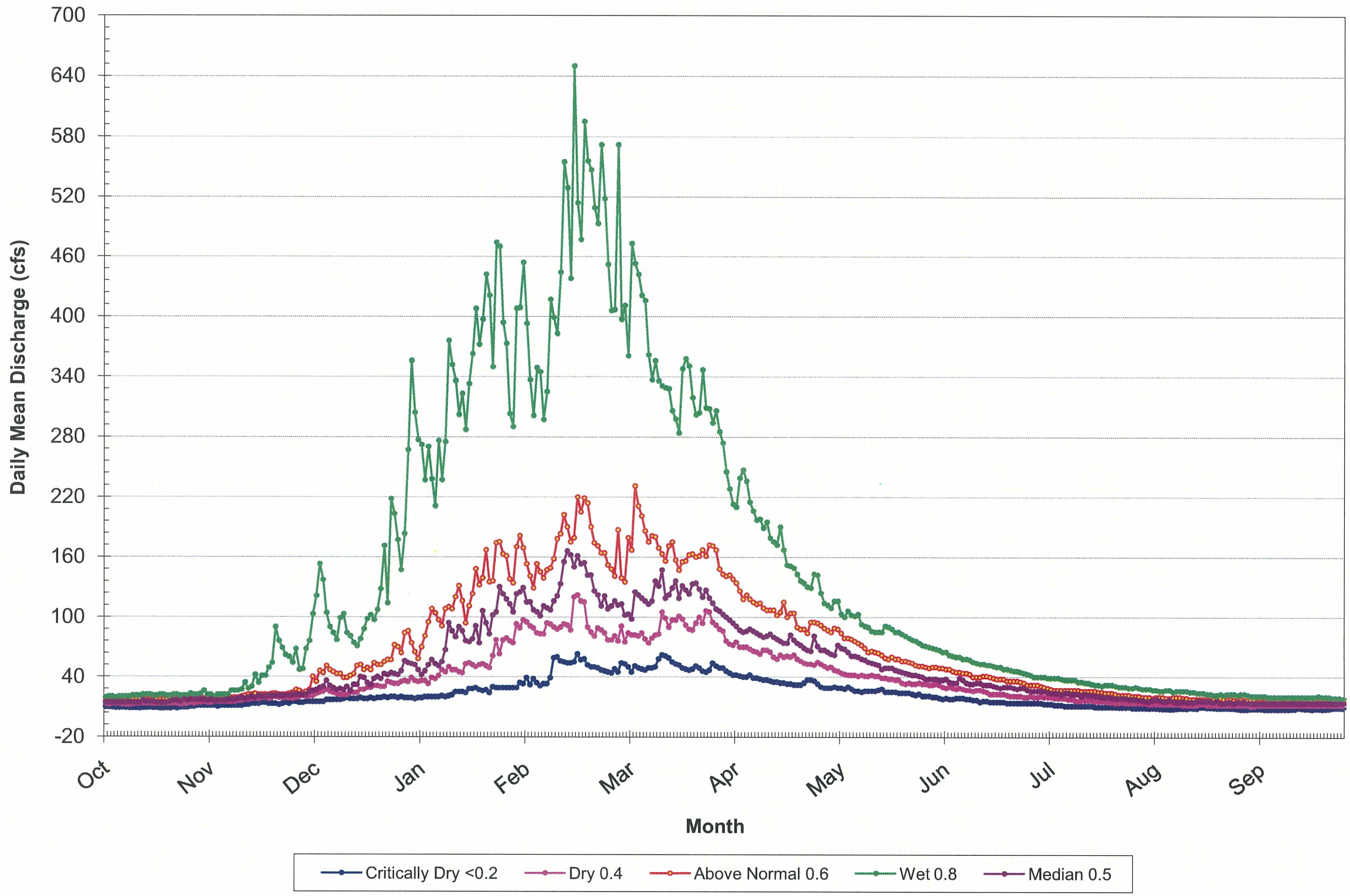
ESR-2

Figure 5-1
Daily Mean Discharge - Annual
54 Year Non-Exceedance Flow Criteria - Data from USGS
Gauging Station #11143000, Big Sur River, near Big Sur, California
El Sur Ranch
Big Sur, California



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Testimony of Paul D. Horton, P.G., C.HG.

ESR--2

Figure 5-2
Daily Mean Discharge - July through October
54 Year Based Non-Exceedance (July-October) - Data from USGS
Gauging Station #11143000, Big Sur River, near Big Sur, California
El Sur Ranch
Big Sur, California

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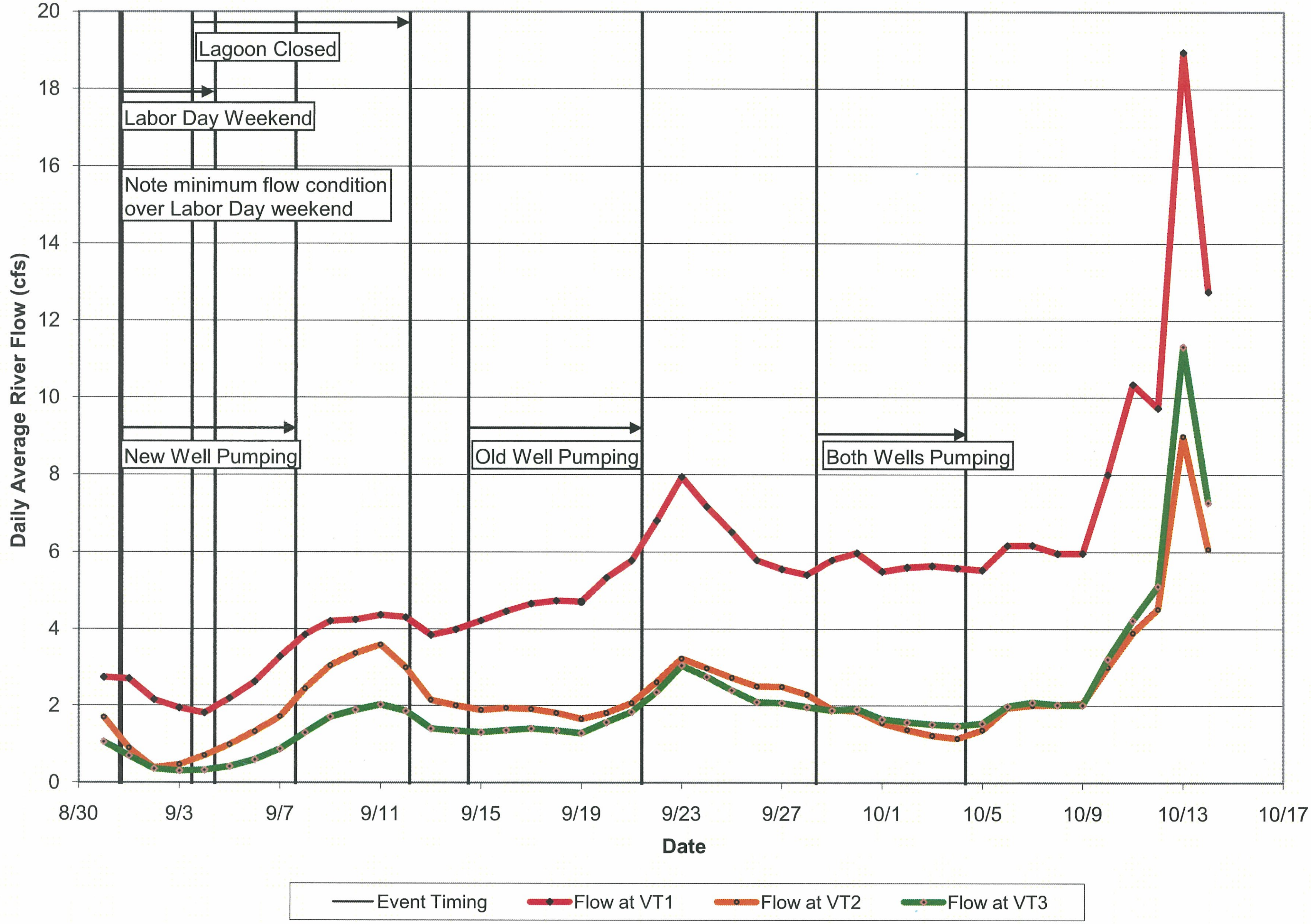
ESR--2

Figure 5-3
Daily Average River Flow
2007 Study Season
El Sur Ranch
Big Sur, California



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Testimony of Paul D. Horton, P.G., C.HG.

Figure 5-4
USGS Gauge Flow Correlation to VT3
El Sur Ranch
Big Sur, California

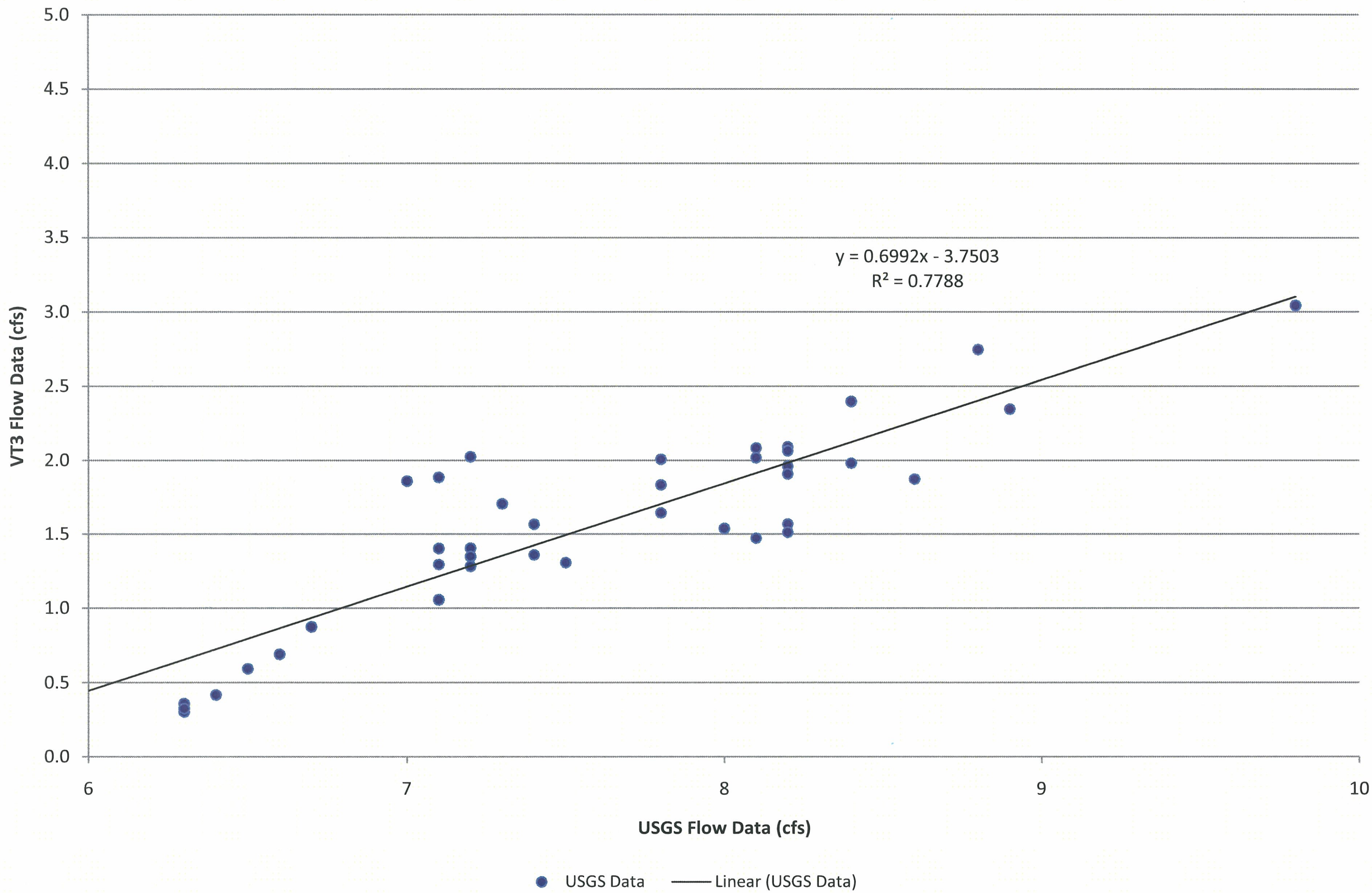

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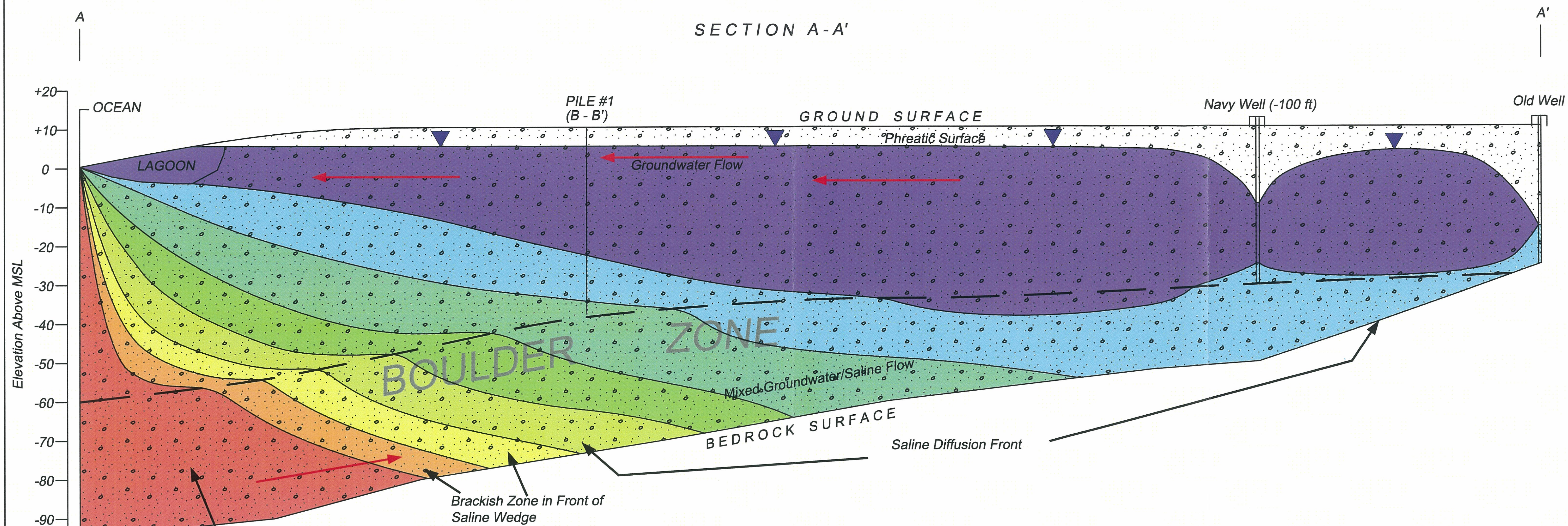
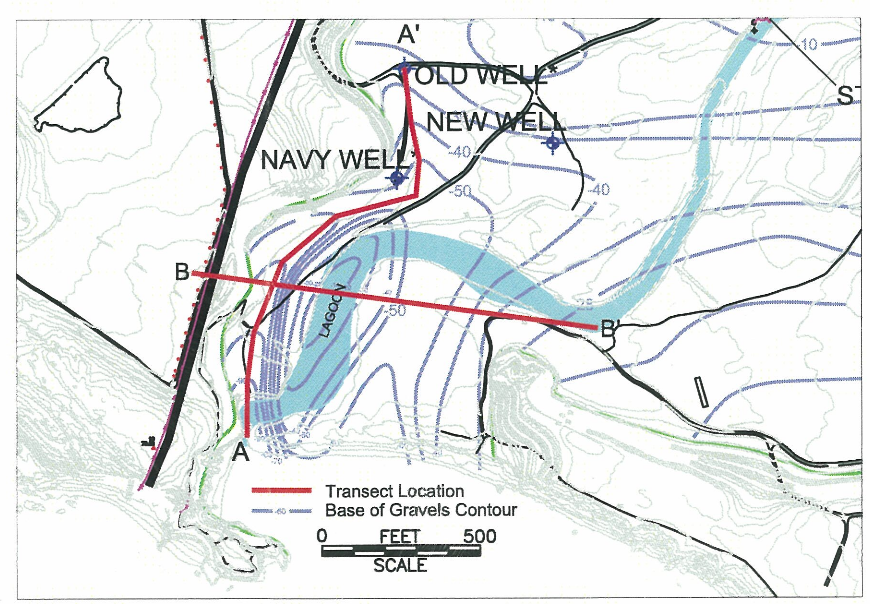
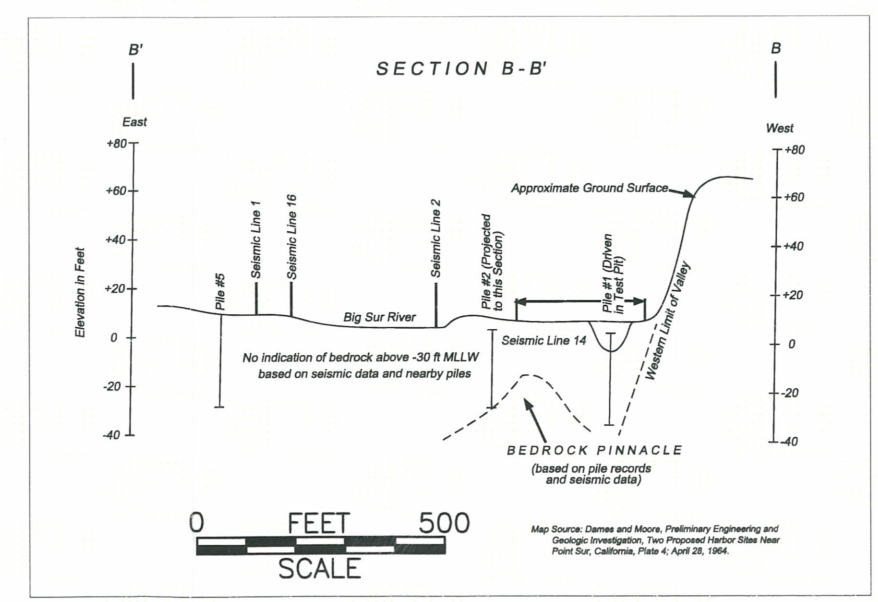
EXHIBIT ESR-2
Testimony of Paul D. Horton, P.G., C.HG.

ESR--2







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PLEASANT HILL, CA 94523

EL SUR RANCH
BIG SUR, CALIFORNIA

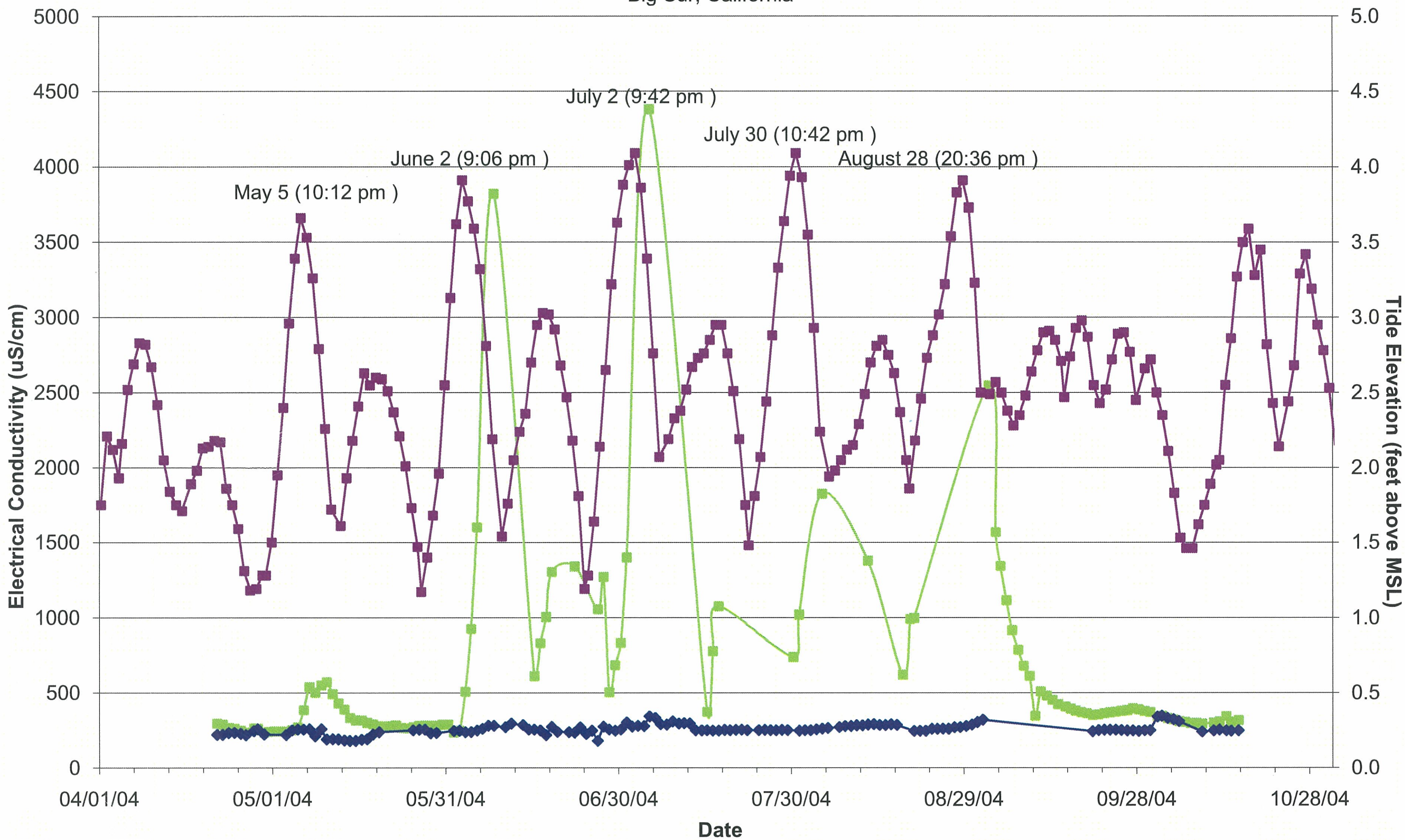
0 50 100 200
APPROXIMATE HORIZONTAL SCALE (FEET)
4X VERTICAL EXAGGERATION

PROJECT NO.	DATE	DR. BY	APP. BY
01-ESR-007	05/09/2011	JP	PH

FIGURE 6-1

CONCEPTUALIZED VIEW OF SALTWATER INTRUSION

Figure 6-2
Spring Tide Effects on Electrical Conductivity in Old Well - 2004
El Sur Ranch
Big Sur, California



Elevated conductivity measurements in Old Well are preceeded by a spring tide event. Note that New Well

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Testimony of Paul D. Horton, P.G., C.HG.

ESR--2

Figure 7-1
Aquifer Response Hydrograph - Well JSA-4 - 2006
El Sur Ranch
Big Sur, California

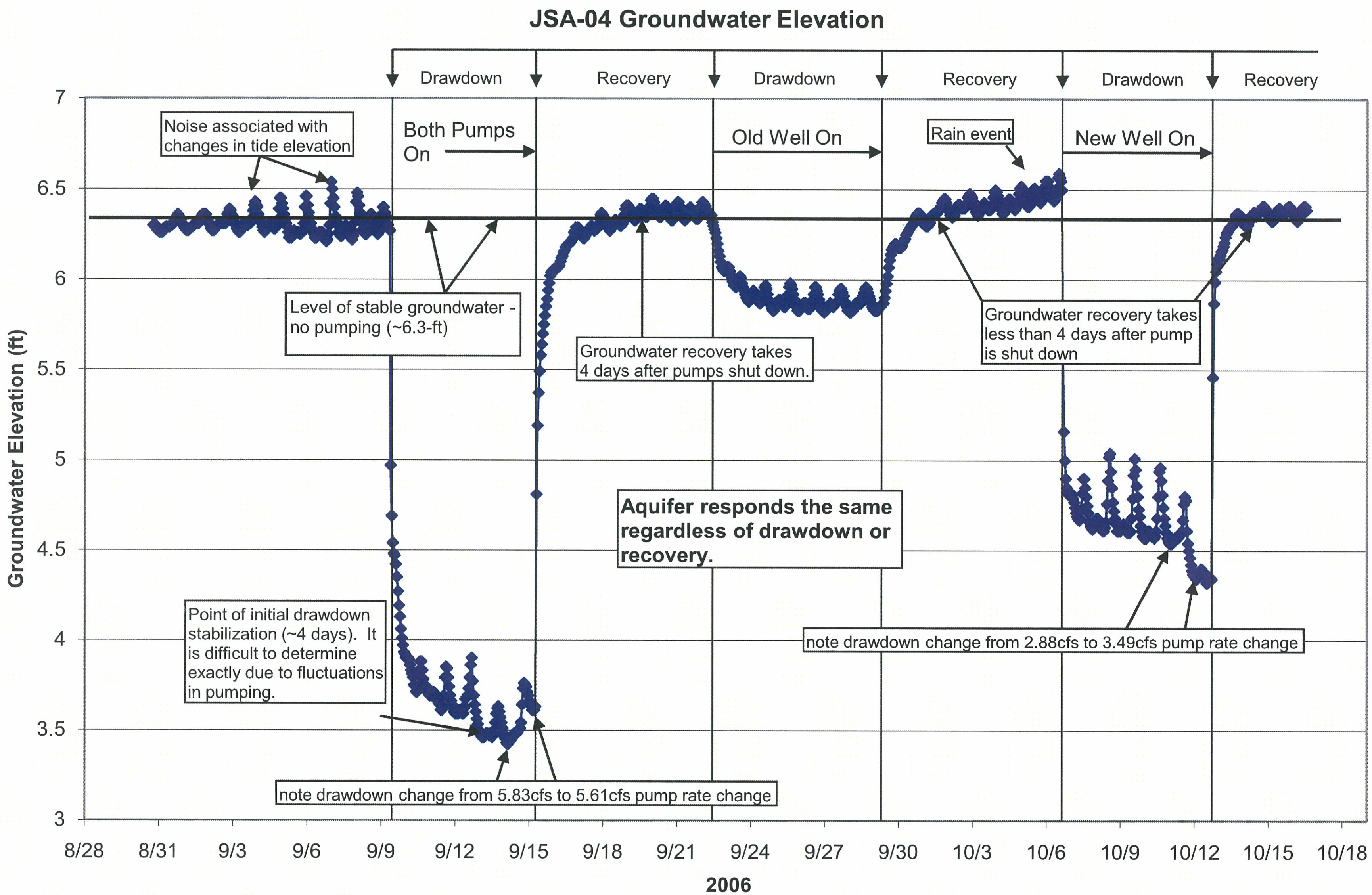

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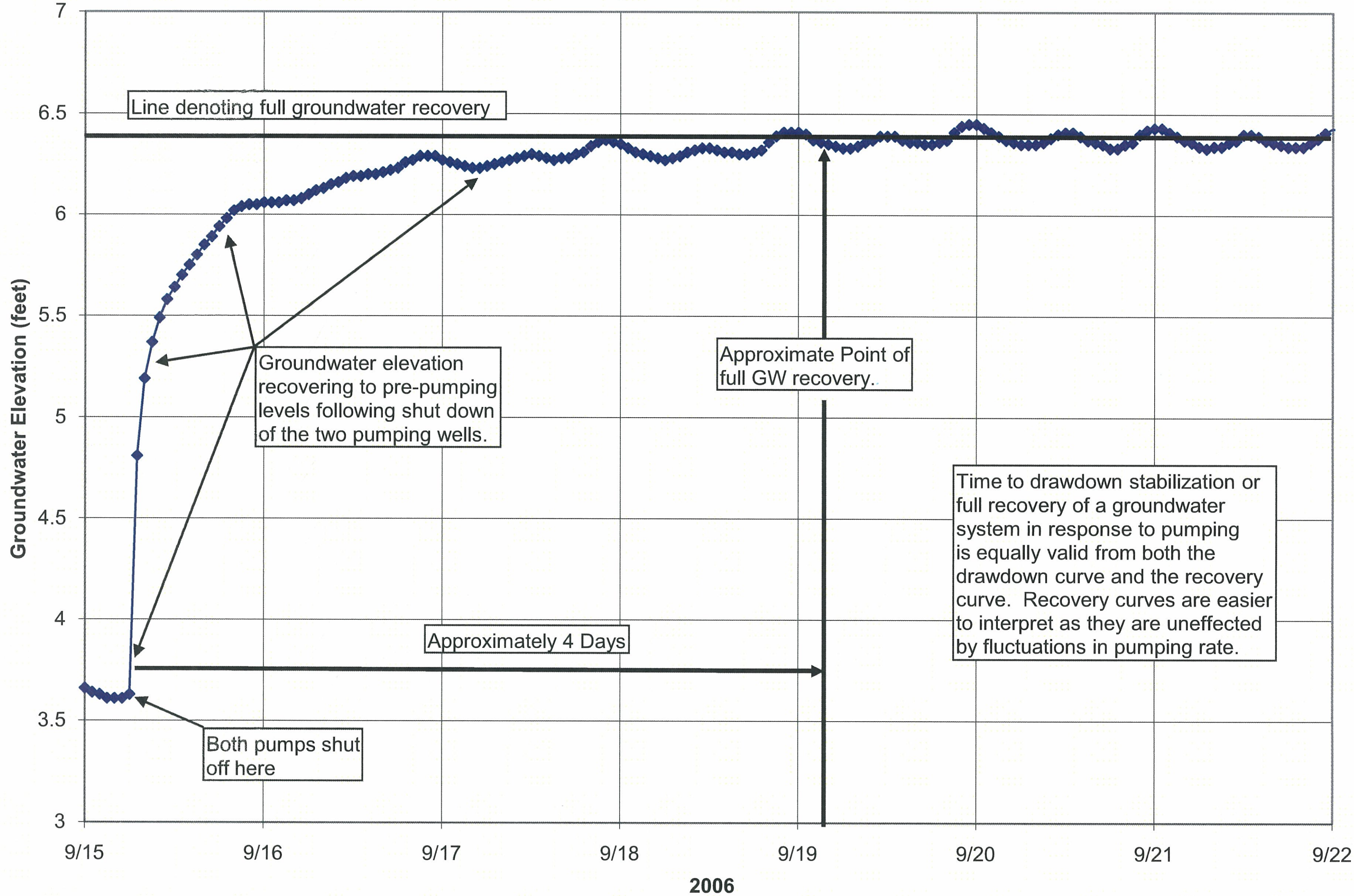
Figure 7-2
Focused Aquifer Recovery Hydrograph - Well JSA-4 - 2006
El Sur Ranch
Big Sur, California



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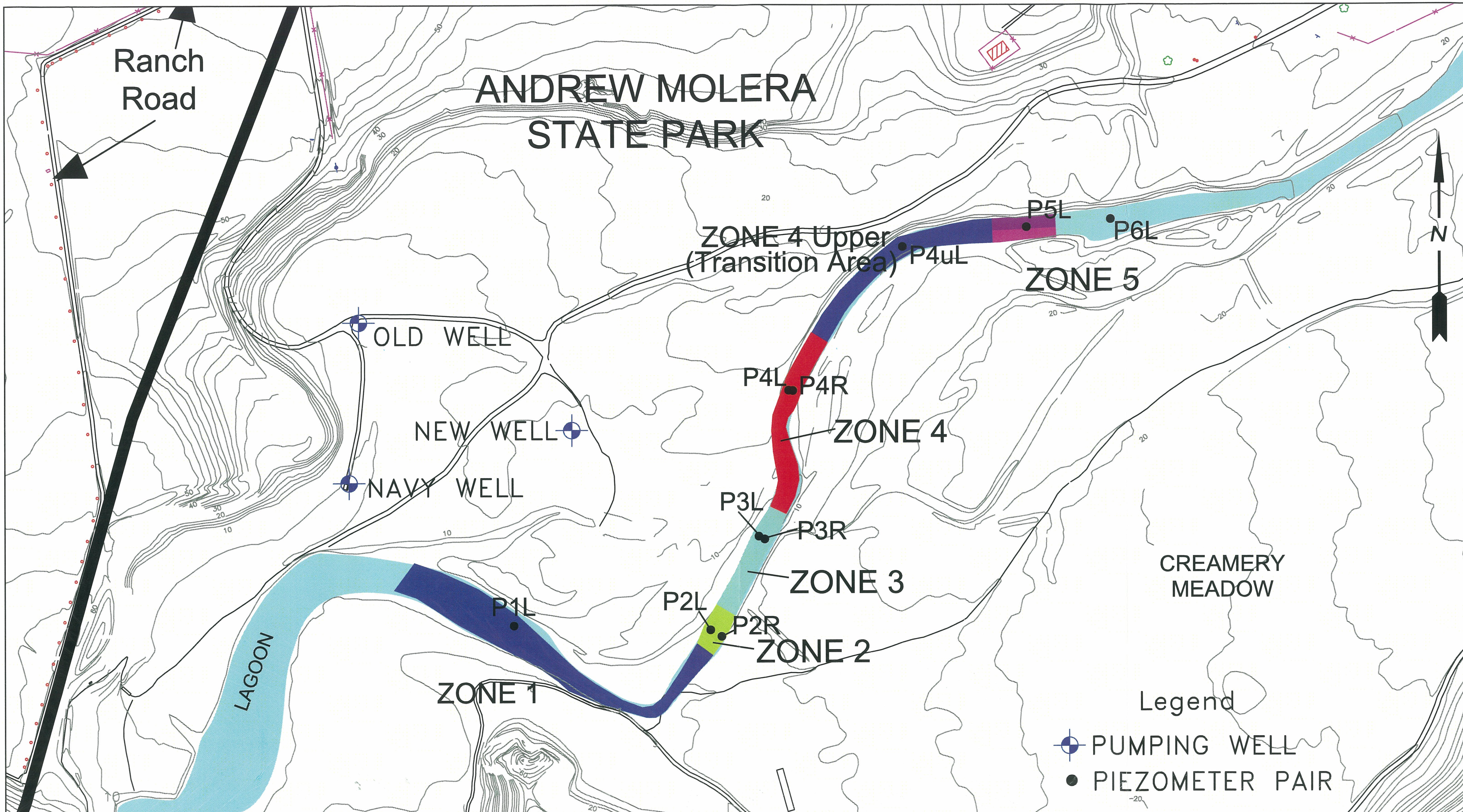

SGI environmental THE SOURCE GROUP, INC. 3451-C VINCENT ROAD PLEASANT HILL, CA 94523	EL SUR RANCH BIG SUR, CALIFORNIA	SCALE 0 200 400 SCALE IN FEET	FIGURE 8-1 INTERPRETED STREAMBED FLUX ZONES - 2007
PROJECT NO. 01-ESR-007	DATE 05/09/2011	DR. BY ML/JP	APP. BY PH

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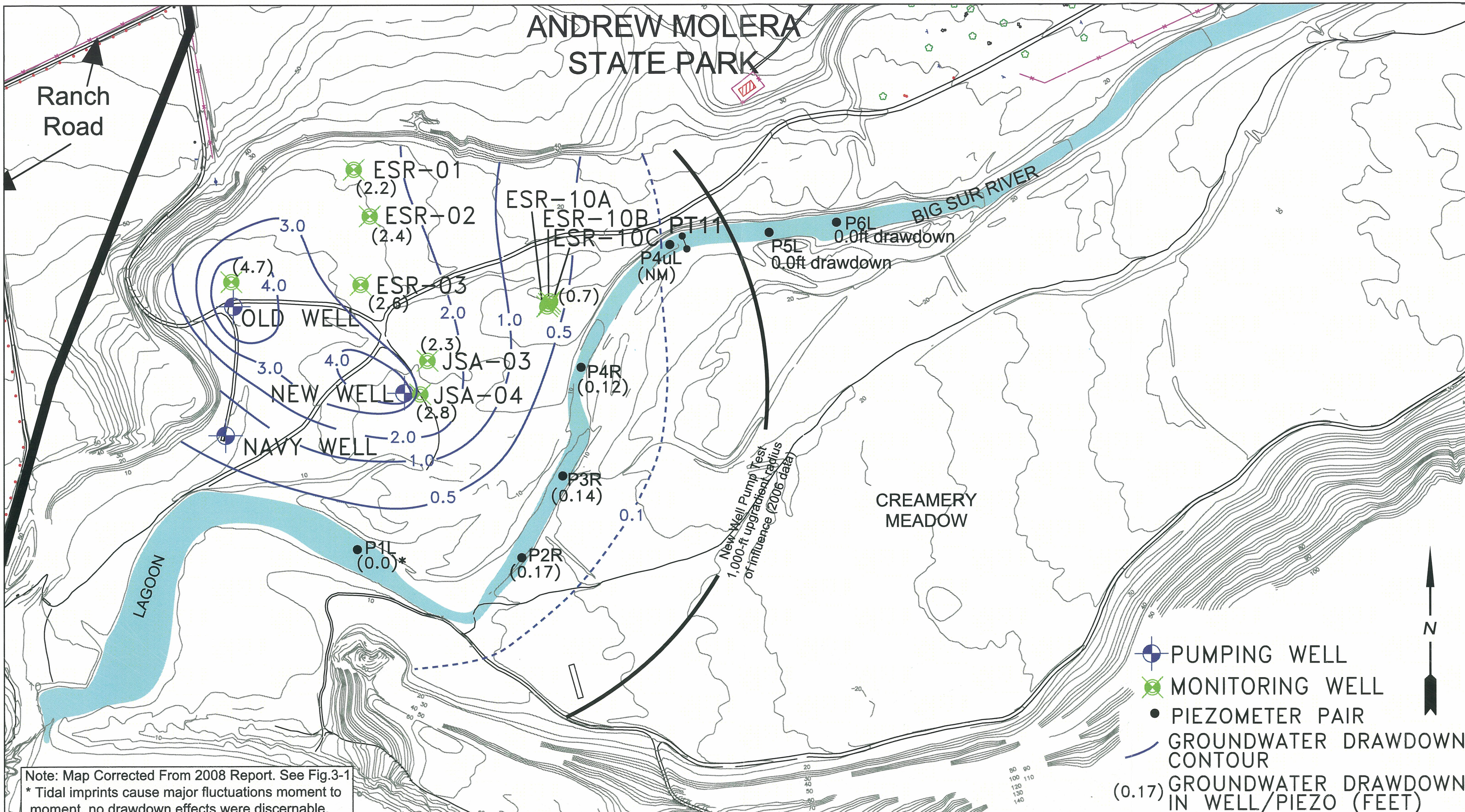
ESR-2



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EL SUR RANCH
BIG SUR, CALIFORNIA

SCALE 0 250 500 SCALE IN FEET

FIGURE 9-1

2007 DRAWDOWN AND RADIUS OF INFLUENCE MAP

PROJECT NO.	DATE	DR. BY	APP. BY
01-ESR-007	05/09/2011	ML/JP	PH

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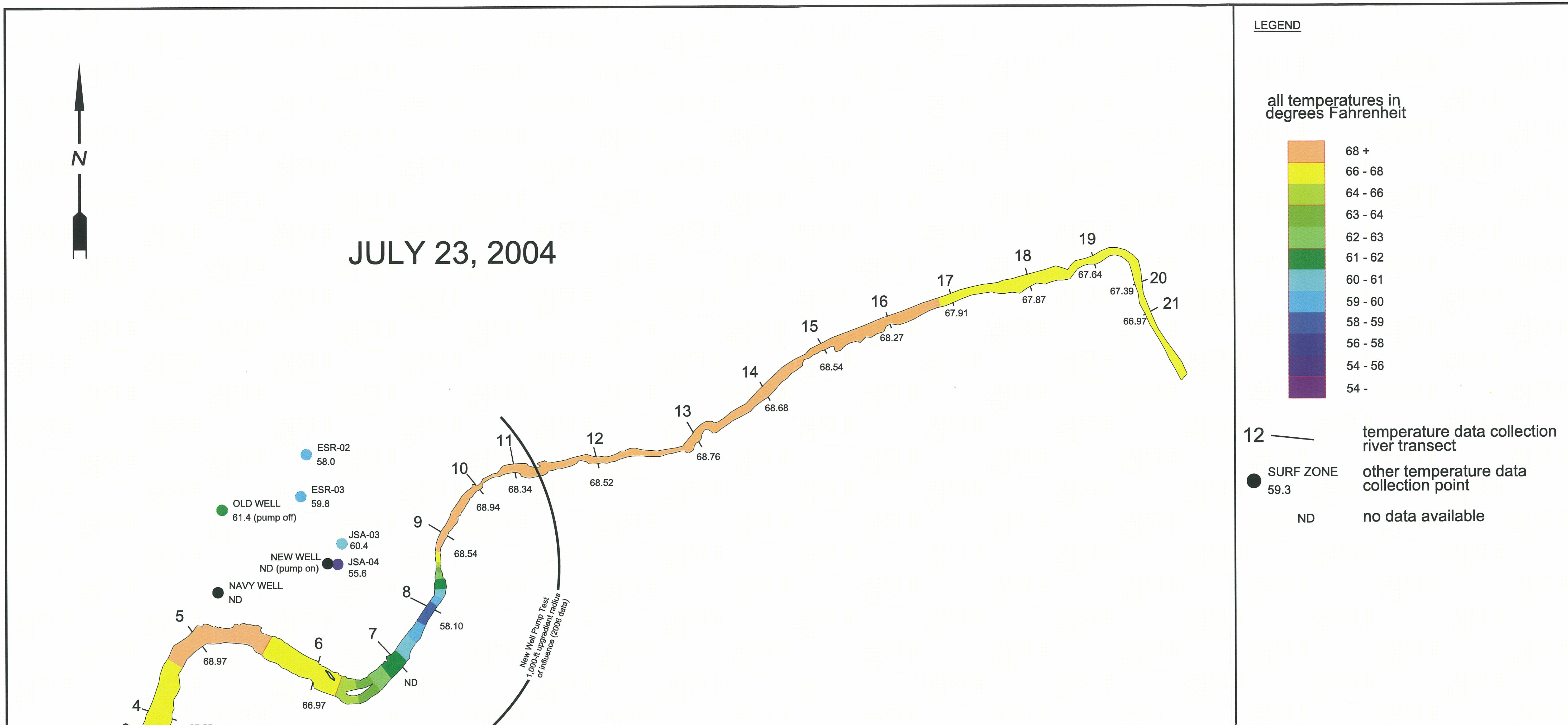

FIGURE 10-1

RIVER TEMPERATURE PROFILE - 2004

EL SUR RANCH
BIG SUR, CALIFORNIA

PROJECT NO.	DATE	DRAWN BY:	APP. BY:
01-ESR-007	05/09/2011	JP	PH

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ESR-2

TABLE

Table 7-1
Simplified Annual Water Balance Analysis - Big Sur Watershed
El Sur Ranch

Upper Big Sur Watershed					
			Volume (Ac-ft/yr)	**% of Total**	**Notes:**
IN	Rainfall (inches) 55	Area (Sq.Miles) 46.5	136,398	100.00%	Rainfall based on USGS 1996.
		Total In	**136,398**		
OUT	USGS Gauge Flow 101 cfs		73,121	53.61%	Average of USGS Gauge flow years 1951-2004. Equals 53.61% of Precipitation.
	Evapotranspiration (ET) 46.39% of Precipitation		63,277	46.39%	Solved for in the water balance.
		Total Out	**136,398**		Note: Total IN must match Total OUT

Lower Big Sur Watershed					
			Volume (Ac-ft/yr)	**% of Total**	**Notes:**
IN	USGS Gauge River Flow 101 cfs		73,121	74.58%	Average of USGS Gauge flow years 1951-2004.
	Rainfall (inches) 39.15	Area (Sq.Miles) 11.9	24,847	25.34%	Based on State Park rain gauge (NRCE, March 2005).
	Return Flow 0.1 cfs		72	0.07%	Calculated by Jones and Stokes, 1998 for Watershed above Andrew Molera State Park.
		Total In	**98,040**		
OUT	Runoff + Underflow to Ocean		85,442	87.15%	Solved for in the water balance.
	Evapotranspiration (ET) 46.39% of Precipitation		11,527	11.76%	Based on ET for Upper Watershed calculated above.
	Diversions and Basin Exports above Transect 1		94	0.10%	Calculated by Jones and Stokes, 1998 for Watershed above Andrew Molera State Park.
	Total Diversions Below Transect 1		977	1.00%	Average calculated ESR pumping rate 1975-2004 (NRCE, Jan 7, 2005) plus estimated annual navy well rate of 40 ac-ft/year.
		Total Out	**98,040**		Note: Total IN must match Total OUT

Total Watershed					
			Volume (Ac-ft/yr)	**% of Total**	**Notes:**
IN	Rainfall (inches)	Area (Sq.Miles)			
	55	46.5	136,398	84.55%	Upper Watershed
	39.15	11.9	24,847	15.40%	Lower Watershed
	Return Flow to Lower Water Shed		72	0.04%	Calculated by Jones and Stokes, 1998 for Watershed above Andrew Molera State Park.
		Total In	**161,317**		
OUT	Runoff + Underflow to Ocean		85,442	52.97%	Taken from lower watershed balance above.
	Evapotranspiration (ET) 46.39% of Precipitation		74,804	46.37%	Solved for in the water balance representing blended ET for entire watershed.
	Diversions and Basin Exports above Transect 1		94	0.06%	Calculated by Jones and Stokes, 1998 for Lower Watershed.
	Total Diversions Below Transect 1		977	0.61%	Average calculated ESR pumping rate 1975-2004 (NRCE, Jan 7, 2005) plus estimated annual Navy well rate of 40 Ac-ft/year.
		Total Out	**161,317**		Note: Total IN must match Total OUT

APPENDIX A

PAUL HORTON CURRICULUM VITAE
(EXHIBIT ESR-2)

Paul D. Horton, P.G., C.HG.

Principal Hydrogeologist

Hydrogeologic/ Hydrologic Expertise

River-Aquifer Dynamics
Hydrogeologic Conceptual Models
Watershed Evaluation
Water Balance Evaluations
Aquifer Pumping Tests
Tracer Studies
Flow Simulations
Fate and Transport Modeling
Mass Flux Calculation
3-D Visualization

Summary

I am a Principal Hydrogeologist and Chairman of the Board of Directors for The Source Group, Inc., a full service hydrogeologic and environmental consulting firm that I co-founded in 1997. I received a Bachelor of Science (B.Sc.) degree in geology with an emphasis in chemistry from Olivet Nazarene University in 1984. I was awarded the Amoco Fellowship in Geophysics to attend Western Michigan University in 1984 and received a Master of Science (M.S.) degree in geology with an emphasis in geophysics and contaminant hydrogeology in 1987. I am registered in California and Oregon as a Professional Geologist and am additionally registered in California as a Certified Hydrogeologist.

I have over twenty four years of applied experience working in California and throughout the nation in both the technical and management aspects of hydrogeologic evaluation and environmental projects. As an expert Hydrogeologist, I have constantly been involved in the general evaluation of hydrogeologic systems from the local scale to the large watershed scale. I have been conducting intense field studies and extensive data analysis of the interaction of the hydrologic and hydrogeologic systems of the Big Sur River steadily for the last seven years. This work has been documented in detail in three separate reports beginning in 2004, the results of which are summarized in this Declaration.

In addition to extensive study of the Big Sur River, I have worked as a specialist providing evaluation of complex hydrogeologic systems at sites across the United States. A few of the projects I have conducted relevant to work on the Big Sur River include the following:

Relevant Project Experience

Upper Sacramento River – Big Springs, Mount Shasta, CA – Work conducted over a period of 15 years has included watershed evaluation of the northern headwaters of the Sacramento River as it pertains to Big Springs in Mount Shasta. This work has included development of hydrogeologic conceptual models, water balance evaluations within the watershed, surface water flow studies, spring source recharge area determination, evaluation of river-aquifer dynamics at Big Springs, tracer testing confirming river-aquifer dynamic models, aquifer testing, evaluation of pumping radius of influence related to stream and spring flow, and isotopic source water provenance analysis.

Pinal Creek Basin, AZ – Work conducted over a period of 8 years of study included development of a complete watershed hydrogeologic and hydrologic conceptual model, development of a basin wide water balance model calibrated to 90 years of precipitation data in the basin, analysis of alluvial aquifer and stream water relationships specifically focused on water balance questions, evaluation of correlations between precipitation and alluvial aquifer responsiveness, 3-D groundwater flow modeling, and area specific 3-D data models representing geologic and chemical data. This work included detailed evaluations of groundwater-surface water relationships and evaluation of the nature of gaining and losing stream conditions over a 10 mile stretch of Pinal Creek. The work included evaluation of underflow discharge rates and history including correlation of underflow and surface flow in various portions of the watershed.

Arkansas River, Tulsa, OK – Continuing work conducted over the last 10 years has involved development of a complete hydrogeologic and hydrologic conceptual model for the Arkansas river and its hydraulic relationships to inflowing groundwater in the Tulsa area. Analysis has included development of a study area water balance, development of 3-D flow models of the coupled groundwater-river hydraulics, development of mass discharge model relating the migration of poor quality groundwater to resultant surface water quality impacts, and area specific 3-D data models representing geologic and chemical data. The work has included evaluation of underflow discharge rates and history including correlation of underflow and surface flow in the specific study area.

Relevant Project Experience *(Continued)*

Squaw Valley Creek, McCloud, CA - Work conducted over a period of 10 years included watershed evaluation of a main tributary of the McCloud River as it pertains to several major springs emanating from the flanks of Mount Shasta. Accomplishments include development of a conceptual hydrogeologic model, a spring source recharge area determination, documentation of spring and creek flow rates, evaluation of river-aquifer dynamics at Intake Springs, investigations to determine the specific nature of spring discharge defining the geologic and hydrogeologic conditions that create the spring emanation points, and isotopic source water provenance analysis.

Santa Cruz, CA - Conducted a comprehensive hydrogeologic study of an operating sand quarry near Santa Cruz, California. The work included collection and analysis of geologic and water quality data, development of a hydrogeologic conceptual model, development of a facility wide water balance model, development of 3-D representations of hydrogeologic conditions, Meetings with the local regulators and participation in round table meetings with local water resource management councils, preparation of information for distribution at a public meeting, and the presentation of results to the local water council were all a part of this project.

Lathrop CA Municipal Water Supply - Working over the last 8 years with the City of Lathrop as an expert hydrogeologist in support of their long term planning for their groundwater supply well field. This work has involved development of a complete hydrogeologic conceptual model, development of a 3-D groundwater flow model, evaluation and assessment of groundwater quality issues related to encroaching saline and other contaminated water, oversight of the coupling of the groundwater flow model with a pumping optimization model, and development of long term groundwater pumping plan for the City that optimizes both production and quality of their groundwater resource so that they can keep apace with their growth demands for water supplies.

Ripon CA Municipal Water Supply – Worked over a period of three years overseeing hydrogeologic support services that has involved development of a hydrogeologic conceptual model of the City and surrounding area, evaluation of water quality data, and evaluation of nitrate impact vulnerability for the future pumping of a new municipal supply well.

Education

M.S., Hydrogeology, Western Michigan University, 1986
B.S., Geology, Olivet Nazarene College, 1984

Registrations/Certifications

Professional Geologist, California (No. 5435)
California Certified Hydrogeologist (No. 581)
Registered Geologist, Oregon (No. G1522)
40-Hour OSHA Health & Safety Certification (29 CFR 1910.120.
8-Hour OSHA Supervisor's Certification

APPENDIX B

SALINE WATER INTRUSION MODELING DOCUMENTATION
(EXHIBIT ESR-3)

1.1 Saltwater Intrusion Modeling

Numerical modeling was conducted in 2004/2005 to further evaluate the conceptual hydrogeologic model with respect to the mechanism for seawater encroachment resulting in measured saline impacts in both the Navy Well and the Old Well. Specifically, information for the lower reach of the Big Sur River Valley gathered during this study was processed using the equations that describe groundwater flow physics in a coastal environment in an attempt to reproduce the observed groundwater quality distributions. The U.S. Geological Survey (USGS) SEAWAT-2000 model (Langevin et al., 2003) was used to simulate density-dependent groundwater flow and transport at the site during the irrigation season at the mouth of the Big Sur River. SEAWAT-2000 was chosen because it couples the variable-density fluid flow (using a modified version of MODFLOW-2000) and the transport of solutes that contribute to the density variation (using MT3DMS) into a single program for variable-density flow. MODFLOW-2000 and MT3DMS are industry standard USGS numerical models with wide acceptance within the scientific community. The area evaluated by the model (the model domain) is depicted in Figure B-1.

A multi-layered model was used for the simulation with 12-layers extending from 20 to minus-100 ft msl, with 10-foot grid spacing in all three coordinate directions. A total of 480,000 finite difference grid cells were used with 116,600 cells active. Because only flow through the alluvium was modeled, the surrounding rock was considered impermeable consistent with known site conditions. The inflow (east) and outflow (south) boundaries were represented as constant-head boundaries. The inflow boundary remained constant with time at 7 ft msl, while the outflow boundary varied in order to simulate tidal fluctuations. The outflow boundary heads were based on tide data during the period from June 15 to July 10, 2004 when a spring tide occurred (Figure B-2). A hydraulic conductivity value of 1,500 ft/d was applied throughout the shallow model area with a channel of higher conductivity gravels included in the deeper layers of the model along the north valley wall to simulate the boulder-filled channel (15,000 ft/d). Hydraulic Conductivity values were assumed to be the same in all three coordinate directions. The bottom surface of the model followed the interpreted bedrock surface as depicted on Figures B-3 and B-4. The aquifer thickness varied with location according to the bedrock elevation and the model calculated water table elevation. The following table summarizes other significant parameters used in the model.

Summary of Modeling Parameters El Sur Ranch	
Well Pumping Rates	
Old	1,800 gpm
New	1,800 gpm
Navy	0 gpm
Specific Storage	0.001
Specific Yield	0.15
Dispersivity	
Longitudinal	3 ft

Summary of Modeling Parameters El Sur Ranch	
Transverse (horizontal)	1 ft
Transverse (vertical)	0.3 ft
Sea Water Concentration	2.2 lb/ft^3

Evapotranspiration was not included in the model nor was recharge from or discharge to the river. The known condition of groundwater discharging into the river in the area adjacent to the pumping wells was approximated in the model by increasing well pumping rates in this preliminary model. Well pumping rates were simulated as 150% of the average operating rates in order to account for the water loss from the groundwater system due to upwelling into the river.

1.1.1 Saltwater Intrusion Modeling Results

Information for the lower reach of the Big Sur River gathered during this study was processed using equations that describe groundwater flow physics in a coastal environment in an attempt to reproduce the observed groundwater quality distributions and evaluate the physical viability of the interpreted mechanism for saltwater intrusion derived from analysis of site data. Such reproduction of water quality distributions is generally viewed as support for the validity of a conceptual model. The U.S. Geological Survey SEAWAT-2000 model (Langevin et al., 2003) was used to simulate density-dependent groundwater flow and transport at the site during the irrigation season at the mouth of the Big Sur River. The area evaluated by the model (the model domain) is depicted in Figure B-1.

The results of this preliminary and simplified modeling exercise are presented as a plan view map of the movement of a saline wedge and accompanying saline diffusion front towards the Old well (Figure B-5), and as a oblique view of the 3-D saline wedge and diffusion front as it moves preferentially towards pumping being conducted in the Old Well (Figure B-6). Figure B-6 presents the modeled three-dimensional image of the salinity plume depicting impacts reaching the Old Well following the time of peak spring tide following 26 days of the simulation.

Evaluation of the modeling results presented on these figures demonstrates how the salinity wedge and accompanying diffusion front migrates into the Old well area in response to the high spring tides, culminating with flow to the Old Well as the peak high spring tides are occurring. The shape of the ancestral canyon controls the movement of the salinity plume with salinity movement splitting around the subsurface knob located beneath the lagoon and preferentially takes the deeper path. The primary pathway for greater movement of the salinity plume towards the pumping wells is the deeper ancestral canyon on the northern boundary of the alluvial aquifer (Figure B-7). Prior to the occurrence of the tide exceeding the 3-foot level, modeling results depicted oscillation of the front of the salinity plume near the area of the Navy Well. As the tides exceeded 3 feet and approached the high of just over 4 feet, the salinity plume turned the corner and rapidly migrated to the Old Well in response to its pumping. The modeling results also indicate that the flow physics within the mouth of the river do not lend to any significant movement of the salinity plume to the New Well consistent with historical salinity data collected from the New Well.

In summary, the results of this modeling exercise confirms that the groundwater flow physics at the mouth of the Big Sur River as a result of the shape and depth of the aquifer bottom, the high hydraulic conductivities associated with a boulder zone at depth in the alluvium, the high summer spring tides combined with pumping stresses and the density driven flow of a saltwater wedge are completely consistent with the interpretation that salinity impacts to the Navy and Old Wells are the result of subsurface saltwater intrusion and the movement of its accompanying diffusion front.

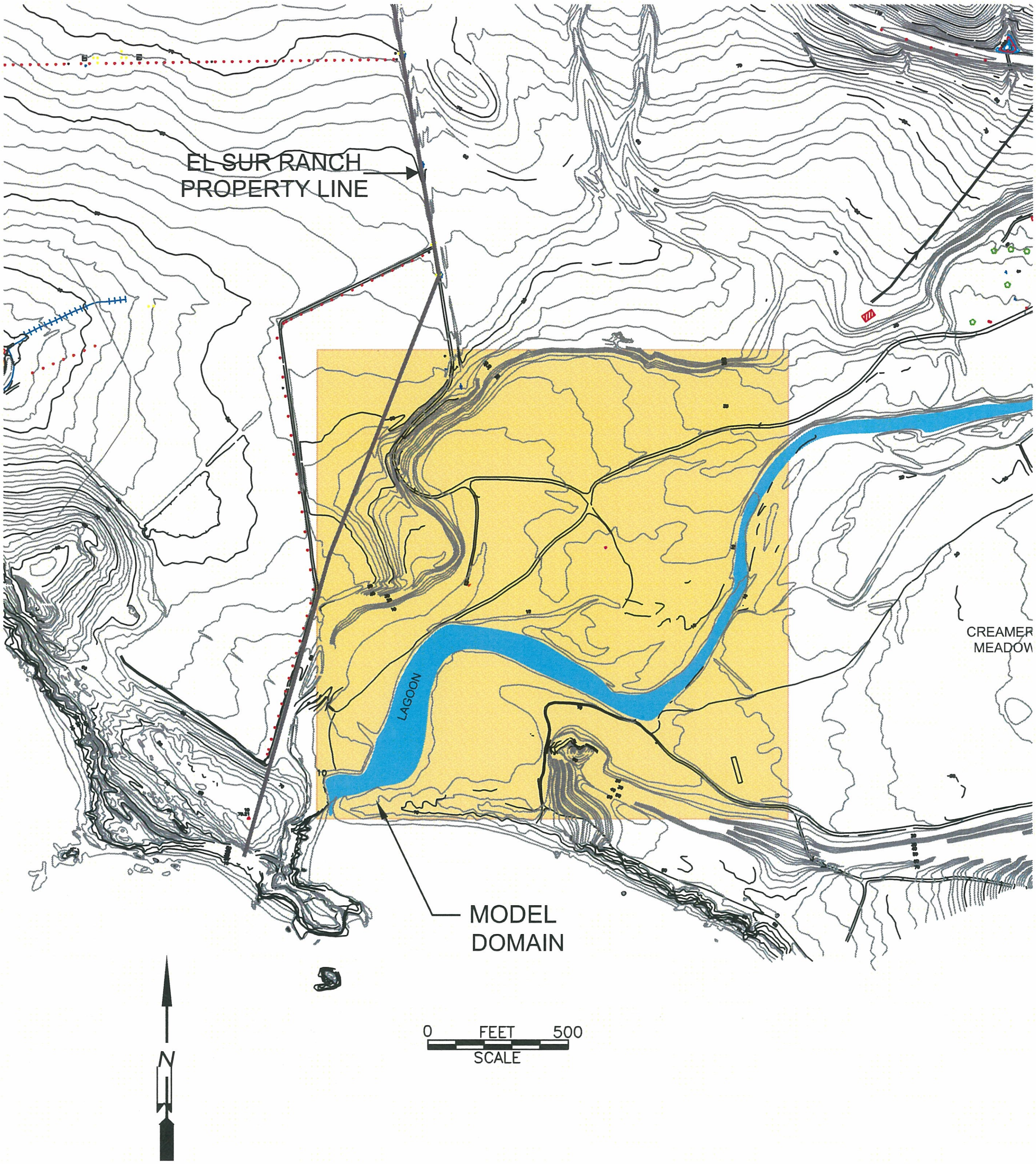
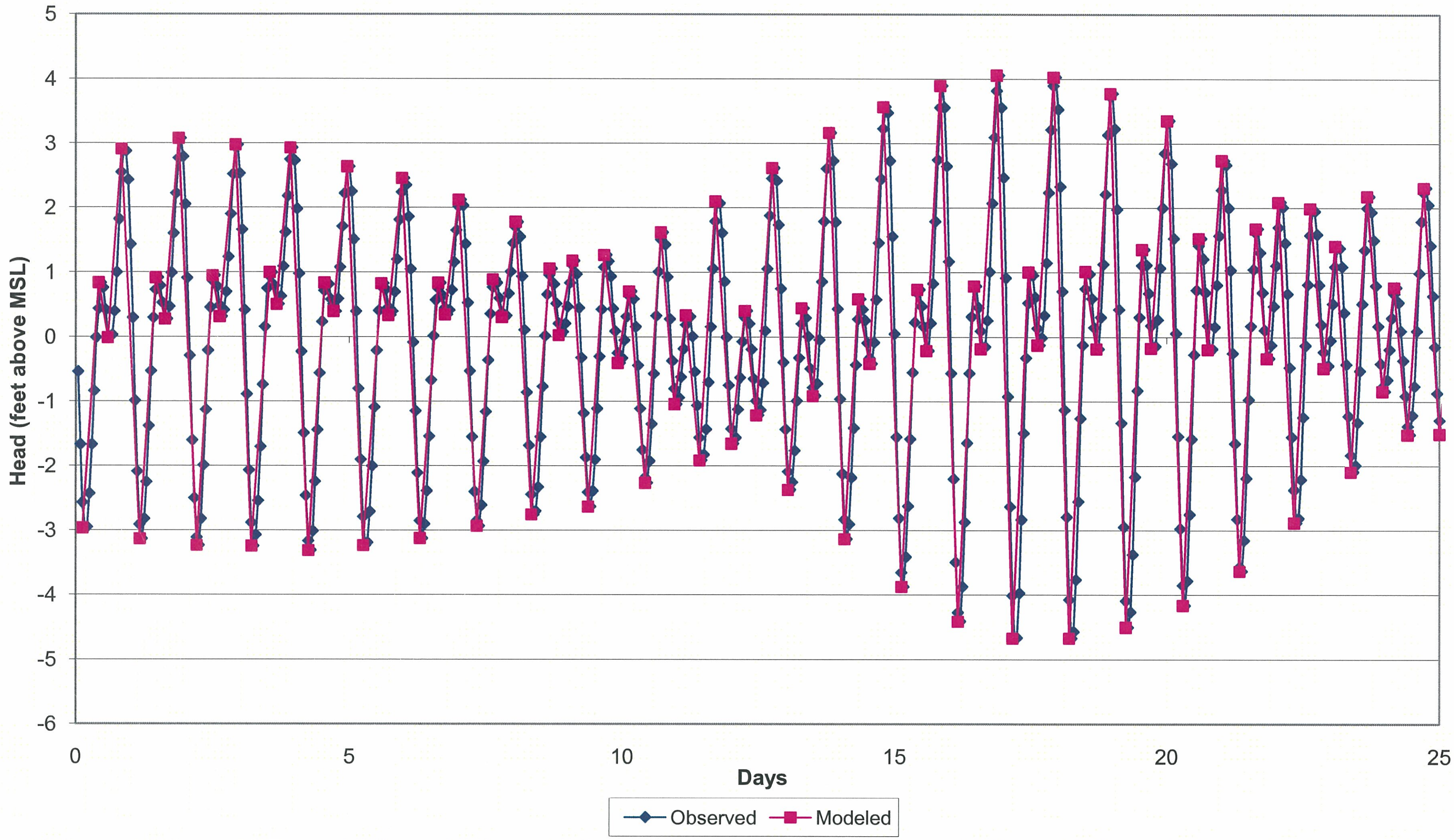


EXHIBIT ESR–3
Testimony of Paul D. Horton, P.G., C.HG.

SGI environmental THE SOURCE GROUP, INC.	EL SUR RANCH BIG SUR, CALIFORNIA			NUMERICAL MODEL GRID
	DATE 3/11/05	DR. BY CP	APP. BY SM	PROJECT NO. 01–ESR–001 / FIGURE NO. B–1

ESR--2

Figure B-2
Outflow Constant Head Boundary Values
El Sur Ranch



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Testimony of Paul D. Horton, P.G., C.HG.

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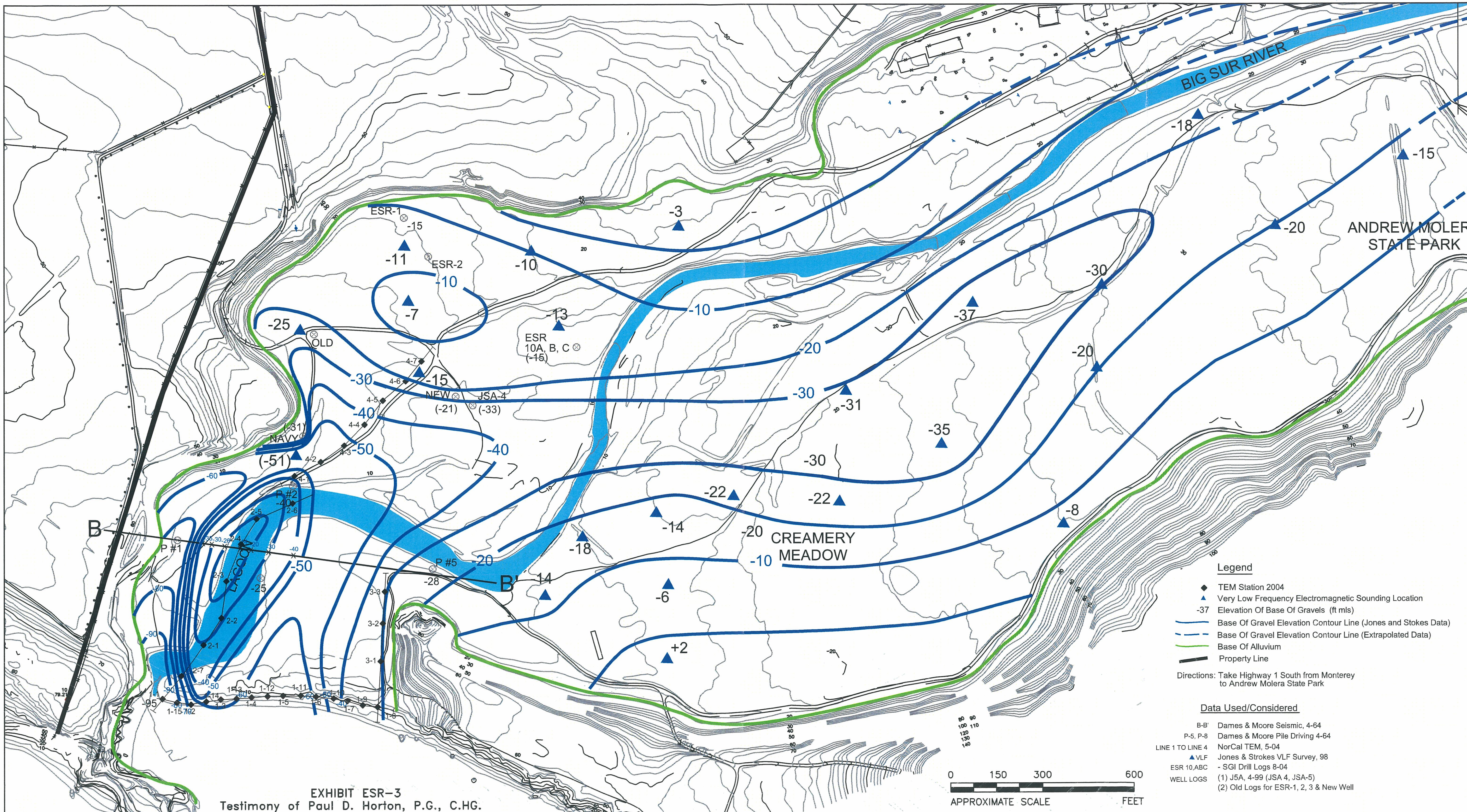

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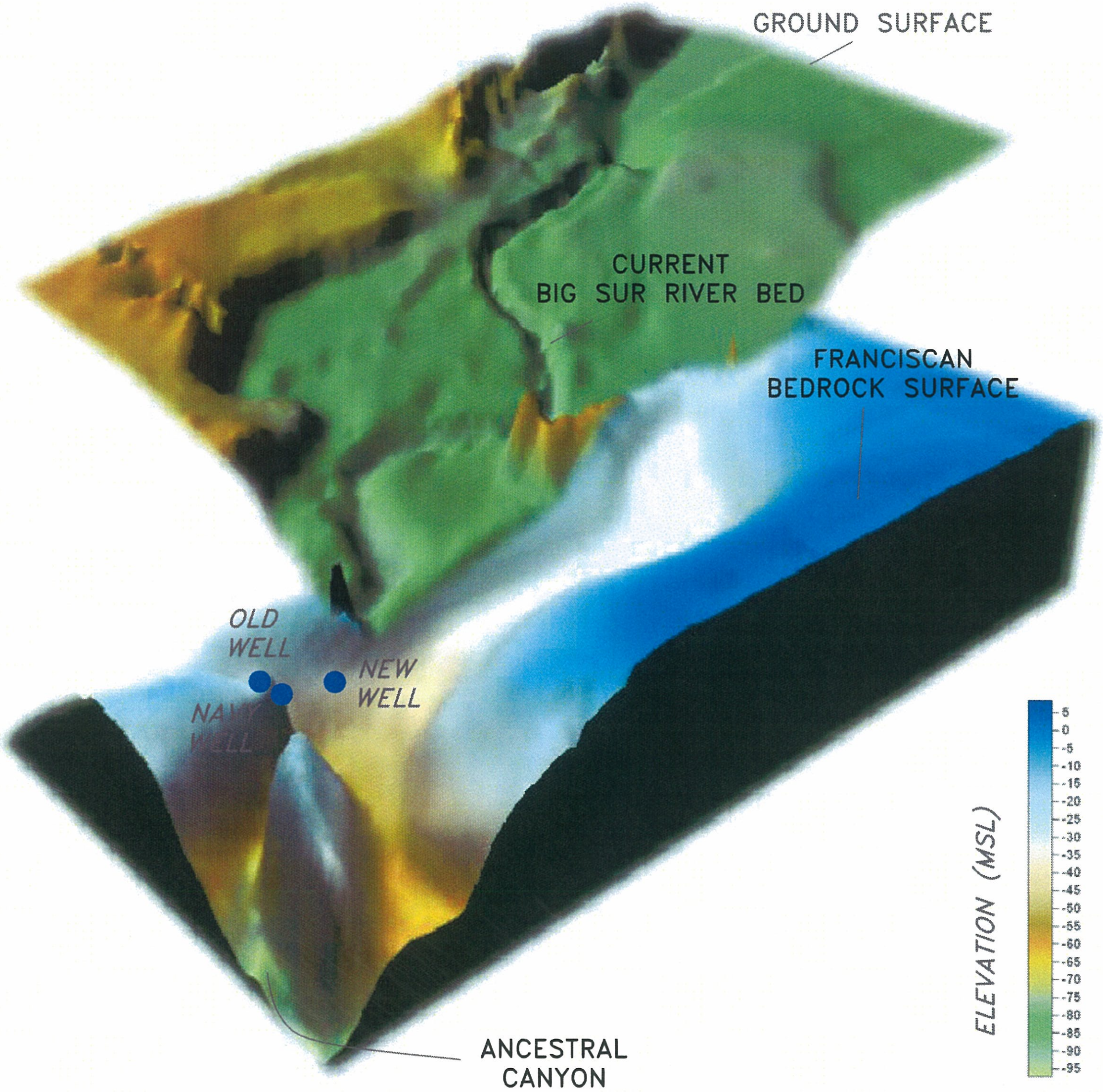
PLEASANT HILL, CA 94523

EL SUR RANCH
BIG SUR, CALIFORNIA

PROJECT NO.	DATE	DR. BY	APP. BY
01-ESR-007	05/09/2011	MM	KT

FIGURE B-3

BASE OF AQUIFER ELEVATION MAP



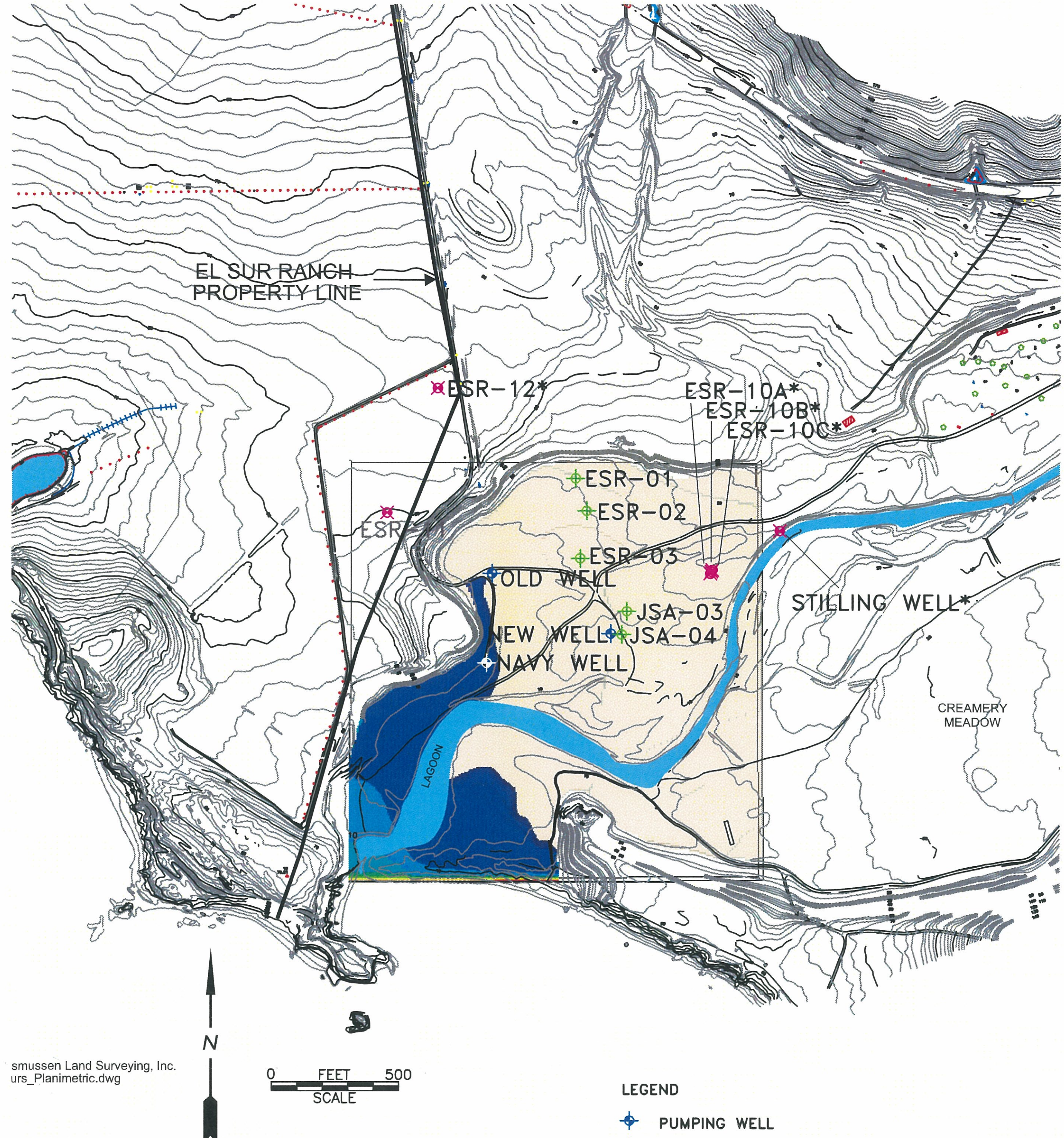
Vertical Exageration (ground surface) approx. 5X

Vertical Exageration (bedrock surface) approx. 10X

EXHIBIT ESR–3

Testimony of Paul D. Horton, P.G., C.HG.

SGI environmental THE SOURCE GROUP, INC.	EL SUR RANCH BIG SUR, CALIFORNIA		3D REPRESENTATION OF BEDROCK & GROUND SURFACES	
	DATE 3/11/05	DR. BY SB	APP. BY DRAFT	PROJECT NO. 01–ESR–001	FIGURE NO. B–4



LEGEND

- PUMPING WELL
- EXISTING WELL
- WELL INSTALLED SEPT 2004
- SATURATED ALLUVIAL AQUIFER
- SALINE DIFFUSION FRONT IN BASE OF ALLUVIUM

EXHIBIT ESR-3
Testimony of Paul D. Horton, P.G., C.HG.

SGI environmental THE SOURCE GROUP, INC.	EL SUR RANCH BIG SUR, CALIFORNIA			MODEL PREDICTED SALINE DIFFUSION FRONT LOCATION 26 DAYS
	DATE 3/11/05	DR. BY SB	APP. BY SM	PROJECT NO. 01-ESR-001 / FIGURE NO. B-5

ESR--2

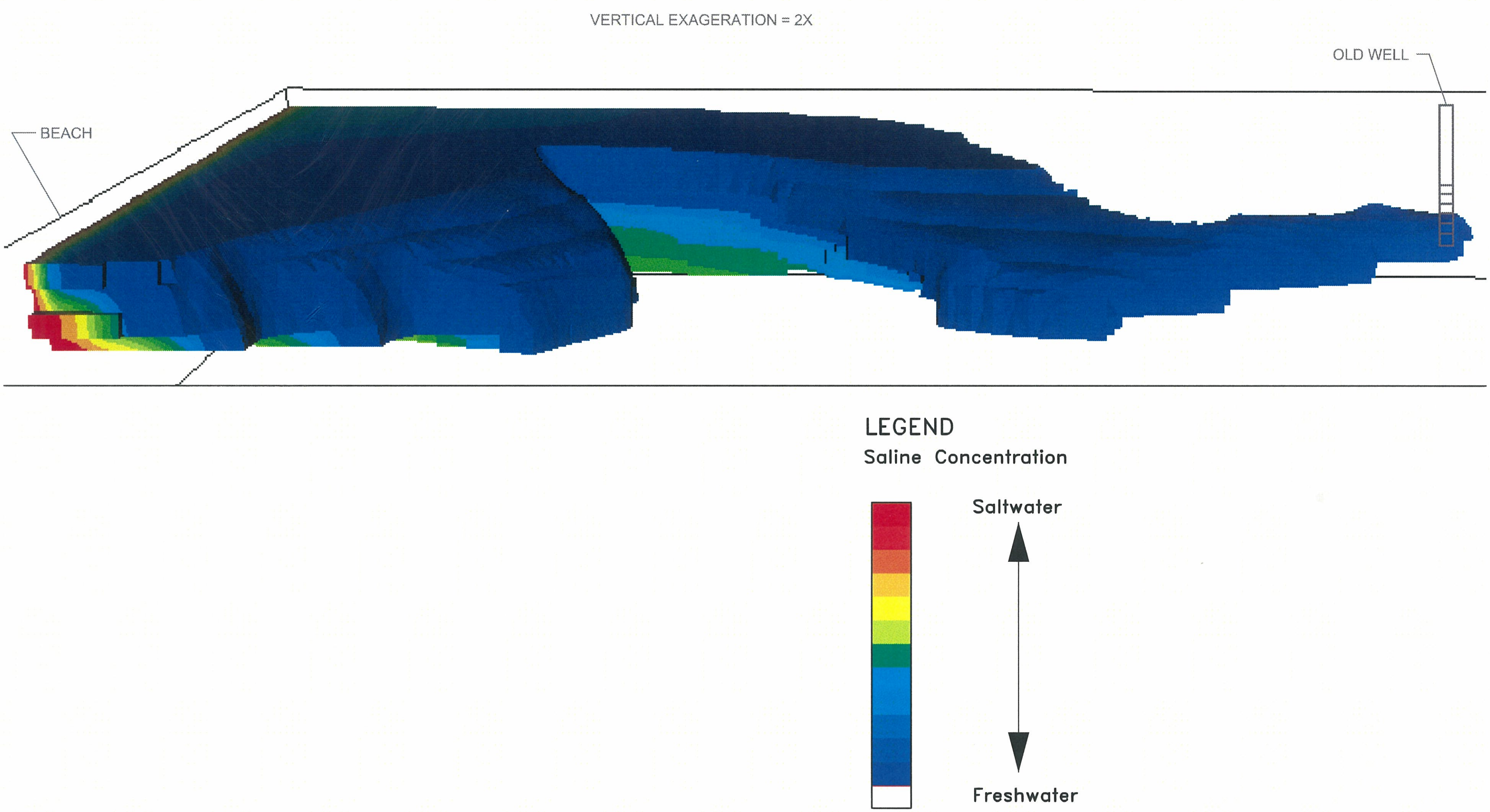


EXHIBIT ESR-3
Testimony of Paul D. Horton, P.G., C.HG.

SGI environmental THE SOURCE GROUP, INC.	EL SUR RANCH BIG SUR, CALIFORNIA			MODELED 3-D CUT-AWAY IMAGE OF SALINE FRONT ENCROACHMENT 26 DAYS
	DATE 3/11/05	DR. BY SB	APP. BY SM	PROJECT NO. 01-ESR-001 / FIGURE NO. B-6

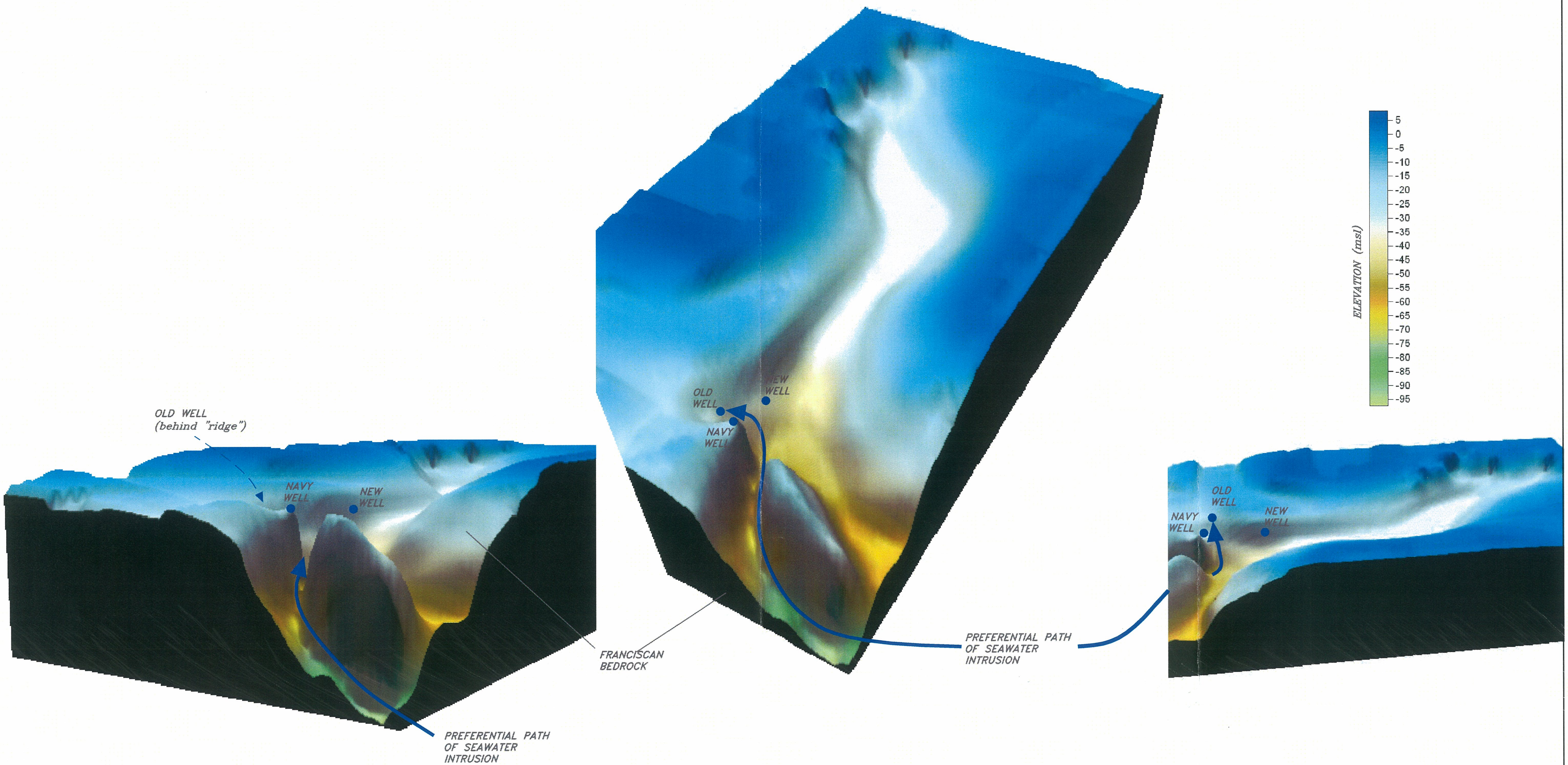


EXHIBIT ESR-3
Testimony of Paul D. Horton, P.G., C.HG.

SGI environmental THE SOURCE GROUP, INC.	EL SUR RANCH BIG SUR, CALIFORNIA				FIGURE B-7 THREE ROTATED VIEWS OF A 3D REPRESENTATION OF THE BEDROCK SURFACE
	PROJECT NO. 01-ESR-001	DATE 5/3/05	DR. BY SM	APP. BY SM	