ABSTRACT

El Sur Ranch (ESR) is located in Monterey County on the California Central Coast about 1 1/2 miles south of Point Sur Lighthouse. ESR seeks a permit for diversion of pumped well water from the lower reach of the Big Sur River for irrigation of a historic and existing ranching operation. (Water Right Application #30166) El Sur Ranch, irrigable pasture area totals approximately 292 acres. The irrigated portion is approximately 267 acres, which includes a portion of Swiss Canyon that is irrigated by seepage. The remainder of the 292 acres includes non-irrigated riparian lands, a tailwater reclamation/runoff collection pond, non-irrigated pasture, and a dune area. Approximately 25 acres of the 292 irrigated pasture area are riparian land to the Big Sur River, with 23 acres of the 25 acres currently being irrigated. Diverted water is provided by two wells located at Andrew Molera State Park. The land upon which the wells are located, was initially gift deeded to the California Department of Parks and Recreation (DPR) by El Sur Ranch in 1971.

The Big Sur River is comprised of two primary types of flow: **surface flow** (from tributaries and surface runoff) and **underflow** (subsurface flows through the alluvium within a deep ancestral canyon carved by river flows through the millennia). At issue are the impacts, if any, to surface flows due to diversion (well pumping). It is the Board's jurisdiction to determine whether impacts from the pumping result in impacts to public trust values. Therefore, the inquiry has been focused upon identifying impacts caused by pumping/diversion and irrigation/use within the Point of Diversion and the Place of Use respectively.

The Point of Diversion (POD) has been identified as the geographic extent of pumping influence or within a 1,000-foot radius, up gradient from the New Well, when the New Well is pumping. See SGI Figure 3-9. The Place of Use (POU) is identified as any 267 irrigated acres within approximately 292 acres of pasture. Figure 2 Site Plan, attached hereto.

In order to provide further scientific evidence in support of its application for a water right within the Lower Reach of The Big Sur River, ESR supplemented its contracts with retained consultants in hydrogeology, The Source Group, Inc., biology, Hanson Environmental, Inc., and agricultural water use, NRCE, Natural Resources Consulting Engineers, Inc. and retained the services of Miriam Green Associates and Rogers E. Johnson & Associates. The additional technical reports are provided herein and include the following:

Addendum To Hydrogeologic Investigation and Conceptual Site Model Within the Lower Reach of the Big Sur River, El Sur Ranch, Big Sur, California March, 2007. The Source Group, Inc. (SGI)

Geologic Evaluation of Erosion Issues on Irrigated Pasture Lands El Sur Ranch, March 2, 2007, Rogers E. Johnson & Associates Consulting Engineering Geologists.

Evaluation of the Potential Relationship Between El Sur Ranch Well Operations and Aquatic Habitat Associated with the Big Sur River During Late Summer and Early Fall, 2006. March, 2007. Hanson Environmental, Inc. (Hanson Environmental)

Water Level and Habitat Monitoring from Rainfall Runoff and Surface Irrigation Excess Overflow Changes within Swiss Canyon, El Sur Ranch, in Late Summer and Early Fall, 2006, March, 2007, Hanson Environmental, Inc.

Erosion Monitoring from Rainfall Runoff and Surface Irrigation Excess Overflow on Coastal Bluffs Bordering El Sur Ranch Pastures 7 and 8 in Late Summer and Early Fall, 2006, March, 2007, Hanson Environmental, Inc.

Results of Biological Surveys in the El Sur Ranch Study Area, Monterey County, California, December 21, 2006, Miriam Green Associates.

(Update of May 18, 2005 Report) Reasonable Beneficial Use – Land Use Study for El Sur Ranch Irrigated Pastures Water Rights Application #30166, March 2007. Natural Resources Consulting Engineers, Inc. (NRCE)

Further biologic survey work is contemplated for the last two weeks of March or the first week of April 2007, by Miriam Green & Associates, in order to complete the spring assessment for certain species not observed during the 2006 survey. A letter report will be provided to the State Board as soon as possible after the survey work is completed.

2006 Study Area

During the 2004 Study the Study Area was described as lying within the lower Big Sur River Basin, on the western slope of the Santa Lucia Mountain Range and included the last mile of the river before it flows into a lagoon, then into the Pacific Ocean. It included El Sur Ranch irrigated pastures and Andrew Molera State Park.

The 2006 Hydrogeologic study was primarily focused upon a 2,000-foot section of the lower Big Sur River bounded downstream by and including a portion of the upper lagoon and upstream by the 'deep pool' area (former location of the 2004 Study's 'Temperature Logger #3' data collection point). It is along this section that the alignment of the River changes from running parallel to Creamery Meadow groundwater flow to running perpendicular to the groundwater flow. See SGI 2006-07 Study, Figure 1-2 for a map describing the 2006 Study Area.

Prior Site Work and Studies

- *Hydrogeologic Investigation and Conceptual Site Model Within the Lower Big Sur River.* May, 2005. The Source Group, Inc. (SGI)
- *Assessment of Habitat Quality & Availability Within the Lower Big Sur River: April-October 2004.* March 11, 2005. Hanson Environmental, Inc. (Hanson Environmental)
- *Reasonable Beneficial Use - Land Use Study for El Sur Ranch Irrigated Pastures, Water Rights Applicant #30166.* May 18, 2005. Natural Resources Consulting Engineers, Inc. (NRCE)
- Engineering and geologic investigation conducted at the mouth of the Big Sur River evaluating the feasibility of constructing a harbor (Dames & Moore, 1964);

- Hydrogeologic investigation work conducted in the late '90s including:

  installation of three monitoring wells during 1991 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)

  Continuous water level monitoring for two El Sur Ranch wells conducted between August 1997 and June 1998, and one monitoring well from July through September 1998 (Jones & Stokes, 1999)

- Compilation of prior work/findings for the Big Sur River drainage regarding the historical occurrence of steelhead/rainbow trout and habitat conditions (Titus, 2003); and

- Biological surveys performed in 1995 (BioSystems, 1995).

More general studies of the surrounding area, occurring over the course of the last 78 years, are provided as a listing of reference materials within the 2004-05 SGI and Hanson Environmental reports.

Summary of Findings and Conclusions

Scope of 2006 Hydrogeologic Study

The goal of the additional hydrogeologic data collection and analysis for the 2006 Hydrogeologic Study was to refine and/or evaluate for:

1. a correlation between pumping rates and loss of surface water through the bed of the River,

2. the relationship of any identified correlation between pumping rates and loss of surface water, to the total stream-flow entering the Study Area in order to identify the potential for impacts due to pumping,

3. the ability of the pumping to create drawdown impacts within Creamery Meadow,

4. the cause and extent of movement inland of the saline wedge and identification of impacts, if any, to the lagoon and riparian zones from such movement,

5. the availability of water for irrigation, during the driest months of the year based upon a water budget evaluating varying year types, and

6. the effects pumping has upon concentrations of dissolved oxygen and temperature within the Study Area.

Results and Conclusions of 2006 Hydrogeologic Study

1. The geographic extent of pumping influence upon the River system is approximately 1,000-foot radius, up-gradient from the New Well, when the New Well is pumping. See SGI 2006-07 Study, Figure 3-22.
2. Within the identified geographic extent of pumping influence influence, the only identified correlation between irrigation well pumping and the flow of water in the River is between pumping rate and rate of groundwater accretion. Across River Zones 2 through 4, the natural condition is for the flow of the River to increase in response to the addition of water from groundwater accretion (i.e. groundwater upwelling into the River). Pumping reduces this gain in River flow by reducing the amount of groundwater accretion. Conservatively, for every 1 cfs of water pumped by the irrigation wells, the amount of groundwater accretion is reduced by 0.3 cfs.
3. During the dry months (i.e. September through October) of a critically dry year, River flow within the geographic extent of pumping influence is estimated to be 3.8 cfs or lower under normal September pumping conditions (i.e. a groundwater pumping rate of approximately 2.7 cfs) or 2.8 cfs or lower under maximum permitted pumping conditions (i.e. a groundwater pumping rate of approximately 5.84 cfs). In all but the most critically dry years, pumping does not significantly reduce the continuity of surface flow within the river. Within the geographic extent of pumping influence the calculated drawdown of groundwater levels beneath Creamery Meadow is 0.20 feet (2.4 inches) at the River bank diminishing to zero within 500 feet up gradient into Creamery Meadow.
4. During September, the driest month of the year, readings in both irrigation wells and the Navy Well reflect no significant correlation between pumping rates and electroconductivity levels regardless of changes in tidal conditions. This lack of elevated electroconductivity levels is attributed to the absence of the higher than normal spring tides which generally occurs in early to midsummer (i.e. May through August). Tidal influence, exacerbated by the summer spring tides, is the dominant mechanism driving saline water inland to the pumping wells. There is no correlation between pumping rate and electroconductivity, and therefore no effect upon saline wedge movement.
5. Data collected during the 2006 Study supports a Water Availability Analysis focused upon the geographic extent of pumping influence, (Zones 1 through 4 of the River). Zones 2 through 4 are where the surface flow moves laterally across the direction of underflow. No effects of pumping have been identified outside of these Zones.
6. Depressed levels of dissolved oxygen existing within the underflow mix with surface flows between Zones 2-4. Pumping does not cause the depressed levels of dissolved oxygen in the subsurface flow. To the contrary, pumping during low flow conditions reduces the rate of accretion of depressed dissolved oxygen waters into the surface flow within the geographic extent of pumping influence.

   Depressed temperatures existing within the underflow also mix with surface flows between River Zones 2-4. Reducing the amount of groundwater entering the River, such as what occurs during ESR diversions, can theoretically increase the localized temperature along the Creamery Meadow bank a maximum of 1.1 °C (2 °F). This increase is relative to the reduced River temperatures that exist when groundwater mixes with the River under no pumping conditions.

Scope of 2006-07 Biologic Studies

The Big Sur River provides a migratory corridor, spawning and egg incubation habitat, and juvenile rearing habitat supporting a population of steelhead (*Oncorhynchus mykiss*). Steelhead inhabiting the Big Sur River have been listed as a threatened species under the Federal Endangered Species Act. The 2006 Biologic Study addresses the potential for El Sur Ranch diversions to adversely affect habitat quality and availability for juvenile steelhead inhabiting the lower river and lagoon.

A fishery habitat investigation was designed and implemented to provide site-specific field information on instream habitat conditions within the lower reaches of the Big Sur River and the lagoon throughout the summer and early fall of 2006 under a range of El Sur Ranch diversions. Steelhead were identified as the primary target species of interest for this investigation. Potential steelhead passage and habitat quality changes within the river resulting from the range of well operations during the study period can serve as an indicator of the potential for adverse effects on habitat conditions for other sensitive and protected wildlife inhabiting the area. The objective of the 2006 experimental investigation was to determine if El Sur Ranch diversion well operations cause adverse impacts to fish and wildlife habitat within and adjacent to the Big Sur River during the seasonal period of low flows and typical El Sur Ranch diversion operations.

Further, a study and analysis was performed looking for impacts due to rainfall runoff and surface irrigation seepage within Swiss Canyon, (*Water Level and Habitat Monitoring from Rainfall Runoff and Surface Irrigation Excess Overflow Changes within Swiss Canyon, El Sur Ranch, in Late Summer and Early Fall, 2006*, Hanson Environmental). While this study was conducted during dry season conditions it examined the study area for physical features that might have occurred due to rainfall runoff.

Results and Conclusions of 2006-07 Biologic Studies

Results of habitat and passage monitoring during the 2006 study period concluded that conditions within the geographic extent of pumping influence, under a range of experimental pumping regimes, remained within a suitable range for juvenile steelhead rearing throughout the summer and fall monitoring period irrespective of ESR diversions. While observing variations of parameters (flow, depth, width, temperature, DO and EC), there was no evidence that well operations resulted in a consistent pattern of habitat change within the river. All parameters measured as part of this 2006 study remained within the range considered to be suitable for steelhead rearing. Additional findings of the 2006 investigation include:

1. Summer, surface baseflows during the 2006 investigation were sufficient to provide physical habitat within the lower river and lagoon to support juvenile steelhead/rainbow trout rearing;

2. Surface streamflows were sufficient to maintain connectivity among habitat units within the study reach throughout the 2006 study period;

3. At all times of the Study, water quality conditions, including water temperatures, electrical conductivity, and dissolved oxygen concentrations, were within the range considered to be suitable for juvenile steelhead/rainbow trout rearing;

4. Steelhead passage monitoring, including critical riffle habitats, concluded that no barriers/impediments to fish migration resulted from ESR diversion operations and no patterns were detected between passage transect depth variations and diversion operations;

5. Analyses incorporating results of the SGI mixing model (SGI 2007) and habitat thresholds conclude that ESR diversions cannot adversely impact steelhead habitat in the study reach by raising temperature above naturally occurring levels;

6. Analyses incorporating results of the SGI mixing model (SGI 2007) and habitat thresholds conclude that ESR diversions cannot adversely impact steelhead habitat by depressing dissolved oxygen concentrations below naturally occurring levels;

7. Neither the 2004 nor the 2006 study periods provided any evidence of adverse effects on juvenile steelhead habitat quality and connectivity or availability as a result of ESR irrigation well operations. Similarly, the absence of adverse effects on aquatic habitat for juvenile steelhead, serves as an indicator that adverse effects to other sensitive and protected aquatic species inhabiting the lower Big Sur River would not be expected, based on environmental conditions and irrigation well operations that occurred during the 2004 and 2006 study period flow conditions, and;

8. Under the conditions surveyed, no evidence exists that ESR diversions adversely effect vegetation within Creamery Meadow or any of the areas within the geographic extent of pumping influence.

9. Swiss Canyon was observed to be characteristically dry upstream of ground water influence. The main contributing source of flows was ground water upwelling. No changes in habitat or populations were observed.

Scope of 2006 Biologic Surveys

The purpose of the 2006 Biologic Surveys (*Results of Biological Surveys in the El Sur Ranch Study Area, Monterey County, California, December 21, 2006, Miriam Green Associates*) was to gain baseline information on plant communities and wildlife resources within the POD and the POU both for the CEQA process and public trust analysis. The Surveys identified the potential for special-status plant and wildlife species including federally and state-listed species within the POD and POU. The study also examined the POD and the POU for impacts due to diversion and irrigation across a variety of operational scenarios.

Conclusions of the 2006 Biologic Surveys

1. No federally or state-listed plants were observed during the 2006 surveys.

2. Two plant species, tracked by the California Native Plant Society were observed: Arroyo Seco bushmallow and Monterey Indian paint brush.

3. The California red-legged frog (Rana aurora draytonii) a federally-threatened species, was recorded in the River in the early 1990s and in Swiss Canyon in 2006. It was not observed during the survey. The southwestern pond turtle, a California species of special concern, was also observed in the 1990s in the River. The reclamation pond within the POU provides suitable habitat for both species.

4. Suitable habitat is present for the Smith's blue butterfly and California tiger salamander, both federally-listed species. Suitable habitat is also present for 11 California species of special concern an/or fully protected species, including: the Monterey dusky-footed woodrat, ringtail, American badger, pallid bat, golden eagle, northern harrier, white-tailed kite, long-billed curlew, California horned lark, Coast horned lizard and Coast Range newt. Only the golden eagle, Cooper's hawk, northern harrier, white-tailed kite, long-billed curlew and California horned lark were observed during 2006 surveys.

5. No significant adverse biologic effects due to ESR irrigation practices were observed.

6. Significant beneficial impacts due to irrigation were observed including: sustenance of a diverse riparian corridor within Swiss Canyon, capable of supporting amphibians such as the federally-listed, California red-legged frog and the more common Pacific chorus frog as well as reptiles and mammals.

7. Irrigation seepage within the POU allows the structural diversity of the vegetation to be maintained as evidenced by the presence of a diverse avian community.

8. Within the geographic extent of pumping influence, visual observations confirm no signs of dieback or physical stress to vegetation.

Scope of 2006-07 Geologic Evaluations of Soil Stability Issues

The purpose of the 2007 Geologic Evaluation of Erosion Issues (*Geologic Evaluation of Erosion Issues on Irrigated Pasture Lands El Sur Ranch,* March 2, 2007, Rogers E. Johnson & Associates, Consulting Engineering Geologists), was to determine whether ESR irrigation practices contribute to erosion along the banks of Swiss Canyon or to erosion of coastal bluffs that border the southern end of the POU.

The purpose of the 2006-07 Erosion monitoring study, (*Erosion Monitoring from Rainfall Runoff and Surface Irrigation Excess Overflow on Coastal Bluffs Bordering El Sur Ranch Pastures 7 and 8 in Last Summer and Early Fall, 2006,* Hanson Environmental) was to evaluate the potential for irrigation flows and rainfall runoff to contribute to surface erosion of the steep slopes of the bluff bordering the southern edge of the ESR irrigated pasture, on the Pacific Ocean.

Conclusions of the 2006-07 Geologic Evaluation of Soil Stability Issues

1. ESR irrigation practices have had no discernable effect on rates of coastal bluff retreat within the study area.

2. Storm driven surf, particularly when combined with high tides, are the primary agents affecting bluff retreat. The chief variable affecting the rate of bluff retreat is the intensity and the direction of major storms which cause the surf to attack this stretch, particularly the pasture located south of the outlet of Swiss Canyon.

3. No evidence of increased erosion due to irrigation practices was observed, within Swiss Canyon. In fact, gullying and slumping has diminished during irrigation over the last 50 years.

Scope of 2007 Land and Water Use Analysis

In May 2005, NRCE completed a report that described ESR water use for irrigated pasture (NRCE, 2005). At that time it was envisioned that the report would be updated after climate data specific to ESR was obtained. The information summarized below replaces the May 2005 report.

The primary objective of the 2007 study by Natural Resources Consulting Engineers, Inc. (NRCE) is to determine the agricultural water needs of the ESR pastures, and to evaluate whether ESR's historical water uses have been reasonable and beneficial.

Physical Conditions

ESR is the largest of the remaining working cattle ranches that once existed on the coast between San Simeon and Monterey. The irrigated pasture on ESR is an essential component of the cattle operation, providing high quality forage during the dry summer period.

The use of ESR land is consistent with and protected by both the California Coastal Act (CCA) and the Monterey County Local Coastal Program, including the Big Sur Area Land Use Plan (LUP), which recognizes agriculture as a priority use of coastal lands.

ESR irrigable pasture area has a total of approximately 292 acres. The irrigated portion is approximately 267 acres, which includes a portion of Swiss Canyon that is irrigated by seepage. The remainder of the 292 acres includes non-irrigated riparian lands, a tailwater reclamation/runoff collection pond, non-irrigated pasture, and a dune area. Approximately 25 acres of the 292 irrigated pasture area are riparian land, with 23 acres of the 25 riparian acres currently being irrigated.

The climate along the Big Sur coastal area can vary significantly within a short distance and for that reason, in August of 2004 an electronic weather station was setup on the ESR irrigated pasture.

The average maximum monthly temperatures range from 59 to 66 °F with minimum average monthly temperatures ranging from 44 to 52 °F.

ESR's irrigated pastures have high winds and mostly sunny conditions in the day during the summer months.

The estimated average long-term annual precipitation is about 27 inches with about 90 percent of the total rainfall occurring from November through April during the period from 1975 through 2006.

Winter months are generally wet and the summer months are almost always dry.

The average mean temperature at El Sur pasture is around 55° Fahrenheit and freezing temperatures are rare.

The 2.5 years of meteorological data collected at ESR was used in correlation with other climate data to estimate crop water and irrigation needs.

Conclusions of 2007 Land and Water Use Analysis

1. The irrigation system and irrigation process is concluded to be efficient and after review and consideration of other alternatives, the most appropriate system for the physical conditions of the pastures.
2. Evapotranspiration ("ET") of the pasture crops is estimated to be 43.31 inches per year for the 1975 - 2006 period and 33.4 inches for the March-October months during the same period.
3. The calculated maximum annual diversion requirement (over a 58 year period of record (1949-2006)) is 1,433 acre-feet. For that 58 year period, the calculated average annual diversion needed for crop production is 1,170 acre-feet (average 1,180 acre-feet for 1975-2006).
4. The maximum diversion rate of 5.84 cfs or a running 30-day average of 5.34 cfs, is adequate to provide the amount of irrigation needed to maintain crop production.
5. ESR's average annual (January – December) irrigation for the 1975 – 2006 period is 3.43 feet (41.16 inches). After consideration of leaching requirements, the average on-farm irrigation efficiency for ESR is calculated to be 71% for 1975- 2006 and 82% for 1994-2006. The 71 percent average irrigation efficiency is not the recommended target irrigation efficiency for ESR.
6. The irrigation efficiency on ESR pasture is concluded to be reasonable and supported by conditions and limitations of water supply, the irrigation system, soils, labor constraints, and imperfect forecast of rainfall events. Based upon observation and analysis of available information, the irrigation system is concluded to be well-managed and efficient and as a result the pastures are found to be in good health suitable for maximizing crop production.
7. Potential soil erosion is well controlled by dense ground cover and constructed embankments to prevent runoff from eroding steep unprotected slopes.

ORT SOURCE:

THE SOURCE GROUP, MAY 2005

EL SUR RANCH
BIG SUR, CALIFORNIA

PROJECT NO.	DATE	DR. BY	APP. BY
NA	3/11/05	SB	PH

FIGURE 2

SITE PLAN

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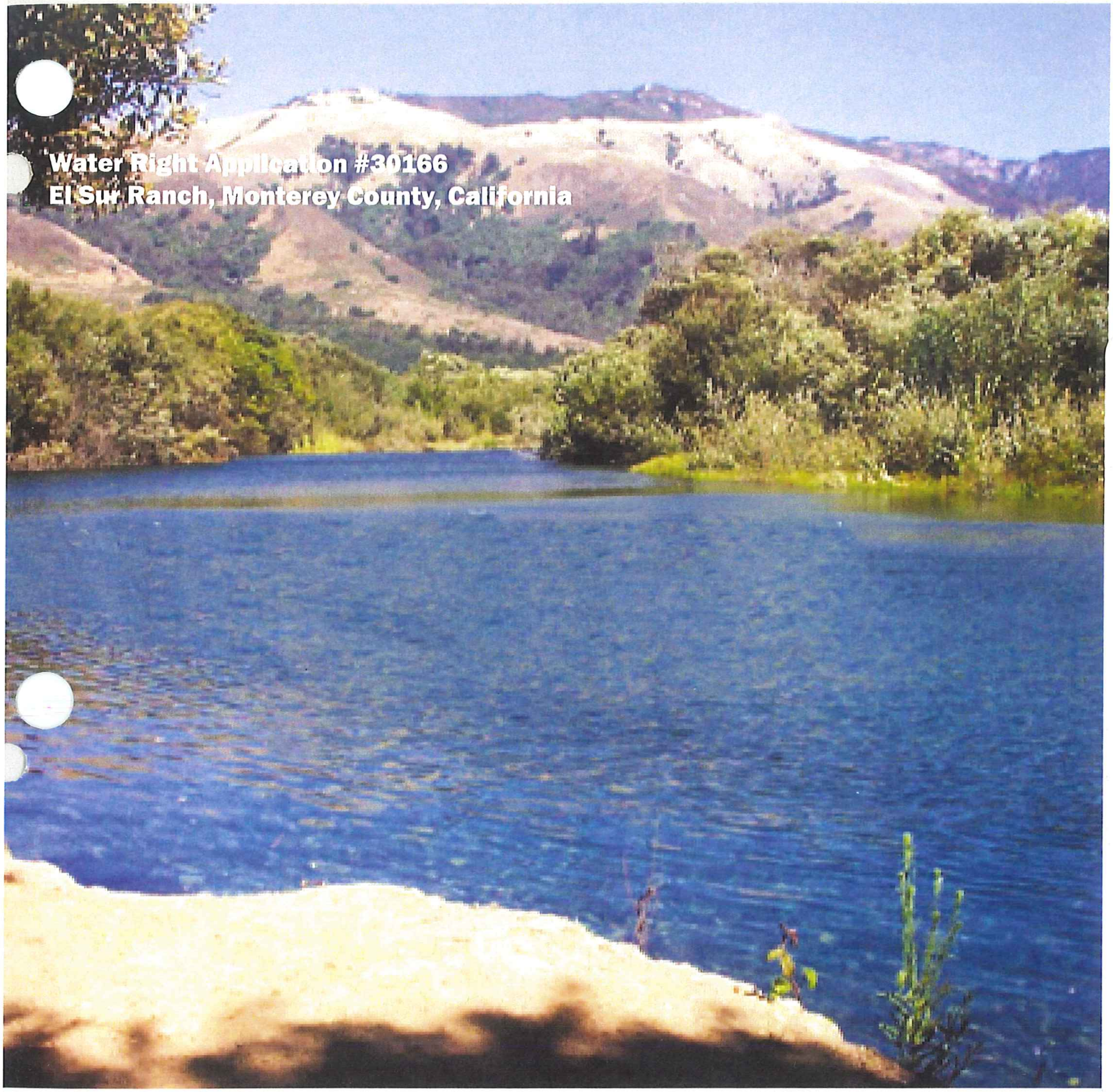
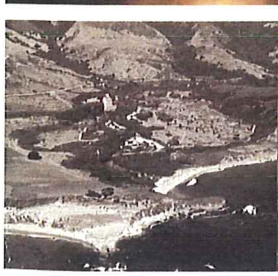


Water Right Application #30166
El Sur Ranch, Monterey County, California



Hydrogeology

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ADDENDUM TO HYDROGEOLOGIC INVESTIGATION AND CONCEPTUAL SITE MODEL WITHIN THE LOWER REACH OF THE BIG SUR RIVER

El Sur Ranch
Big Sur, California

01-ESR-003

Prepared For:

Applicant
El Sur Ranch
Monterey County, California

Prepared By:

PROFESSIONAL GEOLOGIST
JON R. PHILIPP
No.7945
STATE OF CALIFORNIA

SGI environmental THE SOURCE GROUP, INC.

3451-C Vincent Road
Pleasant Hill, California 94523

CERTIFIED HYDROGEOLOGIST
PAUL D. HORTON
HG 581
STATE OF CALIFORNIA

March 23, 2007

Prepared By:

Jon R. Philipp, P.G., C.HG.
Senior Hydrogeologist

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

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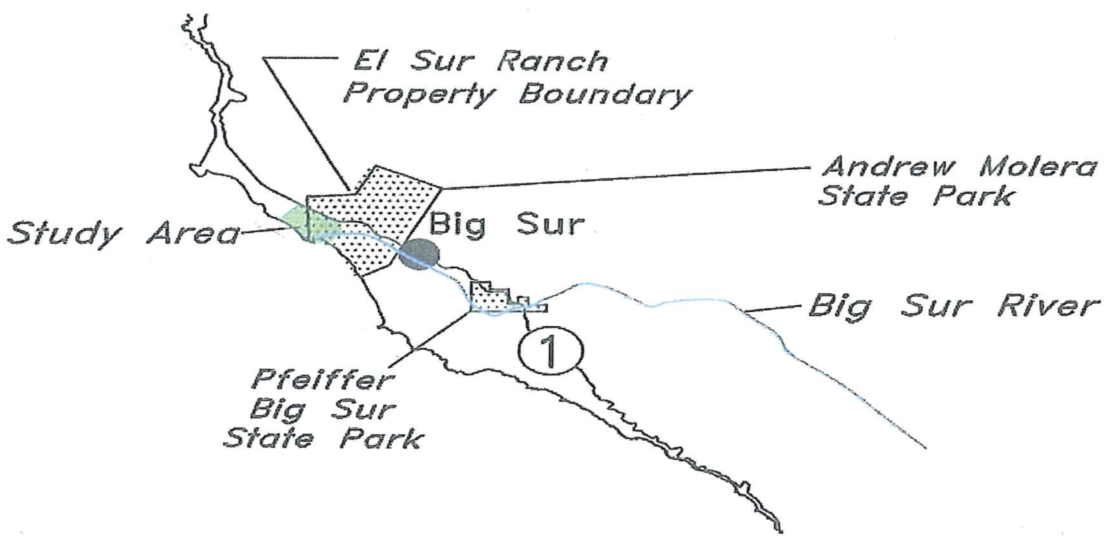
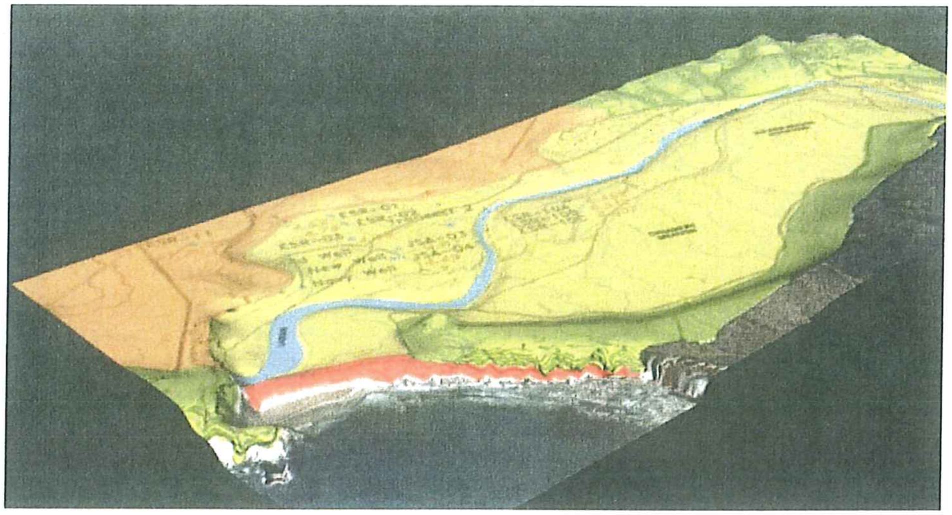
EXECUTIVE SUMMARY

A series of investigations dating back to 1997 have been conducted on the last mile of the Big Sur River as it empties into the Pacific Ocean in an attempt to ascertain any effects of pumping by the El Sur Ranch (ESR) irrigation wells on River flow and underflow.



A comprehensive hydrologic and hydrogeologic investigation was conducted in 2004 that incorporated the results of all previous investigations, and is summarized in the May 2005 Source Group, Inc. (SGI) report titled *Hydrogeologic Investigation and Conceptual Site Model Within the Lower Reach of the Big Sur River* (HI-CSM). The 2004 Study resulted in the development of a detailed hydrogeologic conceptual model describing groundwater and surface water dynamics and interactions in the Study Area.

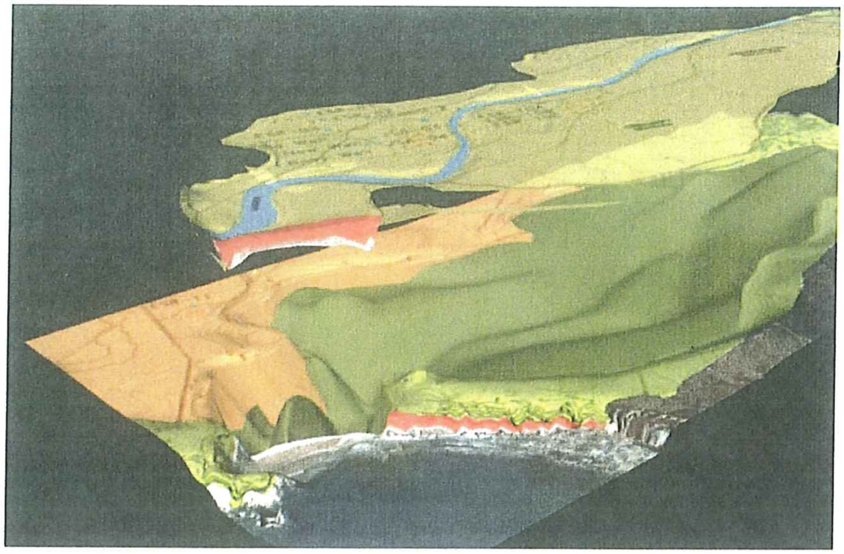
Simply stated, the hydrogeologic conceptual model describes the sand, gravel, cobble and boulder deposits that fill the ancestral canyon carved through the Big Sur River Valley by the Big Sur River, from the USGS flow gauge in Pfeiffer-Big Sur State Park to the River's confluence with the Pacific Ocean. These deposits make up a highly permeable alluvial aquifer allowing for significant transmission of groundwater. All surface water and groundwater drainage from the Big Sur River watershed ultimately travels on and in these deposits to a final discharge into the Ocean.



(Study Area with Alluvial Aquifer in Yellow)

Flow rates in the Big Sur River respond immediately to rainfall events. Due to the permeable nature of the sand, gravel and cobble deposits on which the River flows, groundwater moving within the alluvial aquifer is hydraulically well connected to surface flow in the River. Due to this direct connection, the mere presence of the flowing River indicates that the alluvial groundwater aquifer is in equilibrium with the River during the summer months when the River is at a base flow condition. As the River approaches its mouth, it jogs to the south crossing the normal direction of groundwater flow. It is along this stretch that the River becomes a gaining stream, with groundwater upwelling and mixing with the River water. The River then turns back to the west and enters the ponded area of the River called the 'lagoon' before its final discharge into the Ocean.

At the River's mouth, the ancestral canyon bottom was carved into two channels that are split by a subsurface knob of hard rock. 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. Groundwater in the lagoon area of the River is directly hydraulically connected to the Ocean through the interface of the submarine alluvial canyon. As a result of this connection, groundwater levels respond to tidal fluctuations as do lagoon surface water levels.



(Study Area with Bottom of Alluvial Aquifer Exposed to Show Ancestral Canyon)

The natural fluctuating tidal condition results in a constantly moving saline water wedge under the fresh groundwater outflow within the deepest part of the ancestral canyon. The most significant landward migration of saline water is in response to summer spring tide events. The deeper, northwestern subterranean channel acts as a preferential pathway for the natural migration of the saline wedge beneath the fresh groundwater as far inland as the Navy Well and, in extreme cases, the El Sur Ranch Old Well. Following each spring tide event, the saline water retreats, and has no lasting effect on groundwater quality. The seasonal advancement of the saline wedge has no measurable impact to surface water quality in the lagoon or the River. Pumping did not induce any measurable surface water quality changes during the 2004 investigation.

Review and analysis of the 2004 Study data and analyses by stakeholders resulted in the development of additional technical questions focused on specific and definable connections between pumping of El Sur Ranch irrigation wells and River flow and water quality. The 2006 Study addendum was formulated and implemented to answer these questions. The main purpose of the 2006 Study was to collect data and gain additional understanding of the groundwater-river dynamic system such that a correlation could be made between irrigation well pumping and any loss of surface water through the bed of the Big Sir River in response to the pumping. In addition, the 2006 Study evaluated the potential for irrigation pumping to induce drawdown impacts in the adjacent Creamery Meadow. Monitoring of River water quality focused on temperature, dissolved oxygen, and detection of pumping based water quality impacts. Additional monitoring of the movement of the saline wedge inland was evaluated to further address concerns over the impact of saline water to the lagoon and riparian zones. Finally, a monthly based water budget for various water year types was considered, specifically focused on the later summer months when pumping has the most potential to cause an impact.

The results of the 2006 Study confirm and expand upon the hydrogeologic conceptual model defined during the 2004 Study. The 2006 Study has led to an increased level of understanding of the specific nature of influence of the irrigation pumping wells on the Big Sur River. Analysis of the 2006 data was focused on the potential for impact to steelhead fishery habitat. Based on the results of biologic studies conducted in 2004 and as part of the 2006 Study, the perspective for evaluating the potential fishery impact focused on the ability of pumping to reduce habitat continuity to less than that needed for fish passage and/or to reduce water quality within the River which might have an adverse effect on steelhead habitat quality. Additional focus was on the potential for impact to the local ecosphere (flora and fauna access to fresh water) via exacerbating natural saline wedge intrusions, or causing undue groundwater level drawdown in Creamery Meadow affecting root zone access to fresh water. The following paragraphs summarize the findings of the 2006 Study with respect to these questions.

Pumping Correlation

<u>Can a correlation be drawn between irrigation well pumping and a loss of water from the River?</u>

<u>Yes.</u>

This question was specifically answered by the 2006 Study. Data from the 2006 Study show that in the River reach closest to the pumping wells, the River naturally gains water from the underlying aquifer (i.e., groundwater upwelling). Irrigation well pumping has the effect of reducing the rate of groundwater upwelling that occurs within the radius of influence of the pumping wells. The reduction is directly correlated to the amount of water pumped. The worst case scenario measured shows that within the area of influence of the pumping wells, every 1 cubic foot per second (cfs) of water pumped by the wells reduces groundwater inflow into the River by 0.30 cfs. This indicates that for every unit volume of water pumped, 0.30 of that volume, or 30%, 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 volume of water pumped is comprised of underflow that was destined to discharge to the Ocean without ever entering the River. For the average September irrigation well pumping condition of 2.7 cfs, this 30% equates to a reduction in total volume of groundwater inflow to the River across Zones 2 through 4 of approximately 48 acre-feet for the month of September. The total volume of River flow exiting Zone 2 for the month of September 2006 is estimated to be 1,166 acre-feet. This indicates that groundwater inflow reduction resulting from average September pumping accounts for approximately 4.1% of the volume of flow past the area of influence in September of 2006. The River continued to gain groundwater across the pumping area of influence, even during periods of maximum pumping.

Saline Wedge

<u>Does pumping of the El Sur Ranch irrigation wells drive the inland migration of the coastal saline wedge?</u>

<u>No.</u>

The Old Well, located nearly 1,200-feet from the ocean, would occasionally exhibit elevated electroconductivity levels during the pumping season suggesting that pumping itself might be responsible. The 2004 Study demonstrated that a) the subterranean ancestral canyon filled with alluvial material acts as a preferential pathway for saline water wedge migration from the Ocean to the Old Well location, b) there is a correlation between spring tide events and elevated electroconductivity levels in the Old Well, and c) there is no correlation between irrigation well pumping and electroconductivity levels in the Old Well. The hydrogeologic conceptual model concluded that the spring tides provided the driving force for the saline wedge to migrate up the subterranean alluvial channel to the general location of the Old Well. Pumping simply pulled the nearby high saline water into the well to be sampled. Additional monitoring of Navy Well water quality during the 2006 study indicated no saline impact as a result of continuous pumping of both the Old Well and the New Well as predicted by the conceptual model. In short, data indicate that pumping has no effect on saline wedge movement.

Creamery Meadow Impacts

Does pumping of the El Sur Ranch irrigation wells have any effect on groundwater levels beneath Creamery Meadow?

Yes, but minimal.

One of the conclusions reached in the 2004 Study was that pumping has no effect on Creamery Meadow. Specifically, the conceptual model indicated that the River acts as a recharge boundary, isolating Creamery Meadow from the effects of pumping. More detailed data collected during the 2006 Study revealed that the River does not completely isolate Creamery Meadow from the effects of pumping. During periods of maximum pumping, these effects were limited to less than 0.2 feet of groundwater drawdown at the River's far edge opposite the pumps, diminishing to zero drawdown several hundred feet into Creamery Meadow. Analysis of data allowed calculation and mapping of the specific area of potential groundwater level drawdown in Creamery Meadow. Based on this defined level of impact, evaluation of the significance of impact on the flora via root zone access to water can be accomplished.

River Water Quality Impacts

Does pumping of the El Sur Ranch irrigation wells have any effect on the quality of the water in the Big Sur River?

Yes.

Data collected during the 2004 Study showed highly variable water quality along the stretch of River nearest to the pumping wells and upstream of the Lagoon. This was determined to be the result of inflowing groundwater mixing with the River water, as the most significant water quality variations occurred along the Creamery Meadow side (i.e., the right side) of the River. The 2006 Study confirmed that groundwater, characterized as being depleted in dissolved oxygen content and lower in temperature relative to River water, does inflow and mix with the water in the River. Most of the groundwater flows into the River from the Creamery Meadow side and has the effect of lowering both dissolved oxygen and temperature of the River water. The pumping of the irrigation wells reduces the total inflow of groundwater along the section of the River that is within the area of influence of pumping. Simple mass balance analysis indicates that a reduction in total inflow of groundwater with depleted dissolved oxygen and lower temperature can only result in two effects; a) dissolved oxygen levels in the River across this section will increase in response to pumping, and b) temperature of the River across this section will increase in response to pumping. Any increase in dissolved oxygen can only improve the habitat conditions for Steelhead, therefore any amount of pumping will be beneficial. Reducing the amount of groundwater entering the River, such as what occurs during irrigation well pumping, will incrementally increase the temperature of the River water. When considering average September pumping conditions and all flow conditions, the maximum calculated theoretical effect is approximately 1 degree Centigrade. Thus, the effects of pumping are significant only when steelhead habitat conditions in the River have already reached a critical stage.

Water Availability

<u>At what point does pumping the El Sur Ranch irrigation wells have an effect on the availability of water in the River?</u>

<u>The Big Sur River maintains an available, continuous surface flow even in the driest years.</u>

The combination of data and analysis conducted as part of the 2006 Study along with the watershed and Study Area water balances calculated during the 2004 Study (HI-CSM) allows for the calculation of a simplified surface flow water balance for the River within the irrigation well area of influence. The surface flow water balance was calculated for the lowest flow month of the year (September) in order to provide a conservative basis for planning decisions. The water balance was calculated for both the 2004 and 2006 Study periods as well as for various theoretical flows indicative of a 'Critically Dry' water year type. The water balance calculations indicate that during 'Critically Dry' years accompanied by typical September pumping conditions, River flow in the pumping area of influence (Zones 2-4) could be 3.8 cfs or below. During the summer of 1991, River flow conditions as measured by the USGS gauge reached a low of 5.3 cfs in October while irrigation pumping continued. This flow is below the 5% non-exceedance value of 5.5 cfs at the USGS gauge, indicative of a condition well below the critically dry year cutoff of 20% non-exceedance. Water balance calculations indicate that at this low level, River flow in the area of influence could have been as low as 1.4 cfs while irrigation pumping was occurring. No discontinuity of River flow was noted in the documented pumping area of influence during the 1991 pumping year as a result of this low flow rate. This fact is especially significant for long-term management planning given that the 1991 pumping year was preceded by four years of low rainfall and low total summer River flows. This analysis of water availability combined with knowledge of the historic response of the River to pumping indicates that even under the lowest of flow conditions, irrigation pumping will not serve to interrupt the continuity of River flow within the documented area of influence of the pumping wells.

1.0 INTRODUCTION

1.1 Purpose and Goals

The purpose of this addendum to the 2004 Study Report *Hydrogeologic Investigation and Conceptual Site Model Within the Lower Reach of the Big Sur River* (HI-CSM), May 2005, is to develop a correlation between the groundwater pumping rates of the two El Sur Ranch (ESR) irrigation wells and the calculated loss of surface water through the bed of the Big Sir River (River) in response to the pumping. In addition, the effects of pumping on drawdown impacts to the River and the adjacent Creamery Meadow were evaluated. Also, monitoring the movement of the saline wedge inland was evaluated to further address concerns over the impact of saline water to the lagoon and riparian zones. Finally, a monthly based water budget for various water year types was considered, specifically focused on the later summer months when pumping has the most potential to cause an impact.

The work performed was based upon the August 17, 2006 Technical Memorandum titled *Hydrogeologic Workplan Elements for Proposed 2006 Data Collection Program* (2006 Data Collection Program). This 2006 Study was carried out in cooperation with the biological consulting firm Hanson Environmental (Hanson), and was conducted coincident with the implementation of their August 19, 2006 workplan titled *Proposed Monitoring Program to Evaluate the Potential Relationship Between El Sur Ranch Well Operations and Fish and Wildlife Habitat Associated with the Big Sur River During 2006* (Hanson Work Plan). The results of the implementation of the Hanson Work Plan are summarized in Hanson's *Evaluation of the Potential Relationship Between El Sur Ranch Well Operations and Fish and Wildlife Habitat Associated with the Big Sur River During Late Summer and Early Fall, 2007* (2007 Hanson Report), published concurrently with our results.

1.2 Previous Work

Much of the general information regarding the ESR Study Area, including climate, regional geology and hydrogeology, details of local geology, aquifer characteristics, general River hydrology, and previous site investigations have been covered in detail within the HI-CSM Report. The HI-CSM Report detailed the methods, results and conclusions of the 2004 investigation of the Big Sur River Study Area (2004 Study). Although this addendum report is designed to compliment the HI-CSM Report, it is an independent report and as such may suggest conclusions contrary to those reached in the HI-CSM.

1.3 Study Area

During the 2004 Study, the Study Area was defined as 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 that stretch of River (Figure 1-1). For the 2006 Study, the bulk of the work was focused around a 2,000-foot section of the lower Big Sur River bounded downstream by the upper lagoon and upstream by the 'deep pool' area (former location of the 2004 Study's 'Temperature Logger #3' data collection point). It is along this section that the alignment of the River changes from running approximately parallel to Creamery Meadow groundwater flow to approximately perpendicular to the flow. This stretch constitutes the 2006 Study Area. See Figure 1-2 for details of the focused 2006 Study Area.

1.4 Methods of Investigation

This section summarizes the activities that were conducted as part of this investigation. Further information regarding details and methodologies used to complete the activities summarized below are provided in Section 2.0.

The methods of investigation included a combination of direct field measurements from within the Study Area and acquisition of data generated by the United States Geological Survey (USGS) and the National Oceanic and Atmospheric Administration (NOAA). A renewal of the Permit to Conduct Biological, Geological, or Soil Investigation/Collections for this work was approved by the Department of Parks and Recreation and can be found in Appendix A. Investigation activities included the following:

- A temporary gauging station was established on the River upgradient from the 2006 Study Area to periodically measure River water velocity and overall flow. Data from this gauging station was correlated with continuously recorded water level data from an adjacent stilling well to achieve a continuous record of River flow entering the Study Area.
- Continuous monitoring and recording of River water dissolved oxygen (DO) content was established at two locations within the Study Area. The data were used to assess diurnal changes and interaction between surface water and groundwater.
- Nine pairs of piezometers were installed in the bed of the River at five locations within the Study Area. Each pair consisted of a deep and shallow piezometer equipped with a data logging transducer that allowed continuous recording of water level (pressure) and temperature data. The head (water level elevation) difference between each piezometer pair indicates the magnitude of the groundwater flow gradient into or out of the River at the piezometer pair location.
- Continuous groundwater elevation and temperature data was monitored and recorded from nine groundwater monitoring wells and two in River stilling wells within the Study Area. The data were used to assess water level fluctuations, diurnal events and degree of connection between groundwater and surface water.

- Contemporaneous manual water level measurements were routinely collected from nine wells within the Study Area.
- Water quality parameter data, including DO, temperature, and electroconductivity (EC) were collected using handheld field instruments from both groundwater and River water periodically during this investigation. These data were used to describe the general water quality and to characterize significant conductivity and temperature differences between groundwater, surface water and ocean water.
- All of the monitoring wells, stilling wells, piezometer locations and river transects used for data collection were surveyed by a licensed surveyor. The survey data were used in the construction of the potentiometric surface maps and for accurately placing the measurement locations on a base map.
- Streambed hydraulic conductivity testing was conducted using a permeameter.
- Acquisition of public domain data.

2.0 WORK PERFORMED

2.1 Field Reconnaissance

On August 25, 2006, a detailed field reconnaissance was conducted along the 2,000-foot section of the lower Big Sur River bounded downstream by the upper lagoon and upstream by the 'deep pool' area. This portion of the Study Area, known as the 2006 Study Area, was the focus of the work conducted during the 2006 Study. The survey was conducted by walking and inspecting this stretch of the River, which allowed for the accurate location of transects, piezometers, sensors, and other equipment as outlined in the 2006 Data Collection Program and the Hanson Work Plan.

2.2 Monitoring Station Installation

The installation of monitoring equipment at various locations was conducted over the period of August 25 to September 8 as equipment availability allowed based on the requirements of the 2006 Data Collection Program and the Hanson Work Plan. The locations of all monitoring stations are depicted on Figure 2-1. See Appendix B for photos of select installed equipment. Note that all station identification information assumes a frame of reference looking upstream (i.e., station identification numbers count upward going upstream and reference a river bank (left or right) relative to looking upstream). The following sections present the details of station installations.

2.2.1 Monitoring Well Water Level Transducers

During the 2006 Study, Global Water™ model WL15 data logging pressure/temperature transducers were installed in nine groundwater wells located within the Study Area, recording both water temperature and head of water above the transducer (groundwater elevation) on an hourly basis. Each transducer was factory calibrated prior to installation. The nine wells fitted with WL15 transducers included ESR-01, ESR-02, ESR-03, JSA-03, JSA-04, the Original Old Well, and the triple nested well cluster ESR-10A, ESR-10B, and ESR-10C. In addition, the groundwater level in the Navy Well was similarly monitored using a Troll 9500 data logging transducer, recording temperature, electroconductivity (EC) and head of water above the transducer (groundwater elevation) on an hourly basis.

2.2.2 Passage Transects

Eleven passage transects were installed along the River within the 2006 Study Area as part of the Hanson Work Plan. They were labeled Passage Transect 1 through 11 (PT1 – PT11) starting at the downstream end of the 2006 Study Area and working upstream (Figure 2-1). Each passage transect consisted of a pair of rebar stakes installed on opposite banks of the River. On a twice weekly basis, the depth profile was measured at each passage transect by recording the depth of the River from bank to bank in half-foot increments. From the resulting data, the wetted width of the River at each location could be calculated.

2.2.3 Gauging Station

A temporary gauging station was set up several hundred feet downstream of the Andrew Molera State Park parking lot, at the same location as the upstream velocity gauging station (Velocity Transect 1) that was set up during the 2004 Study (Figure 2-1). For the purposes of this report, the temporary gauging station will continue to be identified as Velocity Transect 1 (VT1). VT1 consisted of two rebar markers located on opposite banks of the river. To measure River flow, a measuring tape was attached to the rebar markers and stretched across the River. Along this tape, water velocity was measured and recorded at 0.5-foot increments using a portable flow meter. Using the aggregate results of all the water velocity measurements, overall River flow can be calculated.

2.2.4 Stilling Wells

At two locations, stilling wells equipped with a pressure/temperature data logging transducer were installed to monitor and record River water levels. The first, located adjacent to VT1, was designed to monitor water levels which, when correlating the data to the measured River velocities, would provide an hourly record of River flow within the Study Area throughout the 2006 Study. The second, located near PT3, was used to monitor diurnal and tidal fluctuations within the lagoon.

The stilling well near the VT1 was constructed using 3-feet of 2-inch inside diameter Schedule 40 PVC well casing connected to 5-feet of 0.020-inch machine slotted flush threaded Schedule 40 PVC well screen. The angle of the joint between the casing and the screen was 90-degrees. The well casing was oriented vertically and buried in the right bank of the River. The slotted section of the well was embedded several inches into the River bed, oriented parallel to the River surface approximately 1-foot underwater. The lagoon stilling well was constructed using 4-feet of 2-inch inside diameter PVC well casing attached vertically to an immense tree trunk and left open at the bottom. An In-Situ Level Troll 700 pressure/temperate data logging transducer was installed in each stilling well which measured and recorded water height above the sensor (pressure) and water temperature hourly. See Figure 2-2 for a cut-away view of the VT1 stilling well.

2.2.5 Piezometer Well Nests

A total of nine piezometer well nests were installed at five different locations within the 2006 Study Area as shown on Figure 2-1. Each nested pair consisted of a shallow piezometer (installed 6-inches into the River bed) and a deep piezometer (installed 36-inches into the River bed). The piezometers are identified by which of the five locations they are installed at (P1 through P5), which bank of the River they are closest to (L or R), and if they are installed shallow or deep (S or D). Each piezometer was equipped with an In-Situ™ Level Troll 700 which measured and recorded water level elevation (pressure) and temperature every hour.

Data from each piezometer pair was designed to yield a continuous record of the vertical hydraulic gradient at each of the nine locations throughout the 2006 Study. Vertical hydraulic gradient is the change in hydraulic head over the change in vertical distance between the measurement points. The piezometers were installed specifically to measure the vertical hydraulic gradient across the upper 3-feet of the bed of the River, the maximum depth to which vertical hydraulic conductivity (K) was likely to be significantly altered by the effects of River water flow. This depth was thought to be conservative as most processes effecting shallow streambed vertical hydraulic conductivity generally take place in the upper 0.82-feet (0.25-meters). The deep piezometers were installed 3-feet into streambed while the shallow piezometers were installed in such a manner as to effectively make them River stilling wells.

The shallow piezometers were each constructed of a 6-inch long by ¾-inch diameter PVC probe attached to a PVC transducer housing measuring 1.5-inches in diameter by approximately 40-inches long. The probe was radially perforated approximately 2-inches from the tip. Each was installed into the streambed by entirely burying the probe end of the piezometer, leaving only the transducer housing projecting up from the bed of the River and the top end exposed above the surface of the water. The shallow piezometers were additionally secured by strapping each to an adjacent piece of rebar which had been driven approximately 18-inches into the bed of the River. The effect of mechanically burying the shallow piezometers into the streambed enhanced their hydraulic connection to the River, effectively making them River stilling wells.

Each deep piezometer was constructed of a 6-inch long by ¾-inch diameter stainless steel screen drive point attached to a 30-inch long by ¾-inch diameter stainless steel drive pipe which in turn was connected to a PVC transducer housing measuring 1.5-inches in diameter by approximately 40-inches long. The drive points used were Solinst™ Model 615, composed of a stainless steel cylindrical filter screen protected within a ¾-inch stainless steel body. The drive point was threaded into one end of the drive pipe and hand driven approximately 36-inches into the bed of the River until only the threaded tip of the drive pipe was visible above the River bed. The housing was attached to the drive pipe with the top end exposed above the surface of the River.

Each piezometer was equipped with an In-Situ™ Level Troll 700 pressure/temperature data logging transducer. The transducer cable was securely attached to a cap covering the top of the transducer housing, allowing the transducer to hang free within. The other end of the transducer cable contained the data uplink connector, which was routed through the housing and attached to the outside, enabling easy access for routine data downloading. See Figure 2-3 for an idealized cross section of a piezometer well pair installation.

2.2.6 Electroconductivity Transducer

An In-Situ Model 9500 data logging transducer capable of measuring groundwater temperature, pressure, and electroconductivity (EC) was installed within the Navy Well (Figure 2-1). The transducer data cable was anchored at the top of the well housing, extending down into the well casing allowing the transducer to hang under water. This transducer measured and recorded the EC of the well water on an hourly basis. The transducer was installed to monitor changes in salt water content of the Navy Well water as the Old Well and New Well pumps were run.

2.2.7 Dissolved Oxygen Transducers

Two In-Situ Model 9500 data logging transducers capable of measuring the dissolved oxygen (DO) content of the River water were installed in the River within the 2006 Study Area. DOx1 was located near the right bank of the River near PT7. DOx2 was located near the right bank of the River midway between PT10 and PT11 (Figure 2-1). Each transducer was contained in a perforated PVC pipe with an attached lead weight and allowed to hang nearly vertically underwater via steel leader cable attached to an anchor point. The transducers measured and recorded the concentration of DO in the River water on an hourly basis. The transducers were installed to monitor changes in DO content of River water as the Old Well and New Well pumps were run.

2.3 Streambed Hydraulic Conductivity Measurements

One of the key factors needed to determine the amount of groundwater gain or loss to the River is the quantification of vertical hydraulic conductivity in the upper 0.82-feet (0.25-meters) of the streambed. Measurements were be taken by conducting falling-head tests using a field permeameter. The field permeameter consisted of a 14.5-inch internal diameter smooth walled schedule 80 PVC pipe with beveled ends, approximately 4-feet in height. At each test location, the permeameter was pushed into the bed of the River by hand as far as possible, though making every effort not to disturb the streambed within the permeameter. Gaps between the permeameter and the various shaped cobbles that make up the streambed were sealed using similar streambed materials (silt and/or fine to coarse grained sand). Falling head tests were conducted via the introduction of water to a pre-determined height followed by the monitoring of the drop in water level as the column exits the pipe through the streambed. Water level drop was monitored visually using a graduated scale within the permeameter and timed using a stopwatch. The collected data were analyzed using Horslev solutions to the falling head permeameter tests. The test design was based on Landon's comparison of methods used to measure hydraulic conductivity in sandy streambeds (Landon 2001).

2.4 Elevation/Location Surveying

In April 2003 and September 2004, Rasmussen Surveyors developed a benchmark at the location of the Old Well and surveyed wellhead and ground surface elevations for all accessible wells including Old Well, New Well, ESR-01, ESR-02, ESR-03, JSA-03, JSA-04, ESR-10A, ESR-10B, ESR-10C, ESR-11 and ESR-12. In September of 2006, Rasmussen Surveyor surveyed in the locations of all of the transect rebar markers (PT1 through PT11, and VT1), all nine piezometer pairs, and the two stilling wells. A copy of the survey data is provided in Appendix C.

2.5 Monitoring Program

The collection of field measurements and monitoring equipment was conducted on a regular basis during the course of the 2006 Study. These activities included:

- The collection of groundwater levels from nine monitoring wells, nine piezometer pairs and two stilling wells (twice weekly).
- The measurement of River flow velocity and stage (twice weekly).
- The collection of water quality parameter data from nine monitoring wells and 12 transects along the River within the Study Area (twice weekly).
- The download of data from all accessible deployed transducers (weekly).
- The measurement of River flow from the temporary gauging station (twice weekly).

2.5.1 Groundwater Levels

Global Water™ model WL15 data logging transducers were used to collect and record temperature and groundwater head (amount of water above the sensor) measurements from monitoring wells within the Study Area. See Figure 2-1 for the location of each transducer equipped well. The data recorded by the transducers were downloaded to a handheld computer (PDA) on a weekly basis. Each transducer was factory calibrated prior to deployment. According to the manufacturer, the accuracy of the pressure transducers is ± 0.2% of the full pressure range between 35 °F to 70 °F. This equates to an accuracy of ± 0.006-ft (± 0.07 inches) for the pressure transducers with a 3-ft pressure range (used in wells ESR-01, ESR-02, ESR-03, JSA-03, ESR-10A, ESR-10B, and ESR-10C) and an accuracy of ± 0.03-ft (± 0.36 inches) for the pressure transducers with a 15-ft pressure range (used in JSA-04 and Original Old Well). The pressure transducers used are known as "differential water level monitors", meaning that they automatically compensate for changes in atmospheric pressure and that no post data retrieval corrections are required.

In-Situ Level Troll 700 data logging transducers were used to collect and record temperature and surface water head (amount of water above the sensor) measurements from the piezometers and stilling wells within the Study Area. See Figure 2-1 for the location of each transducer equipped well. The data recorded by the transducers were downloaded to a handheld computer (PDA) on a weekly basis. Each transducer was factory calibrated prior to deployment. According to the manufacturer, the accuracy of the pressure transducers is ± 0.05% of full scale at 60 °F. This equates to an accuracy of ± 0.006-ft (± 0.07 inches) as full scale for these transducers is 11.5-ft. The pressure transducers are also "differential water level monitors", meaning that they automatically compensate for changes in atmospheric pressure and that no post data retrieval corrections are required.

On a twice weekly basis, depth to groundwater was measured manually in each well, stilling well and piezometer. A Heron™ "Little Dipper" water level meter was used to assess depth to water. According to the manufacturer, the instrument conforms to the upcoming American Society for Mechanical Engineers (ASME) performance standard for steel measuring tapes (reference B89.1.7).

2.5.2 River Stage and Flow

River stage and flow at Velocity Transect 1 (VT1) was measured manually on a weekly basis. Data from the stilling well pressure and temperature transducer was downloaded to a handheld computer (PDA) concurrent with the stage and flow readings (see section 2.6.2 for specification for the In-Situ Level Troll 700 data logging pressure/temperature transducer used in the stilling well).

A Marsh-McBirney Flow-Mate 2000 electromagnetic velocity meter was used to measure river flow. River velocity was measured and recorded at 0.5-foot intervals along a transect oriented perpendicular to the direction of river flow, with depth to river bottom being measured concurrently, from which river flow volume could be calculated. According to the manufacturer's specifications, the meter can record velocities in the range of -0.5 feet per second (ft/sec) to +20 ft/sec, with an accuracy of ± 2% of the reading. This allows for a maximum error of ± 0.2 ft/sec at maximum velocity. The sensor is calibrated by placing it in a pan of standing water and 'zeroing' the unit. Periodic maintenance is confined to simply cleaning the sensor and checking the strength of the batteries.

In general, there is a direct correlation between river flow velocity and stage height such that as flow velocity increases, stage height will increase proportionally. Once the data from the 2006 Study was collected, correlating the weekly velocity measurements with the continuously recorded measurements of River stage height yielded a continuous record of River flow.

2.5.3 River and Groundwater Temperatures

Groundwater temperatures were monitored via Global Water model WL15 data logging temperature transducers installed in the Study Area groundwater wells, with an accuracy of ± 1.0 °F. The data recorded by the transducers were downloaded to a handheld computer (PDA) on a weekly basis. When practical, temperature was measured manually in monitoring wells with suitable accessibility using a YSI 556 water quality meter (see section 2.5.4 for YSI 556 meter specifications).

River water temperatures were additionally monitored via the In-Situ Level Logger 700 data logging transducers installed in the Study Area stilling wells and piezometers with an accuracy of ± 0.1 °C. The data recorded by the transducers were downloaded to a handheld computer (PDA) on a weekly basis.

2.5.4 River and Groundwater Water Quality Parameters

Twice weekly, water quality parameters were collected from 12 different locations along the Big Sur River. These stations include PT1 through PT11 and VT1 (Figure 2-1). A YSI 556 multiprobe system was used to measure temperature, electrical conductivity and dissolved oxygen content of both groundwater and river water at each location. The temperature sensor has an accuracy of ± 0.15 °C (± 0.27 °F) and does not require periodic calibration. The electrical conductivity sensor has an accuracy of ± 0.5% of reading + 1.0 micro-Siemans per centimeter (µS/cm) (example: a reading of 250 µS/cm would result in an accuracy of ± 2.25 µS/cm) and requires periodic calibration. The dissolved oxygen sensor has an accuracy of ± 2% of reading or 0.2 mg/L, whichever is greater (example: a reading of 12 mg/L would result in an accuracy of ± 0.24 mg/L) and requires periodic calibration and sensor maintenance. The YSI multiprobe was calibrated by a manufacturer certified facility prior to field deployment, then on a frequency of every two weeks during the study period. At each calibration, the conductivity meter was calibrated to a 1,000 µS/cm standard solution and the dissolved oxygen sensor was calibrated using a water saturated environment, all following YSI published procedures. In addition, the dissolved oxygen sensor permeable membrane was replaced at each calibration as recommended by the manufacturer.

In general, three readings were collected from each station corresponding to the left edge, the right edge, and the center of the River. Additionally, water quality parameters were collected from accessible monitoring wells using the YSI 556 water quality meter. On a daily basis, the temperature, conductivity and dissolved oxygen of effluent water was measured and recorded from any active pumping well using the YSI-556.

2.5.4.1 Dissolved Oxygen

Two In-Situ Model 9500 data logging transducers were used to measure and record hourly the concentration of DO in the River at two locations within the Study Area. The In-Situ Model 9500 was equipped with a 'Clark Electrode' which can measure dissolved oxygen concentrations with an accuracy of ± 0.2 mg/L. Each transducer was factory calibrated prior to deployment. Due to the difficulty in accessing these transducers, data was only downloaded twice; once midway through the 2006 Study and then again at the end. See Figure 2-1 for the locations of the two DO transducers.

2.5.4.2 Electroconductivity

An In-Situ Model 9500 data logging transducer was used to monitor the electroconductivity (analogous to salinity) of the groundwater within the Navy Well. The In-Situ Model 9500 was equipped with a sensor able to measure EC to within ± 2.0 µS/cm. The transducer was factory calibrated prior to deployment. Data from this transducer was downloaded weekly during the 2006 Study. See Figure 2-1 for the location of the Navy Well.

2.5.5 Public Domain Data Acquisition

Much of the data needed for the study was being collected by other entities and was available via Internet download. The following data was collected:

2.5.5.1 Big Sur River Gauge Flows

United States Geological Survey (USGS) stream gauge #11143000 is located on the Big Sur River above the Study Area. This gauge records stage height and stream flow of the Big Sur River every fifteen minutes. The data was obtained from the following USGS Internet web page: http://waterdata.usgs.gov/ca/nwis/uv?dd_cd=02%2C03&format=html&period=31&site_no=11143000.

2.5.5.2 Tidal Conditions

NOAA tidal station #9413450 is located in Monterey Harbor within Monterey Bay. This station records tidal changes every six minutes. Data from this station is collected and maintained by the Center for Operational and Oceanographic Products and Services (CO-OPS). The data was obtained from the following Internet web page:
http://tidesandcurrents.noaa.gov/data_menu.shtml?stn=9413450%20Monterey,%20CA&type=Tide%20D
ata

3.0 DATA ANALYSIS AND STUDY RESULTS

3.1 Groundwater Pumping

In order to facilitate monitoring a stabilized groundwater system, ESR did not run any of the irrigation pumps between August 7 and the September 9 start of the 2006 Study. Monitoring equipment was installed between August 25 and September 8 to quantify the pre-study stabilized condition of the groundwater system. Beginning on September 9, the active portion of the 2006 Study was initiated and included periods of pumping at the 'maximum rate possible' followed by system stabilization periods when no pumping occurred as follows:

- Both Old Well and New Well were actively pumped at the maximum rate achievable from September 9 through September 15. The average extraction rate totaled 5.83 cfs.
- Pumping the Old Well alone occurred from September 22 through September 28. The average extraction rate totaled 2.43 cfs.
- Pumping the New Well alone occurred from October 6 through October 12. The average extraction rate totaled 3.03 cfs.

During the week of February 16, 2004, pumping tests were conducted on each of the two irrigation wells in order to document operation parameters and limits under different scenarios. The results show that the Old Well is operated with a constant backpressure, meaning that the pumping output is generally constant regardless of what field is being irrigated. The output of the New Well, on the other hand, is operated such that pump backpressure is dependant on the elevation of the pasture being irrigated. The lower the elevation of the pasture, the less backpressure there is on the New Well which results in a higher pumping rate, and vice versa. Therefore, to get the most water out of the pumping wells, the New Well has to be set to irrigate the El Sur Ranch pastures at the lowest elevations. Without taking Ranch operations into account, pumping at the 'maximum rate possible' is achievable by continuously irrigating the field at the lowest elevation.

During the 2006 Study, the goal was to run the irrigation pumps at the 'maximum rate possible', but within the constraints of day to day El Sur Ranch operations. The first constraint was that pumping to the same field(s) for six straight days would lead to over-watering, significant water runoff and possibly erosion. Surface water runoff and potential erosion concerns were voiced by the Department of Parks and Recreation in 2004 and 2005. Three separate field inspection events were conducted in 2005 to evaluate concerns over potential irrigation water runoff issues to park lands as documented in Appendix D. To ensure that the pumping tests conducted in 2006 did not create conditions of irrigation water runoff, the fields being irrigated had to be switched periodically mid-test to prevent this from occurring. The second constraint was that, during the tests, there were occasional leaks in the piping that conveyed the water from the pumps to the fields. This sometimes resulted in pumping to fields at a higher elevation in order to bypass a leak as it was being repaired. Again, not immediately bypassing the leak would result in excess water runoff and possibly erosion. Keeping the two constraints in mind, every effort was made to bias pumping to fields at lower elevations in order to keep groundwater extraction rates up during the 2006 Study. However, the operational 'maximum rate possible' is less than the theoretical 'maximum rate possible'.

The extraction rates during the 2006 Study pumping tests varied dependent on the operation requirements of the Ranch. Every effort was made to keep pumping rates high by biasing irrigation toward the fields at lower elevations. Although this resulted in pumping outputs that were less than the theoretical maximum output achievable by the two irrigation wells, they very closely approximate, if not exceed, the real world maximum pumping rates required by Ranch operations.

3.1.1 Stabilization of Pumping Conditions

Groundwater levels in monitoring wells surrounding the two ESR irrigation wells were measured and recorded hourly via data logging pressure transducers for the duration of the 2006 Study. The hydraulic effects of pumping are discernible in the recorded groundwater levels (hydrographs) for nearly all of the monitoring wells, and clearly demonstrate that four days or less are required to achieve groundwater drawdown stabilization following the start of sustained groundwater extraction. The hydrographs for all nine wells can be seen in Appendix E, and their spatial locations relative to the ESR irrigation wells are shown on Figure 3-1.

Drawdown stabilization occurs when a sustained rate of pumping produces no further decrease in groundwater levels as measured in surrounding monitoring wells. However, during the course of each pumping test, Ranch operations dictated the need to alter which pasture(s) received irrigation water (Section 3.1) resulting in variations in groundwater extraction rates. Table 3-1 shows the daily groundwater extraction rate(s) and the corresponding pasture(s) receiving water during each pumping test conducted.

The ESR irrigation well pumping tests achieved effective groundwater drawdown stabilization, though the various mid-test changes in extraction rate resulted in an upward or downward shift in groundwater stabilization elevation. When pumping well extraction rates are not constant during a pumping test, recovery test data (i.e., data recorded after the pumps are turned off showing groundwater returning to pre-pumping levels) are more reliable than drawdown data (Kruseman and DeRidder, 1989). Both groundwater drawdown and groundwater recovery data were analyzed to determine stabilization times.

The effect of the change in extraction rate on drawdown stabilization elevation is clearly seen in the hydrograph of well JSA-04 as shown on Figure 3-2a. This well is located adjacent to the New Well irrigation well (see Figure 3-1). The pumping test involving both irrigation wells started on the morning of

September 9. Approximately four days into that pumping test, the groundwater elevation in JSA-04 had dropped from an initial elevation of approximately 6.25-ft to below 3.5-ft. At this point, groundwater stabilization has been achieved, though diurnal tidal cycles add a component of noise to the data. Starting somewhere between 4pm and 5pm on September 14, the elevation of the groundwater in JSA-04 rises nearly 0.25-feet during an approximate 2-hour span of time. The rise groundwater level is coincident with the change in irrigated pastures that occurred at 4:32pm as seen in Table 3-1, which likewise corresponds with the drop in the pumping output for New Well. This upward shift in the groundwater drawdown stabilization elevation was in response to the mid-test decrease in total pumping well output from 5.83 cfs to 5.61 cfs. Likewise, the last day of the New Well only pumping test shows a significant drop in the groundwater drawdown stabilization level as measured in JSA-04 relative to the previous six days. Again, Table 3-1 shows that on the last day of the pumping test, a change in the field receiving irrigation water resulted in an increase in the pumping well extraction rate from 2.88 cfs to 3.49 cfs. It is likely that the close proximity of JSA-04 to New Well amplifies the changes in the groundwater drawdown stabilization point resulting from changes in the rate of groundwater extraction.

Once groundwater pumping stopped, groundwater elevations rebounded to pre-pumping levels. The hydrodynamics that govern the time it takes for the groundwater elevations to recover to pre-pumping elevations are the same that govern the time it takes for groundwater drawdown stabilization to occur during a pumping test. The JSA-04 hydrograph on Figure 3-2a shows both the groundwater elevation drawdown curve and the groundwater elevation recovery curve for all three pumping tests. Figure 3-2b focuses on groundwater recovery in well JSA-04 following the end of the two well pumping test. The point at which the pumps are shut off is followed by a rapid rise in groundwater elevation. Within approximately 4-days, groundwater elevations were fluctuating around pre-pumping levels, denoting full recovery.

Similar review of the hydrographs for the rest of the monitoring wells (Appendix E) illustrates that groundwater recovery was achieved within 4-days after the cessation of pumping. Groundwater levels were fully recovered for the start of each pumping test. In summary, the collected data indicate that drawdown stabilization and groundwater recovery take approximately 4-days to be established after the start of pumping and following the cessation of pumping, respectively.

3.2 Pumping Area of Influence

The hydraulic effects of pumping are clearly discernible in hydrographs for all water level monitoring points with the exception of those obtained from piezometer set 5 (P5). Figure 3-2a presents a hydrograph of well JSA-04 demonstrating the nature of these hydraulic impacts (i.e., groundwater drawdown is induced during pumping, followed by groundwater recovery when the pump(s) are shut off). Hydrographs for all monitoring points are included in Appendix E. The hydraulic impacts of pumping in the piezometer data are most clearly seen by plotting the head differentials (the difference between contemporaneous measurements of groundwater elevation) between deep and shallow piezometer well pairs. Figure 3-3 depicts the nature of the hydraulic impacts on the River resulting from the three pumping events as seen in data from piezometer set P4. Consistent with the pumping condition, the water levels exhibited a correlated response. As total pumping increased, the groundwater drawdown response in the monitoring wells and deep River piezometers increased. The maximum response correlates with pumping both wells at a maximum rate. The next biggest response in the deep River piezometers correlates to pumping the New Well alone, which is the well closest to the River. The smallest response correlates to pumping the Old Well alone, which is the well farthest away from the River piezometers and pumps at a lower total pumping rate. These same water level response signatures are seen in all of the water level monitoring data collected in monitoring wells and piezometers with the exception of data collected from piezometer sets P5L and P5R.

River piezometer data indicate that the area of influence of the pumping wells does not extend to piezometer set 5 (P5L and P5R), located 1,100-feet up-gradient from the New Well and 1,500-feet up-gradient of the Old Well. Figures 3-4 and 3-5 depict the P5 hydrographs for both shallow and deep piezometers on River left and right, respectively. These hydrographs include the River flow graph at location VT1 for comparison. The changes in water level in each of these piezometers tracks with the changes in River flow with no discernible correlation between water level changes and the periods of pumping activity. Figure 3-6 presents the hydraulic head differential between the deep and shallow piezometers at both River left and right locations for the P5 piezometer set. Review of this graph also shows no discernible hydraulic effect of pumping on the water levels in these piezometers. This finding is consistent with data collected from the stilling well installed during the 2004 Study at station 'transect 2' located 760-feet up gradient from the New Well (Section 3.4.8.2 of the 2004 HI-CSM discusses this data). Data collected at the 'transect 2' stilling well showed the possibility of a discernible hydraulic impact on one pumping occasion and no discernible hydraulic impact measurable during another pumping occasion. This can be explained by the knowledge that the location is near the edge of the area of effective influence of these wells. Based on the data from the 2004 Study combined with the 2006 Study data from the P5 piezometers, it can be concluded that the effective up-gradient radius of influence of pumping on the River is somewhere between 800 and 1,100 feet.

A distance drawdown analysis of the pumping tests for the Old Well and New Well was conducted to calculate an up-gradient area of influence. Drawdown data from wells located directly up-gradient of each of the pumping wells were used as they were least likely to demonstrate impacts related to the lateral geologic boundaries of the aquifer. Monitoring well distances from the pumping well and the maximum drawdowns observed in the monitoring wells during the pumping test were plotted on a semi-log graph. A line fit to the data was projected out to the point of zero groundwater drawdown and the corresponding distance indicates the pumping well maximum radius of influence. Figures 3-7 and 3-8 present these distance drawdown graphs on semi-log paper with a fitted line and projection to zero drawdown. Based on maximum groundwater drawdowns observed in the surrounding monitoring wells during the Old Well only and New Well only pumping tests, the up-gradient area of influence was projected to be approximately 720-feet and 1,000-feet up-gradient of the New Well location, respectively.

It is important to address the effect on groundwater drawdown and up-gradient radius of influence when both wells are pumping simultaneously. According to Fetter (Fetter, 1988), drawdown at any one point is approximately additive when the areas of influence of two pumping wells in an unconfined aquifer overlap. Figure 3-9 shows the area of influence for both the New Well and the Old Well in the up-gradient direction from the New Well. The monitoring well JSA-3 is within the area of influence for both the New Well and the Old Well. Pumping New Well alone was able to drawdown groundwater levels in well JSA-3 by 1.6-feet, while pumping the Old Well alone was able to drawdown groundwater levels by 0.75-feet. Pumping the two wells together should be able to drawdown groundwater levels in JSA-3 by 1.6-feet plus 0.75-feet, or 2.35-feet. The plot of groundwater drawdown in JSA-3 (Appendix E) demonstrates that this was indeed the case. The corollary is that outside the area where two pumping wells can influence the same point, there is no additional drawdown effect. The New Well can affect drawdown approximately 1,000-feet up-gradient of its location, while Old Well can only affect drawdown approximately 720-feet up-gradient of the New Well. Therefore, Old Well and New Well pumping together have no ability to induce additional groundwater drawdown beyond 720-feet up-gradient of the New Well when compared to New Well pumping alone (Figure 3-9).

Finally, it should be made clear that when the areas of influence of two pumping wells overlap, they do not increase the area of influence of any single well. The New Well pumping alone has an radius of influence that extends approximately 1,000-feet in the up-gradient direction. Simultaneously pumping the Old Well will not increase the New Well's radius of influence. Additionally shown on Figure 3-9 is a conceptualized groundwater drawdown map of the 2006 Study Area. The map depicts the predicted maximum amount of groundwater drawdown based on actual drawdowns measured when both irrigation wells were pumping at maximum.

In summary, the hydraulic impacts of pumping were only discernible in groundwater and River piezometers in the area of the River that curves around the pumping well field. Based on data analysis, the up-gradient limit to the hydraulic influence of pumping both wells at maximum production rates on the River and groundwater is approximately 1,000-feet up-gradient of the New Well correlating with the area around the first bend of the River to the south as it enters the focused 2006 Study Area.

3.2.1 Creamery Meadow Pumping Influence

Piezometer well nests P2R, P3R, and P4R measured the vertical gradients on the right bank of the River. They indicated that a positive flow condition (i.e., groundwater flowing into the River) existed during all pumping periods regardless of River and pumping conditions. Data collected from piezometer nest P2R indicated that when both irrigation wells were pumping, the groundwater gradient fluctuated from positive (i.e., groundwater flow into the River) to slightly negative (i.e., water flow from the River to the underlying aquifer) dependant on tidal cycles. At high tides, groundwater gradient remained positive. At lower tide conditions, a slight negative gradient developed as depicted on Figure 3-10 (P2R gradient graph). The average vertical gradient condition during this period remained positive at 0.019-feet/foot at the P2R piezometer area. Although pumping did not change the general condition of groundwater discharge from beneath Creamery Meadow into the River, it did create measurable drawdown in groundwater elevations as measured in the piezometers along the right bank of the River. Total drawdown in P2R deep reached a maximum of 0.20-feet (2.4-inches) during pumping both wells (Figure 3-11). Total drawdown in P3R deep reached a maximum of 0.17-feet (2.0-inches) (Figure 3-12). Total drawdown at P4R deep reached a maximum of 0.16-feet (1.9-inches) (Figure 3-13). Projecting from the right bank of the River to the limit of influence of pumping in Creamery Meadow, total groundwater drawdowns are predicted to be less than 0.2-feet (2.4-inches) diminishing to zero feet as the distance approaches the New Well 1,000-foot pumping radius of influence limit. These drawdowns represent the impact at maximum pumping conditions. Additionally, the pumping area of influence limit should be considered an overestimation as the contributions of water from the River to pumping are not taken into account.

The up-gradient radius of influence for both ESR irrigation wells pumping at the maximum rate has been determined to be 1,000-feet from the New Well as described in Section 3.2. This analysis actually represents a very conservative viewpoint of maximum radius of influence for the Creamery Meadow side of the River. Specifically, the distance drawdown analysis does not account for the River as a source of water for the pumping wells. Water being drawn from the River during pumping would reduce the amount of water drawn from beyond the River in Creamery Meadow. Figure 3-14 shows the drawdown data from wells JSA-3, JSA-4, and ESR-10A, along with data from the deep River piezometers located adjacent to Creamery Meadow, P2R, P3R, and P4R. The data from the piezometers lie inside the line fit to the monitoring well data which projects to the point of maximum area of influence. This suggests that in reality, the actual pumping well area of influence within Creamery Meadow was less than the area calculated from the monitoring well distance drawdown data.

3.3 Streambed Hydraulic Conductivity Testing

Hydraulic conductivity, conventionally represented by the letter 'K', quantifies the relative ease with which groundwater moves through the pore spaces of a sediment matrix. In our case, the sediment matrix is the aquifer that forms the Big Sur River Valley, and is composed of sands, gravels, and cobbles with minor amounts of silts and clays. It is generally much easier for groundwater to move horizontally through sediments than it is to move vertically, a result of the way sediments are deposited. Sediment particles (silt particles, cobbles, etc.) are generally deposited in layers, with successive layers of particles overlapping the particles beneath them much akin to shingles on the roof of a house. It is the nature of this overlapping that preferentially transmits water horizontally within layers of sediment, but resists the vertical movement of water between the layers. Due to this inequality, the hydraulic conductivity of an aquifer is generally broken up into a horizontal hydraulic conductivity component and a vertical hydraulic conductivity component. As a general rule of thumb, vertical hydraulic conductivity is ten times less than horizontal hydraulic conductivity. With regard to the aquifer beneath the Big Sur River, it is horizontal K that governs groundwater flow down the valley to the Ocean and vertical K that governs the movement of water between the aquifer and the River above.

The vertical hydraulic conductivity of the bed of the River (streambed) was determined through permeameter testing conducted along the entire stretch of the 2006 Study Area, paying particular attention to the areas adjacent to the piezometer locations. The testing method was based on a research paper by Landon (Landon, 2001), in which various methods for measuring the hydraulic conductivity of a streambed were compared and evaluated. The general conclusion was that conducting falling head tests and analyzing the data using Hvorslev's method was advantageous for measuring vertical K values in the upper 0.82-feet (0.25-meters) of a streambed. See section 2.3 for details of the equipment and methods employed to measure vertical K. Appendix B contains a picture of the permeameter employed.

The majority of the streambed within the 2006 Study Area was composed of cobbles, ranging in size from several inches to over a foot in diameter, intermixed with gravel, sand and silt. In most places, the streambed was covered with a layer of algae and other organic matter. As the permeameter did not mate well to the streambed owing to the irregular shapes of the cobbles, local materials such as silts and sands from the River's edge were used to seal the resulting gaps. In a small area around PT-8, the streambed was covered with an approximately 1-inch thick layer of organic material, including silt and decomposing leaves. In this area, the permeameter could be pushed into the organic matter and the testing could be conducted without the need to seal any gaps between the permeameter and the streambed cobbles. The loss of integrity through the seal material was indicated by the rapid return to equilibrium of water within the permeameter coupled with small eddies of displaced seal material seen in the River current. If this occurred, the seal was reestablished and the test restarted.

At each test location, multiple permeameter runs were completed to check for reproducibility and to reduce the possibility of measurement error. For each area tested, a maximum, minimum and median K value was computed (Landon, 2001). Finally, a median K value was calculated based on all the valid runs within the 2006 Study Area. The resulting data set had a range of K values from 36 ft/d to 311 ft/d with a geometric mean value of 104 ft/d. See Table 3-2 for permeameter testing results.

From the 2004 Study Report (HI-CSM, page 3-8), a horizontal K for the Big Sur River Valley aquifer was calculated from pump test data to be approximately 3,623 ft/d. The vertical K value of 104 ft/d is significantly less than 1/10th the horizontal K value we expected from the effects of depositional layering, or shingling, as described in the opening paragraph of this section. This disparity results from "colmation", the process which can lead to the congestion of a streambed by the deposition of fine particles, further reducing its vertical hydraulic conductivity (Veličković, 2005). When River velocities are high, as is seen during the winter months, the streambed is scoured, breaking up the clogged material and retaining fine grained particles in suspension. When River velocities slow down, which rapidly occurs following the cessation of the winter rains, suspended sediments are deposited on the streambed and the clogging process is accelerated. This process generally occurs in the upper 0.5-feet of the streambed, and can take between a few days and several months until a relatively steady state streambed vertical K value is reached (Schälchli, 1992). The K of this thin zone of material is the effective K controlling the rate of water exchange between the River and the underlying aquifer.

Various references provide verification for the calculated range of K values derived from the permeameter testing. Chen and Goeke, as part of a 2002 USGS research grant completion report, used similar methods to determine the K of sandy gravely streambeds of several rivers in south-central Nebraska. They found K values to fall between an extreme range of 65 ft/d to 321 ft/d with a common range between 98 ft/d and 131 ft/d (Chen and Goeke, 2002). Ann Calver compiled a set of K values for various streambed tests assembled from published and unpublished sources. The data range for tests conducted in similar sand, gravel and cobble streambed environments ranged from approximately 10 ft/d to approximately 150 ft/d (Calver, 2001). Although every river system is unique, general similarities in streambed composition and morphology will result in similar values of K.

It is understood that there will be variations in K along the bed of the River within the 2006 Study Area. However, the median calculated K value of 104 ft/d has been found to be a good overall value for use in calculating realistic water exchange rates between the River and the underlying aquifer.

3.4 Streambed Response to Pumping

The data collected from River piezometers at stations P1 through P5 demonstrate the direction and magnitude of the vertical hydraulic gradients across the upper 3-feet of the streambed during the duration of the 2006 Study. Appendix F contains hydrographs of all the River piezometers including graphs of head differentials and calculated vertical gradients across the streambed at each piezometer nest location.

Station P5 is located 1,100-feet up gradient of the New Well, the data from which showed no discernable response to pumping, as discussed in Section 3.2. The vertical hydraulic gradient between the deep and the shallow piezometers remained negative (i.e., water was flowing out of the River into the underlying aquifer) throughout the 2006 Study with minor fluctuations related to changes in River flow entering the Study Area. The changes in River flow are seen in the shallow piezometers as changes in the height of the water in the River, known as River stage. The maximum change in River stage recorded was approximately 0.1-feet (1.2-inches). The hydraulic gradients on both the left and right sides of the River at the P5 location were comparable and steadily negative indicating that the natural condition for the River in this area was to lose water to the aquifer (Figure 3-15).

Piezometer stations P3 and P4 were located up gradient of the New Well within the section of River that runs perpendicular to the general direction of groundwater flow within the underlying aquifer (Figure 2-1). The vertical hydraulic gradients in both the River left (P3L and P4L) and River right (P3R and P4R) remained positive (i.e., water was flowing into the River from the underlying aquifer) during the 2006

Study for both of these stations. The magnitudes of the vertical hydraulic gradients were significantly higher on right side of the River. This disparity in magnitude was the result of the River flowing perpendicular to the flow of groundwater at piezometer stations P3 and P4. Higher hydraulic pressures were generated on the up-gradient side of the River (i.e., the right side or the 'up hill' side of the River) relative to the down-gradient side of the River (i.e., the left side or the 'down hill' side of the River). The higher hydraulic pressures on the right side were responsible for the increased vertical gradient. The effects of the three pumping periods are clearly discernible in the P4 and P3 vertical hydraulic gradient graphs (Figure 3-16 and 3-17). The effect of pumping was to reduce the magnitude of the positive vertical gradients in this area. This effect serves to reduce the amount of groundwater in-flow from the aquifer to the River during times of pumping. Simultaneous pumping of both irrigation wells at maximum rates was not enough to reverse the positive vertical gradients across the streambed (i.e., result in a loss of River water to the underlying aquifer) along this stretch. Shallow piezometers at P3 appeared to show a response to pumping. This response was likely due to a reduction in River flow resulting from diminished groundwater inflow. The maximum recorded change in stage was approximately 0.1-feet (1.2-inches).

Piezometer station P2 is located 550-feet southeast of the New Well within the section of River that cuts across the direction of groundwater flow, just before the River turns to the northwest. The vertical hydraulic gradients at River right (P2R) remained positive (i.e., water was flowing into the River from the underlying aquifer) during the 2006 Study with the exception of the period when both irrigation wells were pumping at maximum rates (Figure 3-18). During that period, the gradients measured by the P2R piezometers fluctuated from positive (i.e., groundwater flow into the River) to slightly negative (i.e., River water loss to the underlying aquifer). A correlation can be found between the fluctuating gradients and diurnal tidal fluctuations. The cumulative effect of the pumping impacts overlain by tidal variations was to create a neutral vertical gradient average condition (i.e., no net exchange of water between the River and the underlying aquifer) on the right half of the River during the two well pumping period. Unlike the conditions at River right, the measured gradients at River left (P2L) were predominantly negative (i.e., water was flowing out of the River into the underlying aquifer) during the 2006 Study. It can be seen in the P2L hydrograph that pumping has the small but noticeable effect of increasing the magnitude of the negative vertical gradients. Like at P3 and P4, the disparity in vertical hydraulic gradients between P2L and P2R were the result of the River flowing perpendicular to the flow of groundwater at piezometer station P2. In summary, the P2 piezometers indicate that the River was receiving groundwater on the up gradient side (i.e., the right side of the River, closest to Creamery Meadow) while simultaneously losing water to the underlying aquifer on the down gradient side (i.e., the left side of the River, away from Creamery Meadow) during the 2006 Study. Shallow piezometers at P2 also show a response to pumping that is slightly greater than that seen at P3. This was due to P2 being further downstream from P3, and was thus recording changes from an aggregate greater loss of flow. The maximum recorded change in stage was approximately 0.13-feet (1.6-inches).

Piezometer station P1 was located within the lagoon area of the River, approximately 450 feet south of New Well. The P1 station consisted of a single pair of piezometers placed just north of the mid-channel point of the lagoon (i.e., located closer to the pumping well side of the lagoon). The hydraulic gradients recorded by the P1 piezometer pair were highly influenced by changing tidal conditions, which had a significant impact on water levels in the lagoon (Figure 3-19). The vertical hydraulic gradients varied from positive to negative during the 2006 Study (Figure 3-20). Gradient changes resulting from pumping were largely masked by more significant changes caused by fluctuating tidal and River flow conditions. Data obtained from this station during the late part of the New Well pumping test was compromised due to a high tide event that swamped and disabled one of the transducers.

In summary, the data indicates that the exchange of water between the River and the aquifer in the lagoon area naturally moves between a losing and gaining status dependent on the combined effects of tides, River flow fluctuation, and pumping, with the impact of tides being predominant.

3.5 River – Aquifer Connectivity

Permeameter measurements have indicated that the geometric mean vertical hydraulic conductivity (K) of the upper 0.82-feet (0.25-meters) of the River bed is approximately an order of magnitude less then the general hydraulic conductivity of the surrounding aquifer, as discussed in section 3.3. The processes that reduce vertical hydraulic conductivity in the shallow streambed include the effects of colmation (bed clogging by fine particles, see section 3.3) and surficial algal growth. The process of colmation generally occurs in the upper 0.5-feet of a streambed, and can take between a few days and several months too develop following bed scouring by winter flows (Schälchli, 1992). The K of this thin zone of streambed material is the effective K controlling the rate of water exchange between the River and the underlying aquifer. Further reduction in the vertical hydraulic conductivity of the streambed is caused by the observed growth of an algal mat on the River bottom. The presence of this algal growth is obvious on inspection of the streambed within the 2006 Study Area and can be seen in photographs contained in Appendix B. The result of this streambed conductivity contrast is that the connectivity between water in the River and water in the underlying aquifer is reduced, restricting the exchange of water between the two.

The effects of the conductivity contrast can be seen in review of River piezometer hydrographs. Figure 3-21 presents the hydrographs for the P4L shallow and deep piezometers depicting their hydraulic response to pumping (All piezometer hydrographs are presented in Appendix F). The P4L shallow piezometer was mechanically dug into the upper 6-inches of the streambed with the inlet openings approximately 3-inches to 4-inches below the bed surface. The method of installation locally disrupted the colmation zone, forming a direct connection between the River and the shallow piezometer (i.e., effectively making the shallow piezometer a River stilling well). The P4L deep piezometer was installed 3-feet into the bed of the River, with open screen from 2.5-feet to 3.0-feet below the streambed surface. Although the inlets of the two piezometers were vertically separated by less than 2.5-feet, the pumping induced drawdown of water levels recorded in the P4L deep piezometer were not discernible in water levels recorded in the P4L shallow piezometer. Conversely, the effects of natural fluctuations in River flow are visible in the hydrograph of the shallow piezometer (P4LS) while muted in the hydrograph of the deep (P4LD). The water levels measured by the shallow and deep piezometers at P4L and, by extension, all piezometer pairs, reasonably measure hydraulic conditions both directly above and directly below the zone of colmation. Therefore, vertical hydraulic gradients across the zone of colmation calculated from piezometer pair water level data are also reasonable.

A river which slices through its alluvial base (i.e., aquifer) such that the bottom intersects the underlying bedrock (or other confining material) is considered to be 'fully penetrating'. A river that does not penetrate to the underlying bedrock, such that there is some aquifer material below the base of the river, is considered to be 'partially penetrating'. A well pumping groundwater on one side of a fully penetrating river cannot influence groundwater on the far side. The pumped water would come from the aquifer on the well's side of the river and the river itself. The fully penetrating river is considered to be a 'competent recharge boundary' for that pumping well. If there were a layer of aquifer material between the base of the river and the underlying bedrock, the river is considered to be only 'partially penetrating' (i.e., the river only penetrates part way into the aquifer). In this case, a pumping well on one side of the river would draw water not only from the river, but from groundwater on the far side through the underlying aquifer material. Generally, the less penetrating the river is (i.e., the greater the thickness of the underlying aquifer material relative to the depth of the river), the more water can be drawn from the far side. In the 2006 Study Area, the Big Sur River is generally less than 3-feet deep while the underlying aquifer is between 10-feet and 35-feet thick (HI-CSM, figure 3-8) and is thus considered to be only partially penetrating.

Section 3.2.1 shows that the ESR irrigation wells were able to affect drawdown in Creamery Meadow. Distance drawdown calculations based on pumping induced groundwater drawdown in monitoring wells located north of the River suggests that the pumping influence extends approximately 500-feet into Creamery Meadow. However, these calculations do not take water contributions from the River to the pumping wells into account. Combining the monitoring well drawdown data with drawdown data from deep piezometers P2R, P3R, and P4R (Figure 3-14) demonstrates that the River has an appreciable effect, reducing both the distance into Creamery Meadow that can be affected by pumping and the amount of groundwater drawdown.

Conclusions reached based on the collected data regarding connectivity between the River and the underlying aquifer are as follows: 1) the significantly lower conductivity of the shallow streambed serves to reduce the rate of transfer of water between the aquifer and the River; 2) the lower streambed conductivity serves to mute the hydraulic impacts of pumping on River flow; 3) due to the presence of the conductivity contrast combined with limited penetration into the aquifer, the River does not serve as a competent recharge boundary, though it does contribute water to the pumping wells thereby reducing groundwater drawdown in Creamery Meadow; and 4) as a result of these conditions, the area of influence of the two ESR irrigation wells extends beneath the River into Creamery Meadow as discussed in section 3.2.1. Worst case scenario impacts to water levels in Creamery Meadow are calculated to be less than 0.2-feet (2.4-inches), diminishing to zero as the distance approaches 500-feet from the right bank of the River.

3.6 Analysis of River Gains and Losses

Piezometer pair water level data allow for the calculation of vertical hydraulic gradient magnitude and direction across the streambed throughout the 2006 Study at each piezometer pair location. In order to estimate the rate of flow (Q) across the streambed using Darcy's Law (Q = K x dh/dl x A), these vertical gradients (dh/dl) are multiplied by the shallow streambed's vertical hydraulic conductivity (K), and the area (A) of streambed over which the measured vertical gradients are distributed. As discussed in section 3.3, the geometric mean streambed vertical hydraulic conductivity (K) in the 2006 Study Area has been measured at 104 feet/day. This streambed conductivity was applied to flow calculations across the entire 2006 Study Area section of River. Figure 3-22 depicts the interpreted streambed Zones associated with the hydraulic gradients measured at each of the piezometer well nests. The wetted areas for each piezometer station associated streambed Zone were calculated based on survey measurements of the River's edge taken at each of the 11 passage transect stations depicted on Figure 2-1. The data indicate that the nature of streambed flux in the 2006 Study Area is variable between different Zones of the River and between different halves of the River within the same Zone. The following paragraphs discuss the results of streambed flow calculations at each Zone depicted on Figure 3-22.

Zone 5 represents the area around piezometer set 5 (P5). The boundary of this Zone was defined by the approximate location of PT11 downstream and an approximately equivalent area upstream. This area of the River was experiencing a loss of water to the underlying aquifer during the entire 2006 Study. Additionally, this area lies outside of the pumping well's area of influence. Figure 3-23 depicts the flux of water from the River to the underlying aquifer (shows as a negative flux on the graph) from the left and right River sections and includes the combined calculated flux in this area totaling a nearly constant 1.3 cfs of outflow.

Zone 4 Upper (Figure 3-22) represents the area of transition between the natural losing condition at P5 and the natural gaining condition at P4. Zone 4 Upper includes the area where the River makes a turn to the south. At this point, the direction of River flow changes from running parallel to the direction of groundwater flow in the aquifer to perpendicular to the direction of groundwater flow. As the River makes this change, it transitions from negative flux (i.e., water flow from the River to the underlying aquifer) to positive flux (i.e., water flow from the underlying aquifer into the River) through the streambed. In this flow analysis, the net flux across the streambed for this natural transition area is interpreted to be effectively zero.

Zone 4 represents the area around piezometer set 4 (P4). The boundary of this Zone was defined by the midway point between P4 and P3 downstream and an equivalent area upstream. This area of the River was experiencing a steady gain of groundwater inflow during the entire 2006 Study. Figure 3-24 depicts the calculated groundwater flux through the left and right River streambed sections. The figure also includes the combined calculated groundwater gain (shows as a positive flux on the graph) in this Zone of approximately 1.1 cfs when not influenced by pumping. Pumping does reduce the magnitude of the vertical gradients across the streambed, which in turn reduces the rate of groundwater inflow from the aquifer to the River. With both irrigation wells pumping at maximum capacity, the inflow of groundwater was reduced from 1.1 cfs to approximately 0.4 cfs, a reduction of around 0.7 cfs. At no point during the 2006 Study did the total Zone 4 groundwater flux to the River turn negative (i.e., change conditions from groundwater flowing into the River to water flowing out of the River into the underlying aquifer).

Zone 3 represents the area around piezometer set 3 (P3). The boundary of this Zone was defined by the midway point between P3 and P2 downstream and the midway point between P4 and P3 upstream. This area of the River was experiencing a steady gain of groundwater inflow during the 2006 Study. Figure 3-25 depicts the calculated groundwater flux through the left and right River streambed sections. The figure also includes the combined calculated groundwater gain (shows as a positive flux on the graph) in this Zone of approximately 0.6 cfs when not influenced by pumping. Pumping does reduce the magnitude of the vertical gradients across the streambed, which in turn reduces the rate of groundwater inflow from the aquifer to the River. With both irrigation wells pumping at maximum capacity, the inflow of groundwater was reduced from 0.6 cfs to approximately 0.15 cfs, a reduction of around 0.45 cfs. At no point during the 2006 Study did the total Zone 3 groundwater flux to the River turn negative (i.e., change conditions from groundwater flowing into the River to water flowing out of the River into the underlying aquifer).

Zone 2 represents the area around piezometer set 2 (P2). The boundary of this Zone was defined by the sharp bend in the River downstream and the midway point between P3 and P2 upstream. Figure 3-26 depicts the calculated groundwater flux across the streambed for the right half of the River within Zone 2. Groundwater flux was predominantly positive (i.e., water flow from the aquifer to the River) throughout the 2006 Study, though the influence of irrigation well pumping reduced the flux to around zero (i.e., no net exchange of water across the streambed) when both wells were extracting groundwater at the maximum rate. The groundwater flux across the streambed for the left half of the River was predominantly negative (i.e., water flow from the River to the underlying aquifer) throughout the 2006 Study. The influence of irrigation well pumping had the effect of increasing the magnitude of the flux across the streambed (i.e., increased the amount of water flowing from the River to the underlying aquifer) to a maximum of approximately 0.4 cfs, occurring when both wells were extracting groundwater at the maximum rate. The final chart on Figure 3-26 shows the combined water flux across the streambed for both the left and right sides of the River in Zone 2. During the period when the irrigation wells were not pumping, the net flux was approximately zero. When both irrigation wells were pumping at their maximum rate, the maximum rate of River water loss to the underlying aquifer (i.e., negative flux) was 0.4 cfs. High tide events can result in a temporary swing from negative flux (i.e., River water loss to the aquifer) to positive flux (i.e., River water gain from the aquifer), even during periods of maximum pumping. It should be noted that more water was lost from Zone 2 than Zone 3 and Zone 4, even though they were located in similar hydraulic environments (i.e., River flow in the three Zones is perpendicular to groundwater flow and each of the Zones are approximately equidistant from the pumping wells). What is different is the thickness of the aquifer beneath each zone. The aquifer is between 20-feet and 30-feet thick under Zone 4, up to 35-feet thick under Zone 3, while generally less than 20-feet thick beneath Zone 2 (HI-CSM, figure 3-8). As aquifer thickness decreases, River penetration increases (see section 3.5 for explanation of river penetration). It is this increased River penetration that likely results in the greater loss of water from Zone 2.

Zone 1 represents the lagoon area of the River adjacent to the pumping wells. The boundary of this Zone was defined by PT1 downstream and the sharp bend in the River upstream. This area is unique in that it is significantly tidally influenced and its hydraulic behavior is more akin to a lake than a river. Figure 3-27 presents a graph of calculated flux across the streambed of Zone 1. On a daily basis, the rates of water exchange fluctuate as much as 1 cfs in response to changes in tidal elevation. The graph also seems to indicate that the effect of initiating the pumping of both irrigation wells was to increase the rate at which water flowed from the River to the underlying aquifer (i.e., the flux became more negative). In the middle of this pumping period, however, the flux shifts from a maximum outflow (i.e., negative flux) of approximately 1.8 cfs to an inflow (i.e., positive flux) of over 1 cfs, a swing of nearly 3 cfs. Figure 3-27 includes the calculated Zone 1 flux graph overlain with the average daily tide condition and the daily River flow condition (measured and recorded at station VT1). Review of these comparison graphs show that a combination of both the daily average tide condition and fluctuations in River flow have more of an influence on groundwater flux within the lagoon area than does irrigation well pumping.

3.7 River Water Quality Monitoring Results – Dissolved Oxygen

Comparing the data from the continuously recording DO loggers reveals the influence of the accretion of low DO content groundwater on River water quality. The upstream DO logger, DOx2, was located approximately midway between PT10 and PT11 (Figure 2-1) along the right bank of the River. The graph of the raw data for this location shows a daily DO fluctuation of approximately 2 mg/L, and a steady average concentration of approximately 13 mg/L. The DO logger DOx1 was located in the 'Cold Pool' area (Figure 1-2) near PT7, also along the right bank of the River. Data from DOx1 also shows the same daily 2 mg/L fluctuation and an average concentration trend that varied from approximately 8 mg/L to 12.5 mg/L through out the 2006 Study. See Figure 3-28 for a comparison of the raw data from the two loggers.

The 2 mg/L diurnal fluctuation in DO seen in data from both loggers was the result of the respiration of plant and algal material in the River. Figure 3-29 compares incoming solar radiation data obtained from a weather station located on El Sur Ranch with the DO concentrations recorded by DOx2. DO concentrations rise coincident with the rise in incoming solar radiation, reflecting the release of oxygen from the respiration of plant and algal material in the River resulting from photosynthesis. As solar radiation decreases with the setting sun, the DO released by the photosynthetic process diminishes which resulted in a reduction of DO in the River.

To facilitate the comparison of the data from both loggers, the average daily DO concentrations were computed from both sets of data and plotted against one another as seen in Figure 3-30. This had the effect of removing the diurnal noise created by plant and algal respiration and allowing the focus to be on the overall DO concentration trends that occurred during the 2006 Study. With one exception, the trend recorded by DOx2 remained steady throughout the test, varying only 0.3 mg/L around an average concentration of 13 mg/L. The one exception can be seen on October 5, when the DO fell to a little over 12 mg/L coincident with a rain event which likely had the temporary effect of reducing DO due to the mobilizing of organic matter and other dissolved oxygen consuming materials into the River.

The DO concentration recorded by DOx1 started at just over 8 mg/L, rising steadily to about 9 mg/L in the lead up to the pumping test involving both ESR irrigation wells. The rise in DO continued through that test, through the post test recovery period, finally peaking at approximately 12.5 mg/L midway through the Old Well pumping test. From that point, DO concentrations steadily declined for the remainder of the Old Well test and into the post test recovery period. The rain event recorded by DOx2 was mirrored in the DOx1 data as average DO concentrations dropped from 11.5 mg/L to 9.5 mg/L. Thereafter, DO concentrations exhibited a sinusoidal pattern into the New Well test and then on into the post test recovery period.

Average DO concentrations recorded by DOx1 were significantly reduced and exhibited significant fluctuations when compared to those recorded at DOx2. DOx2 is location in Zone 4 Upper, the transition zone between the natural losing condition at P5 and the natural gaining condition at P4, an area outside the influence of groundwater influx. DOx1 is located in Zone 3, well within the influence of groundwater influx. The influx of groundwater variably effects DO concentrations within the 'Cold Pool' area while the lack of groundwater interaction at the upstream location results in steady DO concentrations as seen in the graphs.

Periodic manual water quality data was collected from near the left bank, in the middle, and near the right bank of the River at the 11 passage transects, PT1 through PT11. The resulting DO concentration data from each passage transect can be found in Appendix G. Data from PT10 (downstream of DOx2) and PT11 (upstream of DOx2) show no significant DO concentration difference between any of the three readings during the 2006 Study, confirming that DOx2 was located in an area not impacted by groundwater influx. PT9 shows a decrease in DO concentrations in the right bank readings on September 18 and 21, and October 2, indicating intermittent groundwater influence from the Creamery Meadow side of the River. Steady reduction of right bank DO concentrations relative to the middle and left bank of the River were seen in data from PT4 through PT8, with the greatest reduction shown at PT7, where the DOx1 logger was located. This indicates significant groundwater influence along this stretch of River. PT1 through PT3 were located within the lagoon area and exhibit only minor separation of DO readings favoring no particular side of the River, indicating negligible groundwater influence. The data showing evidence of groundwater influence, those collected from PT4 through PT9, were coincident with the groundwater Zones 2 through 4, outlined in section 3.6 as zones of groundwater inflow. However, there is no discernable correlation between the magnitude of right bank DO concentration reduction relative to middle and left bank and groundwater pumping.

During the course of the 2006 Study, it was noted that a small but consistent groundwater spring was located adjacent to PT6 near the right bank of the River. When practical, the DO concentration of the spring water was measured and recorded. The resulting data show a steady increase in groundwater DO concentration starting at approximately 4 mg/L and climbing to over 5 mg/L just before the start of the New Well pumping test. This indicates that the concentration of DO in groundwater flowing through Creamery Meadow is much lower than that of the water in the River, and can vary in time by over 1 mg/L. A graph of the data is included in Appendix G.

Figure 3-31 shows the DO concentrations recorded by the DOx1 data logger compared to River flow as recorded at VT1 and average daily tide elevation. Decreases in River flow should increase the amount of aeration in riffle zones due to an increase in turbulent flow, thereby increasing the concentration of DO. Increases in the average daily tide elevation should reduce groundwater flow through the beach and force more groundwater into the River, reducing River DO concentrations. DO concentrations at DOx1 could not be individually correlated to either of these influences. Figure 3-31 also shows the DO concentrations compared to pumping test initiation and shut-down times. It can be discerned that pumping had no measurable effect on DO concentrations recorded by DOx1, which in fact, continued to rise or remained steady during all three pumping tests.

It is likely that a combination of natural effects, including variations in tide elevation and changes in River flow, govern the fluctuating DO concentrations in the River as measured by the DOx1 data logger. A reduction in River water DO concentrations measured along the right bank of the River (i.e., the side closest to Creamery Meadow) demonstrates that groundwater is, in fact, entering the River. However, DO concentrations measured at mid channel and along the left bank show that the volume of groundwater entering the River is insufficient to significantly reduce DO concentrations across the entire width of the river. Sections 3.4 through 3.6 have demonstrated that the pumping of the ESR irrigation wells has the effect of reducing the amount of groundwater that enters the River, sometimes to the point where water flows from the River to the underlying aquifer. The use of ESR irrigation wells can only reduce the amount of low DO groundwater upwelling into the River, and thus does not have a measurable negative effect on River water quality.

3.8 Saline Wedge Movement

Consistent with data reported in 2004, the electroconductivity of groundwater sampled from both ESR irrigation wells remained well below the cutoff standard (i.e., the level above which water from the well is not suitable for field irrigation) of 1,000 µS/cm for each of the three pumping periods during September. A graph of daily pumping well conductivity readings during the pumping periods is presented as Figure 3-32.

Data collected from a data logging transducer installed in the Navy Well included temperature, electroconductivity and groundwater elevation. Groundwater levels in the Navy Well clearly depict the signal from daily pumping of the Navy Well, pumping both Old and New Wells, and the daily tidal impacts to the aquifer near the mouth of the River as demonstrated on the Figure 3-33 hydrograph. Analysis of the water level data as depicted on the hydrograph indicates that the pump installed in the Navy Well normally operates daily from 7 AM to 12 PM and results in an induced drawdown of 0.4-feet. The induced drawdown resulting from pumping the Old and New Wells at the maximum rate steadied out at 1-foot. The induced drawdown due to pumping the Old Well alone and New Well alone steadied out at 0.5-feet and 0.4-feet, respectively. The electroconductivity (salinity) of water within the Navy Well decreased in response to the pumping tests. Hourly conductivity measurements of water in the Navy Well are plotted on Figure 3-34. The Navy Well groundwater exhibited a decrease in salinity correlating with the start of pumping of both wells on September 9. The salinity continued to decrease during the entire dual pumping period, though generally leveled off after 3.5 days. Following completion of pumping the New Well on October 13, salinity in the Navy Well showed a continual increase rebounding towards its original level measured prior to the start of pumping. This data indicates that regardless of the high tide conditions that occurred during the 2006 Study, pumping of both wells and the Navy Well was not able to induce any significant saline movement inland. Salinity measurements in the Navy Well correlate with salinity measured in both the New Well and the Old Well indicating only the presence of fresh water uncontaminated with sea water. Table 3-3 presents a summary of daily pumping well electroconductivity measurements and average daily electroconductivity measured in the Navy Well. These data make it clear that pumping alone is unable to induce landward movement of the saline wedge at the mouth of the River even as far as the Navy Well.

Tidal conditions related to the normal high spring tides in summer ending in the month of August provide the driving mechanism for the natural landward movement of the saline wedge as discussed in the 2004 Report. Data collected during the 2006 Study confirm that pumping from the Old Well that occurs during these high spring tides in effect samples the diffusion front related to the cyclic advancement of the saline wedge resulting in the measured increases in electroconductivity historically noted. In summary, no induced saline mixing zone effects were detected in the Navy Well. In fact, the opposite was detected, indicating preferential movement of fresh water with lower conductivities to the Navy Well location in response to pumping. Thus, no correlation between pumping and saline impacts to water beneath the lagoon in the Navy Well area is plausible.

3.9 Effects of Pumping on River Flow

The area of hydraulic influence of pumping on the River has been determined to be Zones 1 through 4 (Figure 3-22) as discussed in section 3.6. Within this area, piezometer data indicates the average condition was that of groundwater moving through the streambed and adding to the flow of the River (inflow). The impact of this additional groundwater on River water quality can be seen by review of dissolved oxygen data as discussed in section 3.7. The pumping of the ESR irrigation wells served primarily to reduce the naturally positive hydraulic gradients, thus reducing the magnitude of the groundwater inflow. In some cases, such as was occasionally measured in Zone 2 and in the lagoon area that comprises Zone 1 (Figure 3-22), pumping reversed the hydraulic gradient resulting in a loss of River water through the streambed to the aquifer (outflow). No outflow conditions were measured in Zones 3 and 4.

Within Zone 2, groundwater was generally inflowing to the River within the right bank area while generally outflowing within the left bank area. During periods of no pumping, the net change in River flow within Zone 2 was approximately zero (i.e., inflow through the right bank area balanced the outflow through the left bank area). During periods of pumping, outflow through the left bank area increased relative to inflow through the right bank area, reaching a maximum loss in River flow within Zone 2 of approximately 0.4 cfs (Figure 3-26).

The exchange of water through the streambed within the Zone 1 area was highly variable, ranging from a maximum outflow of 1.8 cfs to a maximum inflow of greater than 1 cfs. The maximum outflow condition occurred midway through the period when both irrigation wells were pumping, while the maximum inflow condition occurred just past the point when both irrigation wells were turned off (Figure 3-27). This means that while both irrigation wells were pumping and effecting maximum groundwater drawdown, groundwater flux through the Zone 1 streambed was rapidly changing from outflow conditions to inflow conditions, indicating that a process other than pumping was responsible for this shift. This demonstrates that groundwater pumping is not the dominant process controlling the exchange of water between the River and the underlying aquifer within this Zone. Instead, the process is dominated by variations in River flow and the effect that changing tidal conditions have on the groundwater discharge capacity at the mouth of the River. Because of this, it is not possible to estimate what percentage of the water pumped by the irrigation wells is sourced from lagoon water. Figure 3-27 compares Zone 1 groundwater flux to average daily tide height and River flow as recorded at VT1.

Section 3.6 demonstrated that when the ESR irrigation pumps are not active, groundwater will add to the flow of the River within Zones 1 through 4. Figure 3-35 shows that during these non-pumping periods, groundwater will add anywhere from 0.5 cfs to nearly 3 cfs to the River flow. When the irrigation wells are activated, they capture some of the groundwater that would have added to the flow of the River. The amount of groundwater not added to the flow of the River is directly proportional to the rate at which water is extracted by the irrigation wells. This means that, although the pumps have created a condition in which the net amount of groundwater being added to the River has been reduced, the overall flow of the River is still increasing across Zones 1 through 4. This condition is exemplified on Figure 3-35 as the periods when Old Well only was pumping and when New Well only was pumping. At some point, the rate at which water is extracted by the irrigation wells reduces to zero the net amount of groundwater added to the River (i.e., groundwater is inflowing and outflowing at equal rates). Now, any further increases in pumping rate will result in a net removal of water from the River. This condition can occur when both wells are pumping as seen on Figure 3-35.

Table 3-4 shows the numerical relationship between the irrigation well extraction rate and the effect on the amount of groundwater added to River flow in Zones 1 through 4.

Table 3-4
Correlation Between Pumping Rate and Decrease in Groundwater Inflow to River, Zone 1 Through Zone 4

Wells Active	Total Pumping Rate (cfs)	Calculated Decrease in Groundwater Inflow (cfs)	Is There a Net Gain in River Flow?	Pumping to Groundwater Inflow Reduction Ratio (cfs per cfs)
Both	5.83	2.41	NO	0.41
New	2.91	1.62	YES	0.56
Old	2.43	0.74	YES	0.30
			AVERAGE:	0.42

The 'Pumping to Groundwater Inflow Reduction Ratio' illustrates the reduction of groundwater flow into the River for every 1 cfs of groundwater pumped by the irrigation wells. The average of this ratio for each of the three pumping well configurations is 0.42, which is to say that for every 1 cfs of water pumped by the irrigation wells, the amount of groundwater inflow into the River decreases by 0.42 cfs. Note that the ratio for pumping New Well only, the predominant pumping condition in late summer, was 0.56 (i.e., 0.56 cfs of inflow reduction for every 1 cfs of pumped groundwater). Note the column 'Is There a Net Gain in River Flow?' The answer indicates whether, despite the indicated pumping rate, the River was still gaining water via inflow from the underlying aquifer. Only during the period when both irrigation wells were pumping did the overall flow of the River decline within the Zone 1 through Zone 4 area. This is additionally illustrated on Figure 3-35.

The main focus of the 2006 Study was to determine the degree to which pumping can modify the in-stream fishery habitat with respect to continuity and water quality. The measured gradients at the lagoon piezometer pair (P1L) indicates that there can be an outflow of water from the lagoon area (Zone 1) to the underlying aquifer when both irrigation wells are pumping (Figure 3-27). However, the form and overall hydraulic behavior of the lagoon is more akin to a lake than a river. Fluctuations in the inflow and outflow of water through the bed of the lagoon as a result of pumping had little effect on the lagoon water level or the quality of the lagoon water, and therefore no effect on the suitability of the lagoon as a fishery habitat. The hourly record of the water level in the lagoon compared to tidal record for the same period is shown in Figure 3-36. The similarity in the two traces shows that tidal elevation plays the dominant role in fluctuating lagoon water levels. Section 3.2 of the 2006 Hanson Study details the results of direct measurement of fish passage at three points across the lagoon area, PT1, PT2, and PT3 (see Figure 2-1). At all times, the criteria for fish passage were significantly exceeded (2007 Hanson Study). As noted in Section 3.7, groundwater is significantly depleted in concentrations of dissolved oxygen relative to River water. Therefore any reduction in groundwater inflow results in an increase in the overall dissolved oxygen content of the lagoon. Section 3.3 of the 2006 Hanson Study details the results of direct measurements of water quality in the lagoon area. At all times, the criteria for water quality suitability as acceptable to the habitat for fish were significantly exceeded. Thus, it can be concluded that pumping does not impact habitat continuity or water quality in the lagoon area (Zone 1).

Based on the hydraulic nature of Zone 1, the true area of influence to consider the potential for pumping effects on habitat continuity and River water quality is narrowed to River Zones 2 through 4 as defined on Figure 3-22. Figure 3-37 presents the calculated net River gain across Zones 2 through 4 during the entire pumping period. These calculations indicate that the Zones 2 through 4 area of the River maintained a net gain of flow during the entire 2006 Study including the periods of maximum pumping from both wells. As evident in Figure 3-37, the net effect of pumping on the River flow is to reduce the magnitude of natural gains from discharging groundwater as the River cuts across the underlying aquifer. By way of illustrating this concept, picture a section of river which will represent the Big Sur River flowing through Zones 2 through 4. The middle of the river is intersected by a tributary stream, which represents the real life inflow of groundwater to the Big Sur River. Water leaving the down stream end of the river is equal to the sum of the water entering the upstream end of the river plus the amount of water entering from the tributary. If the amount of water the tributary contributes to the river is reduced by half, there is still more water leaving the down stream end of the river than there is entering the upstream end. This is analogous to reducing the amount of groundwater entering the Big Sur River via pumping, but finding that there is still more water leaving the down stream end of the River at Zone 2 than there is entering the upstream end of the River at Zone 4.

The following table (Table 3-5) presents a summary of the change in net gain in the area of influence of Zones 2 through 4 as a ratio related to average pumping rate during each of the pumping periods.

Table 3-5
Correlation Between Pumping Rate and Decrease in Groundwater Inflow to River, Zone 2 Through Zone 4

Wells Active	Total Pumping Rate (cfs)	Calculated Decrease in Groundwater Inflow (cfs)	Is There a Net Gain in River Flow?	Pumping to Groundwater Inflow Reduction Ratio (cfs per cfs)
Both	5.83	1.59	YES	0.27
New	2.91	0.88	YES	0.30
Old	2.43	0.44	YES	0.18
			AVERAGE:	0.25

The 'Pumping to Groundwater Inflow Reduction Ratio' illustrates the reduction of groundwater flow into the River for every 1 cfs of groundwater pumped by the irrigation wells. The average of this ratio for each of the three pumping well configurations is 0.25, which is to say that for every 1 cfs of water pumped, the amount of groundwater inflow into the River decreases by 0.25 cfs. Note that the ratio for pumping New Well only, the predominant pumping condition in late summer, was 0.30 (i.e., 0.30 cfs of inflow reduction for every 1 cfs of pumped groundwater). Note the column 'Is There a Net Gain in River Flow?' The answer indicates whether, despite the indicated pumping rate, the River was still gaining water via inflow from the underlying aquifer. At no point did the River overall lose flow across the Zone 2 through Zone 4 area. This is additionally illustrated on Figure 3-37.

Considering the highest ratio calculated in Table 3-5 above, that is, for every 1 cfs of water pumped the amount of groundwater inflow to the River decreases by 0.30 cfs. This indicates that for every unit volume of water pumped, 0.30 of that volume, or 30%, 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 volume of water pumped is comprised of underflow that was destined to discharge to the Ocean without entering the River.

For the average September irrigation well pumping condition of 2.7 cfs, this 30% equates to a reduction in total volume of groundwater inflow to the River across Zones 2 through 4 of approximately 48 acre-feet for the month of September. The total volume of River flow exiting Zone 2 for the month of September 2006 is estimated to be 1,166 acre-feet. This indicates that groundwater inflow reduction resulting from average September pumping accounts for approximately 4.1% of the volume of flow past the area of influence. Applying this same calculation to the month of September in a dry year as represented by 2004 data, the total volume of River flow exiting Zone 2 is estimated to be 530 acre-feet, thus the total volume of inflow reduction is estimated to be 8.9% of River flow past the area of influence of pumping.

In summary, data collected and analyzed for the 2006 Study indicate the following; 1) when looked at as a single area, the River across Zones 2 through 4 did not lose flow overall, even during periods of maximum pumping; 2) River flows are not reduced, but, the rate at which River flow accretes groundwater flow is reduced at a maximum rate of approximately 0.30 cfs reduction per 1 cfs of pumping, and; 3) within Zones 2 through 4, River water was lost to groundwater in Zone 2 at a maximum rate of 0.4 cfs, but was more than offset by groundwater inflow in Zones 3 and 4.

3.10 Water Availability Analysis

A water balance and water availability analysis was conducted as part of the 2004 Study as documented in the HI-CSM section 3.4.7. Data collected in the 2006 Study were utilized in combination with information developed from the original Study Area water balance calculations to develop a focused River flow water balance analysis as it relates to the question of maintaining habitat continuity for the fishery within the area of influence of the pumping wells. This analysis begins with a review of the nature of flow conditions as they relate to water year types for the Big Sur River. Specifically, the California Department of Fish and Game (CDFG) has asked for a water balance evaluation considering Wet, Above Normal, Median/Average, Below Normal/Dry, and Critically Dry water year types segregated based on 20-40-60-80 percent non-exceedance flows.

Figure 3-38 presents a graph depicting daily mean discharges of these specified non-exceedance frequencies for the 54 year period of record with validated flow data (USGS 2004). Review of the Big Sur River flows presented on Figure 3-38 indicates that the focus of the water availability analysis should be placed on the low-flow months of mid-to late summer through early fall. Figure 3-39 presents a graph depicting daily mean discharges of the specified non-exceedance frequencies for the months of July through October. This figure shows that the median (i.e., 50% non-exceedance frequency) minimum daily flow of 14 cfs occurs in the month of September and the beginning of October. The 20% non-exceedance frequency daily flows reach a minimum of 8 cfs during September and October. Although not depicted on the graph, the 10% non-exceedance flows for September reach a minimum of 6.6 cfs while the 5% non-exceedance flows for September reach a minimum of 5.5 cfs.

Table 3-6 presents a summary of the calculated average monthly non-exceedance discharge values for the water year types described above covering the months of normal ESR irrigation pumping from April through October. Also included in this table are the average flow conditions during the 2004 and 2006 Study periods. Comparison of the 2004 flow data to the non-exceedance value ranges indicates that the flow conditions during the irrigation pumping period of 2004 fall into the range of a 'Dry' water year type.

Flows recorded for the same months in 2006 indicate that they would be considered a 'Wet' type flow year. Thus, the two study periods provide data that covers a wide range of the water year types.

Data collected during the 2006 Study has served to establish that the area of influence of pumping wells is focused on the section of the River that moves laterally across the aquifer near the pumping wells designated as River Zones 2 through 4. Data has also allowed the calculation of River gains and losses across these areas in response to pumping and non-pumping conditions. This information combined with earlier developed water balance data described in the HI-CSM allows for the calculation of a simple Surface Flow Water Balance for the area of influence. A surface flow water balance was constructed for Zones 2 through 4 of the River for September flow conditions as a tool to evaluate worst case conditions on River flow in response to pumping and a determination of water availability based on various year types.

This water balance includes the following input and output terms:

1. The average Monthly Big Sur River flow gauged at USGS gauging station 11143000 for the month of September.

2. The net loss in flow between the Big Sur gauge and velocity transect VT1. An average flow loss of 3.73 cfs was measured during the 'Dry' late summer conditions of the 2004 Study as documented in section 3.4.7 of the HI-CSM. A secondary value was calculated based on the 2006 Study flow data obtained at VT1 that is characteristic of a 'Wet' year type. Figure 3-40 presents the USGS gauge flow for September 2006 overlain with the measured and calculated River flows at VT1 over the same time period. The average flow loss in September 2006 was calculated at 1.5 cfs.

3. The net loss in flow between VT1 and River Zone 4 as calculated for River Zone 5 in section 3.6.

4. The net calculated non-pumping accretion rate of groundwater in-flow to the River in Zones 2 through 4 based on data discussed in section 3.6.

5. The net calculated reduction in accretion rate through Zones 2 through 4 in response to pumping. The net reduction in accretion rate is calculated by multiplying the pumping rate by the correlated reduction rate of 0.30 cfs reduction per 1 cfs of total pumping as discussed in sections 3.6 and 3.8 and shown on Table 3-5.

6. The average total pumping rate condition for September.

Table 3-7 presents the Surface Flow Water Balance for September Conditions across River Zones 2 through 4. Water balance calculations are provided for the 'Wet' year of 2006 and the 'Dry' year of 2004. Additionally, worst case conditions are represented by a variety of flows characteristic of a 'Critically Dry' which include the 20% (i.e., the upper bound flows for a 'Critically Dry' year), 10% and 5% non-exceedance flow values for the Big Sur River. The water balance calculations presented in Table 3-7 indicate that under normal September pumping conditions and a 'Critically Dry' year, net flow rates across Zones 2 through 4 would drop to 3.8 cfs and below.

3.11 Water Quality Analysis

It has been demonstrated that ESR irrigation well pumping can influence the River across Zone 2 through Zone 4 by reducing the inflow of groundwater. Table 3-5 (section 3.9) demonstrates that approximately 0.30 cfs of groundwater inflow into the River is intercepted for every 1 cfs of water pumped by the wells. Water quality measurements obtained using a portable water quality meter show a distinct reduction in both temperature and dissolved oxygen content at various points along the right bank of the River providing direct evidence of the results of groundwater mixing with River water. Additionally, mass balance considerations suggest that the reduction in groundwater inflow should have an effect on the quality of the water in the River. A simple water mixing model was applied to quantify changes. The effects resulting from the reduction of groundwater inflow to the River on dissolved oxygen and daily average temperature were both explored.

Twice weekly measurements of water quality were taken from 11 points (PT1 through PT11) within the 2006 Study Area. At each measuring point, a water quality reading was obtained from near the left bank, near the right bank, and at center channel of the River. Graphs of the temperatures from each of the monitoring points can be found in Appendix G. The locations of the 11 monitoring points can be found on Figure 2-1. Centered on station PT7, the temperature of the River along the right bank was reduced relative to the temperature at the center or left bank of the River. The reduced temperatures along the right bank are the result of the mixing of groundwater with the River water. The maximum River water temperature reduction resulting from groundwater mixing was just over 2 °C (3.6 °F) as measured at PT7. Also centered on station PT7, the dissolved oxygen content of the River along the right bank was reduced relative to the temperature at the center or left bank of the River, again a result of groundwater mixing with River water. The maximum dissolved oxygen reduction resulting from groundwater mixing was approximately 3.5 mg/L as measured at PT7. Based on these results we understand that a) mixing with groundwater has the effect of reducing both temperature and dissolved oxygen content of the water in the River, and b) mixing is not uniform across the River, but only partially mixes along the right bank where groundwater inflow is greatest. Although water quality measurements were taken during periods of pumping and during periods of no pumping, there was not enough information to determine an effect on River temperatures or dissolved oxygen content resulting from the pumping induced reduction in groundwater inflow.

The mixing model was run for a wide variety of flow conditions, including those observed during the 2006 Study and the 2004 Study, plus the flows calculated in Table 3-7 for the 20% non-exceedance dry year and the 5% non-exceedance dry year (Figures 3-38 and 3-39). Pumping conditions tested include both no pumping at all, and the average September pumping rates as shown in Table 3-7. Dissolved oxygen data was used to calibrate the amount of mixing that occurred during the 2006 Study, which was calculated to be approximately 35%. This can be empirically observed in the manually collected water quality data (Appendix G). Groundwater mixing with River water only affects DO concentrations along the right bank of the River, not the center or left bank. This indicates that groundwater mixed with approximately one third the River water flowing across Zones 2 through 4. An assumption was made that temperature mixed approximately as DO did. The results of 100% mixing were also included, though conditions above 35% mixing were not observed during the 2006 Study or 2004 Study. It was assumed that during lower flow dry years, the percent of River water that gets mixed with groundwater would increase. The results of the mixing model are found in Table 3-8.

Review of Table 3-8 indicates that pumping only increases the concentration of dissolved oxygen in the River. With increased pumping rates, less DO depleted groundwater mixes with River water. It should be noted that during extremely low flow years, corresponding with the 5% non-exceedance dry year condition, groundwater pumping may be essential in raising DO concentrations in the River above the 6 mg/L minimum required for a healthy fish habitat (Hanson, 2005).

The results of the mixing model show that groundwater pumping has the effect of raising temperatures in the River. During the 2006 Study and the 2004 Study, the daily average surface flow temperature entering Zone 4 were 15°C and 17°C, respectively, while the temperature of the incoming groundwater was conservatively estimated at 13°C. Incoming groundwater mixes with the River water to lower its temperature. Reducing the inflow of groundwater should raise the temperature of the River along the right bank, but not beyond the temperature the River water was at as it entered Zone 4. During drier years, temperatures in the River might be higher than those encountered during the 2004 Study. In the model, a worse case scenario of 20°C was used, although there is no data to suggest that average daily temperatures in the River would actually be that high. The results of the model show that average September pumping outputs can raise the temperature of the 35% mixed River water by as much as 1.1°C. If 100% mixing is assumed, the temperature rise is approximately 0.9°C. The daily average temperature in River water to sustain a healthy fish population should be less than 20°C (Hanson, 2005). Based on the results of the mixing model, incoming River water temperatures would have to be several degrees Celsius above 20°C before average September groundwater pumping would raise average mixed water temperatures above 20°C across Zones 2 through 4.

The effects of changes in the mixing of River water and inflowing groundwater were not tested using electroconductivity data. To sustain a healthy fish population, electroconductivity in River water should be less than 1,500 µS/cm (Hanson, 2005). Data collected during the 2006 Study and the 2004 Study indicate that electroconductivity in both River water and groundwater ranged from approximately 200 µS/cm to 400 µS/cm. No amount of mixing or reduction in mixing resulting from pumping would have a detrimental effect on fish populations with respect to electroconductivity.

4.0 SUMMARY AND CONCLUSIONS

As described in the Workplan, the primary goal of the hydrogeological portion of the 2006 Study was to develop and/or evaluate the following:

1. Develop a correlation between the calculated loss of surface water through the bed of the River in response to pumping at typical and maximum pumping rates, then relating this correlation to the total stream-flow entering the Study Area.

2. Evaluate the ability of pumping to create drawdown impacts in Creamery Meadow.

3. To monitor the movement of the saline wedge inland by tracking electroconductivity concentrations in the Navy Well in order to address concerns over potential saline wedge impacts to lagoon and riparian zones.

4. Evaluate a monthly based water budget for various water year types, specifically focused on the later summer months when pumping has the most potential to cause an impact.

The results of the Study with respect to addressing each of the goals listed above are summarized in the following sections. An additional section has been included summarizing the effect ESR pumping has on River water dissolved oxygen and temperature.

4.1 Development of Correlations

Data analysis indicates that the ESR irrigation well's ability to impact fishery habitat continuity and water quality is focused on the section of River adjacent to the pumping well field, an area that is identified on Figure 3-22 as River Zones 2 through 4. Piezometer data indicates that this portion of the River naturally gains groundwater from the underlying aquifer both with and without pumping. This fact is evidenced by both piezometer measured gradients across the shallow streambed and dissolved oxygen data measured in the River. Data also indicates that pumping serves only to reduce the rate of groundwater accretion across Zones 2 through 4. The conservative correlation factor relating pumping to the reduction in rate of groundwater inflow to the River is calculated as a maximum reduction of 0.30 cfs for every 1.0 cfs of groundwater extracted by pumping. This indicates that for every volume of water pumped, 30% 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 Ocean without ever entering the River. Correlation factors for different pumping scenarios tested are summarized in Table 3-5.

4.2 Creamery Meadow Impacts

Data analysis indicates that the maximum radius of ESR irrigation pumping well influence (i.e., the point where groundwater drawdown remains zero despite continued pumping) is 1,000-feet up-gradient of the New Well Location. The maximum area of influence is depicted on Figure 3-10 and demonstrates that hydraulic influence does impact an area of Creamery Meadow. Pumping induced drawdown impacts to water levels in Creamery Meadow are conservatively estimated to be a maximum of 0.20-feet (2.4-inches) at the River bank diminishing to zero less than 500-feet up-gradient.

4.3 Saline Wedge Movement

Electroconductivity data collected from the Navy Well and the Old Well during the 2006 Study indicate that pumping resulted in decreased EC readings in both wells regardless of changes in tidal conditions. Historically, pumping during the months of September from the Old Well has not resulted in the presence of high EC (saline) water in the Well. As detailed in the HI-CSM, the explanation for this observed behavior in groundwater EC during the month of September was the absence of the higher than normal spring tides that occur during the summer months and cause the in-land movement of the naturally occurring saline wedge at the mouth of the River. Data collected during the 2006 Study confirm these conditions and indicate that tide is the dominating mechanism of saline wedge intrusion, and that pumping cannot induce saline impacts to the groundwater beneath the lagoon in the Navy Well area.

4.4 Water Availability

The combination of data and analysis conducted as part of the 2006 Study along with the water shed and Study Area water balances calculated during the 2004 Study (HI-CSM) allows for the calculation of a simplified surface flow water balance for the River within the irrigation well area of influence. The surface flow water balance was calculated for the lowest flow month of the year (September) in order to provide a conservative basis for planning decisions. The water balance was calculated for both the 2004 and 2006 Study periods as well as for various theoretical flows indicative of a 'Critically Dry' water year type. The water balance calculations are summarized in Table 3-7 and indicate that during 'Critically Dry' years accompanied by typical September pumping conditions, River flow across Zones 2 through 4 could be reduced to 3.8 cfs and below.

4.5 River Water Quality

Data collected during the 2004 Study showed highly variable water quality along the stretch of River nearest to the pumping wells and upstream of the Lagoon. This was determined to be the result of inflowing groundwater mixing with the River water, as the most significant water quality variations occurred along the Creamery Meadow side (i.e., the right side) of the River. The 2006 Study confirmed that groundwater, characterized as being depleted in dissolved oxygen content and lower in temperature relative to River water, does inflow and mix with the water in the River. Most of the groundwater flows into the River from the Creamery Meadow side and has the effect of lowering both dissolved oxygen and temperature of the River water. The pumping of the irrigation wells reduces the total inflow of groundwater along the section of the River that is within the area of influence of pumping. Simple mass balance analysis indicates that a reduction in total inflow of groundwater with depleted dissolved oxygen and lower temperature can only result in two effects; a) dissolved oxygen levels in the River across this section will increase in response to pumping, and b) temperature of the River across this section will increase in response to pumping. Any increase in dissolved oxygen can only improve the habitat conditions for Steelhead, therefore any amount of pumping will be beneficial. Reducing the amount of groundwater entering the River, such as what occurs during irrigation well pumping, will incrementally increase the temperature of the River water. When considering average September pumping conditions and all flow conditions, the maximum calculated theoretical effect is approximately 1 degree Centigrade. Thus, the effects of pumping are significant only when steelhead habitat conditions in the River have already reached a critical stage.

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6.0 ACRONYMS AND GLOSSARY

List of Acronyms

bgs	Below ground surface
CDWR	California Department of Water Resources
cfs	Cubic feet per second
DFG	Department of Fish and Game
DO	Dissolved oxygen
DPR	Department of Parks and Recreation
EC	Electroconductivity
ESR	El Sur Ranch
ET	Evapotranspiration
ft/day	Feet per day
ft/ft	Feet per foot
gpm	Gallons per minute
K	Hydraulic conductivity
mg/L	Milligrams per liter
msl	Mean sea level
NBS	National Bureau of Standards
NOAA	National Oceanic and Atmospheric Administration
NRCE	Natural Resources Consulting Engineers, Inc.
PDA	Personal Data Assistant
PVC	Polyvinyl chloride
QA/QC	Quality Assurance/Quality Control
SGI	The Source Group, Inc.
USGS	United States Geological Survey
µS/cm	Micro-siemens per centimeter

Glossary

Aquifer test	A test to determine hydrologic properties of an aquifer, involving the withdrawal of measured quantities of water from, or the addition of water to, a well and the measurement of resulting changes in head in the aquifer both during and after the period of discharge or addition (recharge).
Colmation	The process that can lead to the congestion of a streambed by the deposition of fine particles, leading to a reduction in vertical hydraulic conductivity. This process is generally occurs in the upper 0.5-feet of the streambed, and can take between a few days and several months until a relatively steady state streambed vertical K value is reached.
Cubic feet per second (cfs)	A unit expressing rate of discharge, typically used in measuring streamflow. One cubic foot per second is equal to the discharge of a stream having a cross section of 1 square foot and flowing at an average velocity of 1 foot per second. It also equals a rate of approximately 7.48 gallons per second, 449 gallons per minute, 1.98 acre-feet per day, or 724 acre-feet per year.
Data logger	A data logger is an electronic instrument that records data over time or in relation to location. Increasingly, but not necessarily, they are based on a digital processor (or computer). They may be small, battery powered and portable and vary between general purpose types for a range of measurement applications to very specific devices for measuring in one environment only.
Data logging	(Data acquisition) Storing a series of measurements over time, usually from a sensor that converts a physical quantity such as temperature or pressure, into a voltage that is then converted by a digital to analog converter (DAC) into a binary number. This number is stored electronically pending retrieval via portable computer or similar device.
Discharge	To pour forth, emit, or release contents.
Dissolved oxygen	The amount of free (not chemically combined) oxygen dissolved in water, wastewater, or other liquid, usually expressed in milligrams per liter, parts per million, or percent of saturation.
Diurnal	Having a 24-hour period or cycle; daily.
Diurnal events	Events that reoccur on a 24-hour period or cycle; daily
Drawdown Stabilization	In subsurface hydrogeology, drawdown is the change in hydraulic head observed at a well in an aquifer, typically due to pumping a well as part of an aquifer test or well test. Stabilization is the point that occurs when continued pumping does not result in further changes in hydraulic head.

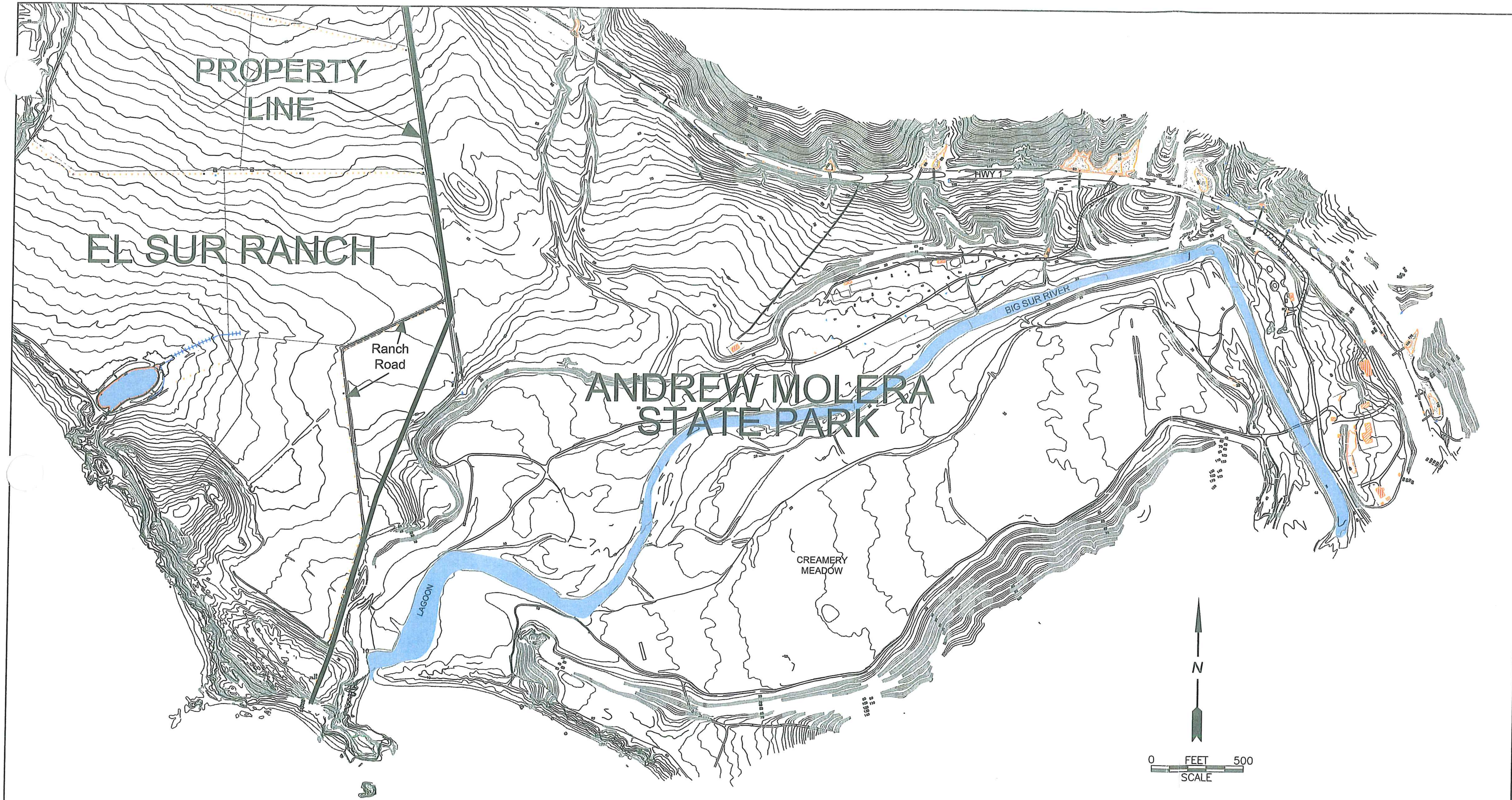
Electroconductivity	A measure of the ability of a solution or media to carry an electrical current.
Electromagnetic velocity meter	Electromagnetic meters produce voltage proportional to the velocity of water flow across the sensor. The working principle of these meters is the same as the pipeline electromagnetic flow meter.
Field measurements	Data manually collected by field personnel within a specified Study Area.
Flow gauging	Measuring the rate of water discharged from a source given in volume with respect to time.
Fluctuations	To vary irregularly.
Gallons per minute (GPM)	A unit expressing rate of discharge, used in measuring well capacity. Typically used for rates of flow less than a few cubic feet per second (CFS)
Gradient	Degree of incline; slope of a stream bed. The vertical distance that water falls while traveling a horizontal distance downstream or through an aquifer.
Groundwater	(1) Generally, all subsurface water as distinct from *Surface Water*; specifically, the part that is in the saturated zone of a defined aquifer. (2) Water that flows or seeps downward and saturates soil or rock, supplying springs and wells. The upper level of the saturated zone is called the Water Table. (3) Water stored underground in rock crevices and in the pores of geologic materials that make up the earth's crust. Ground water lies under the surface in the ground's *Zone of Saturation*, and is also referred to as *Phreatic Water*.
Groundwater flux	(1) Water that moves through the subsurface soil and rocks. (2) The movement of water through openings in sediment and rock that occurs in the *Zone of Saturation*.
Groundwater gradient	The gradient or slope of a water table or *Piezometric Surface* in the direction of the greatest slope, generally expressed in feet per mile or feet per feet. Specifically, the change in static head per unit of distance in a given direction, generally the direction of the maximum rate of decrease in head. The difference in hydraulic heads (h1 – h2), divided by the distance (L) along the flowpath, or, expressed in percentage terms: $I = (h1 - h2) / L \times 100$. A hydraulic gradient of 100 percent means a one foot drop in head in one foot of flow distance.
Hydraulic conductivity	Simply, a coefficient of proportionality describing the rate at which water can move through an aquifer or other permeable medium. The density and kinematic viscosity of the water must be considered in determining hydraulic conductivity. More specifically, the volume of water at the existing kinematic viscosity that will move, in unit time, under a unit *Hydraulic Gradient* through a unit area measured at right angles to the direction of flow, assuming the medium is isotropic and the fluid is homogeneous. In the Standard International System, the units are cubic meters per day per square meter of medium (m3/day/m2) or m/day (for unit

	measures).
Hydraulic head	(1) The height of the free surface of a body of water above a given point beneath the surface. (2) The height of the water level at the headworks or an upstream point of a waterway, and the water surface at a given point downstream.
Hydrogeology	The part of geology concerned with the functions of water in modifying the earth, especially by erosion and deposition; geology of ground water, with particular emphasis on the chemistry and movement of water.
Hydrograph	(1) A graphic representation or plot of changes in the flow of water or in the elevation of water level plotted against time. (2) The trace of stage (height) or discharge of a stream over time, sometimes restricted to the short period during storm flow.
Hydrologic	Of or pertaining to hydrology, that is the science dealing with water, its properties, phenomena, and distribution over the earth's surface.
Monitoring well	A well used to obtain water quality samples or measure groundwater levels.
Monitoring well cluster	A collection of monitoring wells drilled to varying depths located in close proximity to one another. This arrangement is generally used to determine vertical groundwater gradients.
Passage Transect	A cross-section of the River measured to determine if there is enough water for fish to pass. Each passage transect was identified by rebar stakes located on opposite sides of the River. On a twice weekly basis, the depth profile was measured at each passage transect by recording the depth of the River from bank to bank in half-foot increments
Permeameter	A device used to determine the vertical hydraulic conductivity of a streambed.
Piezometer	Small diameter well used to measure the elevation (hydraulic head) of groundwater in aquifers.
Potentiometric surface	A surface which represents the static head of ground water in tightly cased wells that tap a water-bearing rock unit (i.e., aquifer). In relation to an aquifer, the potentiometric surface is defined by the levels to which water will rise in tightly cased wells. If the head varies significantly with depth in the aquifer, then there may be more than one potentiometric surface. The *Water Table* is a particular potentiometric surface for an *Unconfined Aquifer*.
Pressure transducers	A data logger that measures and records water pressure (head of water over the sensor). See data logging.
Pumping test	See aquifer testing.
River stage	The elevation of the water surface at a specified station above some arbitrary zero datum (level).

River transect	A surveyed line (generally constructed with two surveyed posts connected by a string) emplaced perpendicular to river flow across which river velocity data is collected
Saltwater intrusion	The invasion of a body of fresh water by a body of salt water, due to its greater density. It can occur either in surface or ground-water bodies. The term is applied to the flooding of freshwater marshes by seawater, the migration of seawater up rivers and navigation channels, and the movement of seawater into freshwater aquifers along coastal regions.
Saltwater wedge	The wedge shaped body of saltier water that underlies fresher water in poorly mixed estuaries, or underlies fresher groundwater in coastal or estuary situations where the fresher groundwater is discharging to the ocean or estuary over and through a fresh/salt water interface.
Site	Generally refers to the Study Area and may refer specifically to areas of data collection within the Study Area.
Spring tide	The exceptionally high and low tides that occur at the time of the new moon or the full moon when the sun, moon, and earth are approximately aligned.
Stage height	The height of a water surface above some established reference point or *Datum* (not the bottom) at a given location. Also referred to as *Gage Height*.
Stilling well	A device used to allow monitoring of water levels in turbulent flow.
Study Area	The Study Area includes the portion of Andrew Molera State Park from the parking lot to the ocean and a portion of the adjacent EL Sur Ranch property to the north as depicted on Figure 1-2 of this report.
2006 Study Period	The period of field data collection for this report that is inclusive of the time between August 28 and October 17, 2006.
Transducer	A substance or device, such as a piezoelectric crystal, microphone, or photoelectric cell that converts input energy of one form into output energy of another. See data logging.
Velocity transect	see river transect
Water balance	An accounting of the inflows to, the outflows from, and the storage changes of water in a hydrologic unit or system.
Water table	The surface of a groundwater body at which the water is at atmospheric pressure; the upper surface of the ground water reservoir.

FIGURES

FIGURES



Map Source File by Rasmussen Land Surveying, Inc.
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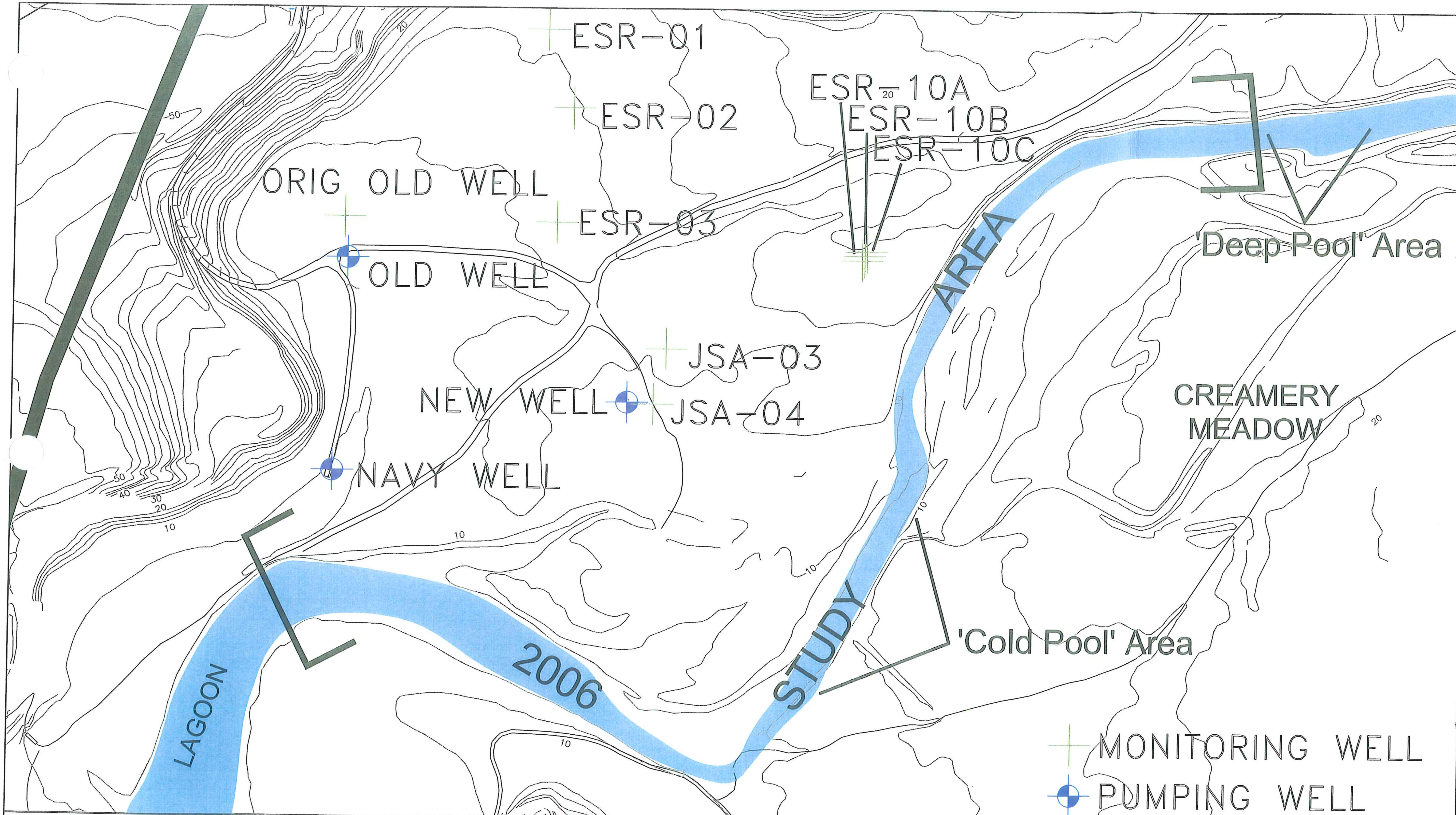
EL SUR RANCH
BIG SUR, CALIFORNIA

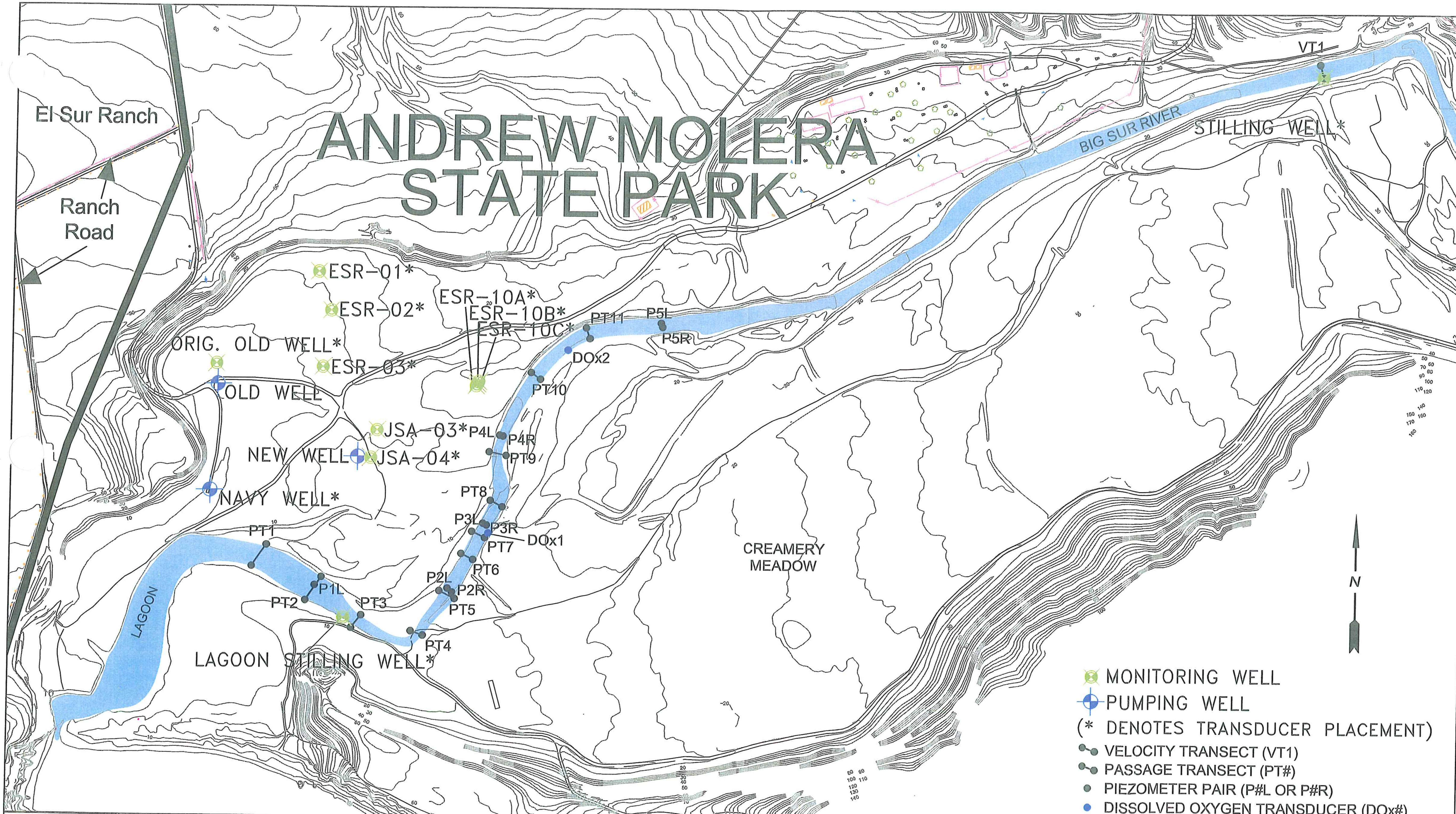
PROJECT NO.	DATE	DR. BY	APP. BY
01-ESR-003	1/12/07	ML/jp	PH

FIGURE 1-1

STUDY AREA BASE MAP



SGI environmental THE SOURCE GROUP, INC.	EL SUR RANCH BIG SUR, CALIFORNIA		SCALE 0 150 300 SCALE IN FEET	FIGURE 1-2 2006 STUDY AREA MAP
	PROJECT NO. 01-ESR-003	DATE 1/12/07	DR. BY ML/jp — APP. BY PH	



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EL SUR RANCH
BIG SUR, CALIFORNIA

SCALE: 0 — 300 — 600
SCALE IN FEET

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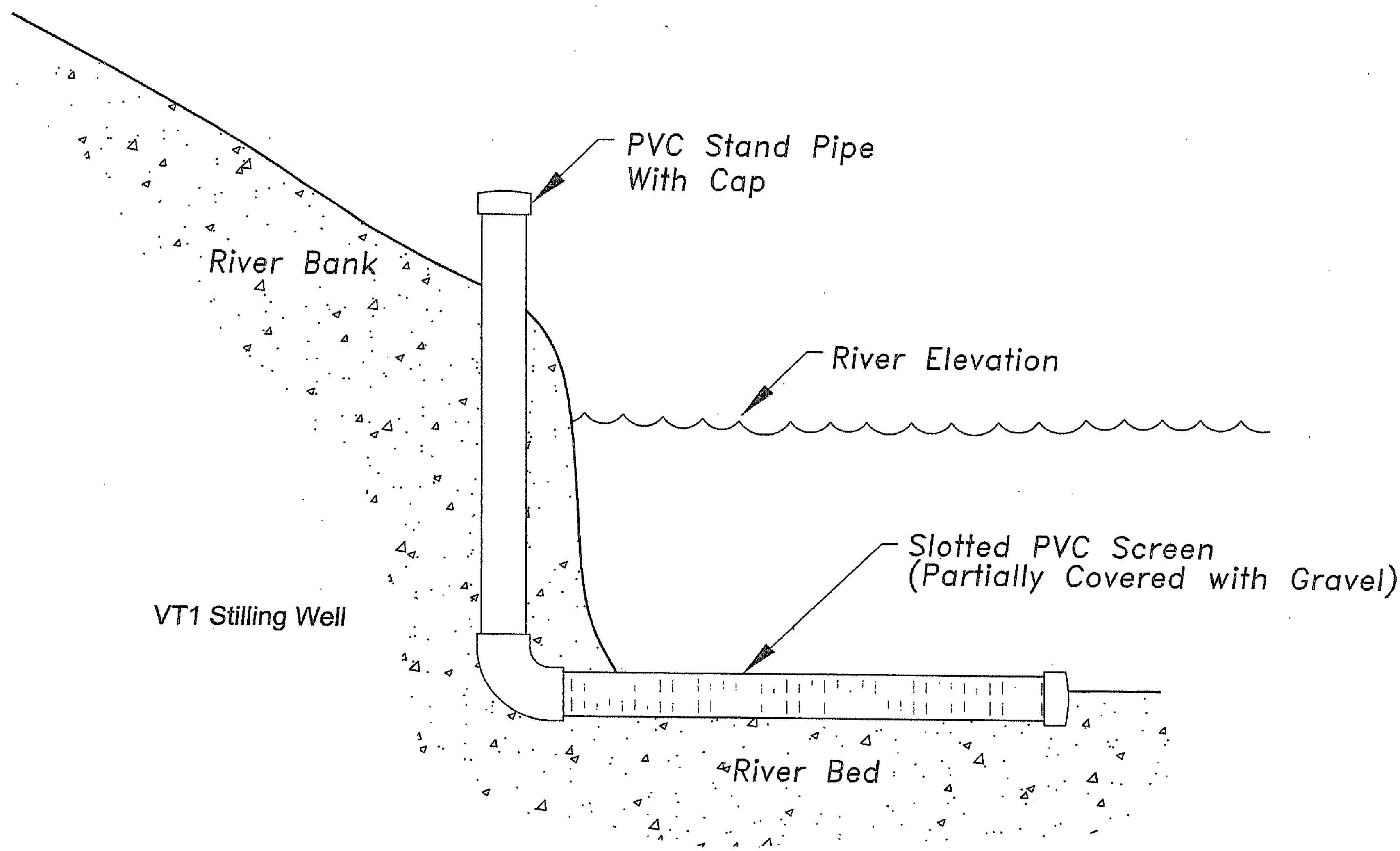
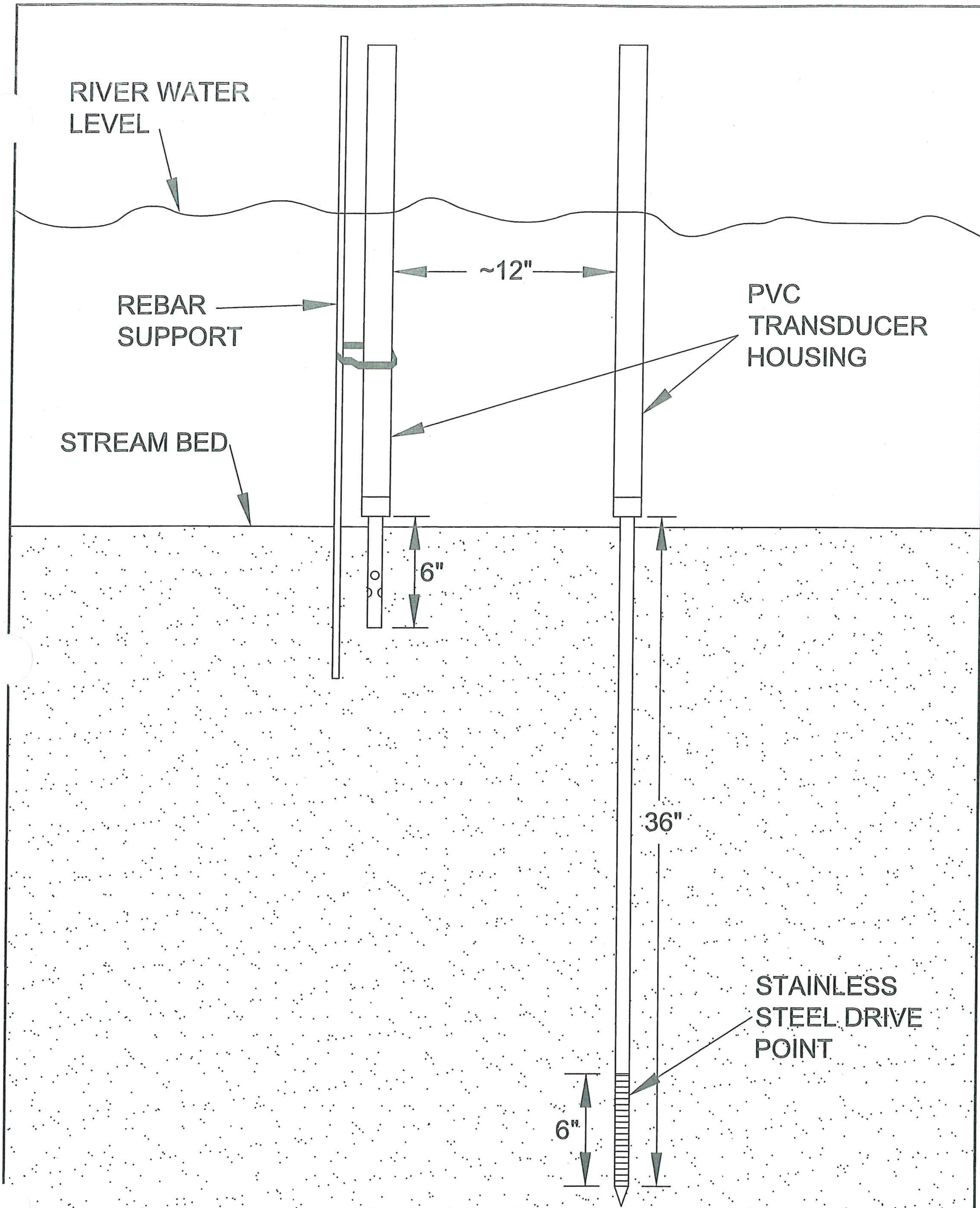
FIGURE 2-1

2006 STUDY AREA MONITORING STATION AND SENSOR LOCATION MAP

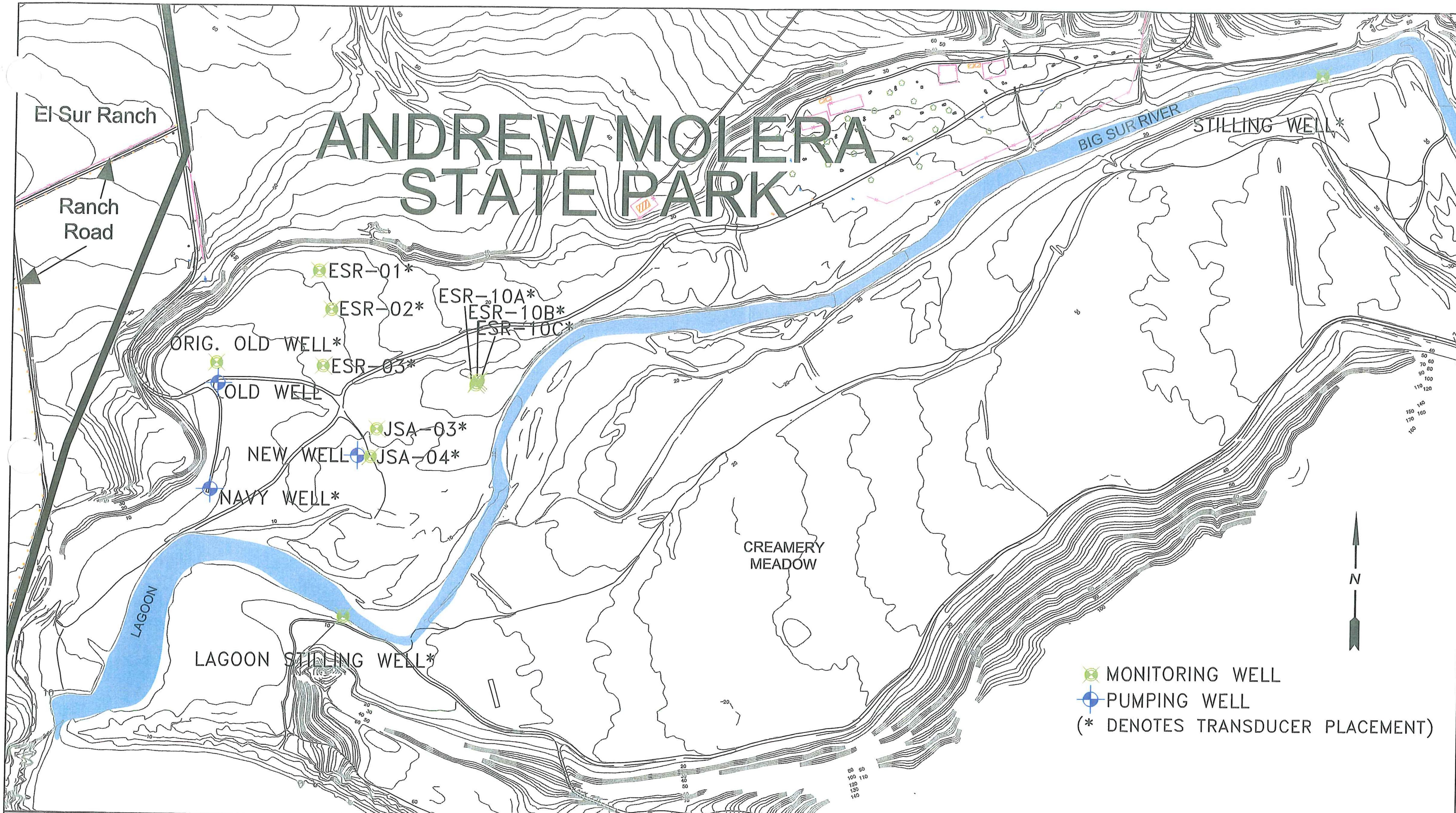


SGI environmental THE SOURCE GROUP, INC.	EL SUR RANCH BIG SUR, CALIFORNIA		FIGURE 2-2 SIMPLIFIED STILLING WELL DIAGRAM	
FILE NAME FIGURE 2-2	PROJECT NO. 01-ESR-003	DATE 1/12/07	DR. BY ML	APP. BY JP

ESR-5



SGI environmental THE SOURCE GROUP, INC.	EL SUR RANCH BIG SUR, CALIFORNIA		**FIGURE 2-3** PIEZOMETER WELL PAIR INSTALLATION SCHEMATIC
PROJECT NO.: 01-ESR-003	DATE: 1-12-2007	DR. BY: DB / APP. BY: JP	ESR--5



SGI environmental THE SOURCE GROUP, INC.	EL SUR RANCH BIG SUR, CALIFORNIA	SCALE 0 300 600 SCALE IN FEET	FIGURE 3-1 WELL LOCATION MAP
	PROJECT NO. 01-ESR-003 | DATE 1/12/07	DR. BY ML/jp | APP. BY PH	

Figu… -2a
JSA-04 Hydrograph
El Sur Ranch
Big Sur, California

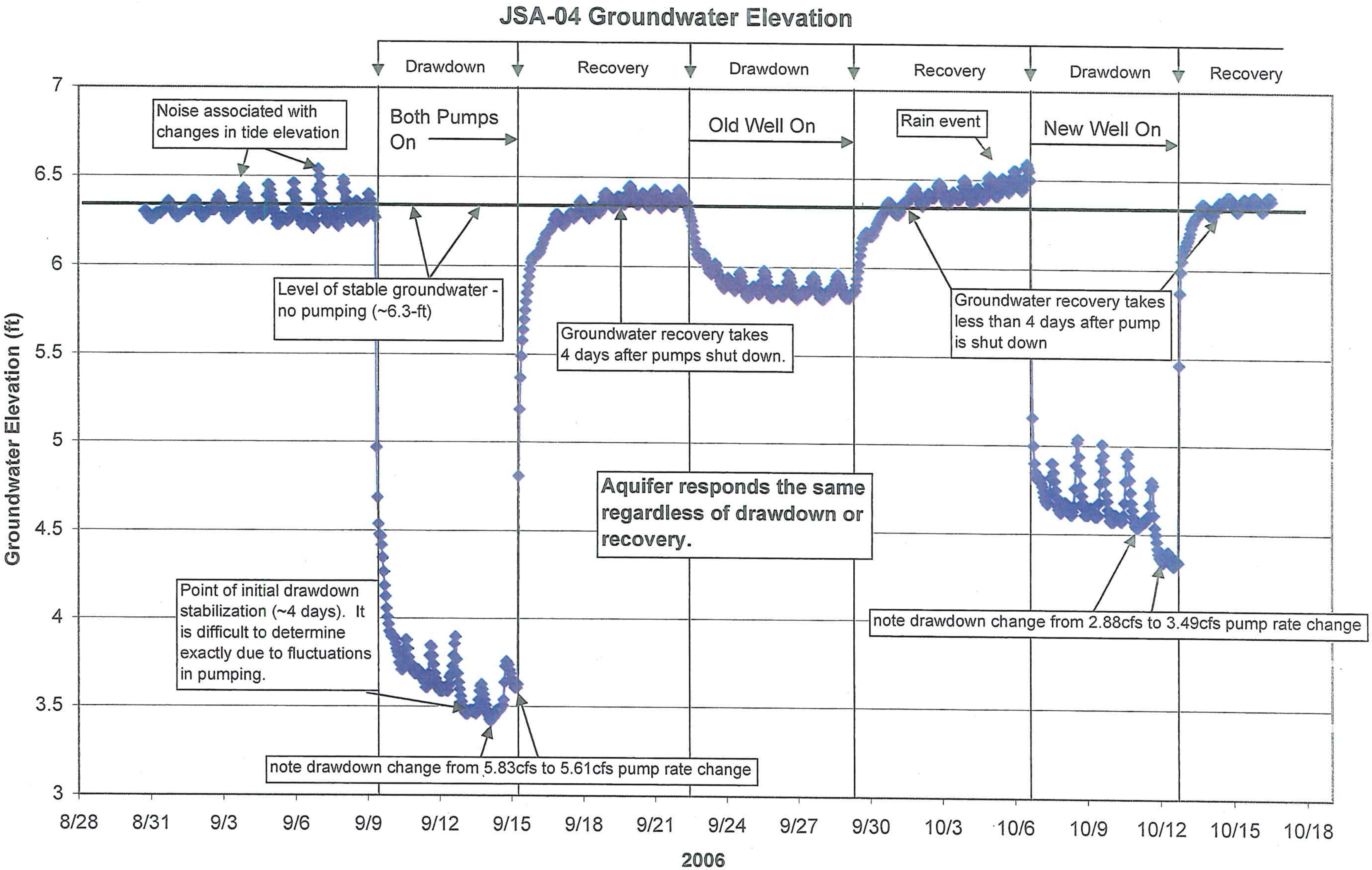


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Figure -2b
JSA-04 Recovery Curve Post Two Well Pumping Test
El Sur Ranch
Big Sur, California

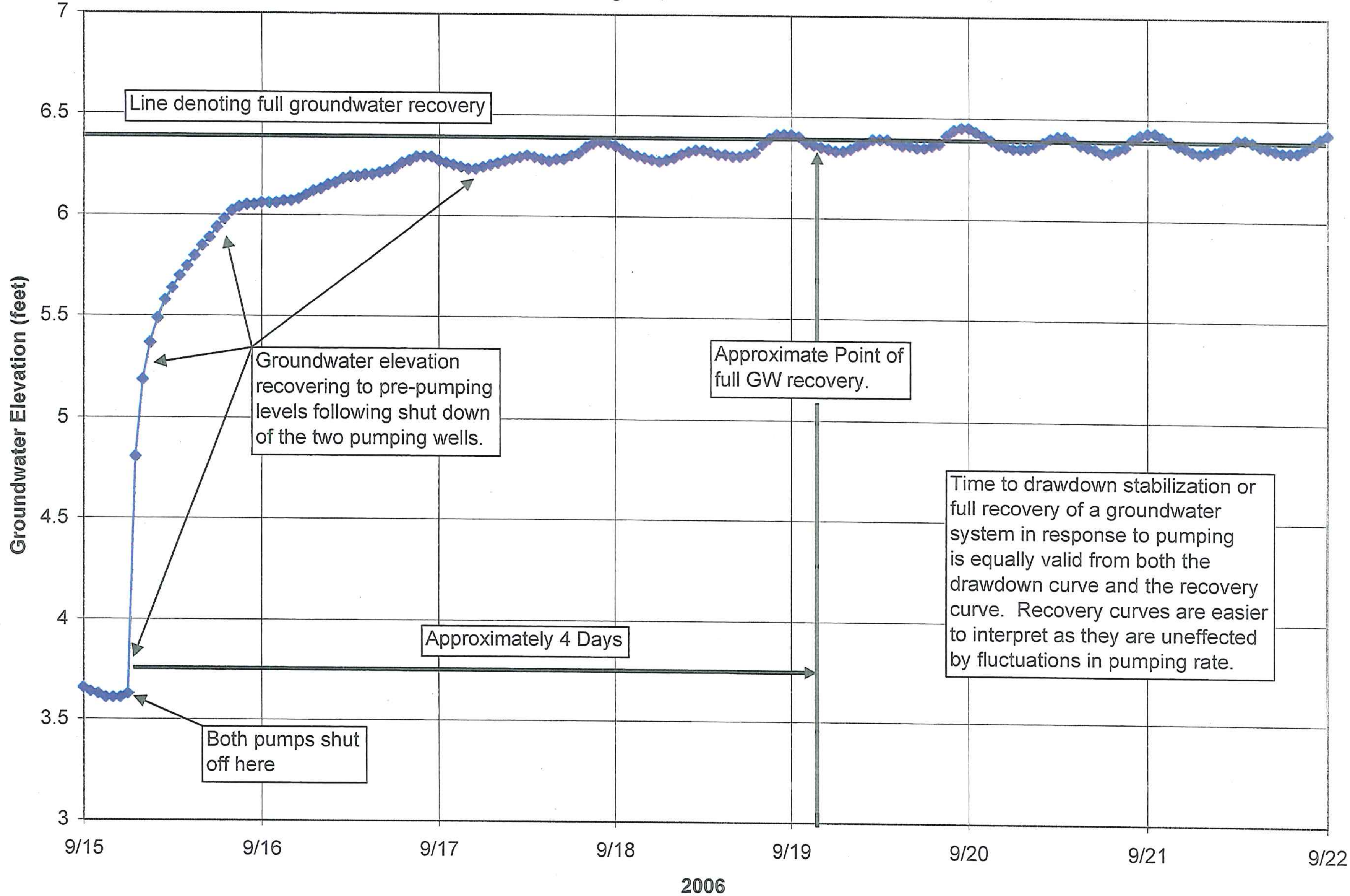

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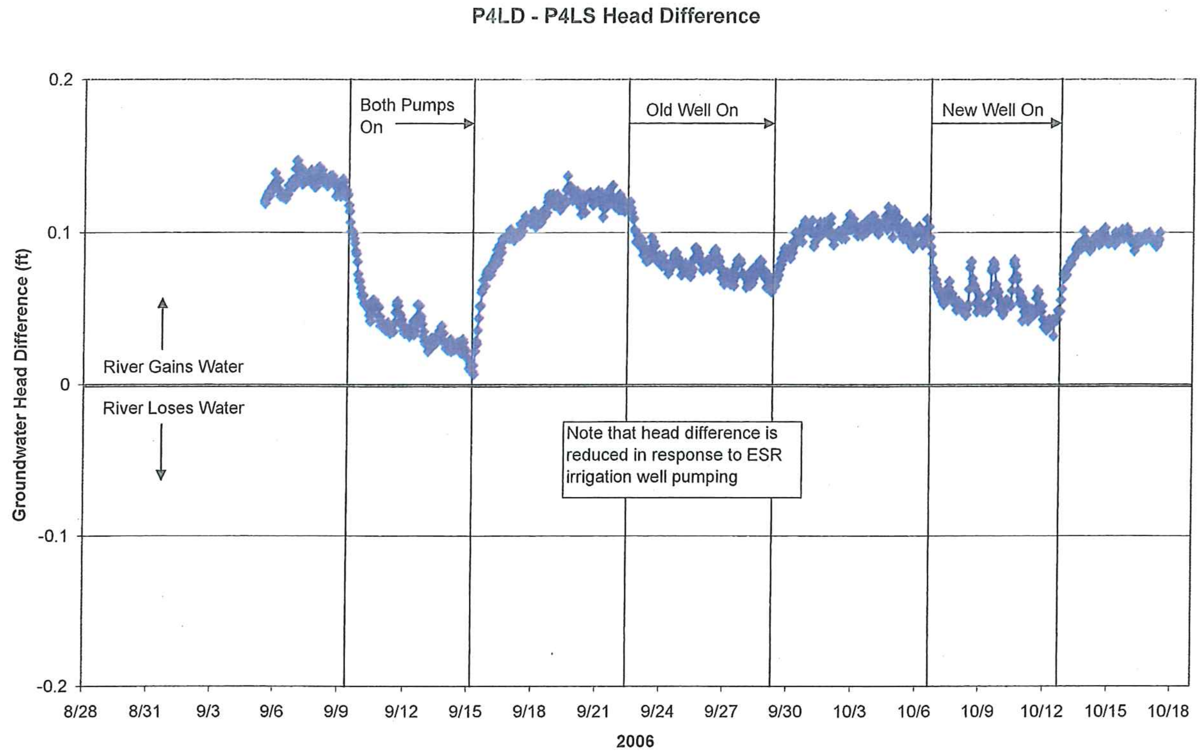
Figure 3-3
Piezometer P4 Head Difference Comparison
El Sur Ranch
Big Sur, California



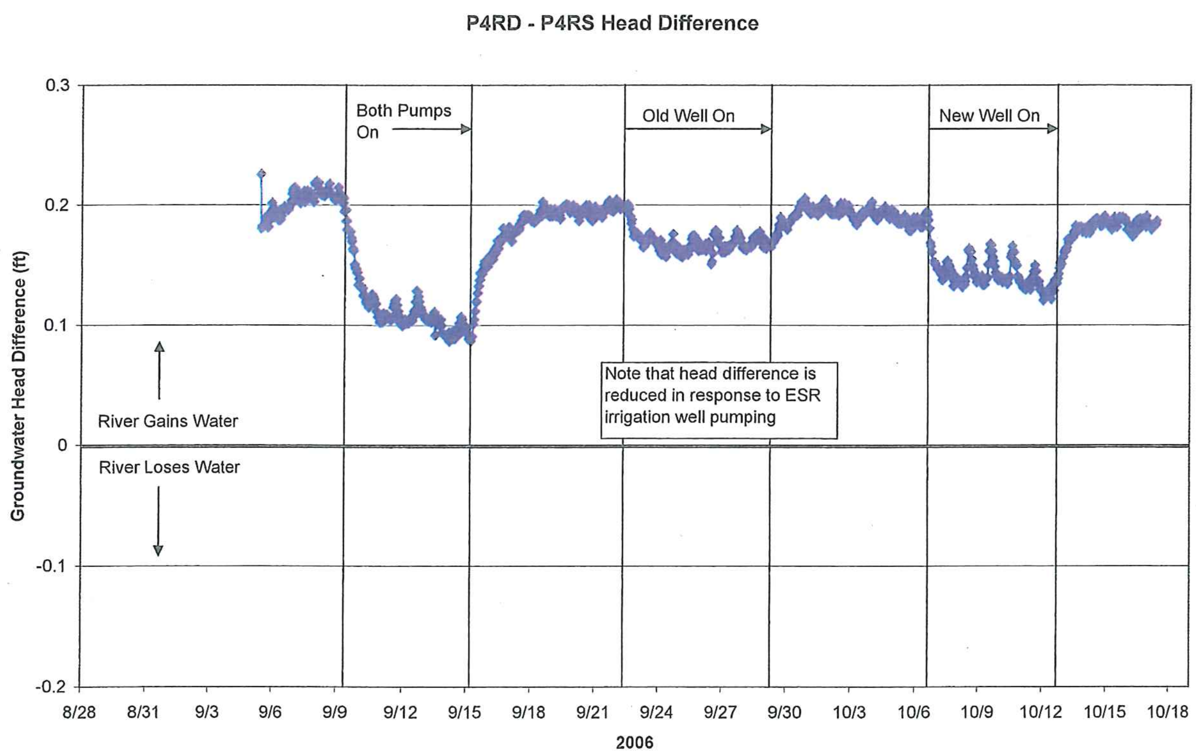


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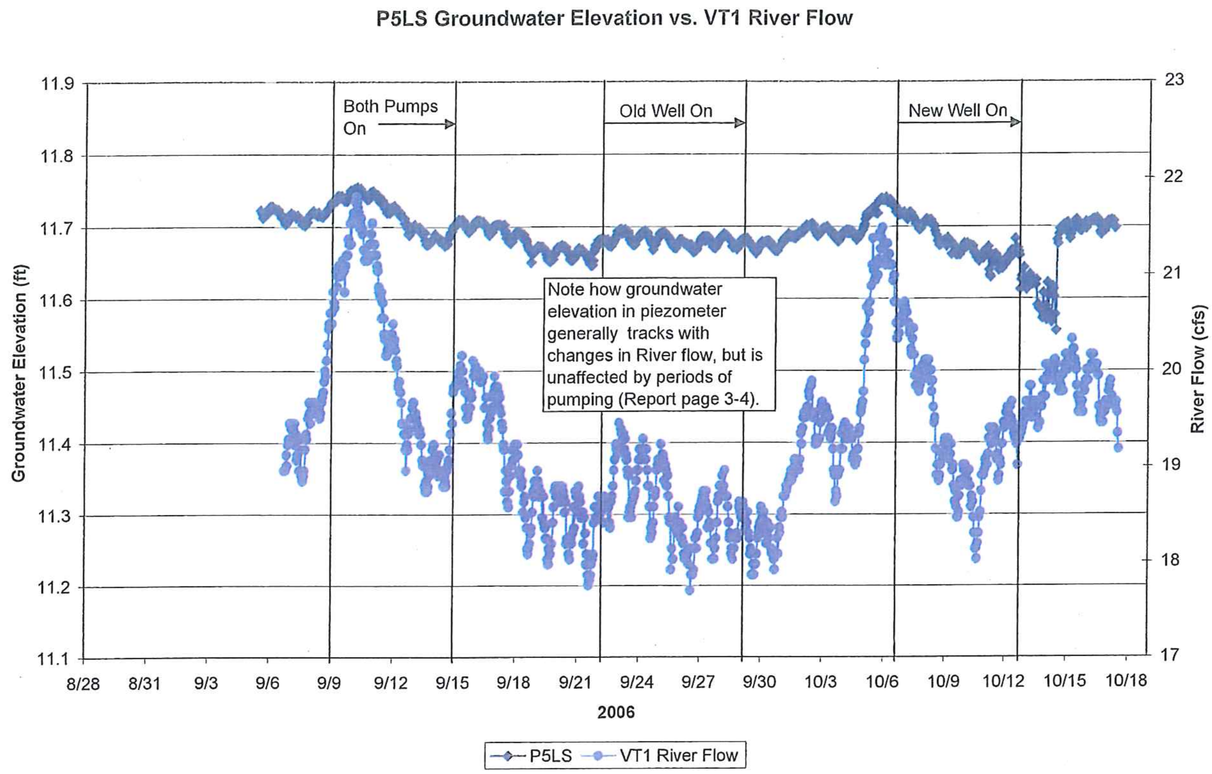
Figure 3-4
Piezometer P5L Hydrographs
El Sur Ranch
Big Sur, California



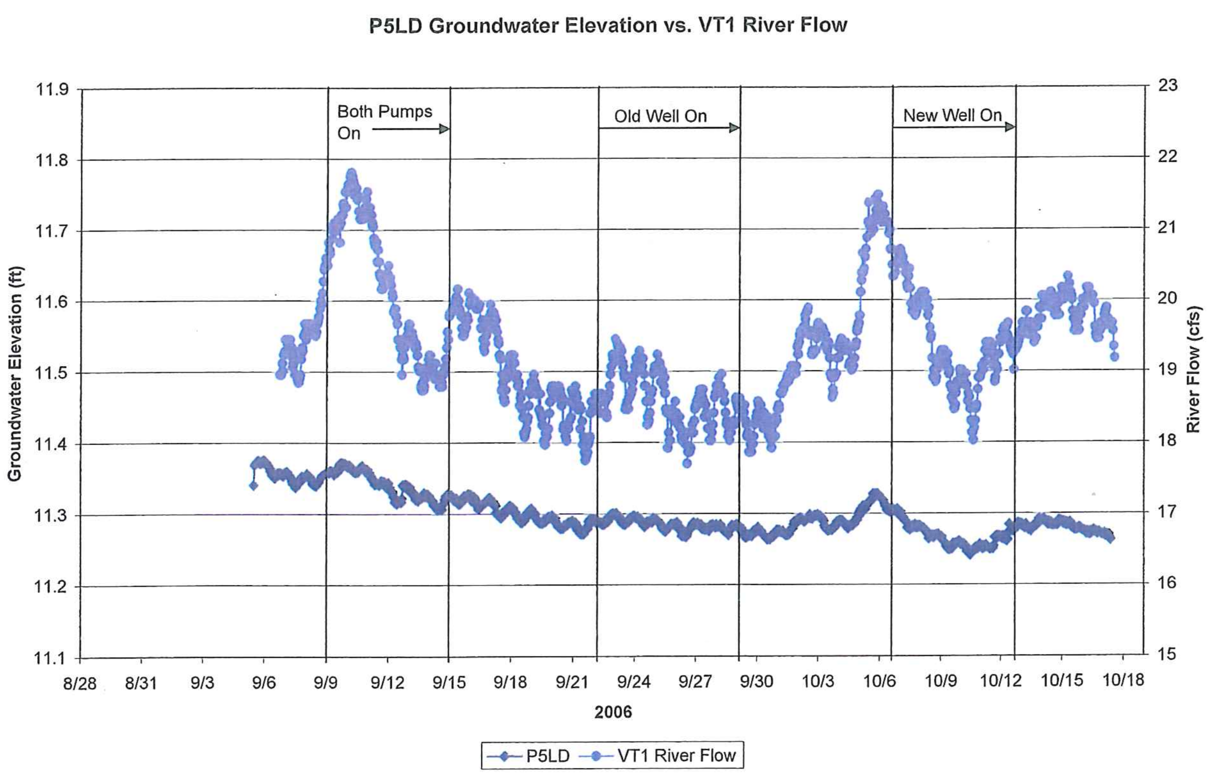


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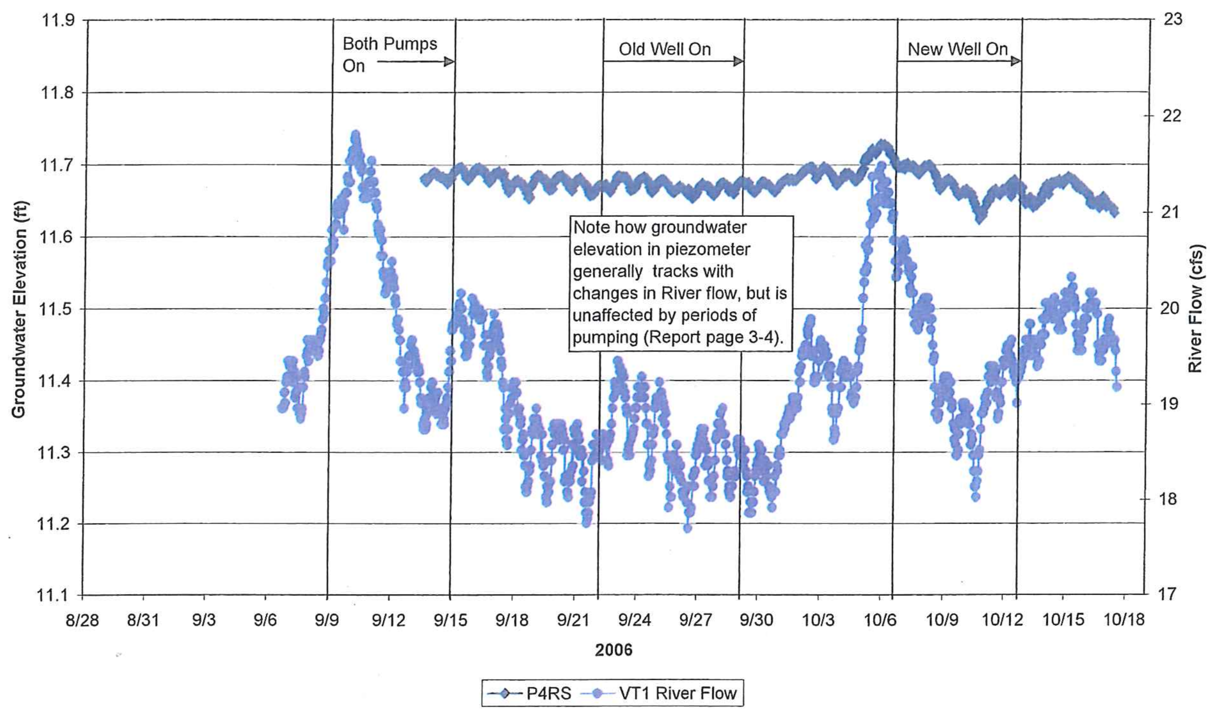
Figure 3-5
Piezometer P5R Hydrographs
El Sur Ranch
Big Sur, California

P5RS Groundwater Elevation vs. VT1 River Flow



P5RD Groundwater Elevation vs VT1 River Flow

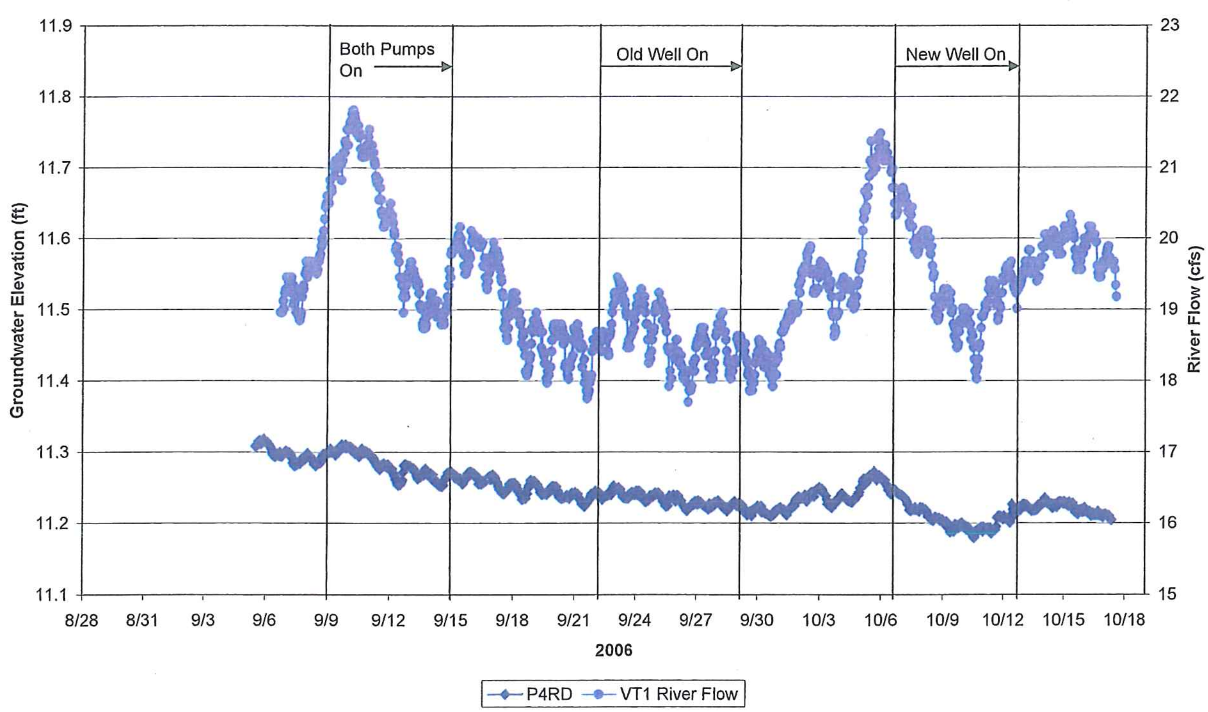


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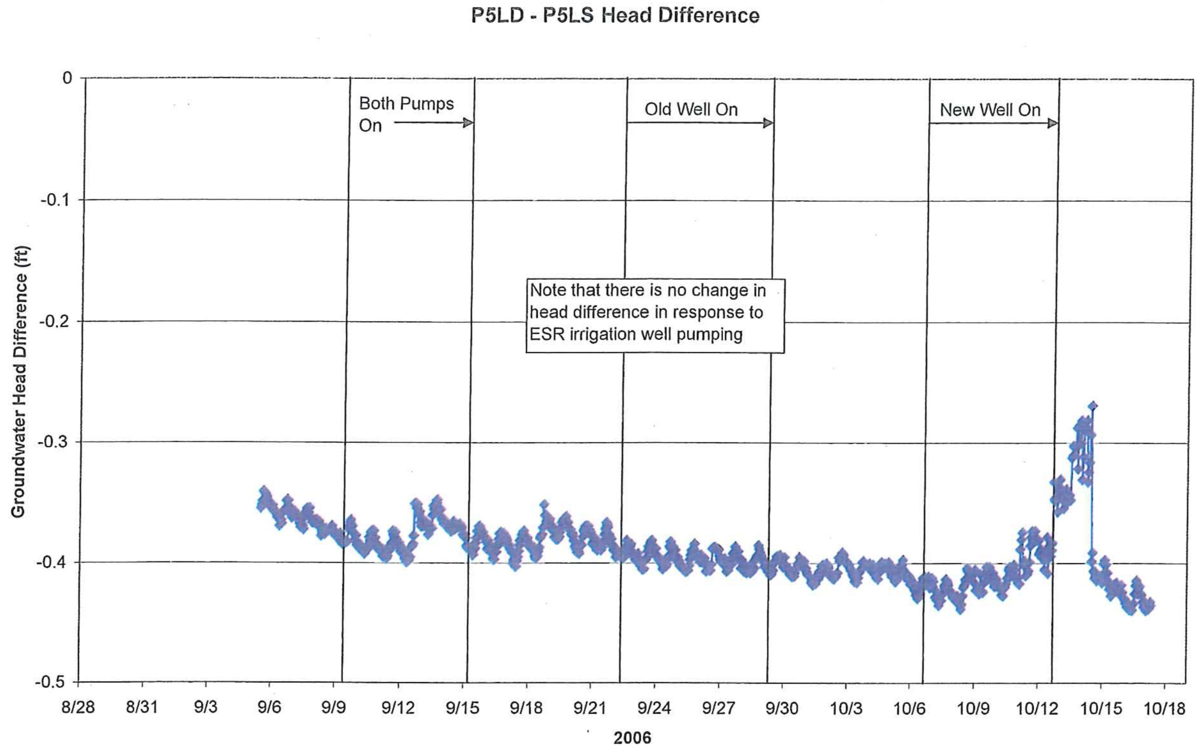
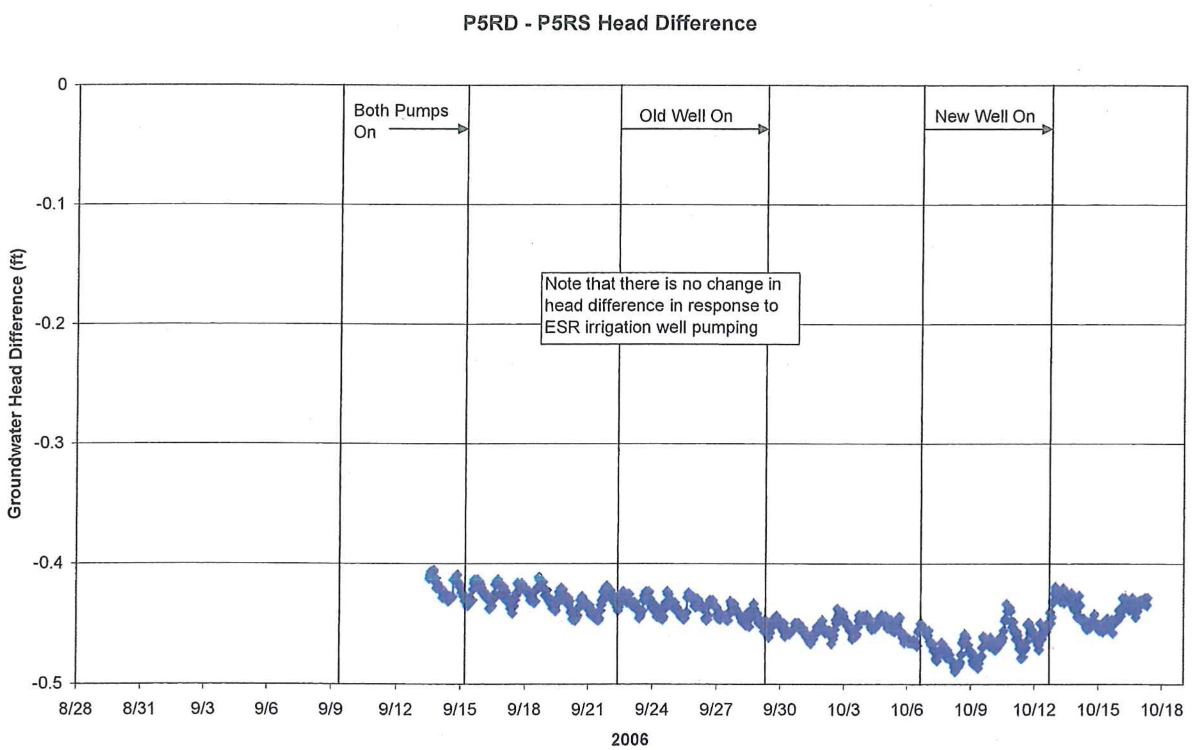
Figure 3-6
Piezometer P5 Head Difference Comparison
El Sur Ranch
Big Sur, California





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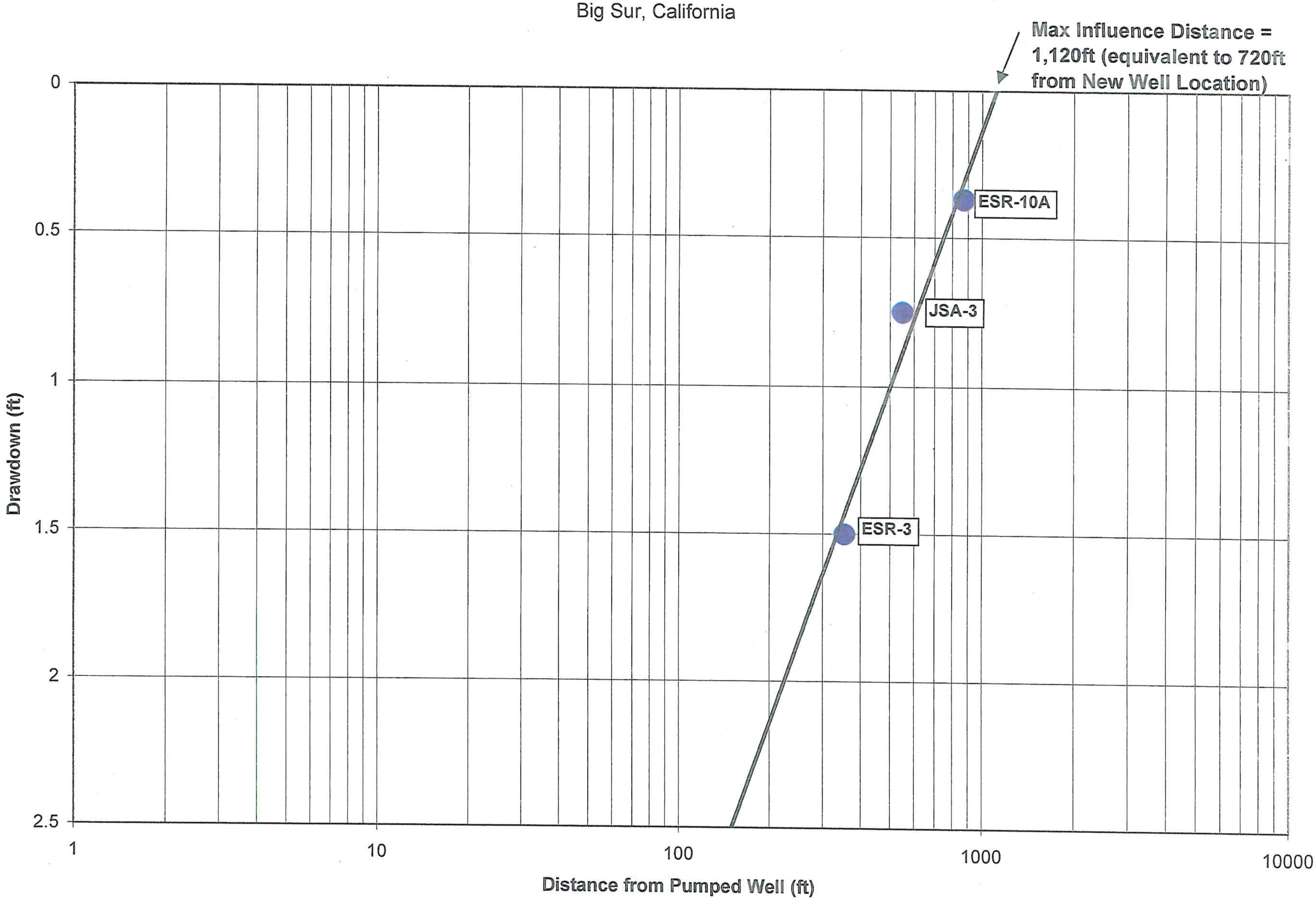
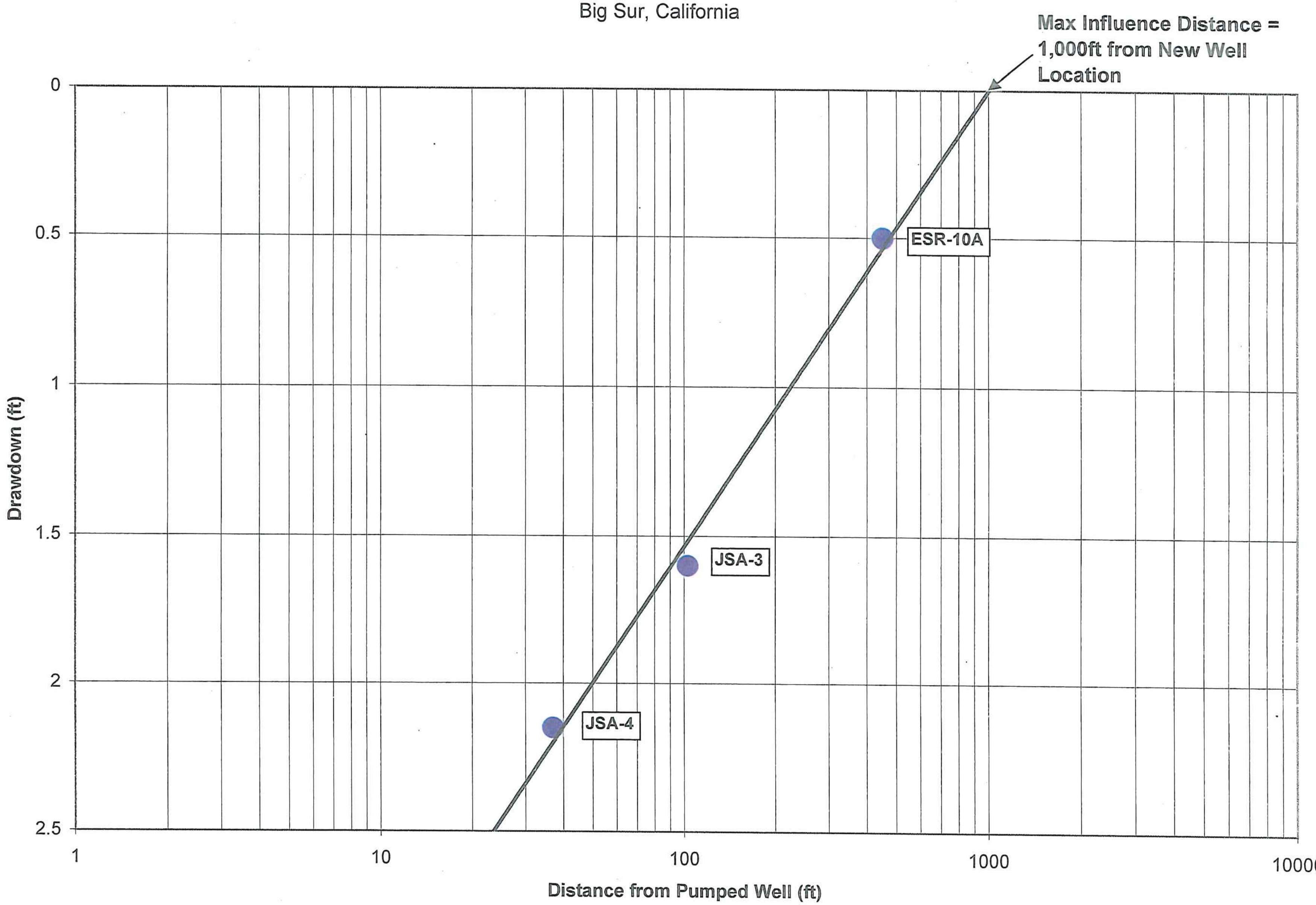
Figu. -7
Old Well Distance Drawdown Graph
El Sur Ranch
Big Sur, California

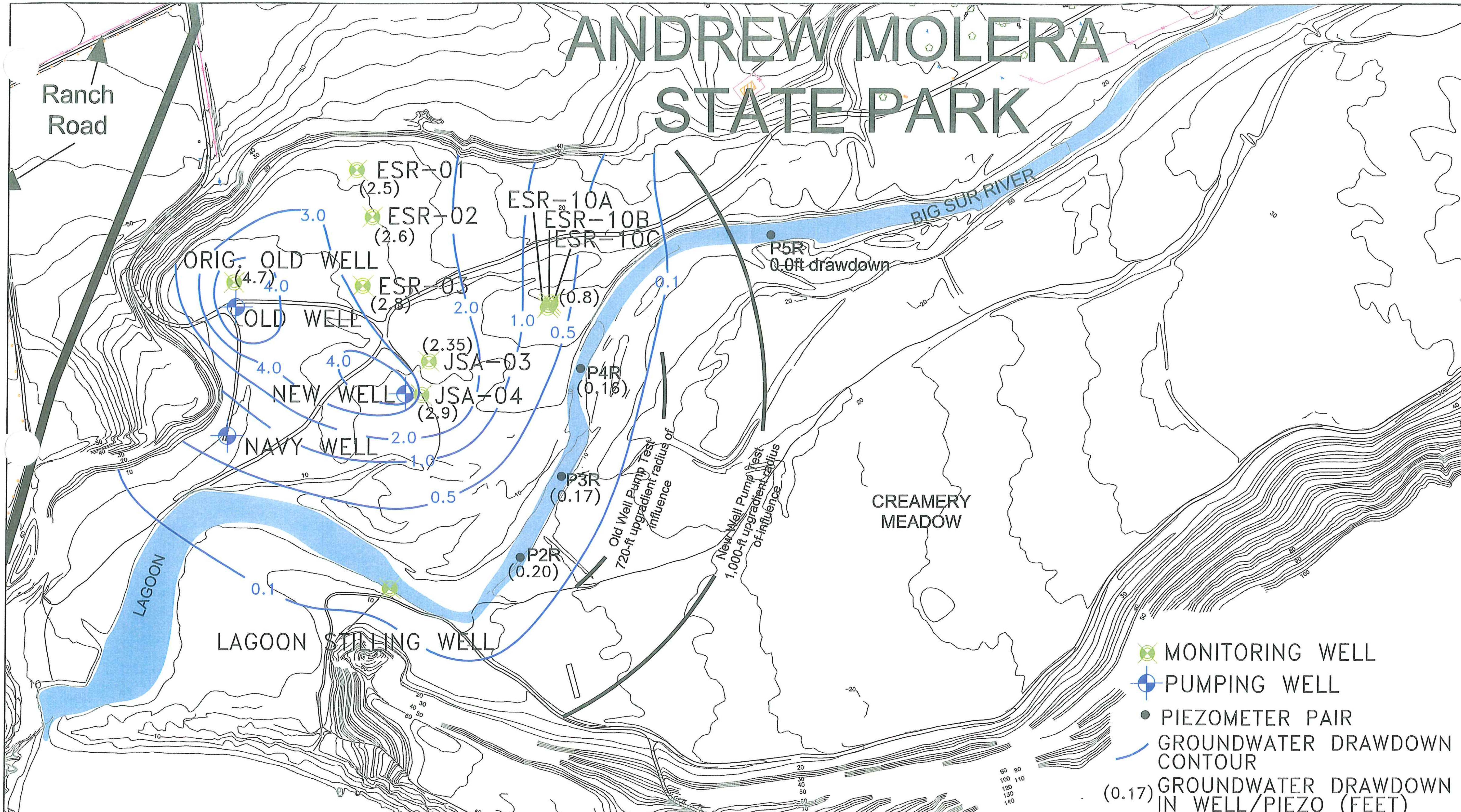


SGI environmental THE SOURCE GROUP, INC.

Figu. -8
New Well Distance Drawdown Graph
El Sur Ranch
Big Sur, California



SGI environmental THE SOURCE GROUP, INC.



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EL SUR RANCH
BIG SUR, CALIFORNIA

SCALE
0 250 500
SCALE IN FEET

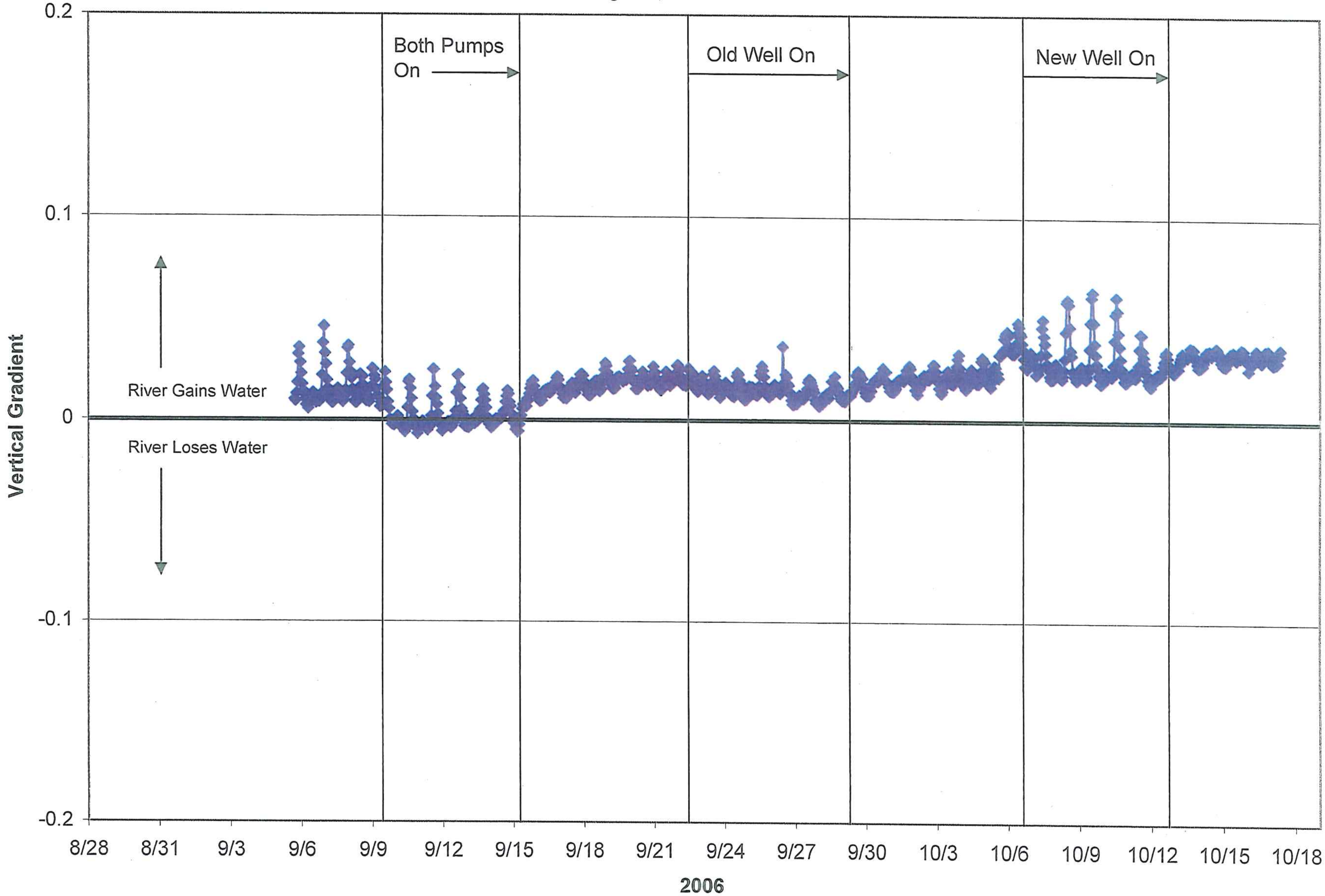
PROJECT NO.	DATE	DR. BY	APP. BY
01-ESR-003	1/12/07	ML/jp	PH

FIGURE 3-9

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

ESR--5

Figure [illegible]-10
P2R Vertical Gradient
El Sur Ranch
Big Sur, California



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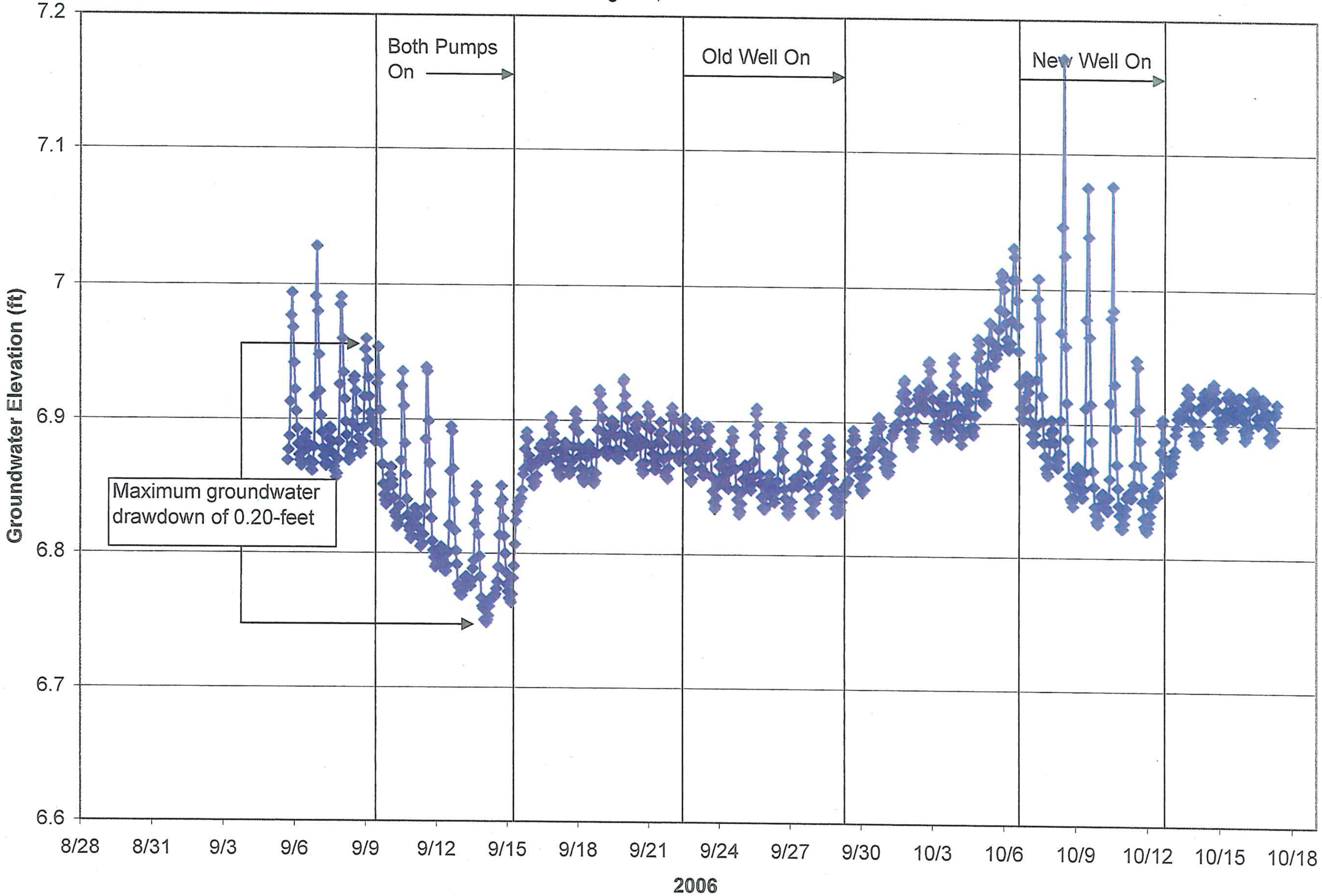
THE SOURCE GROUP, INC.

Figu... -11
P2RD Groundwater Elevation
El Sur Ranch
Big Sur, California



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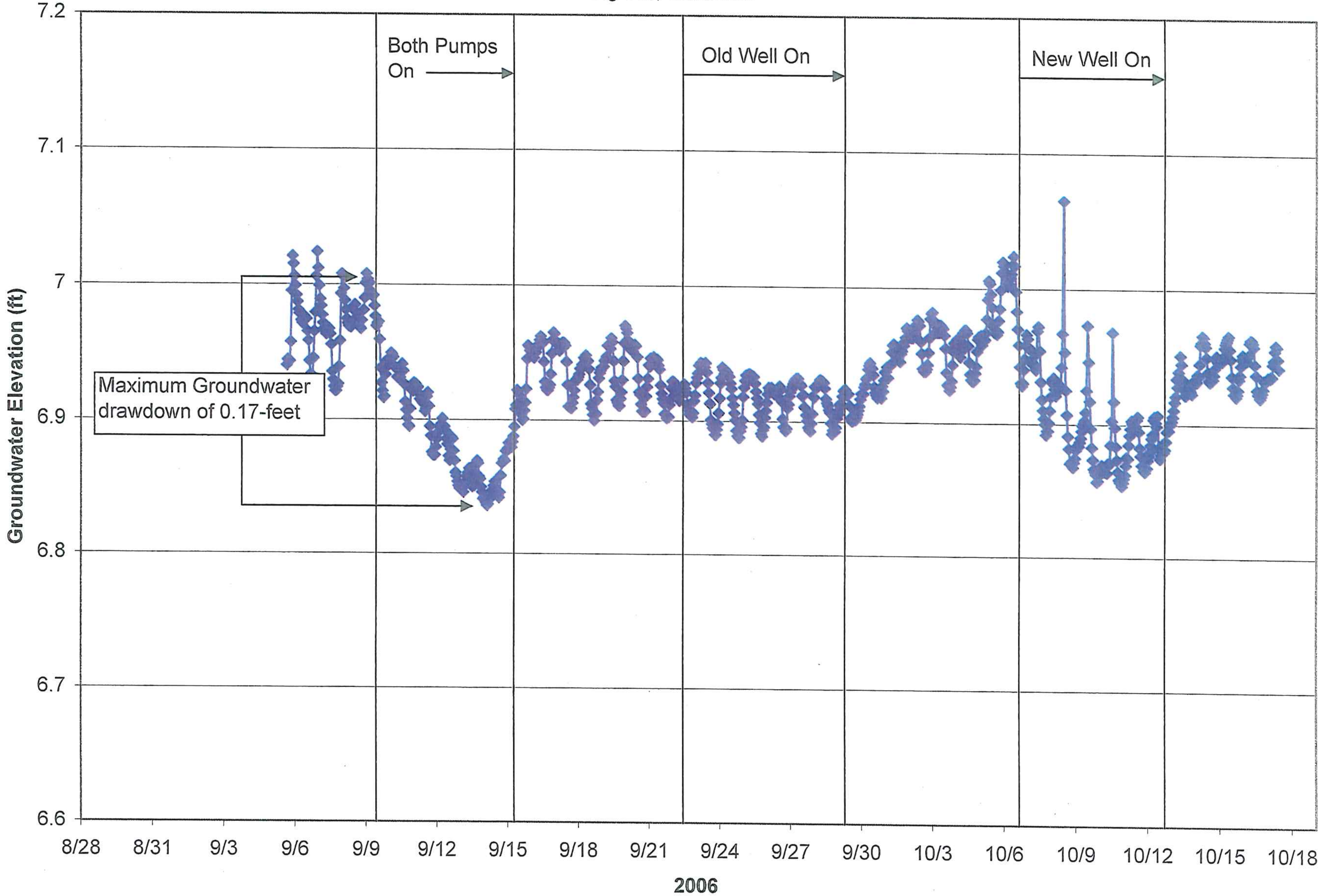
Figur[illegible]-12
P3RD Groundwater Elevation
El Sur Ranch
Big Sur, California



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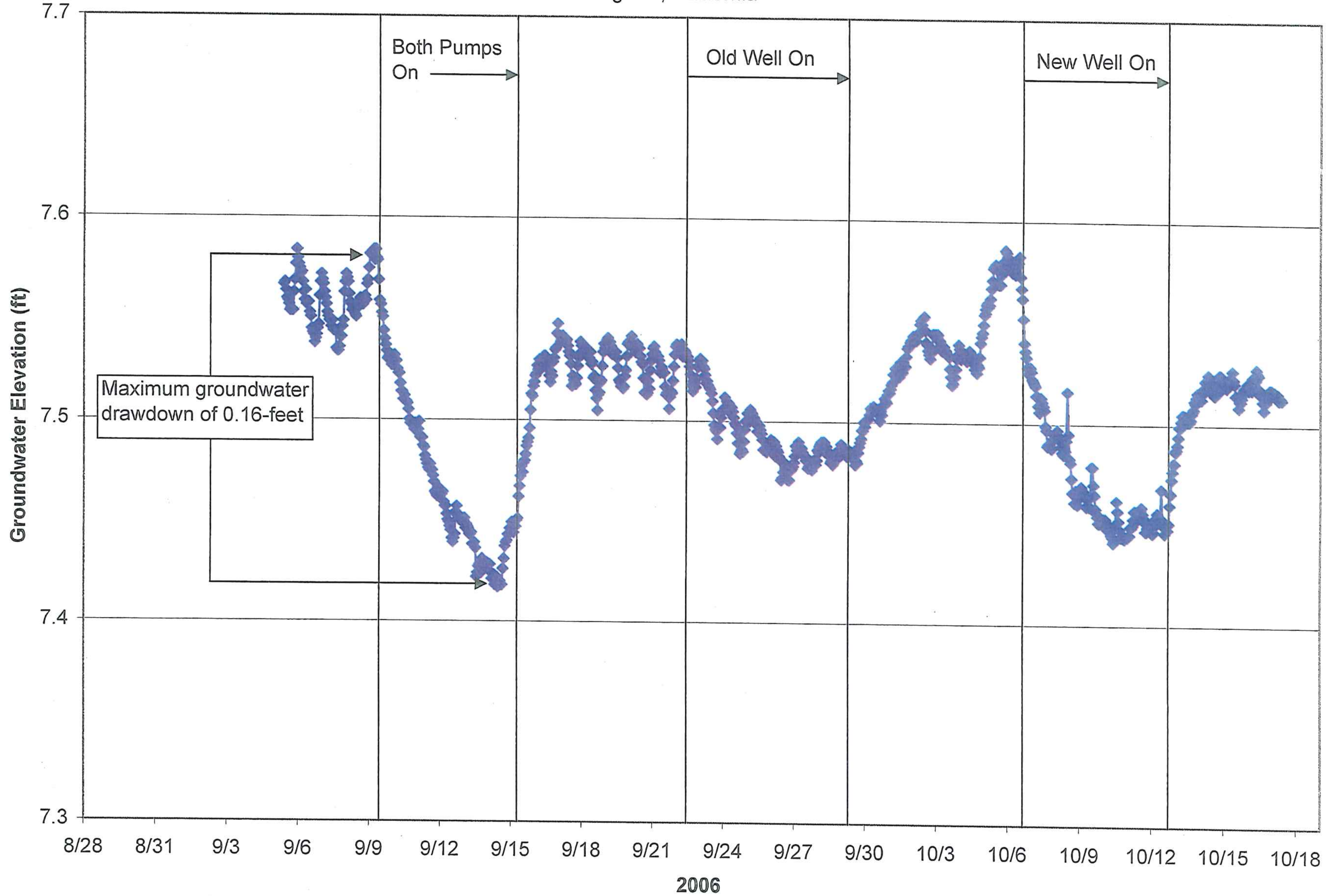
Figur… -13
P4RD Groundwater Elevation
El Sur Ranch
Big Sur, California



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Figur… -14
New Well Distance Drawdown Graph with Piezometer Data
El Sur Ranch
Big Sur, California

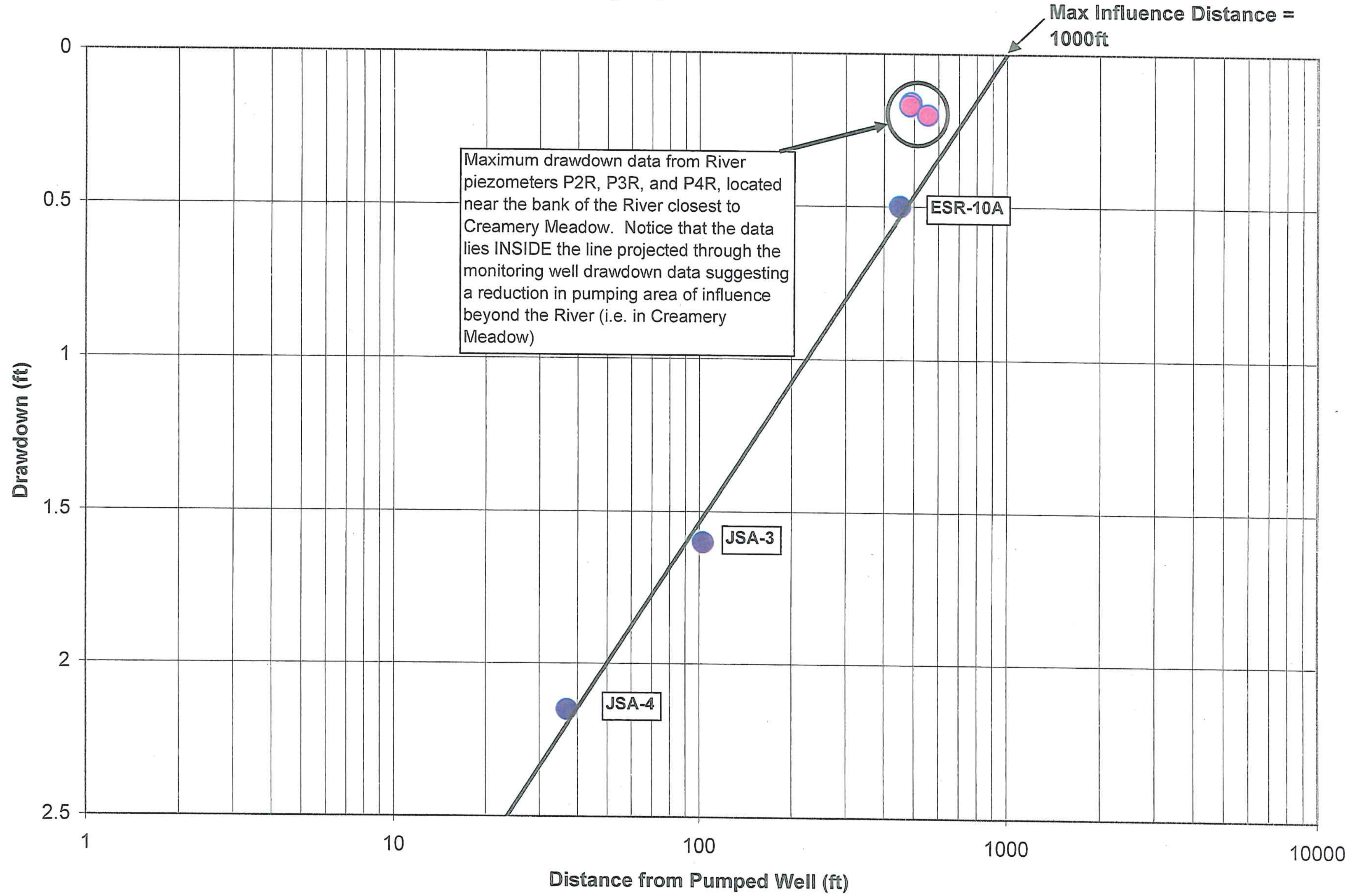

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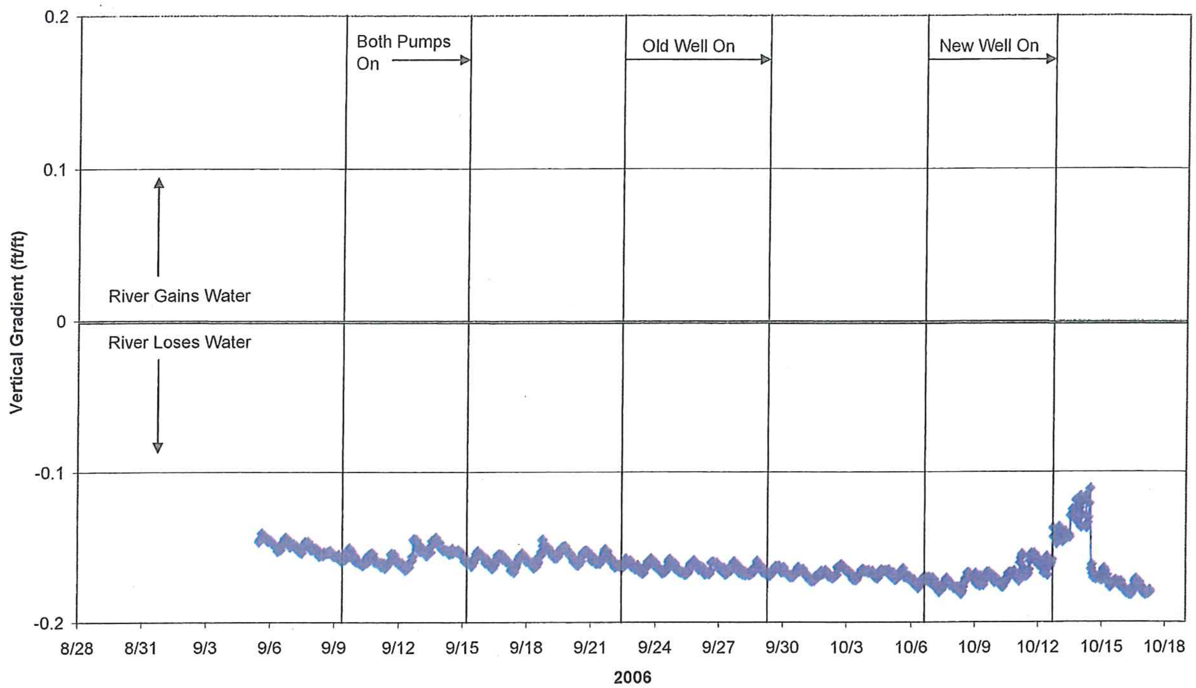
Figure 3-15
Vertical Gradients at Piezometer Station P5
El Sur Ranch
Big Sur, California

P5L Vertical Gradient



P5R Vertical Gradient

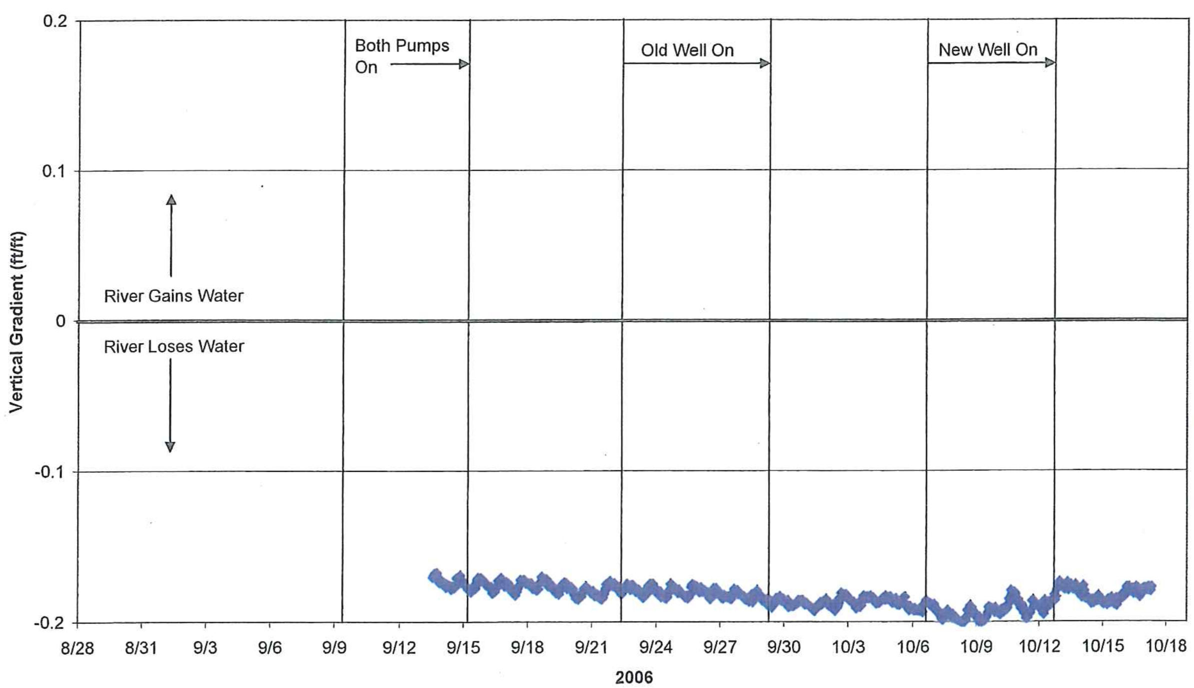


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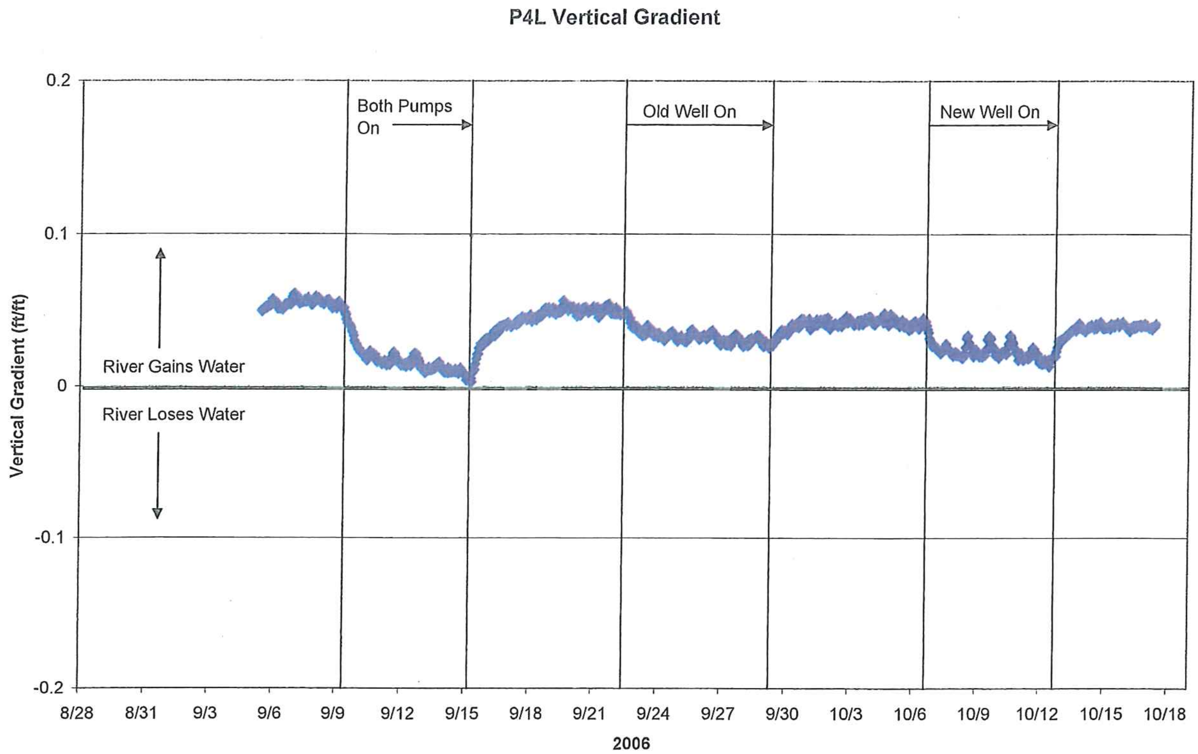
Figure 3-16
Vertical Gradients of Piezometer P4
El Sur Ranch
Big Sur, California



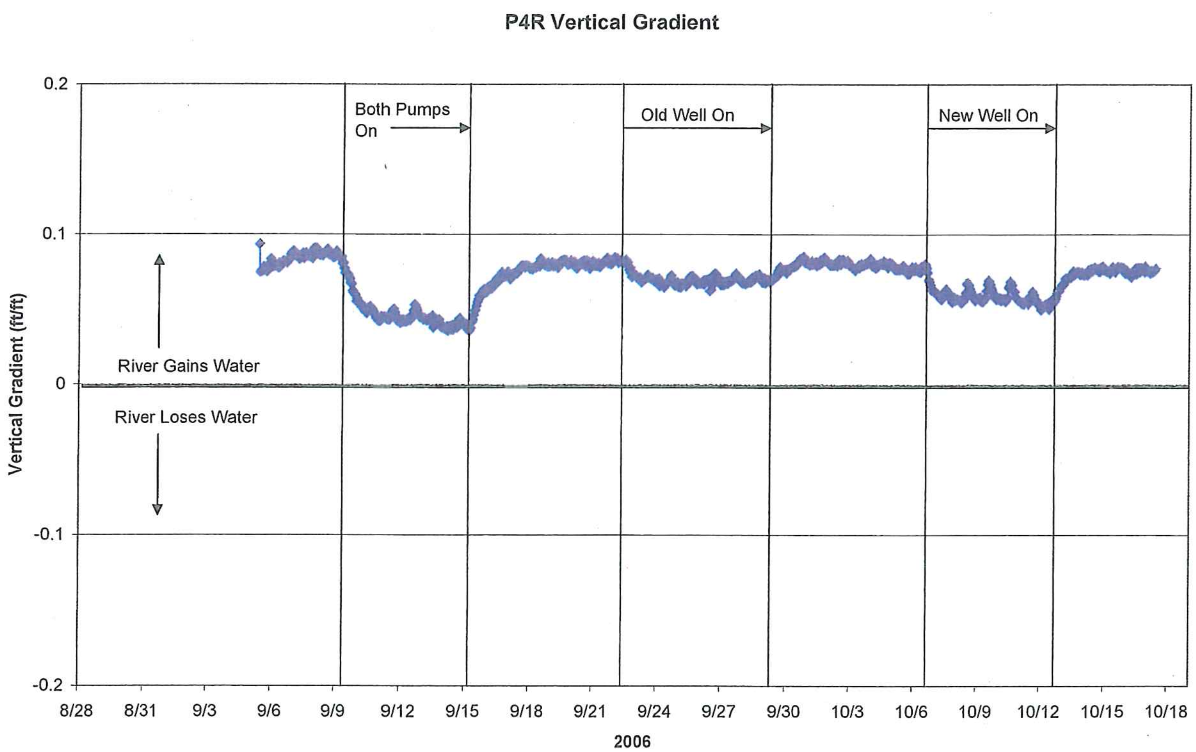


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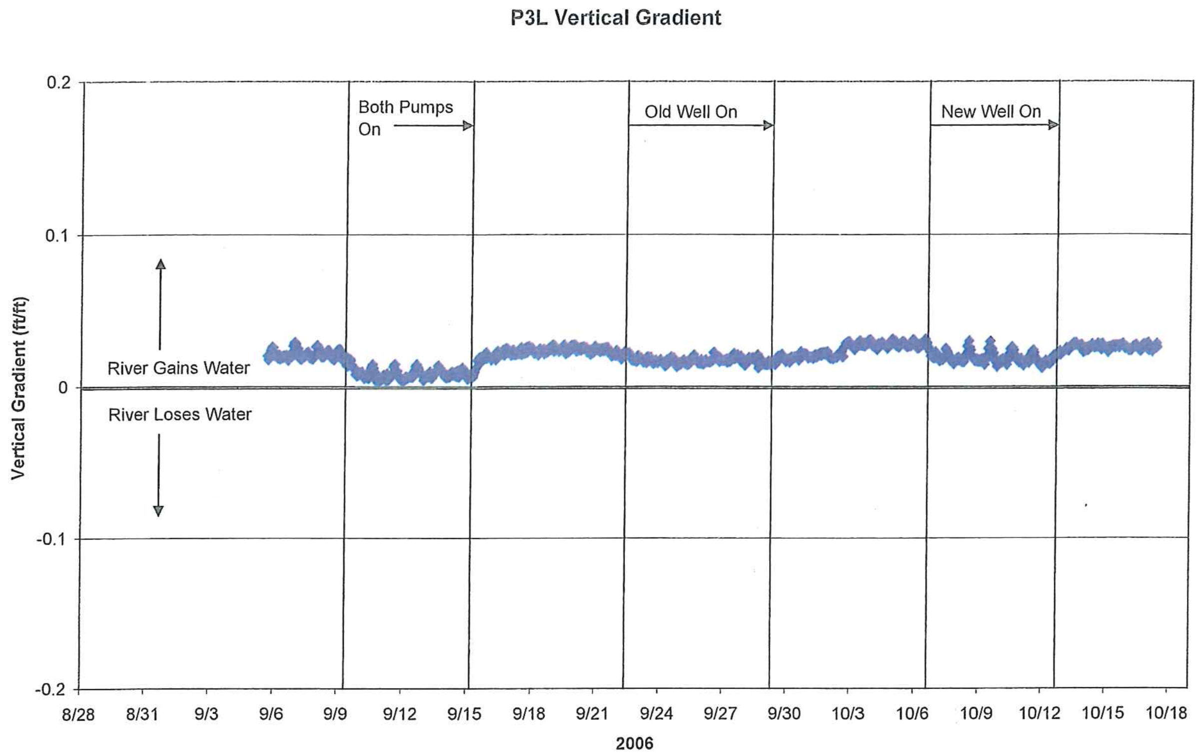
Figure 3-17
Vertical Gradients at Piezometer P3
El Sur Ranch
Big Sur, California



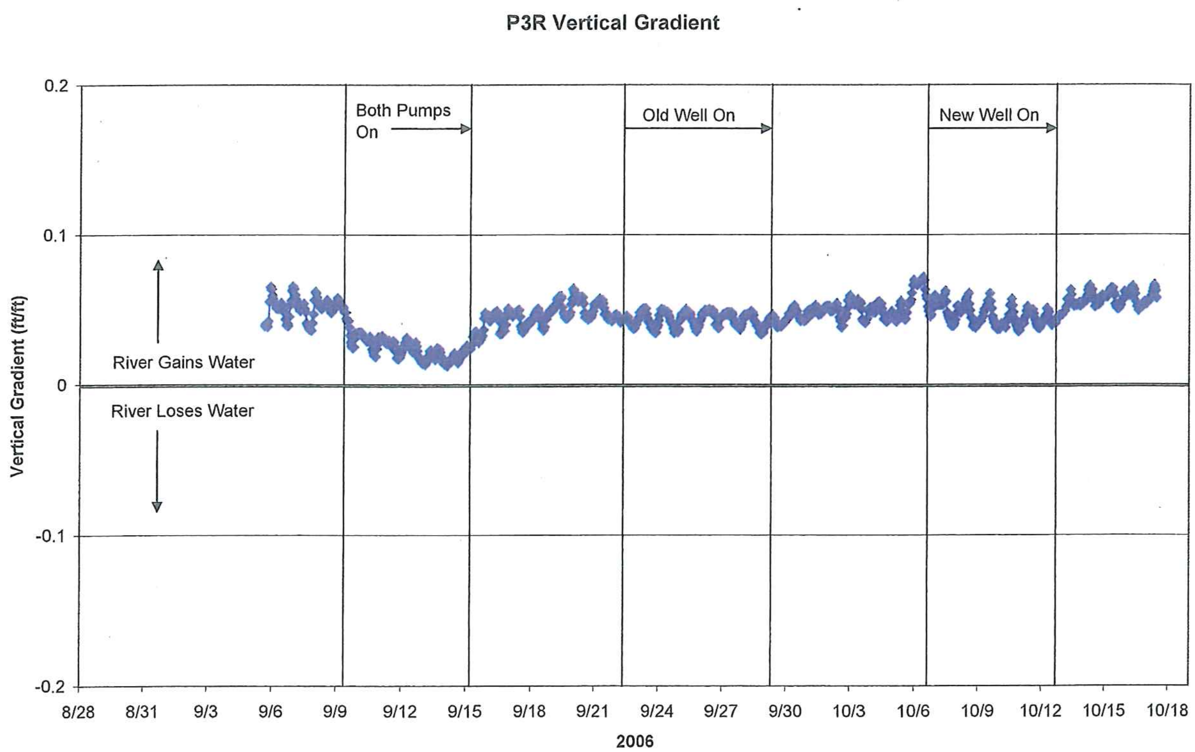
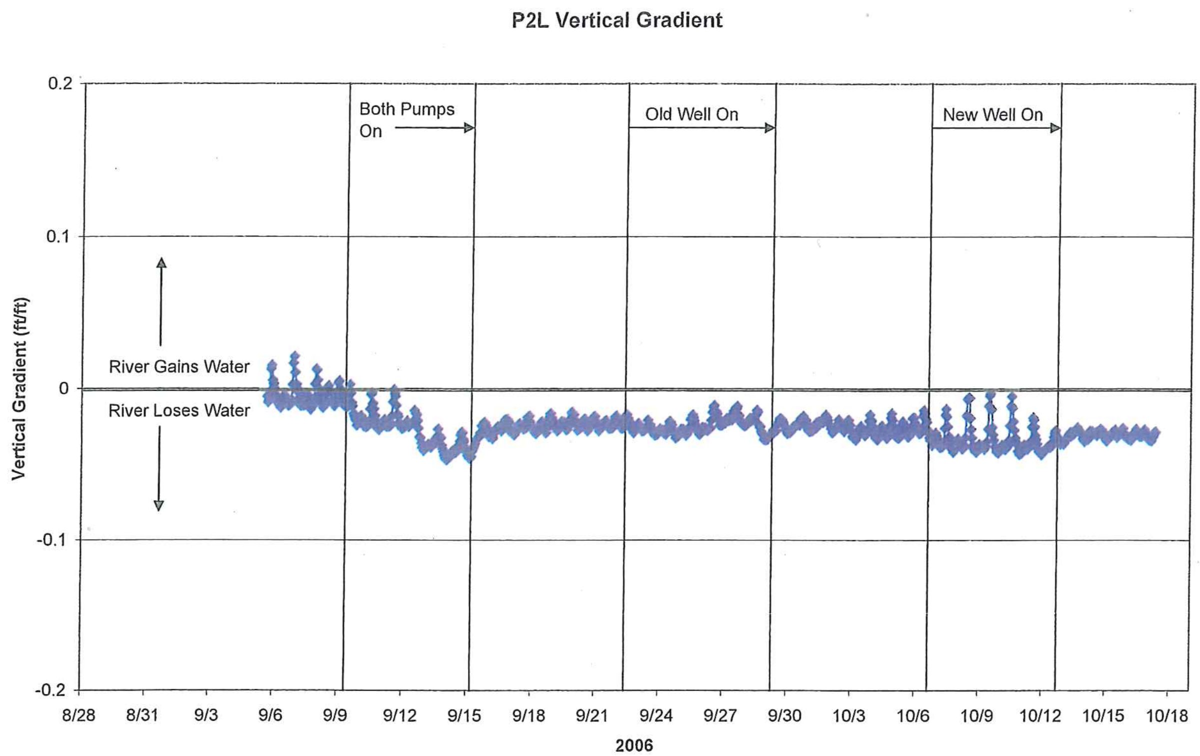
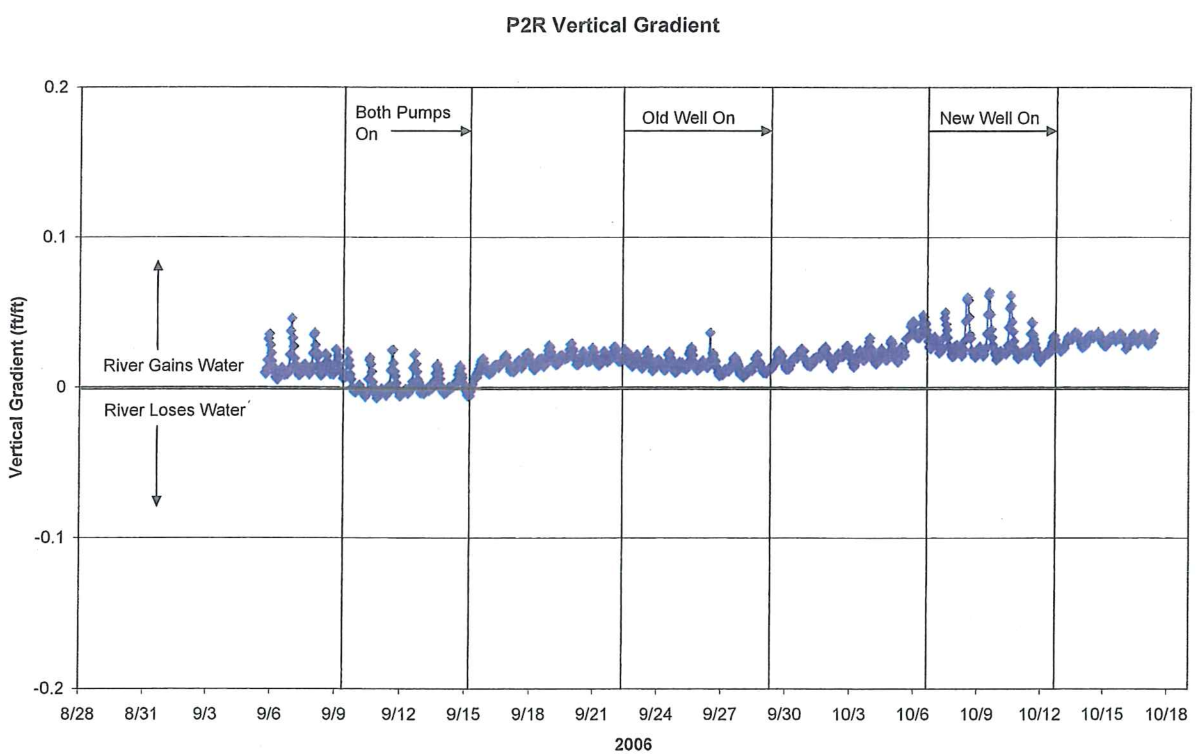


Figure 3-18
Vertical Gradients at Piezometer P2
El Sur Ranch
Big Sur, California





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Figur… 19

Piezometer P1LS Groundwater Elevation vs. Maximum Daily Tide

El Sur Ranch

Big Sur, California

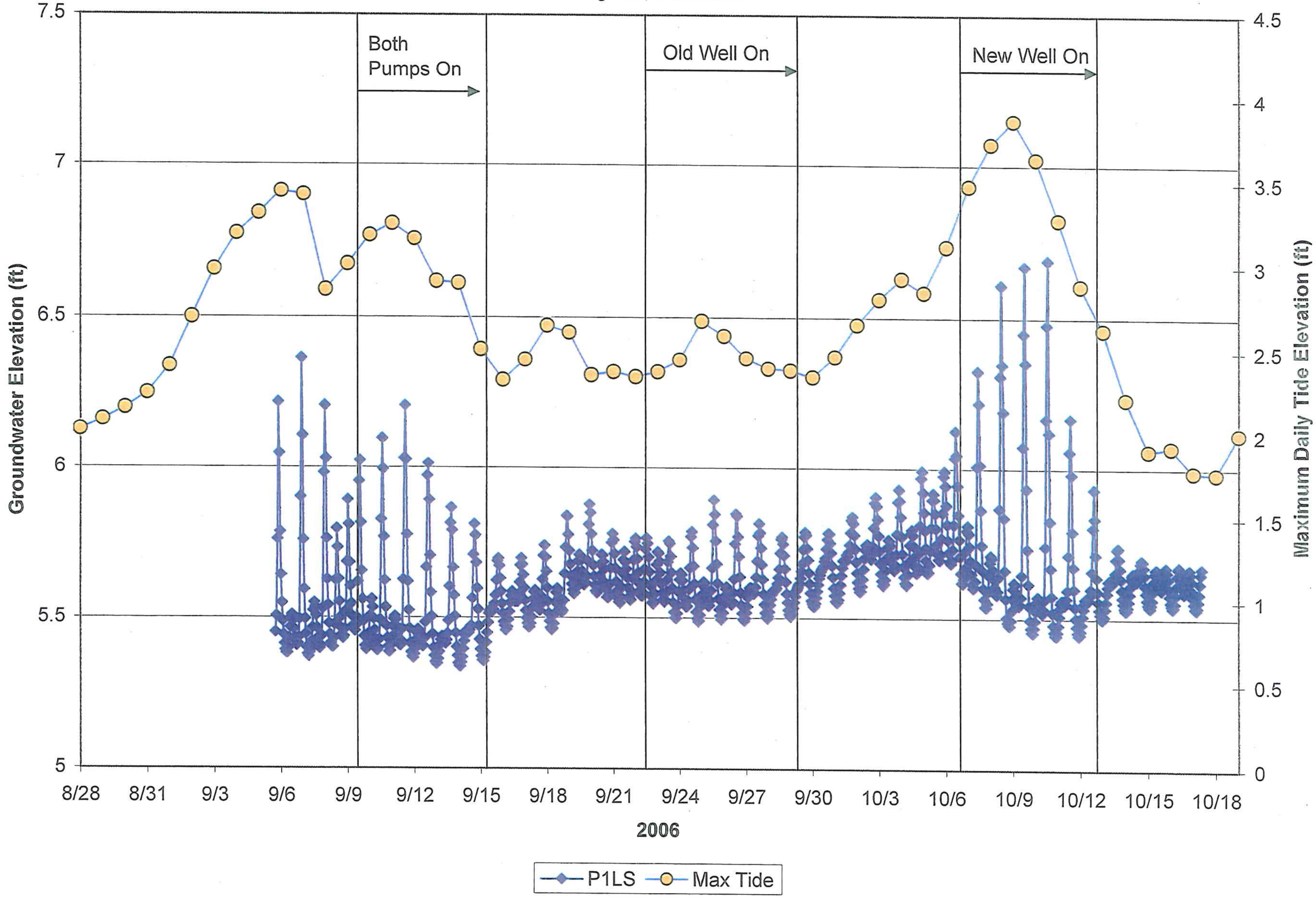

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Figure [illegible]-20
Piezometer P1L Vertical Gradient
El Sur Ranch
Big Sur, California

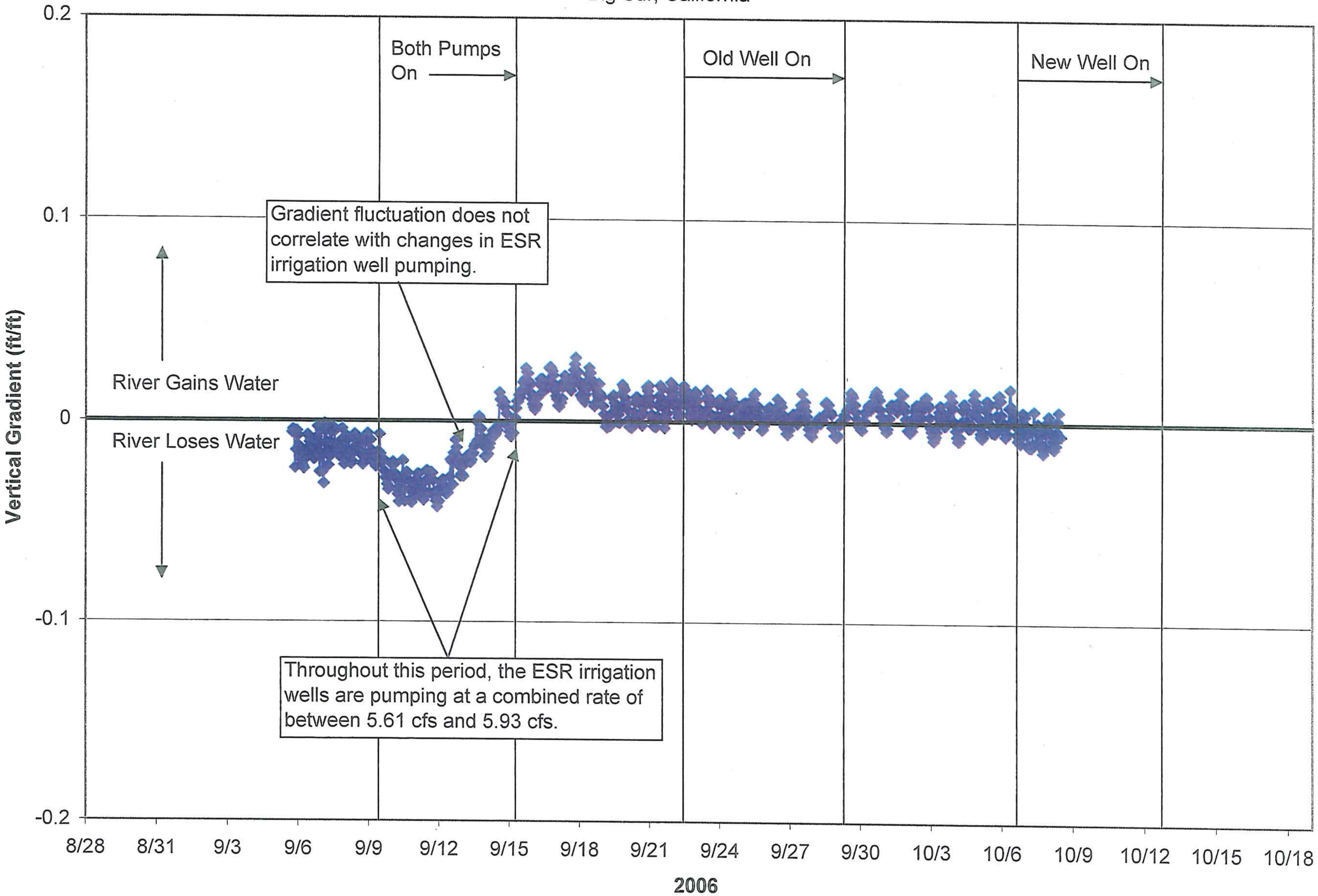

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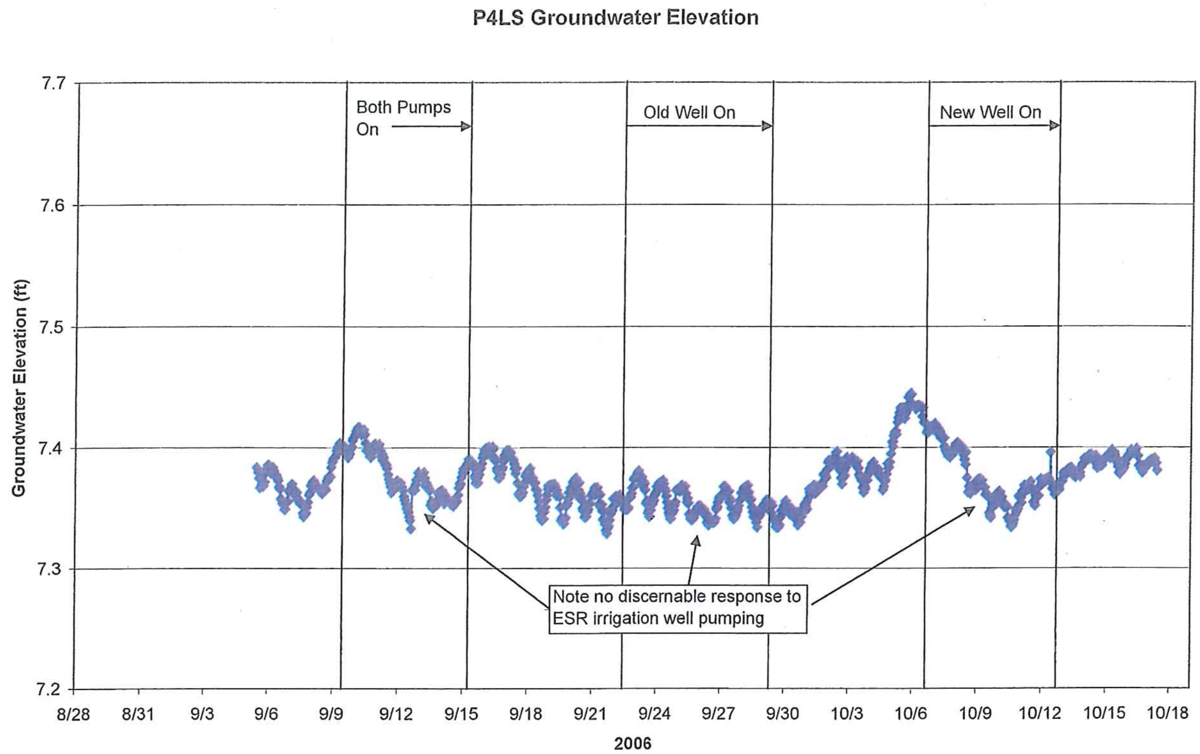
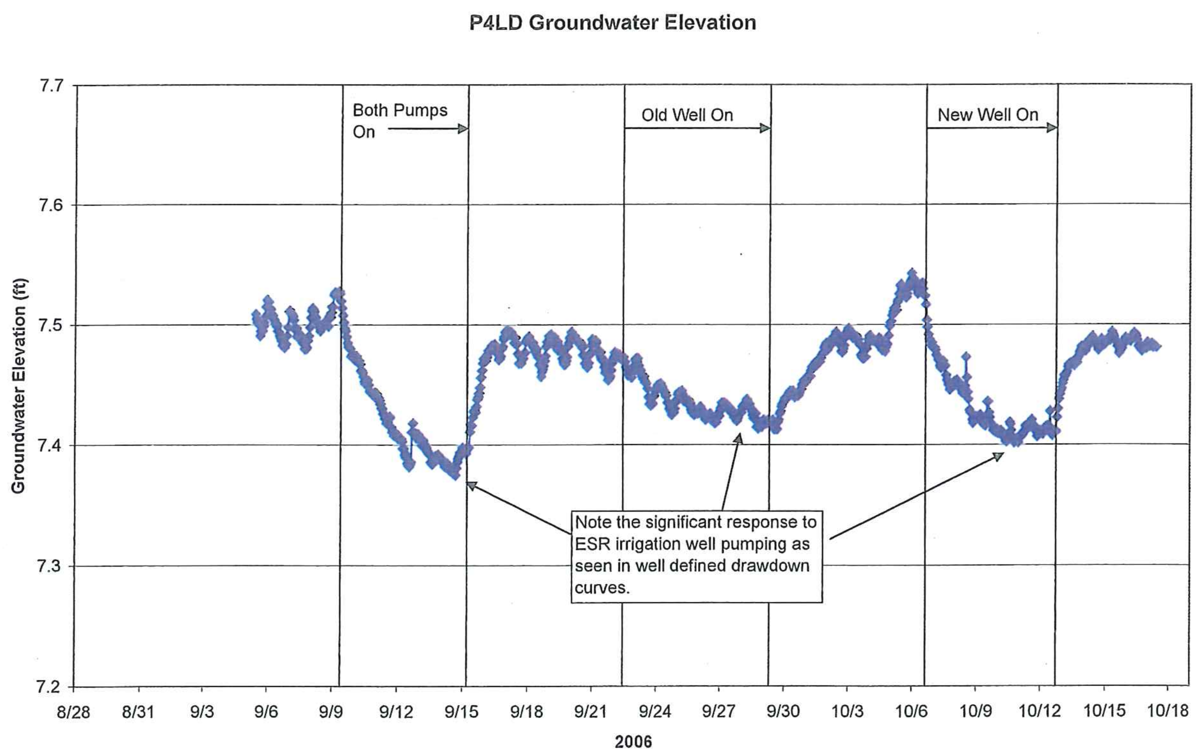
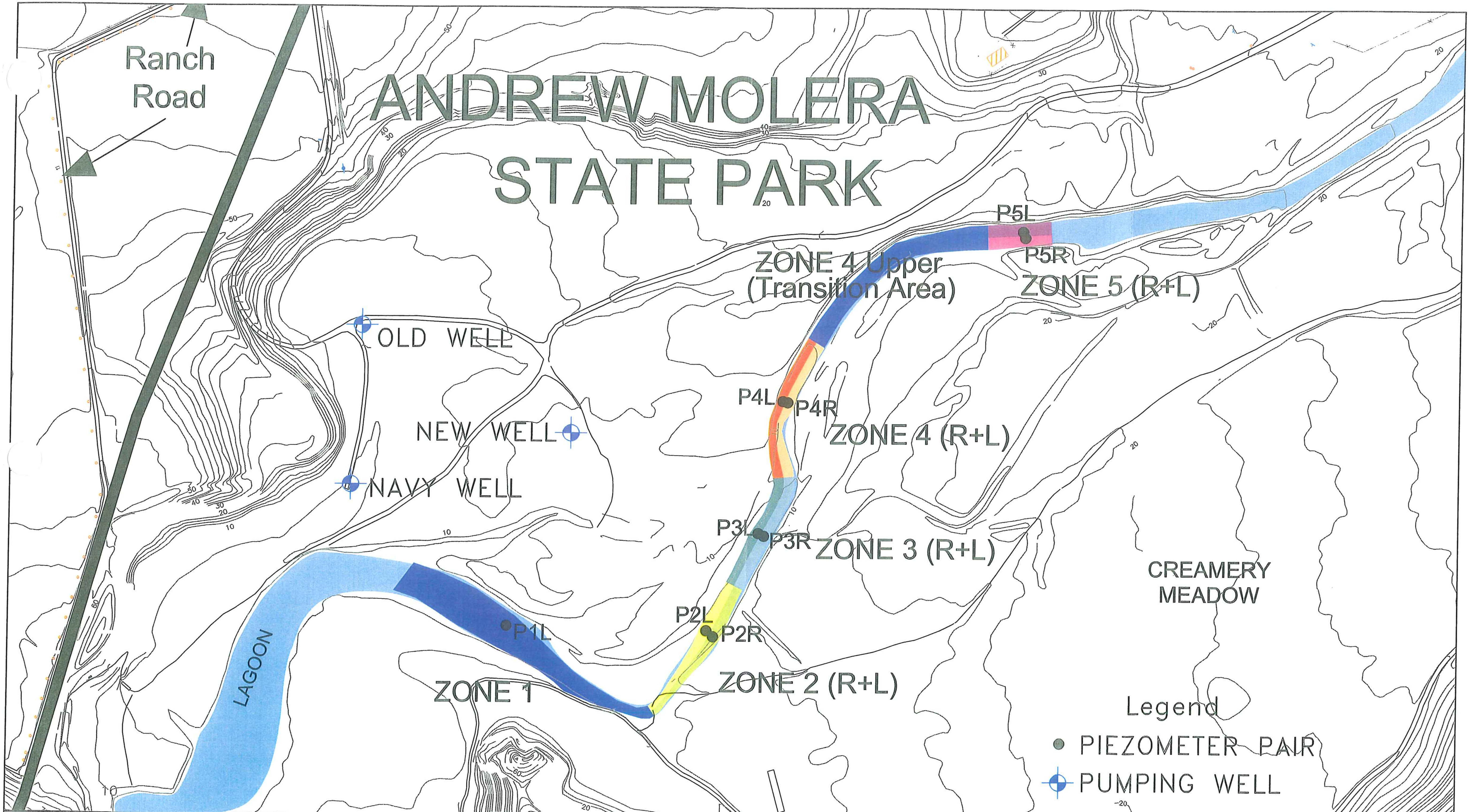
Figure 3-21
Groundwater Elevations at Piezometer Pair P4L
El Sur Ranch
Big Sur, California

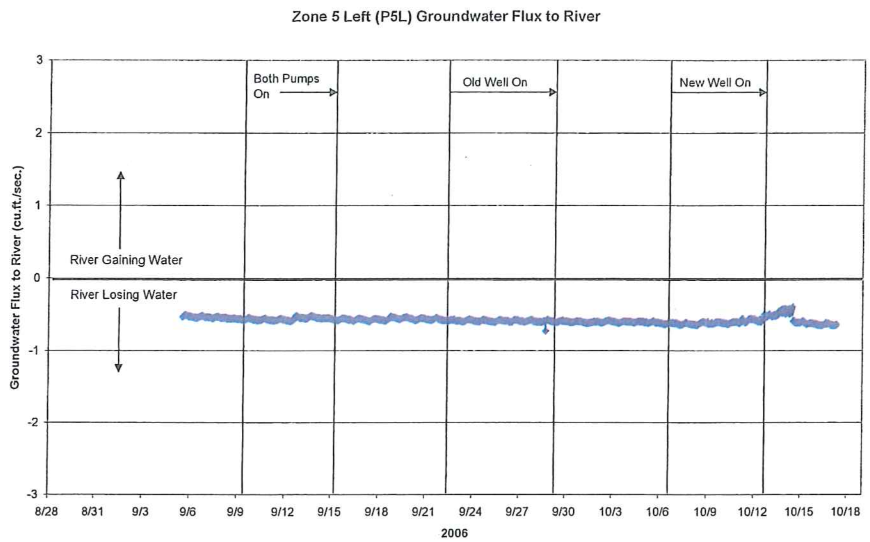


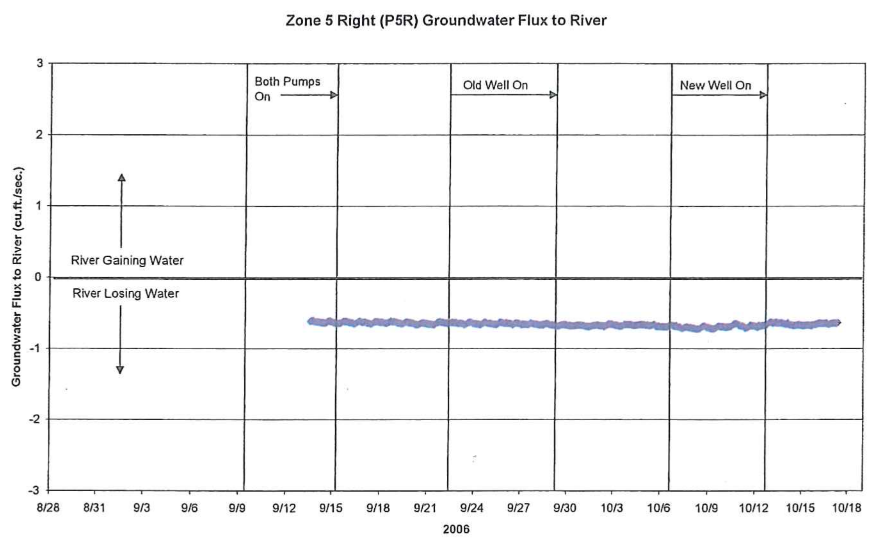




SGI environmental THE SOURCE GROUP, INC.	EL SUR RANCH BIG SUR, CALIFORNIA	SCALE 0 200 400 SCALE IN FEET		FIGURE 3-22 INTERPRETED STREAMBED ZONES
	PROJECT NO. 01-ESR-003	DATE 1/12/07	DR. BY ML/jp	APP. BY PH

Figure 3-23
Zone 5 Groundwater Flux to River
El Sur Ranch
Big Sur, California





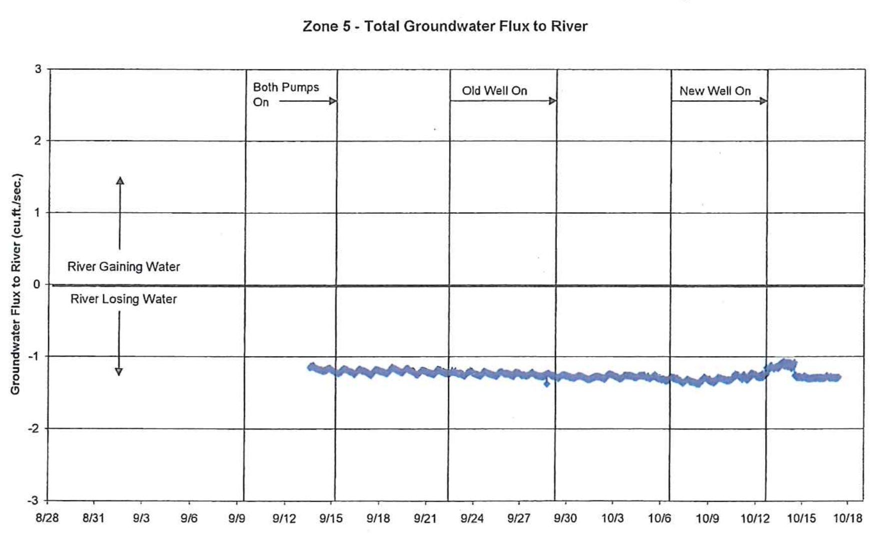
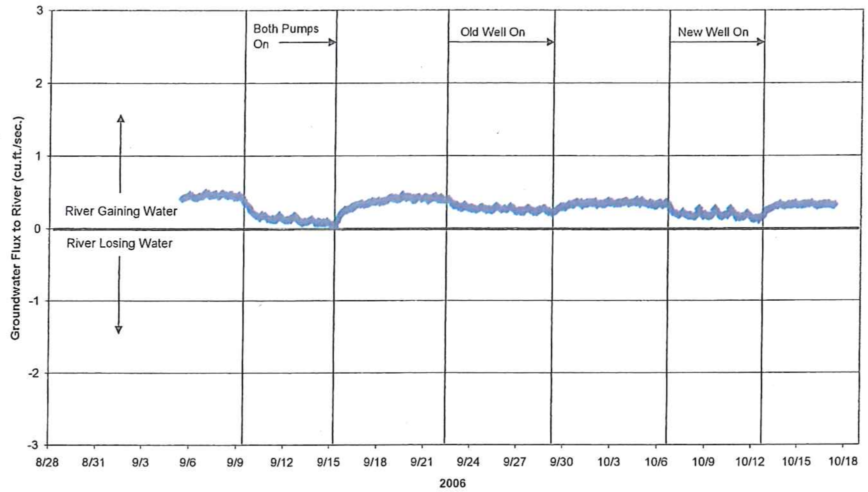
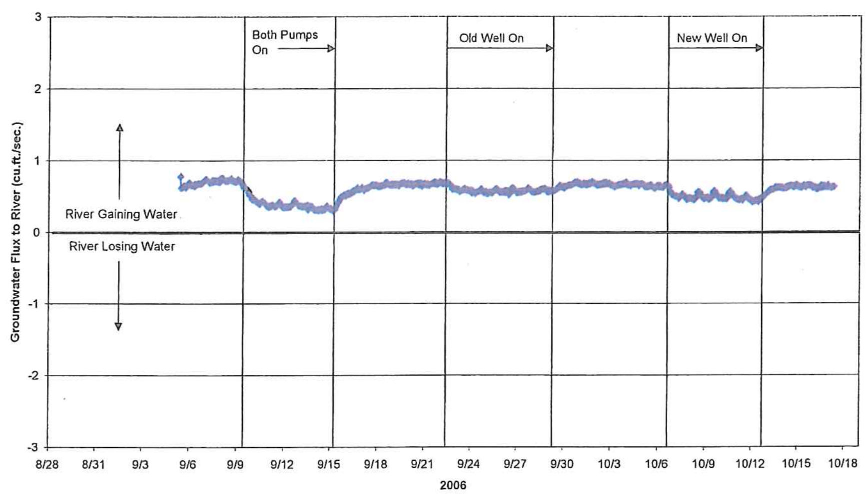


Figure 3-24
Zone 4 Groundwater Flux to River
El Sur Ranch
Big Sur, California

Zone 4 Left (P4L) Groundwater Flux to River



Zone 4 Right (P4R) Groundwater Flux to River



Zone 4 - Total Groundwater Flux to River

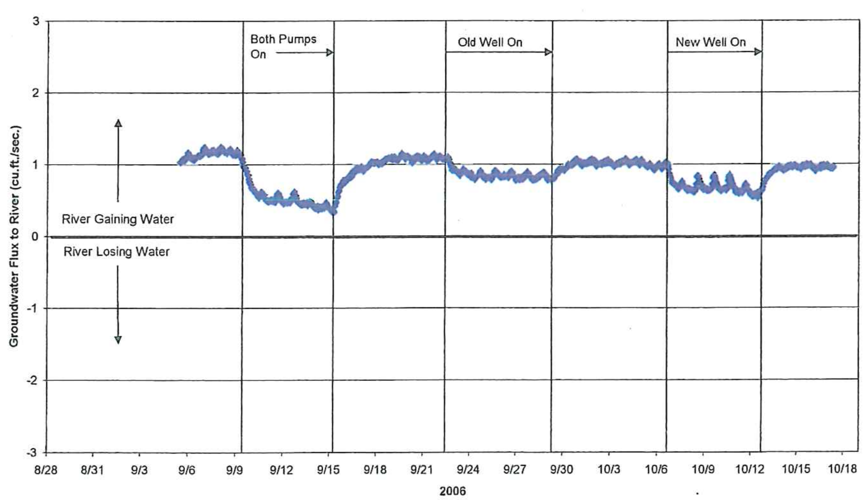
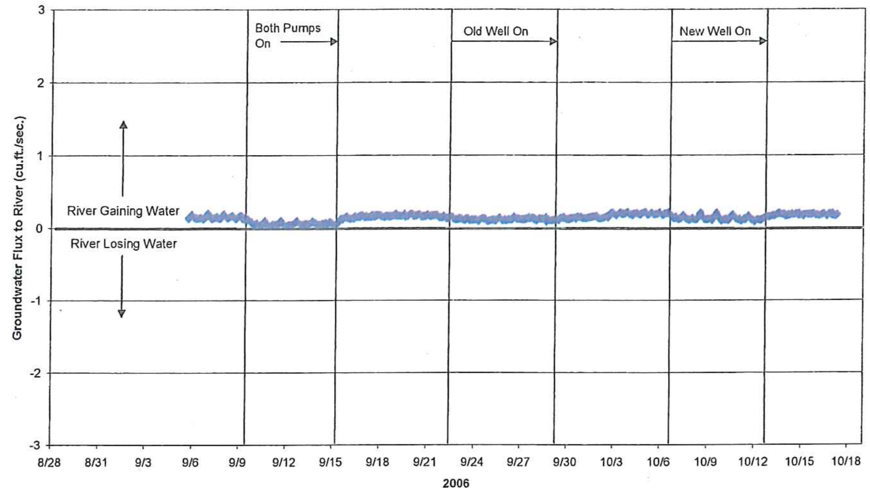
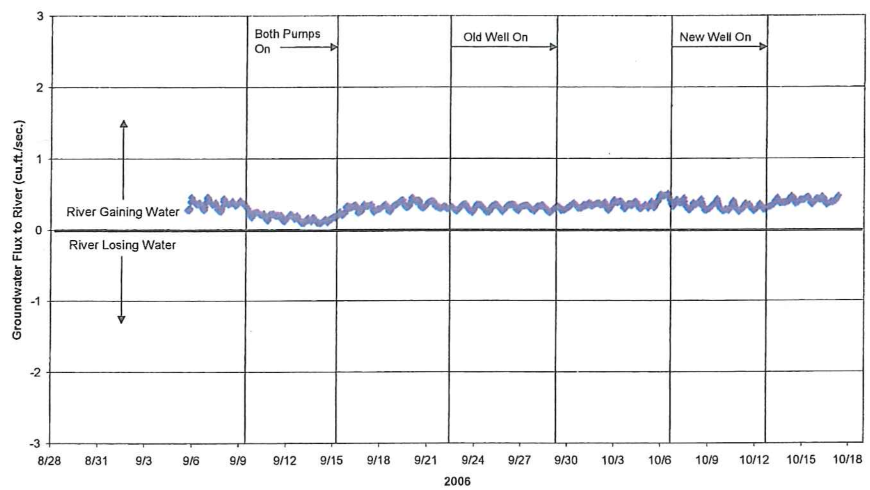


Figure 3-25
Zone 3 Groundwater Flux to River
El Sur Ranch
Big Sur, California

Zone 3 Left (P3L) Groundwater Flux to River



Zone 3 Right (P3R) Groundwater Flux to River



Zone 3 - Total Groundwater Flux to River

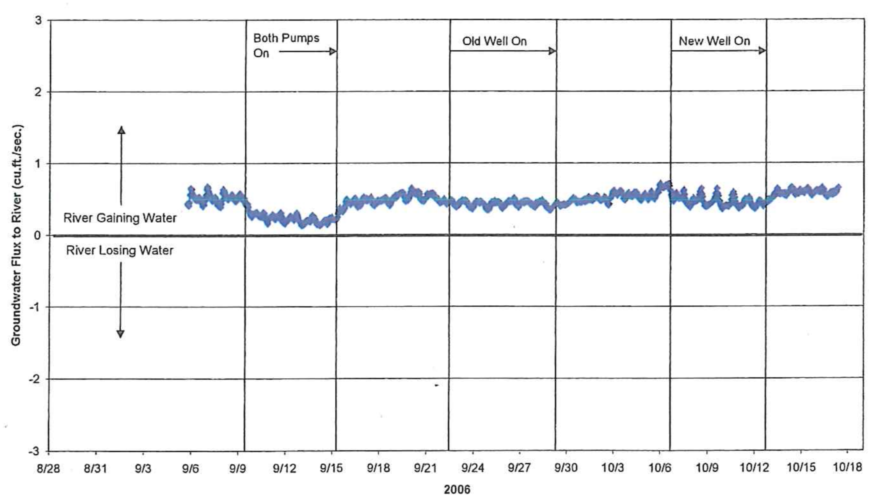
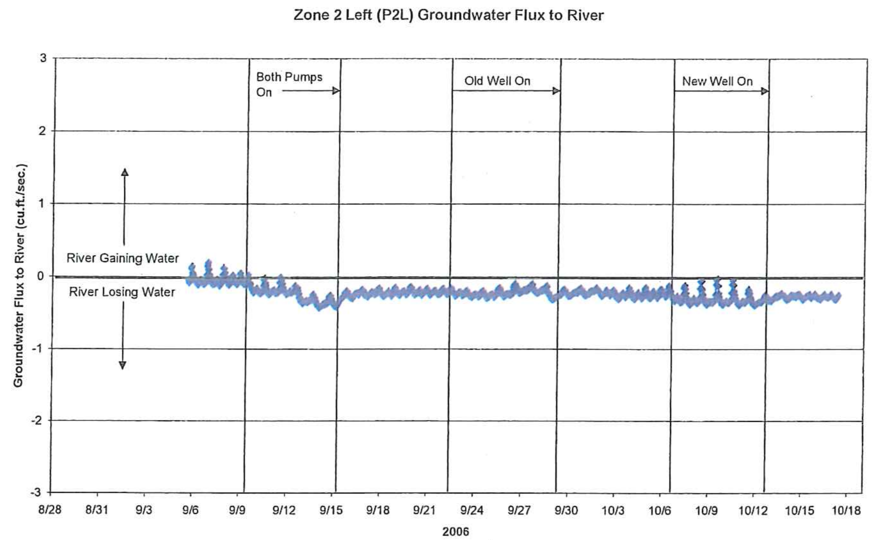
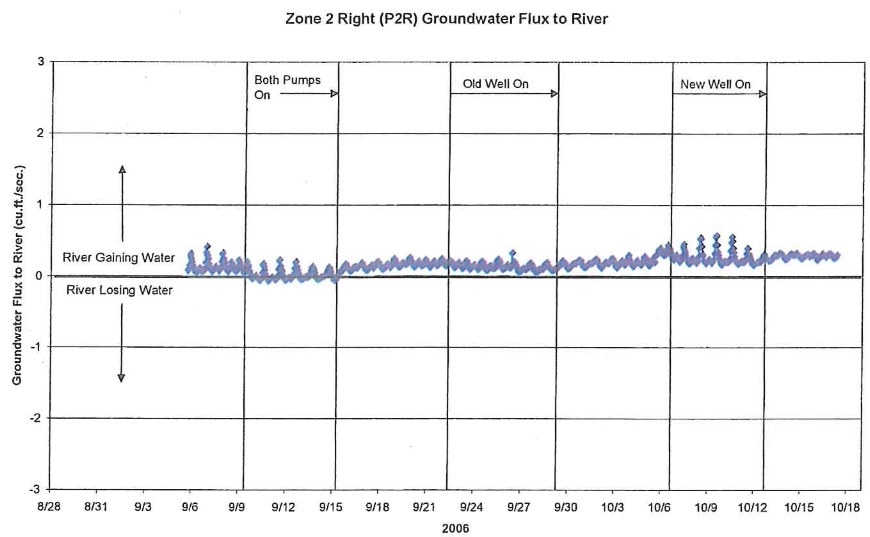


Figure 3-26
Zone 2 Groundwater Flux to River
El Sur Ranch
Big Sur, California





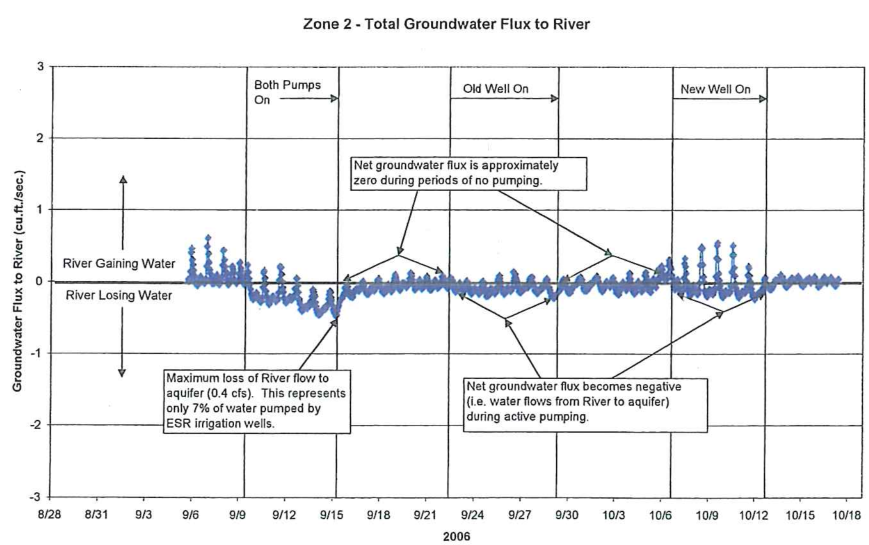
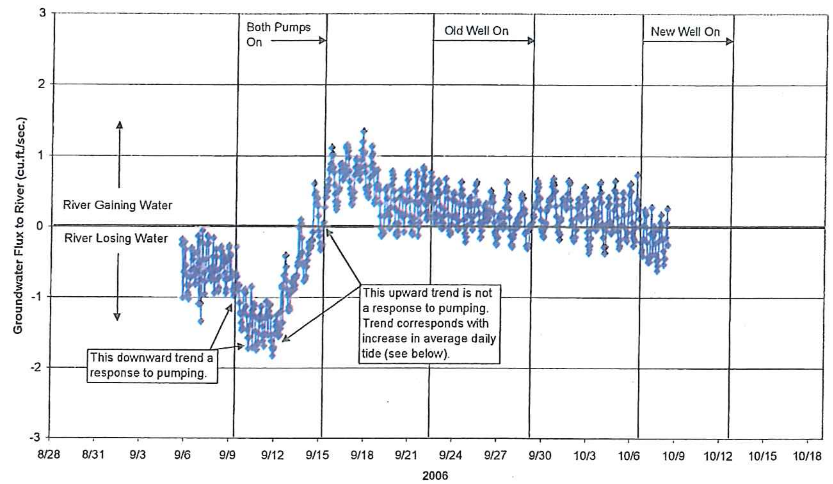
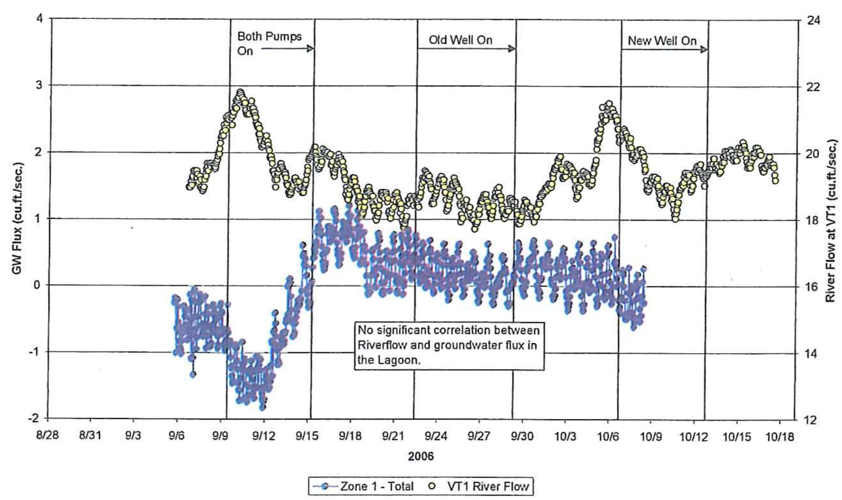


Figure 3-27
Zone 1 Groundwater Flux to River
El Sur Ranch
Big Sur, California

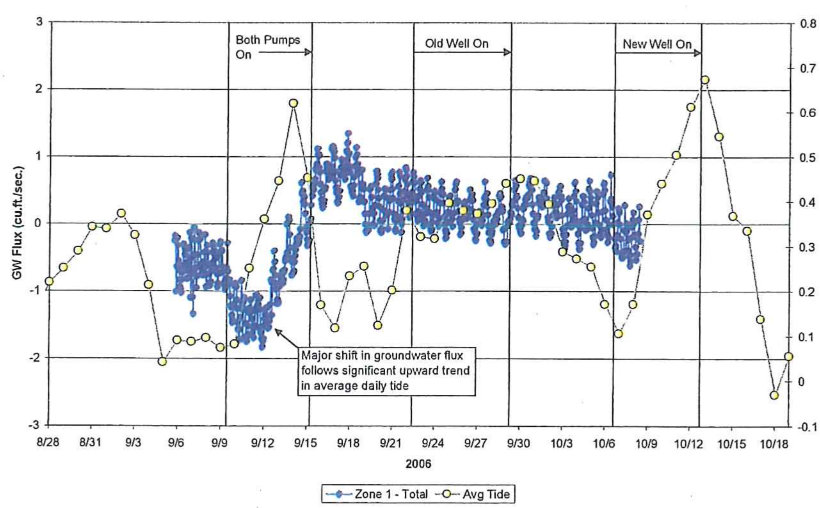
Zone 1 - Total Groundwater Flux to River



Zone 1 Groundwater Flux vs. River Flow at VT1



Zone 1 Groundwater Flux vs. Average Daily Tide



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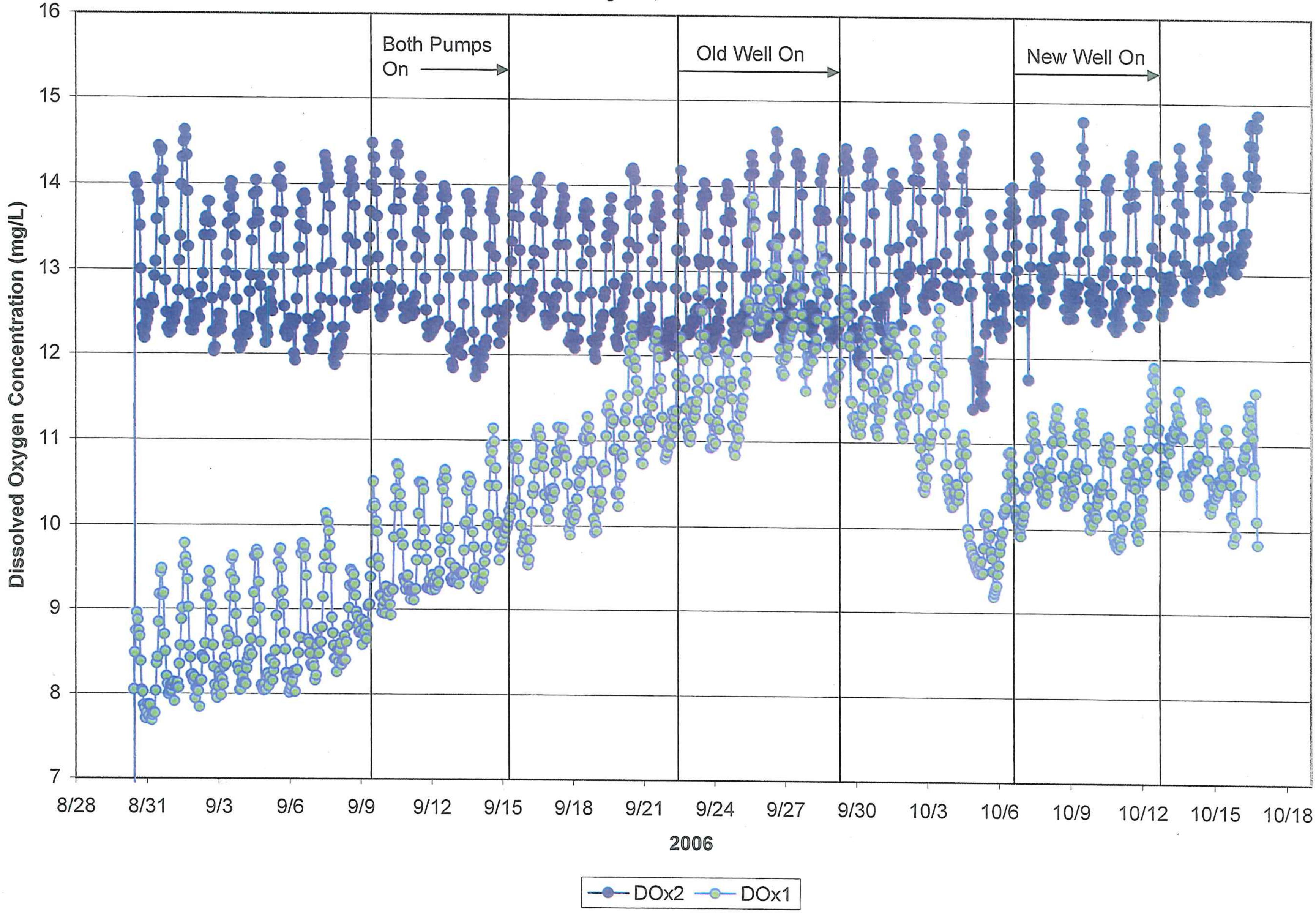
Figu... -28
DOx1 vs DOx2 - Hourly Dissolved Oxygen Comparison
El Sur Ranch
Big Sur, California



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Figu... -29

Comparison of Incoming Solar Radiation and DOx2 DO Concentrations

El Sur Ranch

Big Sur, California

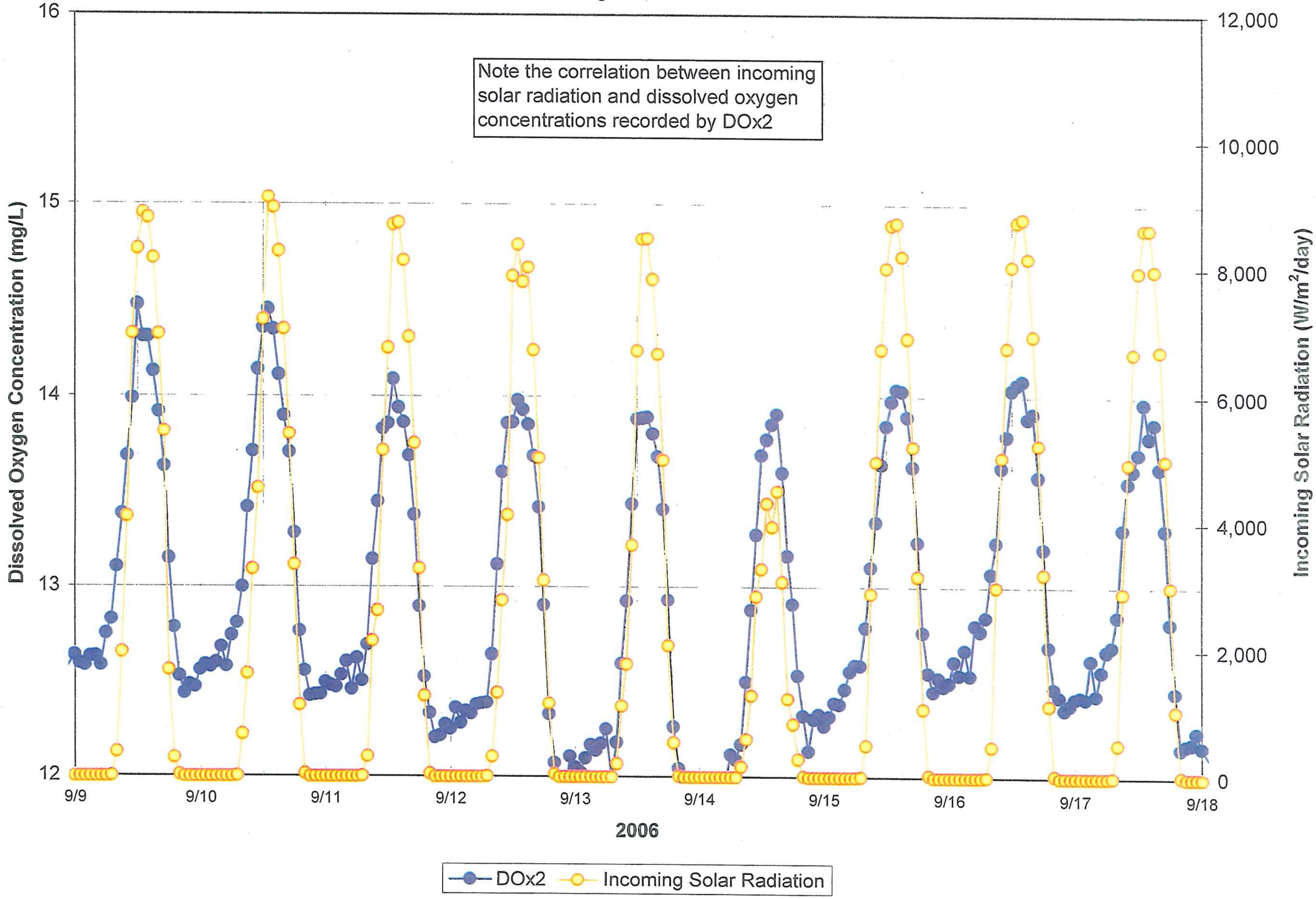

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Figure -30

DOx1 vs. DOx2 - Daily Average River Water Dissolved Oxygen Concentraion Comparison

El Sur Ranch

Big Sur, California

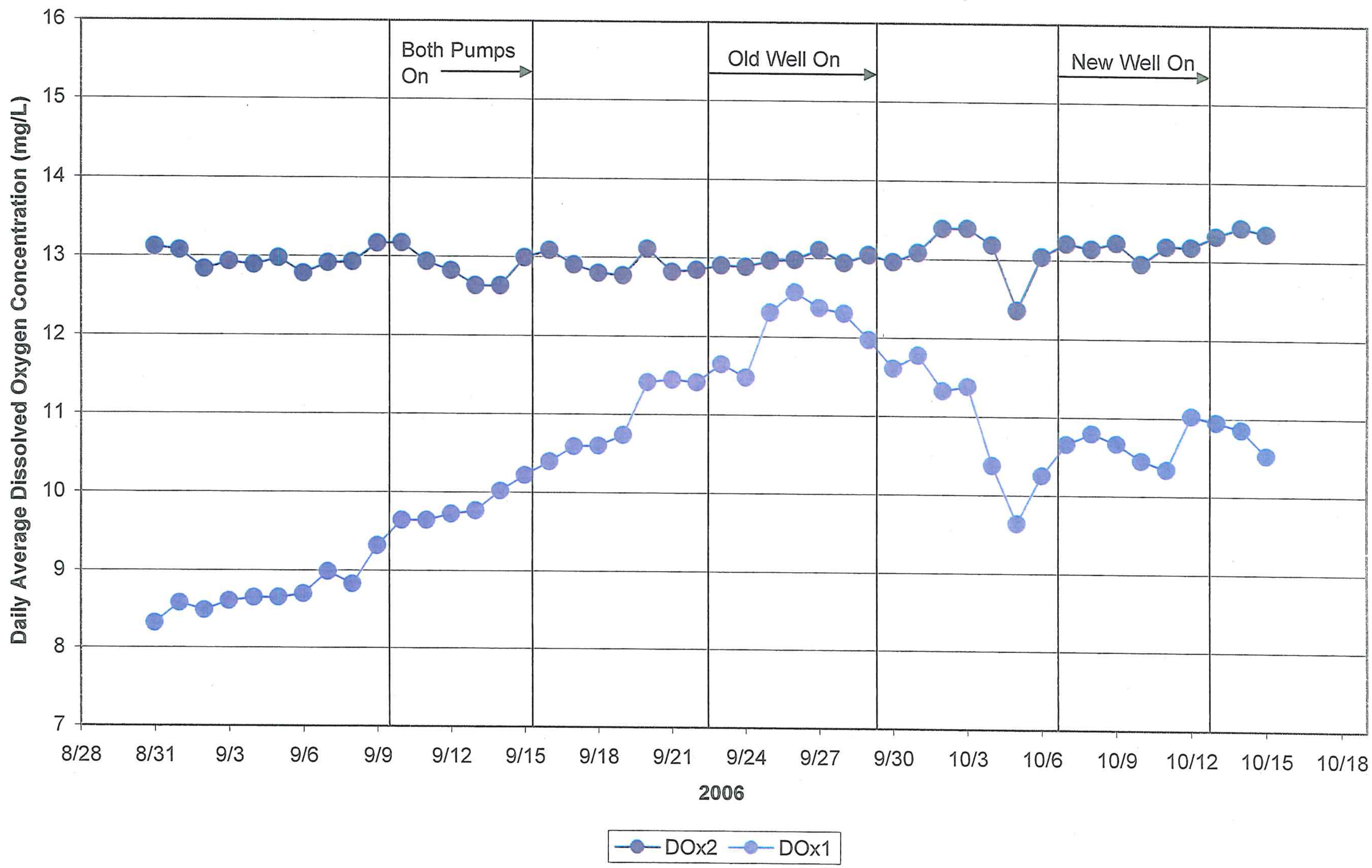

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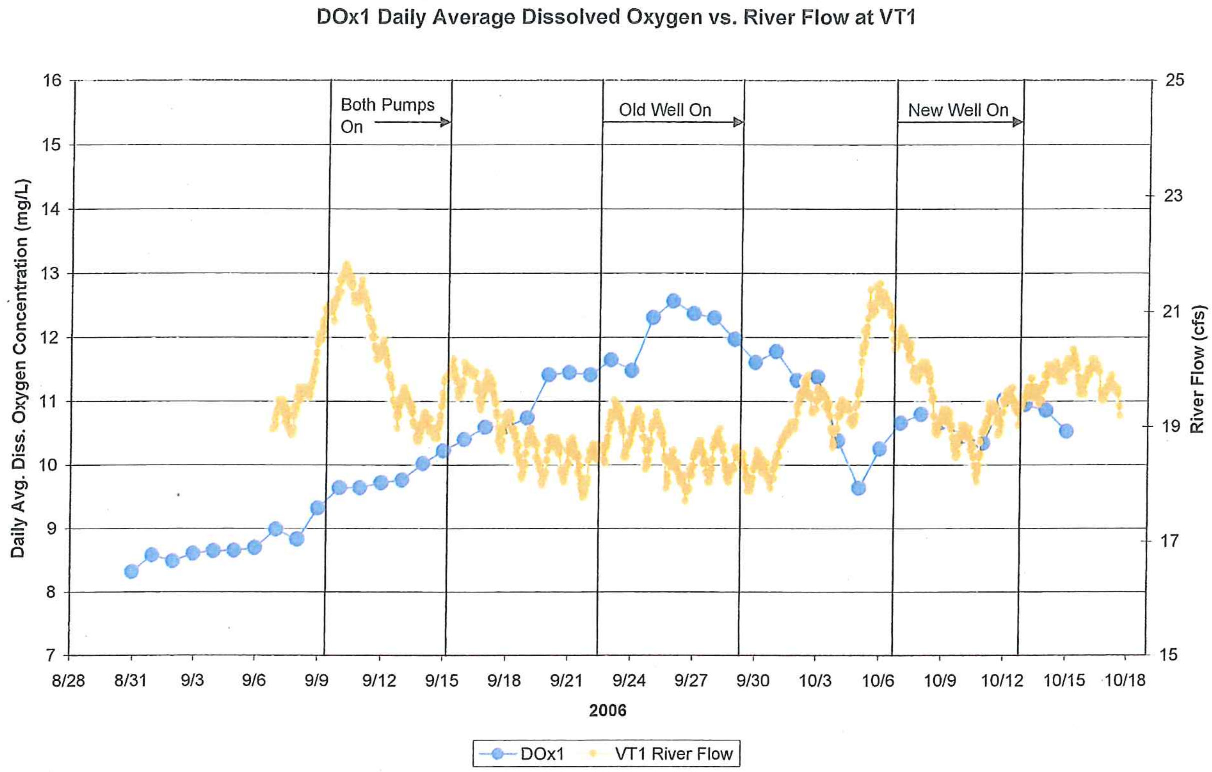
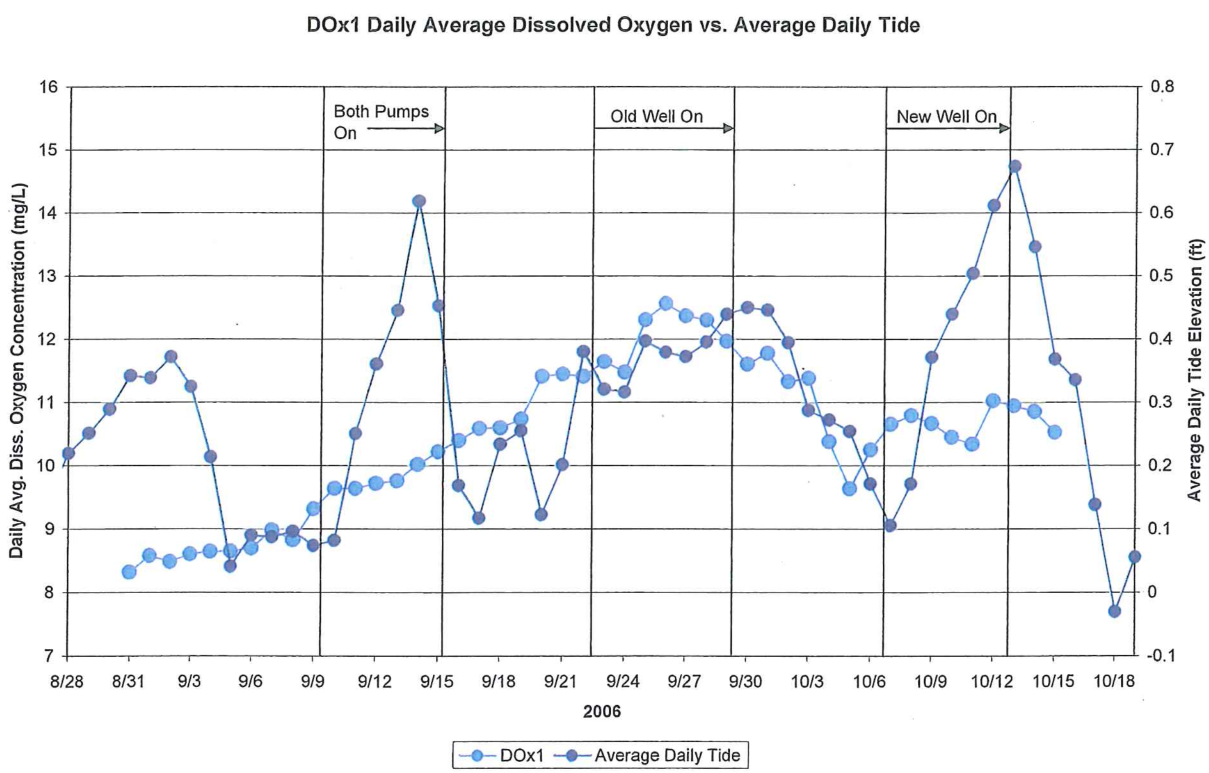
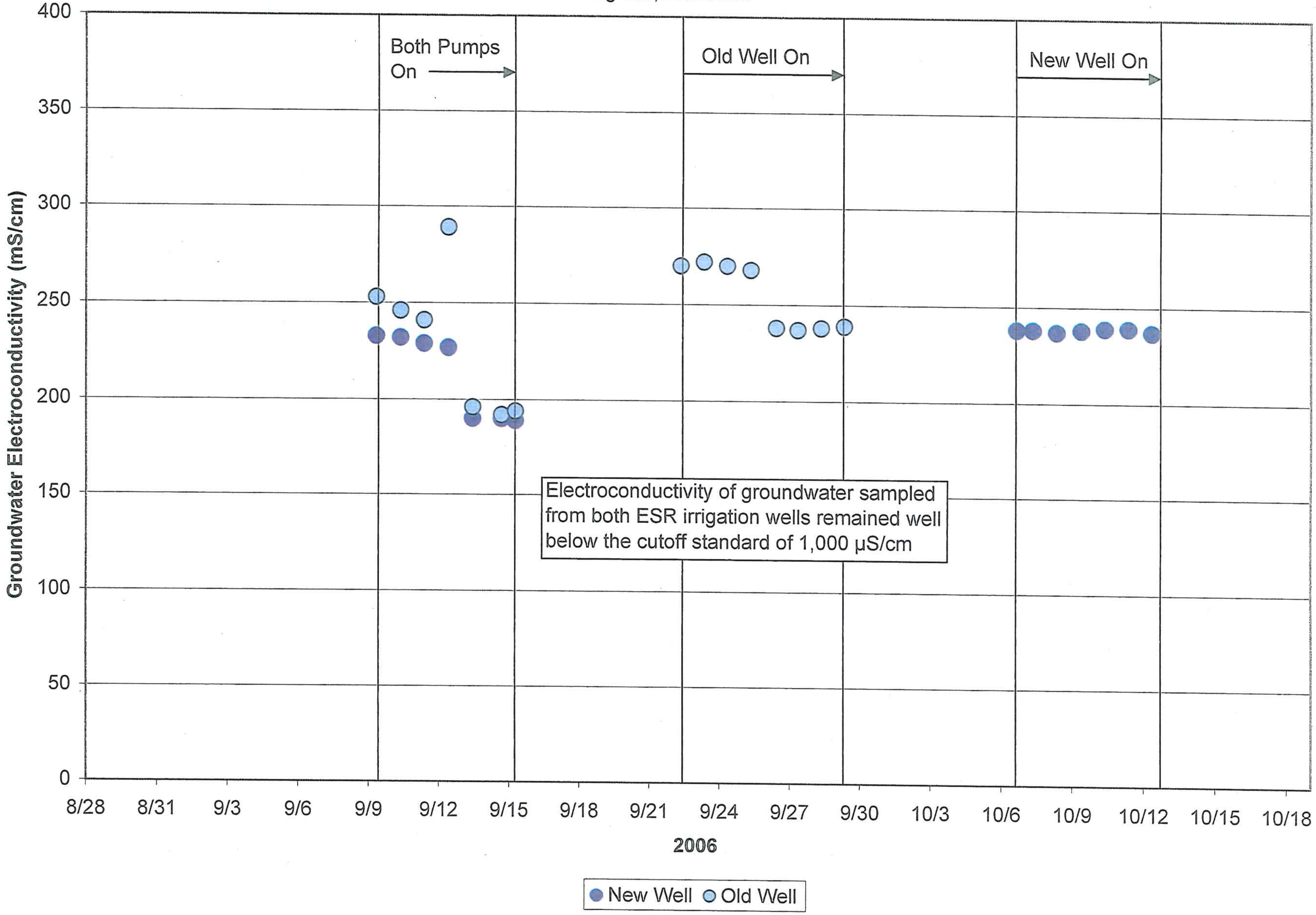
Figure 3-31
DOx1 Daily Average DO vs. VT1 River Flow and vs. Average Daily Tide
El Sur Ranch
Big Sur, California





Figur…-32
ESR Pumping Wells Effluent Water Electroconductivity
El Sur Ranch
Big Sur, California



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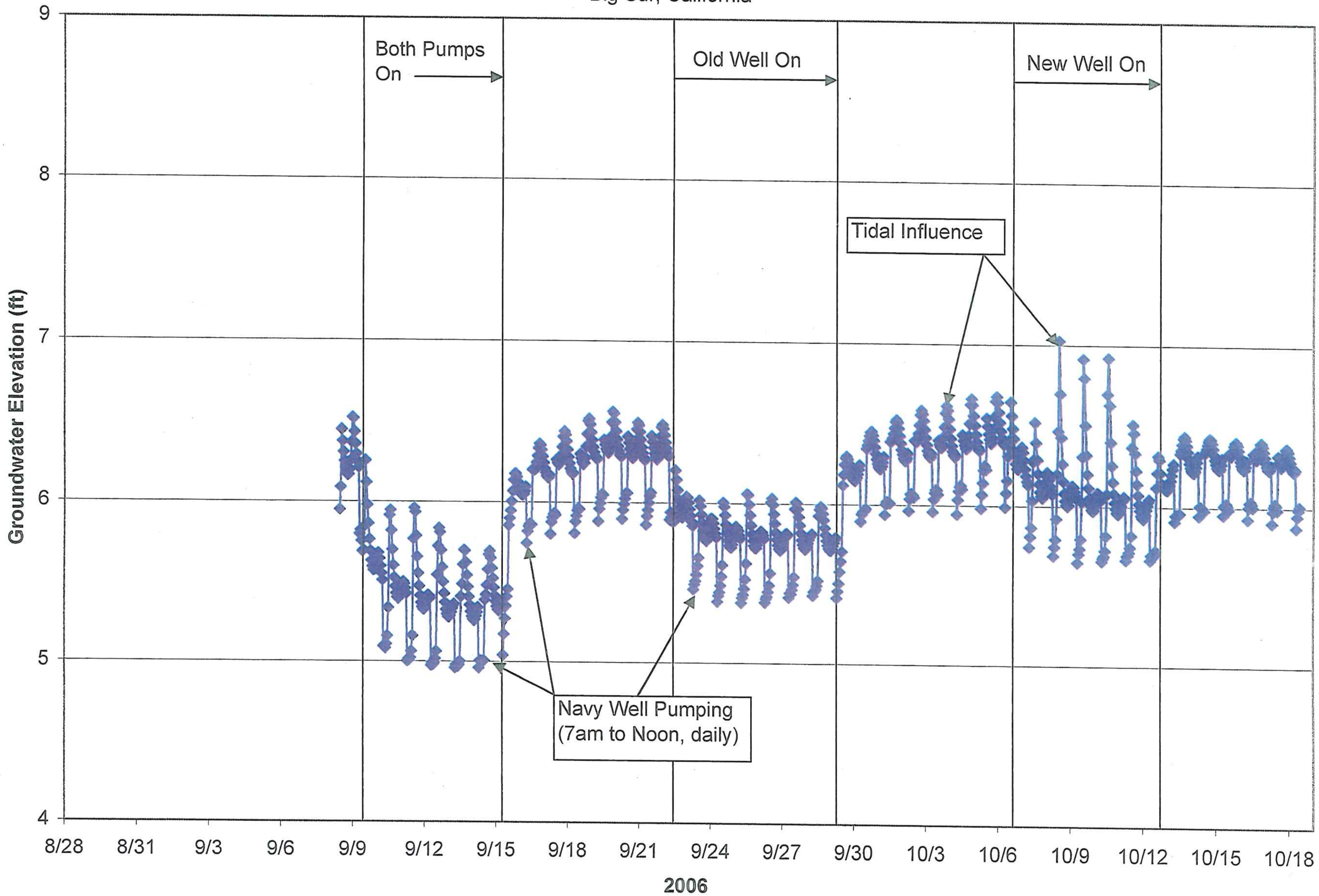
Figu[illegible]-33
Navy Well Groundwater Elevation
El Sur Ranch
Big Sur, California



THE SOURCE GROUP, INC.

Figure -34
Navy Well Electroconductivity
El Sur Ranch
Big Sur, California

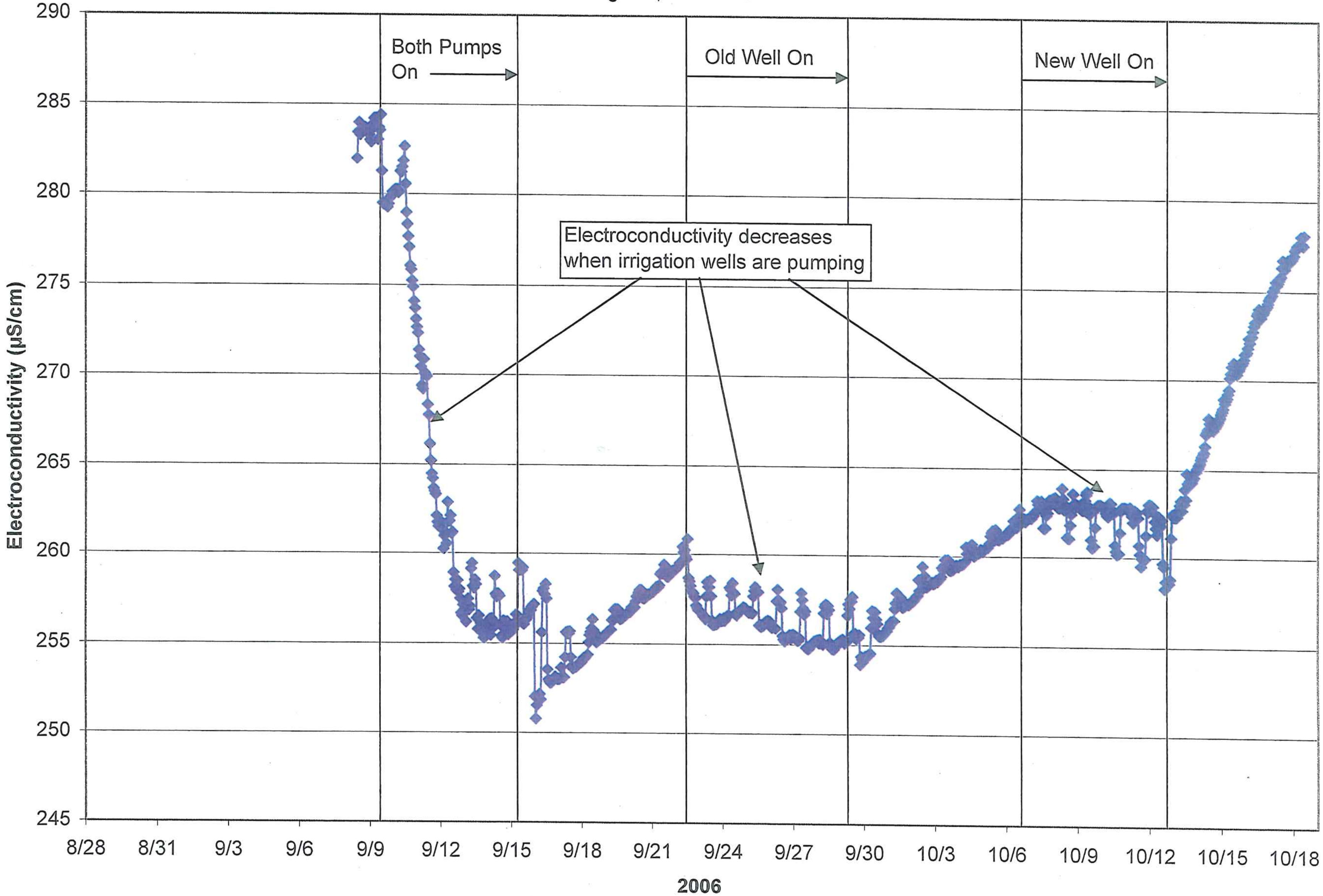


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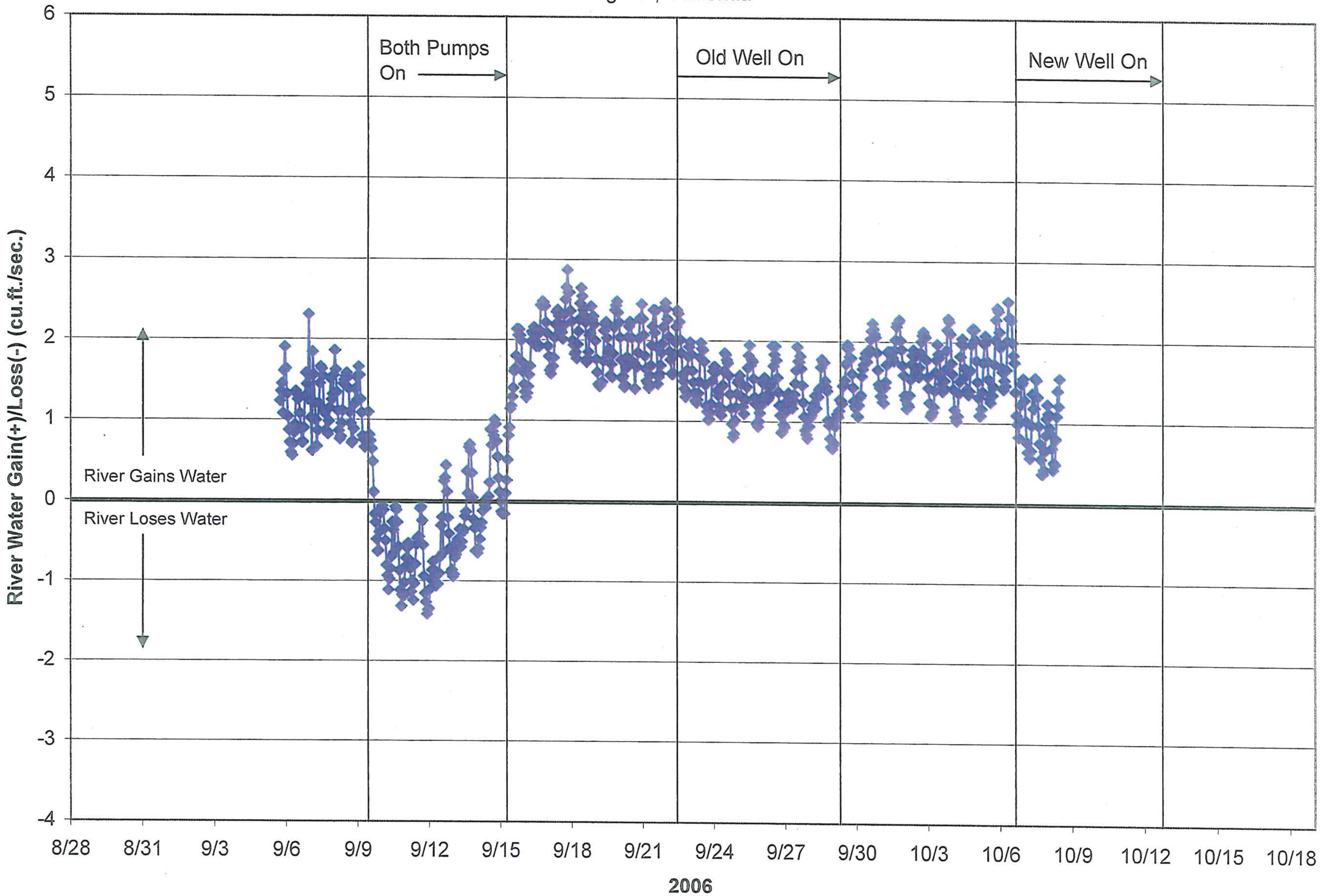
Figure [illegible]-35
Zone 1 thru 4 River Water Net Gain(+)/Loss(-)
El Sur Ranch
Big Sur, California



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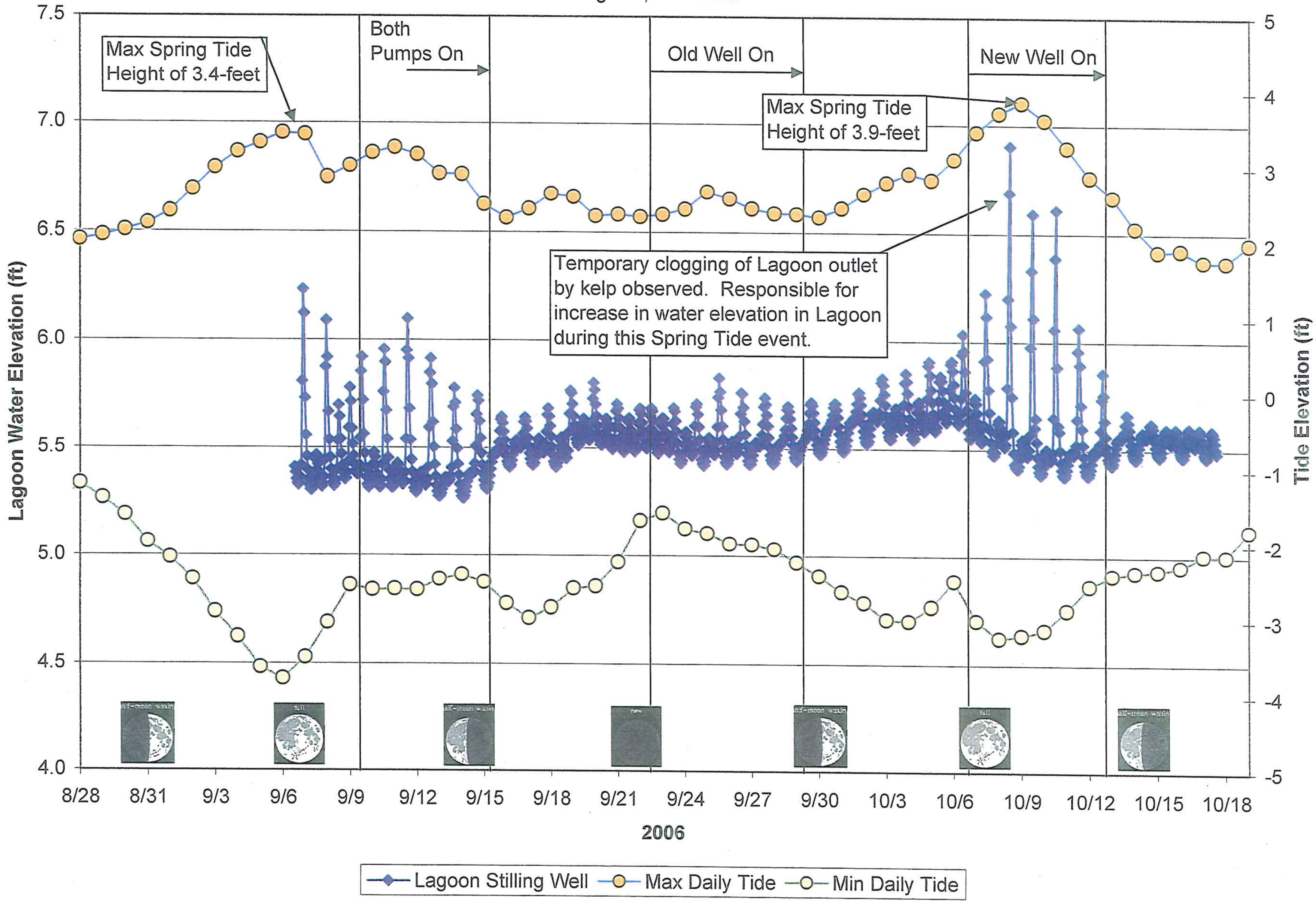
Figur[illegible]-36

Lagoon Stilling Well River Elevation vs. Min and Max Daily Tide Elevation

El Sur Ranch

Big Sur, California



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Figu... 37
Zone 2 thru 4 River Water Net Gain(+)/Loss(-)
El Sur Ranch
Big Sur, California

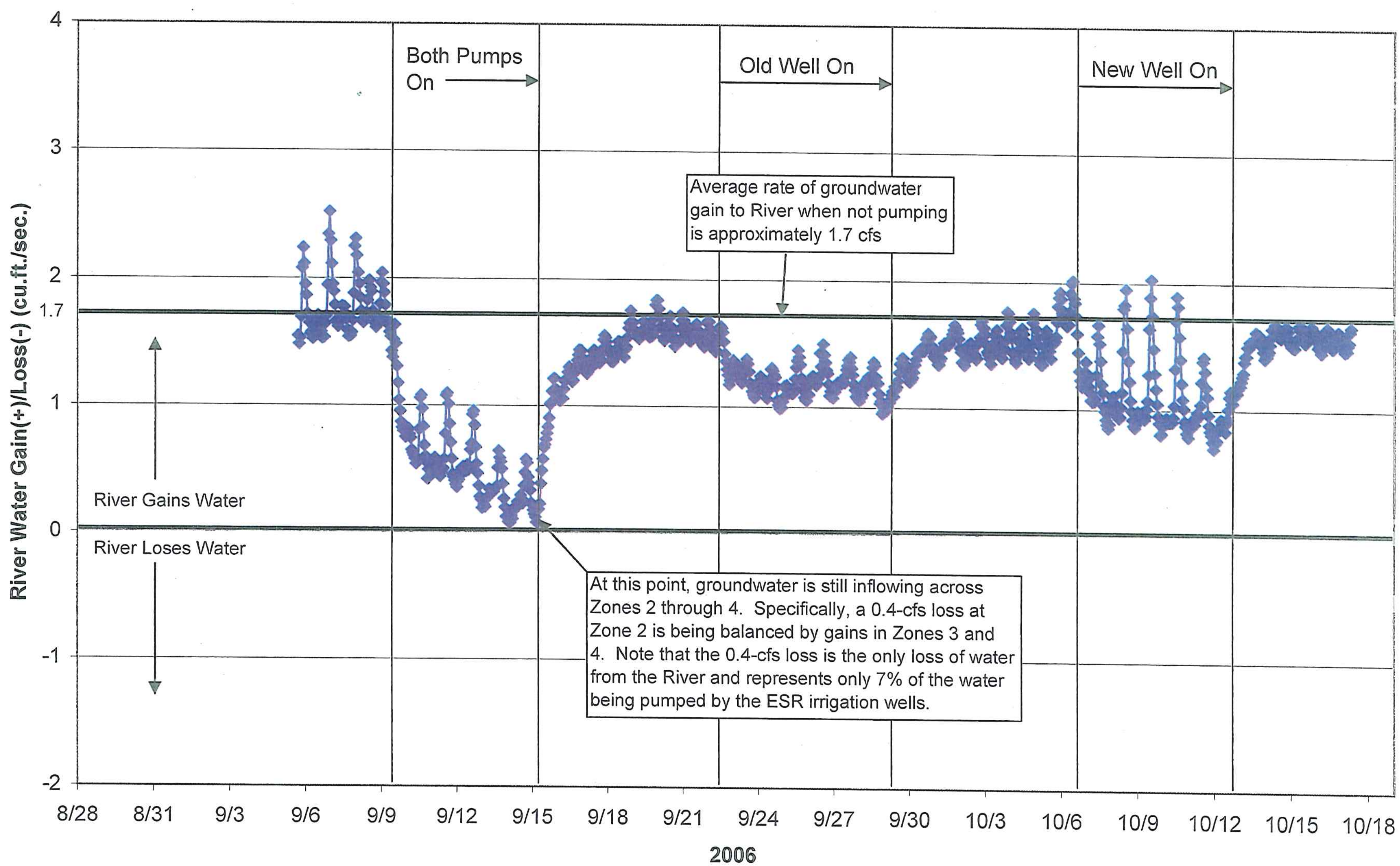

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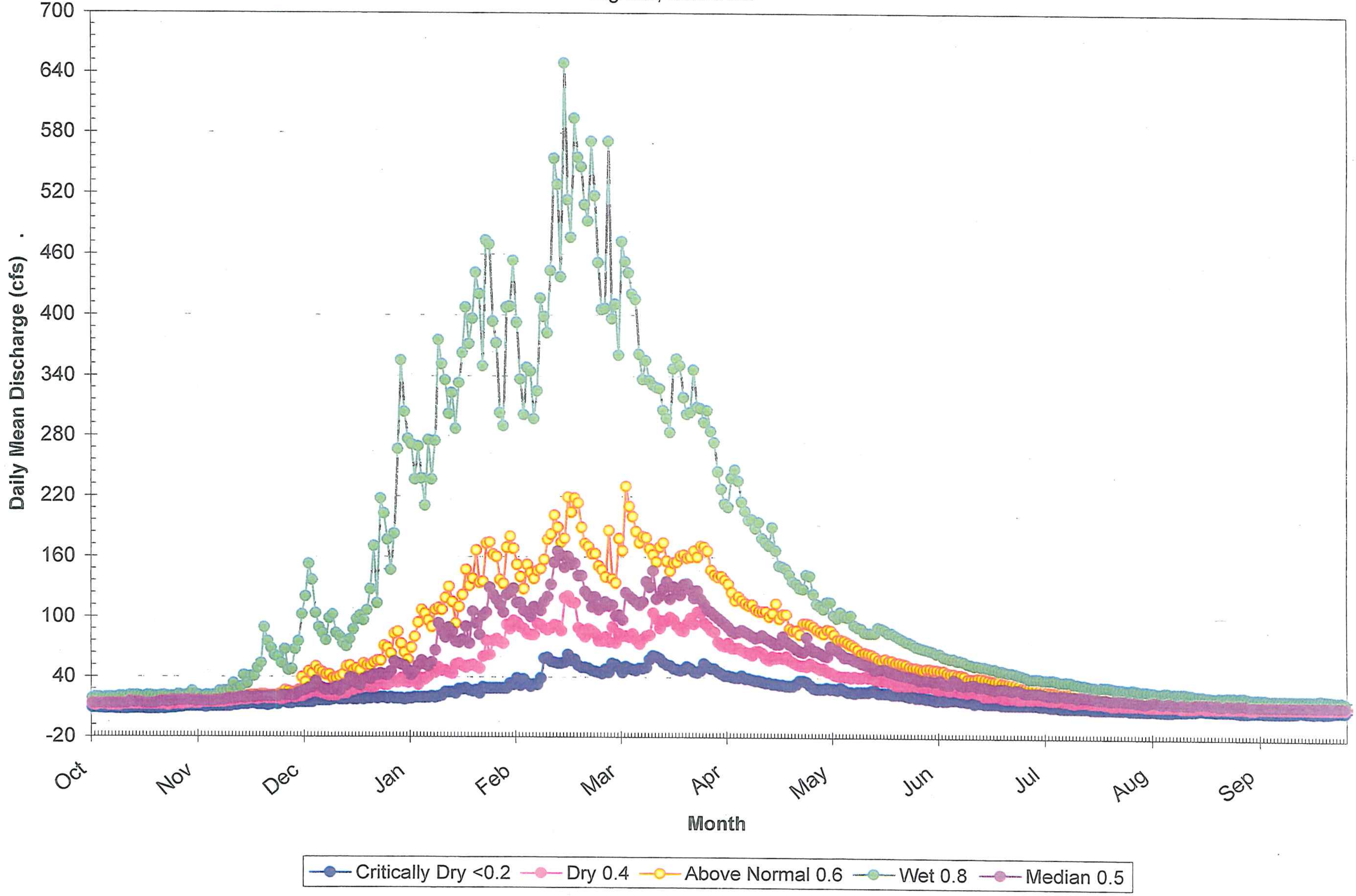
Figure 38
54 Year Non-Exceedance Flow Criteria - Data from USGS
Gauging Station #11143000, Big Sur River, near Big Sur, California
El Sur Ranch
Big Sur, California



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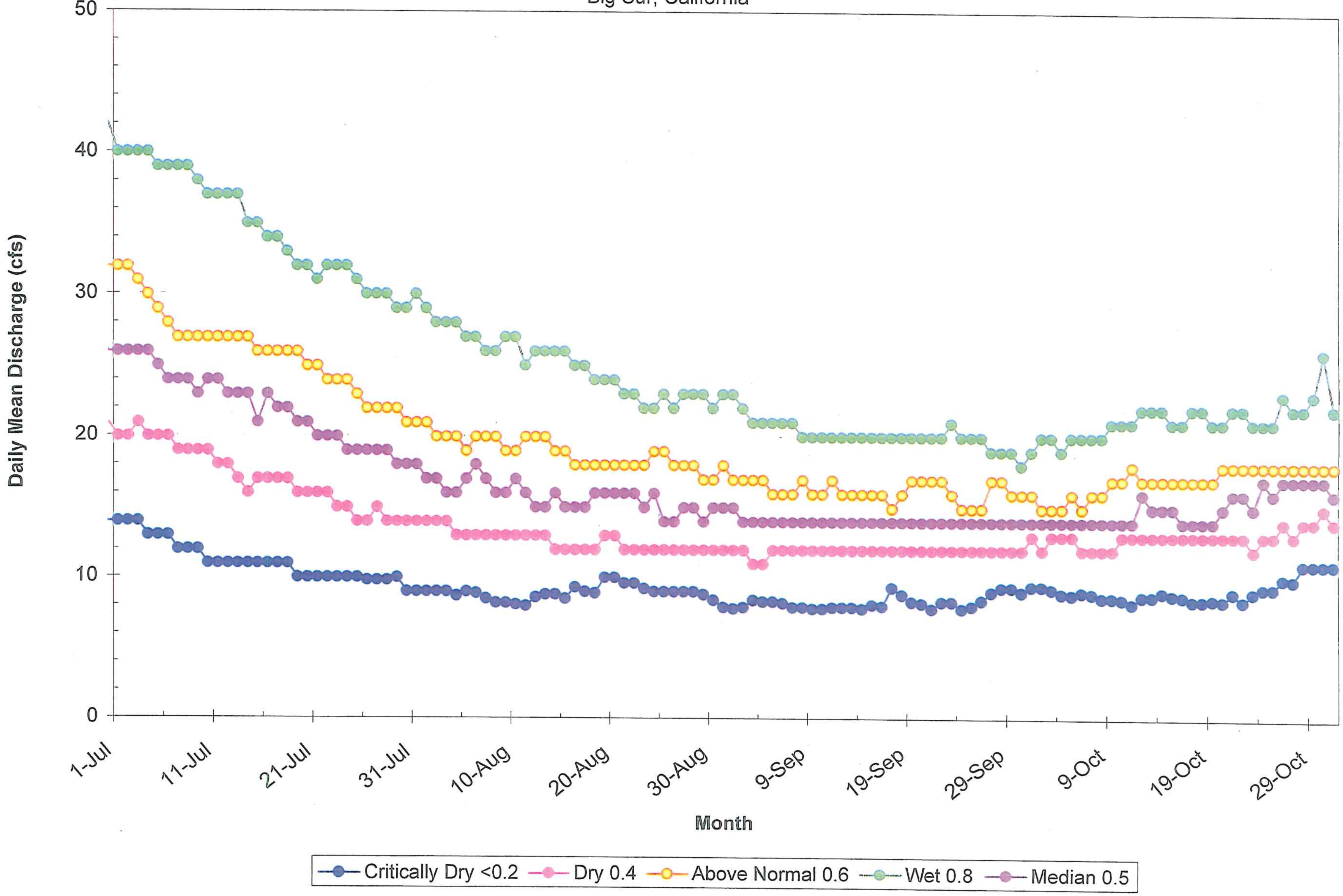
Figu. -39
54 Year Based Non-Exceedance (July-October) - Data from USGS Gauging Station #11143000, Big Sur River, near Big Sur, California
El Sur Ranch
Big Sur, California



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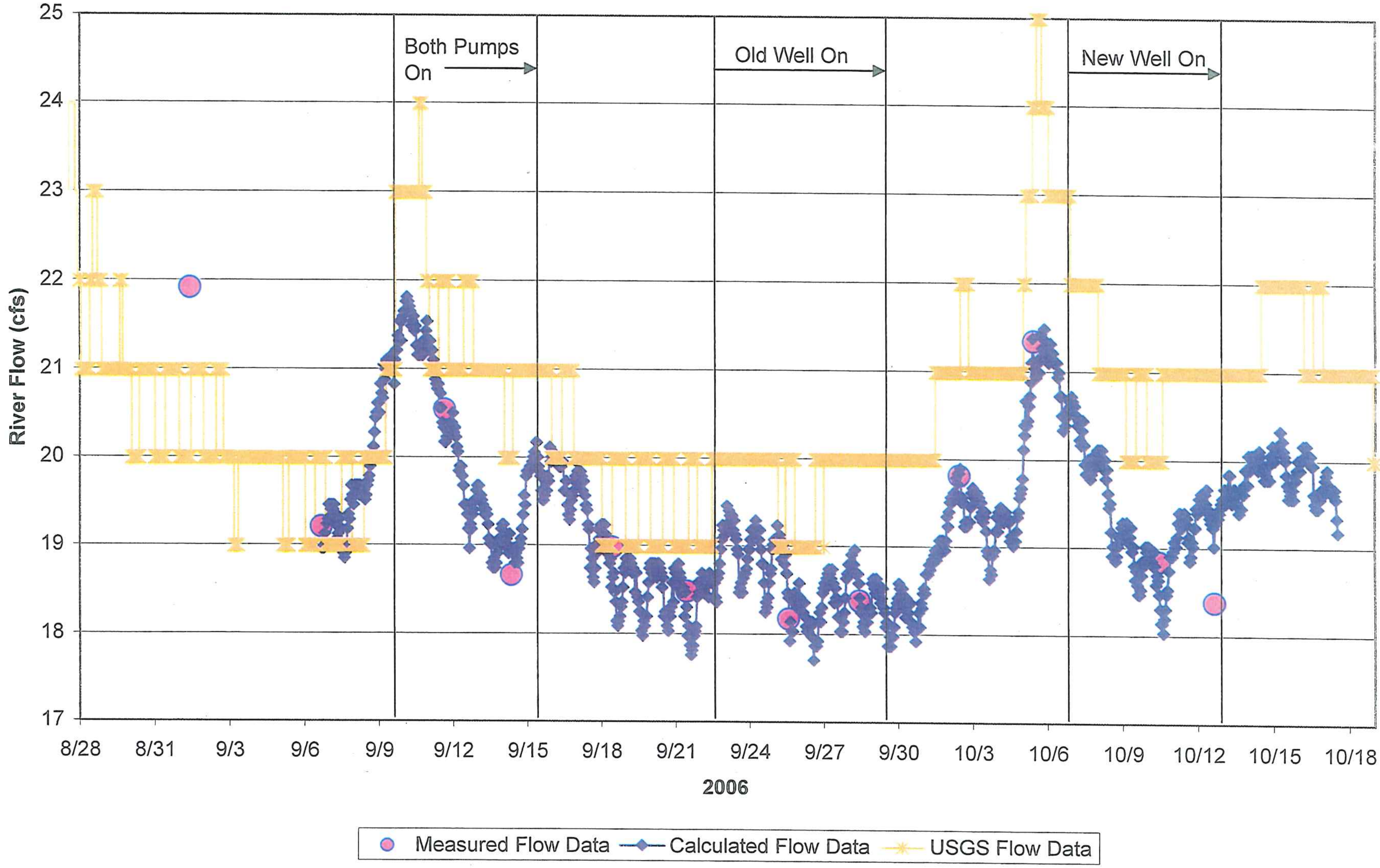
Figur[illegible]-40
Measured and Calculated River Flow at VT1 vs. USGS Big Sur River Gauge Flow
El Sur Ranch
Big Sur, California



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TABLES

TABLES

Table 3-1
Operation Status of ESR Pumping Wells During 2006 Study
El Sur Ranch
Big Sur, California

Date	Time*	New Well			Time	Old Well			New Well (cfs)	Old Well (cfs)	Total (cfs)
		Time On	Time Off	Pasture		Time On	Time Off	Pasture			
09/09/06	8:24 AM	8:24 AM		PH	8:24 AM	8:24 AM		#1	3.52	2.41	5.93
09/10/06	9:10 AM			PH	9:10 AM			#1	3.47	2.41	5.88
09/11/06	9:21 AM			PH	9:21 AM			#1	3.47	2.41	5.88
09/12/06	10:09 AM			PH	10:09 AM			#3	3.42	2.41	5.83
09/13/06	11:00 AM			PH	10:53 AM			#3 & #4	3.42	2.41	5.83
09/14/06	4:32 PM			PH	4:32 PM			#4	3.20	2.41	5.61
09/15/06	6:35 AM		6:35 AM	PH	6:35 AM		6:35 AM	#4			
09/16/06											
09/17/06											
09/18/06											
09/19/06											
09/20/06											
09/21/06											
09/22/06					8:39 AM	8:39 AM		#2		2.44	2.44
09/23/06					8:32 AM			#2		2.45	2.45
09/24/06					8:27 AM			#2		2.44	2.44
09/25/06					8:36 AM			#2		2.31	2.31
09/26/06					10:40 AM			#3		2.57	2.57
09/27/06					8:48 AM			#3		2.39	2.39
09/28/06					8:41 AM			#4		2.43	2.43
09/29/06					8:17 AM		8:10 AM	#4			
09/30/06											
10/01/06											
10/02/06											
10/03/06											
10/04/06											
10/05/06											
10/06/06	3:51 PM	3:51 PM		#8					3.03 **		3.03
10/07/06	8:28 AM			#8					3.03 **		3.03
10/08/06	8:25 AM			#8 & #7					2.96 **		2.96
10/09/06	9:18 AM			#8 & #7					2.96 **		2.96
10/10/06	8:54 AM			#7					2.88 **		2.88
10/11/06	8:45 AM			#7					2.88 **		2.88
10/12/06	8:31 AM		5:41 PM	PH					3.49 **		3.49

* Time that energy use meter readings were taken
** Data derived from February 2004 New Well pumping test data (Pumping Test Report, SGI, March 8, 2004)

Table 3-2
Permeameter Testing Results
El Sur Ranch
Big Sur, California

Location	Date	Test #	Run #	K (ft/day)	Location Notes
PT3	11/7/2006	1	1	139	mid channel in cobbles (located just upstream of Transect 3)
PT3	11/7/2006	1	1	135	mid channel in cobbles (located just upstream of Transect 3)
PT3	11/7/2006	1	1	135	mid channel in cobbles (located just upstream of Transect 3)
PT3	11/7/2006	1	2	131	mid channel in cobbles (located just upstream of Transect 3)
PT3	11/7/2006	1	2	133	mid channel in cobbles (located just upstream of Transect 3)
PT3	11/7/2006	1	2	143	mid channel in cobbles (located just upstream of Transect 3)
PT3	11/7/2006	1	2	149	mid channel in cobbles (located just upstream of Transect 3)
PT3	11/7/2006	1	3	133	mid channel in cobbles (located just upstream of Transect 3)
PT3	11/7/2006	1	3	133	mid channel in cobbles (located just upstream of Transect 3)
PT3	11/7/2006	1	3	135	mid channel in cobbles (located just upstream of Transect 3)
PT3	11/7/2006	1	3	172	mid channel in cobbles (located just upstream of Transect 3)
PT3	11/7/2006	1	4	122	mid channel in cobbles (located just upstream of Transect 3)
PT3	11/7/2006	1	4	126	mid channel in cobbles (located just upstream of Transect 3)
PT3	11/7/2006	1	4	124	mid channel in cobbles (located just upstream of Transect 3)
PT3	11/7/2006	1	4	135	mid channel in cobbles (located just upstream of Transect 3)
PT5	8/31/2006	5	1	84	right bank, shallow sandbar (midway between transect 5 and 6)
PT5	8/31/2006	5	1	71	right bank, shallow sandbar (midway between transect 5 and 6)
PT5	8/31/2006	5	1	68	right bank, shallow sandbar (midway between transect 5 and 6)
PT5	11/7/2006	3a	1	66	slightly left of mid channel in cobbles (located at piezometer pair 2)
PT5	11/7/2006	3a	1	63	slightly left of mid channel in cobbles (located at piezometer pair 2)
PT5	11/7/2006	3a	1	58	slightly left of mid channel in cobbles (located at piezometer pair 2)
PT5	11/7/2006	3a	1	56	slightly left of mid channel in cobbles (located at piezometer pair 2)
PT5	11/7/2006	3a	2	59	slightly left of mid channel in cobbles (located at piezometer pair 2)
PT5	11/7/2006	3a	2	55	slightly left of mid channel in cobbles (located at piezometer pair 2)
PT5	11/7/2006	3a	2	52	slightly left of mid channel in cobbles (located at piezometer pair 2)
PT5	11/7/2006	3a	2	51	slightly left of mid channel in cobbles (located at piezometer pair 2)
PT5	11/7/2006	3a	3	55	slightly left of mid channel in cobbles (located at piezometer pair 2)
PT5	11/7/2006	3a	3	54	slightly left of mid channel in cobbles (located at piezometer pair 2)
PT5	11/7/2006	3a	3	51	slightly left of mid channel in cobbles (located at piezometer pair 2)
PT5	11/7/2006	3a	3	51	slightly left of mid channel in cobbles (located at piezometer pair 2)
PT5	11/7/2006	3b	1	88	slightly right of mid channel in cobbles (located at piezometer pair 2)
PT5	11/7/2006	3b	1	79	slightly right of mid channel in cobbles (located at piezometer pair 2)
PT5	11/7/2006	3b	1	76	slightly right of mid channel in cobbles (located at piezometer pair 2)
PT5	11/7/2006	3b	2	77	slightly right of mid channel in cobbles (located at piezometer pair 2)
PT5	11/7/2006	3b	2	71	slightly right of mid channel in cobbles (located at piezometer pair 2)
PT5	11/7/2006	3b	2	65	slightly right of mid channel in cobbles (located at piezometer pair 2)
PT5	11/7/2006	3b	2	64	slightly right of mid channel in cobbles (located at piezometer pair 2)
PT7	10/3/2006	1	1	59	mid channel in cobbles (in cold pool, downstream of piezometer pair 3)
PT7	10/3/2006	1	1	53	mid channel in cobbles (in cold pool, downstream of piezometer pair 3)
PT7	10/3/2006	1	1	36	mid channel in cobbles (in cold pool, downstream of piezometer pair 3)
PT7	10/3/2006	1	2	58	mid channel in cobbles (in cold pool, downstream of piezometer pair 3)

Table 3-2
Permeameter Testing Results
El Sur Ranch
Big Sur, California

Location	Date	Test #	Run #	K (ft/day)	Location Notes
PT7	10/3/2006	1	2	53	mid channel in cobbles (in cold pool, downstream of piezometer pair 3)
PT7	10/3/2006	1	2	36	mid channel in cobbles (in cold pool, downstream of piezometer pair 3)
PT7	11/7/2006	4	1	140	left of mid channel in gravel with occation cobbles (located at piezometer pair 3)
PT7	11/7/2006	4	2	105	left of mid channel in gravel with occation cobbles (located at piezometer pair 3)
PT7	11/7/2006	4	2	104	left of mid channel in gravel with occation cobbles (located at piezometer pair 3)
PT7	11/7/2006	4	2	107	left of mid channel in gravel with occation cobbles (located at piezometer pair 3)
PT8	8/31/2006	2	1	311	center left channel in silt and leaves
PT8	8/31/2006	2	1	263	center left channel in silt and leaves
PT8	8/31/2006	2	1	231	center left channel in silt and leaves
PT8	8/31/2006	2	1	207	center left channel in silt and leaves
PT8	8/31/2006	3	1	169	center left channel in silt and leaves (six feet upstream from test B)
PT8	8/31/2006	3	1	168	center left channel in silt and leaves (six feet upstream from test B)
PT8	8/31/2006	3	1	189	center left channel in silt and leaves (six feet upstream from test B)
PT8	8/31/2006	3	1	150	center left channel in silt and leaves (six feet upstream from test B)
PT8	8/31/2006	3	2	195	center left channel in silt and leaves (six feet upstream from test B)
PT8	8/31/2006	3	2	176	center left channel in silt and leaves (six feet upstream from test B)
PT8	8/31/2006	3	2	176	center left channel in silt and leaves (six feet upstream from test B)
PT8	8/31/2006	3	2	186	center left channel in silt and leaves (six feet upstream from test B)
PT8	8/31/2006	4	1	184	center left channel in silt (midway between transect 8 and 9)
PT8	8/31/2006	4	1	168	center left channel in silt (midway between transect 8 and 9)
PT8	8/31/2006	4	1	151	center left channel in silt (midway between transect 8 and 9)
PT8	8/31/2006	4	1	146	center left channel in silt (midway between transect 8 and 9)
PT8	8/31/2006	4	2	109	center left channel in silt (midway between transect 8 and 9)
PT8	8/31/2006	4	2	121	center left channel in silt (midway between transect 8 and 9)
PT8	8/31/2006	4	2	128	center left channel in silt (midway between transect 8 and 9)
PT8	8/31/2006	4	2	141	center left channel in silt (midway between transect 8 and 9)
PT11	10/11/2006	2	1	113	mid channel in cobbles (located at piezometer pair 5)
PT11	10/11/2006	2	1	124	mid channel in cobbles (located at piezometer pair 5)
PT11	10/11/2006	2	1	126	mid channel in cobbles (located at piezometer pair 5)
PT11	10/11/2006	2	2	113	mid channel in cobbles (located at piezometer pair 5)
PT11	10/11/2006	2	2	118	mid channel in cobbles (located at piezometer pair 5)
PT11	10/11/2006	2	2	125	mid channel in cobbles (located at piezometer pair 5)
PT11	10/11/2006	2	3	115	mid channel in cobbles (located at piezometer pair 5)
PT11	10/11/2006	2	3	114	mid channel in cobbles (located at piezometer pair 5)
PT11	10/11/2006	2	3	116	mid channel in cobbles (located at piezometer pair 5)
PT11	10/11/2006	2	3	122	mid channel in cobbles (located at piezometer pair 5)
Geomean Value of Valid Test Data				**104**	

Table 3-3
Conductivity Measurements in Pumping Wells and Navy Well
El Sur Ranch
Big Sur, California

Date	Conductivity (µS/cm)		
	Navy Well	New Well	Old Well
9/9/06	282	233	253
9/10/06	279	232	246
9/11/06	267	229	241
9/12/06	260	227	289
9/13/06	257	190	196
9/14/06	256	190	192
9/15/06	257	189	194
9/16/06	254		
9/17/06	254		
9/18/06	255		
9/19/06	256		
9/20/06	258		
9/21/06	259		
9/22/06	259		270
9/23/06	257		272
9/24/06	257		270
9/25/06	257		268
9/26/06	256		238
9/27/06	256		237
9/28/06	256		238
9/29/06	256		239
9/30/06	256		
10/1/06	257		
10/2/06	258		
10/3/06	259		
10/4/06	260		
10/5/06	261		
10/6/06	262	238	
10/7/06	263	238	
10/8/06	263	237	
10/9/06	263	238	
10/10/06	262	239	
10/11/06	262	239	
10/12/06	261	237	
10/13/06	264		
10/14/06	267		
10/15/06	270		
10/16/06	273		
10/17/06	276		

Notes:
1. Conductivity in Navy Well is a daily average based on hourly data
2. Conductivity in Old Well/New Well from single daily measurement
3. µS/cm = micro-Siemans per centimeter

Table 3-4

Correlation Between Pumping Rate and Decrease in Groundwater Inflow to River,
Zone 1 Through Zone 4

El Sur Ranch
Big Sur, California

Wells Active	Total Pumping Rate (cfs)	Calculated Decrease in Groundwater Inflow (cfs)	Is There a Net Gain in River Flow?	Pumping to Groundwater Inflow Reduction Ratio (cfs per cfs)
Both	5.83	2.41	NO	0.41
New	2.91	1.62	YES	0.56
Old	2.43	0.74	YES	0.30
			AVERAGE:	0.42

ESR--5

Table 3-5

Correlation Between Pumping Rate and Decrease in Groundwater Inflow to River, Zone 2 Through Zone 4

El Sur Ranch

Big Sur, California

Wells Active	Total Pumping Rate (cfs)	Calculated Decrease in Groundwater Inflow (cfs)	Is There a Net Gain in River Flow?	Pumping to Groundwater Inflow Reduction Ratio (cfs per cfs)
Both	5.83	1.59	YES	0.27
New	2.91	0.88	YES	0.30
Old	2.43	0.44	YES	0.18
			AVERAGE:	0.25

ESR--5

Ta -6

Big Sur River Gauge Non-Exceedance Flow Criteria Values

El Sur Ranch

Big Sur, California

Average Monthly Non-Exceedance Flow Value (CFS)						Study Period Avg. Flows	
Year Type	**Critically Dry (<.20)**	**Dry (.20-.40)**	**Normal (.40-.60)**	**Above Normal (.60-.80)**	**Wet (>.80)**	**2004**	**2006**
Exceedance %	**80%**	**60%**	**40%**	**20%**	**0%**	**Dry**	**Wet**
April	37	64	81	110	184	50.4	751.2
May	26	40	54	67	92	33.7	158.2
June	14	22	28	34	45	23.4	72.6
July	11	17	22	26	35	14.6	40.5
August	9	13	16	19	25	12.3	26.9
September	8	12	14	16	20	12.2	20.6
October	9	14	15	17	21	13.7	20.5

Notes:

CFS = Cubic Feet Per Second

ESR--5

T -7

Surface Flow Water Balance

September Conditions-River Zone 2-4

El Sur Ranch

Big Sur, California

Flow Term (All Values in CFS)	**2006 (Wet)**	**2004 (Dry)**	**Critically Dry Year** Non-Exceedance <0.2 (<8 cfs)	**Critically Dry Year** Non-Exceedance <0.1 (<6.6 cfs)	**Critically Dry Year** Non-Exceedance <0.05 (<5.5 cfs)
Big Sur Gauge Flow (Avg. Monthly)	20.6	12.2	7.9	6.6	5.5
Net Loss - Big Sur Gauge to VT1 (note 1)	-1.5	-3.7	-3.7	-3.7	-3.7
Net Loss - VT1 Through Zone 5 (note 2)	-1.3	-1.3	-1.3	-1.3	-1.3
Flow of River Entering Zone 4	17.8	7.2	2.9	1.6	0.5
Net Accretion - Zones 2-4 (note 3)	1.7	1.7	1.7	1.7	1.7
Pumping Induced Reduction in Accretion (note 3) (0.30 cfs reduction in accretion for every 1 cfs pumped by ESR Irrigation Wells).	-0.9	-0.9	-0.8	-0.8	-0.8
Reduction Based on ESR Irrigation Well Pumping Rate (note 4)	(2.9)	(3.0)	(2.7)	(2.7)	(2.7)
Net River Flow in Zones 2-4	**18.7**	**8.0**	**3.8**	**2.5**	**1.4**

Notes:
1. Net loss of -3.73 based on data reported in HI-CSM-2004 for Dry Year, Net loss of -1.5 based on calculated loss during 2006, Wet Year
2. Net loss based on calculations of losses from zone 5 in section 3.6
3. Net reduction in gain based on calculations in section 3.6 and as shown on Figure 3-37
4. 2.7 cfs is avg. September pumping for period of record, 3.0 and 2.9 cfs are average for September in 2004 and 2006
5. CFS = Cubic Feet per Second

ESR--5

Table 3-8
Results of Mixing Model Calculations for Dissolved Oxygen and Temperature - River Zones 2-4
El Sur Ranch
Big Sur, California

DISSOLVED OXYGEN	River Condition at Zone 4		Groundwater In		Using Calibrated Mixing Rate of 35% (3)	100% Mixing of River and Groundwater (5)
Conditions	Flow Rate (1)	DO Concentration (2)	Inflow Rate (1)	DO Concentration (2)	Mixed Concentration (4)	Mixed Concentration
2006 water year, no pumping	17.8	12	1.7	4	10.3	11.3
2006 water year, average September pumping	17.8	12	0.8	4	11.1	11.7
NET CHANGE DUE TO PUMPING	--	--	-0.9	--	0.8	0.4
2004 water year, no pumping	7.2	12	1.7	4	8.8	10.5
2004 water year, average September pumping	7.2	12	0.8	4	10.1	11.2
NET CHANGE DUE TO PUMPING	--	--	-0.9	--	1.3	0.7
Dry Year (non-ex <20%), no pumping	2.9	12	1.7	4	7.0	9.0
Dry Year (non-ex <20%), average Sept. pumping	2.9	12	0.9	4	8.2	10.1
NET CHANGE DUE TO PUMPING	--	--	-0.8	--	1.3	1.1
Dry Year (non-ex <5%), no pumping	0.5	12	1.7	4	4.8	5.8
Dry Year (non-ex <5%), average Sept. pumping	0.5	12	0.9	4	5.3	6.8
NET CHANGE DUE TO PUMPING	--	--	-0.8	--	0.6	1.0

TEMPERATURE	River Condition at Zone 4		Groundwater In		Using Calibrated Mixing Rate of 35% (3)	100% Mixing of River and Groundwater (5)
Conditions	Flow Rate (1)	Temperature (6)	Inflow Rate (1)	Temperature (6)	Mixed Temperature (4)	Mixed Temperature
2006 water year, no pumping	17.8	15	1.7	13	14.6	14.8
2006 water year, average September pumping	17.8	15	0.8	13	14.8	14.9
NET CHANGE DUE TO PUMPING	--	--	-0.9	--	0.2	0.1
2004 water year, no pumping	7.2	17	1.7	13	15.4	16.2
2004 water year, average September pumping	7.2	17	0.8	13	16.0	16.6
NET CHANGE DUE TO PUMPING	--	--	-0.9	--	0.6	0.4
Dry Year (non-ex <20%), no pumping	2.9	20	1.7	13	15.6	17.4
Dry Year (non-ex <20%), average Sept. pumping	2.9	20	0.9	13	16.7	18.3
NET CHANGE DUE TO PUMPING	--	--	-0.8	--	1.1	0.9
Dry Year (non-ex <5%), no pumping	0.5	20	1.7	13	13.7	14.6
Dry Year (non-ex <5%), average Sept. pumping	0.5	20	0.9	13	14.1	15.5
NET CHANGE DUE TO PUMPING	--	--	-0.8	--	0.5	0.9

Notes:
Flow Rate in cubic feet per second
DO Concentrations in milligrams per liter
Temperature in degrees Celcius
(1) Data from Table 3-7
(2) DO information from 2006 Study and 2004 Study where appropriate. Data related to Dry Year conditions estimated
(3) Calibrated using manually collected DO data during the 2006 Study. Empirically observed that incoming groundwater only effects DO on right bank of River, not center or left bank, hence complete mixing of River and groundwater does not occur. It is assumed that temperature mixes approximately as DO mixes.
(4) Mix flow is 35% of River flow + 100% of groundwater inflow. Unmixed flow is the remaining 65% of the River flow that did not mix with the incoming groundwater. Mixed DO and temp result from the mix of 35% of River flow + 100% of groundwater inflow
(5) Condition of 100% mixing not observed during 2006 Study or 2004 Study. Reduced flows during Dry Year conditions may lead to higher rates of mixing.
(6) Average daily temperature information from 2006 Study and 2004 Study where appropriate. Data related to Dry Year conditions assumes worse case scenario (no available data suggests that the average temp. in the River during Dry Years would be as high as 20 degrees C).

APPENDIX A

APPENDIX A

PERMITS

State of California - The Resources Agency
DEPARTMENT OF PARKS AND RECREATION

APPLICATION AND PERMIT TO CONDUCT BIOLOGICAL, GEOLOGICAL, OR SOIL INVESTIGATIONS/COLLECTIONS

☐ NEW
☑ RENEWAL

FOR DEPARTMENT USE ONLY	
APPLICATION NO.	DATE RECEIVED
DISTRICT	CEQA
PERMIT TYPE ☐ Biological ☐ Geological ☐ Soil	

APPLICATION

Instructions: *Applications must be TYPEWRITTEN with original signatures. Precise location of proposed work must be shown on attached USGS topographic map and other maps. Application should be sent to the District Office that administers the park unit where the collection/investigation will take place, or to the Resource Management Division for multi-District requests.*

APPLICANT ORGANIZATION
EL SUR RANCH - JAMES J. HILL, III

TELEPHONE NO.
(831) 624-2719

STREET ADDRESS/CITY/STATE/ZIP CODE
P.O. Box 1588, Monterey, California 93942-1588

NAME, TITLE, ADDRESS, TELEPHONE NO., AND AFFILIATION OF PRINCIPAL INVESTIGATOR *(Attach resume or curriculum vitae.)*
Paul Horton, R.G., C. HG., Principal Hydrogeologist
3451-C Vincent Road, Pleasant Hill, CA 94523
(925) 944-2856 ext. 302

NAME, ADDRESS, TELEPHONE NO., AND AFFILIATION OF PERSON IN ACTUAL DIRECT CHARGE OF FIELD WORK *(Attach resume and curriculum vitae if different from investigator.)*
Same as Investigator

COLLECTING ASSISTANT NAME(S)	STREET ADDRESS/CITY/STATE/ZIP CODE	TELEPHONE NO.
Charles Hanson/Justin Taplin	132 Cottage Creek, Walnut Creek, CA 94595	(925) 937-4606
Jon Phillip	3451-C Vincent Road, Pleasant Hill, CA 94523	(925) 944-2856/31

The above applicant hereby applies to the Department of Parks and Recreation for a permit under Title XIV, California Code of Regulations, Section 4309, and Public Resources Code Section 5097.5, to conduct investigations on lands of the State of California as follows:

STATE PARK UNIT(S)
Andrew Molera State Park

COUNTY(IES)
Monterey

TYPE OF HABITAT, GEOLOGICAL FORMATION NAME, OR SOIL TYPE
Riparian - Alluvium - Sand and Gravel

USGS QUADRANGLE(S)
Big Sur, California

LEGAL DESCRIPTION *(Township, Range, and Section of each distinct location.)*
T19S, R1E Latitude 36 17.056 Longitude 12 51.290

1. AIM AND PURPOSE OF COLLECTION ACTIVITY, AND METHODS OF THIS INVESTIGATION *(For excavations, provide a research design and an outline of the report. Attach continuation sheets as necessary.)*
See attached Monitoring Plan, Water Rights Application No. 30166

2. METHOD OF COLLECTION
See attached Monitoring Plan, Water Rights Application No. 30166

3. TYPES OF SPECIMENS *(Species, quantity, size, condition.)*
See attached Monitoring Plan, Water Rights Application No. 30166

4. EXPECTED DURATION OF THE PROJECT *(Specify dates of field investigations, laboratory study, and report completion.)*
See attached Monitoring Plan, Water Rights Application No. 30166

5. GENERAL SCOPE AND NATURE OF APPLICANT ORGANIZATION'S ACTIVITIES AND GOALS
See attached Monitoring Plan, Waters Application No. 30166

6. PLACE AT WHICH LABORATORY WORK WILL BE PERFORMED *(Institution, address, telephone numbers, contact person.)*
Not applicable - no laboratory work

NAME AND LOCATION OF FACILITY THAT HAS AGREED TO CURATE MATERIALS COLLECTED UNDER THIS PERMIT.
. Sur Ranch

PERMIT

STANDARD CONDITIONS AND RESTRICTIONS

It is the intention of the Department of Parks and Recreation to further scientific research within the areas administered by it, and to cooperate with authorized workers to the fullest extent compatible with its charge to preserve all species of flora and fauna and all soil and geologic material in a natural state insofar as is possible.

1. General classroom collection is not allowed under this or any other permit.
2. This permit applies only to non-cultural materials, and is limited to the kind, number, and sizes of specimens described on the front of this form. Archeological material may NOT be collected under this permit.
3. The collections shall be used for scientific or interpretive purposes only, shall be dedicated to the public benefit, and shall not be used for commercial purposes.
4. The collecting must be done away from roads, trails, and developed areas unless such localities are specified in the permit. This collecting shall be done in an inconspicuous manner, and shall not cause damage to the environment. Because of the scarcity or importance of some specimens, the Department of Parks and Recreation may designate other restrictions necessary for the preservation of the area.
5. The permittee shall submit a summary of information gathered to the applicable District where the investigations took place, and to the Chief, Resource Management Division, Department of Parks and Recreation in Sacramento. The Department further requires that the collector make available to the Department any material published as a result of this permit.
6. The collector is to contact the appropriate District Superintendent before collecting, and to present a copy of this permit together with evidences of additional collecting licenses and collecting permits, if required.
7. If collections are not made to the satisfaction of the Department, this permit may be immediately cancelled.
8. All applicable laws and regulations must be observed by the permittee in exercising the privileges granted in this permit.
9. Questions regarding this permit may be directed to the District Superintendent.

I have read the Standard Conditions and Restrictions above.

APPLICANT'S SIGNATURE	APPLICANT'S NAME *(Print or type.)*	DATE
▶ [signature]	Mark Blum on behalf of El Sur Ranch	9-8-06

REVIEWER	SIGNATURE	DATE
District Resource Ecologist	▶ [signature]	9/15/06
District Superintendent	▶ [signature]	9/15/06

APPROVAL SIGNATURE*	TITLE	DATE
▶ [signature]	SPS II	9/15/06

APPLICANT MUST CARRY THIS PERMIT AT ALL TIMES WHILE COLLECTING.

PERMIT VALID FROM 09-01-06 **TO** 12-31-07

PERMIT CONDITIONS:

NOTE: The District Superintendent has the permit authority if one District is involved; the Supervisor, Natural Heritage Section, if more than one District is involved.

DPR 65 (Back)

Copies to: Resource Management Division and District
(Distribute both approved and denied permits.)

DRAFT 2.0

THE SOURCE GROUP, INC.

Technical Memorandum

To: Janet Goldsmith, Mark Blum, Darlene Ruiz, Chuck Hanson

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

Date: 8-17-06

Re: **EL Sur Ranch – Hydrogeologic Workplan Elements for Proposed 2006 Data Collection Program**

Based on the meeting with Kit Custis and Linda Hanson from DFG on August 9th, and our meeting with Linda Hanson, Stacy Lee and Eric Larson on August 16th, I have developed the following specific work scope steps for implementation throughout the month of September, 2006.

Goal of Hydrogeologic Elements of the Monitoring Plan.

The primary goal of the hydrogeological portion of the proposed 2006 study is to specifically develop a correlation between the calculated loss of surface water through the bed of the River in response to pumping at typical and maximum pumping rates. This correlation is to be tied to the total stream-flow entering the study area. The correlation developed may then be used to set permit terms based on flows gauged as they enter the study area at the transect 1 location (just down river of Andrew Molera parking lot). The ability of the pumping to create drawdown impacts in Creamery meadow and up river will also be evaluated through the data collected as part of this study to address the potential for riparian zone impacts there. Thirdly, an attempt to monitor the movement of the saline wedge inland via tracking concentrations in the Navy Well will be conducted to further address questions concerning potential saline wedge mixing effects in the lagoon and riparian zones.

Proposed Hydrogeologic Work Scope:

1 Install a series of 9 piezometer well nests within the River to measure vertical gradient between river bed and underflow (See attached map for locations). Each well nest will be composed of two piezometers with screens set at 0.5 and 3 feet below streambed surface. These piezometers will be constructed of 1.75 inch steel screen and pipe with 6 inches of open screen at the base. The piezometers will be installed by hand and will be driven in place to completion depth. Each of these piezometers will be fitted with data transducers that record water level and water temperature. Readings will be logged and recorded at one hour intervals for the duration of testing. At a minimum, each of the piezometer well nests will be surveyed for relative elevation to allow calculation of head drop between piezometers.

2 Co-incident with the installation of the piezometer well nests, field measurements of streambed hydraulic conductivity will be taken in the vicinity of each piezometer nest. Measurements will be taken by conducting falling-head tests using a field permeameter. The field permeameter consists of a 12 inch diameter smooth walled schedule 80 PVC pipe with beveled ends, approximately 4 feet in height. The pipe will be driven into the streambed by hand to a consistent measurement depth of 0.25 meters +/- .05 meters. Falling head tests will be conducted via the introduction of water to a pre-determined height followed by the monitoring of the drop in water level as the column exits the pipe through the stream-bed. Water level drop will be monitored using a pressure transducer set in the permeameter during testing. Data collected will be analyzed using Darcy and

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Horslev .solutions to the falling head permeameter tests. (Test design basis is "Comparison of Instream Methods for measuring Hydraulic Conductivity in Sandy Streambeds", Matthew K. Landon, David L. Rus and F. Edwin Harvey, Vol. 39, No. 6, GROUND WATER, November-December 2001, pages 870-885).

3 Identical to the 2004 study, a stream-flow gauging station will be re-established near the location of Transect 1 from the 2004 study. The Stream flow station will include a stilling well and a water level transducer set to record level and temperature at one hour intervals for the duration of the study. Intent will be to establish this station at a location that is suitable for the potential installation of a permanent monitoring station. The final location is expected to be at or near the original Transect 1 location, but will be refined based on field inspection of current conditions at the River. Stream flow gauging will be conducted twice weekly during the study period.

4 Water level monitoring will be conducted in the groundwater surrounding the pumping wells via installation of pressure transducers in existing wells. These transducers will record water level and temperature at one hour intervals for the duration of testing. Wells to be fitted include JSA-3, JSA-4, ESR-10A,B and C, ESR 1, ESR2, ESR3, and the Defunct Old Well (if possible).

5 Installation of a conductivity meter and/or scheduling of conductivity readings from the Navy Well in addition to daily temperature and conductivity readings from the Old and New Wells.

Study Implementation Schedule

Monitoring of the stations and transducers installed as above will be continuous during the duration of the proposed pumping cycles of the study period for the month of September. The pumping schedule is based on a complete week for each pumping scenario. Data collected in the 2004 study indicates that recovery times of the groundwater system to pumping are on the order of one to two days. A 7-day period is selected for each step to ensure that data collected for each pumping scenario is representative of a stabilized hydraulic condition in response to the pumping condition. Currently those include one week of pumping only the Old Well at maximum capacity followed by one week of No Pumping followed by one week of Pumping both Old and New Wells at maximum capacity followed by an additional week of no pumping for a total of 4 weeks of continuous monitoring. Measurements of streambed width and depth profile will be also taken twice per week at the location of each piezometer well nest. Stream flow measurements will also be collected twice weekly from the Transect 1 station. Each of these measurements will be conducted at approximately the same time of day each time they are taken. Field measurements of conductivity, temperature and dissolved oxygen will be measured daily from the Old Well, New Well and Navy Well. During the study period, all transducers collecting data will be downloaded weekly to ensure that major data loss does not occur. This data will be immediately backed up to a second laptop that is then backed up on disc and servers back at the SGI office. The following table details the proposed study schedule:

Week of	Monday	Tuesday	Wednesday	Thursday	Friday	Sat.	Sunday
August 20				Inspect River Conditions – begin equipment installation.	Install Monitoring Equipment	Install Monit oring Equip ment	
August 27	Install Monitoring	Install Monitoring	Install Monitoring	Install Monitoring	**Begin Pumping Old Well at**		

	Equipment	Equipment	Equipment	Equipment	**End of Day**		
September 3rd	Take Field Measurements on Streambed and Flow			Take Field Measurements of Streambed and Flow	Download all transducers. **Turn off pump at end day.**		
September 10	Take Field Measurements on Streambed and Flow			Take Field Measurements on Streambed and Flow	Download all transducers. **Turn on Old Well and New Well at Maximum at end day.**		
September 17	Take Field Measurements on Streambed and Flow			Take Field Measurements on Streambed and Flow	Download all transducers. **Turn off pumps at end day.**		
September 24	Take Field Measurements on Streambed and Flow			Take Field Measurements on Streambed and Flow	Download all transducers. **Turn on pumps as needed by ranch at end day.**	Study Perio d is over.	
October 1	Remove all monitoring equipment.	Remove all monitoring equipment.	Remove all monitoring equipment.				

Data Analysis and Development of Correlations

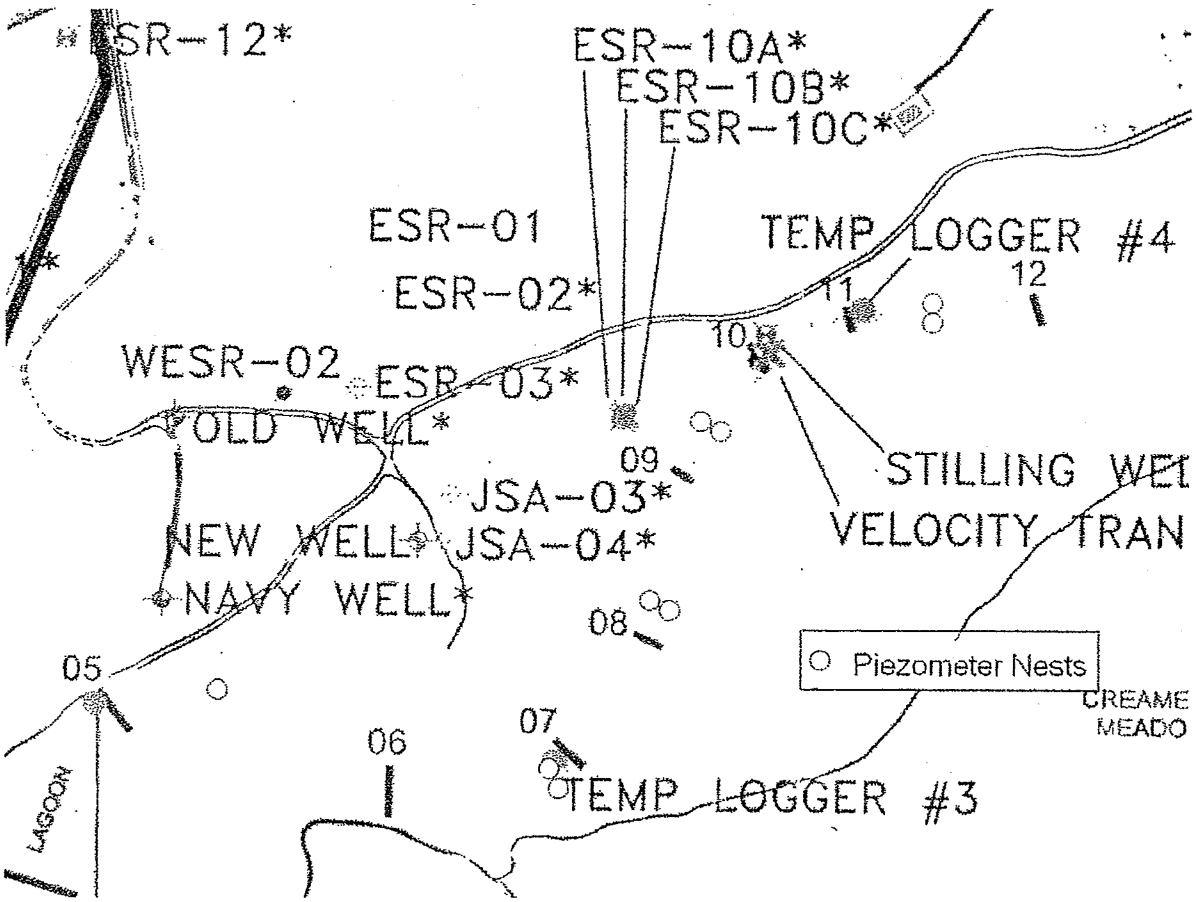
Data collected from steps 1, 2 and 3 above will be used to calculate total loss of river flow through its bed during each study period. Losses will be calculated using Darcy's Law. Water level from the piezometer well pairs will be used to calculate the vertical hydraulic gradient at each location. This value will then be multiplied by the weighted average surface area of the streambed between measurement areas. The streambed areas will be calculated based on the twice weekly streambed measurements taken at each location. This value will then be multiplied by the streambed hydraulic conductivity as determined from the field tests detailed in Task 2 above. The result will be an area averaged calculation of stream loss or gain along the study area section of River. These values will then be correlated to the pumping condition occurring and to the stream flow entering the study area as determined from flow measurements at Transect 1. A correlation factor relating pumping to loss referenced to the stream flow gauge will then be developed.

This analysis will be supplemented via evaluation of transducer data from the monitoring wells as detailed in Task 4. Water elevation data from the monitoring wells will be evaluated to estimate gradients during the differing pumping conditions and their relationship to the calculated stream losses. This data will be used to qualify and inform the analysis of stream loss discussed above. Water level monitoring data will also be utilized to provide a calibration data set for the calculation of the radius-of-influence of the pumping wells on the groundwater system. These calculations are specifically focused on estimating the potential for drawdown impacts up-river from the pumping wells.

Monitoring data collected from Task 5 will be evaluated to determine if any saline wedge mixing zone effects can be detected, and if they are increased as a result of pumping conditions. This will be evaluated by comparing conductivity data specifically during and following high tide events, when it is most likely to occur. Comparisons will be made between the differing pumping conditions and non-pumping conditions.

Finally, data collected during this period (stream flow and stream loss data) will be considered along with all available historical data to prepare a refined water availability analysis. This analysis will be conducted to evaluate a monthly based water budget for various water year types, specifically focused on the later summer months when pumping has the most potential to cause an impact.

Figure Showing Piezometer Nest Locations



August 19, 2006

Proposed Monitoring Program to Evaluate the Potential Relationship Between El Sur Ranch Well Operations and Fish and Wildlife Habitat Associated with the Big Sur River During 2006

Prepared by

Hanson Environmental Inc
132 Cottage Lane
Walnut Creek, CA 94595

The El Sur Ranch operates two wells located immediately adjacent to the Big Sur River that supply water for pasture irrigation. In response to a water right application submitted by El Sur Ranch to the State Water Resources Control Board (SWRCB) the California Department of Fish and Game (CDFG), National Marine Fisheries Service (NMFS), and California State Parks (DPR) identified concerns regarding the potential effects of well operations on surface and groundwater levels within the Big Sur River. It has been hypothesized that well operations may affect instream habitat within the river for Central California Coast steelhead and other aquatic resources, in addition to riparian vegetation and associated wildlife.

A series of pilot studies were designed and implemented during 2004 that provided important information on water quality and fishery habitat within the Big Sur River, hydrogeology of surface and groundwater movement within the lower reaches of the Big Sur River watershed, and information on operations of the El Sur Ranch diversion wells. Information collected from the 2004 investigations serves, in part, as the technical foundation for identifying additional monitoring and the experimental design for an investigation to be conducted during the late summer of 2006 specifically designed to address issues raised by CDFG and other protestants to the water right application. The objective of the 2006 experimental investigation is to determine if there is a significant relationship between indices of steelhead habitat and well operations, and if so, whether the El Sur Ranch diversion well operations may directly cause significant adverse impacts to fish and wildlife habitat within and adjacent to the Big Sur River

The proposed experimental design has been developed to test the null hypothesis that there is a significant relationship between El Sur Ranch well operations and various indices of habitat quality and availability within area of influence. The alternative hypotheses to be tested include (1) well operations do not have a significant relationship to indices of steelhead habitat that may result in a significant degradation of habitat, and (2) well operations do not result in a significant increase in habitat quality or availability. The experimental design developed to test these hypotheses includes manipulation of well operations during the low flow period of 2006 (September) accompanied by both continuous and periodic monitoring. Monitoring conducted as part of the surface water fishery and aquatic resource habitat monitoring outlined below would be coordinated with hydrogeologic monitoring during the same test period as proposed by the Source Group (August 17, 2006).

Monitoring Methods

The proposed monitoring program includes both continuous (approximately hourly or more frequent as needed) monitoring using data loggers as well as periodic (grab sampling) monitoring scheduled to coincide with specific periods of El Sur Ranch well operations. Data loggers would be used to record water elevation within the wells, water surface elevation within the stilling well located within the river, water temperatures within the river, and soil moisture. Data loggers would be downloaded at approximately monthly intervals scheduled to coincide with site visits for grab sampling monitoring and observations. Continuous monitoring would occur over the period from September 1 through October 1 and would include the following parameters:

- Continuous water level monitoring within existing groundwater wells located adjacent to the Big Sur River in the general vicinity of the El Sur Ranch diversion wells;

- Surface water elevation within the Big Sur River in the area adjacent to the El Sur Ranch diversion wells;

- Water quality parameters measured continuously using two data SONDE water quality monitoring units to measure dissolved oxygen concentration (DO), electrical conductivity (EC), and water temperature at one location within the Big Sur River located immediately adjacent to the El Sur Ranch diversion wells and one location downstream adjacent to the coldwater upwelling area identified during the 2004 investigations (immediately downstream of transect 8 and transect 9; Figure 1);

- Water temperature would be measured at approximately 20-minute intervals at ten (10) locations within the lower reaches of the Big Sur River extending from the lagoon upstream past the El Sur Ranch diversion wells (Figure 1). At each of the ten locations water temperature recorders would be positioned near the surface and near the bottom, where channel depth permits, along both the left and right banks of the river (Figure 1).

In addition to the continuous monitoring, periodic (grab sampling) monitoring would occur within the lower reaches of the Big Sur River at a frequency of two surveys during each seven day test interval, which would include the following:

- Streamflow measurements - during each survey velocity and water depth measurements will be made at velocity transect 1 (Figure 1) to estimate river flow entering the study reach and to correlate the stage-discharge relationship to water surface elevation measurements made within the stilling well throughout the study period;

- Instream habitat – ten (10) transect locations would be selected within the reach extending from the lagoon upstream past the El Sur Ranch diversion wells (reach extending from approximately transect 6 to 11; Figure 1), with priority given to locations passing through shallow riffle areas, where river cross-sectional measurements would be made in accordance with specific well operations that include wetted channel width and water depth measured at one-foot intervals across the river (Figure 1). Each of the transect locations would be identified using GPS coordinates, landmarks, and other identifying features to allow measurements at the same river transect locations over a range of experimental well operations. Information gained from transect measurements will be used to assess the suitability of habitat verses flow relationships for adult steelhead passage (Thompson criteria and 0.6 foot water depth during the winter adult migration period) and summer baseflows for juvenile steelhead rearing. Analysis of summer baseflow conditions may not be possible using the data collected in 2006 because of higher streamflow currently in the river and therefore re-analysis of data collected in 2004 at lower flow levels will be examined for use in assessing summer baseflow conditions. Information on channel depth and wetted width will also be used to analyze the potential affect of well operation on instream habitat conditions;

- Water quality sampling would be performed at 10 locations extending from the lagoon upstream of the El Sur Ranch wells using portable hand-held water quality meters to measure DO, water temperature, and EC near the surface and near the river bottom at locations adjacent to the left bank, center of the river, and right bank at each of 10 monitoring sites during each survey; and

- Water quality measurements of dissolved oxygen, electrical conductivity, and water temperature would be made from the monitoring wells for comparison with measurements from various locations within the river during both pumping and non-pumping periods.

Schedule of Experimental Well Operation Manipulations

The El Sur Ranch diversion wells would be experimentally manipulated during September to include periods when no well operations occur, one well is operated continuously, two wells are operated continuously, and after periods of routine irrigation well operations. Each of the primary experimental periods would be seven days in duration. The proposed schedule for experimental well operations and periodic monitoring is outlined below.

Pump operations	Start Date	End Date	Duration (Days)	Survey Dates
Routine operations		September 5		September 5
1 pump	September 6	September 12	7	September 8 and 12
0 pump	September 13	September 19	7	September 15 and 19
2 pump	September 20	September 26	7	September 22 and 26
0 pump	September 27	October 3	7	September 29 and October 3
Routine operations	October 4	End of irrigation season		October 6 and 10

Note: the actual schedule for well operations and field surveys during the test period may be refined or modified based on climate conditions or other factors.

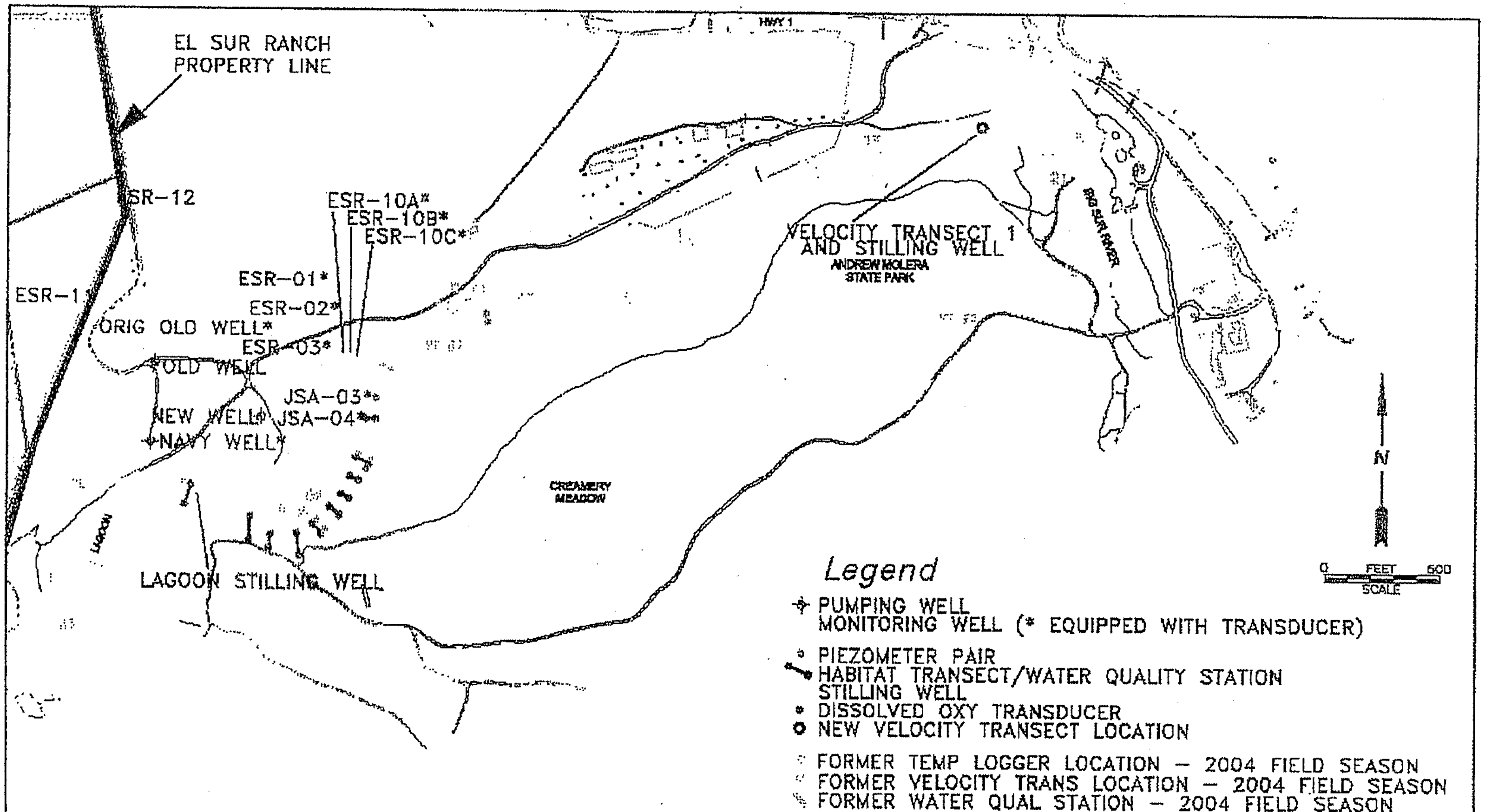
El Sur Ranch would not be held responsible in the event that localized adverse effects are detected as a direct result of the proposed 2006 experimental testing program. In the event of adverse impacts to the ranch or surrounding areas, a report will be prepared documenting well operations, the reason that operation was modified, and any damage that occurred during the test period. El Sur Ranch will resume normal irrigation practices at the completion of the test period.

Analysis

Statistical analyses, using regression techniques, ANOVA, Chi-square, and other appropriate statistical tests, would be performed to determine whether or not significant relationships exist between each of the individual habitat parameters monitored as part of the experimental investigation and corresponding operations of the El Sur Ranch diversion wells. Multivariate statistical analyses will be used to factor temporal and spatial variation into the analysis of the response of different habitat parameters to variation in well operations. Statistical analyses will be conducted under the supervision of a qualified statistician. Statistical significance would be determined by a probability of occurrence of less than 5% ($P < 0.05$). The analysis would be performed to assess the response of various habitat parameters to periods when no diversion well operation occurred (control or reference condition), one well was in operation (treatment 1), and two wells are in simultaneous operation (treatment 2). Estimates would be made of the diversion rate (cfs) associated with each of the individual test conditions. The data analysis will test a number of hypotheses including:

> Ho: there is a significant relationship between well operations and habitat parameters within the river (e.g., water depth, wetted channel width, water temperature, dissolved oxygen, EC);
>
> Ho: there is a significant difference in the habitat response within the Big Sur River between no well operations (reference), one well (treatment 1), and two well operations (treatment 2);
>
> Ho: a bypass flow can be established for adult steelhead passage and juvenile steelhead rearing that will be protective of the species and avoid harm in the event that a significant relationship between indices of steelhead habitat and well operations is detected.

Results of the data collection and statistical analysis would be documented in a draft technical report and provided to SWRCB, CDFG, NMFS, and DPR staff for review and comment. All data collected as part of the 2006 monitoring program would be provided, upon request, to each interested party/protestant for independent review and analysis. Results of the analysis would subsequently be documented in a final technical report that would be used to assess the potential effects of El Sur Ranch diversion well operations on riparian and instream habitat conditions within the Big Sur River and for use in identifying, if necessary, future mitigation and monitoring conditions for El Sur Ranch diversion well operations as part of CEQA environmental documentation and completion of the SWRCB water right permitting process.



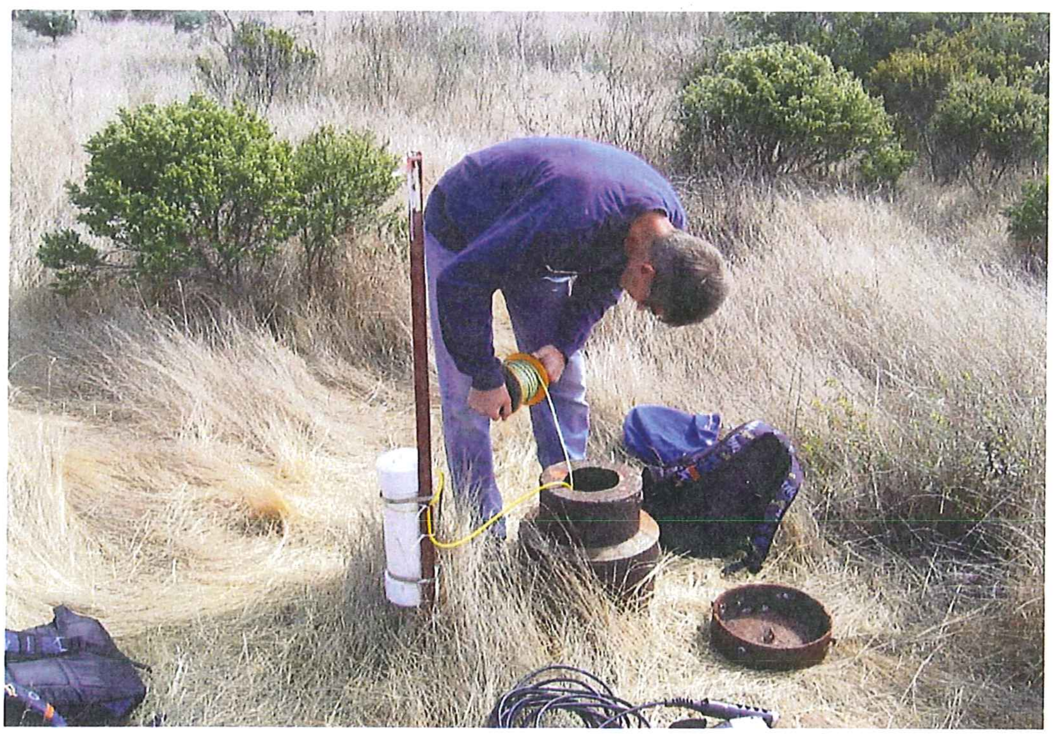
SGI The Source Group, Inc.	EL SUR RANCH BIG SUR, CALIFORNIA				FIGURE 1 **MONITORING STATION MAP 2006 STUDY**
	PROJECT NO. 01-ESR-001	DATE 3/11/05	DR. BY ML/JB	APP. BY PH	

APPENDIX B

APPENDIX B

PHOTO EQUIPMENT

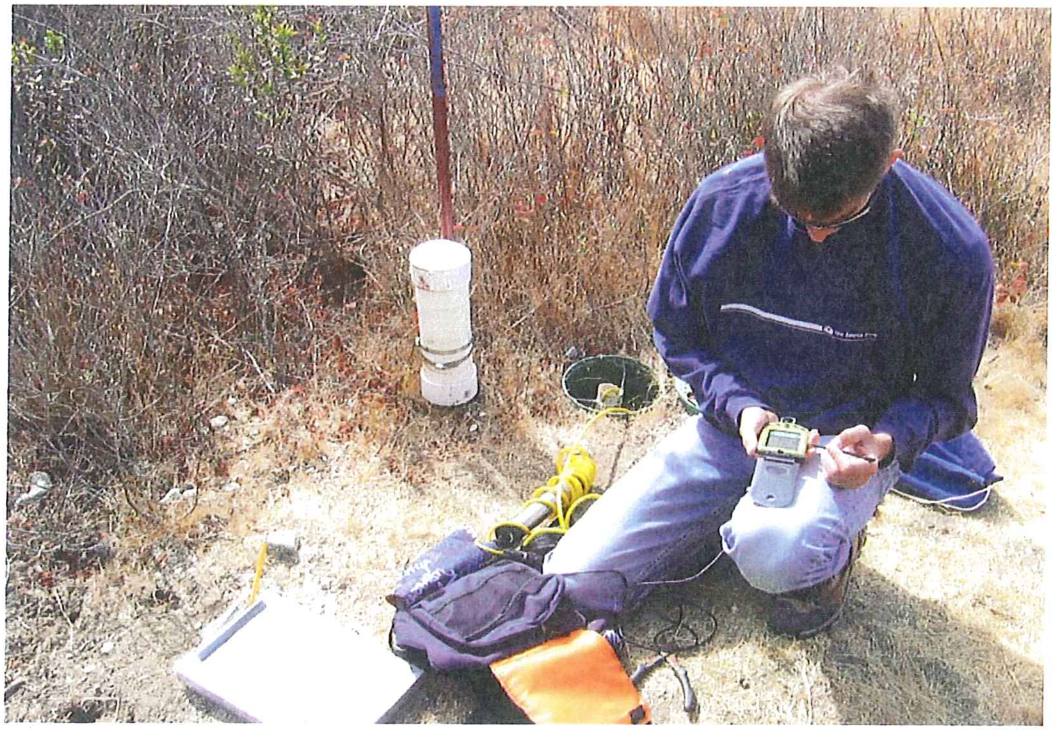
Photograph 1: *Monitoring Well ESR-01*



Photograph 2: *Monitoring Well ESR-02*

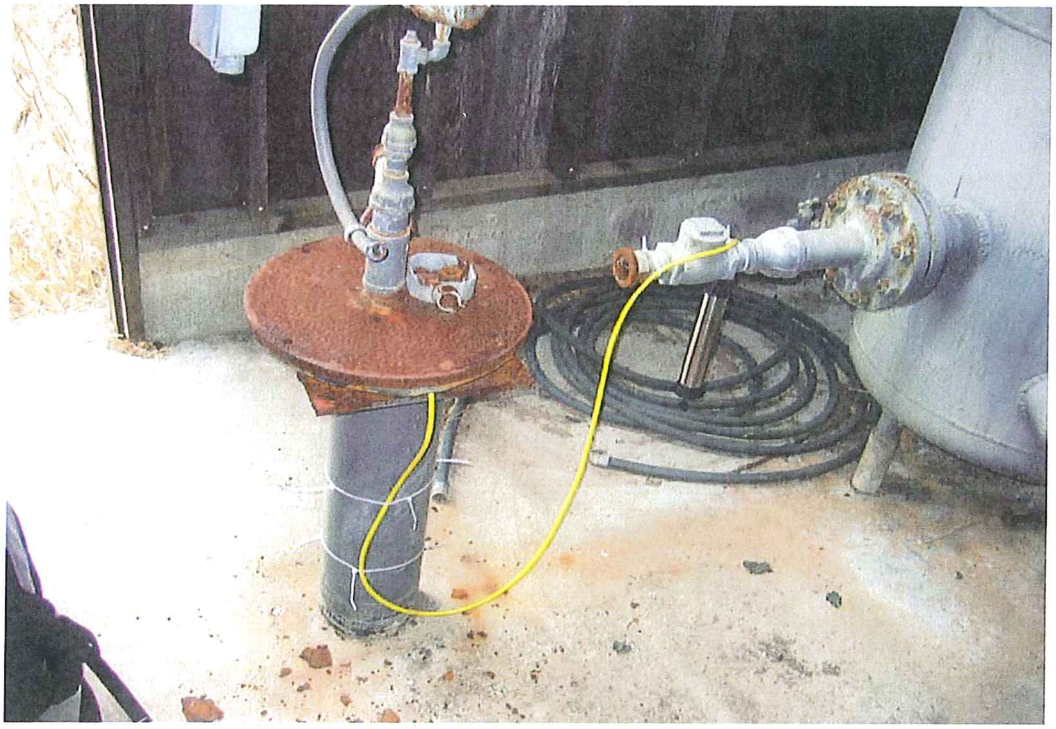
Photograph 3: *Monitoring Well ESR-03*

Photograph 4: *Monitoring Well ESR-10A (ESR-10B and ESR-10C similar)*



Photograph 5: *Monitoring Well JSA-03*

Photograph 6: *Monitoring Well JSA-04 (near New Well irrigation well)*



Photograph 7: *Original Old Well (near Old Well irrigation well)*

Photograph 8: *Piezometer Pair P1 (located in Big Sur River Lagoon)*

Photograph 9: *Piezometer Pair #1 (located in Big Sur River Lagoon)*

Photograph 10: *Piezometer Pair #2 (located near Passage Transect 5)*

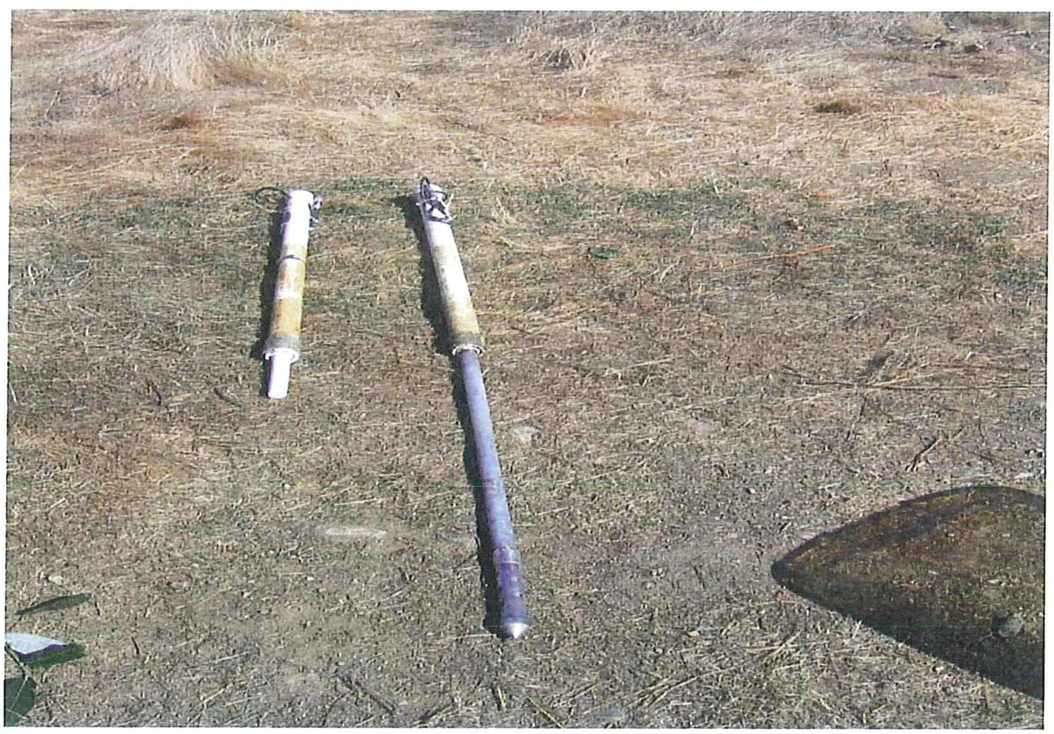
Photograph 11: *Piezometer Pair #4 (located near Passage Transect 9)*

Photograph 12: *Piezometer Pair #4 (located near Passage Transect 9)*

Photograph 13: *Piezometer Pair #5 (located upstream of Passage Transect 11)*

Photograph 14: *Using the 15-inch permeameter near P4*

Photograph 15: *The 15-inch Permeameter*



Photograph 16: *Piezometer Pair (left is shallow, right is deep)*

Photograph 17: *Piezometer Pair (front is shallow, rear is deep)*

Photograph 18: *Passage Transect 1 (Big Sur River Lagoon)*

Photograph 19: *Passage Transect 2 (Big Sur River Lagoon)*

Photograph 20: *Passage Transect 3 (Big Sur River Lagoon)*

Photograph 21: *Passage Transect 4 (in riffle zone)*

Photograph 22: *Passage Transect 5*

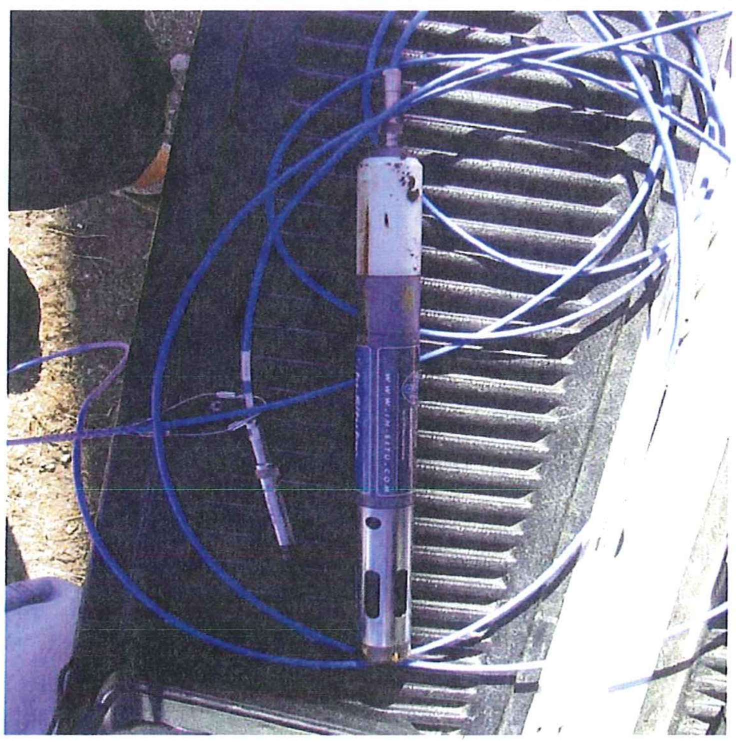
Photograph 23: *Passage Transect 6 (lower Cold Pool)*

Photograph 24: *Passage Transect 7 (upper Cold Pool)*

Photograph 25: *Passage Transect 8*

Photograph 26: *Passage Transect 9 (in riffle zone)*

Photograph 27: *Passage Transect 10 (in riffle zone)*



Photograph 28: *Dissolved Oxygen Transducer (Conductivity Transducer similar)*

Photograph 29: *Stilling Well at Velocity Transect 1*

Photograph 30: *Velocity Transect 1*

APPENDIX C

APPENDIX C

SURVEY DATA

Appendix C
2006 Survey Data

Survey Point Number	Northing	Easting	Elevation (ft-ASL)	Survey Point Name
100	358243.94	1158164.81	5.72	TRANSECT 1 LEFT
102	358138.73	1158348.71	5.4	TRANSECT 2 LEFT
103	358172.66	1158116.4	6.11	TRANSECT 1 RIGHT
104	358060.86	1158295.2	7.49	TRANSECT 2 RIGHT
105	358111.85	1158326.06	6.64	P 1 L D
106	358112.13	1158326.41	6.46	P 1 L S
107	358012.78	1158482.89	5.79	TRANSECT 3 LEFT
108	358005.25	1158424.47	7.43	STILLING WELL
109	357970.74	1158449.79	7.97	TRANSECT 3 RIGHT
110	357960.98	1158648.51	6.86	TRANSECT 4 LEFT
111	357946.56	1158689.06	8.04	TRANSECT 4 RIGHT
113	358103.42	1158768.94	8.79	P 2 L D
114	358103.39	1158769.32	8.95	P 2 L S
115	358090.3	1158783.95	8.93	P 2 R D
116	358089.44	1158784.09	8.52	P 2 R S
117	358068.65	1158793.29	7.48	TRANSECT 5 RIGHT
120	358272.28	1158890.79	7.66	TRANSECT 7 RIGHT
121	358320.49	1158884.16	8.31	P 3 L D
122	358320.4	1158884.7	8.17	P 3 L S
123	358314.9	1158896.18	7.09	P 3 R S
124	358314.48	1158896.45	7.43	P 3 R D
125	358199.29	1158852.95	7.86	TRANSECT 6 RIGHT
126	358218.87	1158813	7.52	TRANSECT 6 LEFT
127	358396.83	1158908.09	8.07	TRANSECT 8 LEFT
129	358547.45	1158958.38	4.7	TRANSECT 9 RIGHT
130	358559.1	1158901.45	8.57	TRANSECT 9 LEFT
131	358615	1158935.63	9.06	P 4 L D
132	358614.71	1158936.23	8.93	P 4 L S
133	358612.48	1158946.84	9.54	P 4 R D
134	358612.7	1158947.54	9.64	P 4 R S
135	358940.66	1159229.56	10.31	TRANSECT 11 RIGHT
136	358976.09	1159217.18	10.21	TRANSECT 11 LEFT
137	358979.95	1159470.51	12.86	P 5 R S
138	358980.76	1159470.12	13	P 5 R D
139	358993.28	1159465.5	12.91	P 5 L D
140	358994.44	1159465.22	12.75	P 5 L S
141	358803.36	1159069.58	9.15	TRANSECT 10 RIGHT
142	358825.24	1159038.56	9.04	TRANSECT 10 LEFT
144	359819.26	1161669.09	32.31	TRANSECT 12 RIGHT (VT1)
145	359861.32	1161657.17	40.21	TRANSECT 12 LEFT (VT1)
147	358848.09	1157990.17	14.17	ON SQUARE PLATE OLD WELL
143	359820.85	1161670.67	21.71	STILLING WELL

Note: Coordinate system used is California State Plane, NAD27.

APPENDIX D

APPENDIX D

EROSION INSPECTION MEMOS OF 2005

Summary of 2005 Erosion Control Memos.

Between March and July of 2005, the Source Group Inc. (SGI) responded to three specific requests to investigate and document both historical claims by the Department of Parks and Recreation (DPR) or specific instances of overland water runoff from El Sur Ranch (ESR) to Andrew Molera State Park (the Park). In all cases, the source of the overland water runoff was irrigation water being fed to the "Pump House Field", the field at the lowest elevation located adjacent to both the Ocean and the Park. See Appendix X for copies of the memos detailing the events and conclusions of the three visits.

The first visit occurred on March 31, 2005 in response to DPR claims that irrigation flow from ESR had historically been observed cascading off of the Ranch property onto portions of the "Headlands Trail" in the Park. It was apparent that some loss of irrigation flow had historically occurred along the property boundary. There was no visible indication of trail damage as a result of the flows. Recent modifications to the irrigation system and the road/berm by ESR at the property boundary appeared to have been an effective change to eliminate future loss of flow. SGI recommended inspections of the area during times of active irrigation to validate the conclusion that the modifications were successful.

The second visit occurred on July 19, 2005, in response to the unintentional overland flow of irrigation water from the "Pump House Field" to the Park. It was determined that there were three factors that contributed to the release: 1) the natural slope of the "Pump House Field" is toward the Park, 2) the "Pump House Field" is clay rich, resistant to the infiltration of water and thus prone to overland runoff, and 3) the lack of training of a new ESR employee to properly manage the watering of the field. It was agreed that proper water management could prevent future occurrences.

The third visit occurred on July 27, 2005, in response to DPR resource ecologist Jeff Fry's claim that he had seen irrigation water runoff from ESR to the Park on several occasions. SGI personnel met with Mr. Fry and ESR ranch employee Jim Grey to investigate the claims. It appeared that water coming off the "Pump House Field" could potentially run off ESR property onto the Park, especially along the dirt road leading from the Ranch to the Park. At the time of the meeting, the road had just been graded so there was no evidence that any runoff had occurred. Jeff Fry agreed to contact Jim Grey directly if irrigation runoff was observed in the future.

Between the three visits, SGI personnel did not witness any adverse effects to Park property as a result of water runoff from the Ranch. Regardless, steps were taken by ESR personnel to reduce the potential for future overland water runoff from the Ranch to the Park.

THE SOURCE GROUP, INC.

Technical Project Memorandum

To: Janet Goldsmith – Kronick Moskovitz Tiedeman & Girard
Larry Horan – Horan Legal

From: Paul Horton, PG, C.HG
Principal Hydrogeologist

CC: Darlene Ruiz – Hunter / Ruiz
James Hill

Date: May 20, 2005

Re: El Sur Ranch Field Investigation – Potential for Irrigation Leakage onto Molera State Park

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On Thursday, March 31, 2005, I met Larry Horan and Jim Gray at the El Sur Ranch for the purpose of observing a specific location near the mouth of the Big Sur River where the El Sur Ranch property abuts the Andrew Molera State Park property. Larry Horan provides legal counsel to Jim Hill and Jim Gray has worked at the El Sur Ranch for a number of years. According to complaints by the Department of Parks and Recreation (DPR), irrigation flow from the El Sur Ranch had historically been observed cascading off of the ranch property onto portions of the "Headlands Trail" in the State Park.

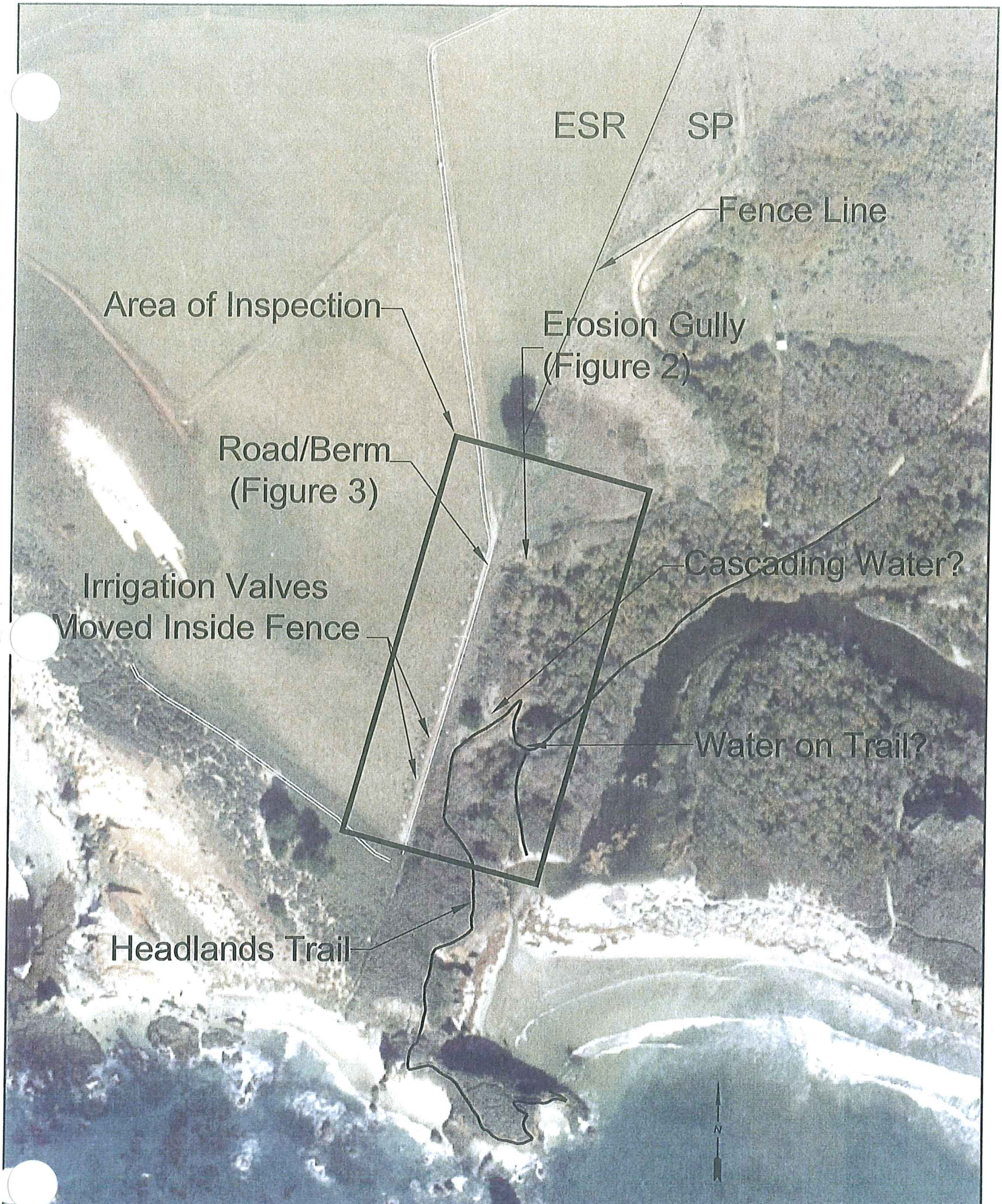
The area in question is located near the junction where the Headlands Trail (trail) splits as indicated on the attached Figure 1. A portion of the trail continues southeast ending at a small beach at the lagoon. The other portion of the trail splits to the north and ascends up some steps to the edge of a cliff and continues around to the point near the mouth of the lagoon as depicted on Figure 1. It was my understanding that DPR personnel had on occasion observed water cascading down the cliff area near the location of the split (trail intersection). Additionally, water had been observed by DPR crossing the trail intersection from northeast to southwest (Figure 1).

As part of my investigation, I hiked the trail and investigated off-trail above the areas in question along the boundary with the El Sur Ranch property as marked by a fence (Figure 1). I also inspected the trail along the steps and the area of potentially cascading water for signs of trail damage. I did not observe any visible trail damage or evidence of cascading water or related erosion in the area of the trail that ascends the cliff and continues to the southwest (Figure 1). I did not observe any visible trail damage in the area of the trail intersection where water had also been observed crossing the trail.

Inspection of the boundary of the park along the El Sur Ranch fence line revealed an area of erosion due to overland flow of water that had apparently cut a gully into the cliff face (Figure 2). There was no evidence that this was a recent occurrence. At the time of inspection, all areas were dry.

Jim Gray indicated that in the past, irrigation water had been observed to escape the ranch in the areas inspected. However, Jim indicated that the irrigation line along the fence boundary had been moved further inside the El Sur Ranch property line and that the boundary road on the inside of the El Sur Ranch fence had been substantially heightened to act as a berm (Figure 1 and 3). These actions appear to have been successful in eliminating the loss of overland irrigation flow from this area onto the lands of Andrew Molera State Park.

In summary, it appears that some loss of irrigation flow had historically occurred along the area of the property boundary inspected as detailed on Figure 1. No indication of trail damage as a result of these flows was visible. Modifications to the irrigation system and the road/berm by El Sur Ranch at the property boundary appear to have been an effective change to eliminate this loss of flow in the future. Inspection of the area in question during a time of active irrigation is recommended to completely validate the conclusion that modifications have been totally successful.



SGI environmental THE SOURCE GROUP, INC.	EL SUR RANCH BIG SUR, CALIFORNIA			*IRRIGATION DRAINAGE* *SITE VISIT – MARCH 31, 2005*
1" = 250'	DATE 8/2/05	DR. BY SMc	APP. BY PDH	PROJECT NO. 01-ESR-001 / FIGURE NO. 1

ESR-5

SGI environmental THE SOURCE GROUP, INC.	EL SUR RANCH BIG SUR, CALIFORNIA			EROSION GULLY	
	DATE 3/11/05	DR. BY CP	APP. BY PDH	PROJECT NO. 01-ESR-001	FIGURE NO. 2

ESR--5

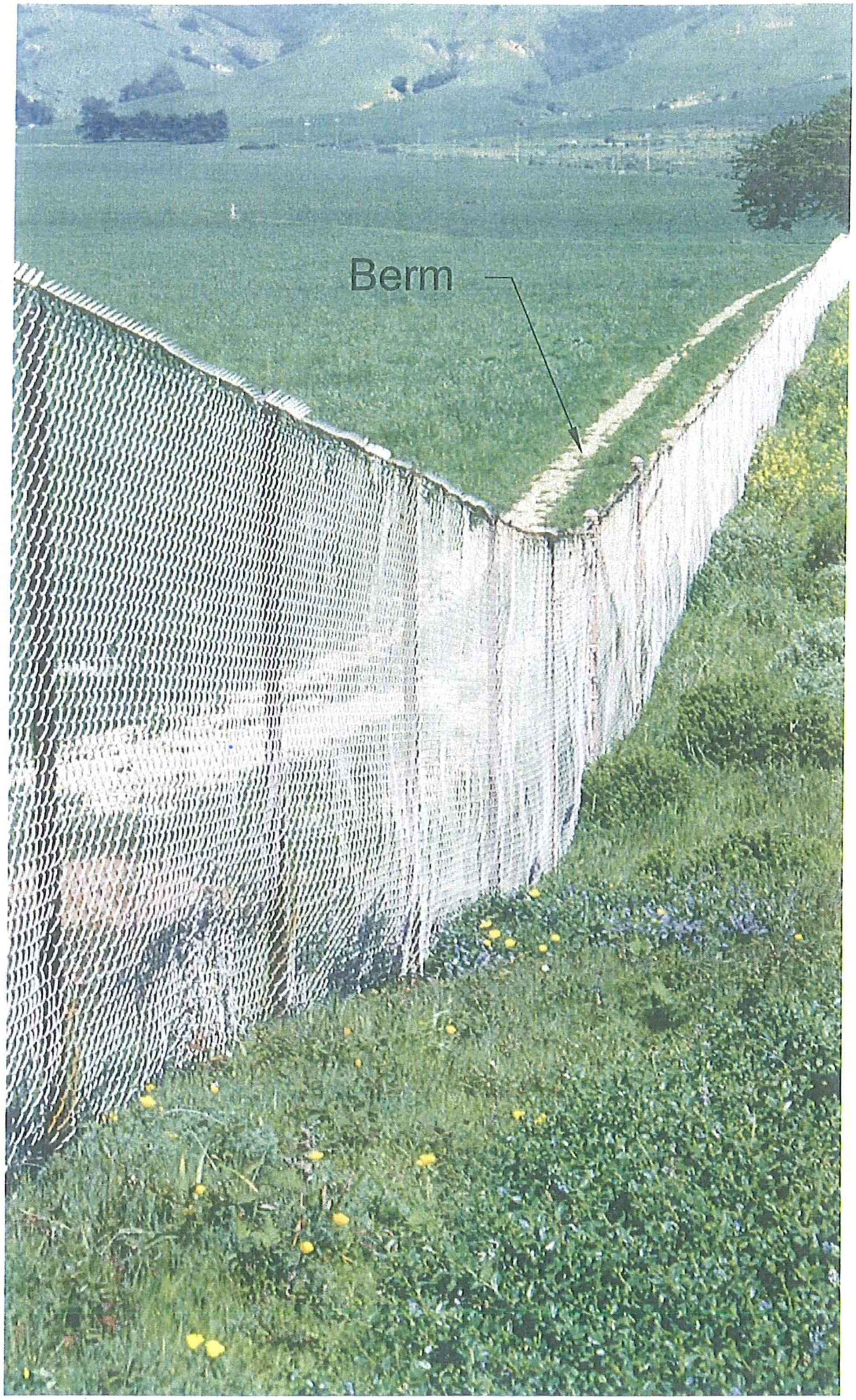


Photo Taken From Molera State Park
Looking North

SGI environmental THE SOURCE GROUP, INC.	EL SUR RANCH BIG SUR, CALIFORNIA			PROPERTY BOUNDARY	
	DATE 3/11/05	DR. BY CP	APP. BY PDH	PROJECT NO. 01-ESR-001	FIGURE NO. 3

ESR--5

SGI environmental THE SOURCE GROUP, INC.

Technical Project Memorandum

To: Janet Goldsmith – Kronick Moskovitz Tiedeman & Girard
Larry Horan – Horan Legal

From: Jon Philipp, PG
Project Hydrogeologist

CC: Darlene Ruiz – Hunter / Ruiz
James Hill

Date: July 21, 2005

Re: Water Runoff at El Sur Ranch, Response to Complaint

On July 19, 2005, I visited El Sur Ranch (ESR) to document the events and circumstances that led to the unintentional overland flow of water from ESR to Andrew Molera State Park (Park). On the evening of Thursday, July 14, 2005, irrigation water was set to flow into the Pump House Field. By the morning of Friday, July 15, the field had not been fully irrigated. The acting ranch foreman, Jim Gray, instructed a ranch hand to set the valves such that the balance of the field would be irrigated. Jim was off the ranch for most of the day on business and the ranch hand, after setting the valves at approximately 8:30am (July 15), worked on other ranch projects for most of the day. At approximately 3:00pm, a complaint was lodged that water was leaving ESR property and flowing overland into the Park. By approximately 4:30pm, Jim had returned to the Ranch, received notice of the complaint and had turned off the water to the Pump House Field.

Several factors contributed to this occurrence. The first is that the natural slope of the field is toward the Park. Figure 1 shows a view along the fence that separates ESR from the Park. Notice that before the Cypress tree that there is a dip in the fence, which corresponds to a natural depression. Figure 2 shows the same fence line looking from the Cypress tree location. In this case, the depression is easily visible. It was through the depression that the water ran off ESR and into the Park. Water from ESR made it across the 'Headlands Trail' within the Park, and likely ended up in the Big Sur River. Figure 3 shows an area of trail that was still wet as a result of the flow from ESR.

The second factor that contributed to this incident is the nature of the soil in the Pump House Field. Unlike the rest of the ESR fields, this one is known for its tight soils. In fact, ranch personnel have nicknamed a portion of the field the 'clay patch'. As water is unable to readily infiltrate into the soils, it is more prone to overland flow.

A third factor that contributed to the incident is inexperience based on input from Jim Gray. The ranch hand that Jim left to set the valves did not do it correctly. Jim Gray assured me that proper water management in the future could prevent something like this from reoccurring.

In addition, I was asked to document the possible occurrence of water flow into Swiss Canyon. Jim told me that there is very little flow from the fields into Swiss Canyon, and that almost all of it occurs at the south-west corner of Field 7 (where Swiss Canyon intersects with the Pacific Ocean). At the time I was there, I observed no water runoff from any source into the Canyon. However, there is evidence of erosion from overland flow at the south-west corner of Field 7. Figure 4 shows the erosional feature formed by the overland flow of water off of Field 7. Figure 5 shows the break in slope from the edge of Field 7 toward Swiss Canyon and the Ocean. Lastly, Figure 6 shows the path the water takes from Field 7, into the erosional feature and then into Swiss Canyon.

Fence that separates El Sur Ranch (right) from Andrew Molera State Park (left). Note the dip in the fence before the large tree.

SGI environmental THE SOURCE GROUP, INC.	EL SUR RANCH BIG SUR, CALIFORNIA			AREA OF SUSPECTED RUNOFF	
	DATE 3/11/05	DR. BY JP	APP. BY JP	PROJECT NO. 01-ESR-001	FIGURE NO. 1

ESR--5

Fence that separates El Sur Ranch (left) from Andrew Molera State Park (right). Note the dip in the fence corresponding to a natural depression.

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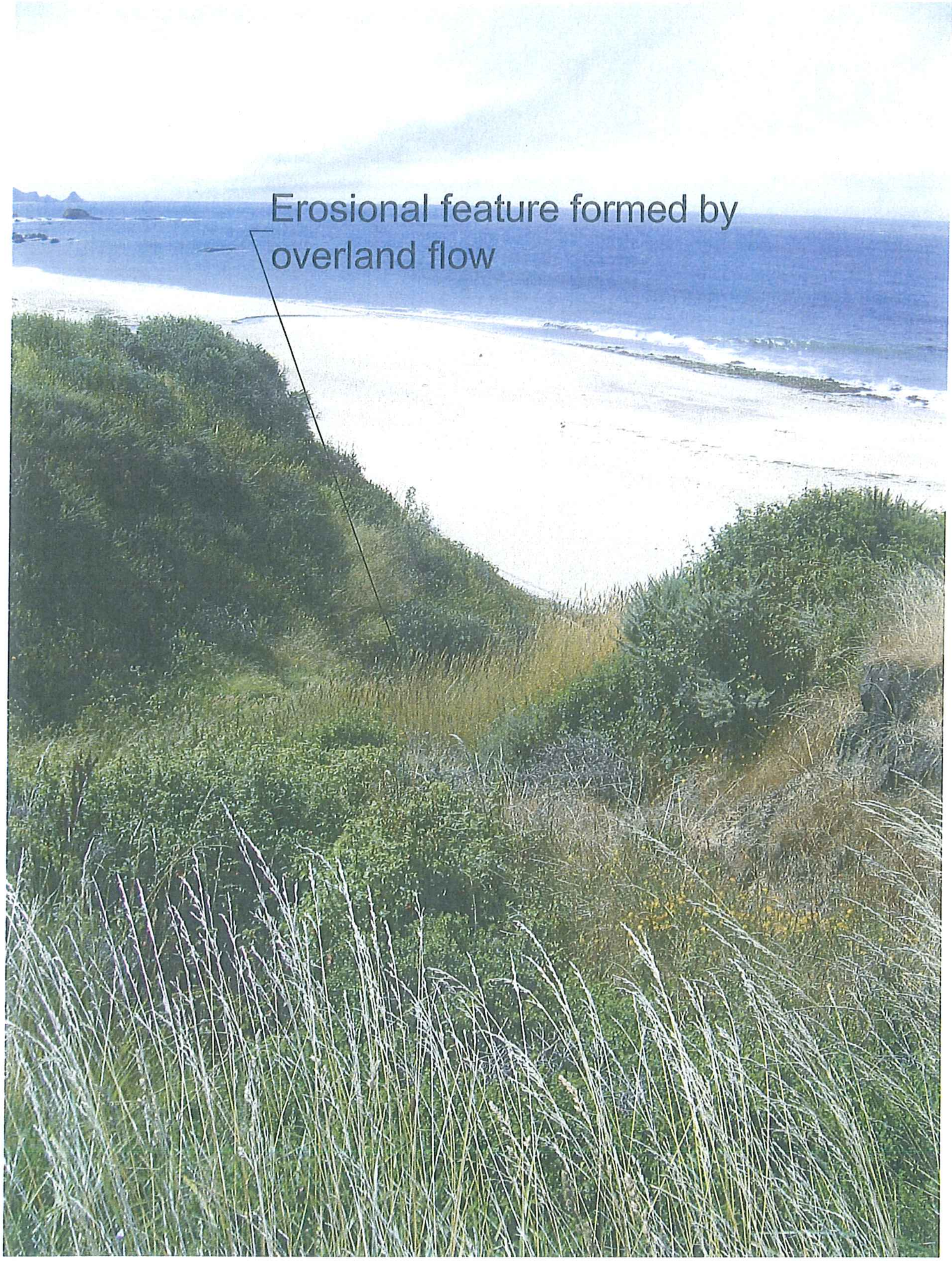
	DATE 3/11/05	DR. BY JP	APP. BY JP	PROJECT NO. 01-ESR-001	FIGURE NO. ESR--5 2

*Andrew Molera State Park trail (Headlands Trail)
moist from recent surface water
runoff from El Sur Ranch.*

SGI environmental THE SOURCE GROUP, INC.	EL SUR RANCH BIG SUR, CALIFORNIA			WET TRAIL FROM SURFACE WATER RUNOFF	
	DATE 3/11/05	DR. BY JP	APP. BY JP	PROJECT NO. 01-ESR-001	FIGURE NO. 3

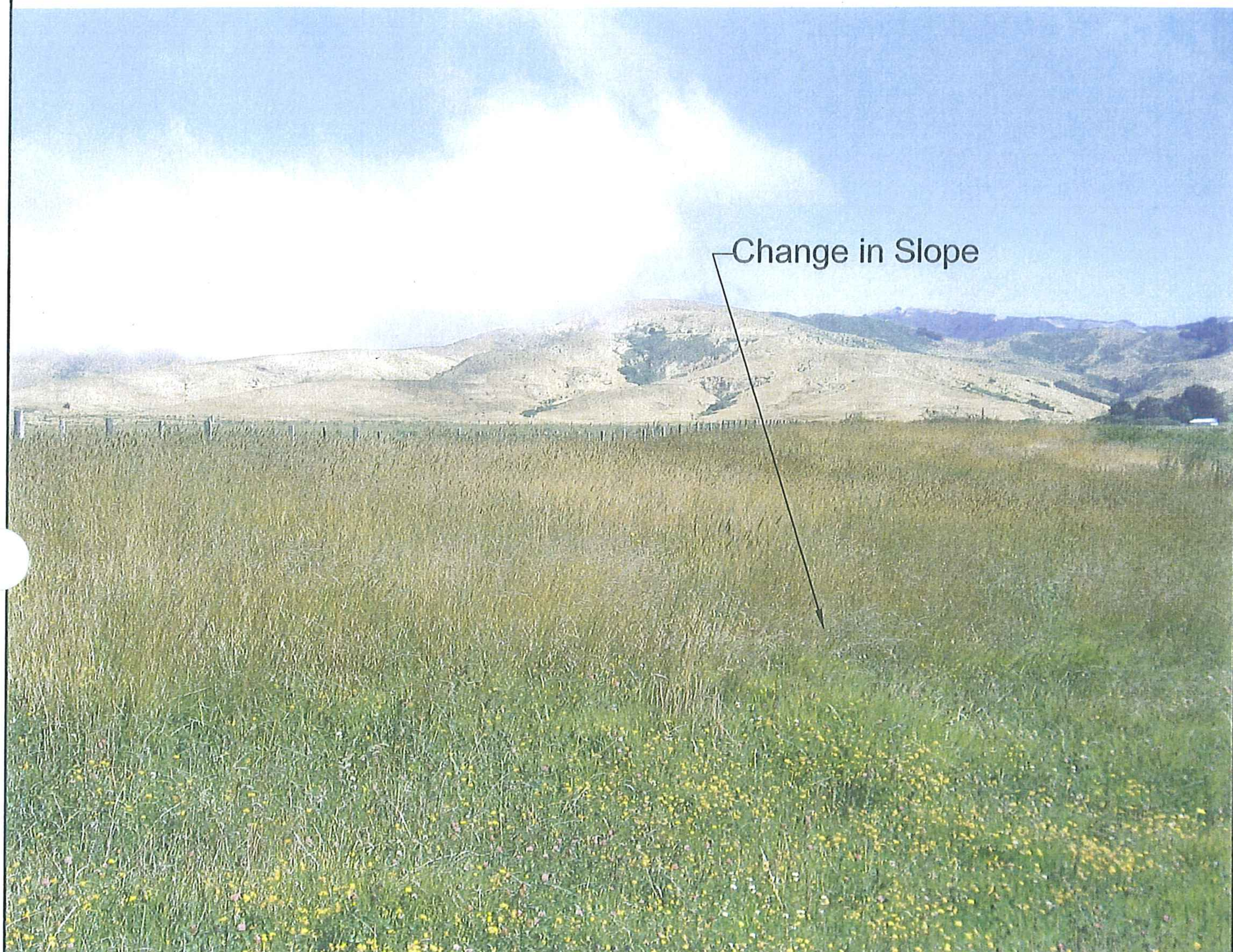
ESR--5



Swiss Canyon
erosional feature caused by overland flow
runoff from El Sur Ranch.

SGI environmental THE SOURCE GROUP, INC.	EL SUR RANCH BIG SUR, CALIFORNIA			WET TRAIL FROM SURFACE WATER RUNOFF	
	DATE 3/11/05	DR. BY JP	APP. BY JP	PROJECT NO. 01-ESR-001	FIGURE NO. 4

ESR--5



Edge of Field 7

SGI environmental THE SOURCE GROUP, INC.	EL SUR RANCH BIG SUR, CALIFORNIA			FIELD 7 CHANGE IN SLOPE	
	DATE 3/11/05	DR. BY JP	APP. BY JP	PROJECT NO. 01-ESR-001	FIGURE NO. 5

ESR--5

Technical Project Memorandum

To: Janet Goldsmith – Kronick Moskovitz Tiedeman & Girard
Larry Horan – Horan Legal

From: Steve McCabe, PG, C.HG
Senior Hydrogeologist

CC: Darlene Ruiz – Hunter / Ruiz
James Hill

Date: August 3, 2005

Re: El Sur Ranch Field Investigation – Potential for Irrigation Leakage onto Molera State Park

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During our presentation of the Technical Reports to the Department of Parks and Recreation (DPR) in Monterey on June 21, 2005, Jeff Fry, a resource ecologist with DPR, mentioned that he had seen irrigation runoff on Andrew Molera State Park (SP) property on several occasions. Therefore, at Darlene's request, I scheduled to meet Jeff at the SP to discuss his concerns. This meeting was scheduled prior to, but due to Jeff's vacation schedule, took place after the July 15, 2005 complaint documented in Jon Philipp's July 21, 2005 memo.

On Wednesday, July 27, 2005, I met Jeff Fry and Jim Gray at the SP parking lot for the purpose of observing specific locations reported by Jeff to have experienced irrigation runoff near the border the El Sur Ranch (ESR) property and SP property as shown on the attached Figure 1. Jim Gray has worked at the ESR for over twenty years. Jeff Fry of DPR stated that on several occasions he has observed water (assumed to be irrigation flow from the ESR) in this area and expressed concern about possible erosion effects.

The area in question is located up on the terrace, along the road leading from the ESR to the well field as shown on the attached Figure 1. Specifically, the reported occurrence(s) of water observed in the road were in the relatively straight section of road prior to the sweeping left turn as you are driving down from the ESR to the well field (see Figure 1). A secondary location mentioned by Jeff includes an area where water tends to "pond" between ESR and the road (Figure 1). Both of these areas are located adjacent to the ESR field that Jim Gray refers to as the "clay patch" which is part of the Pump House Field. The soil type is reportedly fine grained and does not adsorb significant amounts of water. According to Jim Gray, this field is irrigated by a pipeline, which runs approximately NE to SW and supplies water to a series of irrigation troughs that are roughly perpendicular to the pipeline (Figure 1). The slope of the field is away from the pipeline and towards the SP. To irrigate this field, water is released from the pipeline via a series of valves into the troughs. Ideally, just enough water is released to saturate each trough up to the property boundary (fence line) and no more. However, if too much water is released, it continues past the fence line onto SP property, and if too little water is released then the entire field isn't being irrigated resulting in dead grass on the ESR. Therefore, because obtaining this ideal irrigation scenario is difficult, water

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does appear to occasionally make its way onto SP property. According to Jim Gray, and based on my own observations of the topography, the majority of this water should either pond up behind a berm located between the road and the fence-line (Figure 1) or follow a topographic depression paralleling the road. However, based on statements by Jon Philipp and Jeff Fry some of this water does appear to make its way onto the road. Jim Gray stated that he believed the berm was constructed during the 1950's.

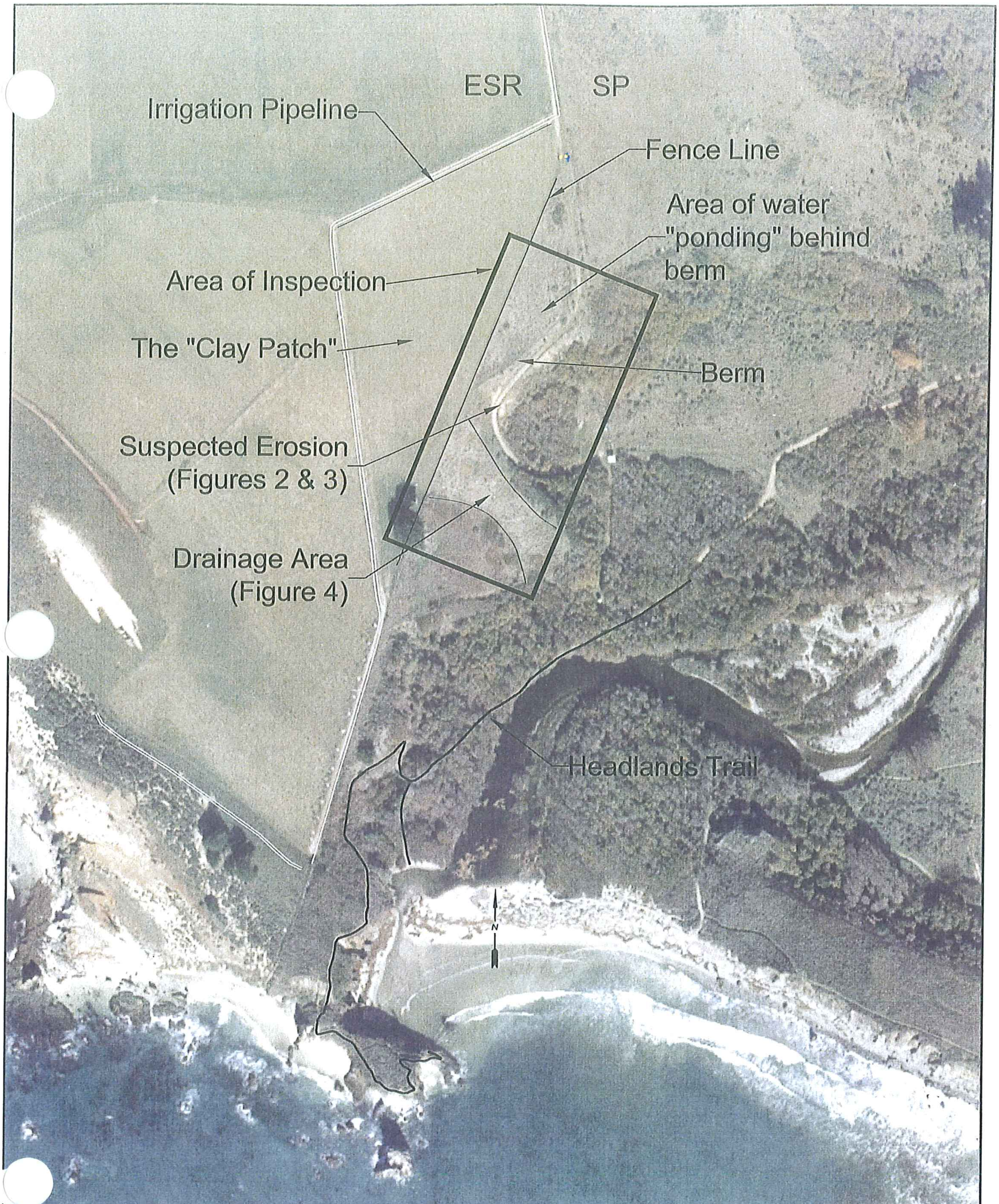
Jeff Fry pointed out an area along the road, where the uphill and downhill banks contain significant amounts of cobbles and relatively little cover vegetation that he thought might be evidence of erosion caused by the irrigation runoff. However, he admitted that he wasn't qualified to make that determination. This area is evident on the aerial photograph shown on Figure 1 and photographs of the area are shown on Figures 2 and 3. Jim Gray said that this area has always been exposed and thinks it is fill material used during road construction. Jim Gray mentioned that Tom Asmus, the former ESR ranch manager, might have first hand knowledge of this fill.

Jeff also mentioned that he previously observed a runnel on the uphill bank paralleling the road. This runnel reportedly cut across the road (from west to east) approximately 50 to 100 feet uphill of the cobble area discussed above. Jim Gray had recently re-graded this section of road so the runnel(s) were not present at the time of my investigation. Jeff suggested that the slope of the road be modified to slope away from the uphill bank so that water would flow off the road. Jim agreed that this could be done, but that it would require widening the road.

As part of my investigation, we hiked the off-trail area between the road and the ESR above the areas in question. During this hike, we observed the topographic low area discussed above and mentioned in Jon Philip's memo. This area was filled with green grasses (unlike most of the SP). This drainage area is evident on Figure 1 and a close-up is provided as Figure 4. Jim Gray indicated that when water goes past the fence line it typically goes into this drainage area, or ponds up behind the existing berm.

I did not observe any visible road damage or other possible erosion effects in the area. I asked Jeff how he would rank this "problem" and he conceded that it really wasn't much of an issue and that other areas of the SP have much more significant erosion issues that are in no way related to the ESR. At the time of inspection, all areas were dry.

In summary, it appears that some loss of irrigation flow occurs off the "clay patch", but that the majority of this water dissipates into a drainage area or ponds up behind the berm (and reportedly infiltrates in a couple of days). However, it does appear that irrigation water may make its way onto the road at times and has reportedly caused minor amounts of erosion in the form of runnels and rivulets. No indication of road damage as a result of these flows was visible at the time of this investigation (however, the road had been recently graded). Irrigation of the "clay patch" requires special attention given the tight nature of the soil and the slope towards the SP. Jeff Fry agreed to contact Jim Gray directly if irrigation runoff is observed in the future.



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1" = 250'

EL SUR RANCH
BIG SUR, CALIFORNIA

IRRIGATION DRAINAGE
SITE VISIT – JULY 27, 2005

DATE	DR. BY	APP. BY	PROJECT NO.	FIGURE NO.
8/2/05	SMc	PDH	01-ESR-001	1

ESR-5

Access Road Leading from ESR to The Well Field. Photo Taken Up On The Terrace Prior To Dropping Down To The Well Field.

SGI environmental THE SOURCE GROUP, INC.	EL SUR RANCH BIG SUR, CALIFORNIA			AREA OF SUSPECTED EROSION	
	DATE 3/11/05	DR. BY CP	APP. BY SMc	PROJECT NO. 01-ESR-001	FIGURE NO. 2

ESR--5

Access Road Leading from ESR to The Well Field. Photo Taken Up On The Terrace Prior To Dropping Down To The Well Field.

SGI environmental THE SOURCE GROUP, INC.	EL SUR RANCH BIG SUR, CALIFORNIA			CLOSEUP VIEW AREA OF SUSPECTED EROSION	
	DATE 8/2/05	DR. BY SMc	APP. BY PDH	PROJECT NO. 01-ESR-001	FIGURE NO. 3

ESR--5

Topograhic Depression Leading Away From
The El Sur Ranch
Photo Taken Near Property Boundary
Looking Towards The Southeast

SGI environmental THE SOURCE GROUP, INC.	EL SUR RANCH BIG SUR, CALIFORNIA			DRAINAGE AREA	
	DATE 8/2/05	DR. BY SMc	APP. BY PDH	PROJECT NO. 01-ESR-001	FIGURE NO. 4

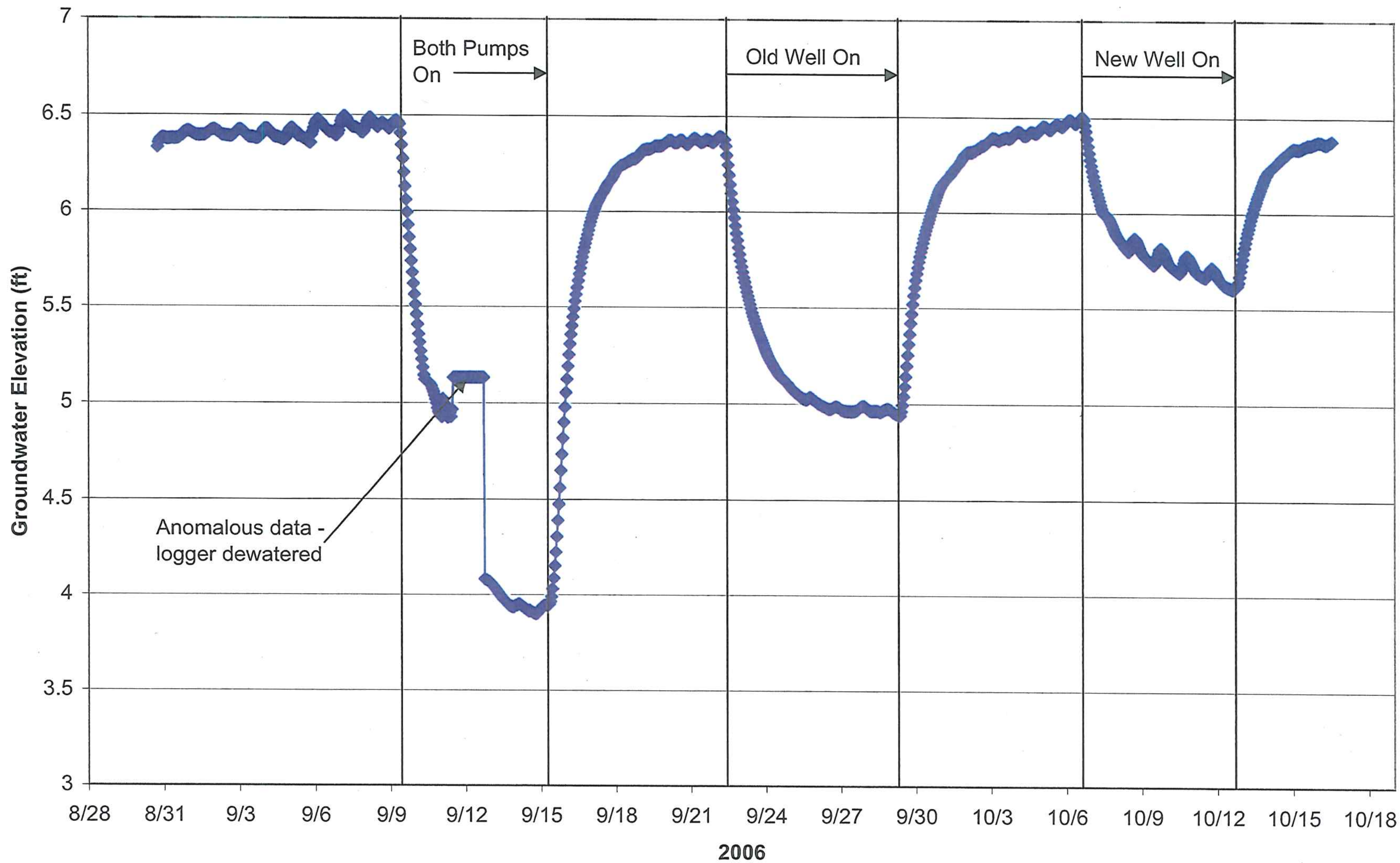
ESR--5

APPENDIX E

APPENDIX E

MONITORING HYDROGRAPHS

ESR-01 Groundwater Elevation



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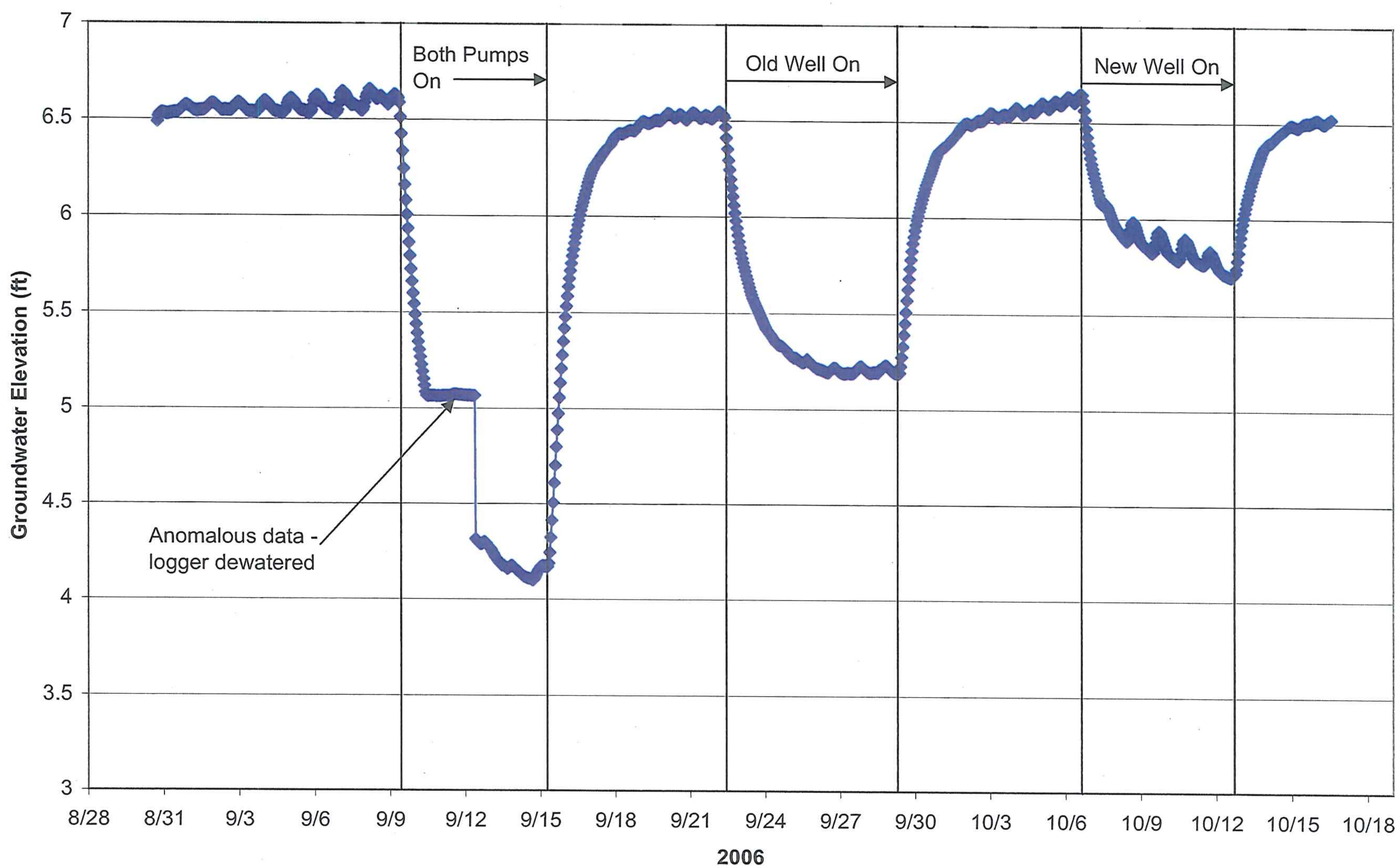
ESR-02 Groundwater Elevation



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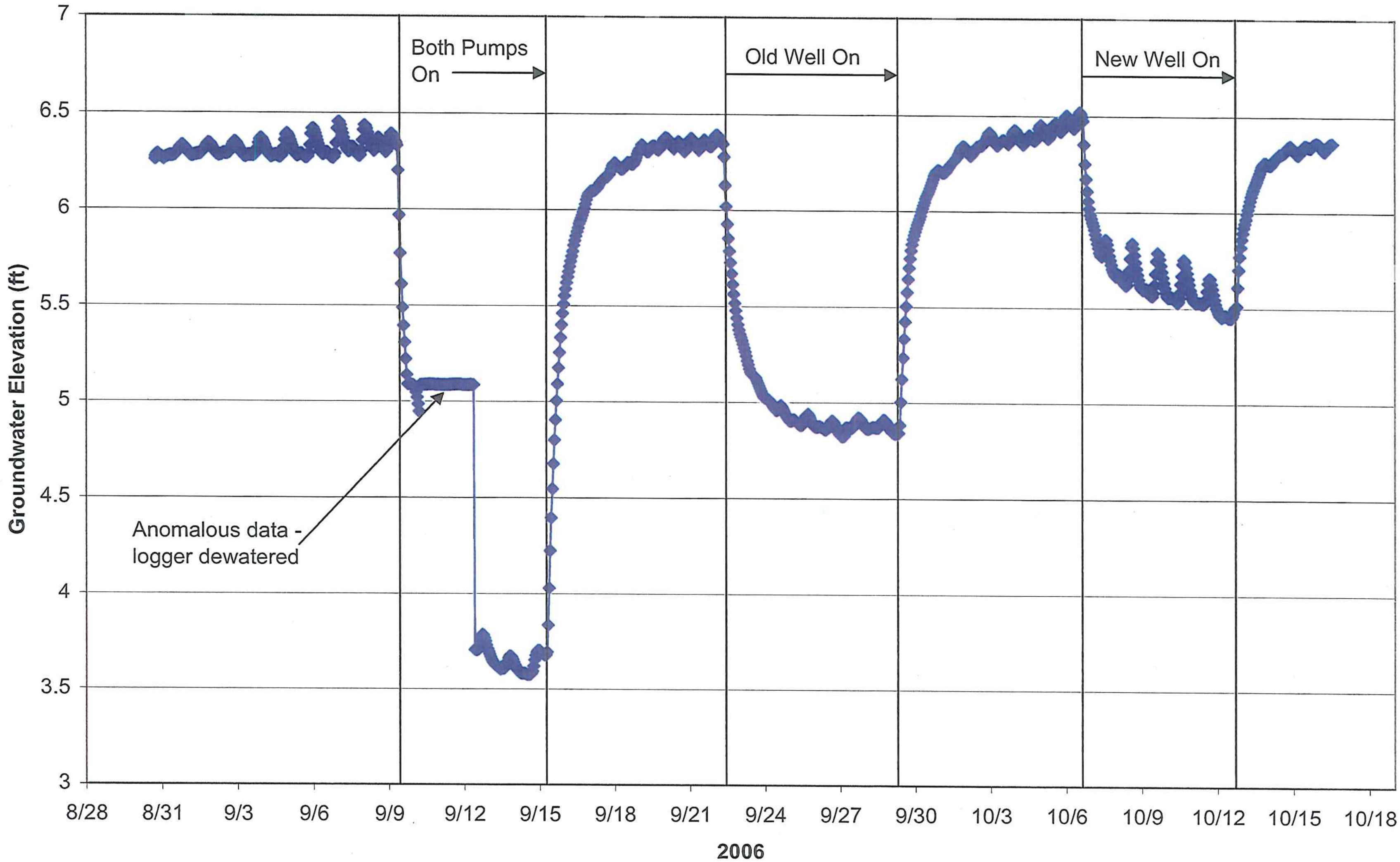
ESR-03 Groundwater Elevation



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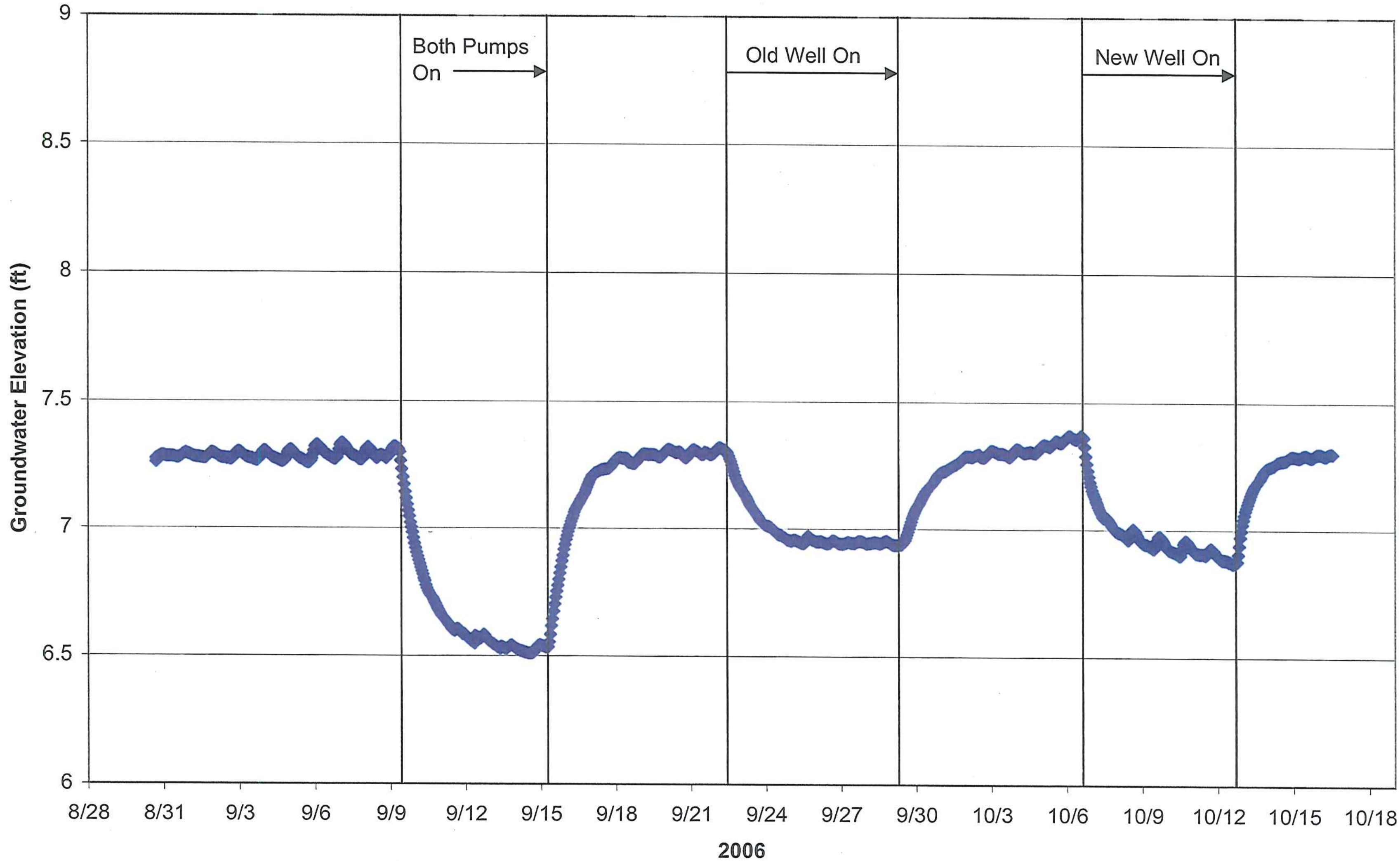
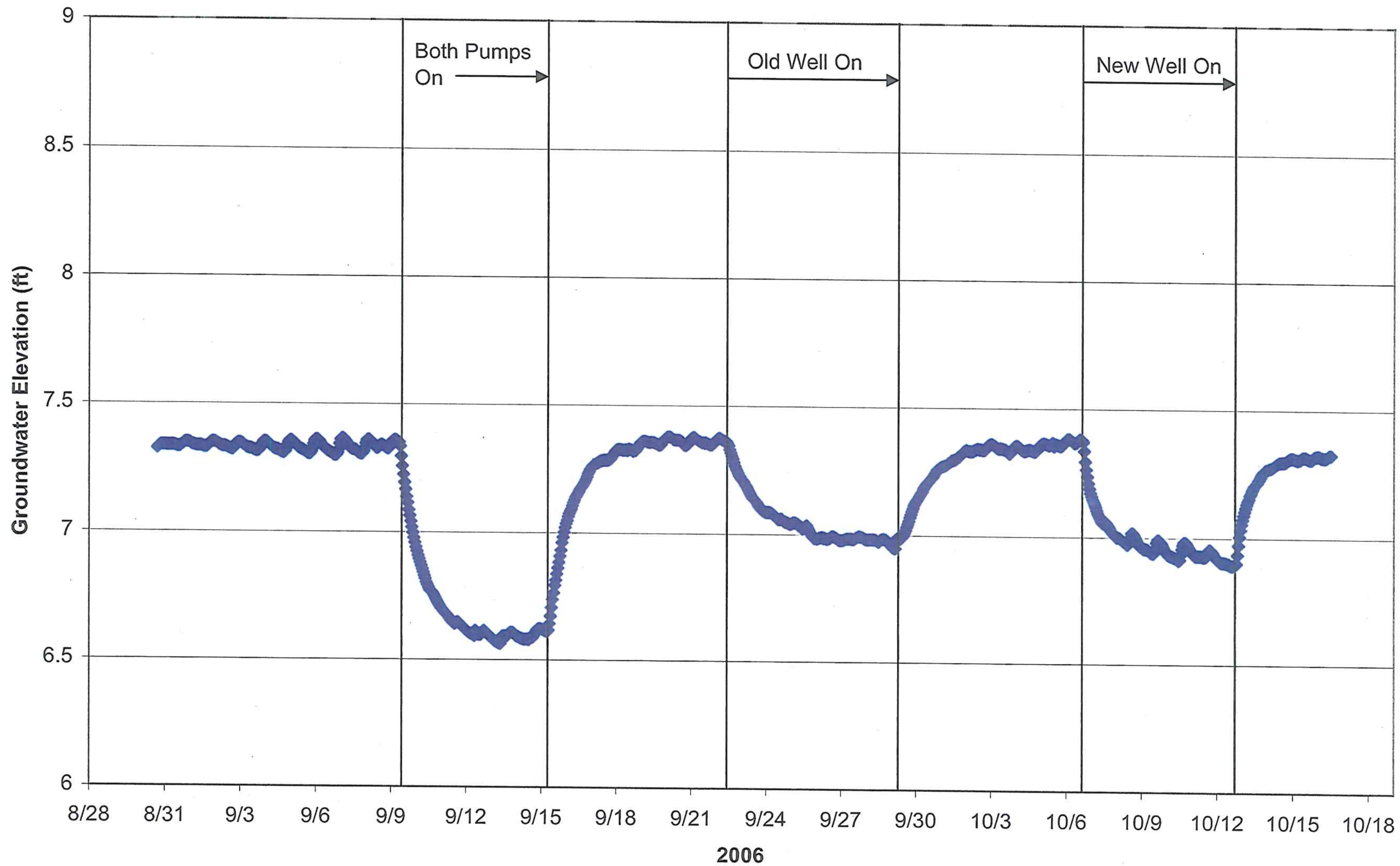
ESR-10A Groundwater Elevation



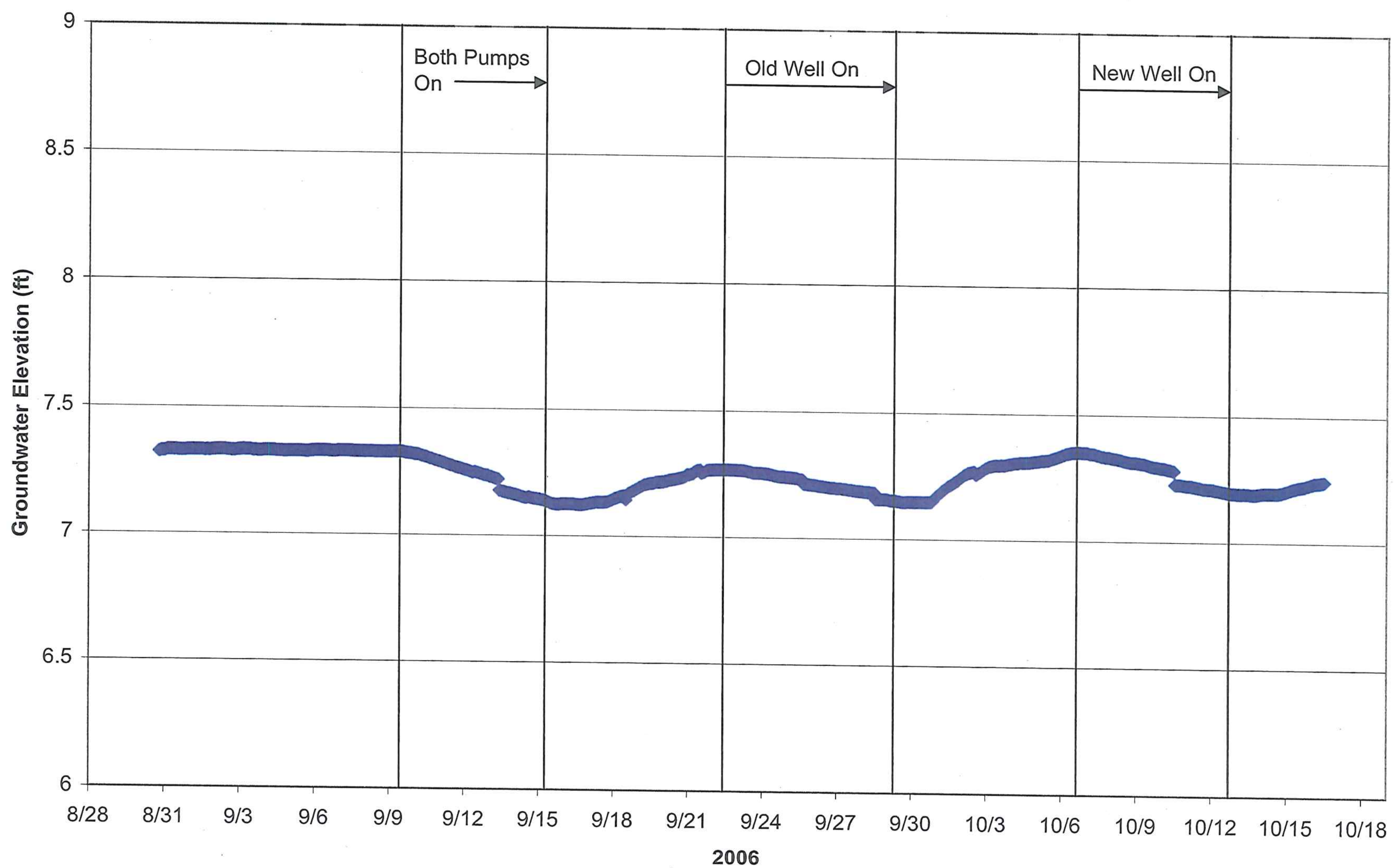
THE SOURCE GROUP, INC.

ESR-10B Groundwater Elevation



THE SOURCE GROUP, INC.
SGI environmental

ESR-10C Groundwater Elevation



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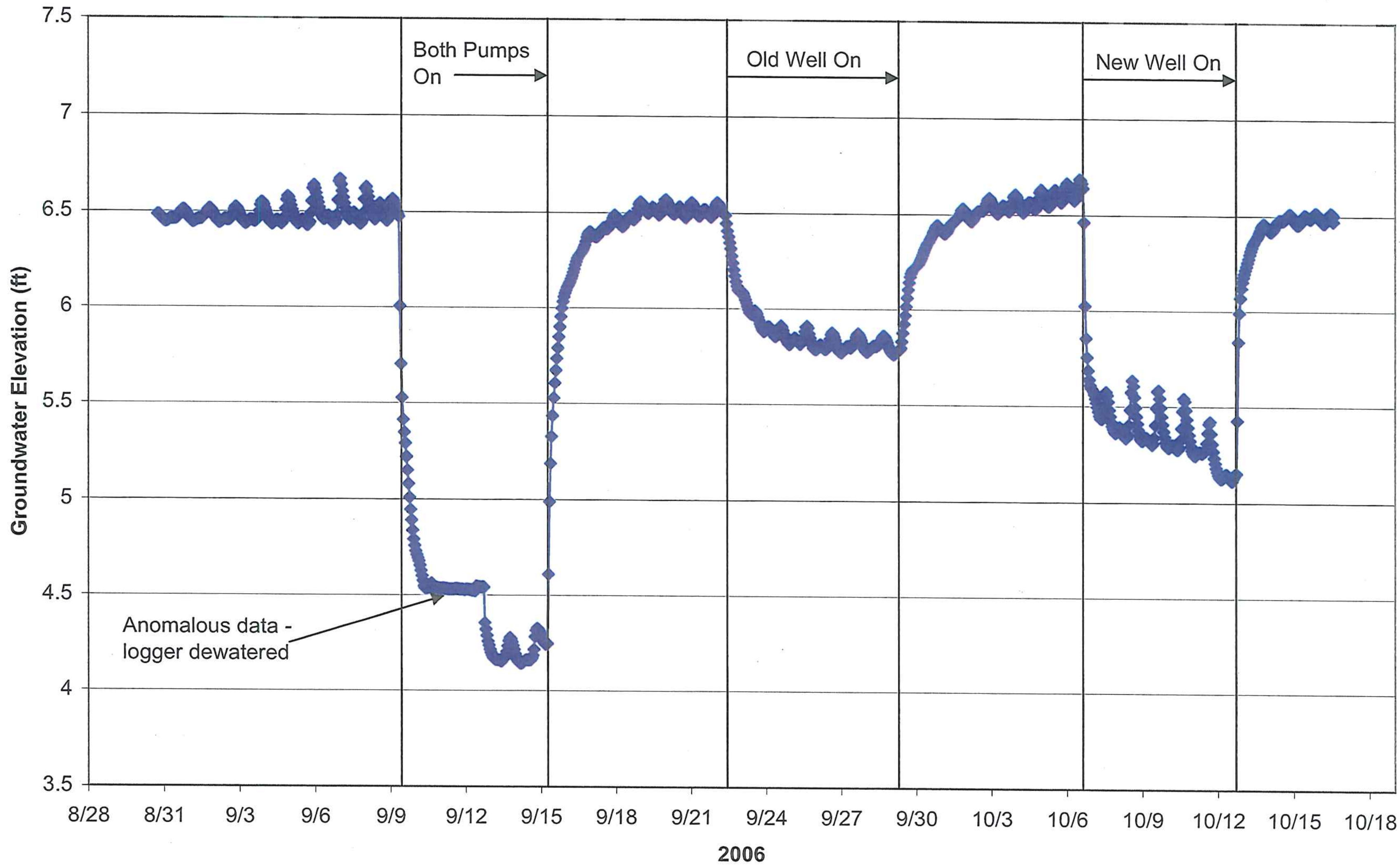
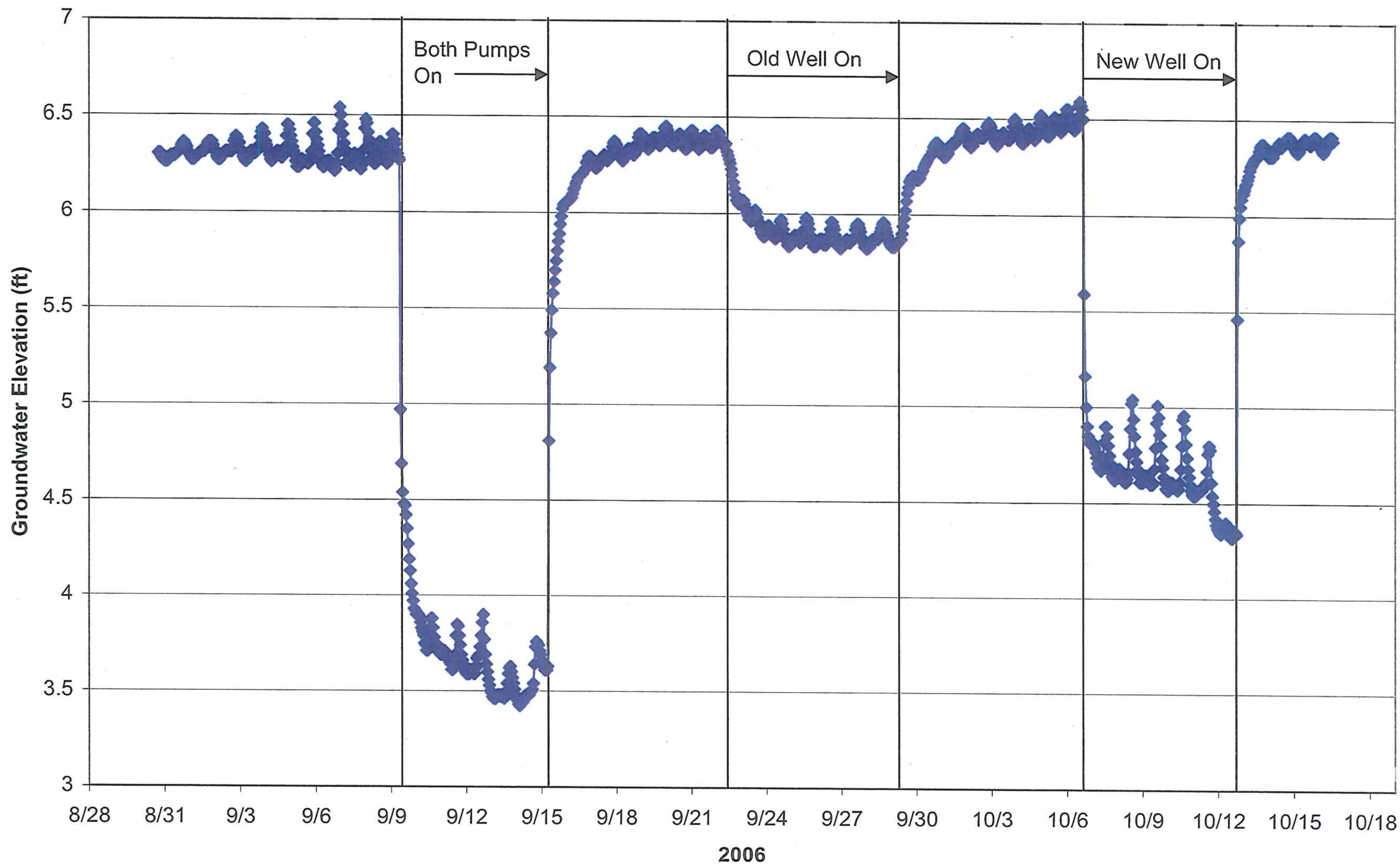
JSA-03 Groundwater Elevation



SGI environmental THE SOURCE GROUP, INC.

JSA-04 Groundwater Elevation



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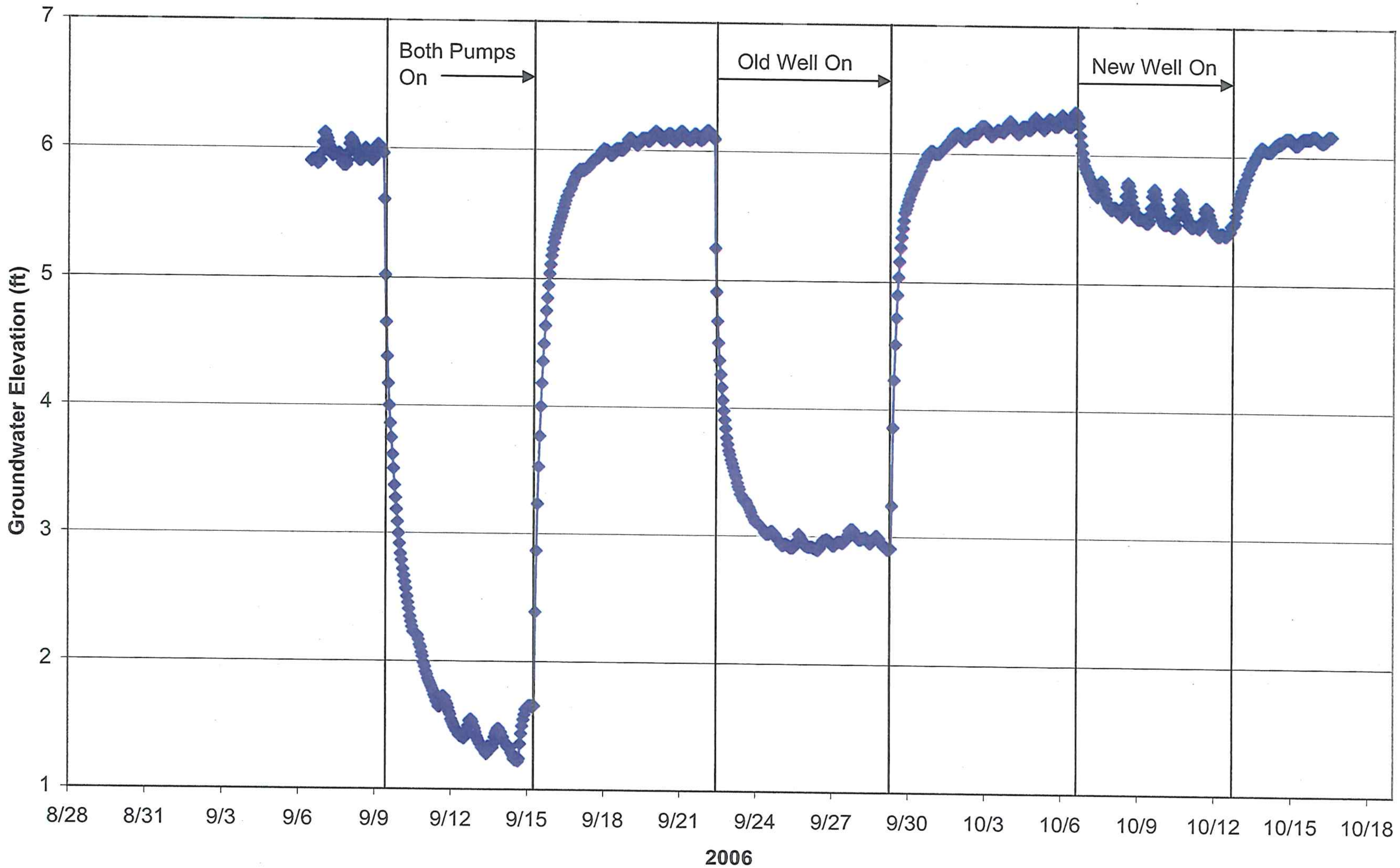
ORIGINAL OLD WELL Groundwater Elevation



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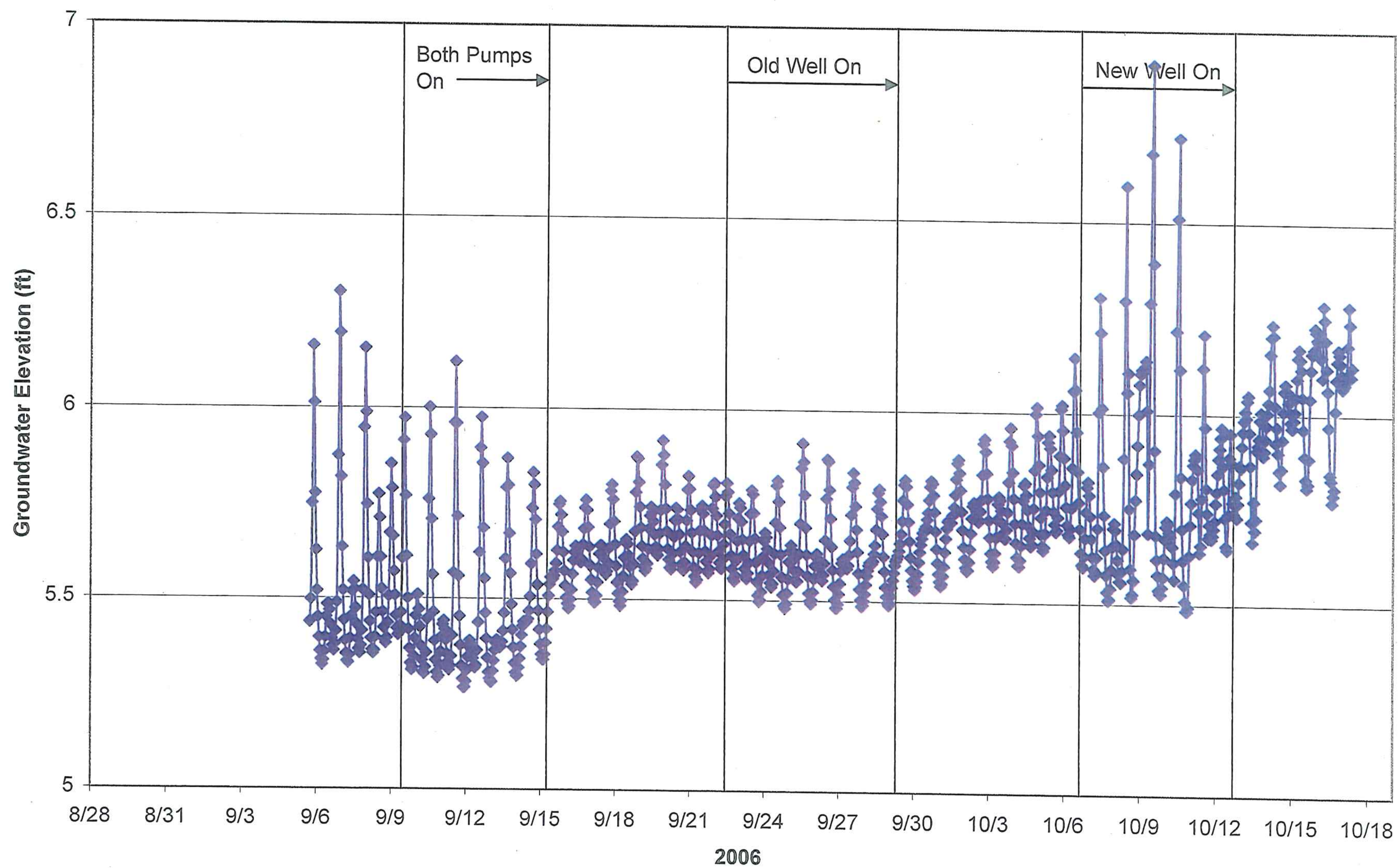
APPENDIX F

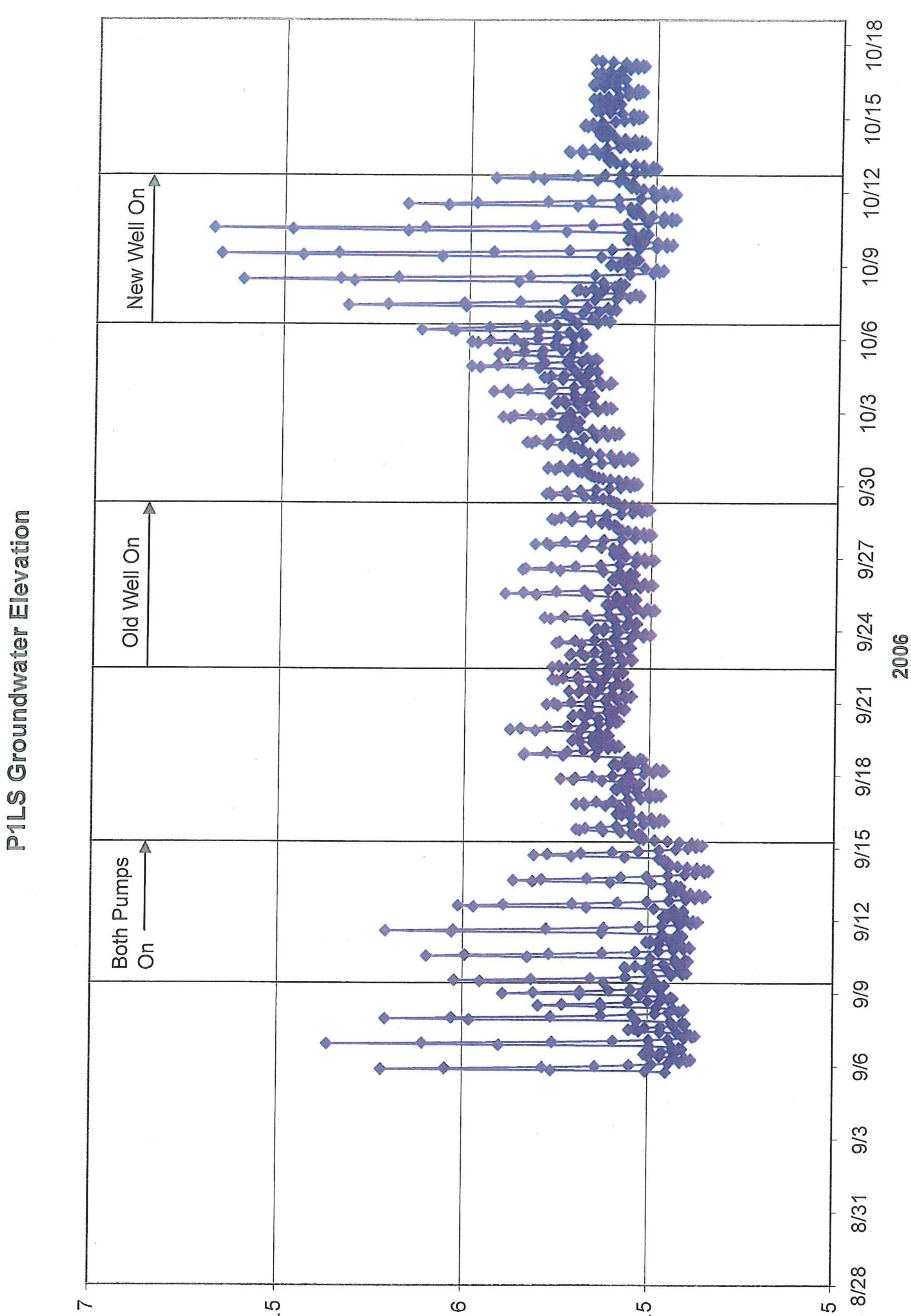
APPENDIX F

RIVER PIEZOMETER HYDROGRAPHS

P1LD Groundwater Elevation

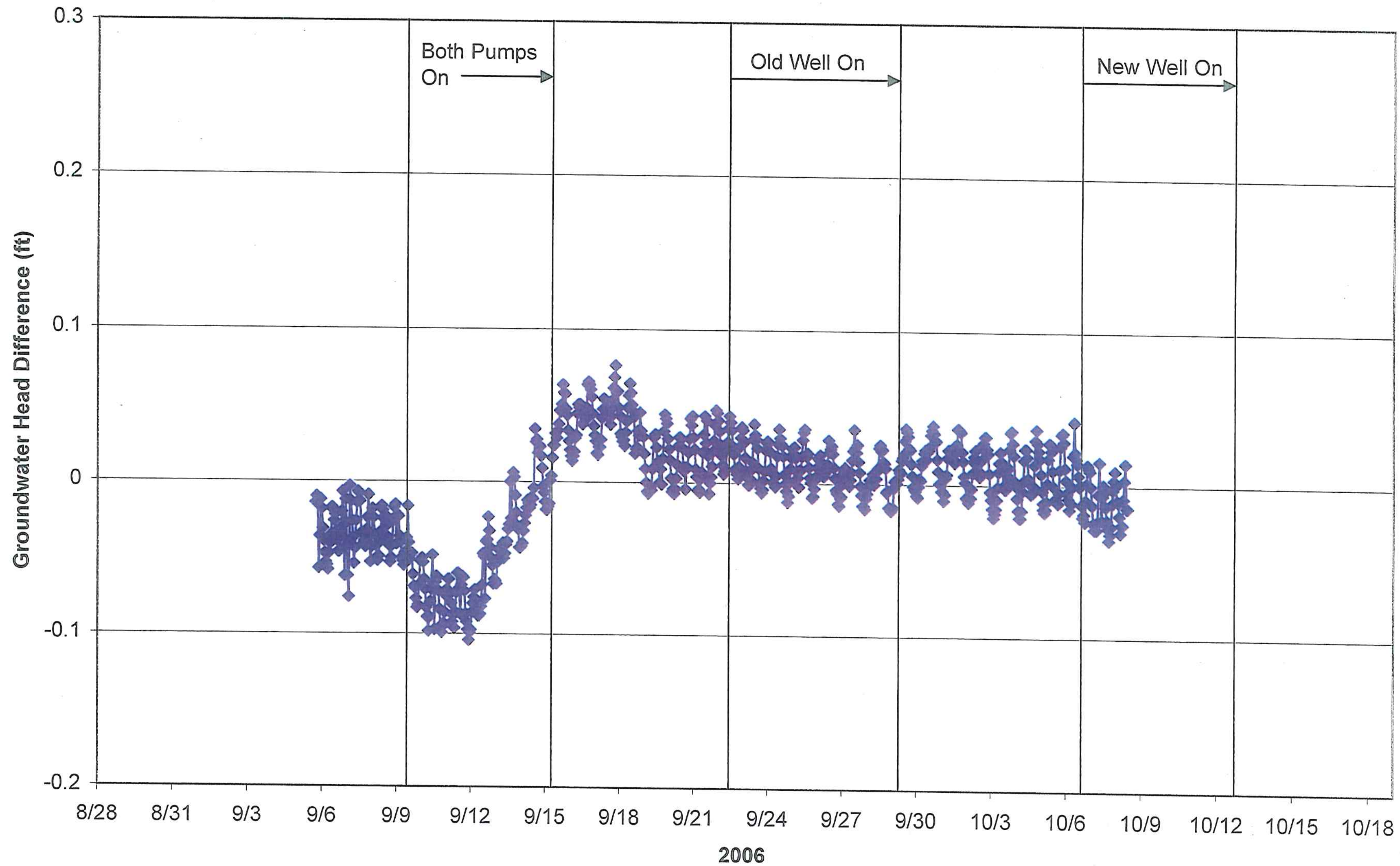


SGI environmental THE SOURCE GROUP, INC.



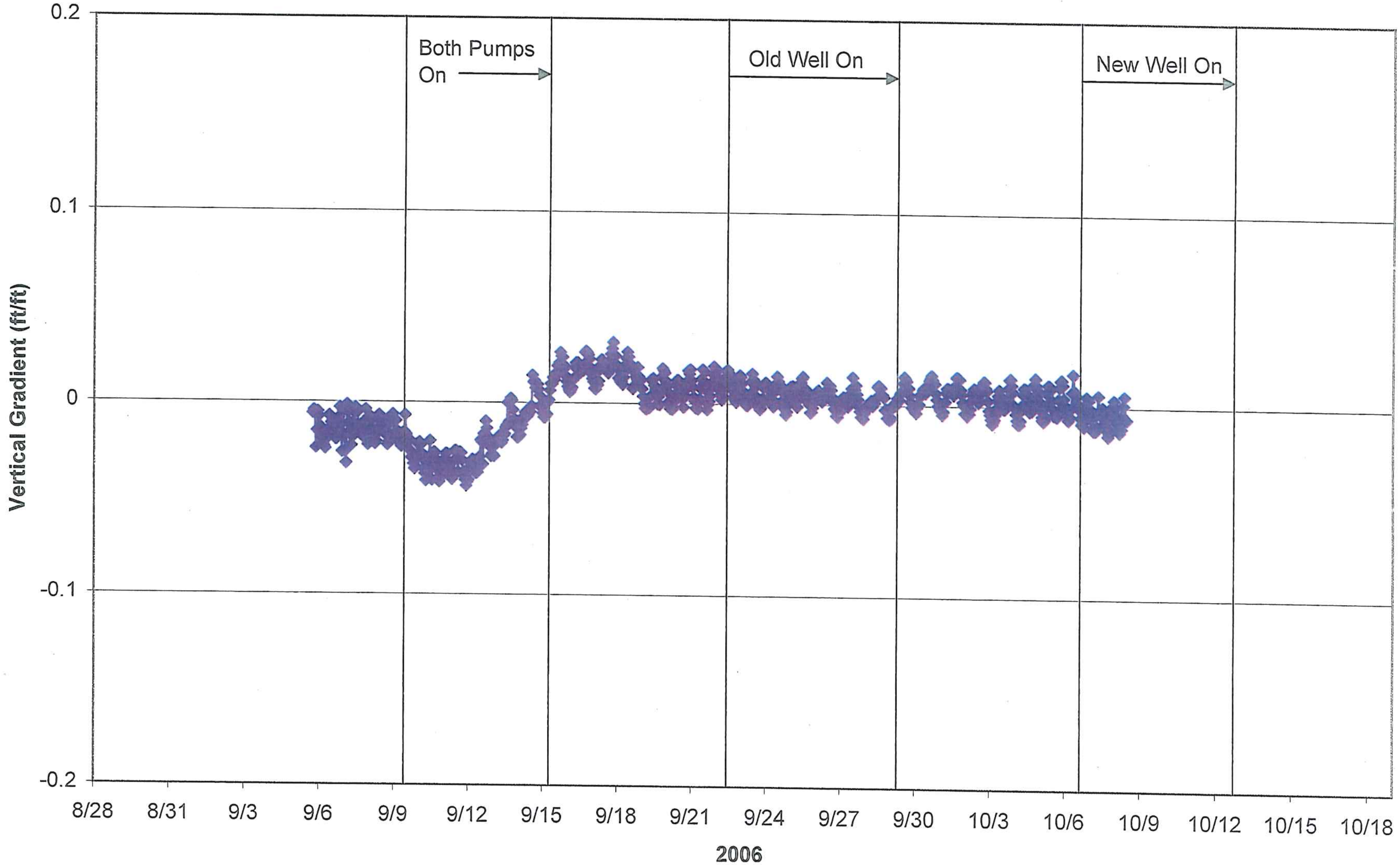
SGI environmental THE SOURCE GROUP, INC.

P1LD - P1LS Head Difference



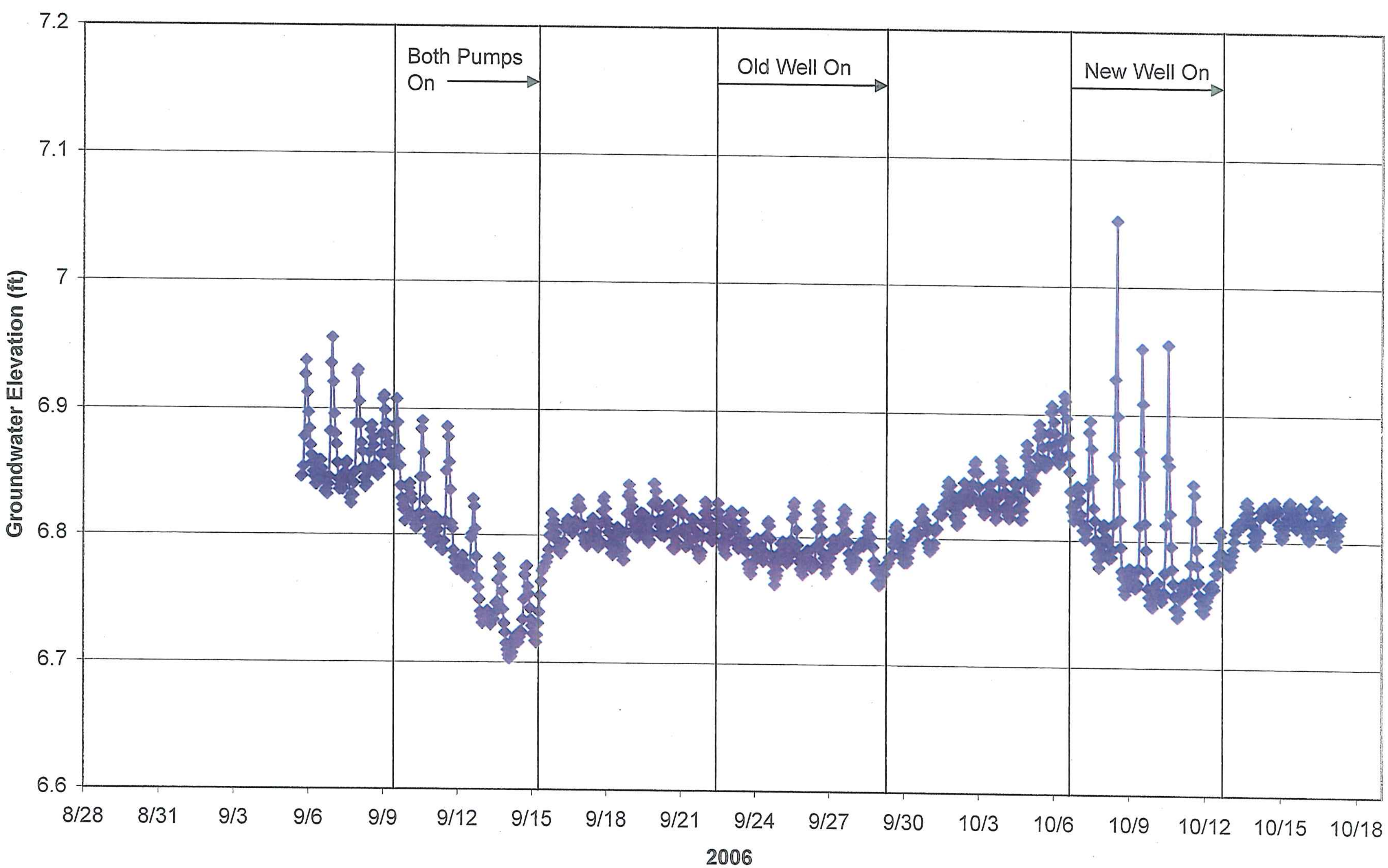
SGI environmental THE SOURCE GROUP, INC.

P1L Vertical Gradient



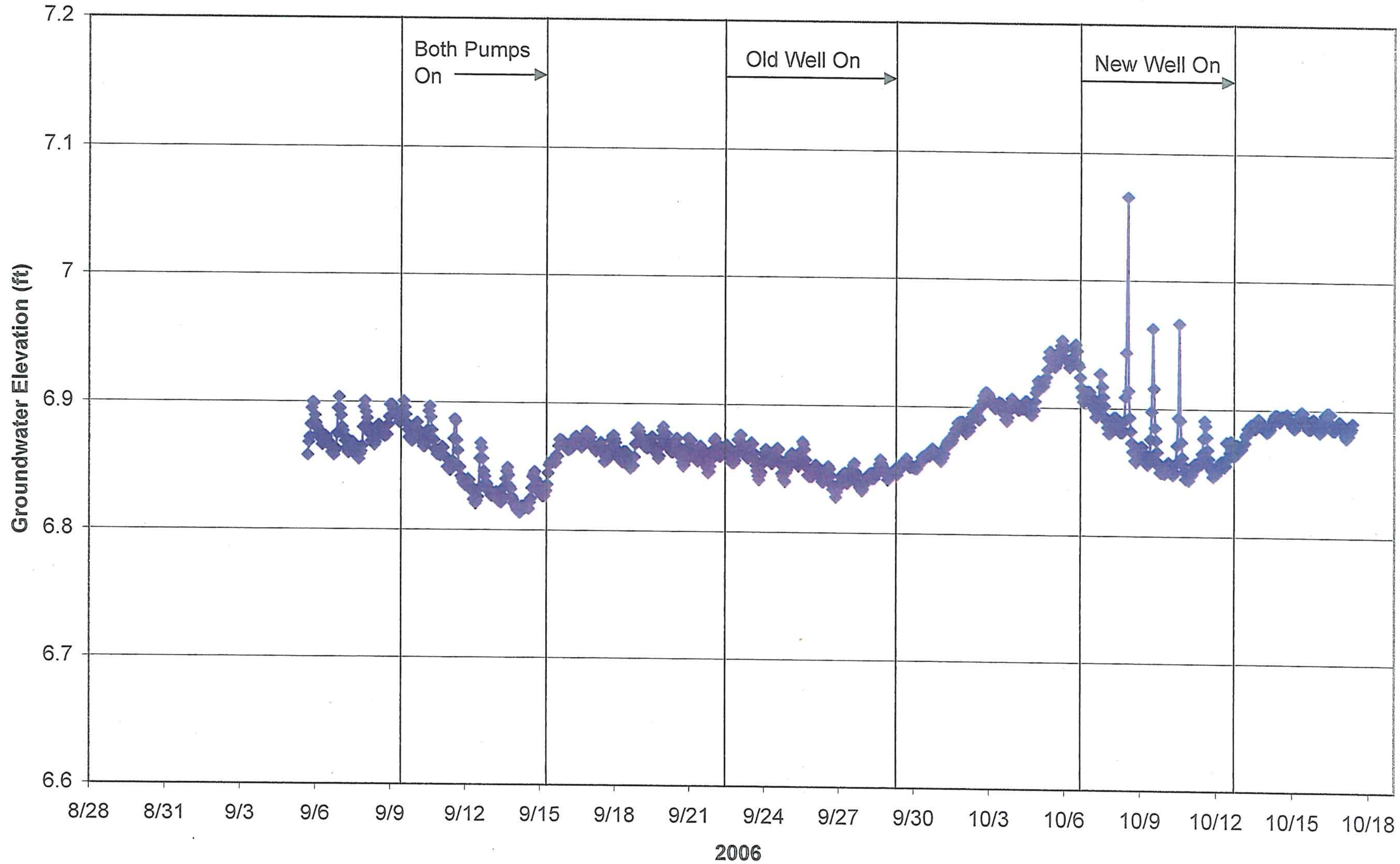
SGI environmental THE SOURCE GROUP, INC.

P2LD Groundwater Elevation



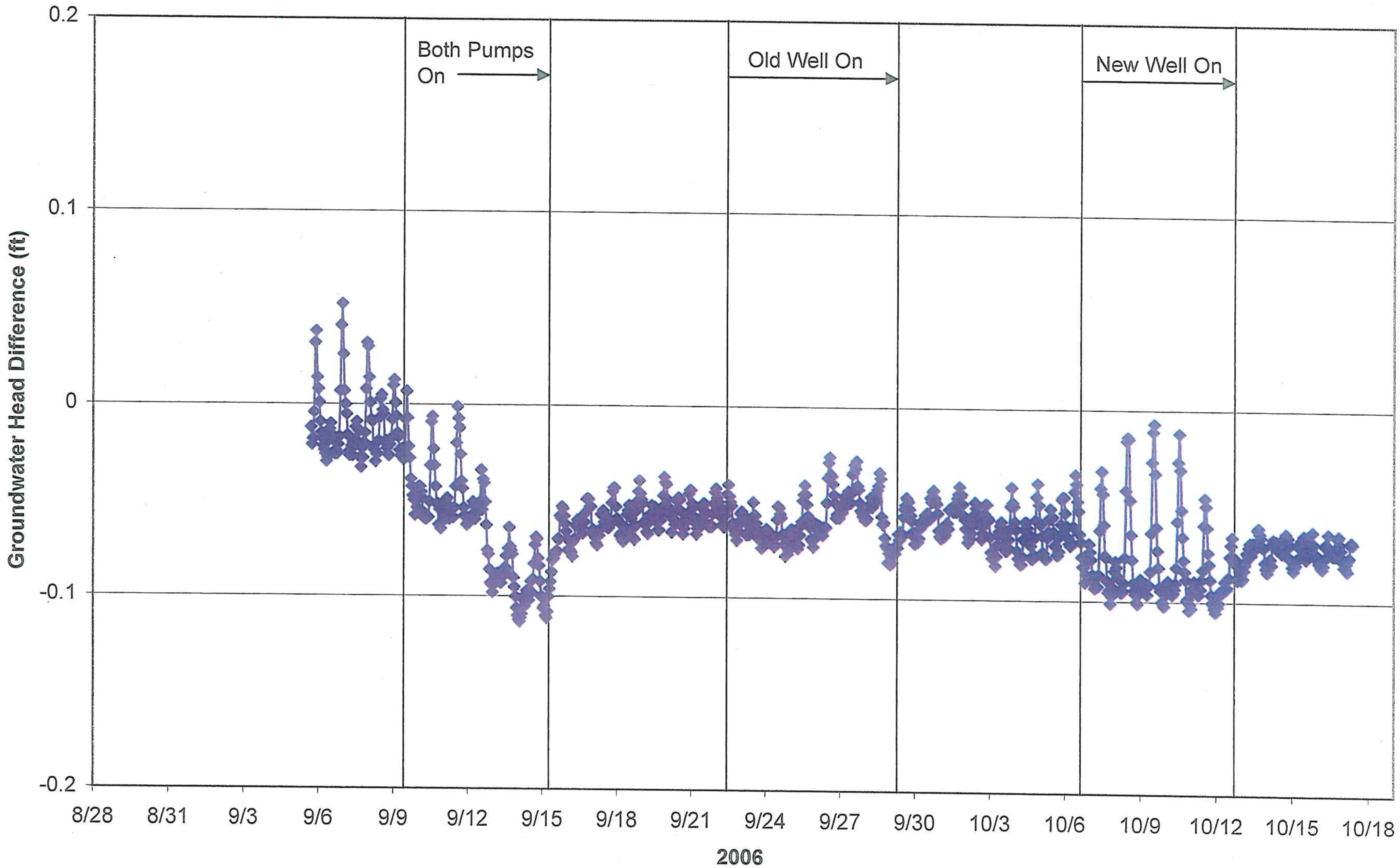
SGI environmental THE SOURCE GROUP, INC.

P2LS Groundwater Elevation



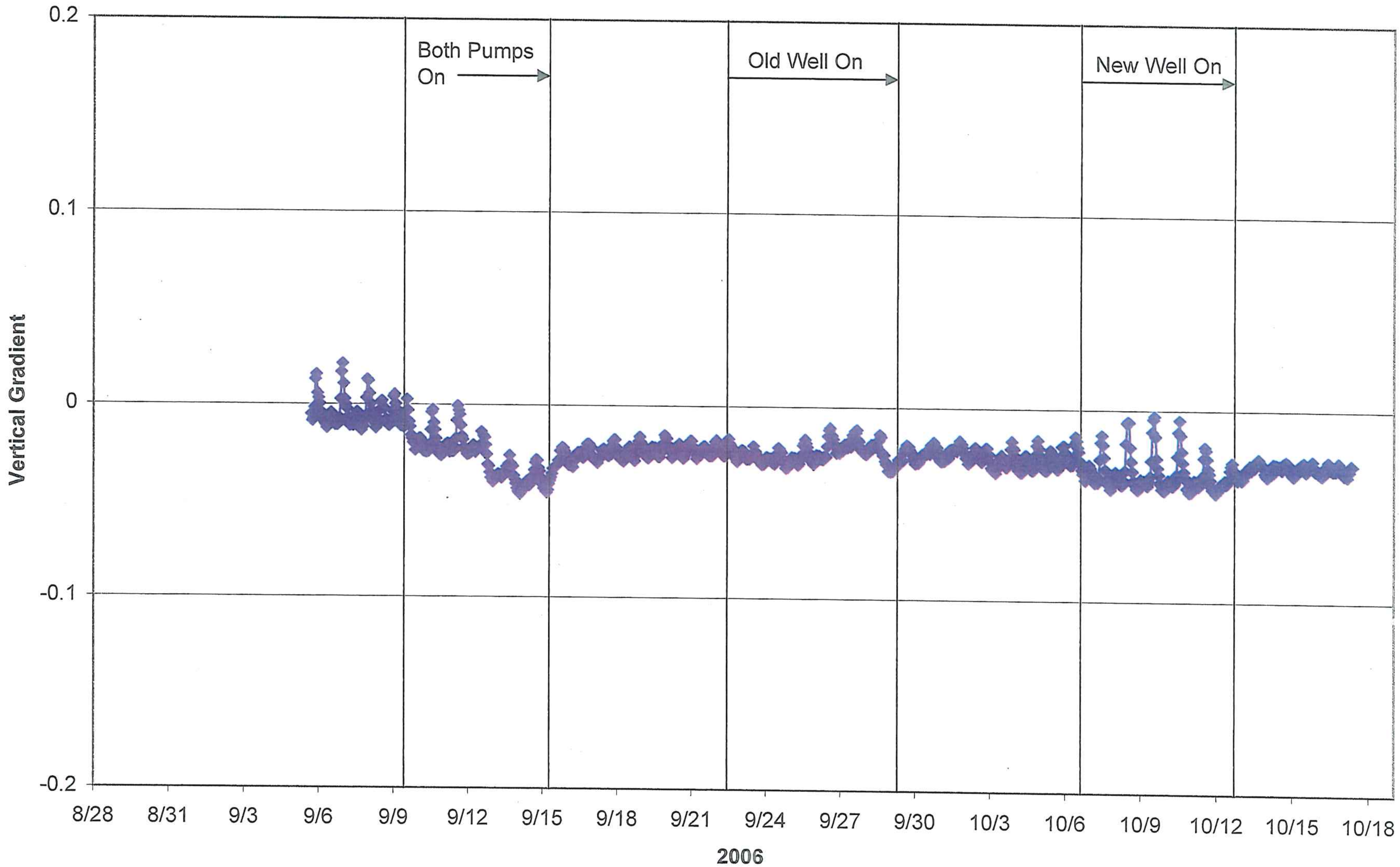
SGI environmental THE SOURCE GROUP, INC.

P2LD - P2LS Head Difference



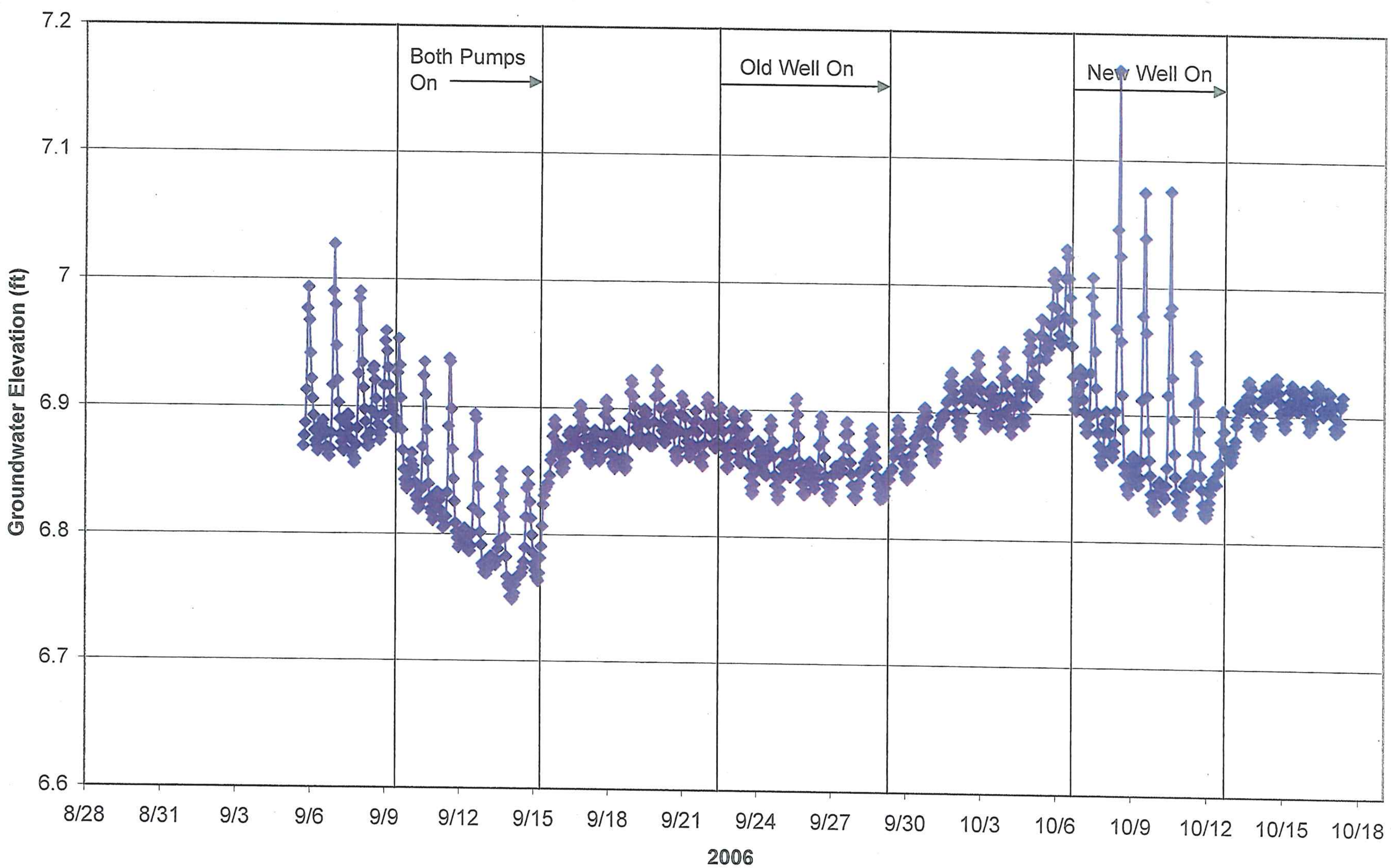
SGI environmental THE SOURCE GROUP, INC.

P2L Vertical Gradient

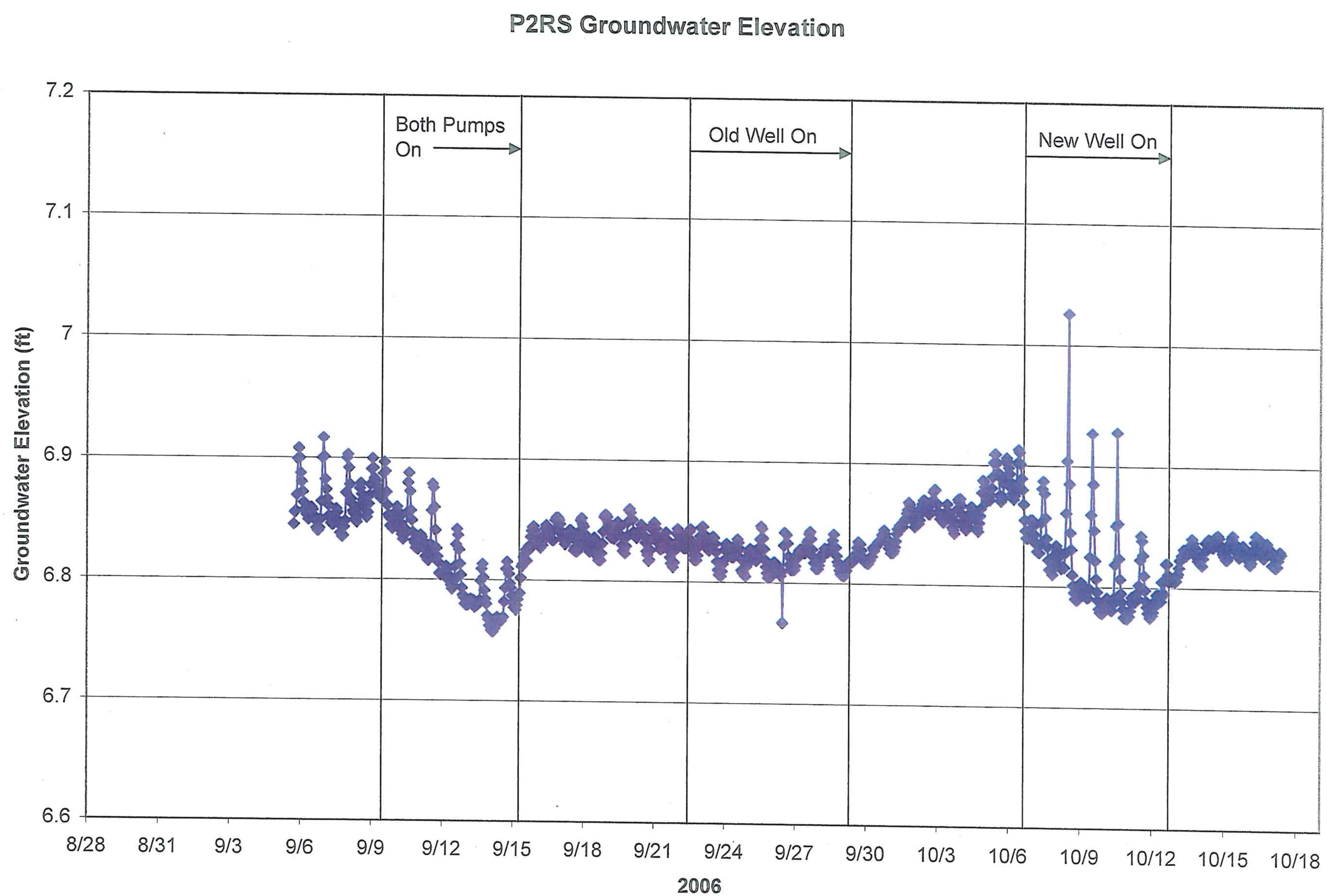


SGI environmental THE SOURCE GROUP, INC.

P2RD Groundwater Elevation



SGI environmental THE SOURCE GROUP, INC.



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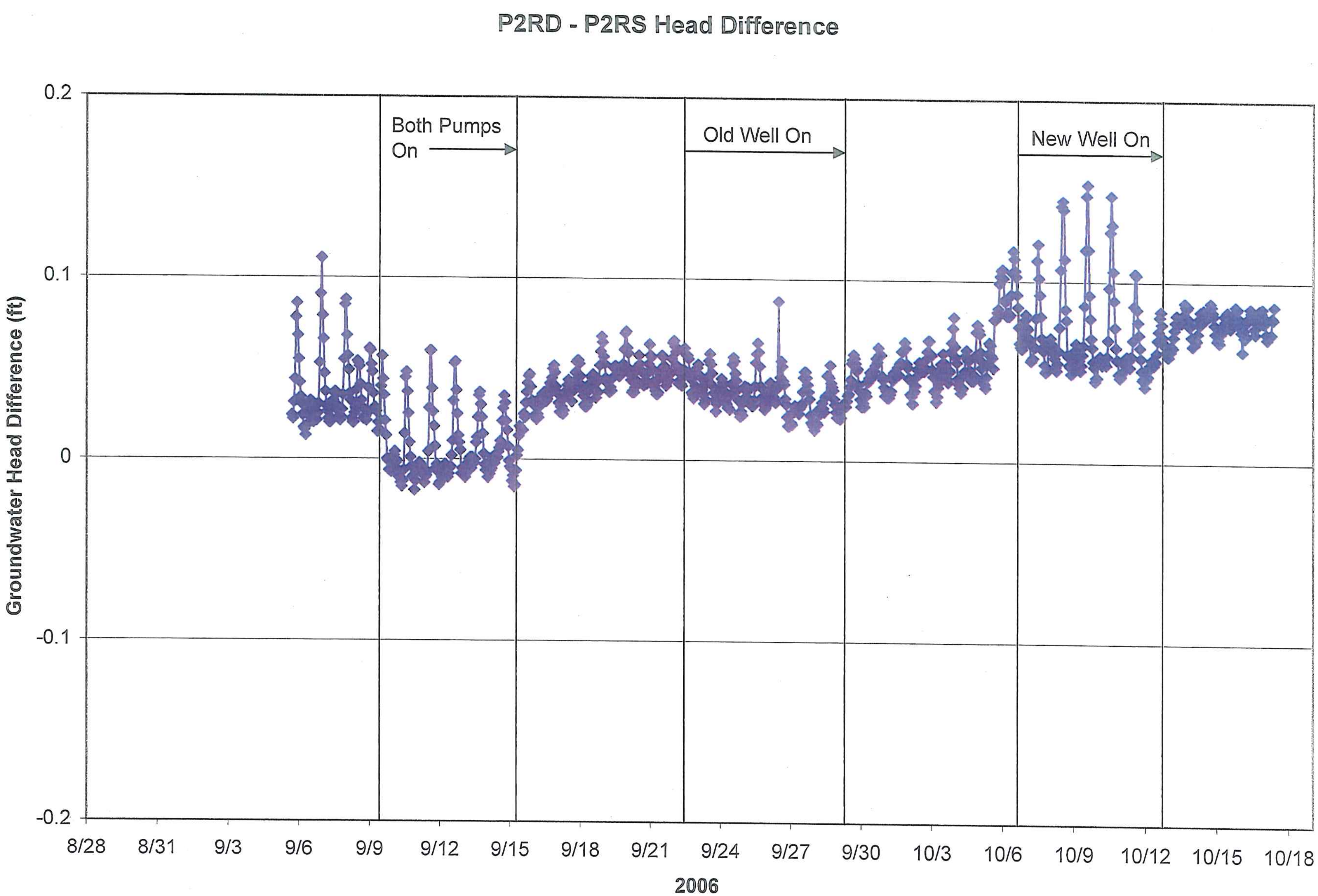
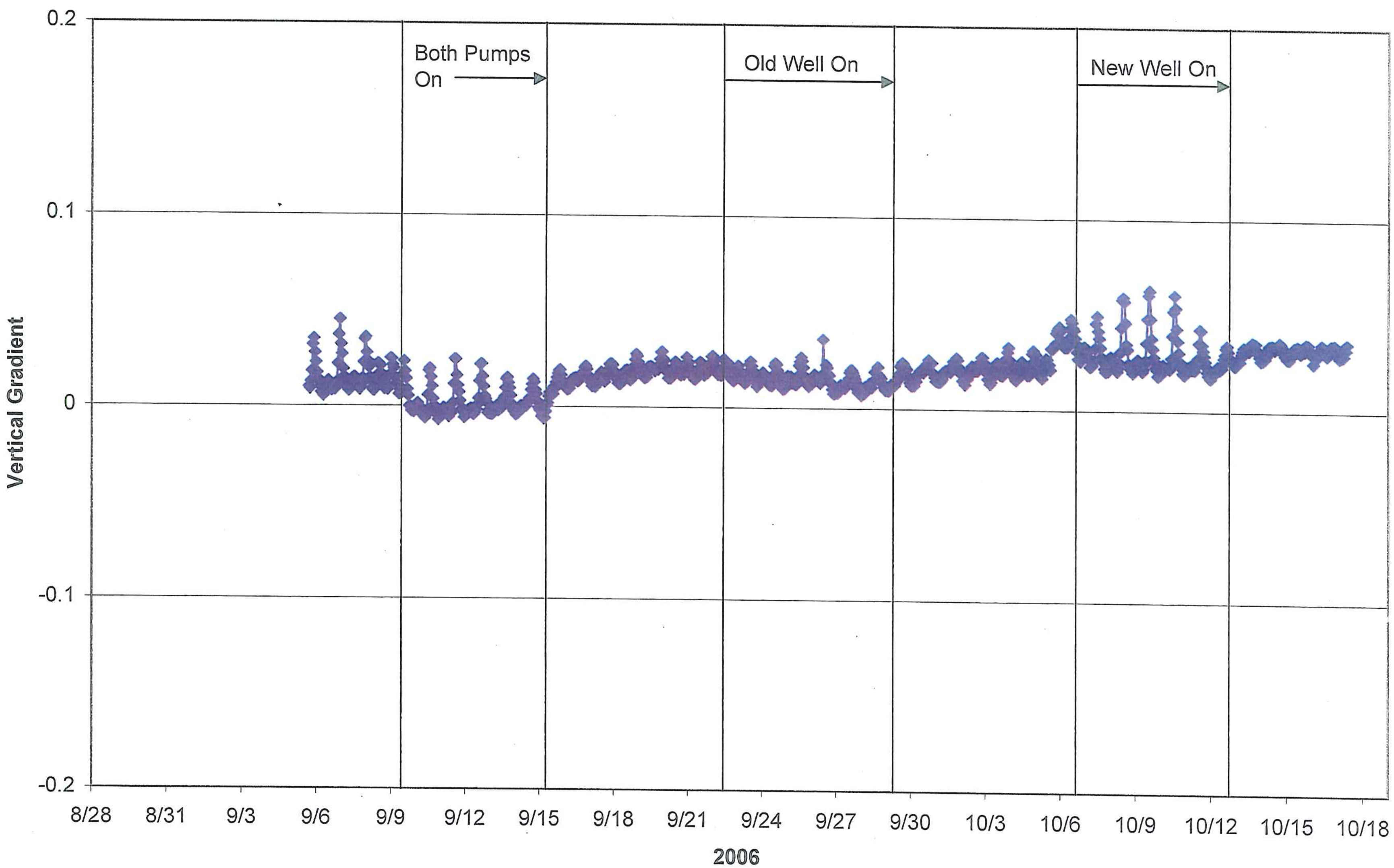


THE SOURCE GROUP, INC.

P2R Vertical Gradient



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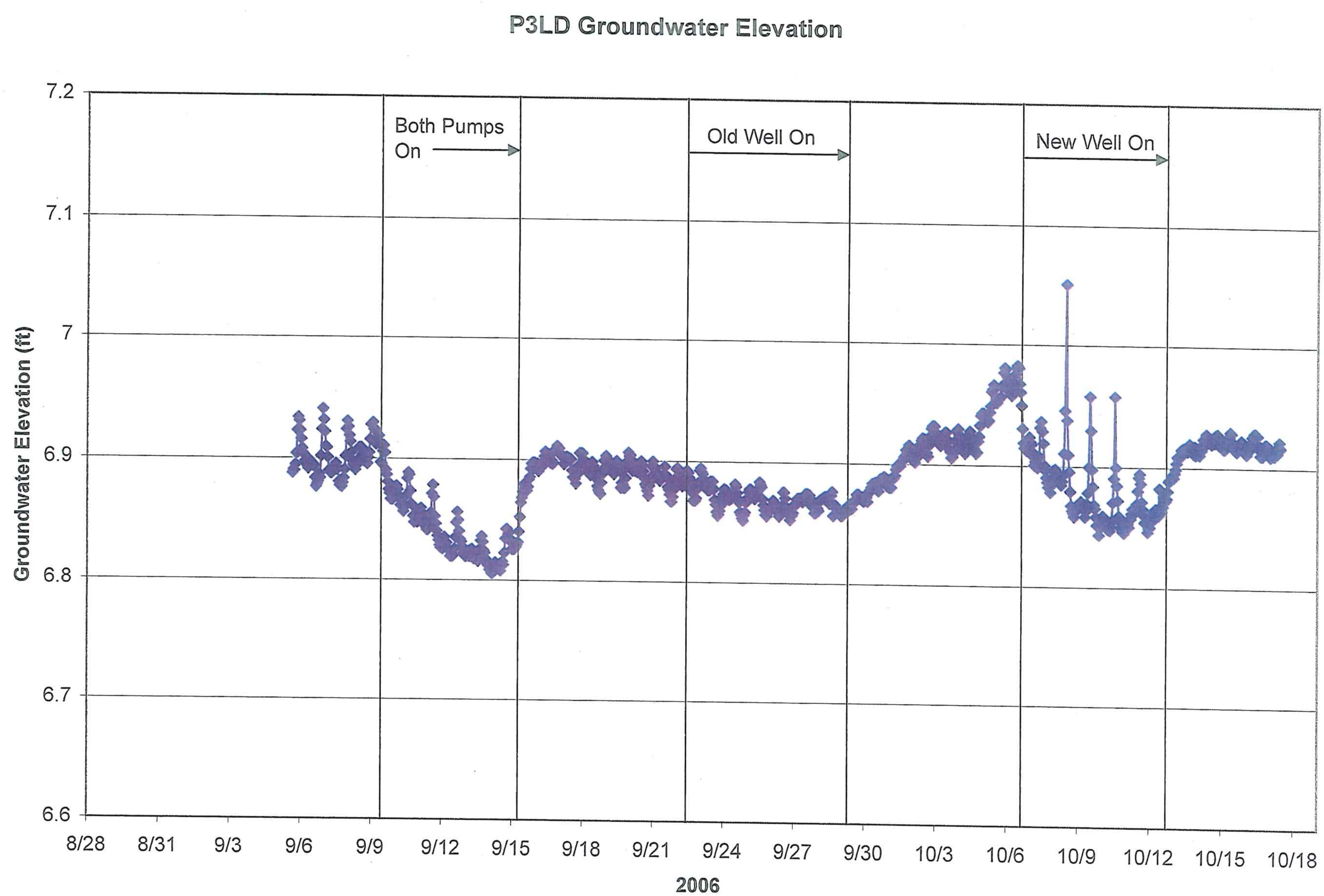

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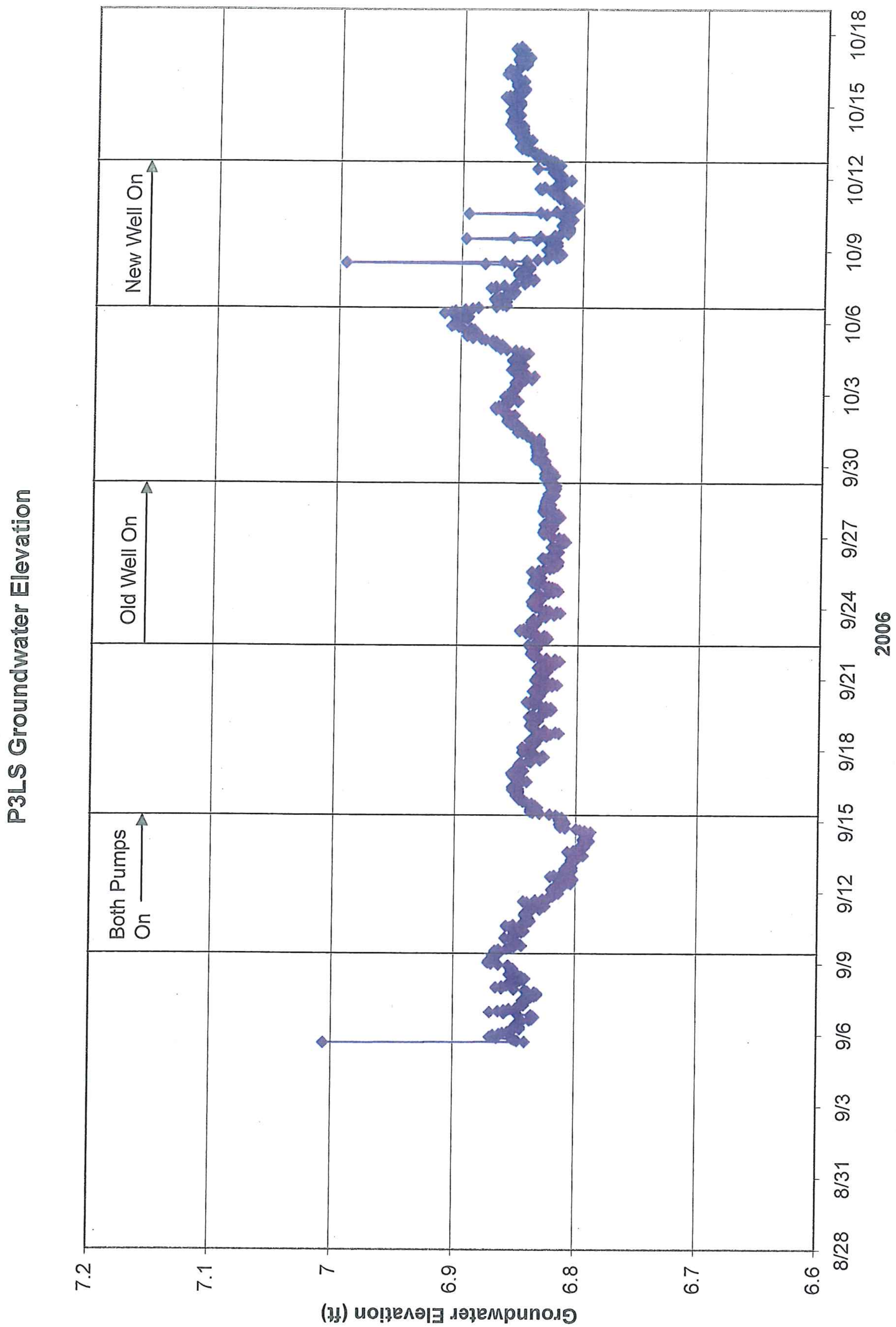

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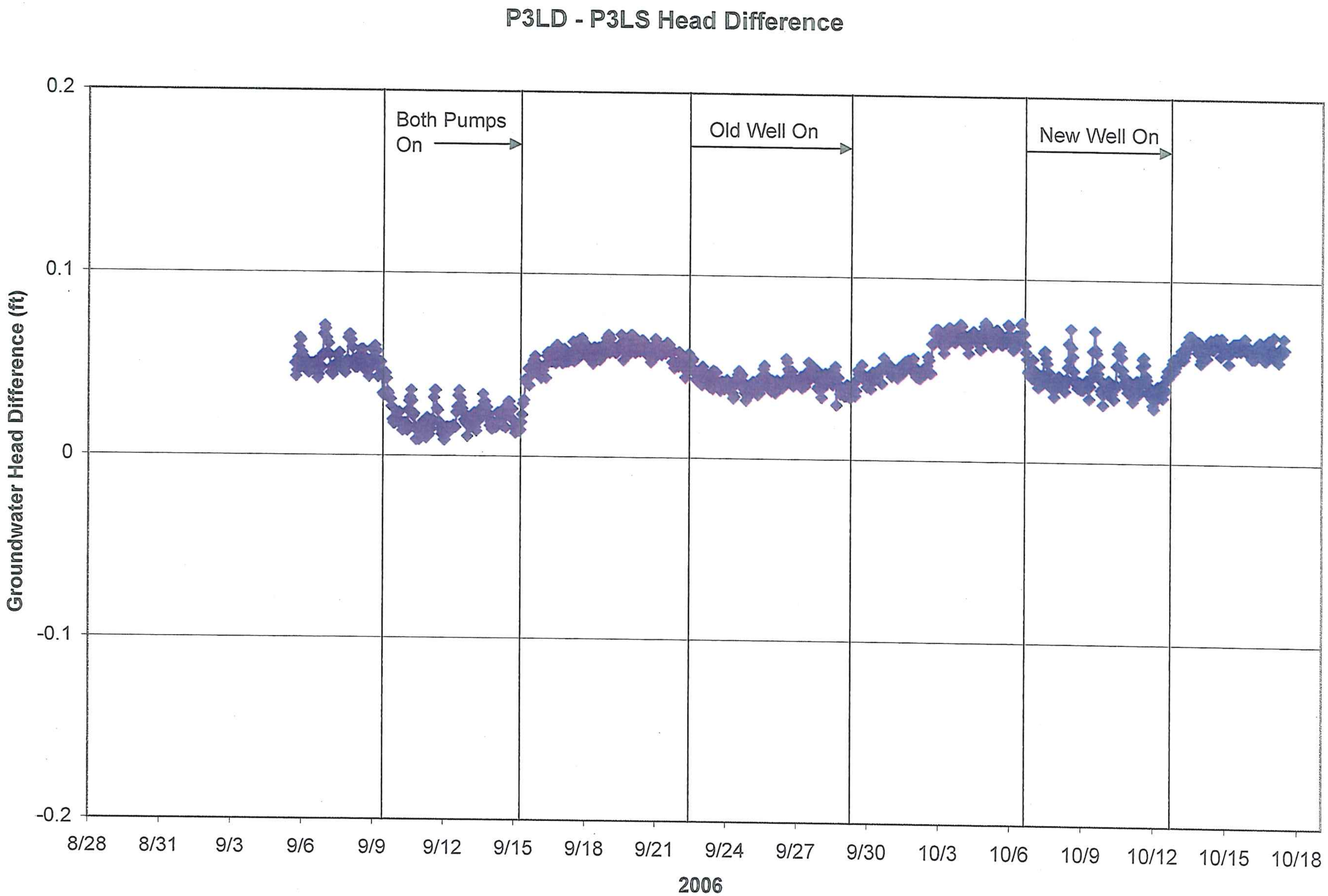
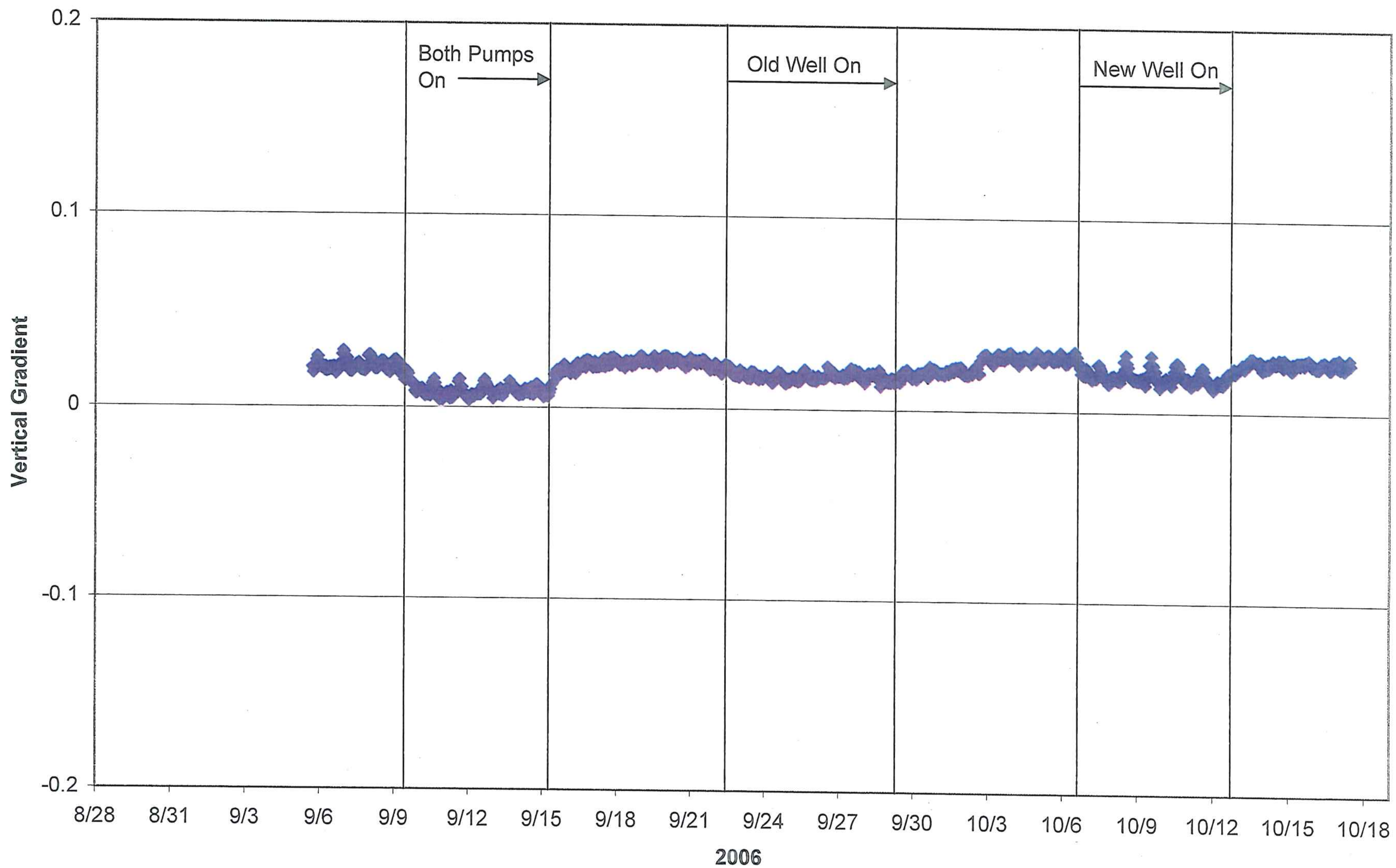


THE SOURCE GROUP, INC.

P3L Vertical Gradient



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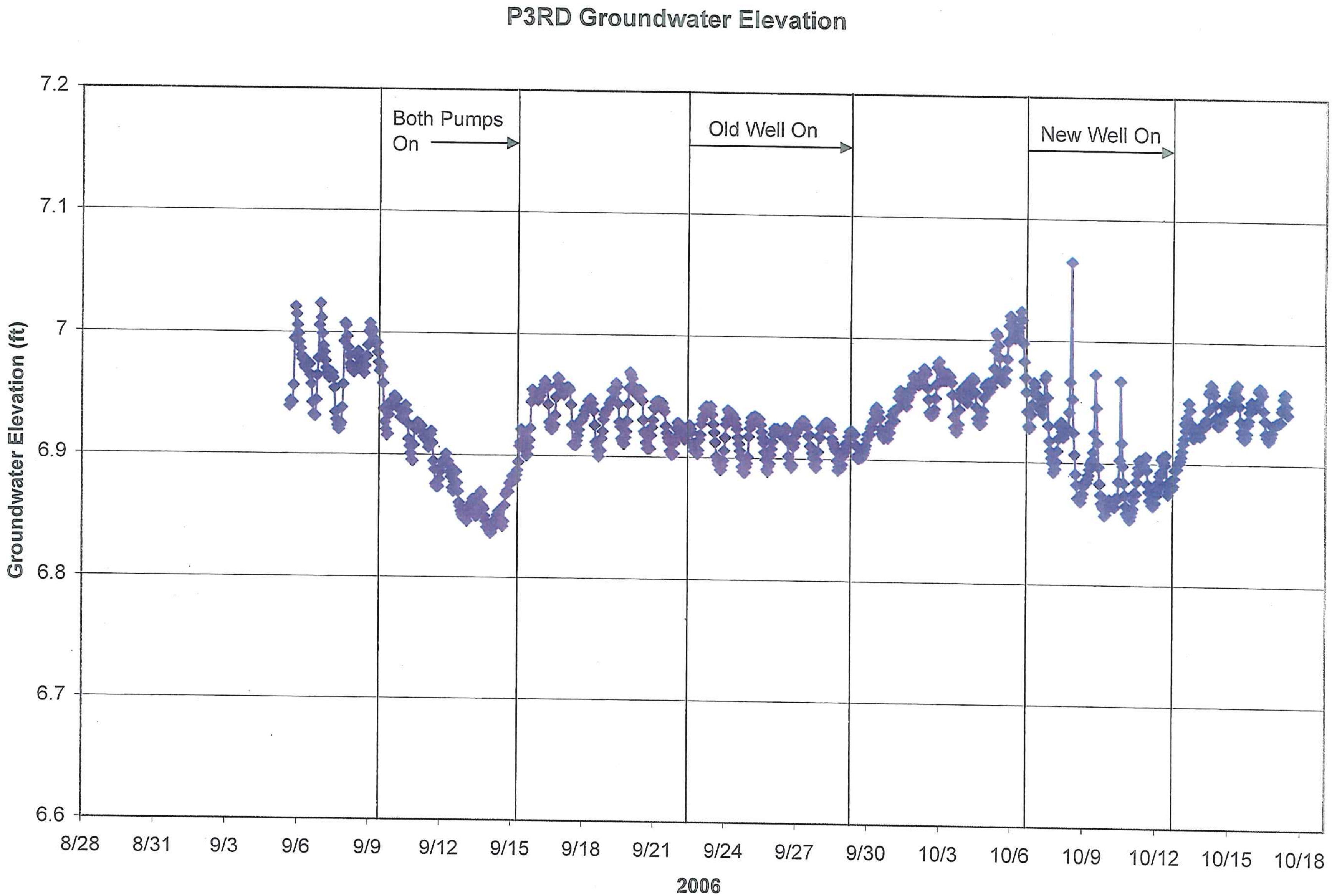

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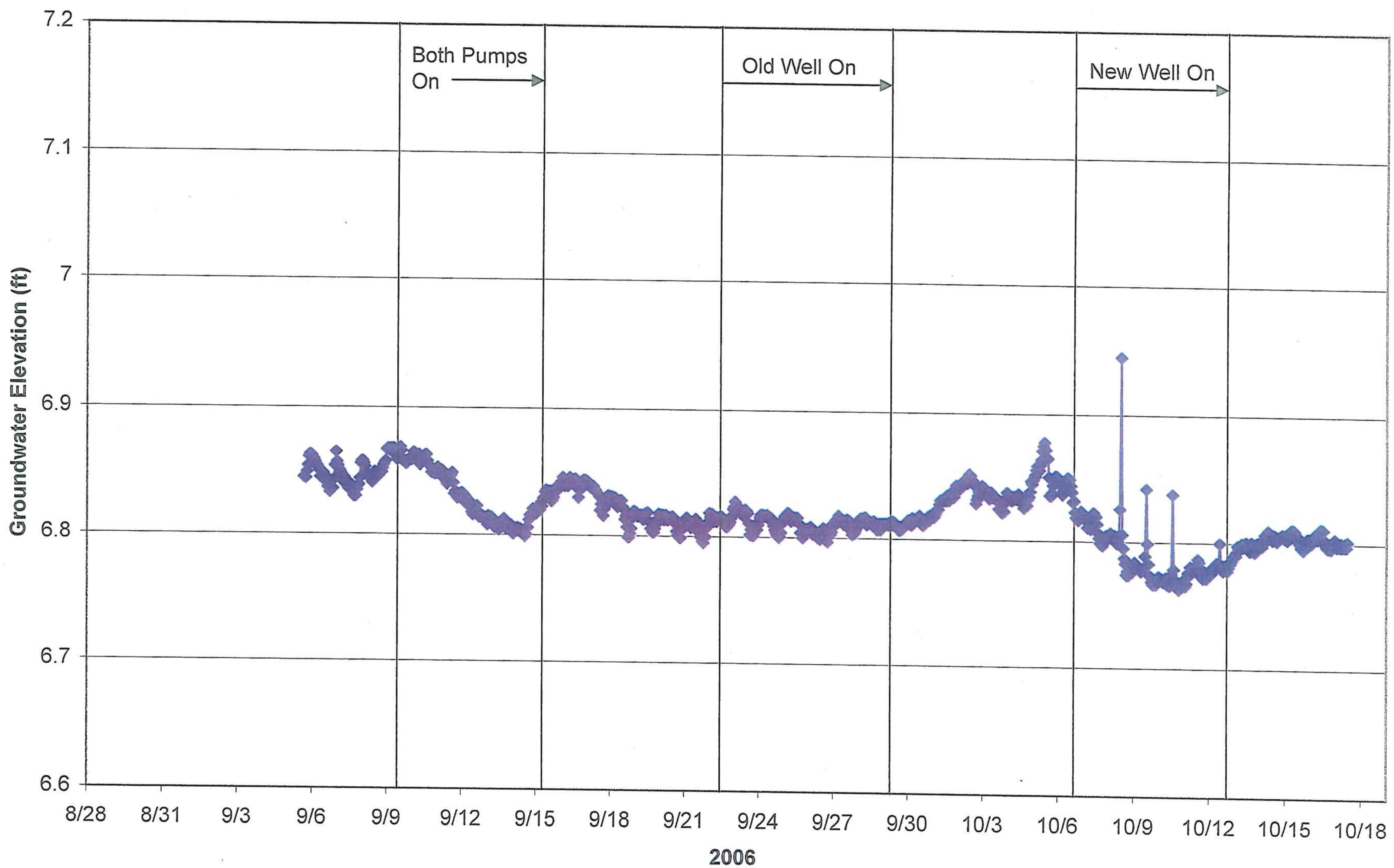
P3RS Groundwater Elevation



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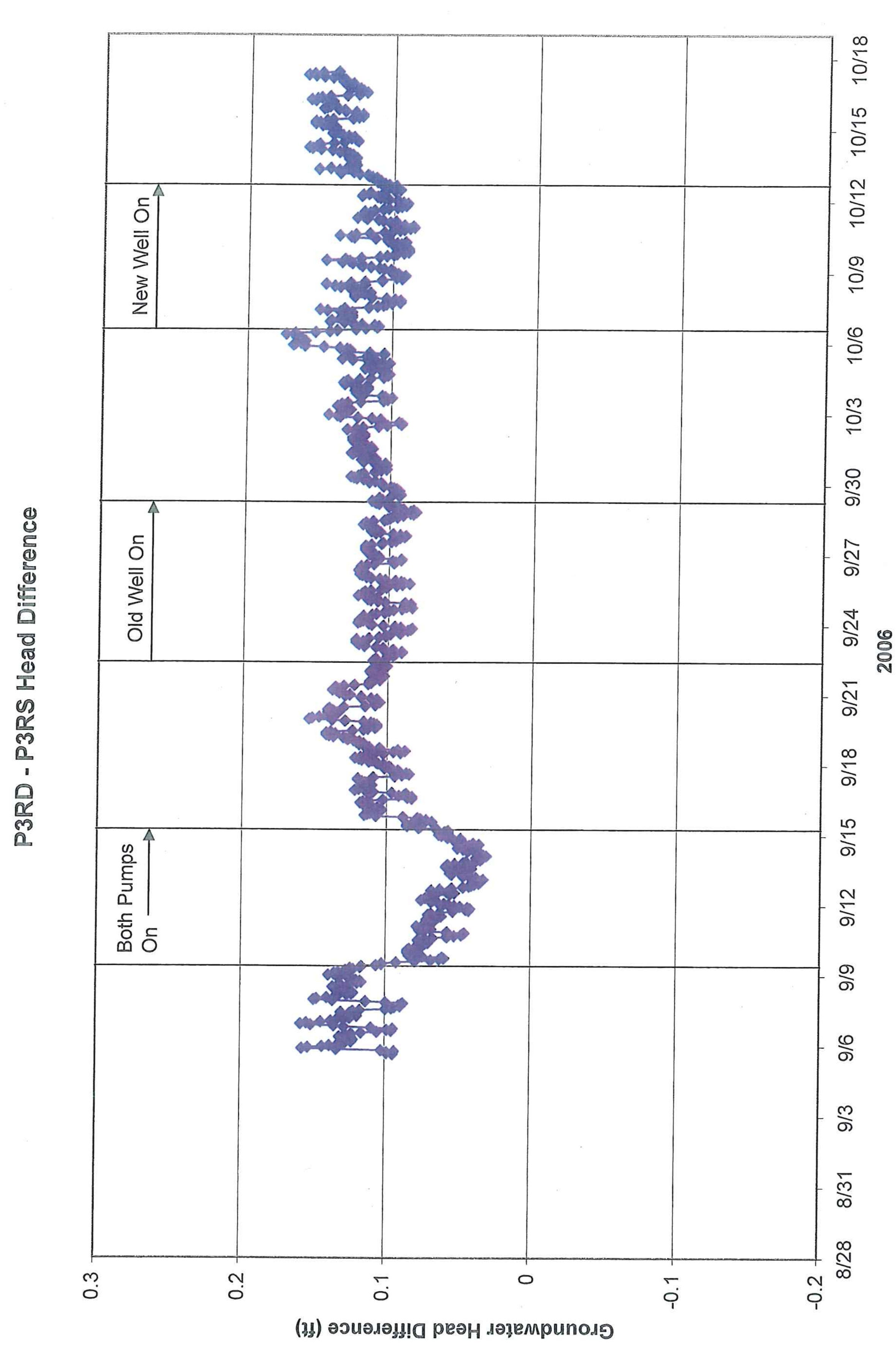
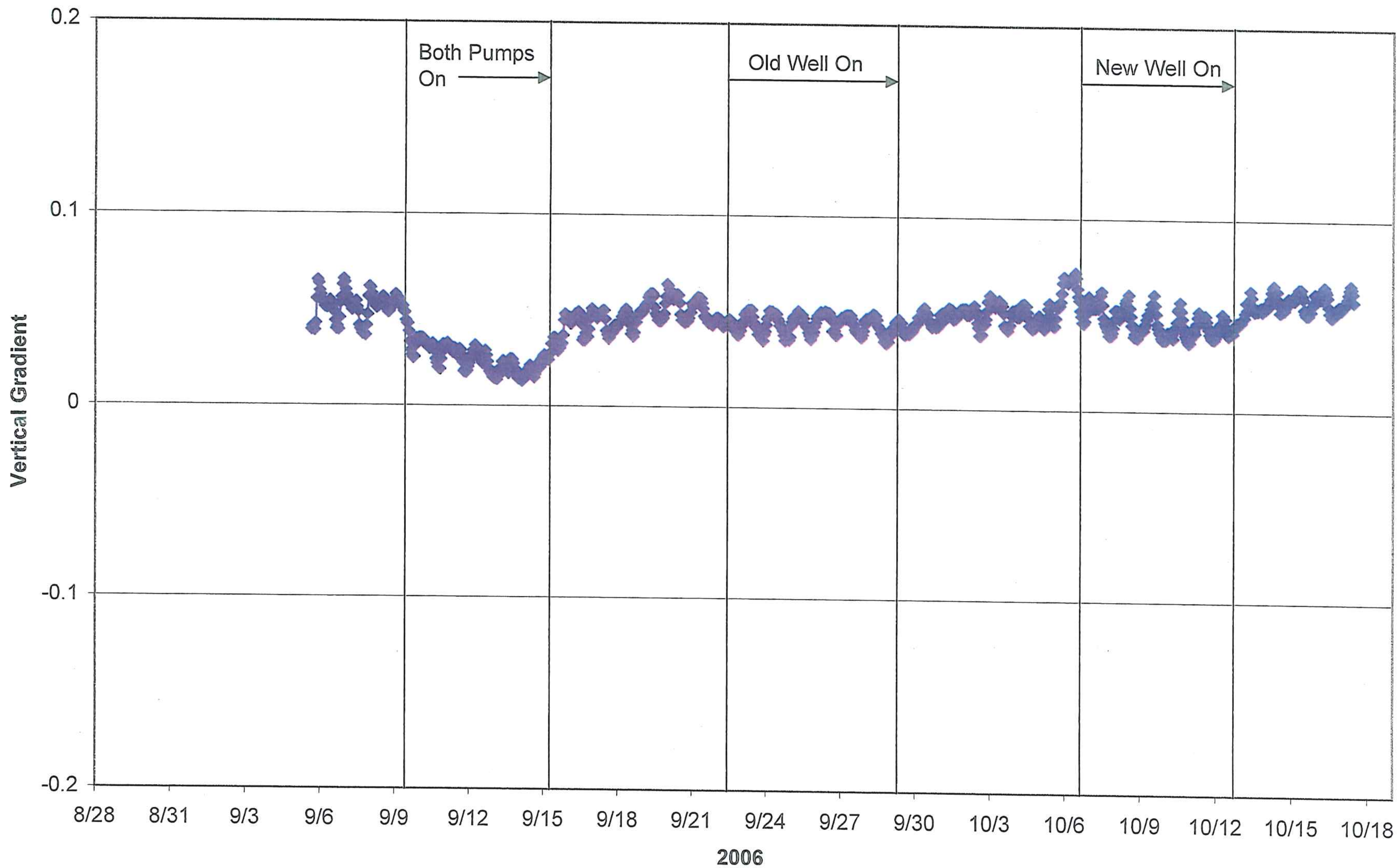


SGI environmental THE SOURCE GROUP, INC.

P3R Vertical Gradient



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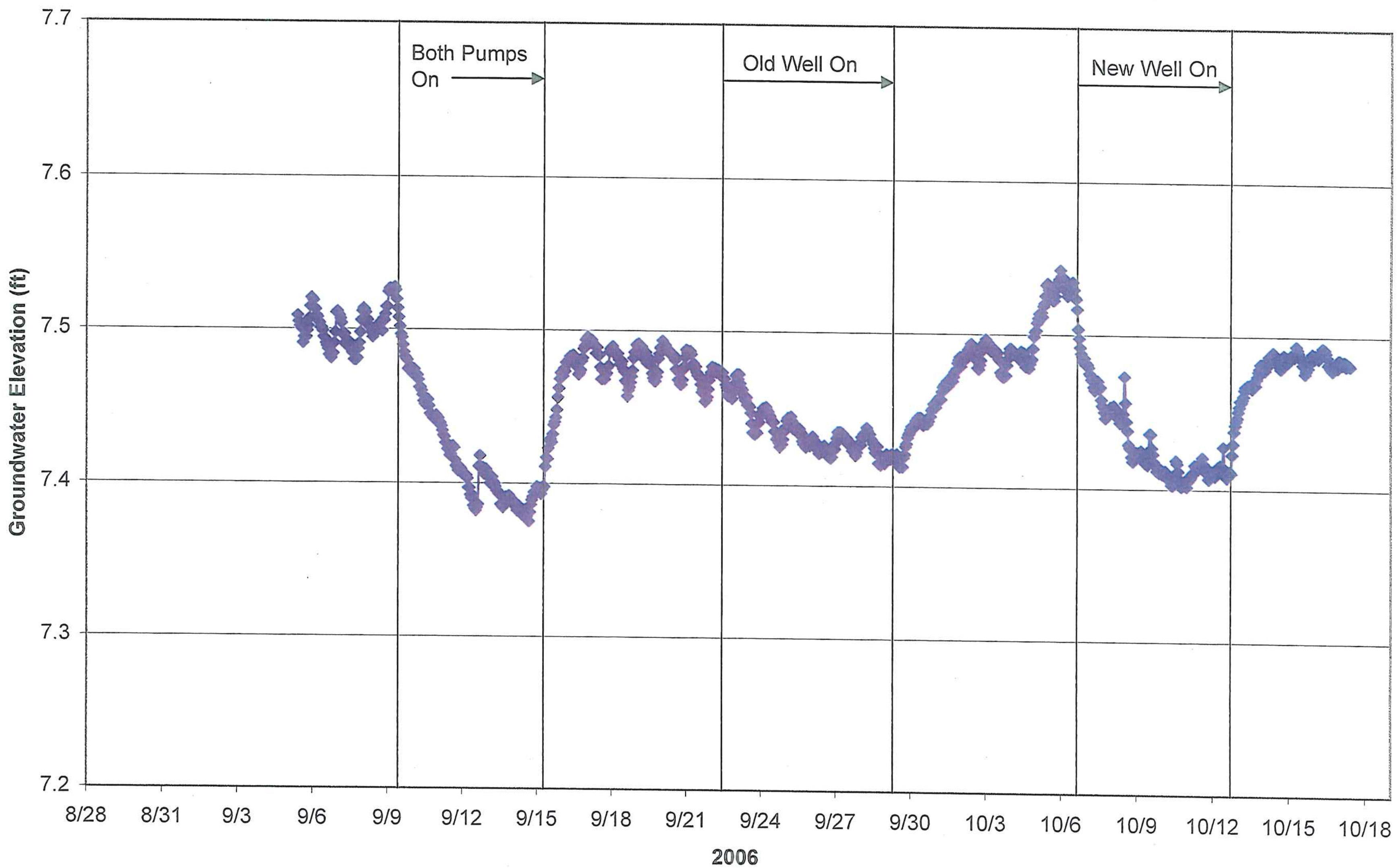
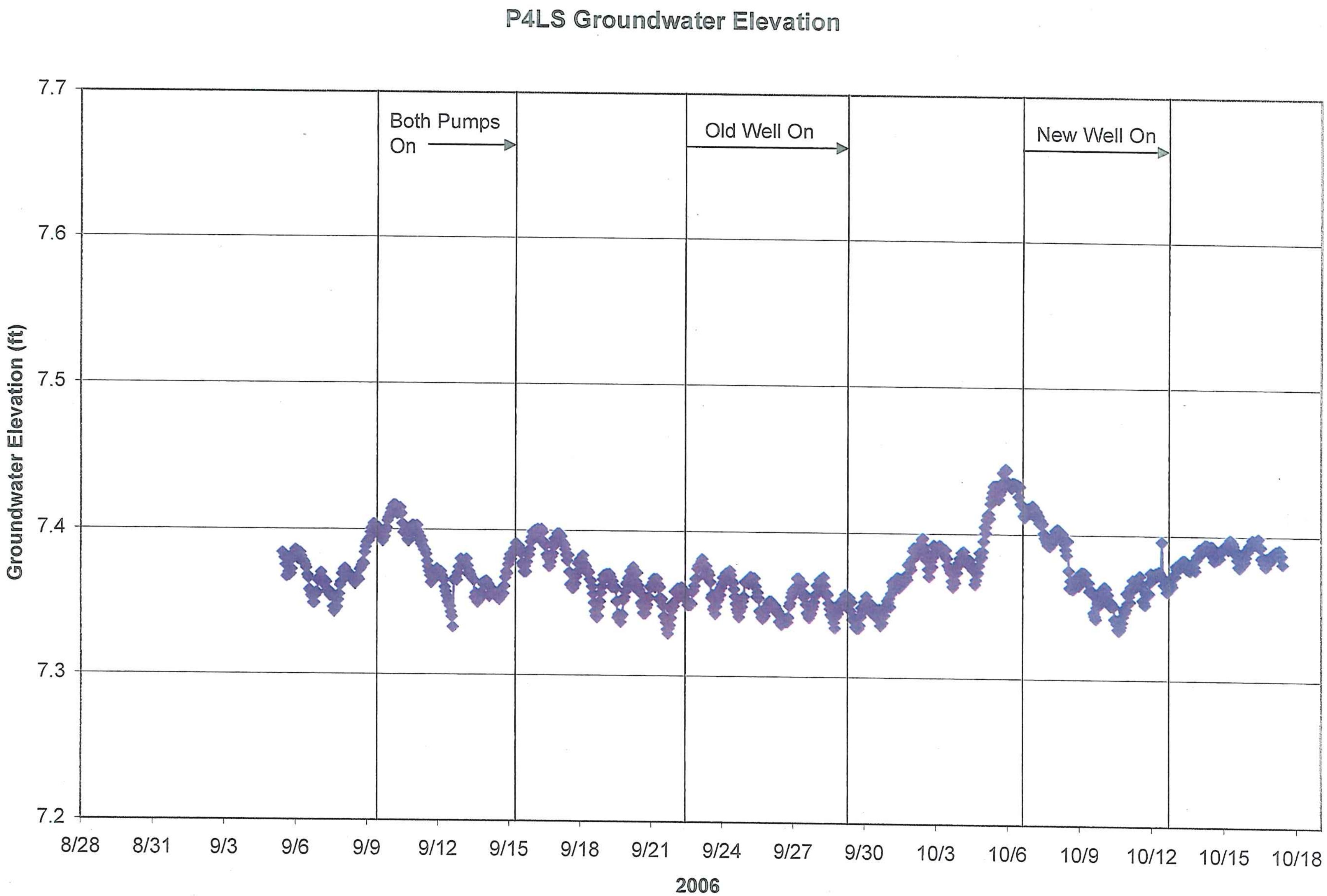
P4LD Groundwater Elevation



THE SOURCE GROUP, INC.



SGI environmental THE SOURCE GROUP, INC.

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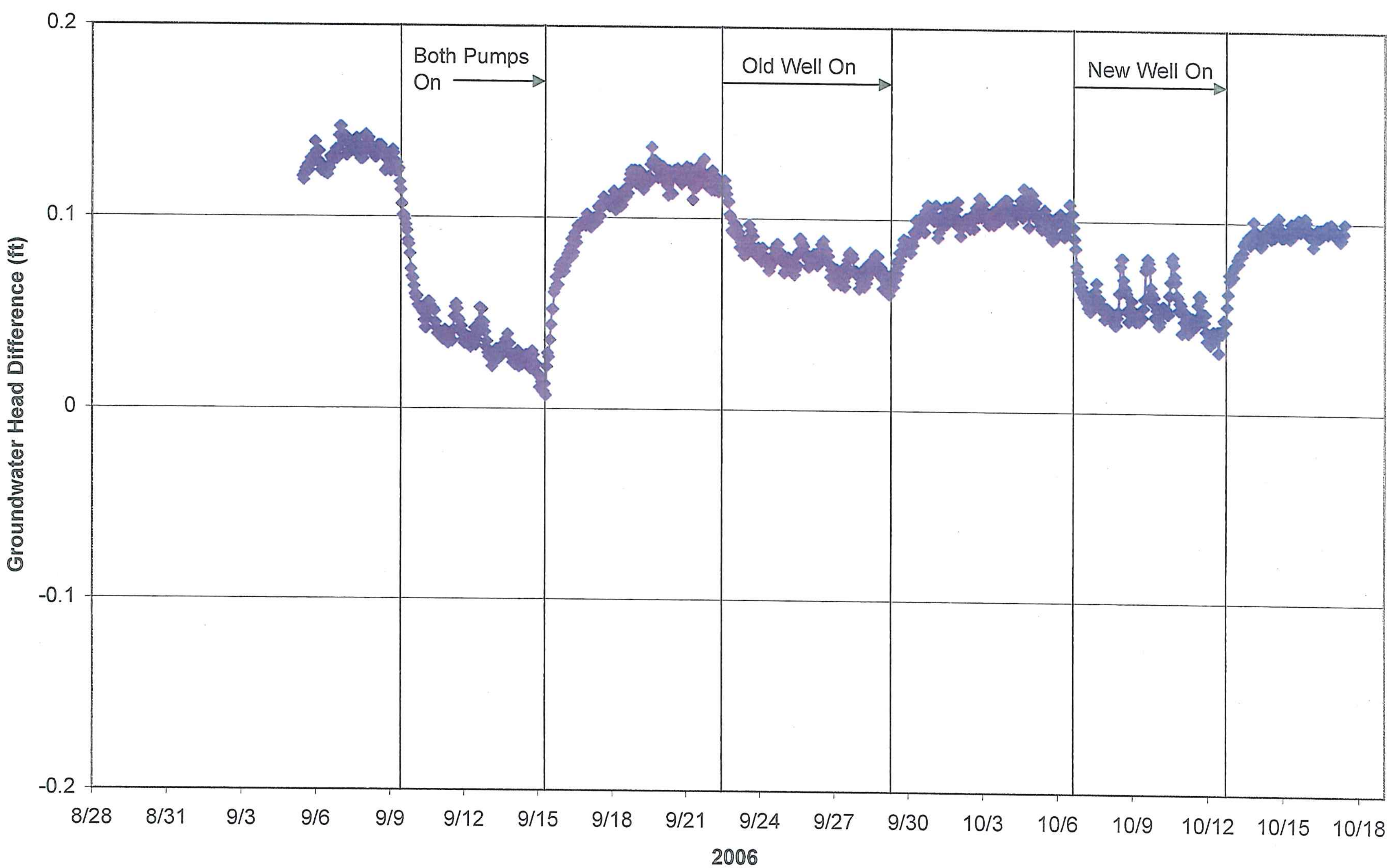
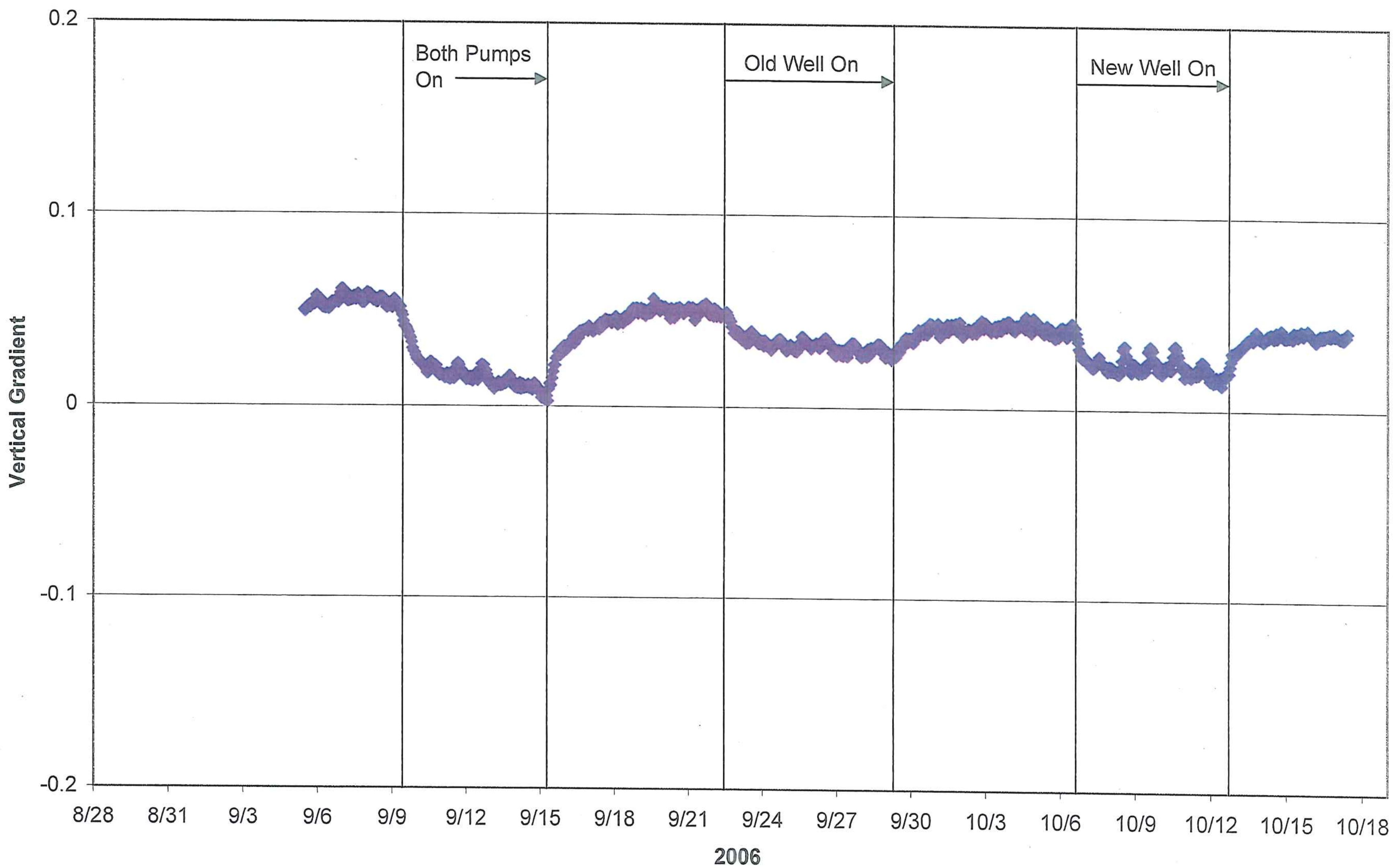
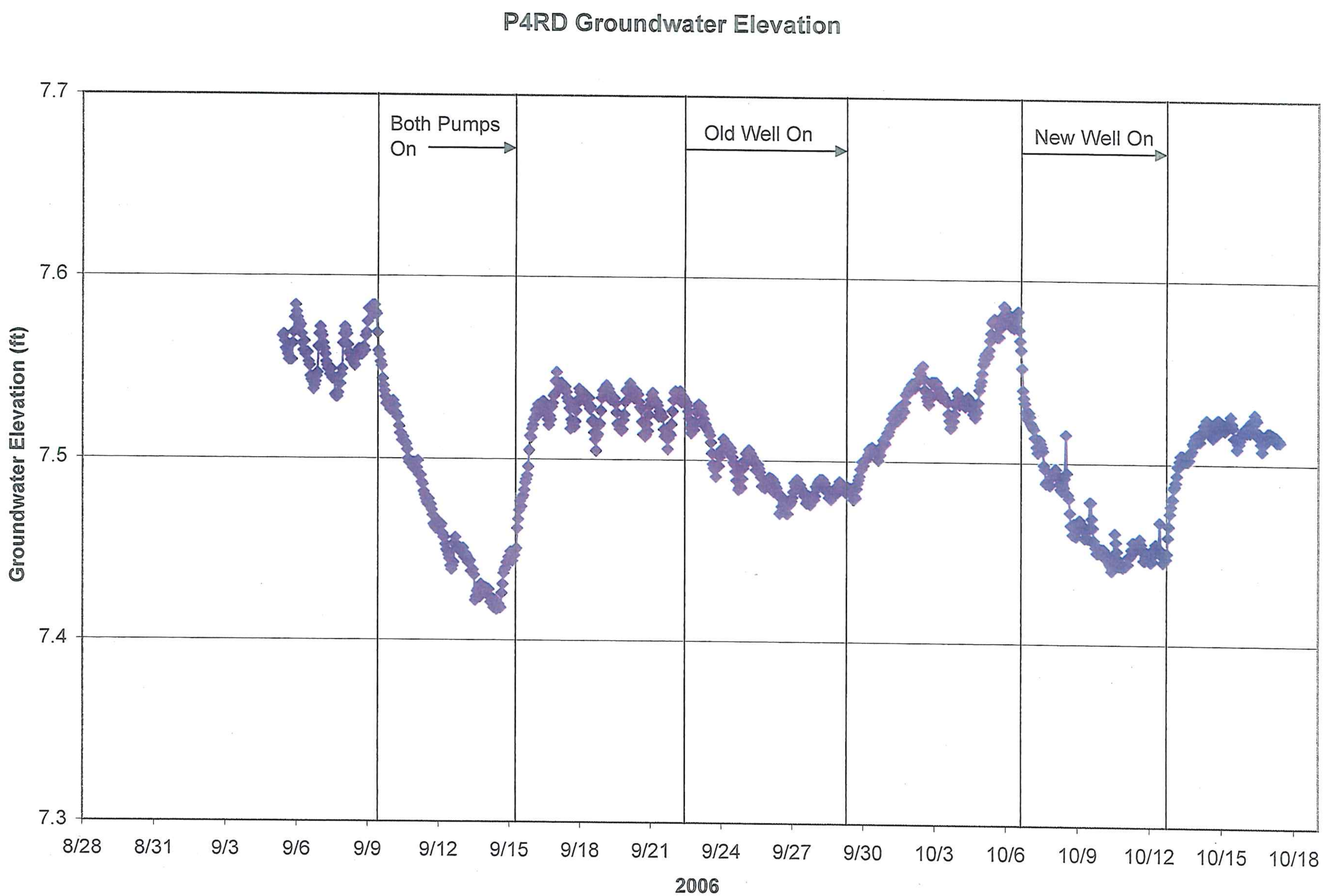


SGI environmental THE SOURCE GROUP, INC.

P4L Vertical Gradient

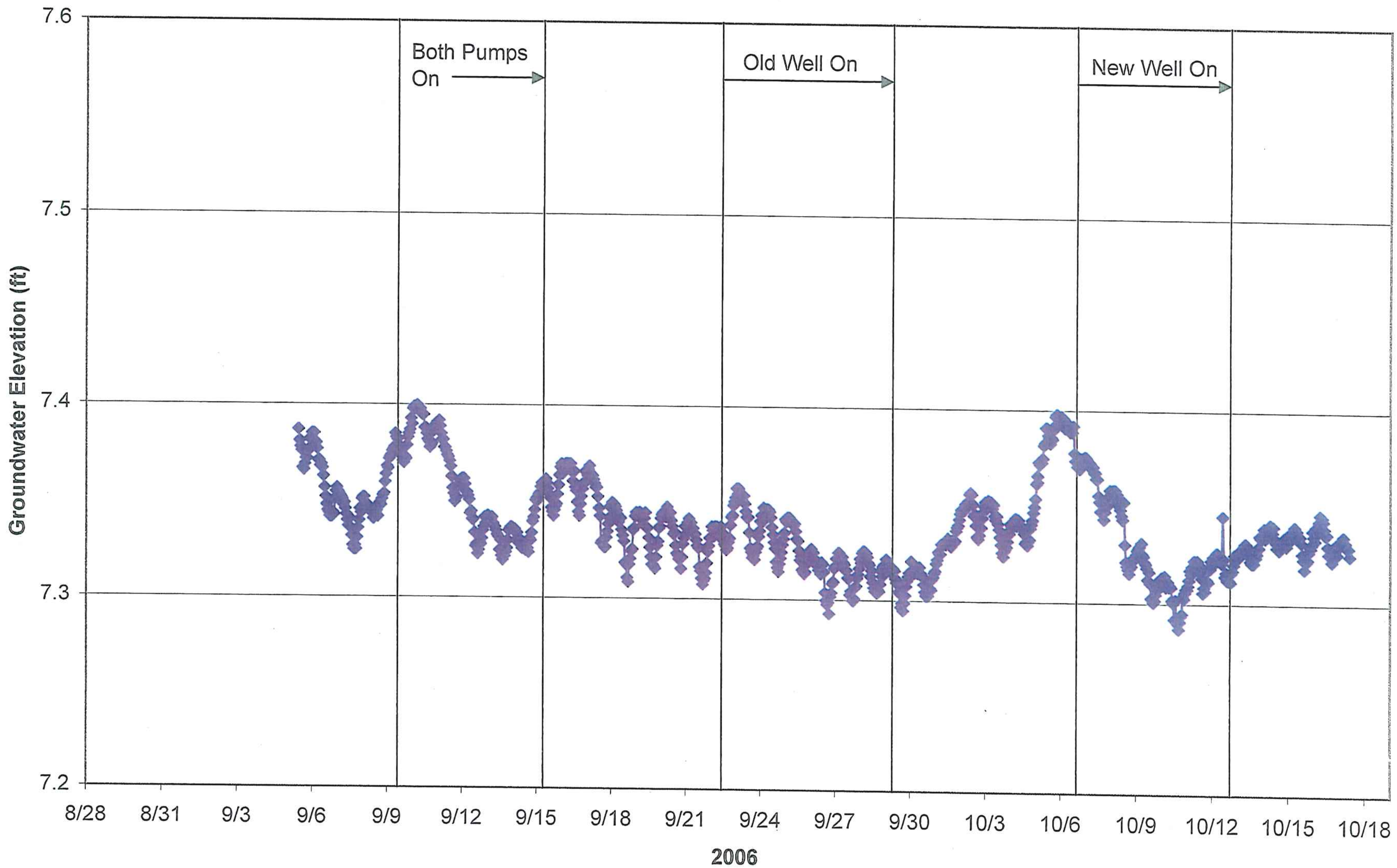


SGI environmental THE SOURCE GROUP, INC.

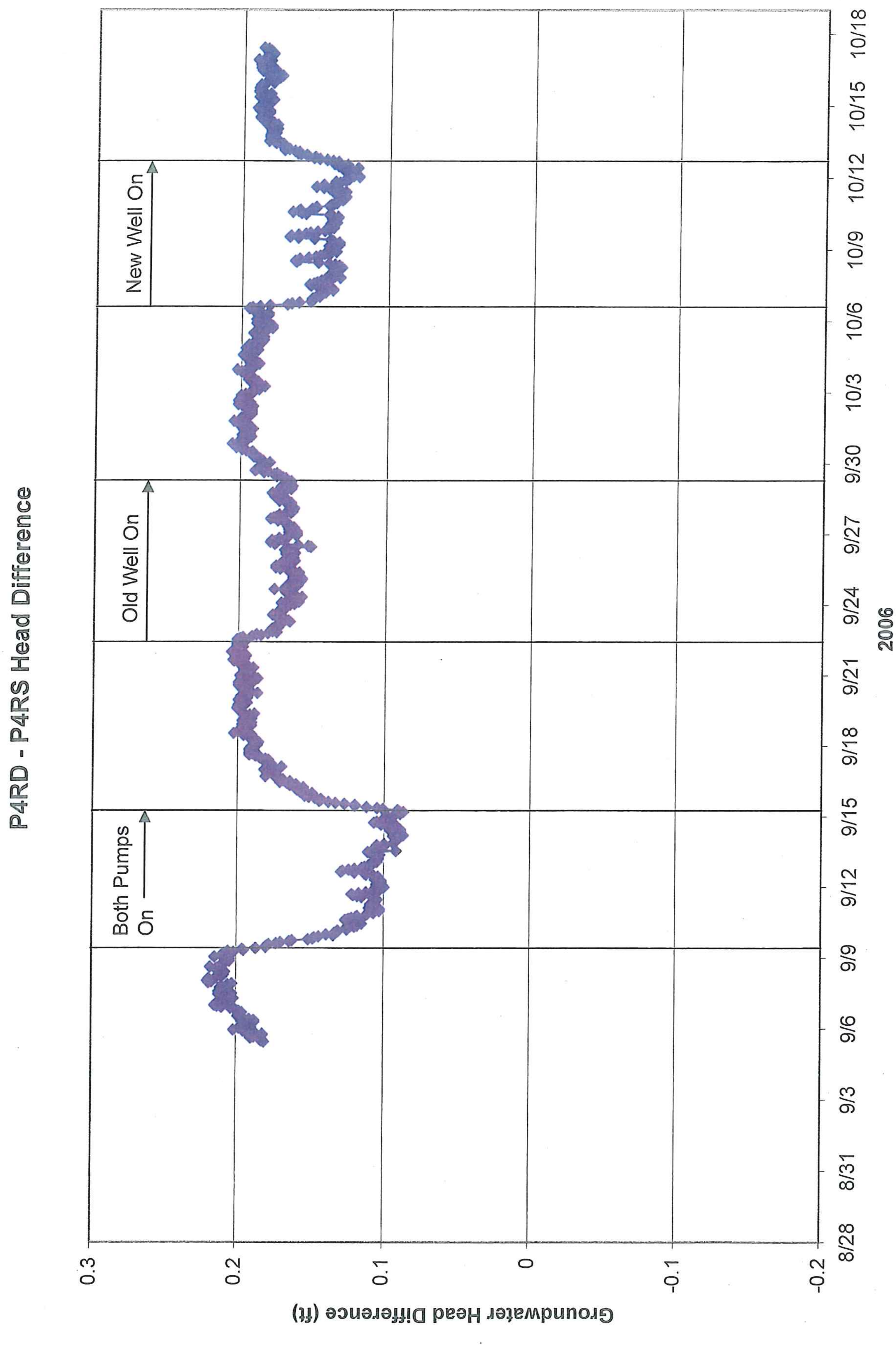


SGI environmental THE SOURCE GROUP, INC.

P4RS Groundwater Elevation

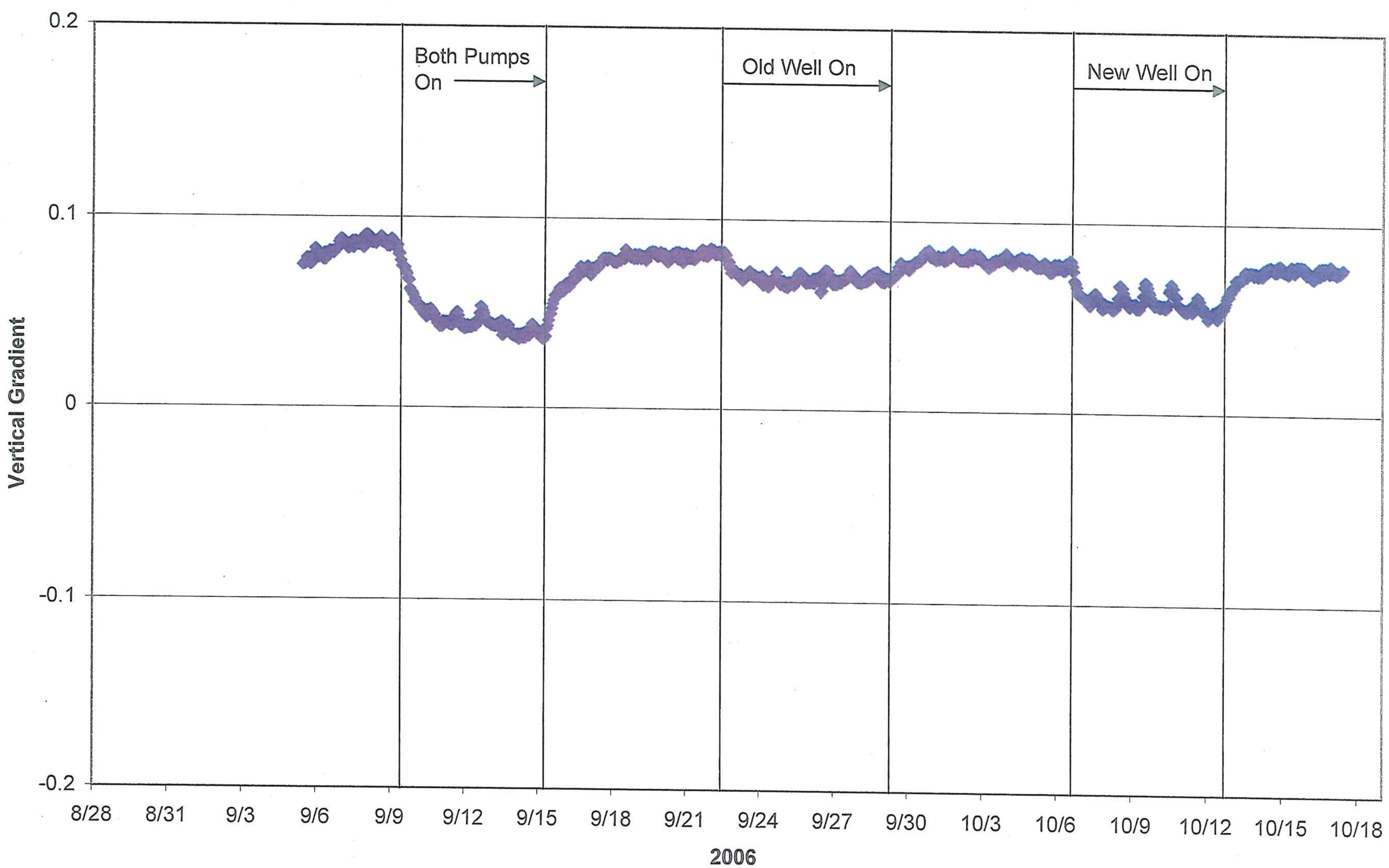


SGI environmental THE SOURCE GROUP, INC.

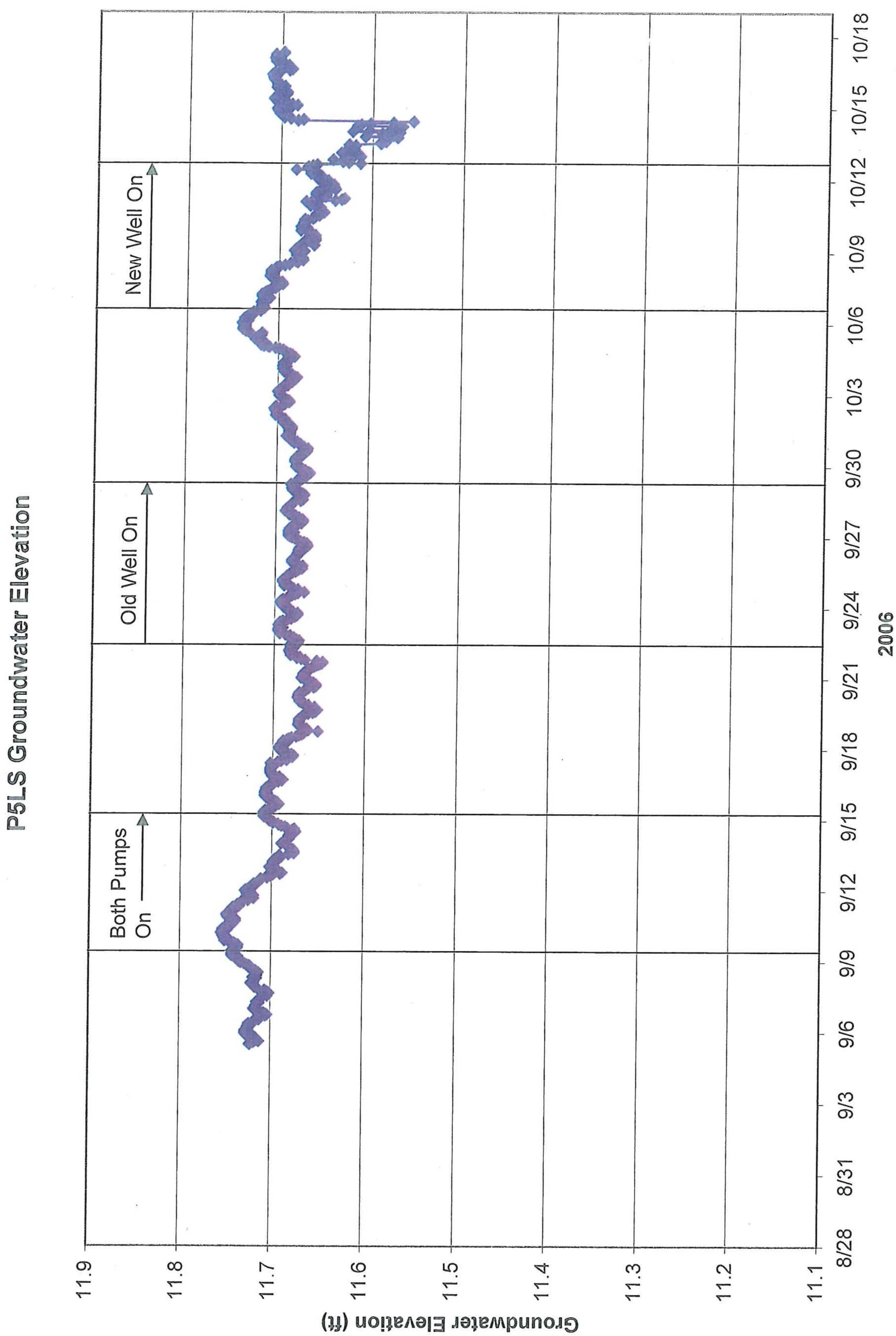


SGI environmental THE SOURCE GROUP, INC.

P4R Vertical Gradient



SGI environmental THE SOURCE GROUP, INC.



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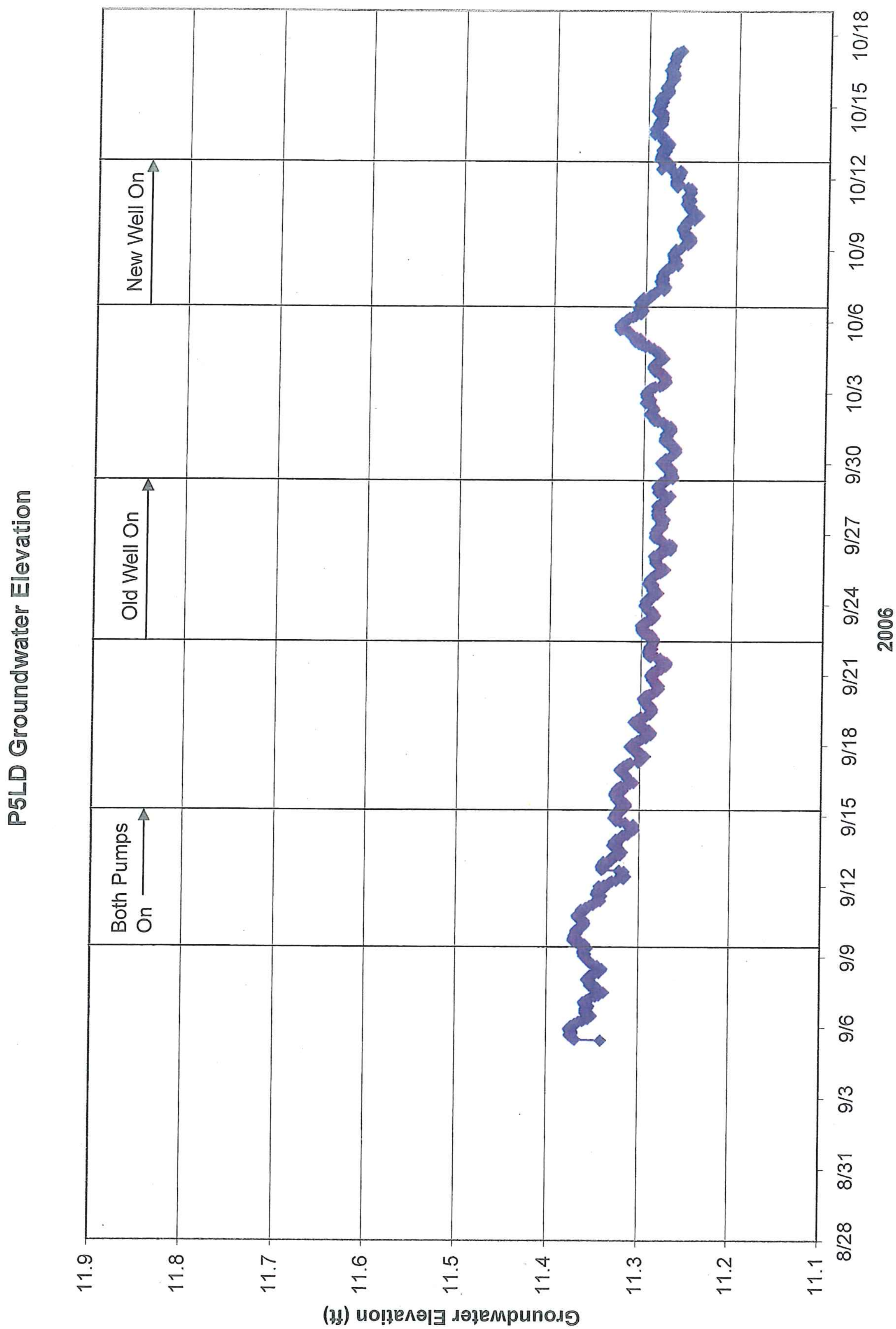
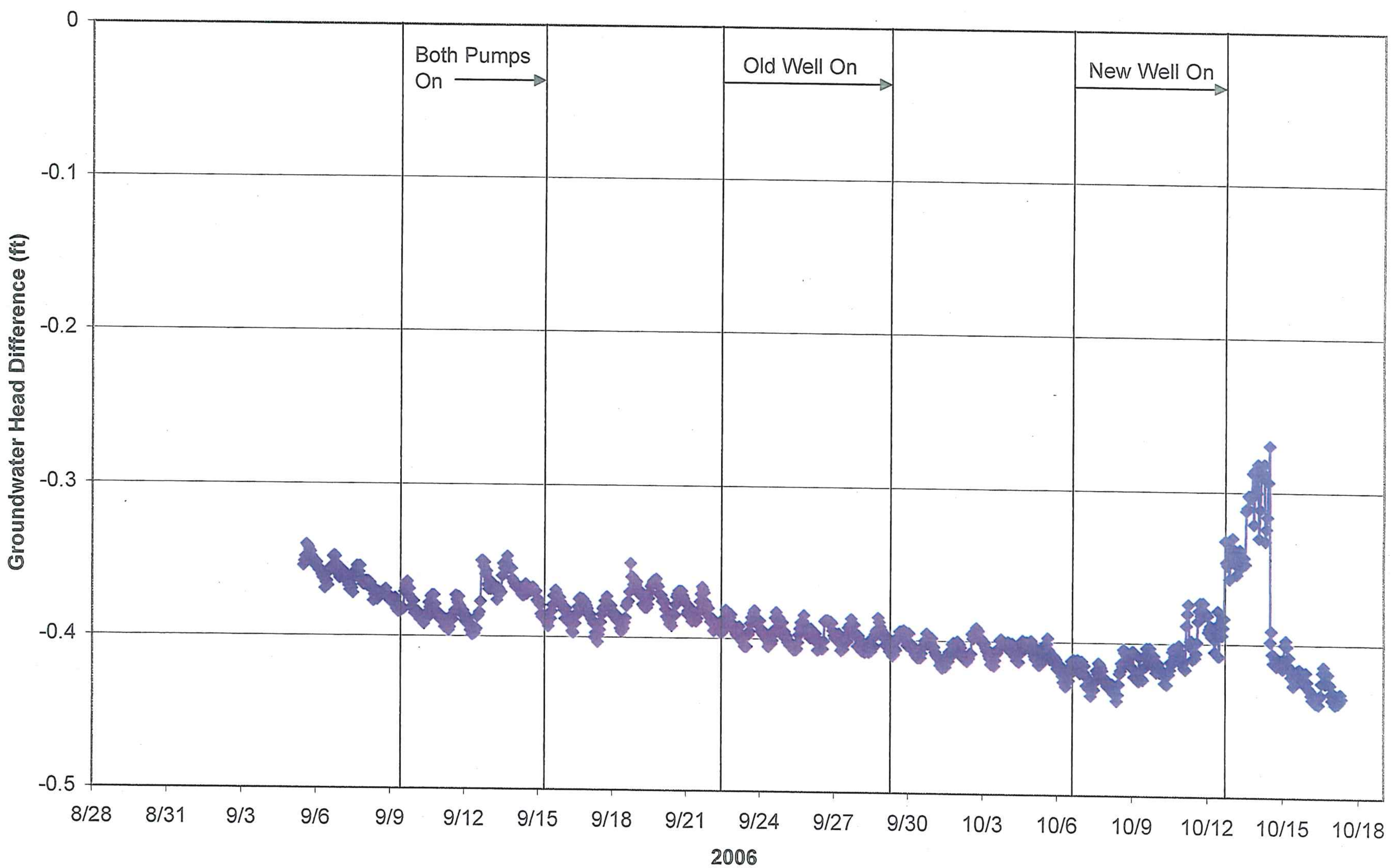


SGI environmental THE SOURCE GROUP, INC.

P5LD - P5LS Head Difference



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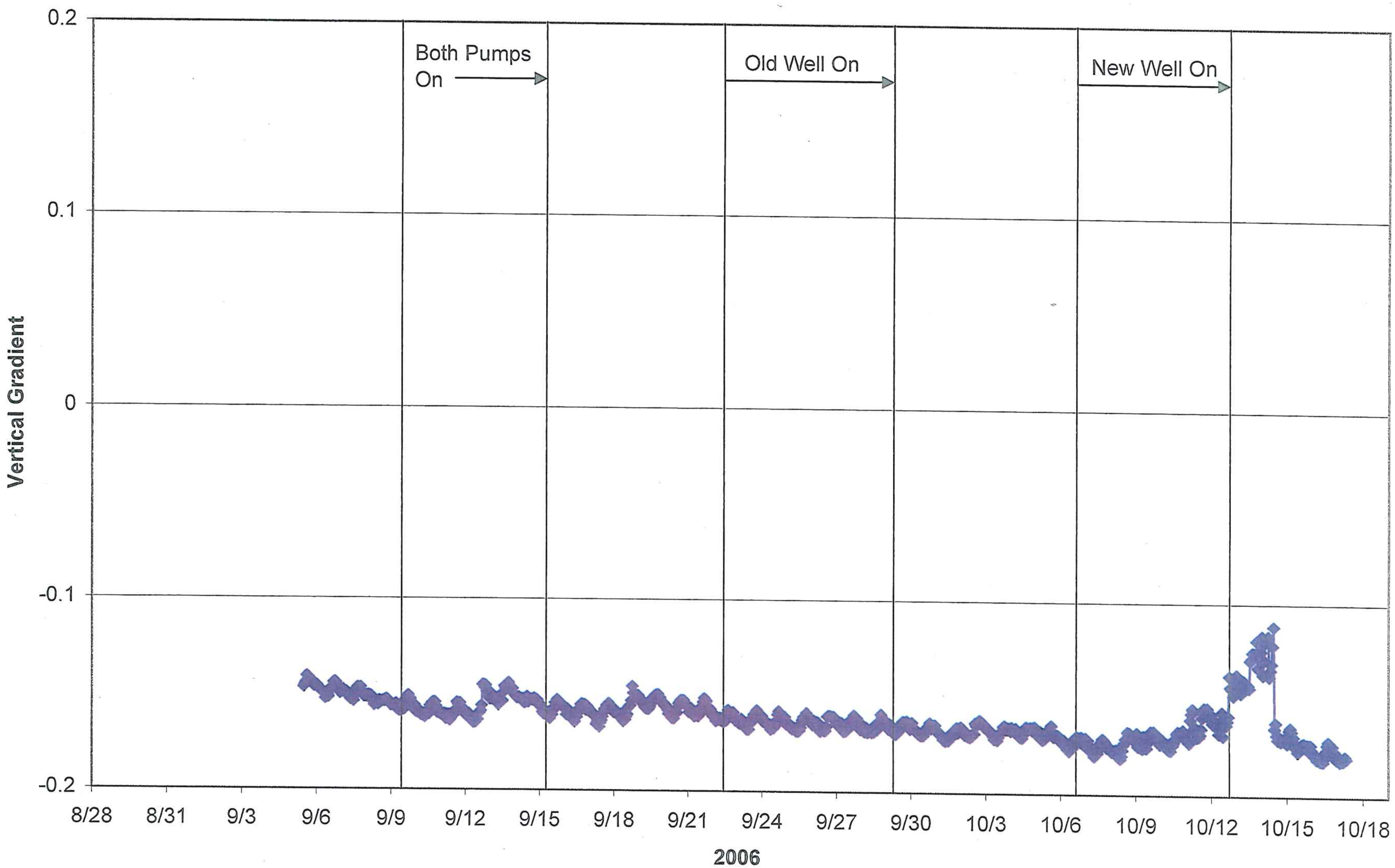
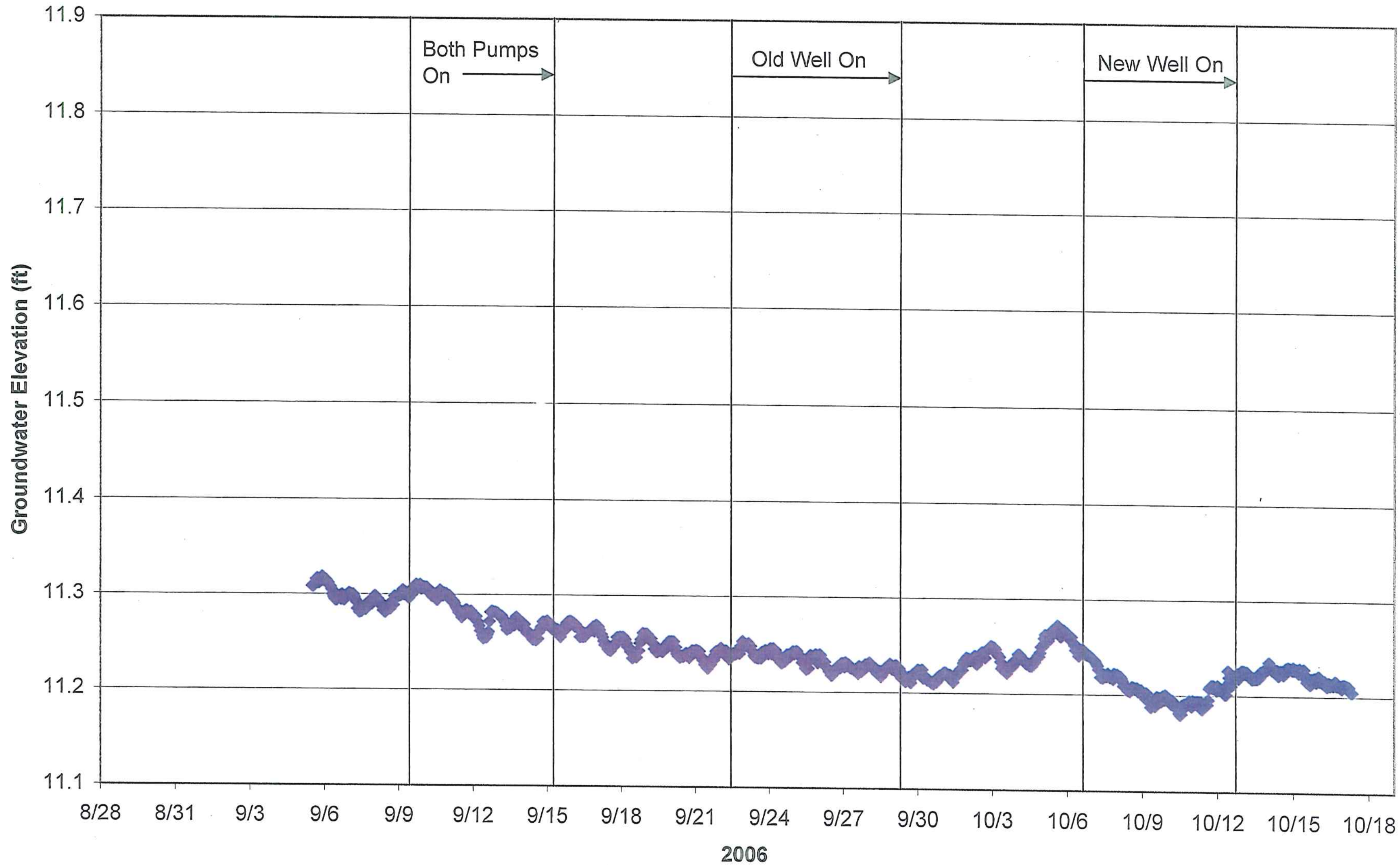


THE SOURCE GROUP, INC.

P5RD Groundwater Elevation



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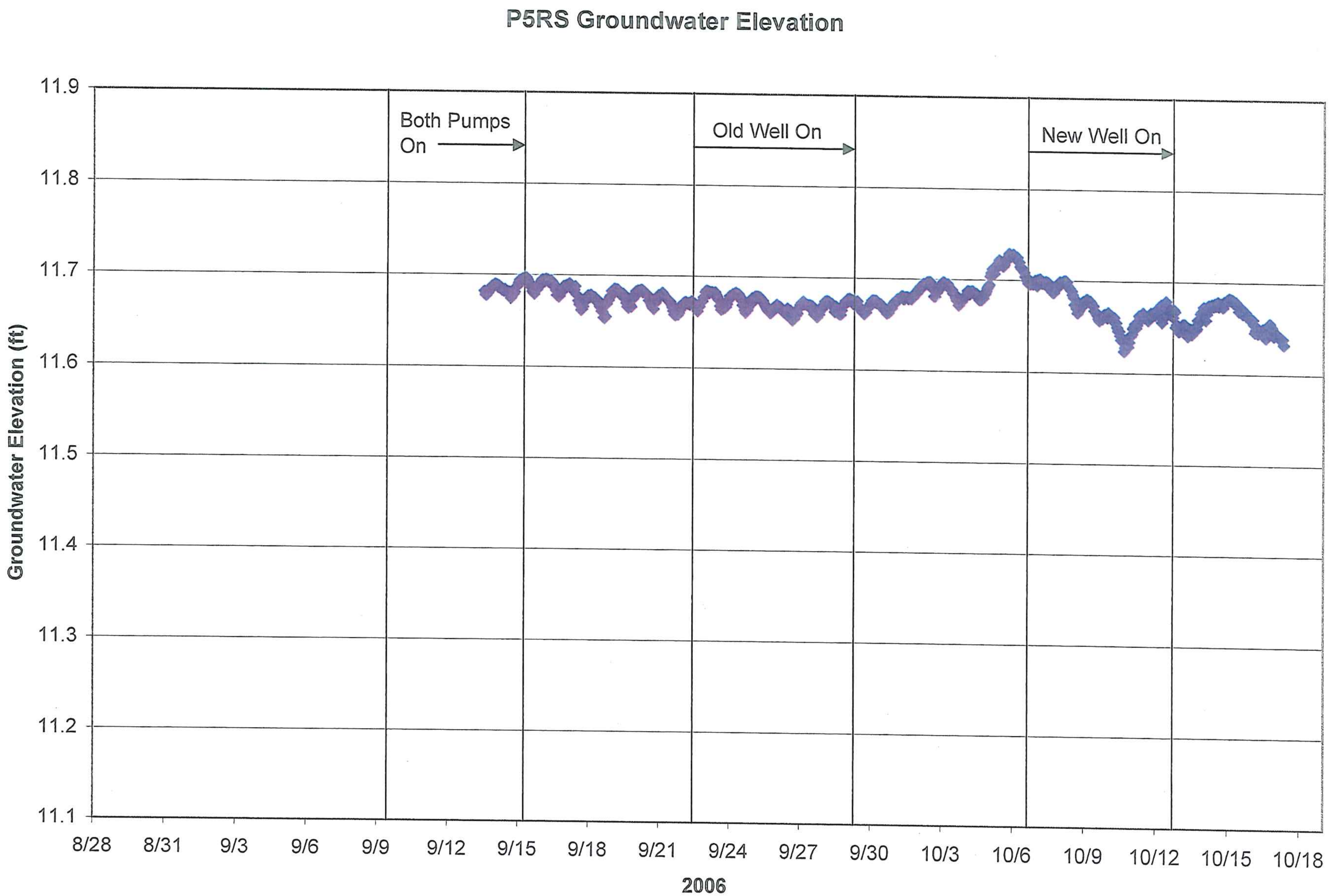

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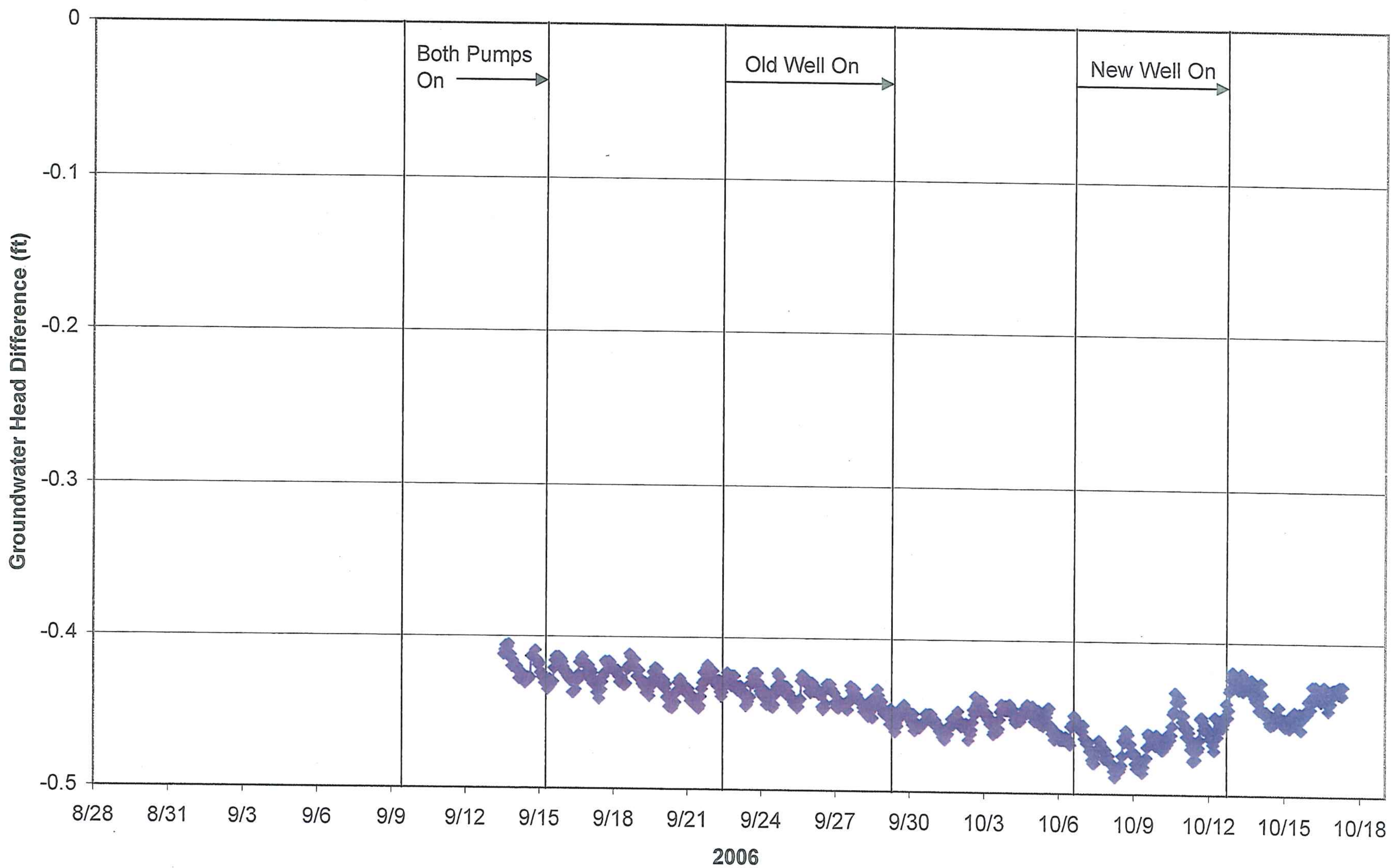

SGI environmental THE SOURCE GROUP, INC.

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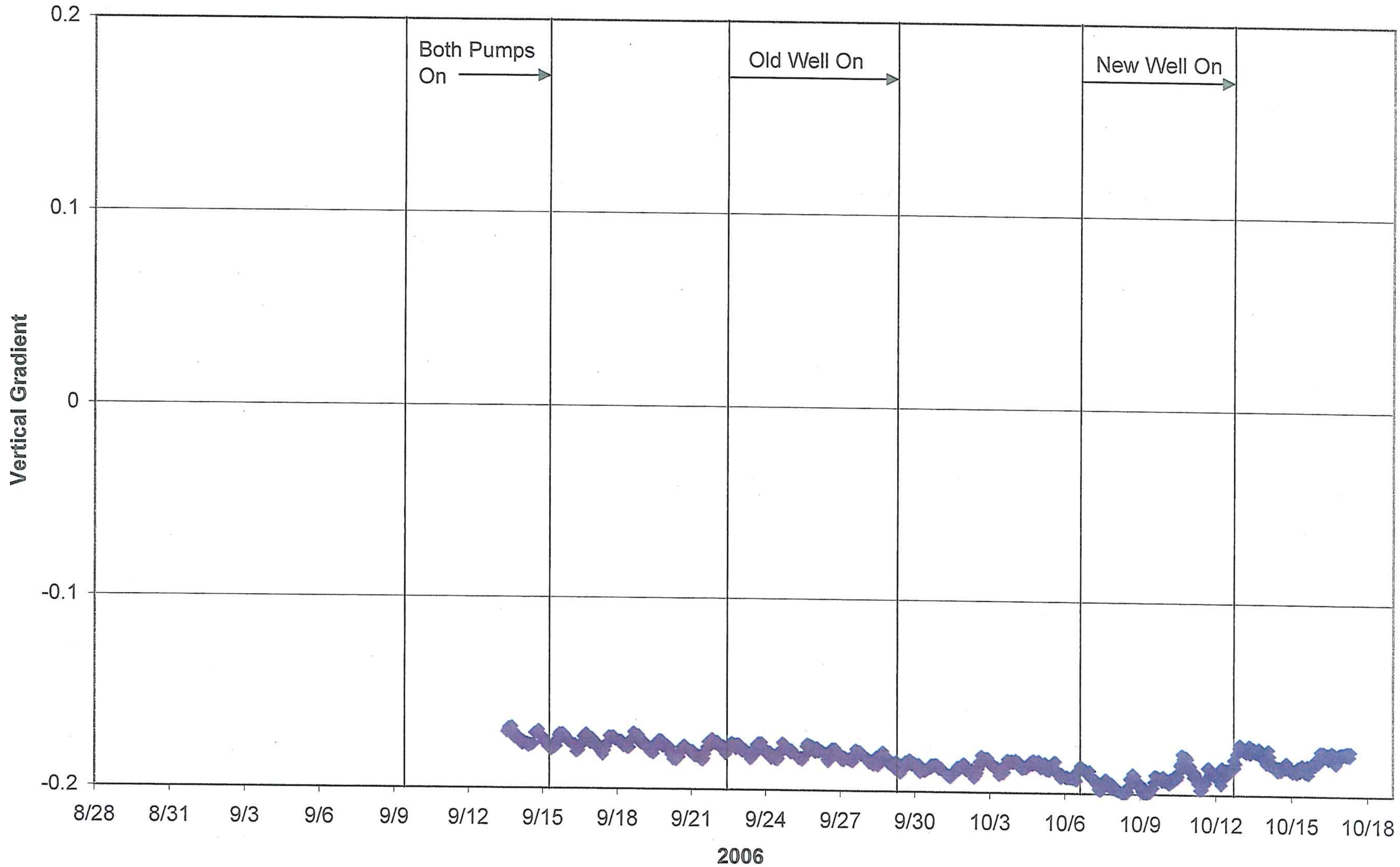
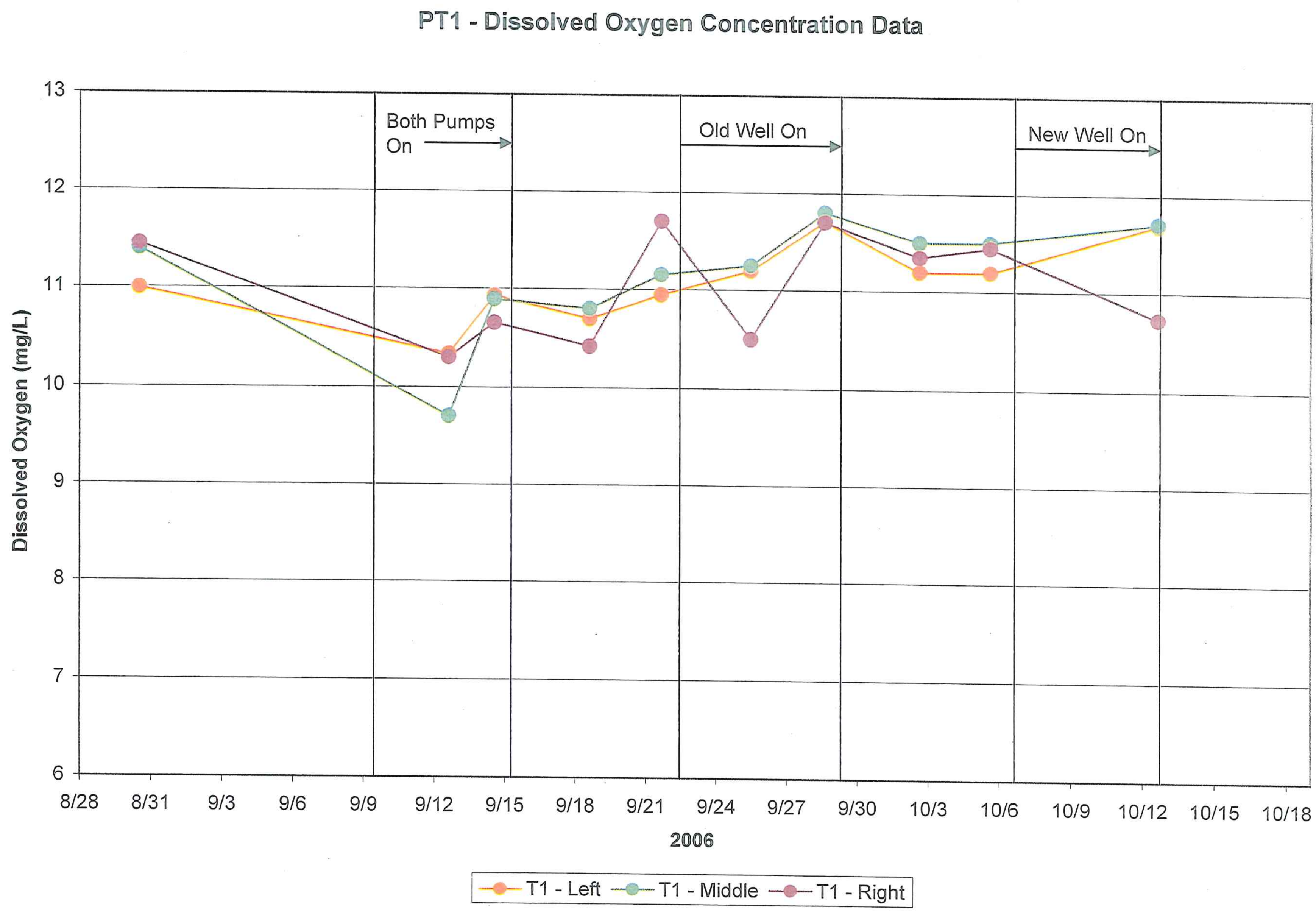


SGI environmental THE SOURCE GROUP, INC.

APPENDIX G

APPENDIX G

PASSAGE TRANSECT DISSOLVED OXYGEN AND TEMPERATURE PROFILES



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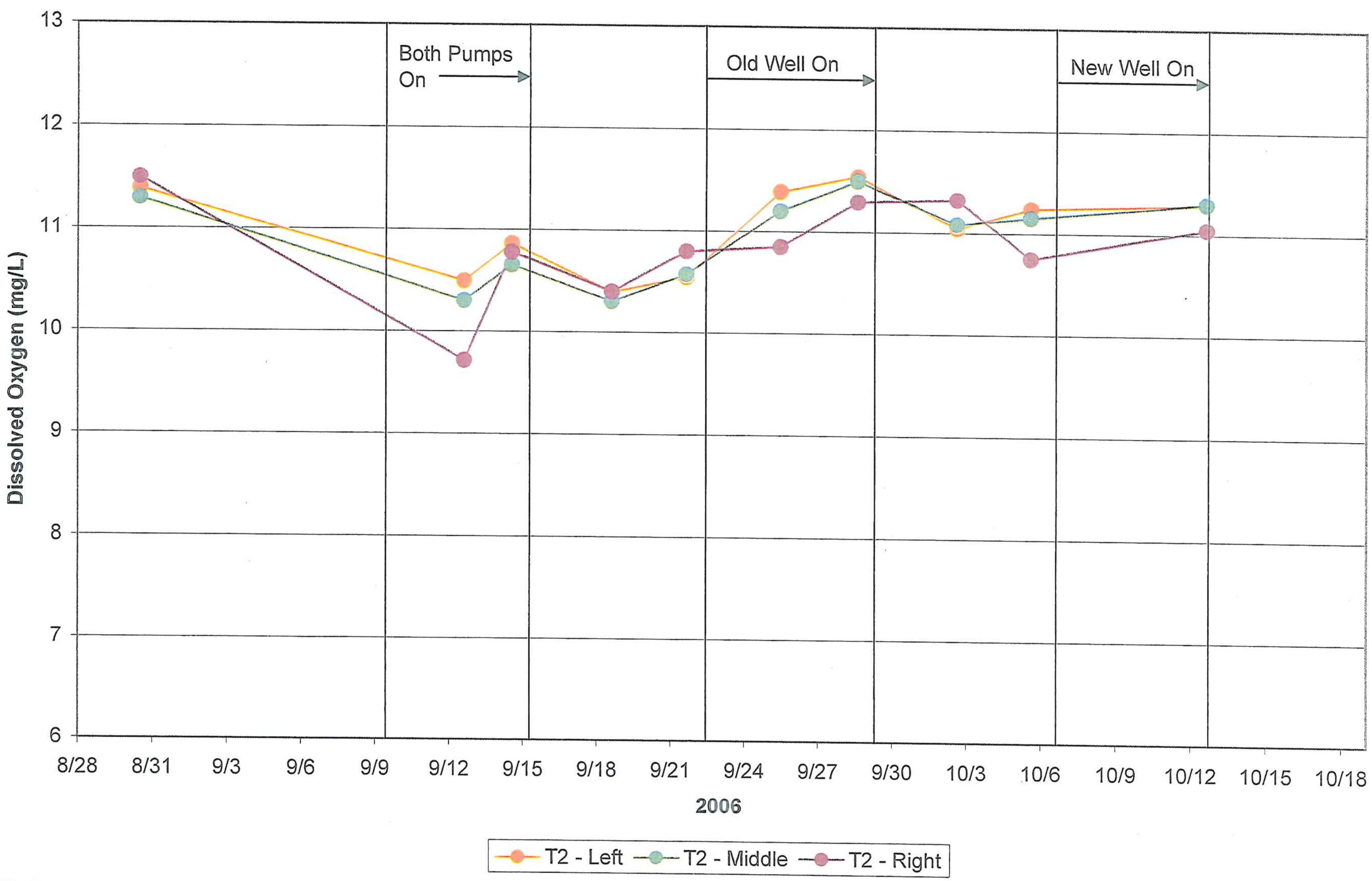
PT2 - Dissolved Oxygen Concentration Data



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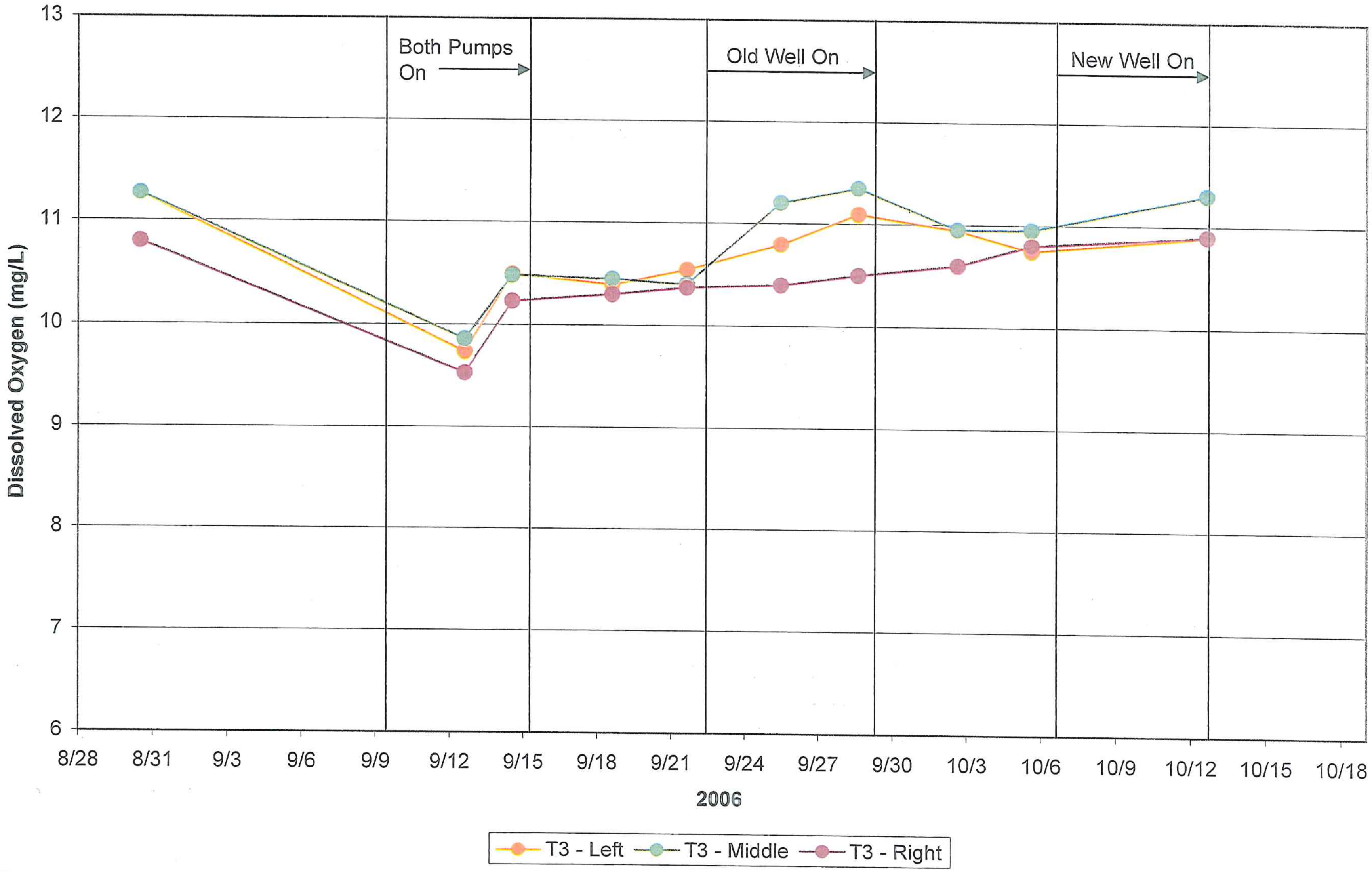

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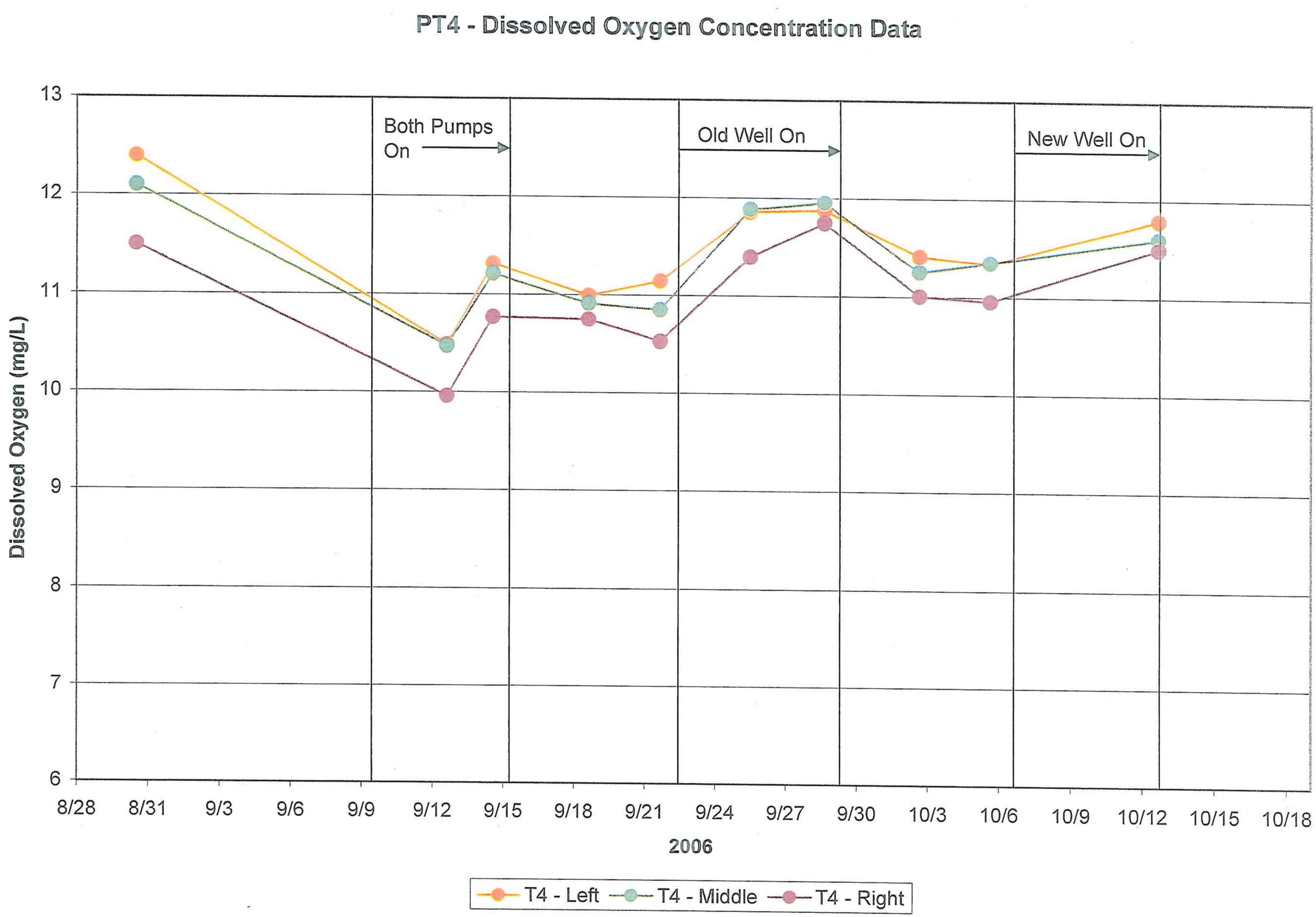

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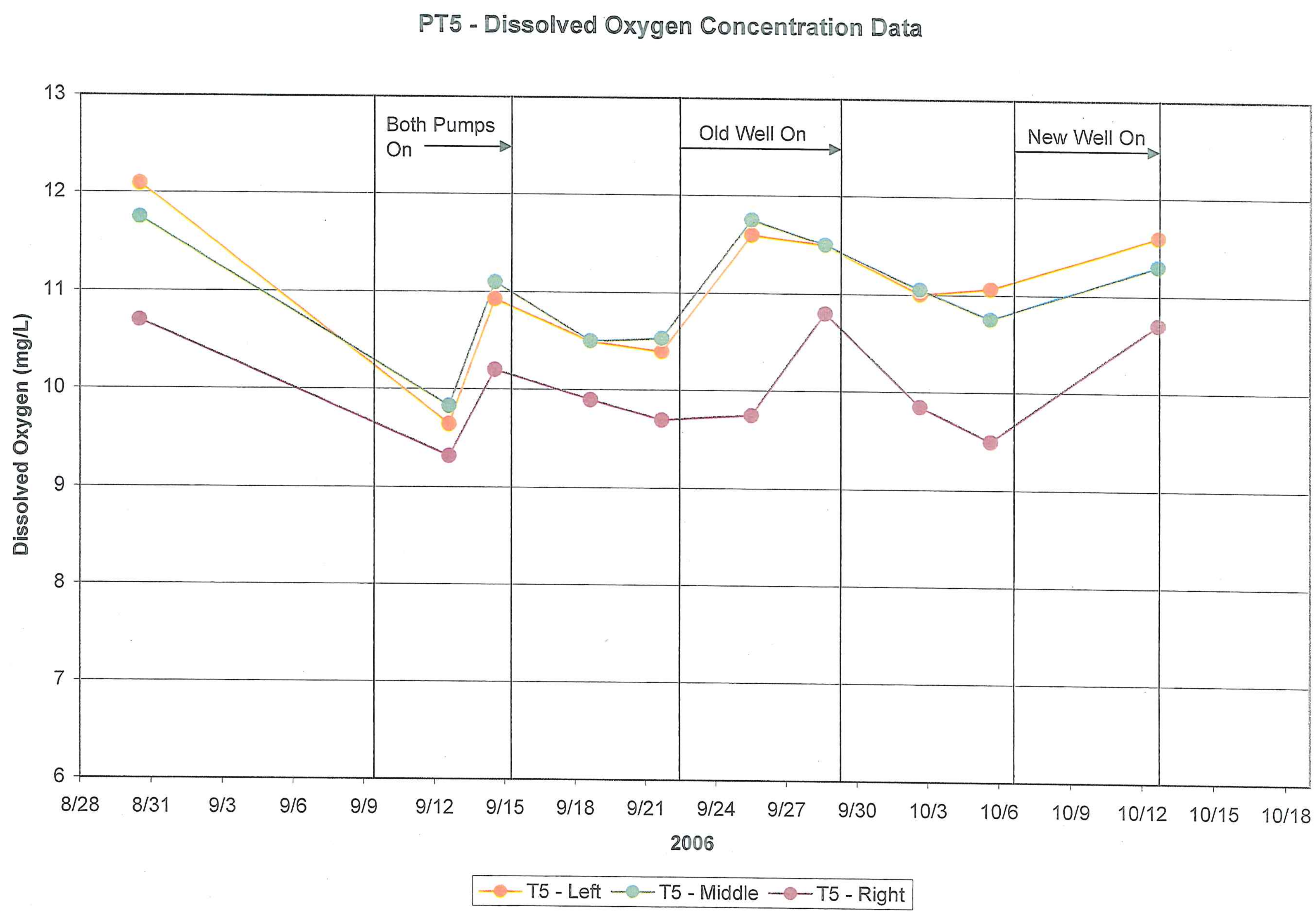

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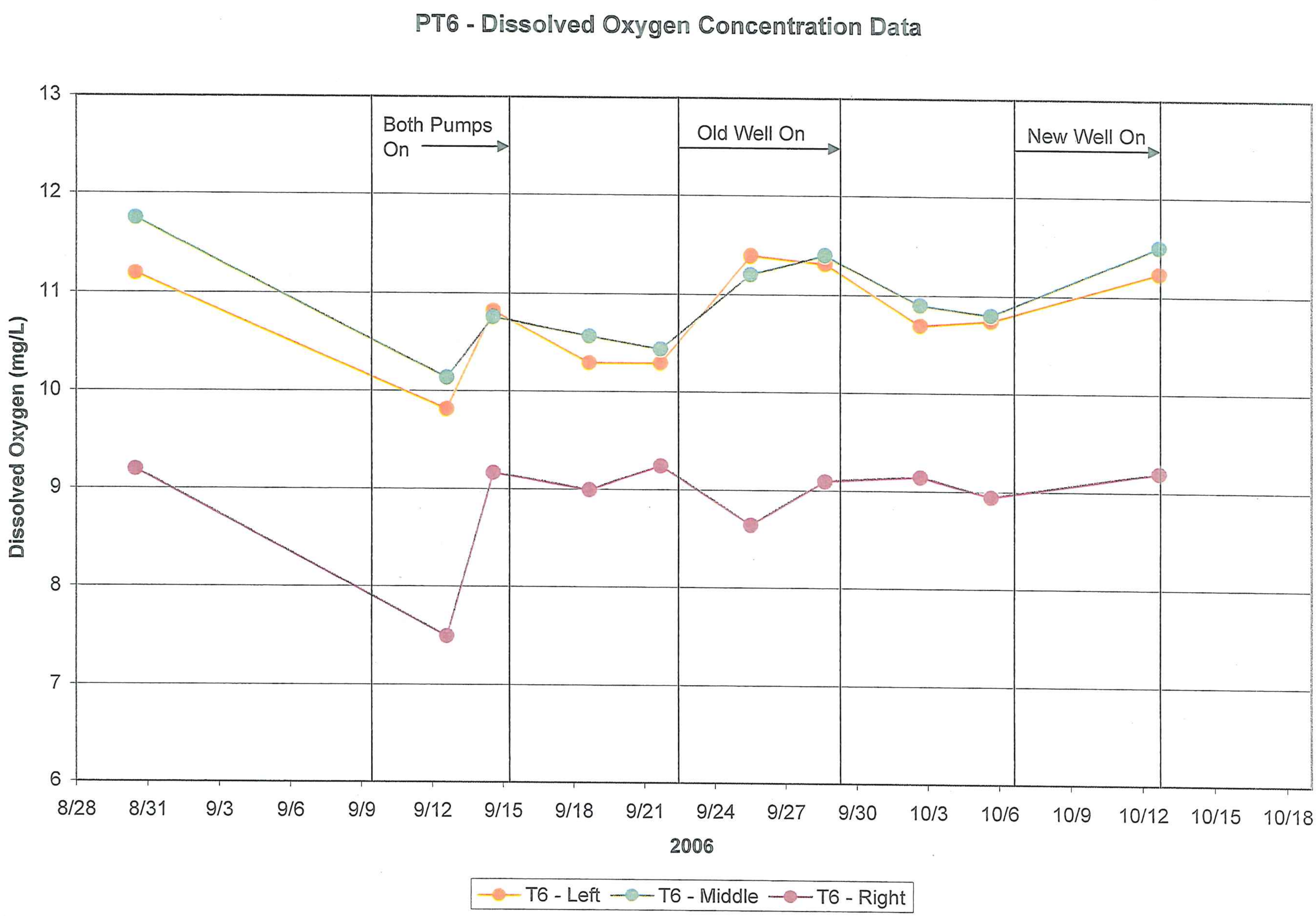

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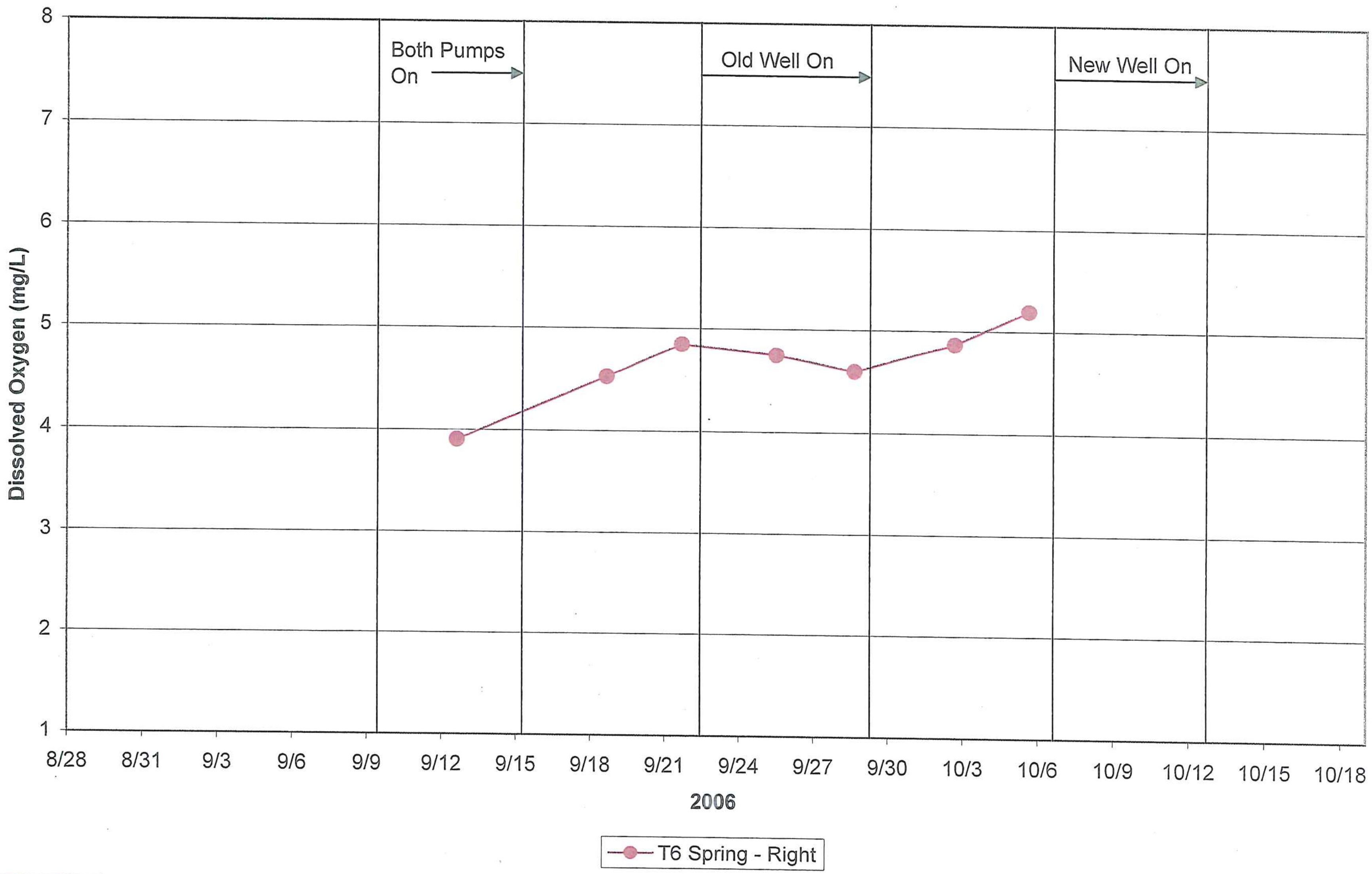
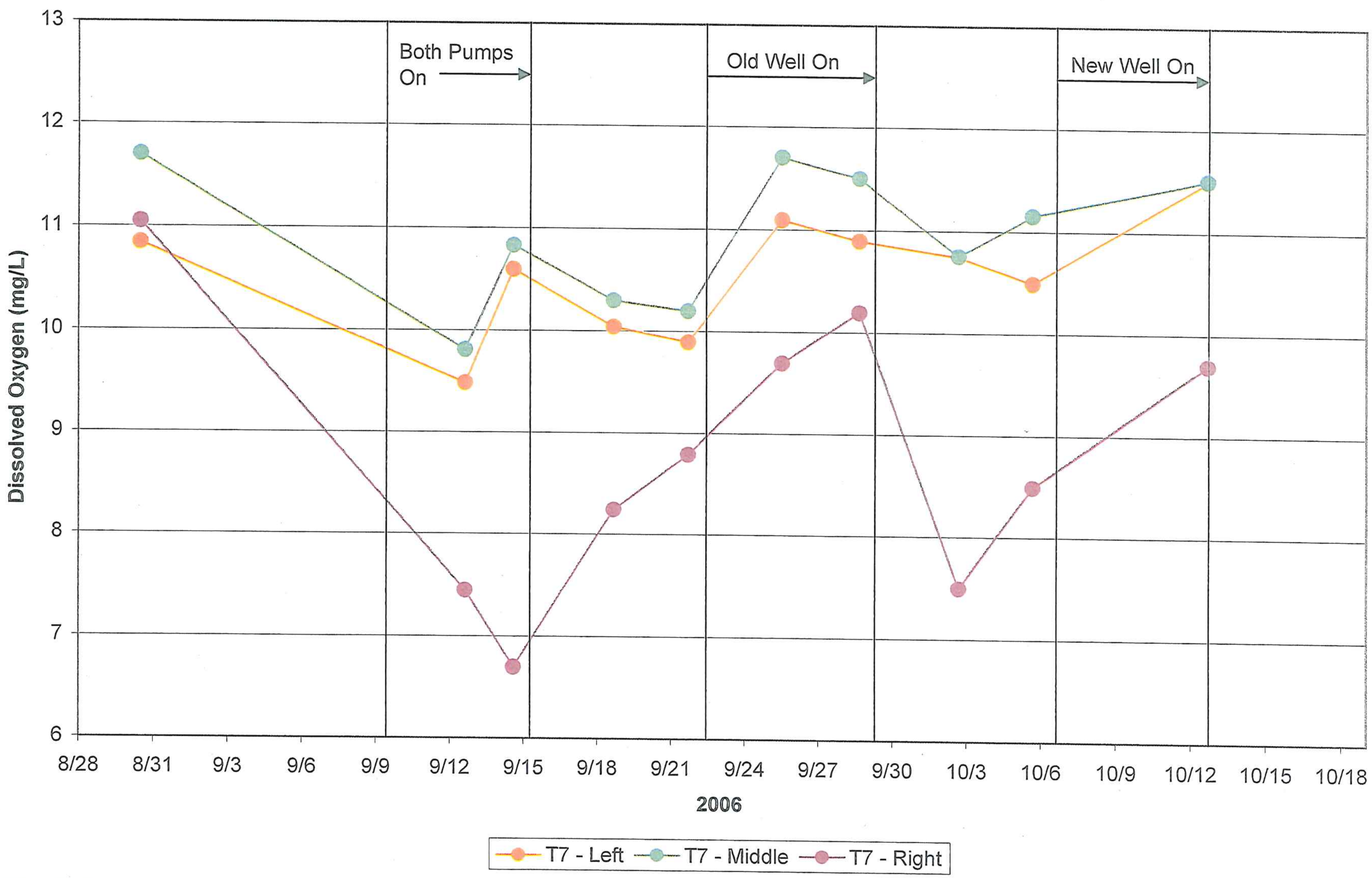
PT6 Groundwater Spring - Dissolved Oxygen Concentration Data



THE SOURCE GROUP, INC. SGI environmental

PT7 - Dissolved Oxygen Concentration Data



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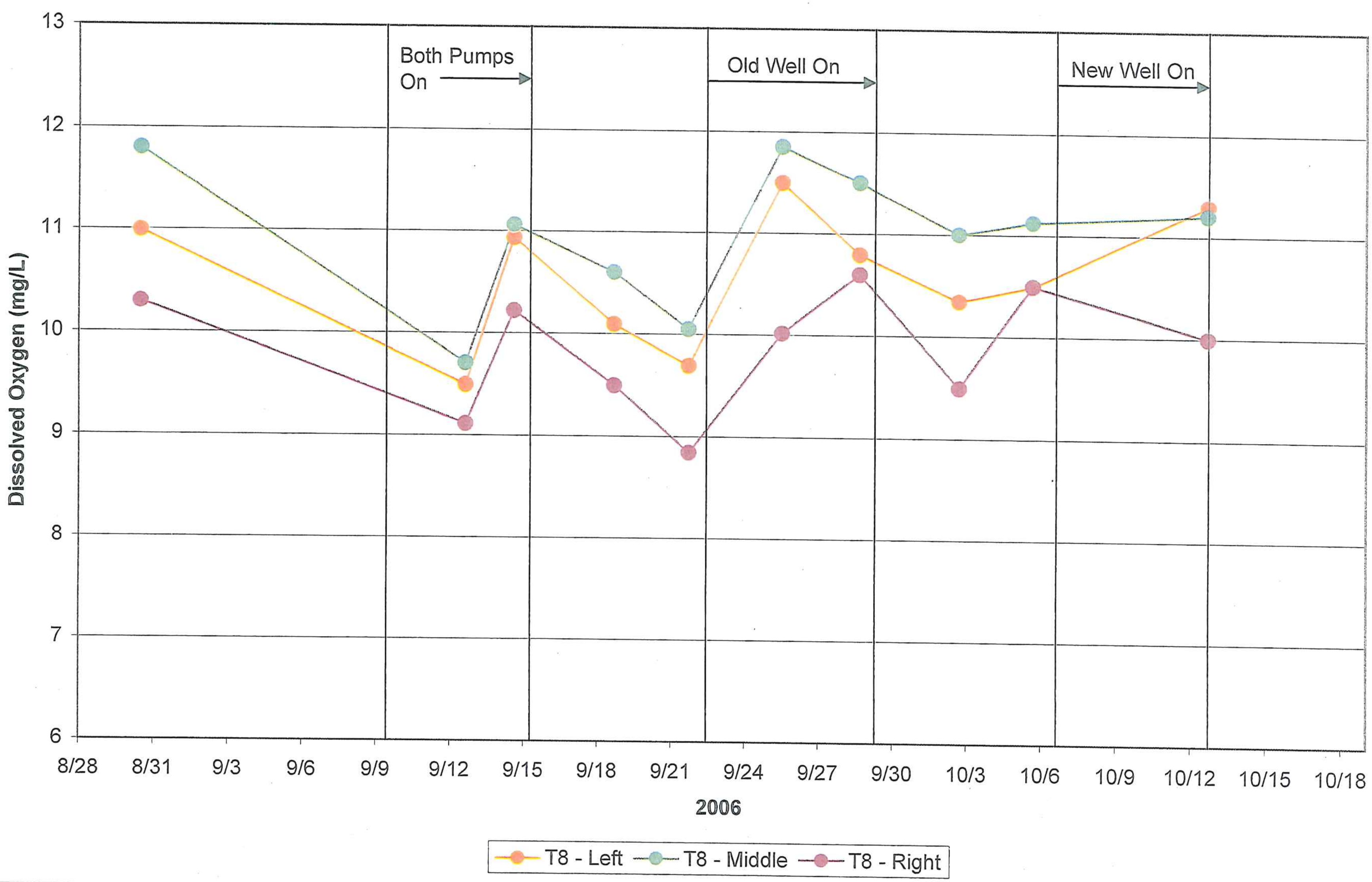
PT8 - Dissolved Oxygen Concentration Data



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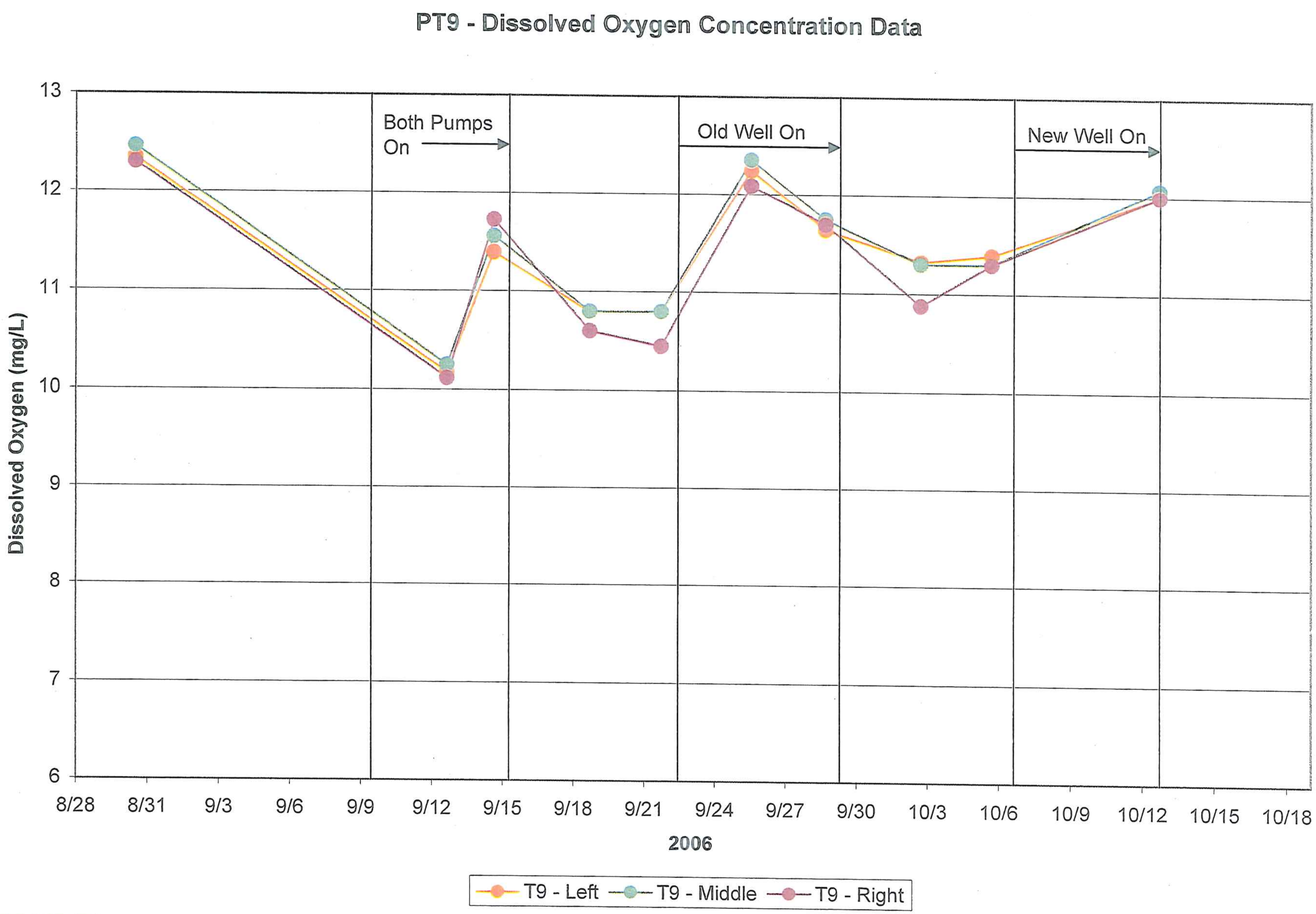

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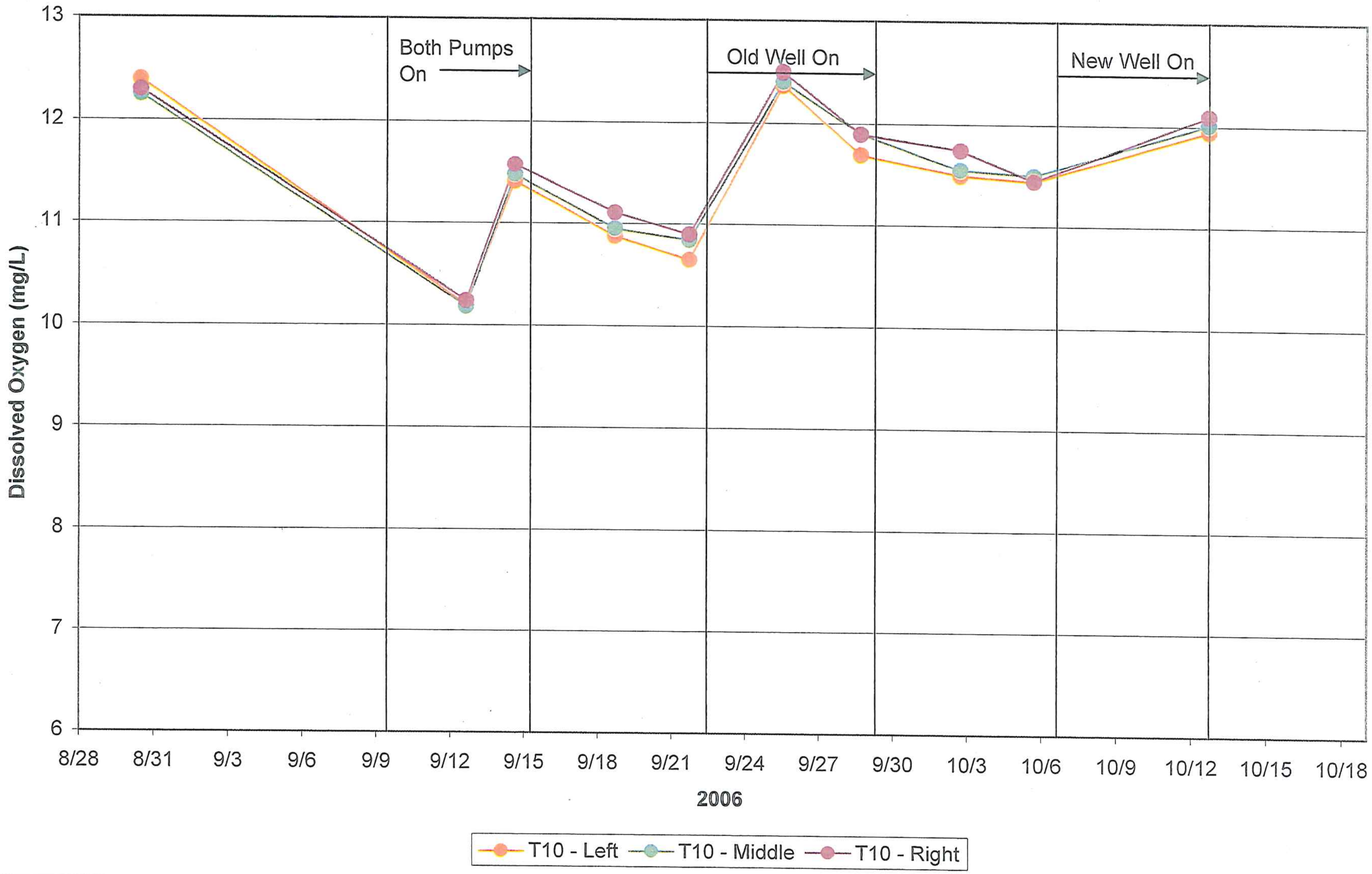

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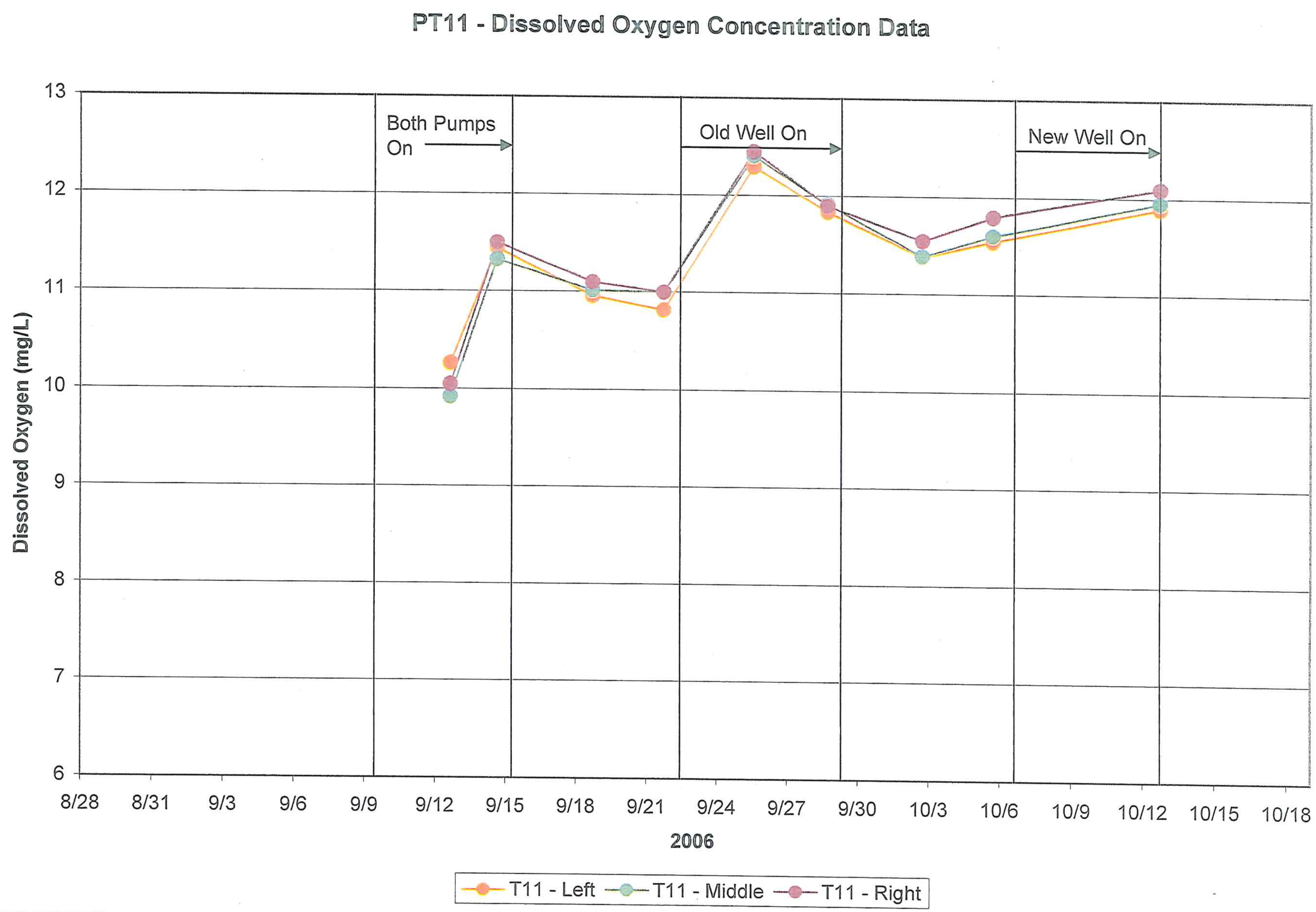

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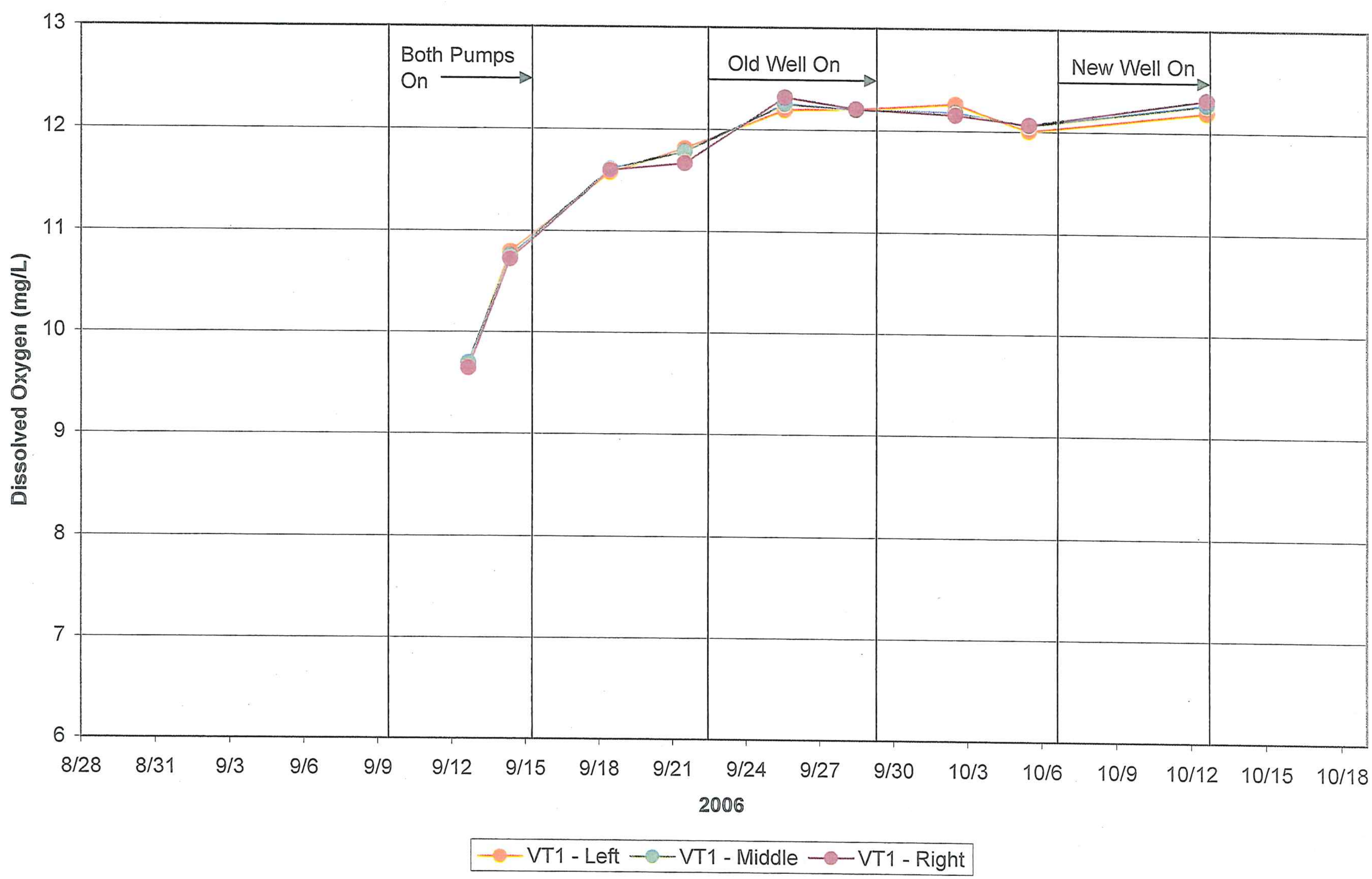
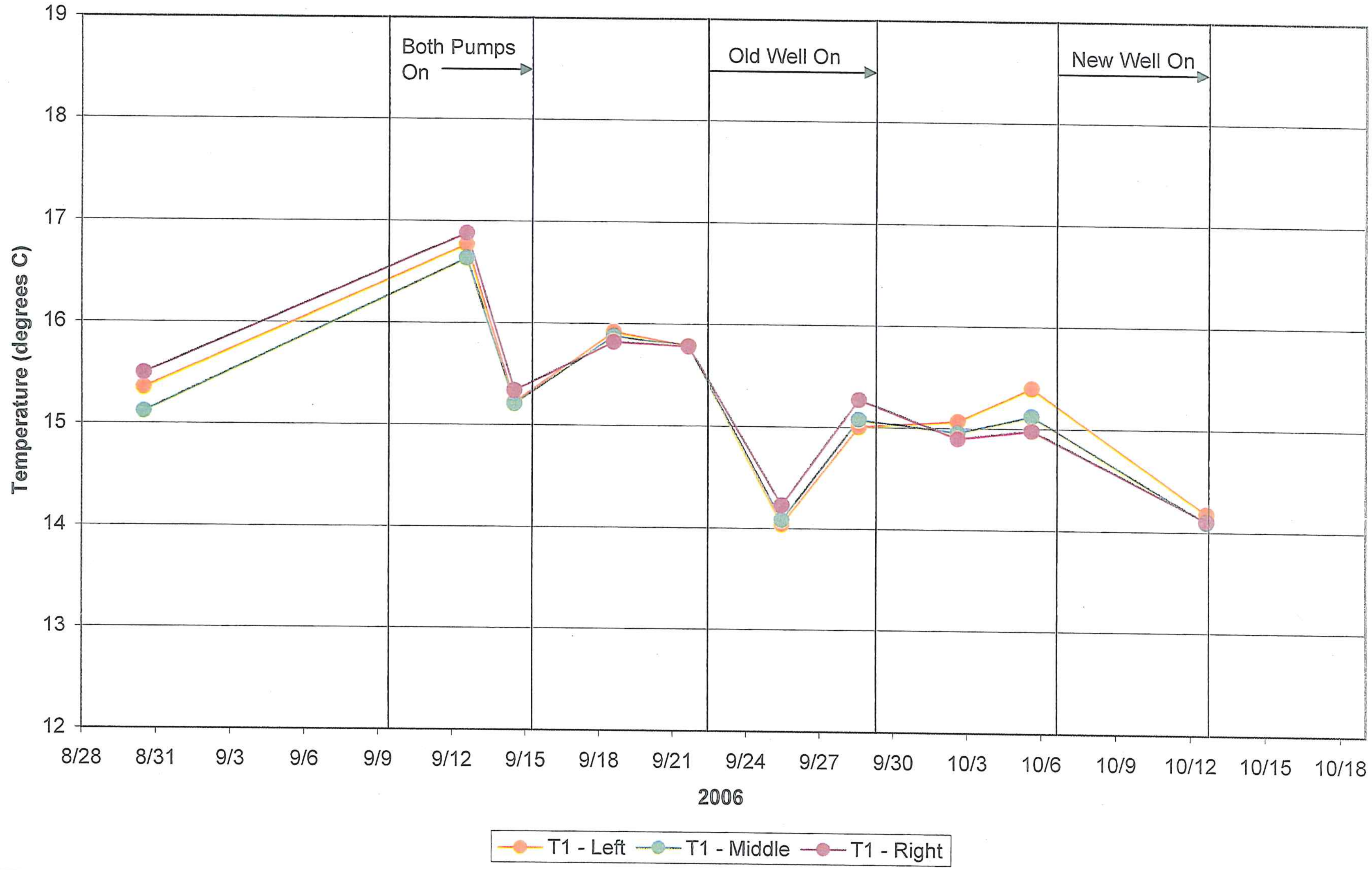
VT1 - Dissolved Oxygen Concentration Data



The Source Group, Inc. — SGI environmental

PT1 - Temperature Data



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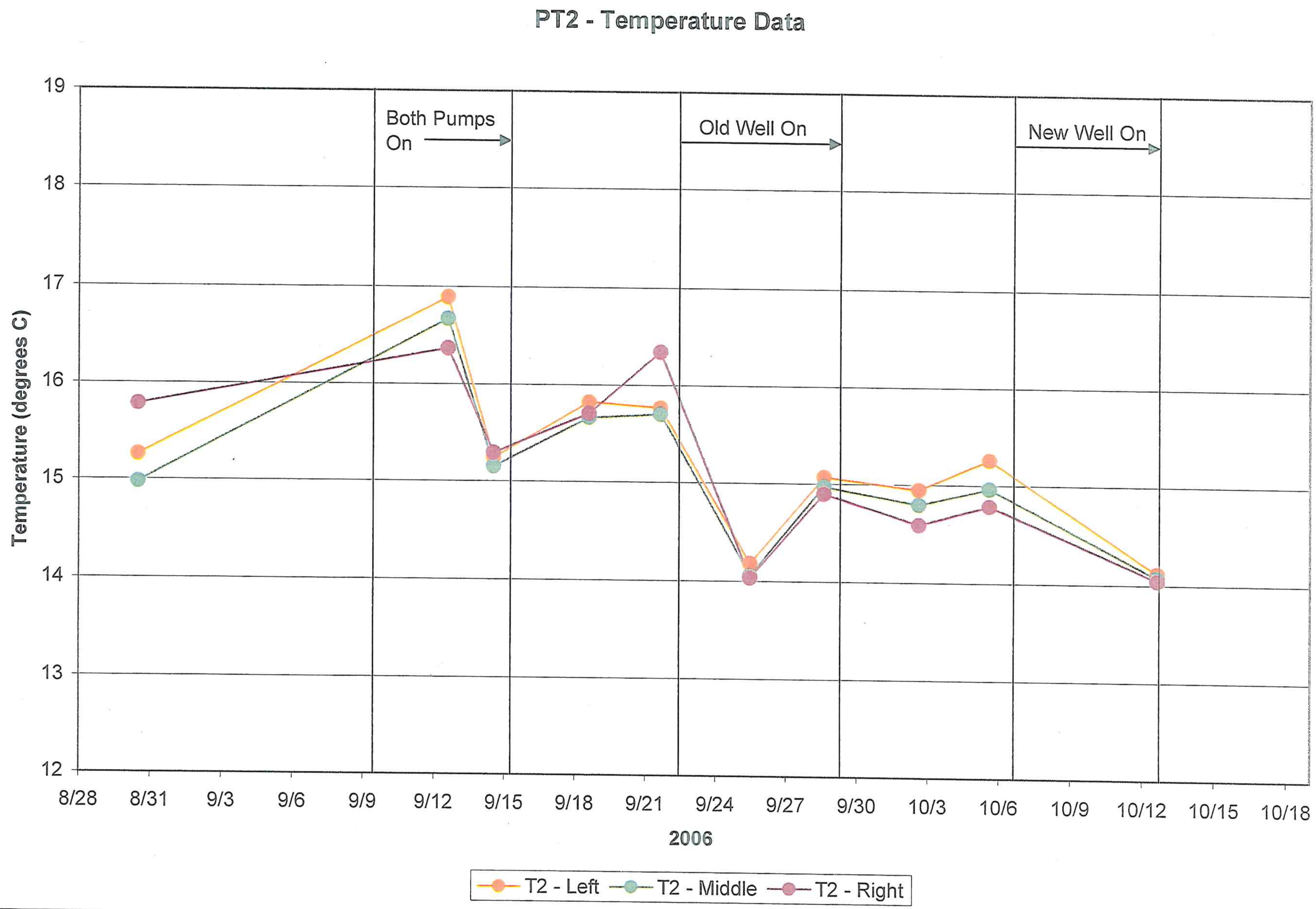

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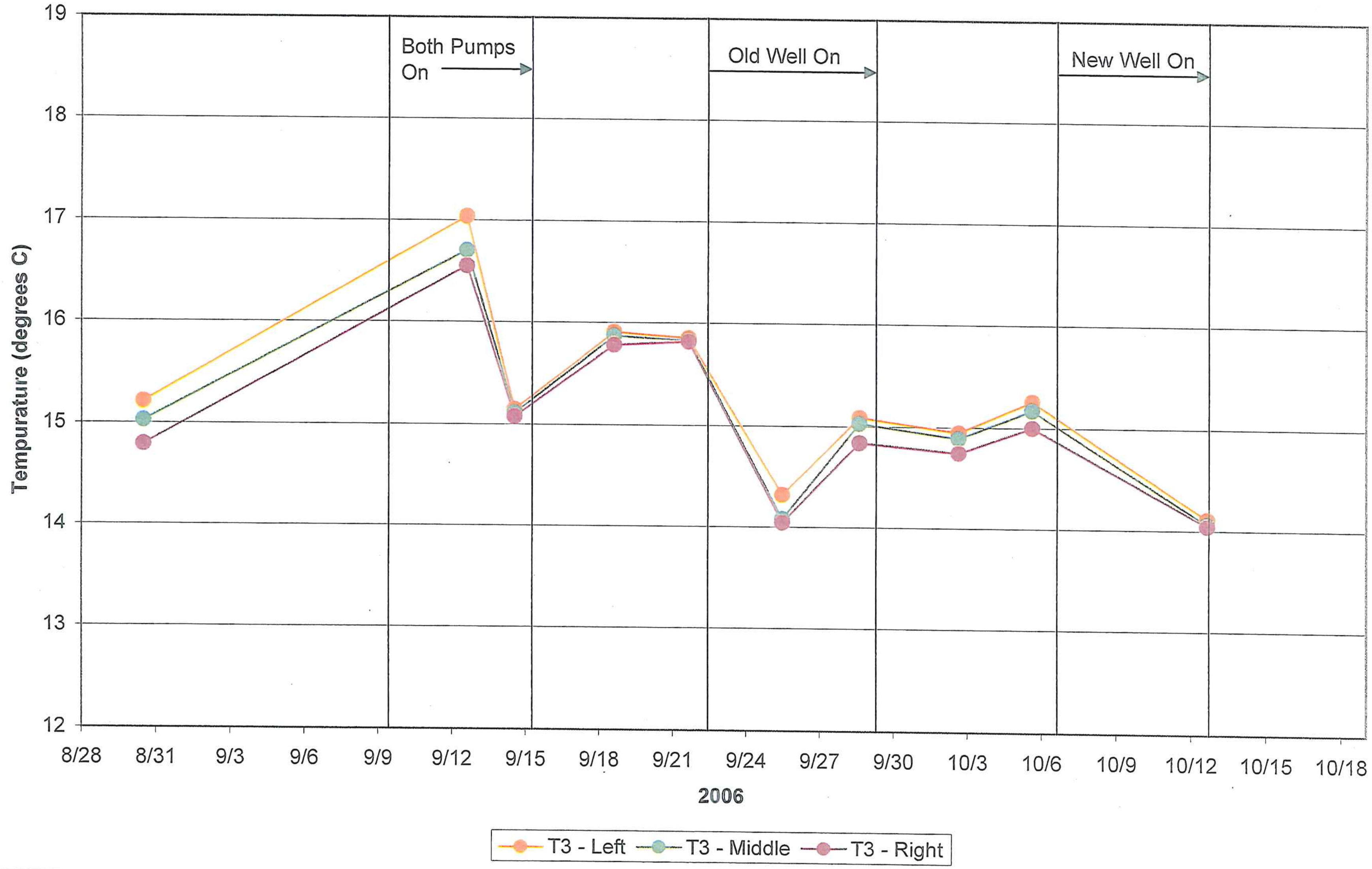

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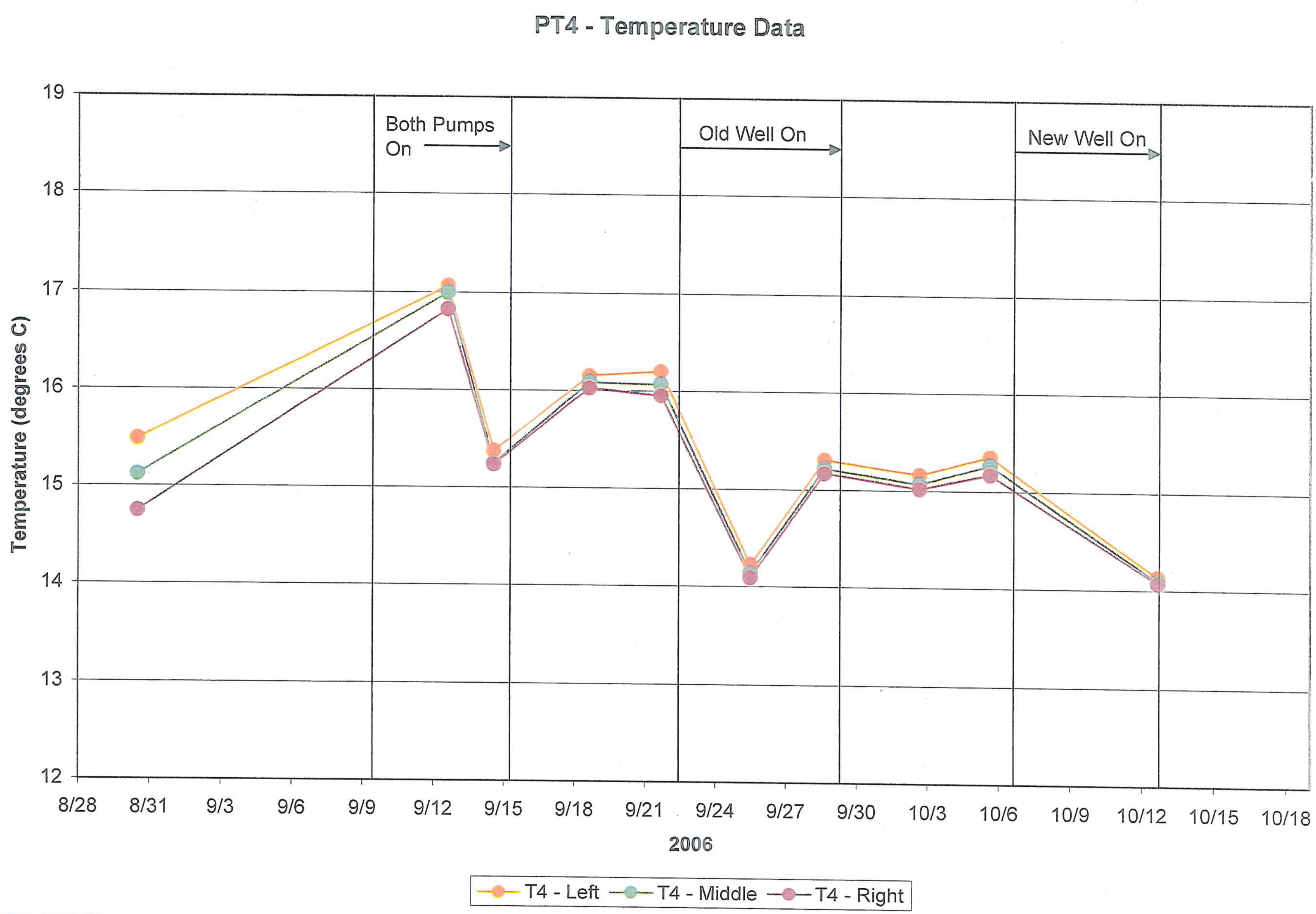

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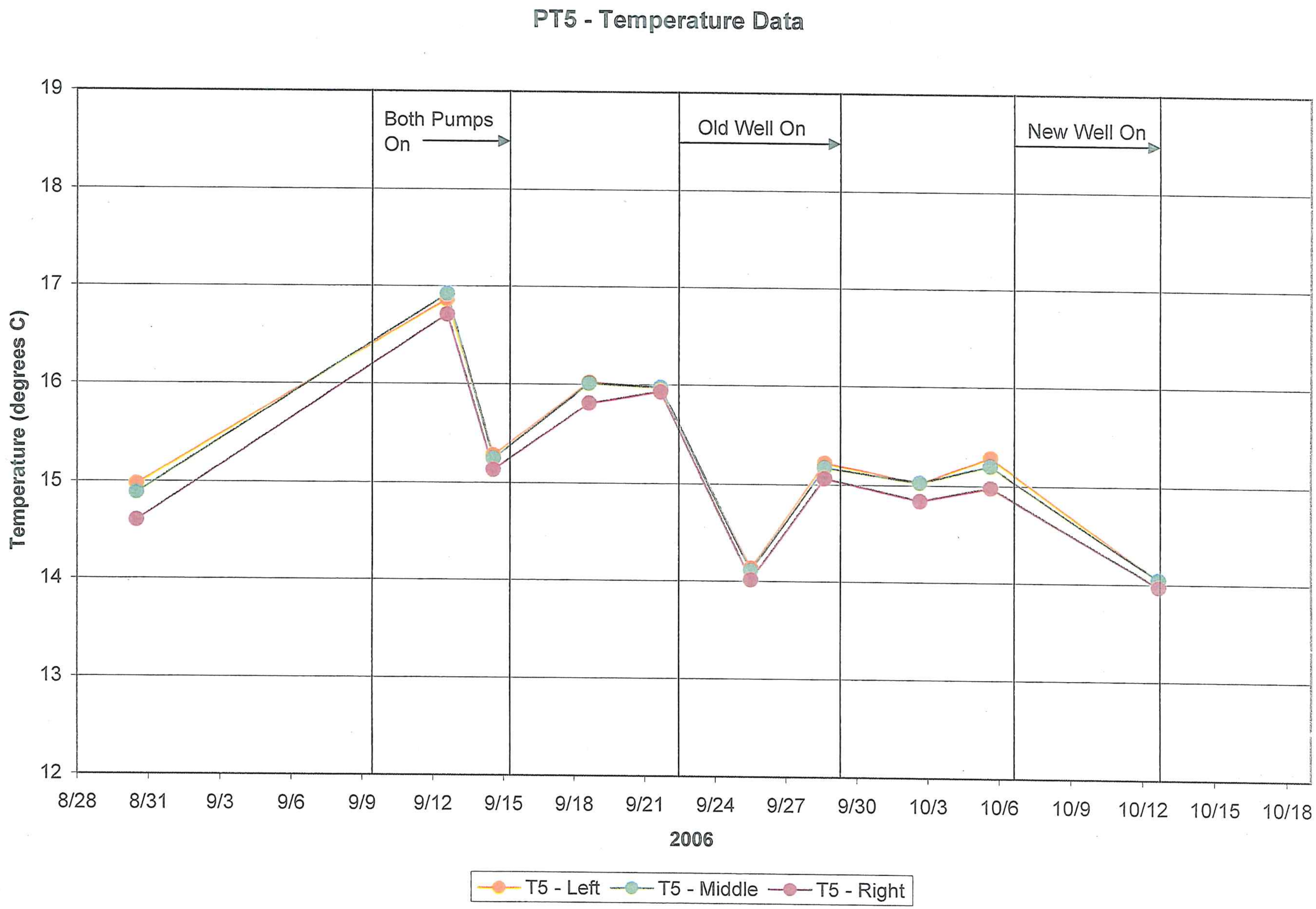

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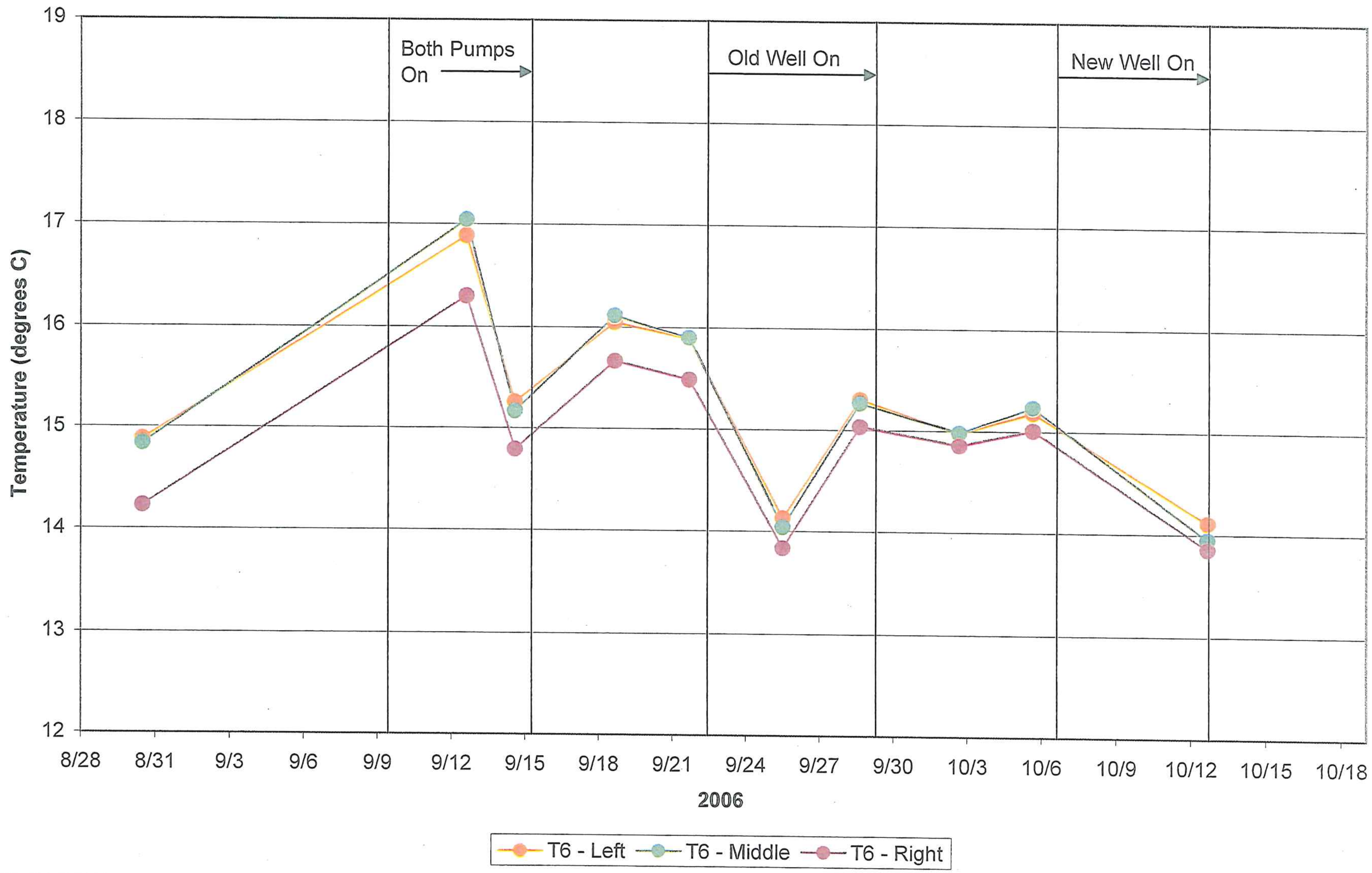
PT6 - Temperature Data



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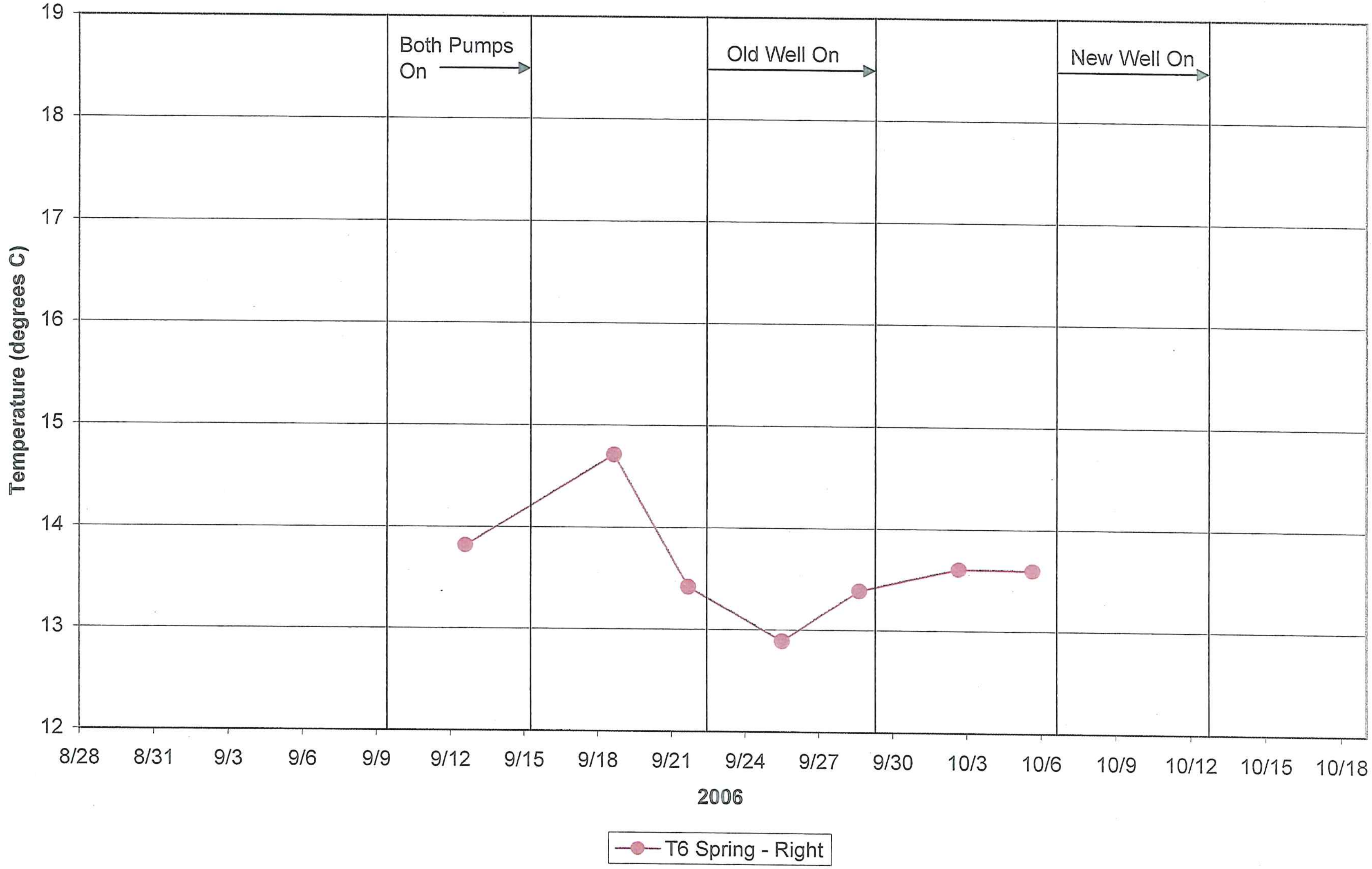
PT6 Groundwater Spring - Temperature Data



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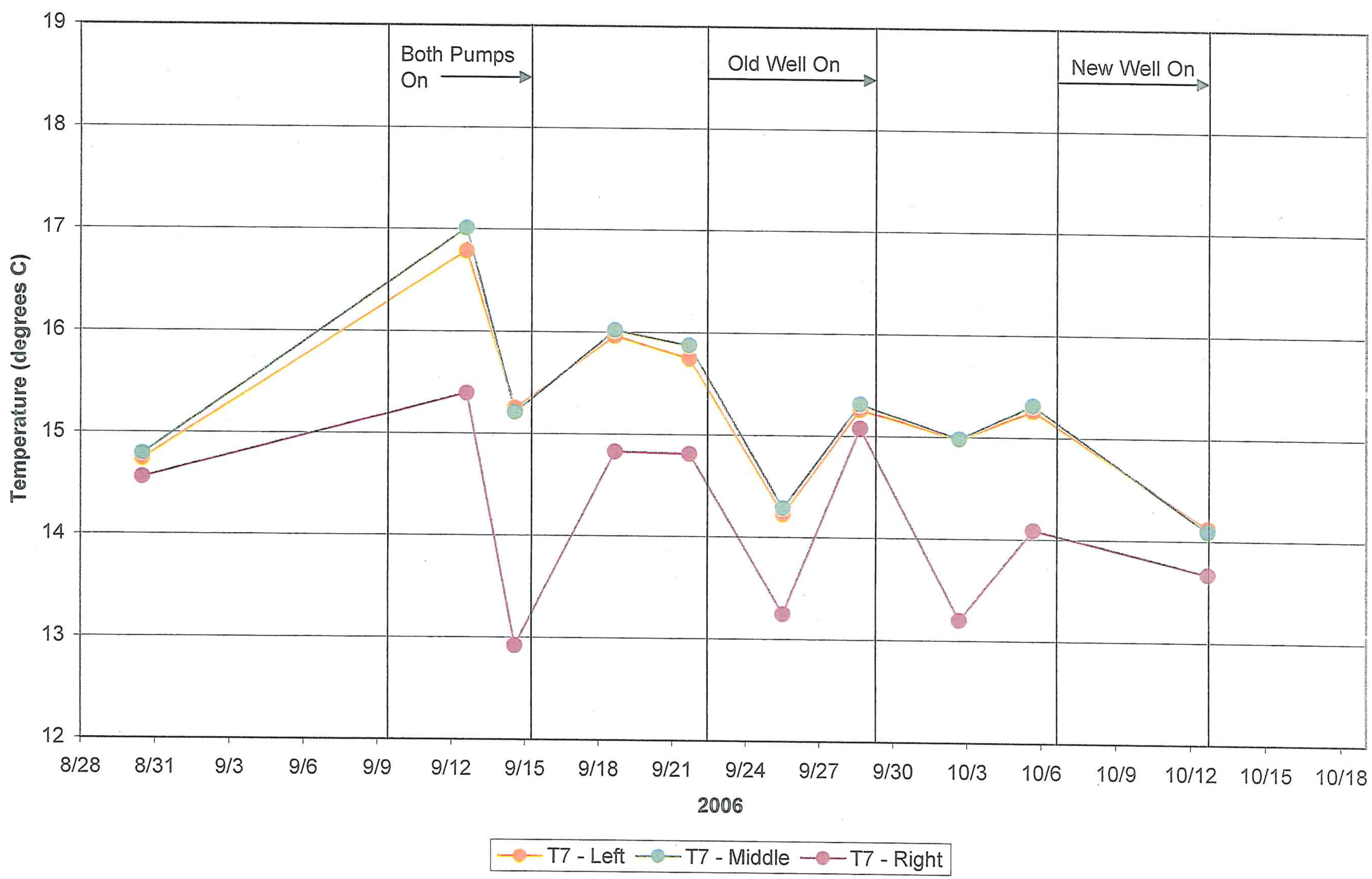
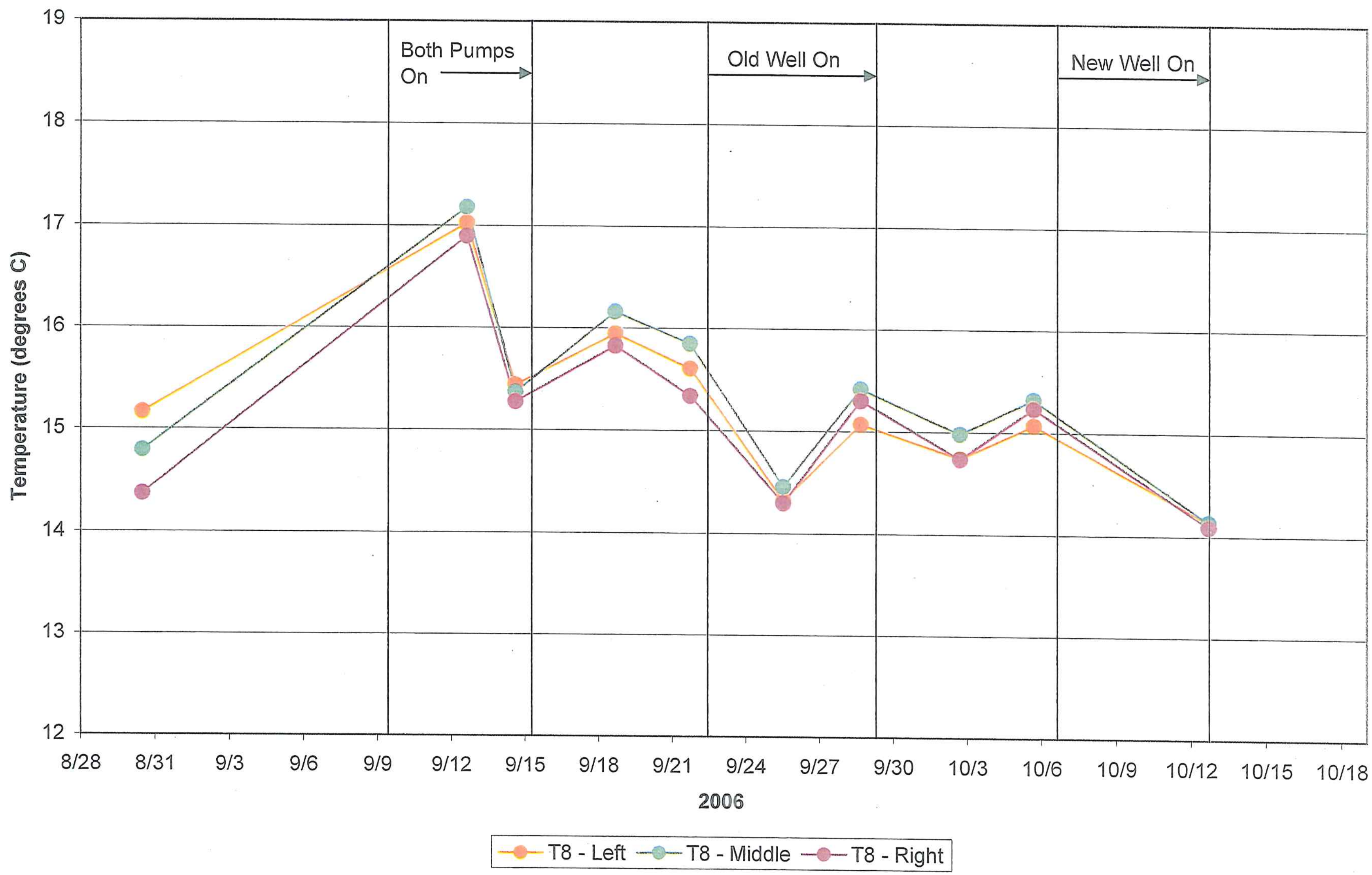
PT7 - Temperature Data



THE SOURCE GROUP, INC.
SGI environmental

PT8 - Temperature Data



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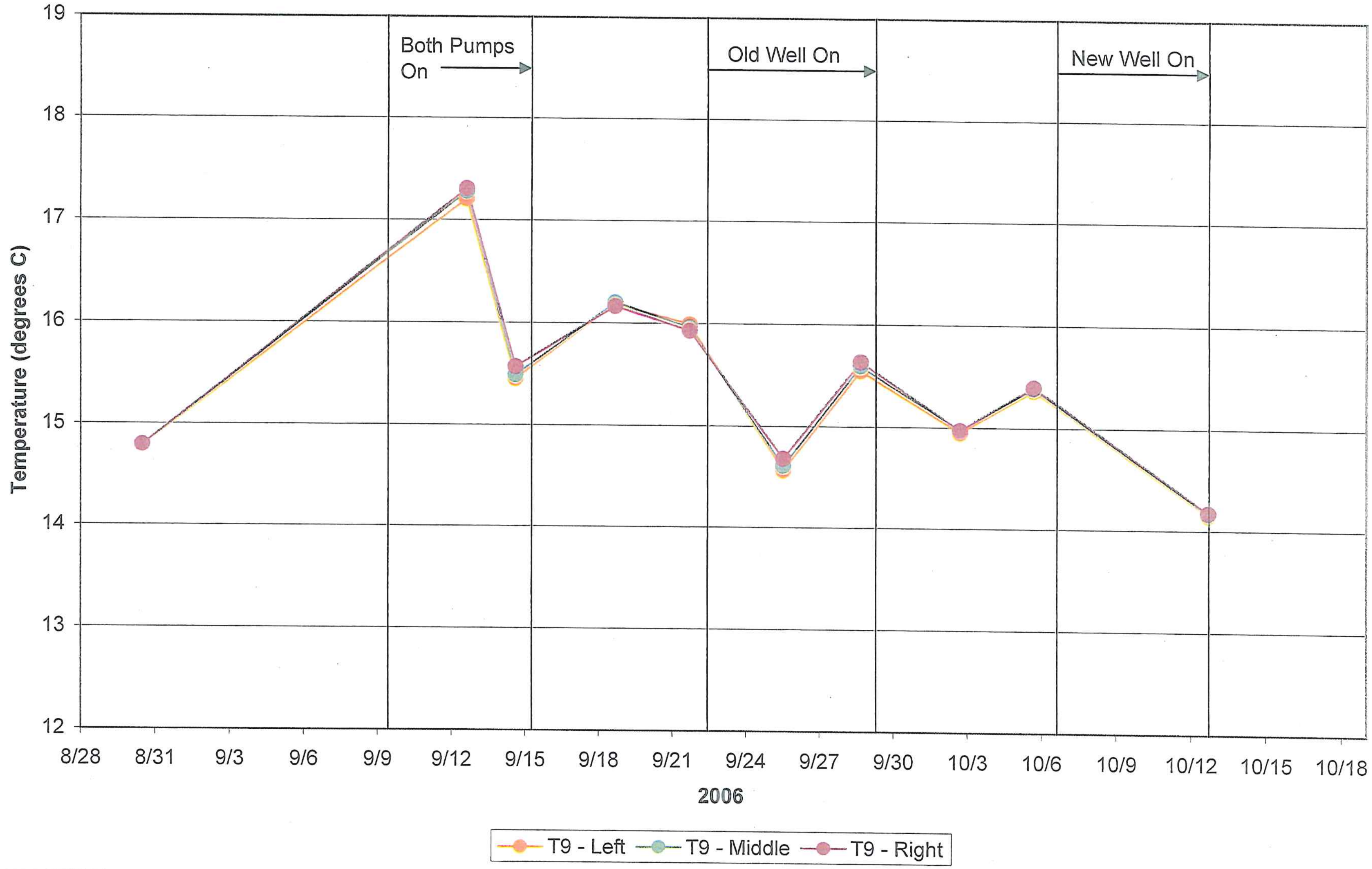
PT9 - Temperature Data



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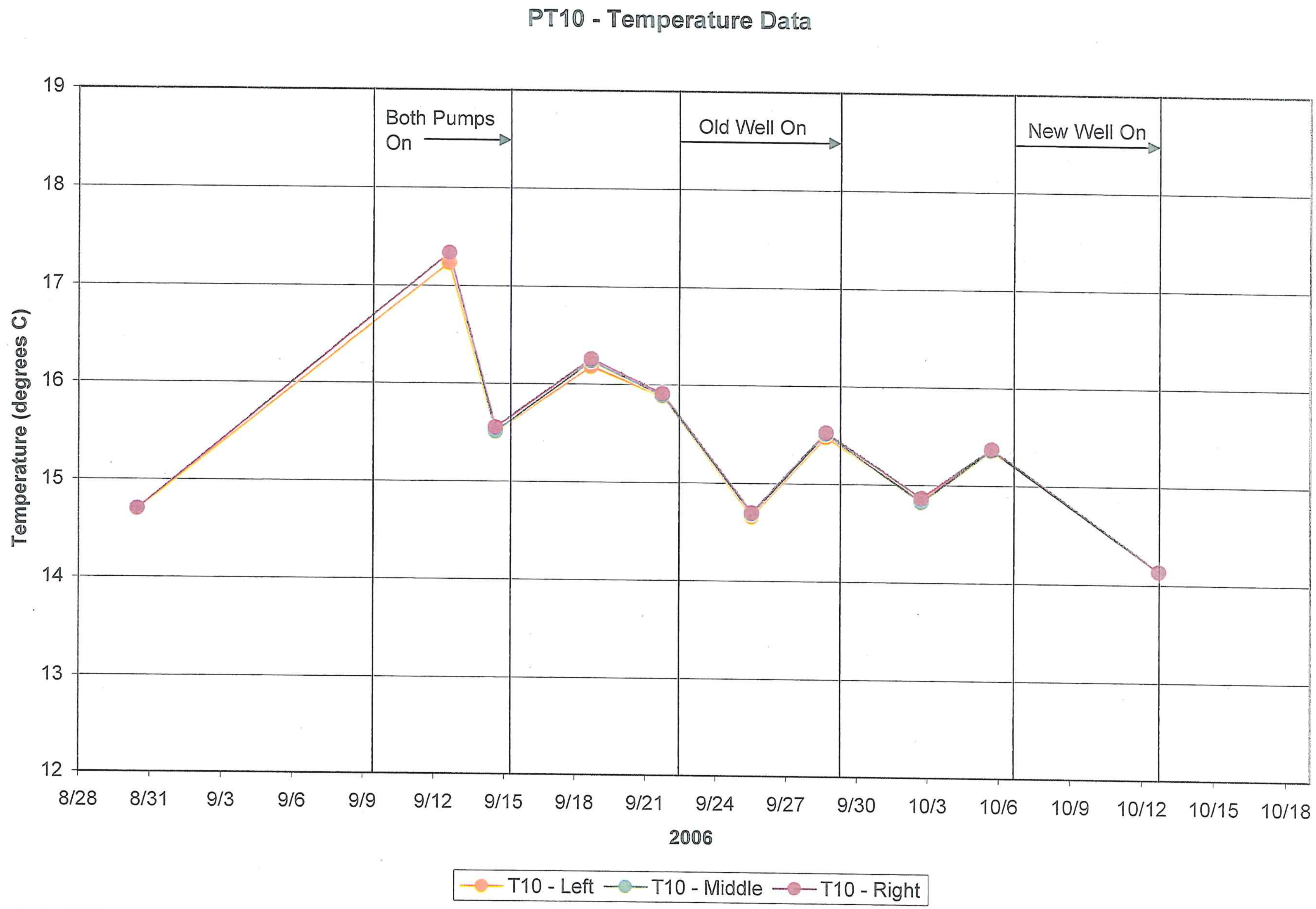

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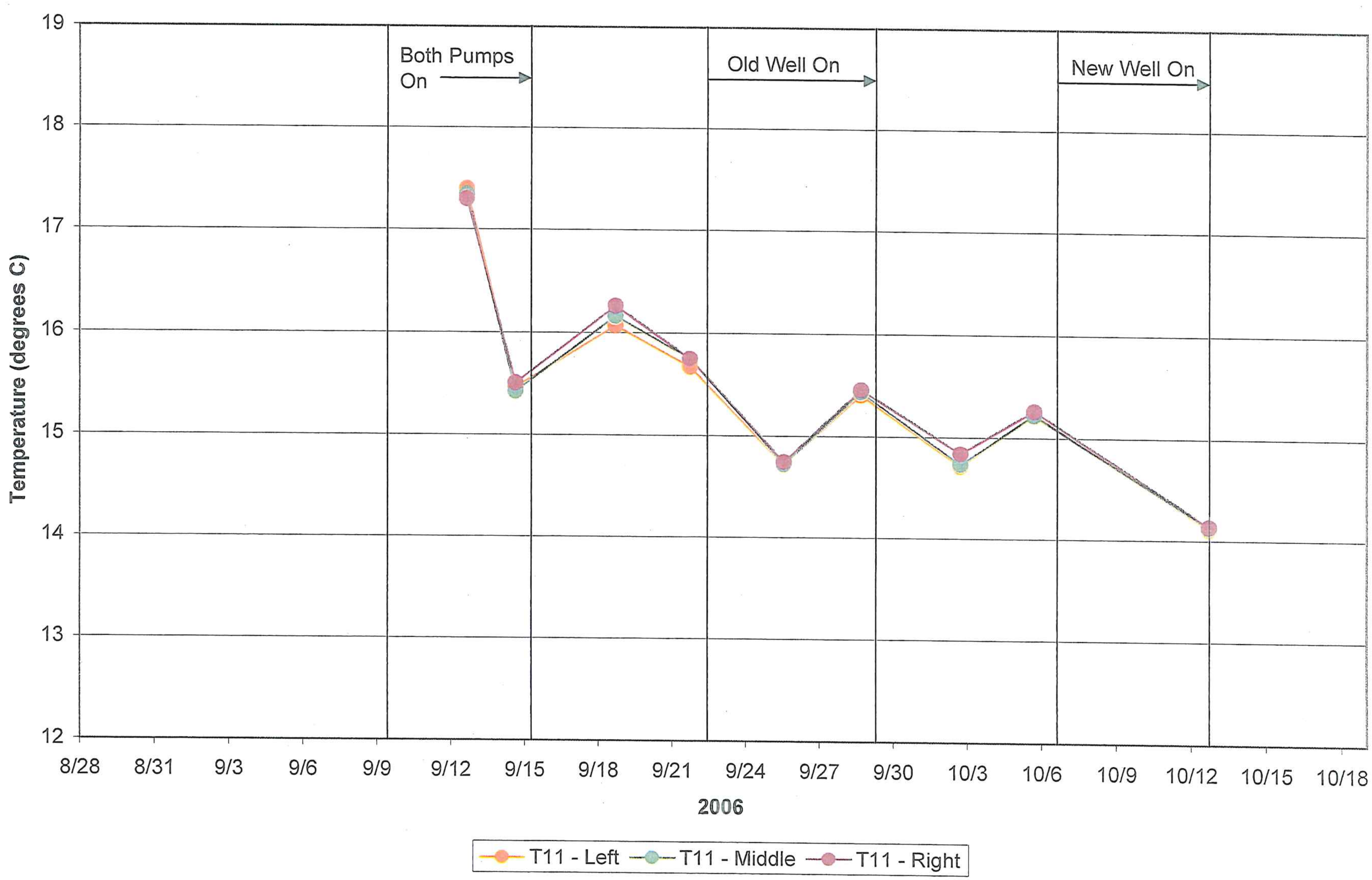

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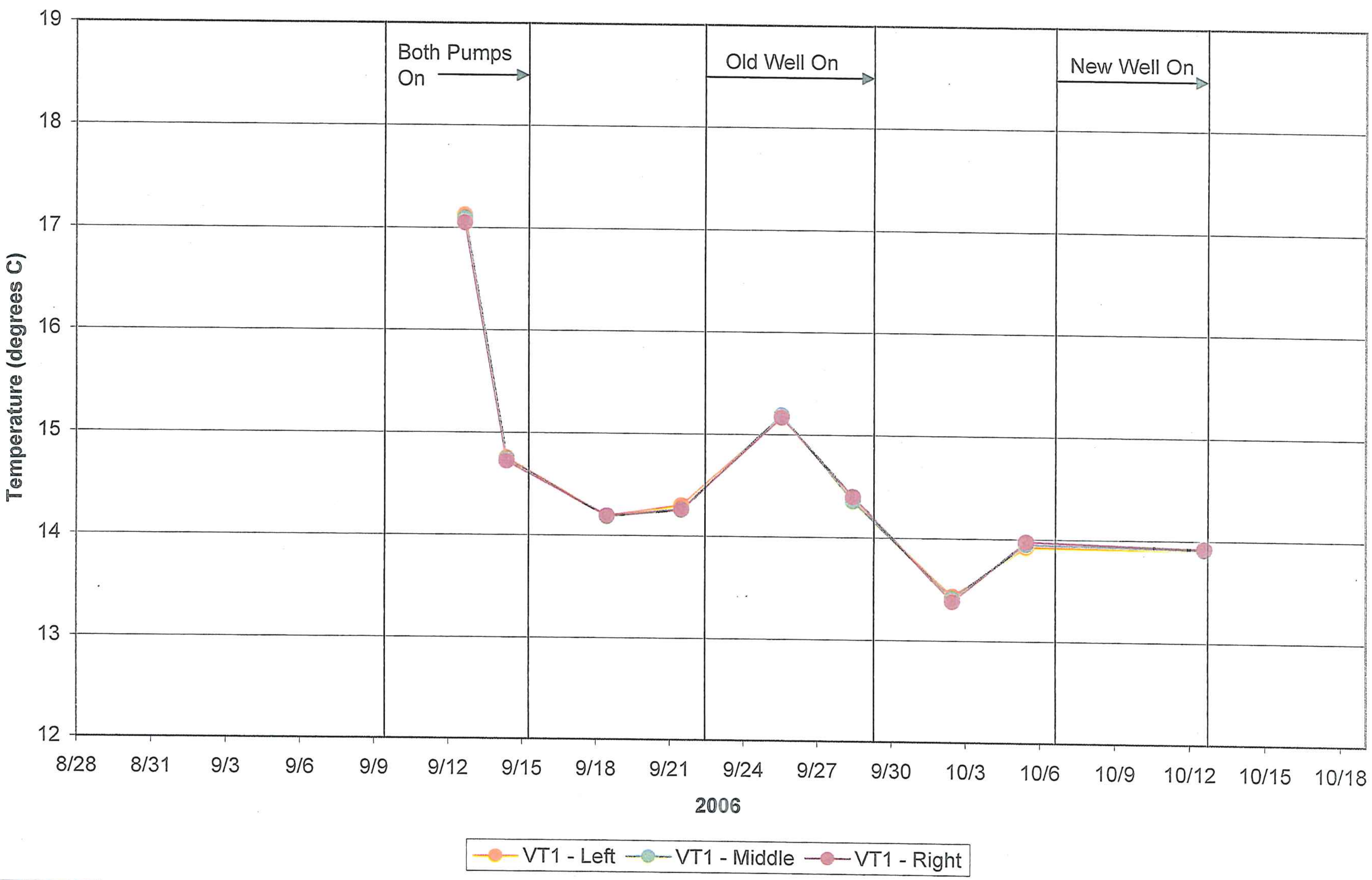
VT1 - Temperature Data



SGI environmental THE SOURCE GROUP, INC.

SOIL STABILY REPORTS

Water Right Application #30166
El Sur Ranch, Monterey County, California

Soil Stability Reports

SOIL STABILIY REPORTS

ROGERS E. JOHNSON & ASSOCIATES
CONSULTING ENGINEERING GEOLOGISTS
41 Hangar Way, Suite B
Watsonville, California 95076-2458
e-mail: reja@bigfoot.com
Ofc (831) 728-7200 • Fax (831) 728-7218

GEOLOGIC EVALUATION OF EROSION ISSUES ON IRRIGATED PASTURE LANDS EL SUR RANCH STATE HIGHWAY 1, BIG SUR MONTEREY COUNTY, CALIFORNIA

REJA Job No. C06044-M13
2 March 2007

ROGERS E. JOHNSON & ASSOCIATES
CONSULTING ENGINEERING GEOLOGISTS
41 Hangar Way, Suite B
Watsonville, California 95076
e-mail: reja@bigfoot.com
Ofc (831) 728-7200 ● Fax (831) 728-7218

2 March 2007

El Sur Ranch
c/o Mark Blum, Esquire
Horan, Lloyd, Karachale, Schwartz, Law and Cook
P.O. Box 3350
Monterey, CA 93942-3350

Job No. C06044-M13

Re: Erosion of Irrigated Pastures on Irrigated Pasture Lands
El Sur Ranch
State Highway 1, Big Sur
Monterey County, California

Dear Mr. Blum:

The attached report presents the results of our geologic investigation of erosion issues at the subject site. Our work focused on erosion of the coastal bluffs fronting the irrigated pastures and erosion along the banks of Swiss Canyon which flows through the irrigated pastures. We also briefly discuss possible methods to mitigate the loss of pasture land due to surf erosion.

Please contact us if you have questions or comments concerning our report.

Sincerely,

ROGERS E. JOHNSON & ASSOCIATES

CERTIFIED ENGINEERING GEOLOGIST
ROGERS E. JOHNSON
No. 1016
Exp. 7/07
STATE OF CALIFORNIA

Rogers E. Johnson
Principal Geologist
C.E.G. No. 1016

REJ/rej/adg

Copies: Addressee (5)

TABLE OF CONTENTS

INTRODUCTION

Staff in the California Department of Fish and Game have expressed concern that continued irrigation of El Sur Ranch pastures, totaling about 292 acres of land, may contribute to erosion along the banks of Swiss Canyon, the major drainage that bisects the irrigated pastures, and of the coastal bluff that borders the southern end of the pastures (Figure 1; Site Location Map). Our work focusing on determining if the allegations have merit. We also briefly discuss a possible method of reducing the loss of pasture due to erosion of the coastal bluffs.

Our scope of work included: review of previous hydrologic and environmental reports commissioned by the El Sur Ranch, analysis of 16 sets of stereo aerial photos of the pasture land and vicinity taken between 1942 and 2003 and a single photo taken in 1929 included in a report by Natural Resources Consulting Engineers, Inc. (2005), analysis of the collected data, field mapping, and preparation of this report.

The El Sur Ranch has been in existence since the early 19th Century. Irrigation of the pastures in question was initiated circa 1950.

GEOLOGIC SETTING

The pastures occupy an elevated marine terrace that is partially overlain by a veneer of dune sand (Figure 2). The terrace slopes gently seaward at about 2-3 degrees. The terrace materials consist of relatively soft, clayey sand containing pebble to cobble-sized rock. These terrace deposits are readily erodible, especially when subjected to surf attack. The terrace deposits are underlain predominately by metamorphosed volcanic rock and graywacke, a type of sandstone (Figure 2). In general, these bedrock types are much more resistant to erosional processes, especially where the bedrock is coherent and relatively unsheared. Exposures of the coastal bluffs fronting the irrigated pastures and within Swiss Canyon, where we performed our field work in February 2007, consisted entirely of marine terrace deposits overlain by soils and in some areas dune sand. No erosion resistant bedrock was exposed within the bluffs along this segment of coastline or within Swiss Canyon.

COASTAL EROSION

Geologic structure plays an important role in rates of coastal bluff retreat within the area of interest; the roughly 1-mile long segment of bluff is fronted by a beach and backed by the irrigated pastures. A broad trough, roughly 750 feet wide, which is underlain by highly sheared bedrock, lies offshore of Pasture 6. The trend of this trough is about North 13 degrees East. The implications of this trough will be discussed in more detail later in this report.

The coastal bluffs are usually protected from surf erosion by a broad sandy beach which absorbs the surf energy before it can attack the base of the bluffs.

Analysis of Aerial Photographs

Our analysis of aerial photographs was the chief tool we utilized for forming our opinion related to both coastal bluff erosion and subaerial erosion along the banks of Swiss Canyon and elsewhere within the irrigated pasture area.

As noted previously, we analyzed 16 sets of stereo aerial photographs of the subject site, taken between 1942 and 2003. These photos were available from the Map Library at the University of California, Santa Cruz campus. In addition to these stereo aerial photos, we also utilized a single aerial photograph, taken in 1929, that was included in a report prepared for El Sur Ranch by Natural Resources Consulting Engineers, Inc. (2005).

Coastal Bluff Retreat

We calculated rates of coastal bluff retreat by comparing the position of the bluff depicted on the aerial photos. Comparison of the 1929 photo with the 1949 photos revealed an average annual rate of bluff retreat varying between about 1.8 to 2 feet per year along the bluff segment fronting Pasture 6. During some time intervals there is virtually no change in the position of the bluff top. For example, comparison of photos taken in 1942 and 1949 show no change in the position of the bluff just south of the mouth of Swiss Canyon.

Obviously, bluff retreat at the site is episodic. Where a combination of high tides and large oceanic storms coming from a direction that affords the least protection from "natural barriers", such as offshore sea stacks, reefs, etc., significant bluff retreat can occur within a matter of days if not hours.

As noted earlier, there is a relatively broad trough of deeper water, about 750 feet wide, that lies offshore of the study area. This trough has formed within a shear zone in the bedrock, as surf action selectively erodes the less competent, sheared rock. This trough of deeper water, which trends onshore North 13 degrees East, is focused on Pasture 6. Offshore, this trough is readily seen on aerial photos as it is light in color (sand) whereas its boundaries are dark in color due to the presence of relatively unsheared volcanic bedrock lying close to the water surface.

Because water within the trough is deeper than the surrounding offshore areas, more powerful waves within the trough can reach the bluff with a consequent increase in the rate of bluff retreat. It is important to note that this phenomenon occurs primarily when the direction of wave attack parallels the trend of the trough (about North 13° East). Where storms approach from the predominant northwesterly direction, the position of the trough has a diminished affect on the power of waves attacking the bluff.

Field Mapping

We inspected the face of the bluff and the shore platform below the irrigated pastures. As expected, we saw no exposure of the bedrock platform within the shear zone oceanward of Pasture 6. Nor is any bedrock exposed in the face of the bluff along the stretch of coastline bounded by the irrigated pasture. Metavolcanic bedrock forms the headland east of the shear zone near the outlet to the Reclamation Pond located near the southeast corner of Pasture 6. To the northwest of the mouth of Swiss Canyon, the bedrock shore platform (oceanward of the bluffs), although covered with sand in some areas becomes more exposed to the northwest. Beyond the northwest corner of Pasture 8, hard bedrock is exposed within the lower portion of the bluff.

SUBAERIAL EROSION

Our evaluation of subaerial erosion along the banks of Swiss Canyon and within the irrigated pasture land relied chiefly on analysis of the 16 sets of stereo aerial photographs dating from 1942 to 2003. We also performed field reconnaissance.

The photographs taken in 1942, 1949, 1954 and 1956 show deeply incised tributary gullies, up to about 350 feet long branching off the northwest side of the main channel of the Reclamation Pond drainage. The main branch of this drainage showed evidence of gullying to a point about 1200 feet back from the outlet at the ocean bluff. Between 1956 and 1967 these gullies had been filled and reclaimed as irrigated pasture.

The banks of Swiss Canyon within the irrigated pasture area south of Highway 1 also showed evidence of deep gullying in the 1942 and 1949 photographs. By 1954 many of the deeper gullies had been filled. The photographs also indicate a general progression of increased riparian vegetation within Swiss Canyon between 1942 and 2003, the date of the latest set of photographs we examined.

Our field work revealed seepage out of the face of the bluff inside the irrigated pasture and outside the irrigated area. Slumping of the bluff was also apparent along segments of bluff adjacent to irrigated as well as non-irrigated pasture.

The banks of Swiss Canyon show evidence of minor slumping and erosion but the degree of erosion and slumping is much less today than it was in the 1940's and early 1950's.

The draft of a short-term study of bluff erosion by Hanson Environmental, Inc. (2007) performed between 9 September and 16 October 2006 showed no changes in the bluff top during that time period.

CONCLUSIONS

Based on our field mapping, analysis of aerial photography and review of prior reports addressing the subject property, it is our opinion that irrigation of pasture land has had no discernable effect on rates of coastal bluff retreat within the study area.

All other factors being equal, the chief variable affecting the rate of bluff retreat is the **direction** from which major storms attack this stretch of coastline; this is especially true of the pasture located south of the outlet of Swiss Canyon (Figure 1, Pasture 6). As noted earlier, strong oceanic swells out of the south-southwest (S 15° W) will subject the coastal bluff to more erosive surf energy here because of the broad offshore trough that is oriented in this direction. A combination of high tides and sustained storms out of the south-southwest does not occur frequently, which helps explain the episodic nature of bluff retreat along this stretch of coast. Obviously, large storms emanating from other directions in combination with high tides, will also reach the bluffs and cause erosion but these storms do not pack the erosional power of the storms out of the south-southwest.

Surf erosion is the primary agent affecting bluff retreat; if surf erosion ceased, the coastal bluffs would soon reach a stable angle of repose regardless of whether or not the land adjacent to the bluffs is irrigated.

Our investigation did not reveal evidence of increased erosional activity during the past 50 years or so, either along the blufftop or on the banks of Swiss Canyon. In fact, subaerial gullying and slumping has diminished over this time period, primarily due to filling of gullies and control of surface runoff.

The ranch may be able to use existing natural materials available on the beach (driftwood logs) to help retard surf erosion. Stacking of "jack strawed" driftwood logs is certainly not as effective as a well built seawall but this type of erosion protection may withstand the scrutiny of the governmental agencies who would issue the necessary construction permits.

REFERENCES

Hall, C.A. Jr., 1991, Geology of the Point Sur-Lopez Point Region, Monterey County, California, Plate 1 of 2, Scale 1:24,000.

Hanson Environmental, Inc. 2007, Draft Report, Erosion Monitoring from Rainfall Runoff and Surface Irrigation Excess Overflow on Coastal Bluffs Bordering El Sur Ranch Pastures 7 and 8, report prepared for El Sur Ranch.

Natural Resources Consulting Engineers, Inc. 2005, Reasonable Beneficial Use - Land Use Study for El Sur Ranch Irrigated Pastures, report prepared for El Sur Ranch.

Aerial Photographs

8 January 1942 (1942-A), frames 489-358 thru 361, black and white, nominal scale 1:30,000, U.S. Army Air Force.

18 August 1949 (1949-C), frames ABG-18F-88 thru 91, 94 and 95, black and white, nominal scale 1:20,000, U.S. Department of Agriculture.

22 May 1954 (1953-54), frames GS-YH 5-14 thru 16, black and white, nominal scale 1:37,400, unknown agency.

14 May and 12 June 1956 (1956-C), frames ABG-4R-85 and 86 and ABG-15R-21 thru 23, black and white, nominal scale 1:20,000, U.S. Department of Agriculture.

3 February 1967 (1967-E), frames 51-1-83 thru 87, black and white, nominal scale 1:12,000, California Department of Fish and Game.

16 April 1969 (1969-F), frames WR-BP-U 1-11 and 12, 18 thru 20, 28 thru 30 and 36 thru 39, black and white, nominal scales 1:18,000 (11 and 12), 1:9,000 (18 thru 20, 28 thru 30) and 1:4,800 (36 thru 39), California Department of Water Resources.

15 May 1970 (1970), frames 76-4-144 thru 150, black and white, nominal scale 1:12,000, California Department of Fish and Game.

5 October 1976 (1976-1977 Color), frames DNOD-AFU-C 7 thru 17, color, nominal scale 1:12,000, California Department of Navigation and Ocean Development.

2 May 1978 (1978-B), frames DNOD-AFU-3-C 301 thru 306 and DNOD-AFU-4C 2 thru 5, color, nominal scale 1:12,000, California Department of Navigation and Ocean Development.

17 August 1978 (1978 Color), frames 615070 378-67 thru 69, color, nominal scale 1:24,000, U.S. Forest Service.

24 June 1980 (1980-G), frames CCL 3-5 thru 8, black and white, nominal scale 1:24,000, Army Corps of Engineers.

12 April 1985 (1985-F), frames WAC-85CA 13-220 thru 223, black and white, nominal scale 1:31,680, unknown agency.

2 April 1986 (1986-87 Color), frames CDBW-APU-C 51 thru 59, color, nominal scale 1:12,000, California Department of Boating and Waterways.

25 April 1997, (1997-A), frames WAC-97CA 12-233 thru 237, black and white, nominal scale 1:24,000, WAC Corporation.

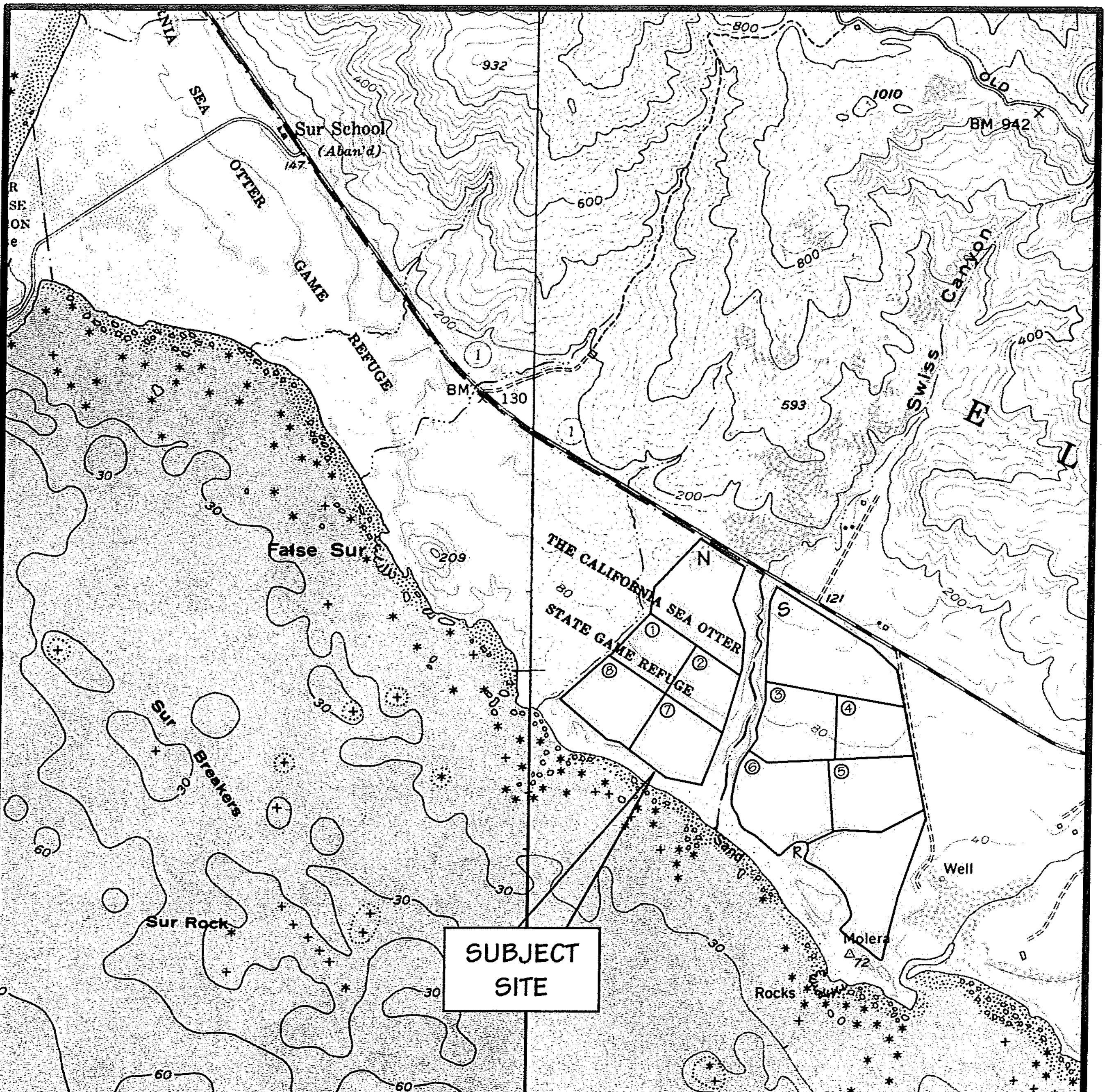
14 June 2001 (2001-A), frames CCC-BQK-C 108-8 thru 10 and 109-2 thru 4, color, nominal scale 1:12,000, California State Department of Water Resources.

1 July 2003 (2003-F), frames AMBAG 507-14 thru 18, color, nominal scale 1:28,800, unknown agency.

Photos are available for viewing at the Map Room in the Science Library at the University of California, Santa Cruz. References to the Map Room collection (e.g., 1990-B, etc.) are provided for convenience.

APPENDIX A

FIGURES 1 thru 10



EXPLANATION

- N North Pasture
- S South Pasture
- ⑧ Pasture #
- R Reclamation Pond

Base Map: BIG SUR QUADRANGLE, California, 7.5 Minute Series, United States Geological Survey, 1956, scale 1:24,000 and POINT SUR QUADRANGLE, California, 7.5 Minute Series, United States Geological Survey, 1956, scale 1:24,000.

N

0 feet 2,000

ROGERS E. JOHNSON & ASSOCIATES Consulting Engineering Geologists 41 Hangar Way, Suite B Watsonville, California 95076 (831)728-7200 FAX (831)728-7218	SITE LOCATION MAP *El Sur Ranch* State Highway 1, Big Sur Monterey County, California	FIGURE # 1 JOB # C06044-M13

Explanation

Qal — Alluvial deposits

Qs/Qds — /Stabilized Dune sand deposits

Qls/Qc — Landslide/Colluvial deposits

Qols — Older rock and mudflow debris

Qt — Stream and marine terrace deposits

Tmpm — Pismo Formation - Miguelito Member

Tmr — Rincon Shale

Tmv — Vaqueros Sandstone

Kush, Kuss — Upper Cretaceous sedimentary rocks (Eastern facies) sh - shale, ss - sandstone

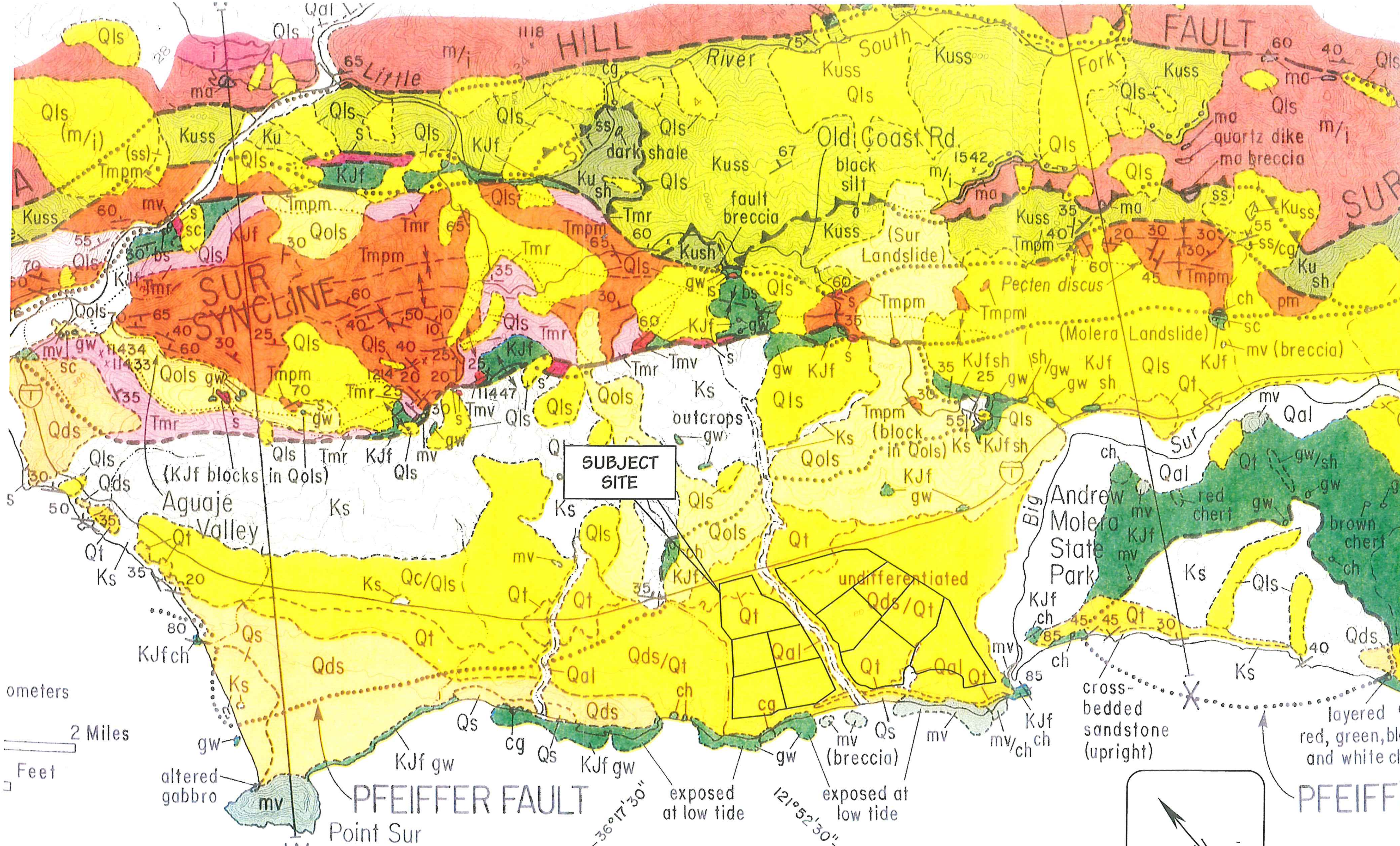
Ks — Upper Cretaceous sedimentary rocks (Western facies)

KJf, mv — Cretaceous-Jurassic Franciscan melange gw - graywacke, ch - chert, mv - metavolcanic rock, gs - greenschist, bs - blueschist, cg - conglomerate, sc - silica carbonates

s — serpentinite

i — Plutonic igneous rocks

m, ma — metamorphic rocks ma - gneiss, schist, marble



Geologic contact - Dashed where approximately located or inferred, dotted where concealed and inferred.

High angle fault - Dashed where approximately located or inferred, dotted where concealed and inferred.

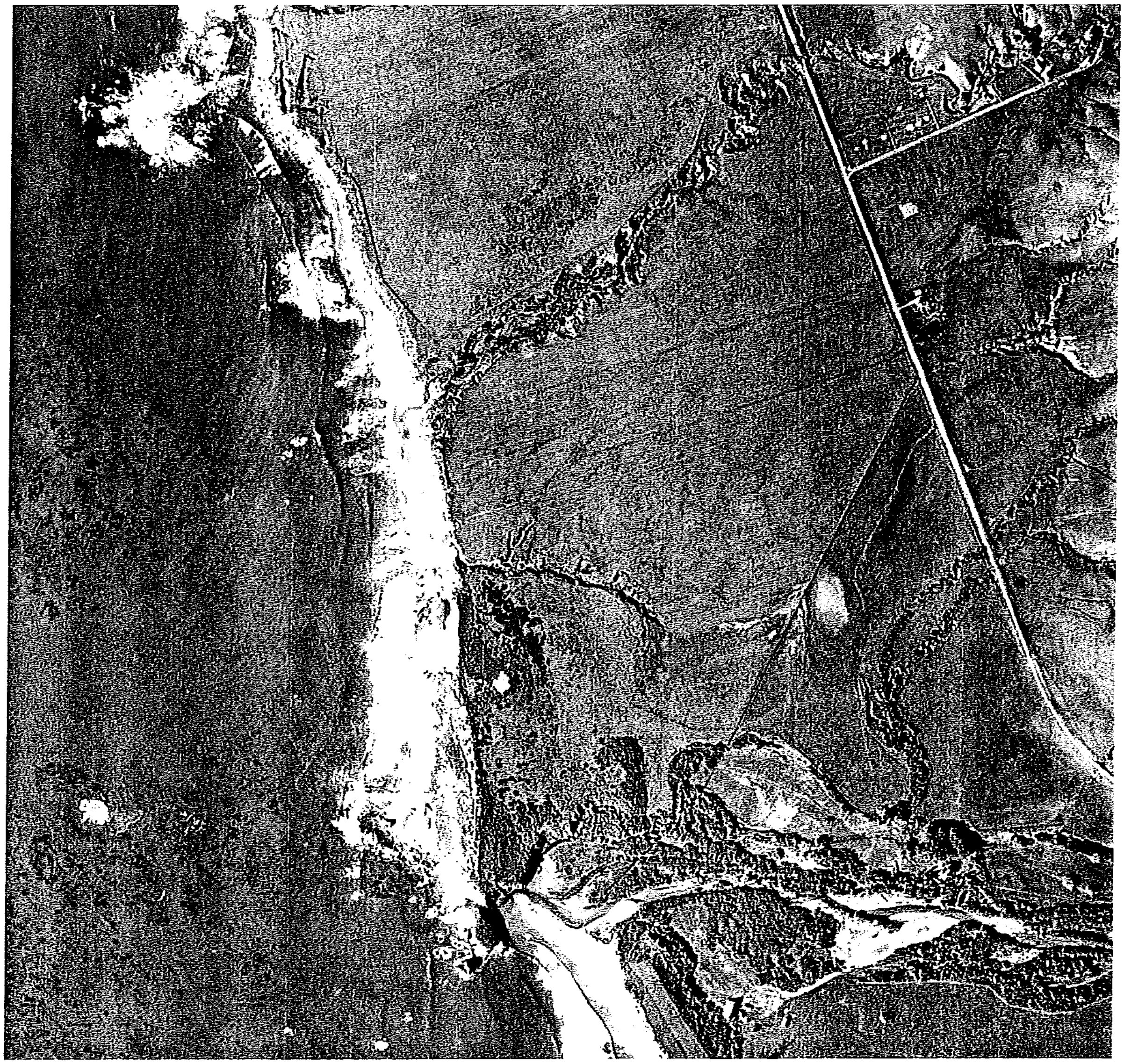
Thrust or reverse fault - Dashed where approximately located or inferred, dotted where concealed and inferred. Sawteeth on upper plate.

Strike and dip of inclined bedding.

Syncline - Showing axis at surface. Dashed where approximately located or inferred, dotted where concealed and inferred.

Anticline - Showing axis at surface. Dashed where approximately located or inferred, dotted where concealed and inferred.

ROGERS E. JOHNSON & ASSOCIATES Consulting Engineering Geologists 41 Hangar Way, Suite B Watsonville, California 95076 (831)728-7200 FAX (831)728-7218	Base Map: "GEOLOGY OF THE POINT SUR-LOPEZ POINT REGION, MONTEREY COUNTY, CALIFORNIA", Hall, C.A.Jr., 1991, Geological Society of America Special Paper 266, Geology of the Point Sur-Lopez Point region, Coast Ranges, California: A part of the Southern California allochthon, Plate 1 of 2, scale 1:24,000.	LOCAL GEOLOGIC MAP *El Sur Ranch* State Highway 1, Big Sur Monterey County, California	FIGURE # 2 JOB # ESR-5



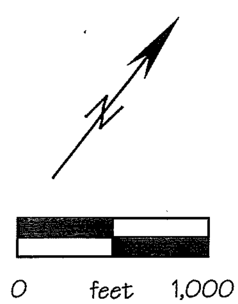
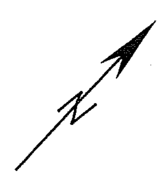


Photo Base: 8 January 1942 (1942-A), frame 489-359, original nominal scale 1:30,000, scale of figure 1:12,000.

ROGERS E. JOHNSON & ASSOCIATES Consulting Engineering Geologists 41 Hangar Way, Suite B Watsonville, California 95076 (831)728-7200 FAX (831)728-7218	1942 AERIAL PHOTOGRAPH OF SITE *El Sur Ranch* State Highway 1, Big Sur Monterey County, California	FIGURE # 3 JOB # C06044-M13



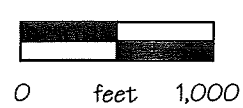
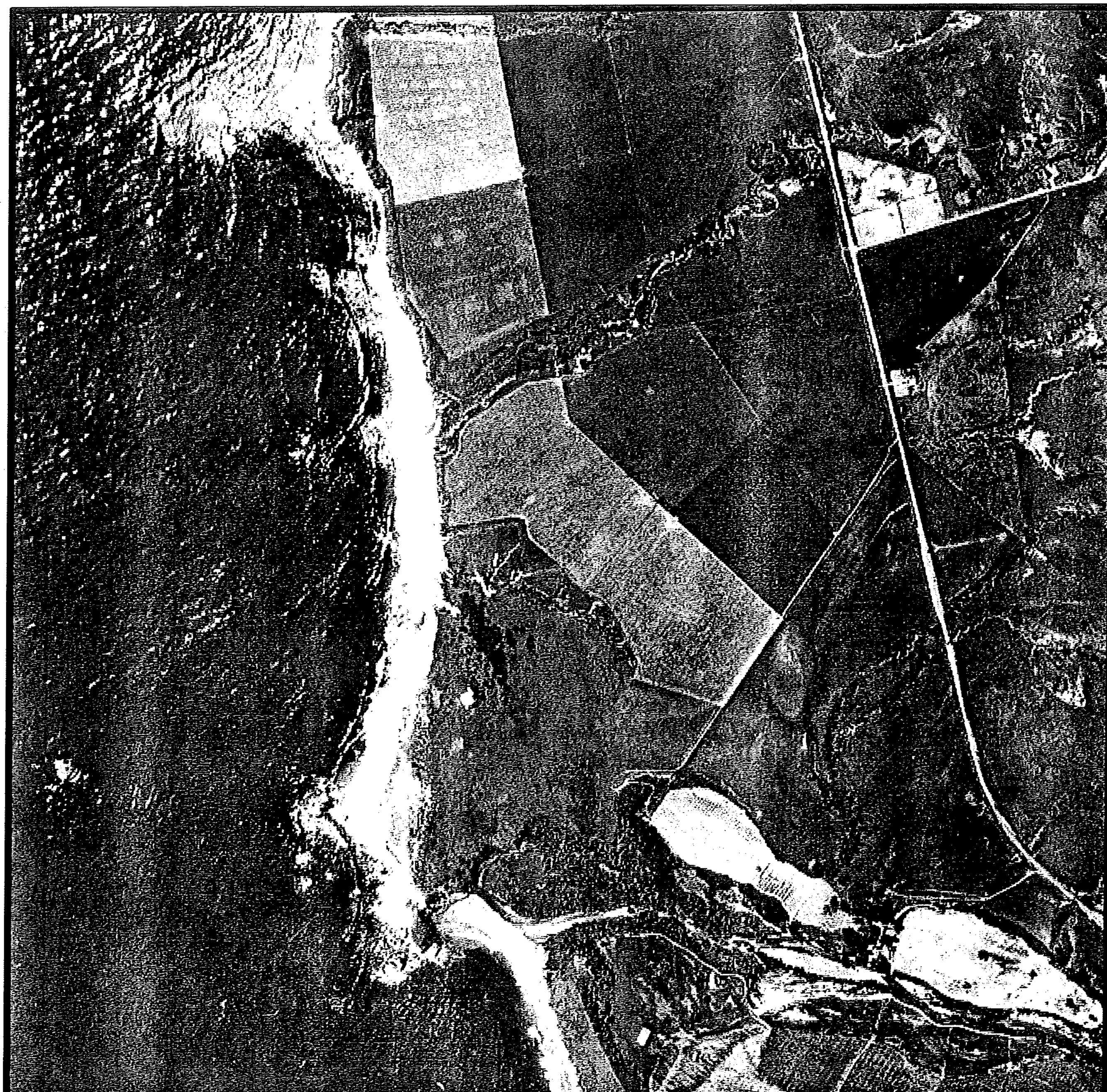


Photo Base: 18 August 1949 (1949-C), frame ABG-18F-94, original nominal scale 1:20,000, scale of figure 1:12,000.

ROGERS E. JOHNSON & ASSOCIATES Consulting Engineering Geologists 41 Hangar Way, Suite B Watsonville, California 95076 (831)728-7200 FAX (831)728-7218	1949 AERIAL PHOTOGRAPH OF SITE *El Sur Ranch* State Highway 1, Big Sur Monterey County, California	FIGURE # 4 JOB # C06044-M13



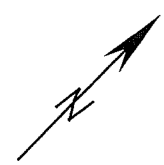
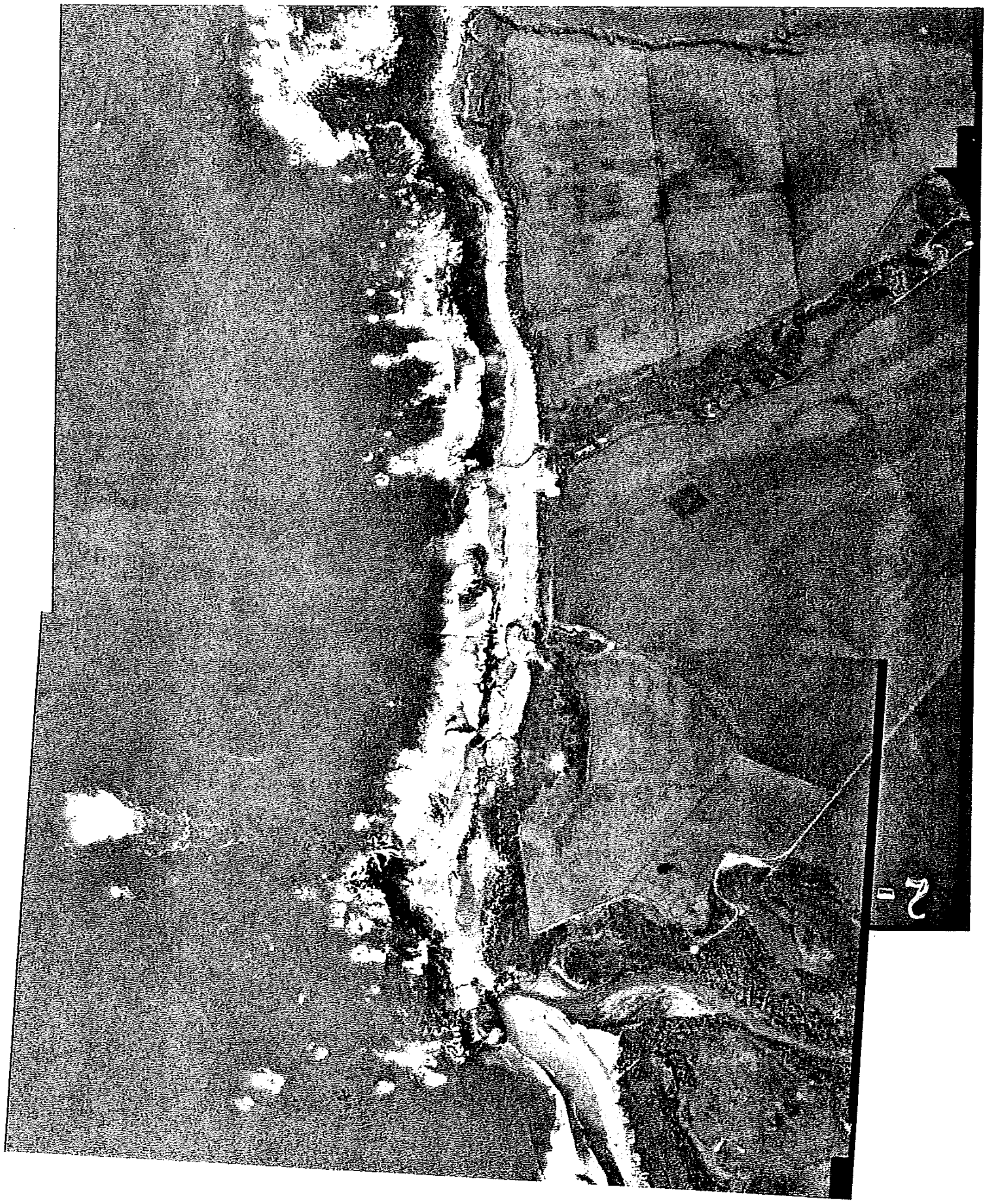


Photo Base: 22 May 1954 (1953-54), frame GS-YH 5-15, original nominal scale 1:37,400, scale of figure 1:12,000.

ROGERS E. JOHNSON & ASSOCIATES Consulting Engineering Geologists 41 Hangar Way, Suite B Watsonville, California 95076 (831)728-7200 FAX (831)728-7218	1954 AERIAL PHOTOGRAPH OF SITE *El Sur Ranch* State Highway 1, Big Sur Monterey County, California	FIGURE # 5 JOB # C06044-M13



N

0 feet 1,000

Photo Base: 3 February 1967 (1967-E), frames 51-1-86 and 87, original nominal scale 1:12,000, scale of figure 1:12,000.

ROGERS E. JOHNSON & ASSOCIATES Consulting Engineering Geologists 41 Hangar Way, Suite B Watsonville, California 95076 (831)728-7200 FAX (831)728-7218	**1967 AERIAL PHOTOGRAPH OF SITE** *El Sur Ranch* State Highway 1, Big Sur Monterey County, California	**FIGURE #** 7 JOB # C06044-M13

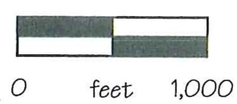
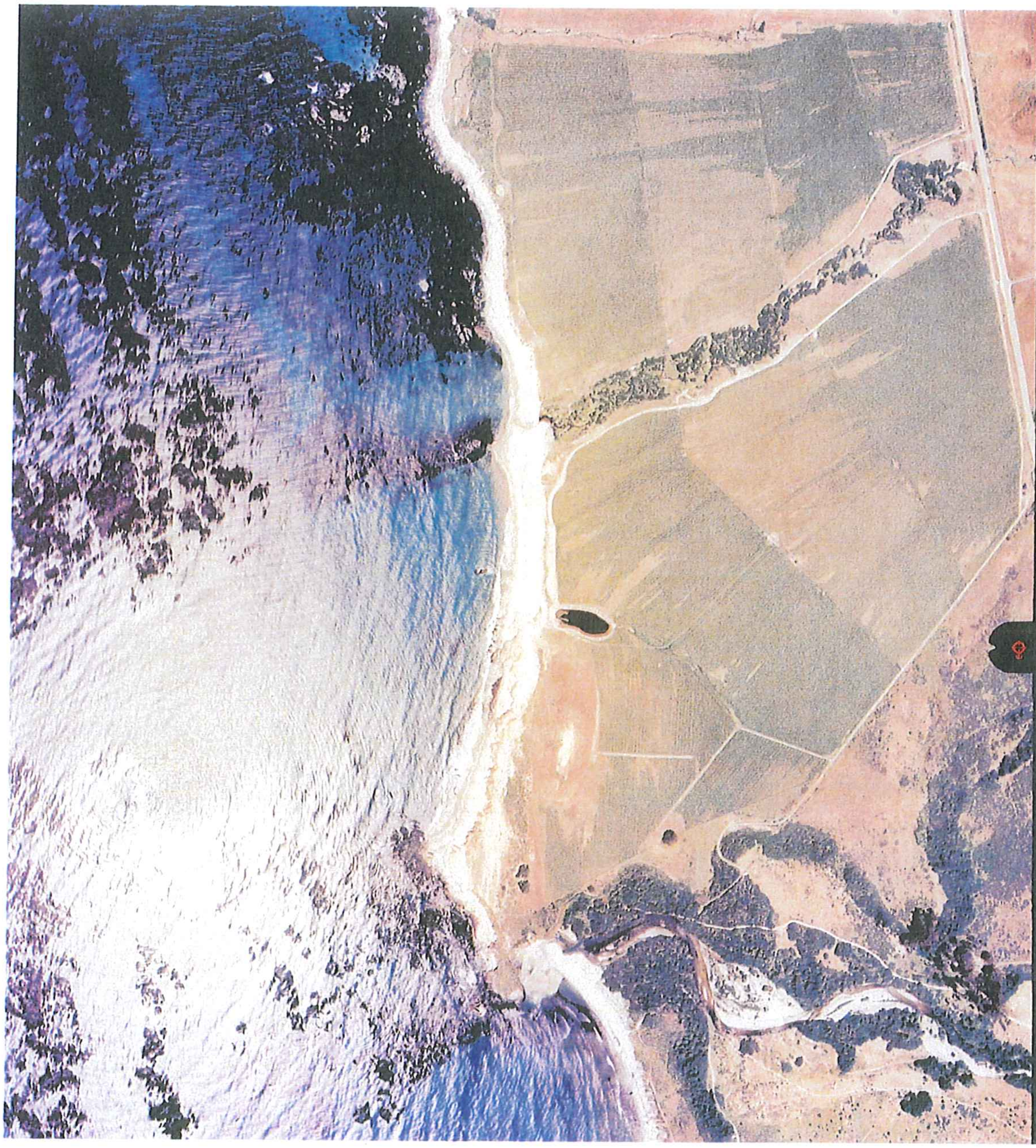


Photo Base: 2 May 1978 (1978-B), frame DNOD-AFU-3-C 302, original nominal scale 1:12,000, scale of figure 1:12,000.

ROGERS E. JOHNSON & ASSOCIATES Consulting Engineering Geologists 41 Hangar Way, Suite B Watsonville, California 95076 (831)728-7200 FAX (831)728-7218	1978 AERIAL PHOTOGRAPH OF SITE *El Sur Ranch* State Highway 1, Big Sur Monterey County, California	FIGURE # 8 JOB # C06044-M13



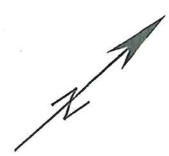


Photo Base: 14 June 2001 (2001-A), CCC-BQK-C 108-9, original nominal scale 1:12,000, scale of figure 1:12,000.

0 feet 1,000

ROGERS E. JOHNSON & ASSOCIATES Consulting Engineering Geologists 41 Hangar Way, Suite B Watsonville, California 95076 (831)728-7200 FAX (831)728-7218	2001 AERIAL PHOTOGRAPH OF SITE *El Sur Ranch* State Highway 1, Big Sur Monterey County, California	FIGURE # 9 JOB # C06044-M13

Photo Base: 1 July 2003 (2003-F), AMBAG 507-15, original nominal scale 1:28,800, scale of figure 1:12,000.

ROGERS E. JOHNSON & ASSOCIATES
Consulting Engineering Geologists
41 Hangar Way, Suite B
Watsonville, California 95076
(831)728-7200 FAX (831)728-7218

2003 AERIAL PHOTOGRAPH OF SITE
El Sur Ranch
State Highway 1, Big Sur
Monterey County, California

FIGURE #
10
JOB #
C06044-M13

Erosion Monitoring from Rainfall Runoff and Surface Irrigation Excess Overflow on Coastal Bluffs Bordering El Sur Ranch Pastures 7 and 8 in Late Summer and Early Fall, 2006.

Prepared For
Applicant
El Sur Ranch
Monterey, CA

Prepared By
Justin Taplin
Charles H. Hanson, Ph.D.

Hanson Environmental, Inc.
132 Cottage Lane
Walnut Creek, CA 94595
(925) 937-4606
www.hansonenvironmentalinc.com

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Appendix A

Introduction

The El Sur Ranch is located within Monterey County approximately 1.5 miles south of the Point Sur Lighthouse and includes 290 acres of irrigated pasture west of US Highway 1 (NRCE 2005). Pasture irrigation is accomplished using two wells located within Andrew Molera State Park. The irrigated pasture is bounded at the northern edge by US Highway 1 and at the southern edge by the Pacific Ocean. The irrigated pasture is bounded by on the east by Andrew Molera State Park and the Big Sur River, which runs through the park. On the west, the irrigated pasture is bounded by a drainage creek. The El Sur Ranch irrigated pasture land and boundaries are shown in Figure 1.

The estimated total annual precipitation is approximately 28 inches with the majority of that rainfall falling between November and April (1975 – 2004; NRCE 2005). The winter months are characteristically wet and the summer months are characteristically dry. Irrigation is always needed during the summer months with some additional irrigation occasionally required during winter months.

The pasture on El Sur Ranch is surface irrigated with borders. Borders are generally perpendicular to the slope of the land and bounded by ridges of soil. The borders on El Sur Ranch pastures are generally 14 feet wide and vary in length from 500 to 1000 feet. Irrigation water is introduced at the top of the pasture via manual adjustment of irrigation pipeline valves bounding the up-slope pastures. The irrigation water then flows to the bottom of the border (Figure 2).

Irrigation flow is operated manually by opening and closing valves at the heads of the 14 foot pasture borders. The management of the surface flow irrigation is dependent, in part, on the available flow, the length of the border, dryness of the soil, length and condition of pasture grass, and set irrigation time (NRCE 2005). The tailwater from all but the bottom set of borders flows into the next downstream set of borders. The irrigation rotation varies seasonally, but generally 21 days is suitable for the water use of pasture and the soil characteristics (NRCE 2005).

Embankments have been constructed along most of the field boundaries where run-off could occur onto steep unprotected slopes. Soil erosion within the pastures is controlled by the dense ground cover of the pasture and by controlling the run-off into the canyons, drainage gullies, and bluff at the bottom of the pasture. Control of the excess surface irrigation flow is achieved on the east side of the pasture by collecting water in a tailwater pond for re-use or discharge into the ocean via water control structures to minimize erosion impacts. On the west side of the pasture, excess surface irrigation tailwater flows into a water control structure that discharges water into the ocean to reduce and control erosion impacts. These erosion control structures for discharging excess surface irrigation flow also act to conserve soils and reduce erosion impacts on the El Sur Ranch pastures and bluff face at the Pacific Ocean boundary during rainfall-runoff events.

Concern has been expressed that surface flow irrigation of this style, as well as rainfall-runoff events may be contributing to surface erosion of the steep slopes of the bluff bordering the southern edge of the El Sur Ranch pasture at the Pacific Ocean. To evaluate this, a study was implemented to monitor and document potential erosion along the bluff during El Sur Ranch irrigation diversions between September 6, and October 16, 2006.

Methods

To monitor potential erosion along the steep slopes of the bluff bordering the southern boundary of the El Sur Ranch irrigated pasture, 5 set monitoring locations were chosen for regular inspections and photographic documentation. The 5 monitoring locations selected along the bluff bordering El Sur Ranch pasture are summarized in Figure 1. Descriptions of these monitoring stations are summarized in Table 1. Stations were selected to give preference to areas of potential high risk of erosion from rainfall-runoff or irrigation excess discharge into the Pacific Ocean.

Station 1 represents an area characterized by natural runoff pathways and steep slopes with areas of dense vegetation at the corner of Swiss Canyon and Field 7. Station 2 is an active area of erosion characterized by recent erosion events resulting in sections of the bluff eroding onto the beach. Station 3 is a manmade tailwater discharge structure at the boundary between Filed 8 and Field 7 (discussed above), discharging into the Pacific Ocean via the beach. Station 4 is an area naturally saturated by a seep that is characterized by steep slopes and may be an area of potential active erosion. Station 5, towards the western boundary of Field 8, is an area of steep slopes, low vegetation cover, and potential runoff erosion.

Once stations were selected, they were marked with flagging tape and GPS co-ordinates were recorded to ensure return inspections were at the same location. Stations 1 through 5 were inspected and documented by photographic record at twice weekly intervals between September 9 and October 16, 2006. Table 2 summarizes the survey dates for Stations 1 through 5. Photographic documentation was taken from the top of the bluff during the first and second surveys for stations 1 through 3 and from the beach during each subsequent survey. This was due to calving occurring along the southern border of Fields 7 and 8. It was decided to continue monitoring away from calving cows to minimize impact on El Sur Ranch operations and reduce risk of scaring calving cows, potentially resulting in abandonment of new born calves. Inspection of each station included visual observation of differences in erosion from runoff between inspections as well as generalized erosion patterns over the entire extent of the bluff during each walking inspection.

Table 3 summarizes El Sur Ranch irrigation diversion operations during the monitoring period. Table 3 gives irrigation locations, volumes, and dates. Table 4 summarizes local rainfall during the study period.

Results and Discussion

During the monitoring period from September 6 through October 16, 2006, local rainfall data shows a total of 0.1 inches of rainfall (Table 4) falling within the study area. No precipitation is recorded for the month previous to this rainfall event, and with end of summer characteristic dry soils along the bluff, it is unlikely this rainfall contributed to any runoff within the study area.

Irrigation during the study period is summarized in Table 3. Fields 1, 2, 7, and 8 were situated to the north of the erosion study area. Surface irrigation on these fields could potentially result in surface flow reaching the bluff erosion monitoring area, and especially irrigation excess flow on Fields 7 and 8. During the study period, Field 1 was irrigated from September 9 through September 11, 2006, at a rate of between 6.94 and 7.21 acre feet per day by New Well and at a rate of between 4.81 and 4.94 acre feet per day by Old Well. Field 2 was irrigated between September 22 and September 25, 2006, at a rate of between 4.81 and 4.86 acre feet per day by Old Well. Fields 7 and 8 were irrigated between October 6 and October 11, 2006, at a rate of between 4.02 and 6.68 acre feet per day by New Well. Following are the results and observations for Stations 1 through 5 for the erosion monitoring conducted between September 9 and Ocober 16, 2006:

Station 1

Photographic documentation of Station 1 erosion surveys during the study period are presented in Station 1, Appendix A. Photographic records and onsite inspections at twice weekly intervals between September 9 and October 16, 2006, recorded no visible active erosion events taking place over the course of the study period. Runoff was not observed at this location at anytime during inspections. Analysis of field observations and photographic records shows no changes in vegetation patterns or densities, no active areas of erosion or runoff, and no change overall in orientation of slope or formation of new runoff culverts or pathways.

Station 2

Photographic documentation of Station 2 erosion surveys during the study period are presented in Station 2, Appendix A. Photographic records and onsite inspections at twice weekly intervals between September 9 and October 16, 2006, recorded no visible active erosion events taking place over the course of the study period. Runoff was not observed at this location at anytime during inspections. Analysis of field observations and photographic records shows no changes in vegetation patterns or densities, no active areas of erosion or runoff, and no change overall in orientation of slope or formation of new runoff culverts or pathways.

Station 3

Photographic documentation of Station 3 erosion surveys during the study period are presented in Station 3, Appendix A. Photographic records and onsite inspections at twice weekly intervals between September 9 and October 16, 2006, recorded no visible active erosion events taking place over the course of the study period. Runoff was not observed at this location at anytime during inspections. Analysis of field observations and photographic records shows no changes in vegetation patterns or densities, no active areas of erosion or runoff, and no change overall in orientation of slope or formation of new runoff culverts or pathways.

Station 4

Photographic documentation of Station 4 erosion surveys during the study period are presented in Station 4, Appendix A. Photographic records and onsite inspections at twice weekly intervals between September 9 and October 16, 2006, recorded no visible active erosion events taking place over the course of the study period. Runoff was not observed at this location at anytime during inspections. Analysis of field observations and photographic records shows no changes in vegetation patterns or densities, no active areas of erosion or runoff, and no change overall in orientation of slope or formation of new runoff culverts or pathways.

Station 5

Photographic documentation of Station 5 erosion surveys during the study period are presented in Station 5, Appendix A. Photographic records and onsite inspections at twice weekly intervals between September 9 and October 16, 2006, recorded no visible active erosion events taking place over the course of the study period. Runoff was not observed at this location at anytime during inspections. Analysis of field observations and photographic records shows no changes in vegetation patterns or densities, no active areas of erosion or runoff, and no change overall in orientation of slope or formation of new runoff culverts or pathways.

Conclusions

Under the recorded rainfall and irrigation conditions present during the runoff erosion monitoring along the bluff bordering the southern boundary of the El Sur Ranch irrigated pastures between September 9 and October 16, 2006, no visible runoff events or active erosion events were recorded. Twice weekly onsite inspections and analysis of photographic documentation of fixed monitoring points showed no changes to the bluff within the context of surface irrigation excess overflow or rainfall infiltration excess runoff.

Figure 1: Map of El Sur Ranch Bluff Survey Points.

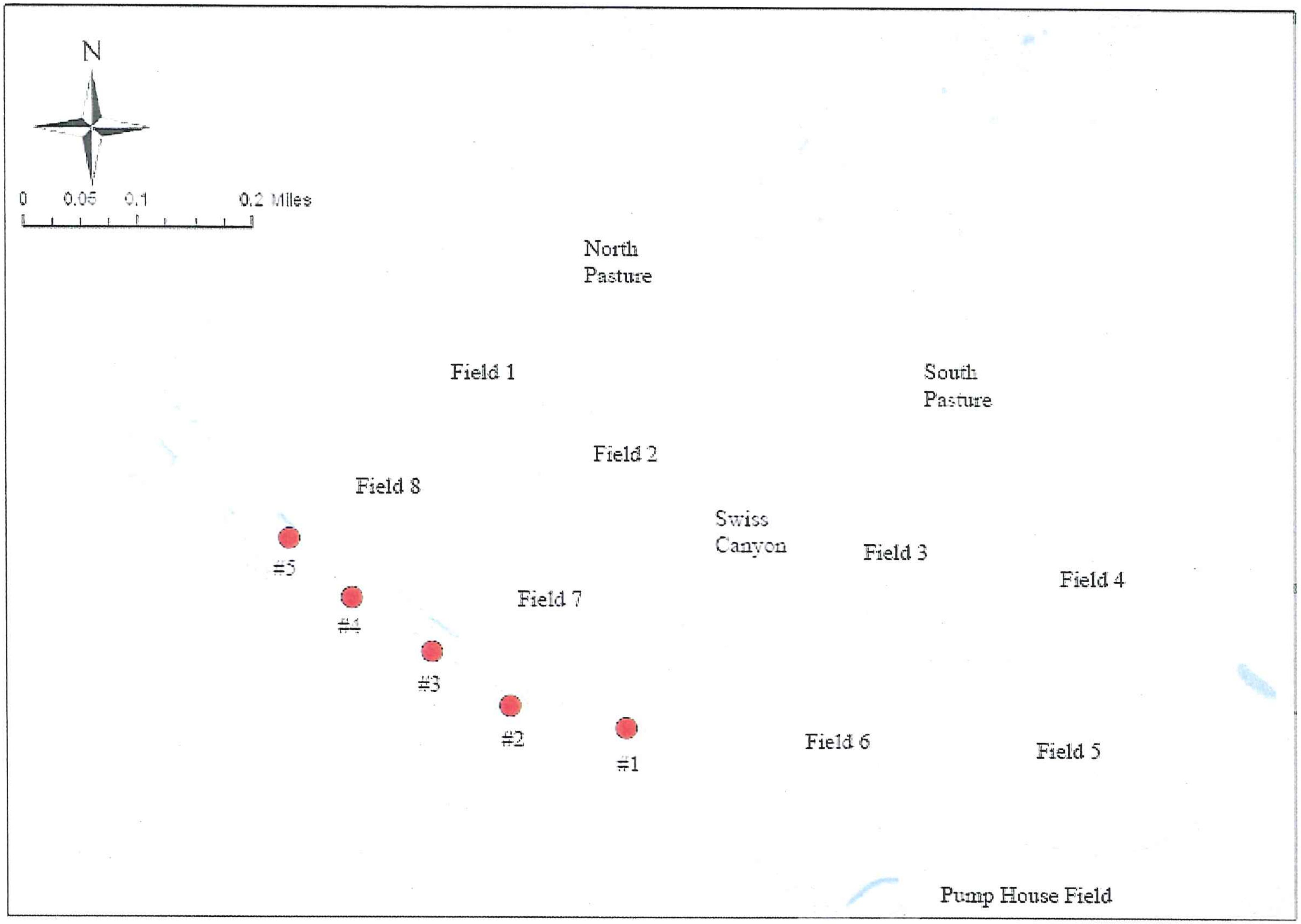


Figure 2. Surface irrigation on El Sur Ranch pastures

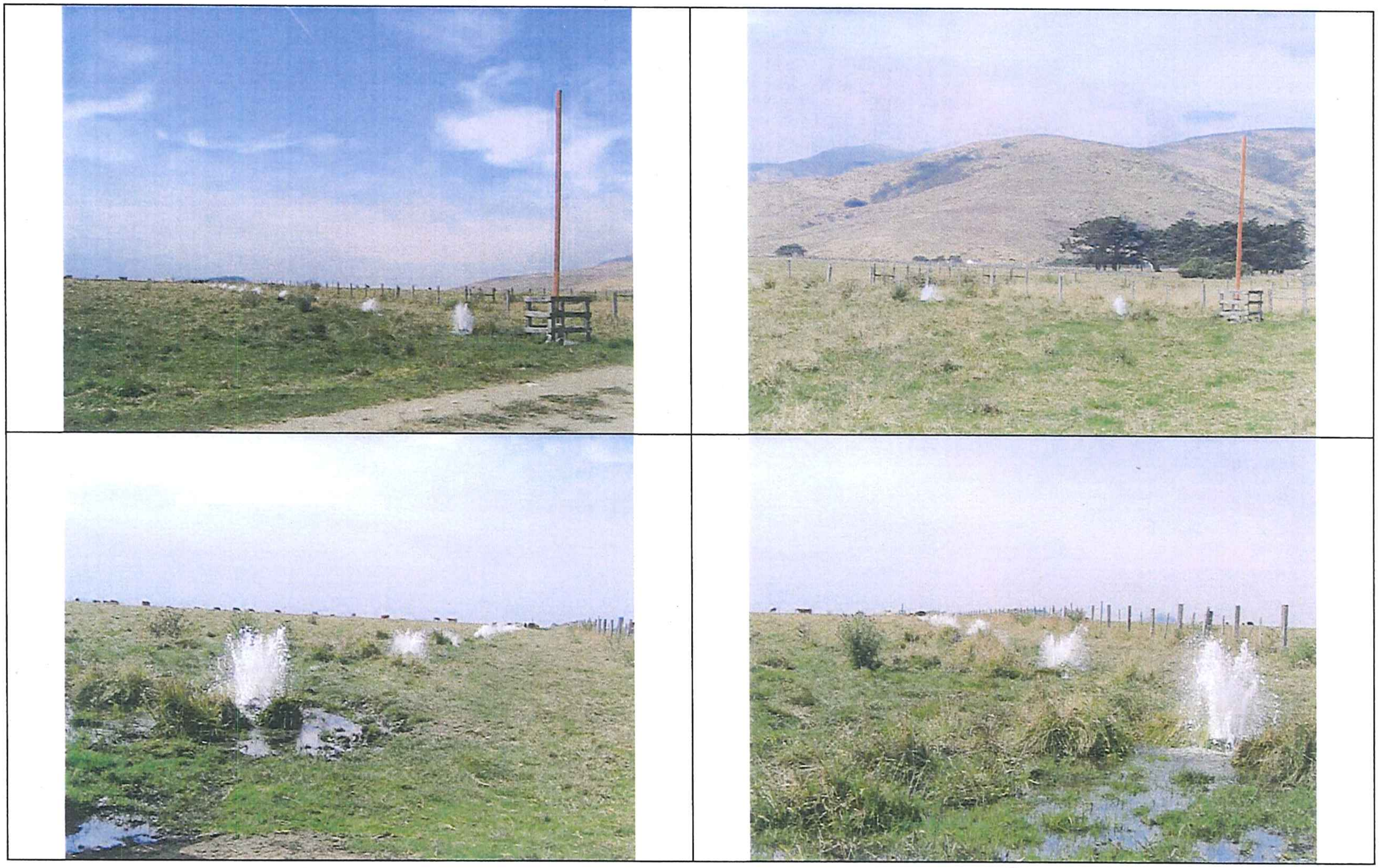


Table 1. Monitoring station descriptions.

Station #	Station Description
1	Naturally formed runoff culvert at confluence of Swiss Canyon and Field 7
2	Area of potential active natural erosion
3	Man made irrigation overflow runoff culvert discharging onto bluff
4	Natural spring seepage discharging onto bluff
5	Area of potential active natural erosion

Table 2. Dates of erosion monitoring for all stations.

Survey	Station				
Date	#1	#2	#3	#4	#5
9-6-06	X	X	X	X	X
9-12-06	X	X	X	X	X
9-18-06	X	X	X	X	X
9-21-06	X	X	X	X	X
9-25-06	X	X	X	X	X
9-28-06	X	X	X	X	X
10-2-06	X	X	X	X	X
10-5-06	X	X	X	X	X
10-10-06	X	X	X	X	X
10-12-06	X	X	X	X	X
10-16-06	X	X	X	X	X

Table 3. El Sur Ranch irrigation diversions during study period.

Date	New Well			Old Well			New Well ac-ft/day	Old Well ac-ft/day
	Time On	Time Off	Pasture	Time On	Time Off	Pasture		
09/06/06								
09/07/06								
09/08/06								
09/09/06	8:24 AM		PH	8:24 AM		#1	7.21	4.93
09/10/06			PH			#1	6.94	4.81
09/11/06			PH			#1	7.11	4.94
09/12/06			PH			#3	6.99	4.92
09/13/06			PH			#3 & #4	8.38	5.90
09/14/06			PH			#4	3.72	2.80
09/15/06		6:35 AM	PH		6:35 AM	#4		
09/16/06								
09/17/06								
09/18/06								
09/19/06								
09/20/06								
09/21/06								
09/22/06				8:39 AM		#2		4.81
09/23/06						#2		4.84
09/24/06						#2		4.86
09/25/06						#2		4.97
09/26/06						#3		4.70
09/27/06						#3		4.72
09/28/06						#4		4.74
09/29/06					8:10 AM	#4		
09/30/06								
10/01/06								
10/02/06								
10/03/06								
10/04/06								
10/05/06								
10/06/06	3:51 PM		#8				4.02	
10/07/06			#8				5.81	
10/08/06			#8 & #7				5.94	
10/09/06			#8 & #7				4.59	
10/10/06			#7				6.68	
10/11/06			#7				5.78	
10/12/06		5:41 PM	PH					

Table 4. Daily temperature and rainfall prior to and during erosion monitoring period.

Date	Ave. Temp (F)	Tot. Rainfall (in)
9/1/2006	55.30	0
9/2/2006	54.40	0
9/3/2006	54.80	0
9/4/2006	55.10	0
9/5/2006	54.70	0
9/6/2006	55.00	0
9/7/2006	55.00	0
9/8/2006	56.90	0
9/9/2006	57.80	0
9/10/2006	56.50	0
9/11/2006	56.60	0
9/12/2006	56.30	0
9/13/2006	56.90	0
9/14/2006	56.50	0
9/15/2006	58.20	0
9/16/2006	60.30	0
9/17/2006	63.90	0
9/18/2006	58.10	0
9/19/2006	56.70	0
9/20/2006	58.10	0
9/21/2006	57.30	0
9/22/2006	57.20	0
9/23/2006	61.50	0
9/24/2006	61.30	0
9/25/2006	56.10	0
9/26/2006	58.00	0
9/27/2006	58.30	0
9/28/2006	57.40	0
9/29/2006	56.10	0
9/30/2006	56.60	0
10/1/2006	57.30	0
10/2/2006	58.00	0
10/3/2006	57.60	0
10/4/2006	56.50	0.01
10/5/2006	57.30	0.09
10/6/2006	56.60	0
10/7/2006	56.30	0
10/8/2006	58.40	0
10/9/2006	55.10	0
10/10/2006	60.50	0
10/11/2006	58.40	0
10/12/2006	57.50	0
10/13/2006	56.90	0
10/14/2006	56.60	0
10/15/2006	57.20	0
10/16/2006	57.80	0
Average/ Total	**57.28**	**0.1**

Appendix A

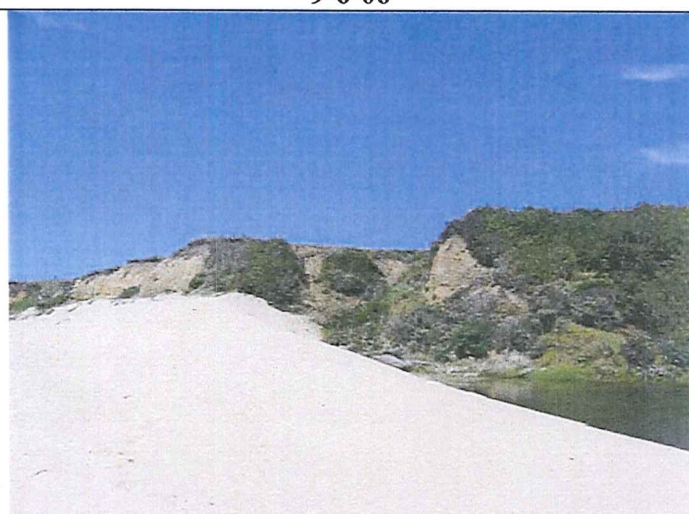
Photographic documentation of erosion monitoring at Stations 1 through 5.

Monitoring conducted from September 9 through October 16, 2006.

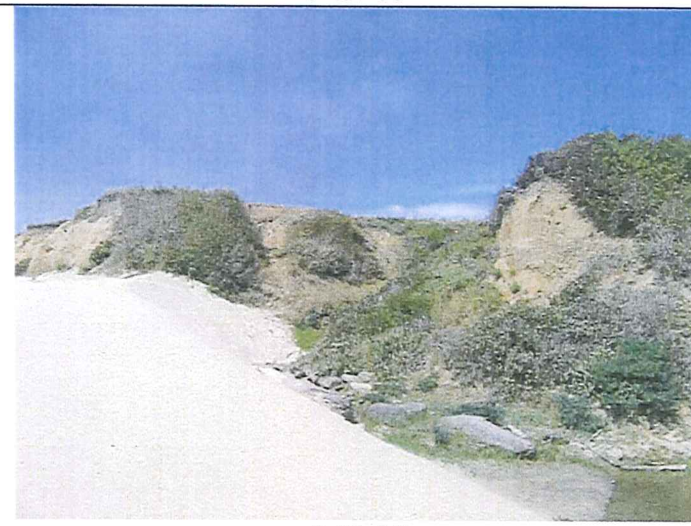
Station 1

9-6-06

9-12-06



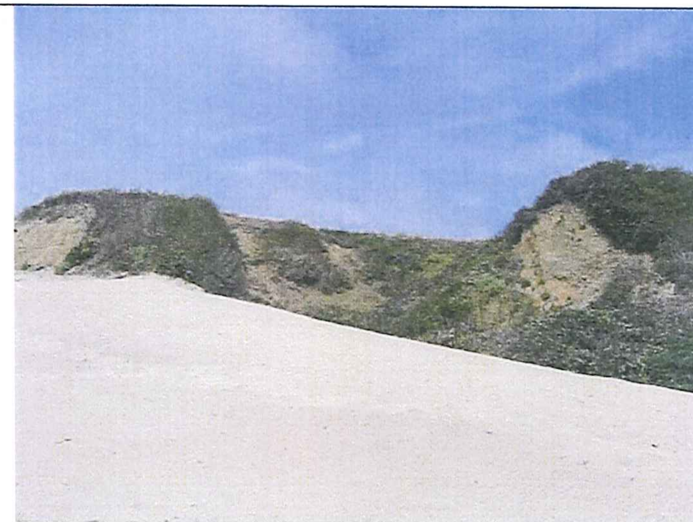
9-18-06



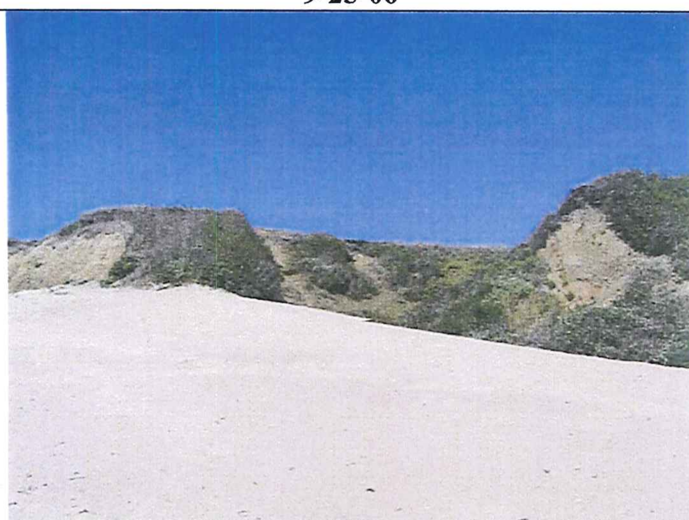
9-21-06

Station 1 (continued)

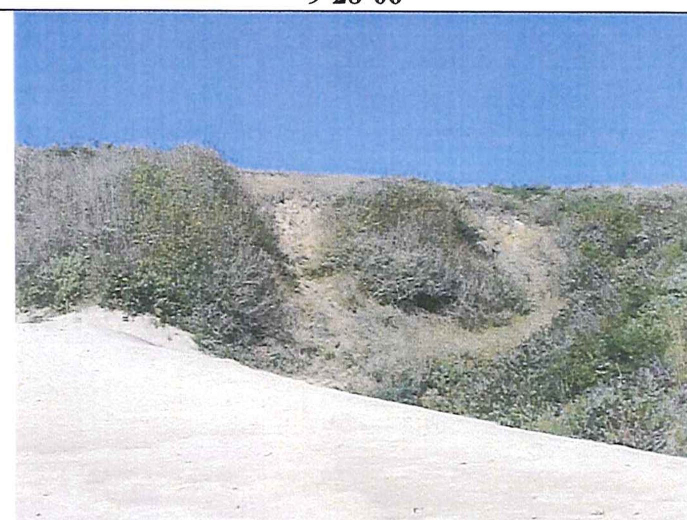
9-25-06



9-28-06

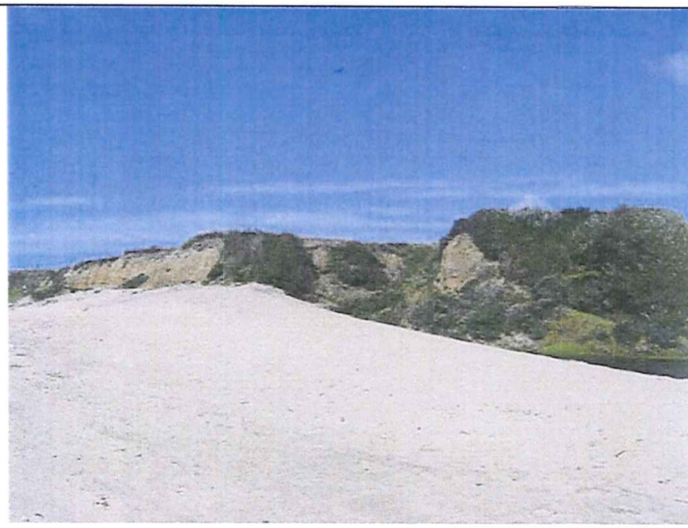


10-2-06



10-5-06

Station 1 (continued)



10-10-06

10-16-06

Station 2


9-6-06


9-12-06


9-18-06

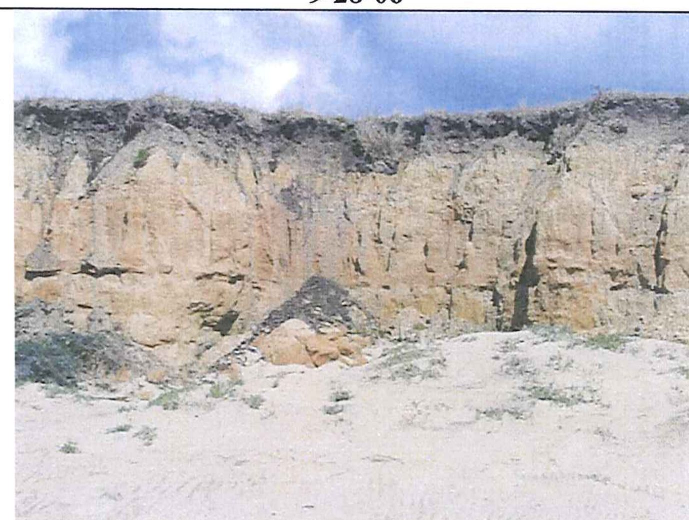

9-21-06

Station 2 (continued)

9-25-06

9-28-06

10-2-06



10-5-06

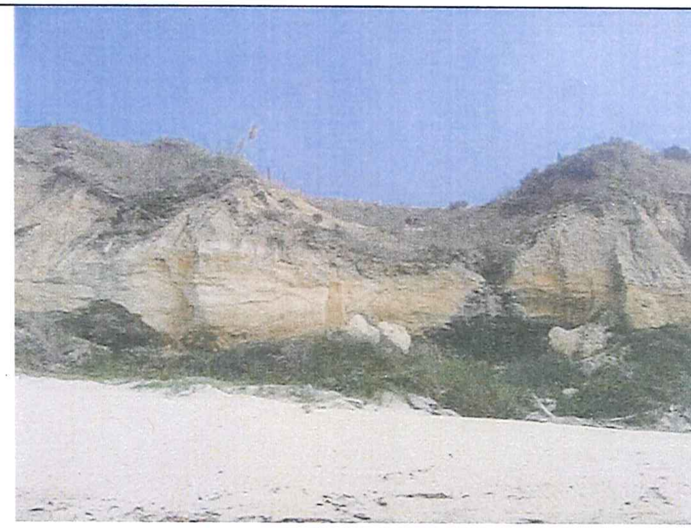
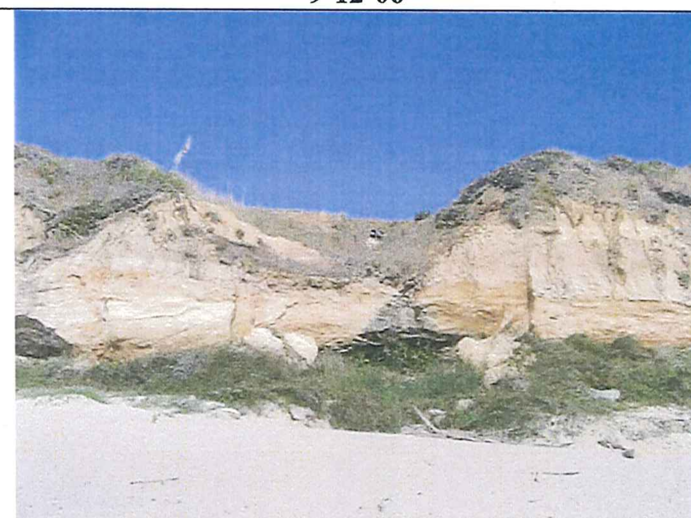
Station 2 (continued)

10-10-06

10-16-06

ESR--5

Station 3

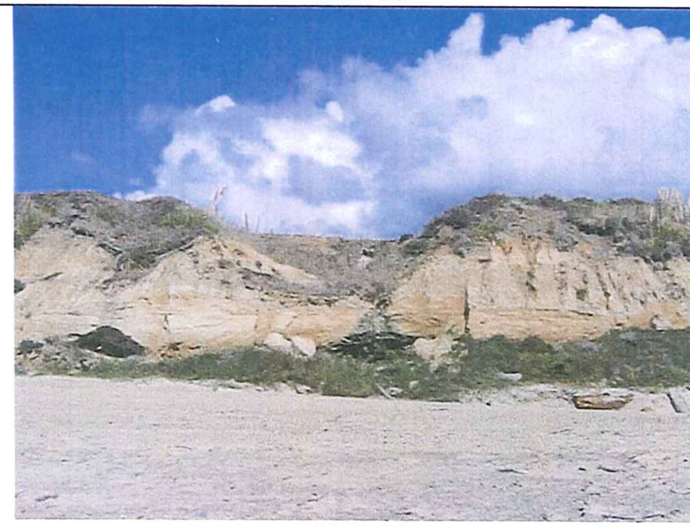
 9-6-06	 9-12-06
 9-18-06	 9-21-06

Station 3 (continued)

9-25-06

9-28-06

10-2-06



10-5-06

Station 3 (continued)

10-10-06

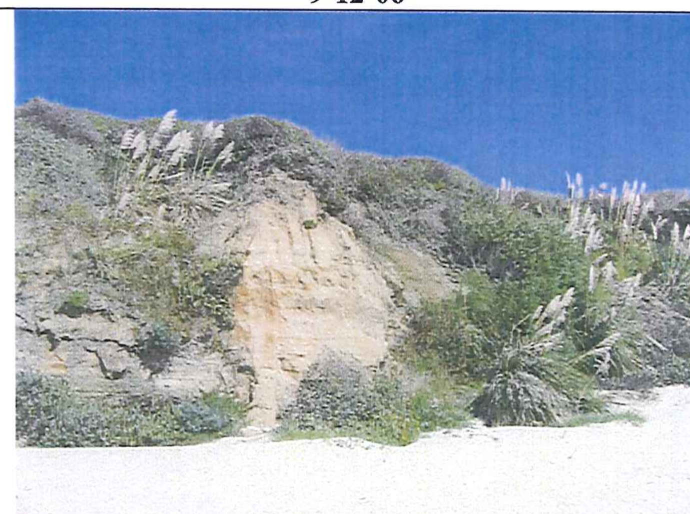
10-16-06

Station 4

9-6-06

9-12-06

9-18-06

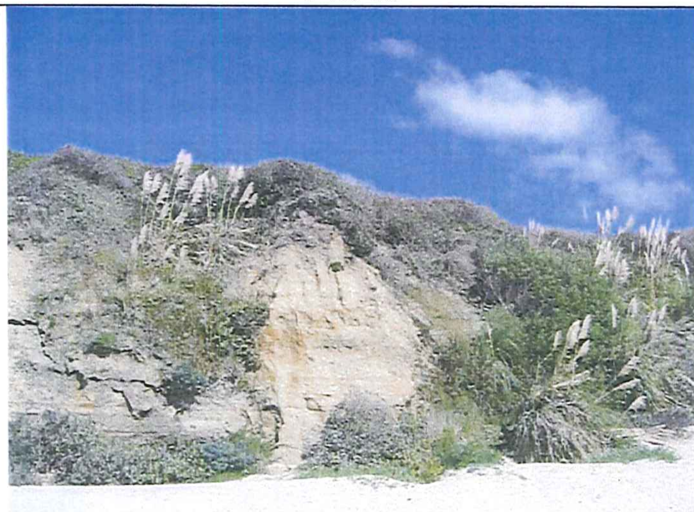


9-21-06

Station 4 (continued)

9-25-06

9-28-06



10-2-06

10-5-06

Station 4 (continued)

10-10-06

10-16-06

Station 5

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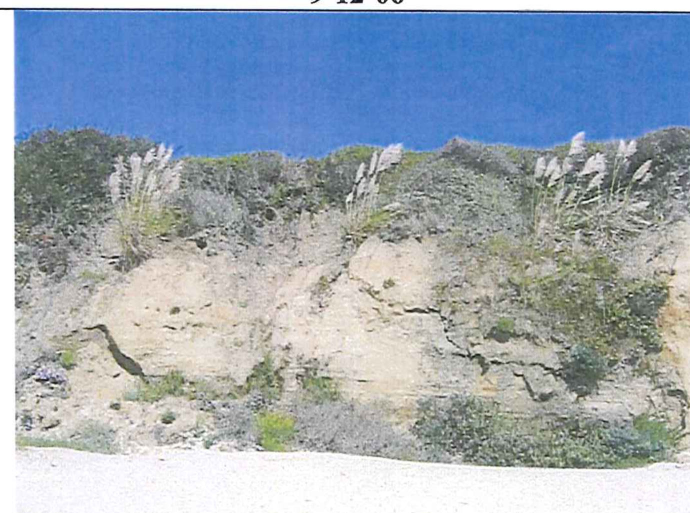
 9-18-06	 9-21-06

Station 5 (continued)

9-25-06

9-28-06

10-2-06

10-5-06

Station 5 (continued)

10-10-06

10-16-06