ASSESSMENT OF THE POTENTIAL EFFECTS OF EL SUR RANCH WELL OPERATIONS ON AQUATIC HABITAT WITHIN THE BIG SUR RIVER AND SWISS CANYON DURING LATE SUMMER AND EARLY FALL – 2007

Prepared For:

Applicant
El Sur Ranch
Monterey, CA

Prepared By:

Charles H. Hanson, Ph.D.
Hanson Environmental, Inc.
132 Cottage Lane
Walnut Creek, CA 94595
(925) 937-4606 (Telephone)
(925) 937-4608 *(Fax)*
www.hansonenvonmentalinc.com

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1.0 INTRODUCTION

The lower Big Sur River (Figure 1) and adjacent habitats support a variety of fish and wildlife species. The Big Sur River provides a migratory corridor, as well as habitat for spawning, egg incubation, and juvenile rearing supporting a population of Central California Coast steelhead (*Oncorhynchus mykiss*). Steelhead inhabiting the Big Sur River have been listed as a threatened species under the federal Endangered Species Act (ESA). El Sur Ranch operates two irrigation wells located adjacent to the Big Sur River (Figure 1). Concern has been expressed regarding the potential for El Sur Ranch irrigation well operations to adversely affect habitat quality and availability for juvenile steelhead and other species inhabiting the lower river and lagoon during the summer and early fall irrigation season.

A series of fishery habitat investigations have been 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 when El Sur Ranch irrigation well operations primarily occur. These investigations began in 2004 and were continued in 2006 and 2007 to represent a range of hydrologic conditions within the Big Sur River watershed. Although the investigations have primarily focused on aquatic habitat within the Big Sur River, with a specific focus on habitat conditions for steelhead, botanical surveys have also been conducted as part of these investigations along both the river corridor as well as the El Sur Ranch coastal pastures, including Swiss Canyon (MGA 2007). Additional observations have been made to characterize changes in aquatic habitat primarily supporting populations of amphibians, including red-legged frogs (*Rana auropa draytonni*) within Swiss Canyon that potentially could be affected by El Sur Ranch irrigation well operations. Field survey data collection activities have been conducted during the summer and early fall months of 2004, 2006, and 2007 as part of a multidisciplinary investigation integrating surveys of potential changes in aquatic habitat conditions in response to El Sur Ranch irrigation well operations, in addition to changes in surface water hydrology and geohydrology in the basin (SGI 2005, 2007, 2008) to provide information on the potential effects of El Sur Ranch irrigation well operations on surface waters supporting habitat for fish and wildlife

It has been hypothesized that the potential effects of El Sur Ranch irrigation well operations on geohydrology and surface hydrology affecting habitat quality and availability for juvenile steelhead and other species would vary in response to both the rate of well diversions by El Sur Ranch (e.g., no well operations, Old Well or New Well operating independently, or both Old and New wells operating simultaneously) and Big Sur River flow rates during the summer and early fall months. It was speculated that if El Sur Ranch irrigation well operations were adversely affecting habitat quality and availability for juvenile steelhead or other fishery resources within the Big Sur River the potential affect would be expected to be greatest during those periods when well operations were highest (both Old and New wells were operating simultaneously) and summer and early fall flow rates within the Big Sur River were at their lowest levels.

Habitat quality and availability within the lower river and lagoon for juvenile steelhead are influenced by a variety of environmental factors. These factors include, but are not limited to, seasonal patterns in stream flows, seasonal water temperatures, dissolved oxygen concentrations, electrical conductivity, surface water connectivity among habitat units, habitat diversity, instream cover (large debris and undercut banks), riparian vegetation, substrate, availability of macroinvertebrates as prey, and a variety of other factors. Many of the factors affecting habitat quality and availability for juvenile steelhead rearing are independent of operations of the El Sur Ranch irrigation wells, such as availability of instream cover, riparian vegetation, and substrate. Other environmental parameters, such as water temperature, dissolved oxygen concentrations, electrical conductivity, and habitat connectivity may potentially be affected by irrigation well operations. To evaluate potential adverse effects to instream habitat, fishery investigations were designed to meet the following primary objectives:

(1) Determine whether or not seasonal changes occur in the lower Big Sur River and lagoon that would adversely affect habitat quality and availability for juvenile steelhead/rainbow trout (steelhead are characterized by a life history

of *O. mykiss* that migrates to the ocean for a part of their life cycle but return to freshwater to spawn; rainbow trout are characterized by a life history of *O. mykiss* that remains within freshwater throughout their life span; for purposes of simplicity the term steelhead is used in this report to represent *O. mykiss* inhabiting the Big Sur River) rearing throughout the summer and fall months;

(2) Determine the geographic distribution of, relative abundance of, and habitat use within the lower Big Sur River by steelhead with respect to instream habitat parameters potentially affected by El Sur Ranch irrigation well operations; and

(3) If changes in habitat quality or availability are detected within the lower river and/or lagoon, assess the potential effects of El Sur Ranch irrigation well operations on habitat conditions for steelhead and/or other sensitive wildlife. Habitat quality and availability for steelhead within the lower Big Sur River was used as an indicator of changes in overall quality of habitat conditions within the lower river and the potential effects of habitat changes on sensitive or protected species.

In addition, periodic surveys and routine monitoring were conducted to characterize changes in aquatic habitat conditions occurring within Swiss Canyon that would potentially be related to El Sur Ranch irrigation well operations.

Specific questions and evaluation criteria used to assess habitat conditions as part of these surveys included:

- Was there a significant reduction in stream flows along the longitudinal gradient from upstream areas outside of the potential influence of the El Sur Ranch irrigation wells and the lower river adjacent Creamery Meadow lying within the zone of potential influence of the irrigation wells and the lagoon?

- Was surface water connectivity disrupted at any location between the lagoon and the parking area for the Andrew Molera State Park? Loss of surface water connectivity among habitat units would adversely affect steelhead habitat and limit the ability of juvenile fish to move and forage among various habitat units and, potentially, could result in stranding of juvenile fish within dewatered reaches of the river. Evaluation criteria used in the field investigations included the identification of any location along the lower river or lagoon where water depths were reduced to less than 0.6 feet over 10% of the channel section for adult steelhead and 0.3 feet over 10% of the wetted channel cross section for juvenile steelhead;

- Were dissolved oxygen concentrations within the lower river or lagoon decreased to a level that would be stressful or unsuitable for juvenile steelhead rearing? For purposes of this evaluation, dissolved oxygen concentrations less than 6 mg/l were identified as stressful and/or unsuitable conditions for juvenile steelhead rearing;

- Were water temperatures within the lower river or lagoon seasonally elevated to a level that would result in stressful or unsuitable habitat conditions for juvenile steelhead rearing? For purposes of this investigation, stressful or unsuitable habitat conditions for juvenile steelhead rearing were identified by average daily temperatures greater than 20°C (68°F) or maximum daily (hourly) temperature greater than 24°C (75°F). The assessment of habitat conditions based on water temperature considered both water temperature conditions along the longitudinal gradient of the lower river and lagoon, and the identification of potential cold-water microhabitat pool refugia habitat that may provide suitable areas for juvenile steelhead to over-summer within the lower river and lagoon;

- Was electrical conductivity (salinity) elevated within the lower river or lagoon to a level that would be considered unsuitable or stressful for juvenile steelhead rearing? Juvenile steelhead are known to successfully rear within brackish water areas in lagoons and estuaries and are tolerant of low levels of salinity during their juvenile rearing period prior to undergoing the physiological smolting transition when they are adapted to higher salinities in preparation for migration into coastal marine waters. For purposes of this habitat assessment, electrical conductivities within the lower river or lagoon in excess of 1,500 uS/cm were identified as potentially stressful or unsuitable juvenile steelhead rearing habitat; and

- Were juvenile steelhead present and rearing within the lower river? What was their abundance, their size distribution, their geographic distribution, and their geographic distribution within the lower river relative to other habitat conditions and the location of the El Sur Ranch irrigation wells?

Aquatic habitat and terrestrial vegetation surveys were conducted during the summer and early fall of 2004 which was characterized by moderately low flows within the Big Sur River. During the 2004 investigations water quality measurements used to characterize fishery habitat conditions were made periodically using grab sample techniques, however no effort was made to coordinate the timing of field surveys with scheduling specific El Sur Ranch irrigation well operations. Although results of the 2004 investigations did not detect a relationship between El Sur Ranch irrigation well operations and aquatic habitat conditions within the Big Sur River, the surveys did identify a localized area in the vicinity of Creamery Meadow that was characterized by reduced water temperatures and reduced dissolved oxygen concentrations thought to be the result of groundwater upwelling into the river channel.

The experimental design for the study was refined during the summer and early fall of 2006 to include the addition of continuously recording dissolved oxygen meters as well as coordinated operations between El Sur Ranch irrigation well diversions (scheduled well operations including no wells, one well, and two wells operating simultaneously) and field data collection measurements. Flows within the Big Sur River during 2006 were moderately high and it was hypothesized that the lack of a detectable relationship between El Sur Ranch irrigation well operations and habitat conditions within the Big Sur River may have been obscured by high flows occurring within the river.

Precipitation on the Big Sur coast was abnormally low during the winter and spring of 2007 resulting in dry hydrologic conditions and substantially reduced flows (critically dry) within the Big Sur River during the summer and early fall 2007. These unusually low flow conditions in 2007 offered an opportunity to conduct additional field measurements and investigations to further evaluate the potential effects of El Sur Ranch irrigation well operations on habitat conditions within the river under critically dry hydrologic conditions. In response to the low flow conditions within the river during the late-summer 2007 additional field surveys were designed and implemented, using continuously recording water temperature and dissolved oxygen monitoring equipment, in addition to routine visual observations, grab sample water quality monitoring, and measurements of river flow and water depth potentially affecting fish passage and habitat connectivity. These field measurements were scheduled to coordinate with specific El Sur Ranch irrigation well operations (e.g., no wells in service, one well operating, both wells operating simultaneously). The 2007 surveys provide the best opportunity to test the potential effects of El Sur Ranch well operations on aquatic habitat conditions within the lower river, including simultaneous operation of both irrigation wells for a maximum diversion rate, in combination with critically low flows within the Big Sur River.

2.0 Methods

2.1 MONITORING REACH

The reach of the Big Sur River selected for habitat and water quality monitoring during the 2004 investigations (Hanson Environmental 2005) extended over a distance of approximately 1 mile from the Andrew Molera State Park downstream to the confluence between the Big Sur River and Pacific Ocean (Figure 1). The study reach encompassed the area adjacent to Creamery Meadow and both the El Sur Ranch Old and New wells. The reach was selected to include reference areas located both upstream and downstream of the Creamery Meadow area that could be used to account for changes in river conditions resulting from natural inter-annual and intra-annual variation in stream flow rates within the Big Sur River. Additional sampling sites were located throughout the river reach to include areas that may potentially be affected by El Sur Ranch irrigation well operations. Although the same reach of the river surveyed in 2004 was included in the 2006 investigations (Hanson Environmental 2007), the majority of data collection activities during the 2006 study focused on a 2000-foot reach of the lower Big Sur River located in the immediate vicinity of the El Sur Ranch irrigation wells and Creamery Meadow. Field data collection activities during 2007 replicated to 2006 station deployment (Figure 2).

Field measurement instruments and monitoring equipment were installed at various locations within the study reach over the period from August 27 through August 31, 2007. The subsequent data collection and monitoring period extended from September 1 through October 11, 2007. Details of 2007 measurement locations are summarized in Appendix A

2.2 FLOW MONITORING

Flow with the Big Sur River was measured using a variety of techniques which included data acquisition from the United States Geological Survey (USGS) stream gauge # 11143000 located on the Big Sur River upstream of the study reach. The USGS streamflow gauge records stage height and stream flow of the Big Sur River every 15 minutes with the resulting data available on the USGS Internet web page at http://water data.usgs.gov/ca/wis.

In addition to streamflow data available from the USGS gauging station, three temporary gauging stations were installed on the river to monitor river stage and flow at locations upstream to the 2007 study area (upstream reference site), as well as within the 2007 study area (Figure 2). The upstream reference gauging station was located approximately adjacent to the Andrew Molera State Park parking lot at the same location as the upstream velocity monitoring station identified as velocity transect 1 (VT-1). The second temporary gauging station, identified as VT-2, was installed at passage transect location number 4 (Figure 2). This location was chosen based on data collected from the 2006 studies as the downstream end of the section of river potentially affected by El Sur Ranch irrigation well operations (Figure 2). The third gauging station, identified as VT-3, was installed at passage transect location 9 (Figure 2) and represented a downstream reference location. Each gauging station consisted of two rebar stakes 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 the measuring tape, water velocity was measured and recorded at 0.5-foot increments using a portable flow meter. The depth profile across the river was likewise measured by recording the depth of the river from bank to bank in 0.5-foot increments. Using the aggregate results of all of the water velocity measurements and corresponding water depth measurements, river flow was calculated.

River stage and flow at each velocity transect (VT-1 through VT-3: Figure 2) were measured manually twice weekly throughout the study period. Water depth was measured using a top-setting depth measuring rod and recorded to 0.05 ft accuracy. Water velocity was measured at each 0.5-foot interval using a Marsh-McBirney Model 2000 Flow-Mate portable electromagnetic velocity meter measuring water flow in cubic feet per second over a 15-second averaging period. According to manufacturer specifications, the velocity meter can record velocities within the range of -0.5 ft/sec to + 20 ft/sec with an accuracy of + or -2% of the reading. This allows for a maximum error of + or -0.2 ft/sec at maximum velocity. The sensor was calibrated by placing it in a pan of standing water and calibrating the unit to a zero reading. Routine instrument maintenance included cleaning the sensor and checking the strength of the batteries.

Total river flow was calculated based on the cross sectional area of each 0.5 ft wide velocity measurement cell (in square feet) and the corresponding water velocity (ft/sec) measured for each cell. The sum of all the cells yielded total estimated flow of the river through the cross-section defined by the rebar posts at each velocity monitoring transect. At each velocity transect location a stilling well was installed containing a water surface elevation transducer that measured water elevation hourly over the duration of the 2007 study period. Each flow rate measurement made at the velocity transect was subsequently compared to the corresponding transducer measurement of river elevation. A linear regression was used to relate river elevation to flow rate (stage-discharge relationship; SGI 2008). Using the resulting stage-discharge relationship and results of the stage monitoring, hourly estimates of flow rates within the Big Sur River at each of the three monitoring locations could be derived (see SGI 2008 for additional flow measurement details).

2.3 DISSOLVED OXYGEN

Dissolved oxygen measurements in the Big Sur River were made using both continuously recording data loggers as well as part of weekly grab sample water quality measurements. *In situ* Model 9500 data logging transducers capable of measuring dissolved oxygen concentrations using an optical dissolved oxygen sensor were used to measure dissolved oxygen concentrations with an accuracy of + or -0.2 mg/l. Each transducer was factory calibrated prior to deployment. *In situ* dissolved oxygen monitoring was made from a series of eight shallow piezometer sites (stations P2, P3, P4, P4u, and P5; Figure 2) hourly in addition to measurements of water temperature and water depth. Piezometers were located adjacent to the left and right banks of the river near the sediment-water interface (shallow) to monitor dissolved oxygen concentrations (SGI 2008). Grab sample dissolved oxygen measurements were made within the Big Sur River during weekly field surveys using an YSI Model 556 water quality meter calibrated by a manufacturer certified facility prior to field deployment. The portable water quality meter used to measure dissolved oxygen concentrations was calibrated every two weeks during the study period. The dissolved oxygen sensor permeable membrane was replaced as part of routine instrument calibration at a two-week frequency as recommended by the manufacturer.

2.4 WATER TEMPERATURE MEASUREMENTS

Water temperatures were measured within the Big Sur River hourly throughout the study period using self-contained computerized temperature monitoring data loggers (Optics Stowaway temperature monitoring units). Temperature loggers were calibrated to NBS traceable standards under controlled laboratory conditions prior to deployment. Water temperature monitoring units were deployed at a variety of locations throughout the study reach (temperature units were deployed on the left and right channel banks at Passage Transects 1 through 11 and at Velocity Transect 1; Figure 2). In addition to the hourly monitoring, water temperature was also measured as part of each of the weekly field data collection surveys using a portable YSI Model 556 water quality meter. The temperature sensor as has accuracy of + or -0.15°C (0.27°F) and does not require periodic calibration.

2.5 ELECTRICAL CONDUCTIVITY (SALINITY)

Electrical conductivity within the Big Sur River was measured at a variety of locations (Figure 2) during the weekly water quality surveys using a portable YSI Model 556 water quality meter. The electrical conductivity sensor as an accuracy + or -0.5% of a reading of +1 micro-semen (uS/cm). The conductivity meter was routinely calibrated to a 1000 uS/cm standard solution.

2.6 PASSAGE

A total of 11 passage transects were identified along the river reach, labeled passage transect 1 through 11 (PT 1 - PT 11) starting at the downstream end of the 2007 study reach and progressing upstream (Figure 2). Passage transects were located primarily at shallow riffle areas identified during the 2007 reconnaissance survey as potential passage impediments. The passage transects selected for measurement during 2007 were similar to the 11 passage transects measured during the 2006 study. Each passage transect consisted of a pair of rebar stakes installed on opposite sides of the river channel. On a weekly basis, the depth profile was measured at each passage transect by recording the depth of the river from bank to bank in 0.5-foot increments. Water depths were measured using a top-setting rod and recorded to 0.05 ft accuracy. In addition, the wetted width of the stream channel was also measured and recorded at each of the passage transects during each weekly survey.

2.7 STEELHEAD SNORKEL SURVEYS

Juvenile steelhead have been reported to rear within the lower Big Sur River and lagoon by Titus *et al.* (2003) and confirmed by snorkel surveys conducted as part of these investigations during 2004 (Hanson Environmental 2005). As part of the fishery habitat investigations, a snorkel survey was performed during October 2007 to characterize the abundance (density), size, and geographic distribution of juvenile steelhead within the lower river and lagoon. Fishery biologists with experience in identifying and enumerating juvenile steelhead performed the snorkel survey. The snorkel surveys followed standard survey protocols. A team of two divers equipped with wet suits, mask, snorkel, fins, thermometer, GPS, pencil and slate tablet performed the surveys. Snorkel surveys were performed by the two divers moving in parallel through each reach of the lower river and lagoon swimming upstream along the river margins on opposite banks, as the divers positioned for the maximum lateral area to be observed (approximately 1.5 m from the river margin depending on visibility). After the upstream survey was completed within each survey reach, one diver descended the river reach in the center of the channel focusing orientation on the mid-line parallel to the margins. The survey protocol has proven to be effective in documenting mid-stream habitat use. Results of the visual observations were transferred to data sheets upon completion of the survey of each reach.

Species were determined by certified divers trained in species recognition, with emphasis on distinguishing between young salmon and trout. Training first consisted of picture identification of all species, juveniles and adults, which utilize habitats within the area. Divers were trained by the senior biologist to correctly identify regional fish underwater. Size estimates were improved by calibrating the divers' underwater vision. Calibration consisted of estimating the size of painted lead weights of known length, underwater. The weights were classified into length groups (0-40 mm, 41-60 mm, 61-80 mm, etc.). The divers typically have a standard error from 3-10% in estimating underwater lengths.

Snorkel surveys were conducted within a 1.04 mile long reach of the Big Sur River extending from Andrew Molera State Park downstream through the Big Sur River lagoon. The reach was partitioned into eight sub- reaches of varying lengths (Figure 3). Subreaches were selected during the 2004 snorkel surveys based on observed variation in hydrology and/or habitat conditions and were, therefore, not of equal length. The same boundaries were used during the 2007 snorkel survey. Descriptions of the latitude and longitude boundaries for each subreach are summarized in Appendix A.

Characteristics of the survey reaches did not change significantly between the 2004 snorkel survey and the snorkel surveys conducted in 2007 with the exception of increased riparian vegetation and in subreaches D through F (Figure 3). The lagoon reach (subreach A) was open and connected to the ocean during the October 2007 survey. Because the distance surveyed differed among the eight subreaches, total numbers of steelhead observed were standardized (CPUE) to an index of the number of fish per linear foot within each subreach surveyed.

3.0 Results

Results of the 2007 water quality and fishery habitat surveys conducted within the lower reaches of the Big Sur River are summarized below. 2007 represents the third year of investigations within the lower river. Results of studies conducted in 2004 and 2006 provide important information on habitat conditions affecting steelhead and other aquatic resources inhabiting the river, however it was hypothesized that results of these earlier investigations may have not detected important effects of El Sur Ranch irrigation well operations on habitat within the river as a result of higher river flows. Hydrologic conditions within the Big Sur River watershed in 2007 were extremely dry and river flows during September 2007 were classified as critical which offered an opportunity to investigate the potential effects of irrigation well operations on habitat conditions within the river under critically dry conditions when the potential effects of irrigation well operations would be expected to be most severe.

3.1 BIG SUR RIVER FLOW

Flow within the Big Sur River measured at the USGS gauging station between September 1, 2004, and October 31, 2007 is shown in Figure 4. The average monthly flow at the USGS gauging station during the September and October, 2007 study period ranged from 7.5 (September) to 9.8 cfs (October). Table 1 presents a comparative summary of the average monthly flows measured at the USGS gauging station during April-October in 2004, 2006, and 2007 (the three study years). Results of the 2007 river flow monitoring (Table 1) showed a pattern of declining flows in the reach extending from the USGS gauging station to VT-1 (upstream reference location). Figure 5 shows a comparison of river flows during the 2007 study between flow monitoring stations VT-1, VT-2, and VT-3. River flow at the downstream monitoring locations, VT-2 and VT-3, was typically lower than the flow upstream at VT-1 (Figure 5). Flow at location VT-2, located at the head of the lagoon and downstream of the Creamery Meadow, was either comparable or greater than flows further upstream at VT-3 located in the general vicinity of the El Sur Ranch wells, showing a general pattern of flow accretions (increasing flow) at the downstream site (Figure 5). The minimum flow in the river observed during the 2007 occurred during the Labor Day weekend (see SGI 2008 for daily flow measurements during 2007); the minimum flow was 0.3 cfs at VT-3 and approximately 0.4 cfs at VT-2. Additional information of flow monitoring within the river during the 2007 study is presented by SGI (2008).

For comparative purposes, flow within the Big Sur River measured at the USGS gauging station (average monthly flow) during April-October 2004 and 2006 study periods, and flow during the 2007 study period, are shown in Table 1. Results of flow measurements show that the highest river flows occurred during the 2006 study period (wet year). The lowest Big Sur River flows occurred during the 2007 study period (critically dry year). Based on a probability of exceedance analysis using the USGS flow, September 2007 had a flow exceedance of greater than 80% reflecting the extremely dry hydrologic conditions occurring within the river during the 2007 study period (this means that average monthly September flow exceeded 8.0 cfs in 80% of the Septembers since 1950). Given the extremely low flows within the river during the summer and early fall of 2007 it was expected that the potential effects of El Sur Ranch irrigation well operations on aquatic habitat within the river would be most detectable, particularly under conditions of maximum diversion rates (both Old and New wells operating simultaneously) during these critically dry hydrologic conditions.

There was no statistically significant difference ($P>0.05$) between flows upstream, at control station VT-1, compared with flows downstream at VT-2 and VT-3, with the pumps off *versus* the pumps on (normalized for variation in river flow). A ratio of flow at VT-1, and VT-2 and VT-3 was used, in order to normalize data for seasonal differences in flow amongst weeks measured during the study period, and a chi-square test was performed on the flow ratios comparing days when both pumps were on (e.g., October 3) to all days when both pumps were off. P values resulting from these tests ranged from 0.23-.092, and thus, did not show that the effects of pumping operations were significant on downstream river flows.

3.2 EL SUR RANCH IRRIGATION WELL OPERATIONS

During the September 1 through October 11, 2007 study period, field surveys and data collection activities were scheduled to coincide with specific operations of the El Sur Ranch irrigation wells. A schedule was established as part of the basic experimental design for the 2007 investigations which included approximately weekly periods when (1) no wells were in operation, (2) either the New Well or the Old Well was in operation, or (3) both the New and Old wells were in operation simultaneously. The schedule of actual El Sur Ranch irrigation well operations during 2007 study period is summarized in Table 2. During those periods when neither the Old Well nor New Well was in operation no water was diverted for El Sur Ranch irrigation. During those periods when the New Well was in operation the diversion rate was estimated to average 2.37 cfs (SGI 2008). During those periods when the Old Well was in operation the diversion rate was estimated to average 2.26 cfs (SGI 2008). During those periods when both the Old and New wells were operating simultaneously the diversion rate was estimated to average 5.02 cfs (SGI 2008).

The well operations schedule established for use during the 2007 investigations was designed to allow comparisons of habitat conditions and water quality parameters, under low river flow conditions during 2007, in response to specific irrigation well operations. During each of the weekly field surveys, data collection was scheduled to occur during the end of a given well operational period to help assure that the hydrodynamics between groundwater and surface water had reached equilibrium (Table 2). It was anticipated that if El Sur Ranch irrigation well operations were having a significant effect on aquatic habitat conditions within the Big Sur River the best method for detecting the effect of well operations would be a comparison between periods when no wells were diverting and when both wells were operating simultaneously for a maximum diversion rate. For those parameters such as hourly water temperature a sufficient number of observations were recorded during the 2007 study to be able to statistically test for differences between those periods when no irrigation wells were operating, when one well was operating, and when both wells were operating together. For other parameters such as EC, dissolved oxygen concentrations, wetted channel width, and water depths within Swiss Canyon the number of observations under each test condition was small and statistical tests were performed to examine differences between adjacent time periods when no wells were operating and when both wells were operating as well as comparisons of periods when no wells were operating versus all other periods when one or both wells were in operation.

3.3 WATER TEMPERATURE

Results of water temperature monitoring within the Big Sur River during the 2004 and 2006 studies showed that late summer and early fall water temperatures were within the range considered to be suitable for juvenile rearing habitat. Observations made during the dry year 2004 snorkel surveys showed that the juvenile steelhead inhabiting the lower reaches of the river, appeared to be growing at a rate comparable or greater than that reported for many other California rivers, showed evidence of a cause-effect smolting characteristics, and appeared active and in good condition (Hanson Environmental 2005). The observations of the 2004 and 2007 snorkel surveys are consistent and support the general finding that water temperatures were suitable of juvenile rearing. Furthermore, results of the earlier studies showed no evidence of a cause-effect relationship between El Sur Ranch irrigation well operations and locally elevated water temperatures within the lower river. To the contrary, results of the earlier studies showed evidence of a localized area in the vicinity of Creamery Meadow (primarily along the right bank of the river) where water temperatures were observed to be cooler than those observed either upstream or downstream. The cooler temperatures were attributed to localized groundwater upwelling into the river. It was hypothesized that this localized area of cooler water temperatures may provide a thermal refuge for juvenile steelhead.

Results of water temperature monitoring in the lower Big Sur River during the 2007 study are similar and consistent with results from the earlier surveys. Hourly and average daily water temperatures measured at each location during 2007 are shown in Figures 6 through 39, extending from the downstream monitoring locations (passage transect 1: Figure 2) upstream toward the Andrew Molera State Park (velocity transect 1; Figure 2). Water temperatures measured during periodic water quality surveys (grab sampling) are summarized in Figures 40 through 51. For reference a horizontal line has been included on each temperature graph showing the average daily temperature criterion of not to exceed 20°C (68°C) and the hourly criterion of not to exceed 24°C (75°C) selected for use in this study to assess the suitability of water temperatures for juvenile steelhead rearing. Also shown on Figures 6 through 51 are the periods when El Sur Ranch irrigation wells were both off, one well was operating, or both wells were operating.

Results of the 2007 water temperature monitoring showed a typical pattern of daily variation in temperatures which were typically within the range of 5-7°C (9-13°F) (daily minimum to daily maximum) or less. The results also show a general pattern of seasonally declining water temperatures between early September and early October reflecting seasonal cooling in atmospheric temperatures (particularly cooling at night during the fall) with a corresponding trend of reduced river temperatures. The exception to this general pattern was observed at passage transect 7 (right bank; Figure 21) and piezometer location 3 (right channel; Figure 23) where water temperatures were typically cooler than at other locations and daily variation in temperatures was reduced, both of which are thought to reflect the influence of groundwater upwelling in this area along the right bank of the river. Both average daily and maximum hourly water temperatures at all location monitored during the 2007 study were within the range considered to be suitable for juvenile steelhead rearing. Based on results of the 2007 study there was no evidence that El Sur Ranch irrigation well operations, under the low river conditions, resulted in elevated water temperatures within the lower river that would adversely impact habitat conditions for rearing steelhead.

To further investigate the potential relationship between El Sur Ranch irrigation well operations and water temperatures within the lower Big Sur River during the 2007 study, hourly temperatures measured at each location were analyzed using the General Linear Model Procedure (GLM) within the Statistical Analysis System (SAS) to determine if water temperatures exhibited statistically significant differences ($P<0.05$) based on variation in irrigation well operations. In addition to well operations the statistical analysis also included consideration of air temperature, river flow, and whether or not the lagoon mouth was open. For purposes of this statistical analysis hourly water temperatures measured at the upstream site (VT-1; Figure 2) were assumed to be independent of well operations and would serve as a reference location to establish naturally occurring variation in river flow and ambient water temperatures. The CONTRAST procedure within SAS was used to test the hypothesis that there were no statistically significant differences in water temperatures between the reference location (VT-1) and other locations and that the differences in temperatures that did occur were independent of irrigation well operations. Least-square estimates of the marginal means of the main effect (LSMEANS) were also calculated with all covariates at the mean value to further assess potential relationships with well operations. The analysis also accounted for data from recorders located on the right or left bank of the river and hour of the day. It was expected that if irrigation well operations were affecting water temperatures within the river the effect would be greatest when both wells were operating simultaneously. More than 23,000 observations were included in the statistical analysis.

Results of the statistical analysis detected significant differences ($P<0.05$) at some locations in water temperatures between periods when there were no irrigation wells in operation, one well was operating, and two wells were operating (in part as a result of the extreme power of the analysis given the large number of observations); however, the absolute differences in temperature were small (all differences were less than 1°C [2°F] with temperatures both increasing and decreasing at various stations between no, one, and two well operations) and were well within the range of natural daily variation. Results of the LSMEAN tests by location and irrigation well operations showed that at only two (PT-5, PT-6; Figure 2) of the locations were temperatures significantly ($P<0.05$) higher when both wells were operating compared to periods when no wells were in operation. The temperatures when no wells were operating at location PT-5 (average 14.0°C[57.2°F]) were less than the temperatures when one well was operating (14.9°C [58.8°F]) and both wells were operating (14.3°C[57.7°F]) with the statistical difference between no well operations and two well operation being less than 0.3°C (0.5°F). Similar results were calculated for location PT-6 where the mean temperature when no wells were operating (13.4°C [56.1°F]) was less than when one well was in operation (14.1°C [57.7°F]) and when both wells were operating (13.7°C [56.7°F]) with the statistical difference between no well operations and two well operation being less than 0.3°C (32.5°F). In a number of comparisons the temperatures measured when one well was operating were greater than when either no wells were in service or when both wells were operating. We hypothesized that the statistically significant difference in water temperature (when temperatures were higher under the one well operating condition when compared to either no wells or the two well operating condition) detected several stations (PT4, PT5, PT6, PT7, PT8, PT9, PT10, PT11, VT1; Figure 2) were the result of some covarying environmental factor other than irrigation well operation (e.g., opening or closing the lagoon mouth). Since the increased temperatures when one well was operating (less than 1 C increase when compared to either no wells or two wells in operation) occurred at a number of locations along the river, including stations located upstream and out of the area of potential well influence, no physical cause-effect relationship between the observed results and El Sur irrigation well operations was identified. The inclusion of the lagoon mouth being open or closed did not significantly affect results of the statistical analysis.

Results of the 2007 water temperature monitoring have shown that under critically dry hydrologic conditions there was a statistically significant relationship between water temperatures at two locations within the lower river (PT5 and PT6) and well operations, however the differences in average water temperatures at both locations was less than 0.3°C (0.5°F) between no well and two well operations. As part of the evaluation and interpretation of results of the 2007 study we considered whether differences in environmental parameters such as water temperatures were statistically different as well as evaluating whether observed or statistically significant differences were biologically meaningful to the suitability and availability of juvenile rearing habitat within the river (a difference in a parameter such as water temperature may be statistically significant when comparing conditions when no wells are in operation and when two wells are in operations but may not be biologically meaningful to the observed habitat conditions in the river; e.g., the observed variation is within the range of natural diel variation, or water temperatures are within the suitable range independently of a small difference related to one or more factors such as well operations). The small statistical increase in water temperatures detected at these locations with both wells in operation (<0.3°C [0.5°F]) would not result in adverse effects on habitat quality or availability for juvenile steelhead rearing within the range of water temperatures observed during the critically low flow conditions that occurred in 2007. This conclusion is consistent and supported by the observation that neither the maximum hourly water temperature nor the average daily water temperatures at any of the monitoring locations within the lower river exceeded the selected criteria for steelhead habitat suitability. Water temperatures even under critically low flows in September were consistently within a range considered to be suitable for juvenile steelhead rearing independently of whether no wells, one well, or both irrigation wells were in operation. Results of water temperature monitoring in 2007 are consistent with results in 2004 and 2006 in showing that habitat within the lower river is suitable for juvenile steelhead rearing over a range of hydrologic conditions and El Sur Ranch irrigation well operations.

3.4 DISSOLVED OXYGEN CONCENTRATIONS

Results of monitoring during the 2004 surveys showed evidence of localized reductions in dissolved oxygen concentrations in the vicinity of Creamery Meadow that were thought to be the result of localized groundwater upwelling along the right bank of the river. Evidence of localized groundwater upwelling was consistent with observations of reduced water temperatures in the same areas as reduced dissolved oxygen concentrations. Under conditions of higher river flows, such as those during the 2006 studies, the higher flows were thought to reduce the influence of localized groundwater upwelling on localized changes in dissolved oxygen by providing greater dilution and more rapid mixing under higher flows. Based on these observations it was hypothesized that the potential effects of El Sur Ranch irrigation well operations on dissolved oxygen concentrations and habitat conditions for juvenile steelhead rearing within the lower river would be most detectable, particularly with both the Old and New wells operating simultaneously, during the 2007 critically dry hydrologic conditions.

Results of continuous dissolved oxygen monitoring within the lower Big Sur River during 2007 are presented in Figures 52 through 55. Results of dissolved oxygen monitoring at location PT4 were not included in the analyses because the probe was frequently fouled by algae and other deposits resulting in unreliable measurements. Results of dissolved oxygen measurements during periodic water quality surveys (grab samples) during 2007 are presented in Figures 56 through 67. During the 2007 studies dissolved oxygen concentrations in early and mid-September (Figures 52-55) were observed to be reduced substantially (to less than 6 mg/l) at piezometer locations 2, 3, and 4 upper (Figure 2) during periods when only the New Well was operating and when both wells were off. The low dissolved oxygen concentrations (within the range from 2 to 4 mg/l) coincided with the period of lowest flows in the river (Figure 5). As flows increased dissolved oxygen concentrations generally increased.

Statistical analyses of the 2007 dissolved oxygen sampling detected statistically significant ($P<0.05$) differences in dissolved oxygen concentrations among locations and between periods when irrigation wells were in operation and when no wells were operating. Dissolved oxygen concentrations were not significantly different ($P>0.05$) during late September and early October when no wells were operating and when both wells were operating at any location other than piezometer pair 2 – left bank (Figure 52). Dissolved oxygen at piezometer pair 3 – left bank was significantly lower than the right bank (Figure 53), both when the irrigation wells were on and off.

Results of the 2007 habitat and water quality monitoring are consistent with findings of the 2004 and 2006 studies in showing that dissolved oxygen concentrations affect habitat quality and availability for steelhead rearing within the lower river (September average flows in the Big Sur River varied substantially among the three years of study averaging 12.2 cfs in September 2004, 20.6 cfs in September 2006, and 7.5 cfs in September 2007; Table 1). Dissolved oxygen concentrations are typically higher during years when river flows are high and are decreased to levels that adversely affect habitat when river flows are critically low.

Results of these studies are also consistent with the hypothesis that localized groundwater upwelling results in locally reduced dissolved concentrations in the vicinity of Creamery Meadow and that these effects are greater when river flows are low. Dissolved oxygen concentrations within the river during 2007 appeared to respond to changes in river flow (e.g., low DO levels in early September when river flows were lowest). Irrigation well operations during the low flow 2007 study appeared to influence localized dissolved oxygen concentrations near Creamery Meadow (locations 2 and3 left bank), however dissolved oxygen concentrations remained within a range considered to be stressful or unsuitable for juvenile steelhead both when irrigation wells were in operations and when they were not. Dissolved oxygen concentrations appeared to be independent of irrigation well operations at other monitoring locations within the lower river.

3.5 ELECTRICAL CONDUCTIVITY

Results of habitat surveys and snorkel surveys conducted within the lower river during 2004 showed that juvenile steelhead inhabited a range of salinities ranging from freshwater in the upper reaches of the river to brackish water habitat within the lagoon. Salinities were typically lower in the river during 2006 when flows were higher with the brackish waters of the lagoon extending further upstream when river flows are low, e.g., 2004 and 2007. The distribution of salinity within the lower river is also affected by opening and closing of the lagoon connection to the ocean by formation of the sand bar. Juvenile steelhead have a relatively high tolerance to salinity and have been reported to rearing in estuaries and lagoons prior to emigrating to the ocean.

During the 2007 study period, electrical conductivity (a measure of salinity) was measured during the periodic water quality surveys as shown in Figures 68 through 79. During the surveys electrical conductivity in the lagoon increased in late-September but appeared to be related to closing the sand bar and was independent of irrigation well operations. Electrical conductivity at locations upstream of the lagoon remained constant throughout the study period and were independent of El Sur Ranch irrigation well operations (no statistically significant differences in EC were detected in relationship to El Sur Ranch irrigation well operations; P>0.05). Based on results of the 2007 studies and similar results from the 2004 and 2006 studies, there was no evidence that irrigation well operations affected habitat quality or availability for steelhead rearing as a result of changes in electrical conductivity.

3.6 FISH PASSAGE AND HABITAT CONNECTIVITY

Results of observations within the lower river during the 2004 and 2006 habitat surveys showed that connectivity was maintained among all habitat units within the lower river, other than during those periods when the sand bar closed and precluded access or movement between the lower river and lagoon and coastal marine waters. Since river depth and habitat connectivity within the lower river vary in response to changes in river flow it was hypothesized that passage among habitats and river connectivity would be most critical during years when river flows are lowest. The critically dry hydrologic conditions that occurred within the river in 2007 offered an opportunity to test whether habitat connectivity varies based on irrigation well operations.

Periodic measurements were made throughout the 2007 study period at 11 transects (Figure 2) to assess changes in wetted channel width and cross-sectional depths during periods when no irrigation wells were in operation, one well was operating, and both wells were operating. During the habitat surveys visual observations were also made of habitat connectivity. Results of the visual observations showed that surface water connectivity was maintained within the lower river throughout the 2007 study period.

Results of channel cross-sectional measurements recorded during the 2007 study are summarized in Tables 3 through 17. Average cross-sectional water depths observed at each transect location are summarized in Figures 80 through 90. Variation in water depths in the lower reaches of the river (e.g., transects 1 – 3) reflected the effects of both the sand bar formation and tidal influences in the lagoon. Variation in water depths at transects located upstream of the lagoon (transects 4 through 11) was substantially lower than that observed in the lagoon reach. Water depths at transects 4-11 maintained surface water connectivity but water depths averaging greater than 0.6 feet occurred at transects 5-8 and did not occur at locations 4 or 9-11. Shallow water depths occurred at passage transects 4 (Figure 83), 9 (Figure 88), 10 (Figure 89), and 11 (Figure 90) that were independent of irrigation well operation (locations 9-11 are upstream of the potential zone of well operations; Figure 2). Shallow water depths at the upstream passage transects appeared to be a response to channel gradient, width, and low river flows that occurred during the 2007 study.

Average water depths within the lagoon were consistently greater than 2 feet during all passage surveys. Lagoon water depths during the 2007 study met the passage criterion independently of El Sur Ranch irrigation well operations (Table 3; Figure 80).

The largest variation is water depth and wetted channel width observed during the 2007 study occurred at passage transects PT2 and PT3 (Figure 2) located immediately upstream of the lagoon. Water depths at passage transect PT2 (Figure 81) varied up to 0.8 feet during the 2007 study while channel wetted width varied by up to approximately 19 feet (Table 4). At passage transect PT3 a similar pattern of variation was observed in both water depth (Figure 82) and wetted channel width (Table 5). The periods of El Sur Ranch well operations (no wells, one well, and both wells operating) are also shown on Figures 82 and 83 with the corresponding average channel water depths during each survey at passage transects PT2 and PT3. Results of water depth and wetted channel width measurements at passage transects PT2 and PT3 showed a reduction in average water depth and wetted channel width at both PT2 and PT3 during periods when El Sur ranch irrigation wells were in operations (one or two wells) when compared to periods when no wells were in operation. Measurements during the first survey (August 30, 2007) when both wells were off may have been influenced by the very low flow in the river during the Labor Day weekend (Section 3.1) and therefore have not been included in the comparisons. Observations during the September and October passage transect measurements also indicated opening and closing the mouth of the lagoon and tidal effects within the lagoon, and the associated backwater effects at the head of the lagoon in the general vicinity of PT2 and PT3 affected water depths and channel wetted width during the passage surveys. Based on results of the periodic passage transect measurements alone the incremental contribution of well operations, variation in river flow, and variation in tidal stage within the lagoon on measurements of water depth and wetted channel width could not be determined.

To further investigate the potential effects of well operation, river flow, and tides on results of the PT2 and PT3 passage transect measurements hourly data was compiled from water depth measurements from the lagoon reflecting tidal effects and corresponding measurement data on river flows at velocity transect VT2 (SGI unpublished data; Figure 2). The lagoon tidal data and VT2 river flow data matched the actual time of day that each passage transect measurement was taken during the four surveys of interest (September 19 – Old Well on, September 26 – both wells off, October 3 – both wells on, and October 10 – both wells off) at both PT2 and PT3. The average channel water depth, wetted channel width, well operations, tide height in the lagoon, and river flow as measured at VT2 for each of these surveys is shown below:

	Date	Time	Well Operation	Average Depth (ft)	Wetted Width (ft)	Tide height (ft amsl)	Flow at VT2 (cfs)
PT2	9/19/2007	11:45	Old Well on	0.64	68	0.9	1.8
PT2	9/26/2007	11:25	Both off	1.32	74.3	2.5	2.9
PT2	10/3/2007	10:20	Both on	0.49	64	0.5	1.4
PT2	10/10/2007	10:30	Both off	1.04	82.6	2.1	3.2
PT3	9/19/2007	12:00	Old Well on	0.27	44.5	1	1.8
PT3	9/26/2007	11:37	Both off	0.85	54	2.5	2.9
PT3	10/3/2007	10:30	Both on	0.23	36	0.5	1.4
PT3	10/10/2007	10:45	Both off	0.74	54.2	2.1	3.2

A correlation analysis was performed to examine the relationships between El Sur Ranch irrigation well operations (average cfs diversion rate), channel water depth and wetted width at PT2 and PT3 and both tidal height in the lagoon and river flow at VT2. Results of the statistical analysis are summarized below:

Coefficient of determination (R^2) for correlations between channel depth, width, tide, and flow in the Big Sur River at PT-2 and PT-3.

	Well Diversion and Tide	Well Diversion and Width	Depth and Tide	Depth and Flow	Width and Tide	Width and Flow
PT 2	0.82*	0.77	0.98*	0.81*	0.68	0.92*
PT 3	0.99*	0.81*	0.97*	0.90*	0.93*	0.94*

*Denotes statistically significant ($P<0.05$) correlations.

To further explore the potential relationships between well operations, tide height, and river flow on conditions within the Big Sur River during the 2007 study a multiple regression was calculated at PT2 and PT3. As a result of the small sample size these analyses were not considered to be robust, but rather were used in an experimental analysis to assess the relative magnitude of the regression coefficients. Results of the analysis using river channel water depth (a primary factor affecting habitat connectivity and potential movement of juvenile steelhead among habitat units. The regressions were:

$$\text{Water depth (PT2)} = 0.495 + (-0.0022)\ \text{well} + (0.555)\ \text{tide} + (-0.194)\ \text{flow}$$

$$\text{Water depth (PT3)} = -0.4710 + (0.092)\ \text{well} + (0.412)\ \text{tide} + (0.183)\ \text{flow}$$

Based on results and observations during the 2007 study it was concluded that tidal height within the lagoon and the back water effect that affected river stage (water depths) at the lower stations at the head of the lagoon (PT2 and PT3). It was expected that if tidal conditions were the primary factor affecting river stage at PT2 and PT3 we expected that the backwater effect would be apparent but of lesser magnitude at locations further upstream within the river. Results of the surveys were consistent with the expected results at upstream locations. The tidal signal was apparent, in reduced magnitude, at all upstream locations (PT4 through PT11). We expected that if the pattern was primarily the result of changes in river flow the magnitude of variation in water depth would have a relative high magnitude (similar to PT2 or PT3) at one or more of the upstream locations. There was no evidence that the magnitude of variation in water depths at upstream locations was as high as that observed at the downstream locations. Results of well monitoring conducted by SGI (2008) as part of the 2007 studies showed that variation in water levels was 0.17 feet or less when El Sur Ranch irrigation wells were in operation or were off. The magnitude of variation in well water elevations were substantially less than the magnitude of variation observed at locations PT2 and PT3.

Based on results and observations it was concluded low river flows under the critical hydrologic conditions that occurred of during the 2007 studies contributed to reduced passage conditions in the river when compared to conditions under higher natural river flows that occurred in 2004 and 2006. Opening and closing of the lagoon mouth and the effects of tidal conditions within the lagoon and the resulting backwater effects in the lower river were identified as the major factor affecting passage measurements at locations PT2 and PT3 with a diminishing effect at locations further upstream within the river. Autocorrelation between water depth and channel cross sectional measurements and El Sur Ranch irrigation well operations obscured the analysis and required analysis of hourly river flow, tidal height, passage conditions at PT2 and PT3 to evaluate and interpret results of the

2007 study. Given the pattern of results observed at the various locations within the river, in combination with detailed monitoring by SGI (2008) as part of the 2007 studies, there was no evidence that well operations were a major factor affecting passage conditions in the river.

3.7 DISTRIBUTION AND RELATIVE ABUNDANCE (DENSITY) OF STEELHEAD AND AQUATIC SPECIES

Conditions were ideal for snorkel surveys during October 2007. Visibility was 12-20 feet and the river was less than 30 feet wide in most areas which allowed for total lateral coverage. The exceptions were in subreach D where instream brush filled the channel and in subreach A where the river width exceeded the effective visibility. The potential for avoidance and counting more than once was high in these two reaches.

Four species of fish were observed during snorkel surveys in October 2007. In order of abundance, steelhead (O. *mykiss*), three-spined stickleback (*Gasterosteus aculeatus*), riffle sculpin (*Cottus gulosus*), and starry flounder (*Platichthys stellatus*) were observed. Additionally, signal crayfish (*Pacifasticus leniusculus*) were observed. Thus, the classical coastal stream fish assemblage was observed during these surveys.

3.7.1 Steelhead

A total of 380 steelhead were observed during the October 2007 snorkel survey. Juvenile steelhead were observed in all subreaches with the exception of subreach H (Figure 3). The steelhead observed rearing in the river were almost exclusively juveniles including young-of-year (YOY) and yearlings. Observed densities were highest from the lagoon through mile 0.24 upstream from the lagoon above which densities sharply declined in subreach C. Subreaches A, B, D and F possessed both the highest numbers and highest relative densities of steelhead (0.03 - 0.49 individuals per linear foot (No/ft)). Reaches C, E, G, and H had relatively low densities of steelhead (0.0-0.007/ft; Appendix B). As in 2004, the lagoon reach had the highest density of juvenile steelhead. The number of steelhead observed in the lagoon reach was 2.5 times greater than all other reaches combined.

In general, the highest observed steelhead densities were in habitat units with extensive cover combined with deep water where large schools were observed (primarily in subreach A). Peak densities (0.05-0.49 individuals per linear ft) occurred in subreaches A through F (Figure 3) where most of the preferred rearing habitat occurred (the availability of deeper pools and instream cover was greater in the lower reaches of the river when compared to stream habitat conditions located further upstream). Localized densities within subreaches were often 10 times greater than the overall average as young steelhead tended to congregate in tight schools in specific areas of habitat units (e.g., non-random habitat use). The primary habitat utilized by juvenile steelhead included cover in the form of large woody debris (LWD) or instream brush located adjacent to deep pools (>3 feet of water). We hypothesize that the distribution of juvenile steelhead within and between subreaches was primarily a reflection of available habitat. Preferred habitat appeared to be deep water pools combined with a cover component. Available cover appeared to be limiting in several of the subreaches surveyed (e.g., subreaches C, G, and H where densities were equal to or less than 0.01 fish/foot; Appendix B) and observed steelhead densities were correspondingly low. No obvious limiting factors to juvenile steelhead survival were observed during the surveys. Spawning habitat was marginal throughout the sample reach due to substrate size and abundant fines.

Classical smolting characteristics (e.g., silvery scales with minimal parr marks) were observed in all steelhead within the lagoon (subreach A). Approximately 70% were fully smolted and the remaining were silvery parr. All steelhead observed upstream of the lagoon reach were parr.

YOY and yearling steelhead were observed during the surveys. Estimated lengths ranged from 60-300/mm with the majority of juvenile steelhead ranging in length between 100 mm and 200 mm. Length frequency distributions varied significantly between reaches (Appendix B), with the majority of the steelhead (100-300 mm) inhabiting subreaches A and G.

One wild adult steelhead approximately 650 mm in length was observed during the survey. The adult steelhead was observed in subreach F (Figure 3) holding in a lateral scour depression. The adult steelhead appeared emaciated but did not look as though it had spawned as there were no abrasions on the caudal fin. The adult may have been attracted into the river by increased flow caused by early October rains in the area as there was evidence of recent increased flows on the stream banks.

3.7.2 Other Aquatic Species

Three-spined stickleback, riffle sculpin, and starry flounder were observed inhabiting the 2007 study reach. Three-spined stickleback were the most abundant species with 715 individuals observed. Highest densities of all non salmonid fish occurred in the lagoon reach (subreach A) and subreach B with another peak density in subreach F (Appendix B). The occurrence of non-salmonid fish was lowest in subreaches E, G, and H (Figure 3; Appendix B).

3.8 SWISS CANYON

The irrigated pasture land (Place of Use) of the El Sur Ranch water right is bisected by Swiss Canyon, a perennial incised drainage channel that discharges into the ocean. Swiss Canyon has a small creek that conveys water from the area upstream of the Highway 1 culvert to the ocean. Swiss Canyon does not provide habitat for fish such as steelhead. Swiss Canyon supports a variety of species including native grasses, shrubs and other riparian plants, birds and other wildlife, and aquatic species including a population of red-legged frogs. The canyon is accessible to cattle grazing.

As part of the 2004, 2006, and 2007 studies, observations and periodic measurements were made within Swiss Canyon to assess the potential effects of irrigation well operations on surface water within the canyon. It was hypothesized that runoff from the pastures was passing into Swiss Canyon, causing erosion across the ocean beach from the ephemeral stream during and after irrigation events. To test this hypothesis in 2007, a series of three transects were established within Swiss Canyon and measurements were made of cross-sectional water depths periodically during the study to coincide with periods when the irrigation wells were not in service, one well was operating, and both wells were operating. It was expected that if irrigation was a major source of water within Swiss Canyon it would be apparent under the dry 2007 conditions and that surface water flows would be observed throughout the canyon which is immediately adjacent to the pastures on both sides and that channel depth in the creek would increase in response to irrigation of the pastures and decrease when no irrigation was occurring.

Results of the 2007 surveys within Swiss Canyon are summarized in Figure 91 and Table 18. No surface water was apparent in Swiss Canyon at either the upstream (near the Highway 1 culvert) or mid-point monitoring locations during any of the 2007 surveys (Table 18). Surface water was always present at the downstream monitoring location during the 2007 survey. Results of water depth measurements at the lower transect location ranged from 0.64 to 0.56 feet (Table 18). Although the water depth measured on October 3 (0.56 ft) with both wells operating was the lowest observed, there was no statistically significant difference ($P>0.05$) in water depths between periods when irrigation wells were in operation (average 0.62 ft) and when the wells were off (average 0.62 feet). Results of these surveys indicate that Swiss Canyon has a limited water supply source during critically dry years in the lower reaches (e.g., groundwater, spring, etc.) with surface water entering the canyon from the upstream drainage area during periods of precipitation and runoff. These results do not support the hypothesis that water from pasture irrigation is supporting surface waters within the creek (the upper two locations were consistently dry irrespective of pasture irrigation). These observations also show that under the critically dry conditions that occurred in 2007, aquatic habitat units remained in the lower reaches of Swiss Canyon and continued to support amphibians and other species. Results of the 2007 study provided no evidence to suggest that El Sur Ranch irrigation practices were an important factor affecting habitat or surface waters within Swiss Canyon in 2007.

4.0 Summary of Findings

Results of studies conducted in 2004 and 2006 provide important information on habitat conditions affecting steelhead and other aquatic resources inhabiting the river, however it was hypothesized that because of higher river flows, results of these earlier investigations may have not detected important effects of El Sur Ranch irrigation well operations on habitat within the river. Critically dry hydrologic conditions in 2007 provided the opportunity to investigate the potential effects of irrigation well operations (i.e., scheduled operations of no wells, one well, or both wells operating simultaneously for a maximum diversion rate), on water quality and fishery habitat under extreme conditions within the river.

Results of the 2004 and 2006 studies showed no evidence of a relationship between El Sur Ranch irrigation well operations and locally elevated water temperatures within the lower river that would adversely impact habitat conditions. Results of water temperature monitoring in the lower Big Sur River during the 2007 study are similar and consistent with results from the earlier surveys. Based on results of the 2007 study, there was no evidence that El Sur Ranch irrigation well operations, under the low river conditions, resulted in elevated water temperatures within the lower river that would adversely impact habitat conditions for rearing steelhead.

To further investigate the potential relationship between El Sur Ranch irrigation well operations and water temperatures within the lower Big Sur River during the 2007 study, hourly temperatures were measured at each location analyzed using the General Linear Model Procedure (GLM) within the Statistical Analysis System (SAS) to determine if statistically significant differences ($P < 0.05$) in water temperatures were caused by irrigation well operations. It was expected that if irrigation well operations were affecting water temperatures within the river the effect would be greatest when both wells were operating simultaneously. Results of the 2007 water temperature monitoring have shown that under critically dry hydrologic conditions there was a statistically significant relationship between water temperatures at three locations within the lower river and well operations however the differences in average water temperatures at all three location were less than 0.3°C (0.5°F) between no well and two well operations. The small statistical change in water temperatures detected at these locations and well operations (<0.3°C [0.5°F]) would not result in adverse effects on habitat quality or availability for juvenile steelhead rearing even during the critically low flow conditions that occurred in 2007 (none of the water temperatures recorded during 2007 exceeded the criteria for suitable rearing habitat). Water temperatures even under critically low flows in September were consistently within a range considered to be suitable for juvenile steelhead rearing independently of whether no wells, one well, or both irrigation wells were in operation. Results of water temperature monitoring in 2007 are consistent with results in 2004 and 2006 in showing that habitat within the lower river is suitable for juvenile steelhead rearing over a range of hydrologic conditions and El Sur Ranch irrigation well operations.

Results of the 2007 habitat and water quality monitoring are consistent with findings of the 2004 and 2006 studies in showing that dissolved oxygen concentrations affect habitat quality and availability for steelhead rearing within the lower river. Dissolved oxygen concentrations are typically higher during years when river flows are high and are decreased in certain localized areas to levels that adversely affect habitat when river flows are critically low. The lowest dissolved oxygen concentrations coincided with the period of lowest flows in the river (0.3-0.4 cfs during the Labor Day weekend in 2007). As flows increased dissolved oxygen concentrations generally increased. Dissolved oxygen concentrations appeared to be independent of irrigation well operations at the monitoring locations within the lower river except at piezometer location 2 on the left bank, which is adjacent to Creamery Meadow.

Results of habitat surveys and snorkel surveys conducted within the lower river during 2004 showed that juvenile steelhead inhabited a range of salinities ranging from freshwater in the upper reaches of the river to brackish water habitat within the lagoon. Salinities were typically lower in the river during 2006 when flows were higher with the brackish waters of the lagoon extending further upstream when river flows are low. Observations during the three years of study showed that salinity/electrical conductivity within the lagoon was influenced by coastal waves overtopping the sand bar and introducing saltwater (and kelp and other marine vegetation) into the lagoon, closure of the lagoon mouth, and surface flow within the river. Water quality monitoring stations located upstream of the lagoon during 2007 showed no statistically significant ($P>0.05$) change in EC in response to changes in river flow, spring or neap tides, closure of the lagoon mouth, irrigation well operations, or other factors. The EC at the two locations within the lagoon was significantly higher ($P<0.05$) than EC measured in the river upstream of the lagoon, however this increase in EC within the lagoon was independent of irrigation well operations.

Since river depth and habitat connectivity within the lower river vary in response to changes in river flow it was hypothesized that passage among habitats and river connectivity would be most critical during years when river flows are lowest. The critically dry hydrologic conditions that occurred within the river in 2007 offered an opportunity to test whether habitat connectivity varies based on irrigation well operations. Results of the visual observations showed that surface water connectivity was maintained within the lower river throughout the 2007 study period.

Cross-sectional water depths and wetted channel width were measured at 11 transects in 2007 during periods when no wells were operating, one well was operating, and both wells were operating. Variation in water depth and channel wetted width was apparent at locations immediately upstream of the lagoon (PT2 and PT3) with diminishing variation at upstream passage sites (PT4 through PT11). Analysis of factors affecting water depth and channel widths at PT2 and PT3 indicated that tidal height, and the resulting backwater effects immediately upstream of the lagoon, was identified as the major factor affecting passage conditions in the lower river. Autocorrelation between tidal height, river flow, and well operations required analysis of hourly measurements of tidal elevation and river flow. Passage conditions within the lagoon were consistently above 0.6 feet (primarily greater than 2 feet) with low river flows resulting in passage conditions that did not meet the criteria at several of the locations further upstream along the reach of the river. Results of water surface elevation measurements by SGI (2008) within the lagoon showed that tidal variation during the study resulted in changes in water depths over 1.5 feet while operation of El Sur Ranch irrigation well operations were found to affect water elevation by 0.17 feet or less. These results are consistent with measurements of water depth and channel wetted width during the 2007 study indicating the effects of tidal conditions on river stage, particularly at the locations immediately upstream of the lagoon under the critical water flow conditions within the river during the study.

Juvenile steelhead were observed inhabiting the lower river in 2007 with the greatest densities in the lower portion of the river and lagoon where habitat conditions (pool depth, cover, etc.) appeared to be most suitable. A total of 380 steelhead, including young-of-the-year and yearlings (demonstrating successful spawning and egg incubation in the river) and one adult were observed in the study reach. The juvenile steelhead all appeared to be healthy and in good condition with those fish inhabiting the lagoon area showing evidence of smolting in preparation for migration to the ocean. These observations are significant in showing that despite the critically low flows that occurred in the river in 2007, localized areas of depressed dissolved oxygen, effects of upstream diversions and water use, and operation of the El Sur Ranch irrigation wells steelhead and other fish species typical of a coastal tributary fish assemblage were able to experience successful rearing within the lower river. As a result of the critical hydrologic conditions that were observed in September 2007, naturally occurring habitat conditions for juvenile steelhead rearing were at or near worst possible conditions. There was no evidence from the 2004, 2006, or 2007 studies that indicated that El Sur Ranch irrigation well operations were a limiting factor affecting the ability of juvenile steelhead to successfully rear within the lower reaches of the Big Sur River.

As part of the 2004, 2006, and 2007 studies observations and periodic measurements were made within Swiss Canyon to assess the potential effects of irrigation well operations on surface water within the canyon. It was hypothesized that runoff from the pastures was passing into Swiss Canyon causing erosion across the ocean beach from the ephemeral stream during and after irrigation events. To test this hypothesis in 2007, a series of three transects were established within Swiss Canyon and measurements were made of cross-sectional water depths periodically during the study to coincide with periods when the irrigation wells were not in service, one well was operating, and both wells were operating. It was expected that if irrigation was a major source of water within Swiss Canyon it would be apparent under the dry 2007 conditions and that surface water flows would be observed throughout the canyon which is immediately adjacent to the pastures bisected by Swiss

Canyon and that channel depth in the creek would increase in response to irrigation of the pastures and decrease when no irrigation was occurring.

No surface water was apparent in Swiss Canyon at either the upstream (near the Highway 1 culvert) or mid-point monitoring locations during any of the 2007 surveys. Surface water was always present at the downstream monitoring location during the 2007 survey. The depth of surface water at the downstream location was independent of irrigation well operations (no statically significant difference ($P>0.05$) was detected in average water depths between periods when the irrigation pumps were on and off). Results of these surveys indicate that Swiss Canyon has a limited water supply source during critically dry years in the lower reaches (e.g., groundwater, spring, etc.) with surface water entering the canyon from the upstream drainage area during periods of precipitation and runoff. These results do not support the hypothesis that water from pasture irrigation is supporting surface waters within the creek (the upper two locations were consistently dry irrespective of pasture irrigation). These observations also show that under the critically dry conditions that occurred in 2007 aquatic habitat remained in the lower reaches of Swiss Canyon and continued to support amphibians and other species. Results of the 2007 study provided no evidence to suggest that El Sur Ranch irrigation practices were an important factor affecting habitat or surface waters within Swiss Canyon in 2007.

5.0 References

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6.0 Acronyms & Glossary

ACRONYMS & ABBREVIATIONS

cfs	cubic-foot-per-second
°C	Degrees Celsius
CDFG	California Department of Fish and Game
CPUE	catch-per-unit effort
DO	dissolved oxygen
EC	electrical conductivity
ESA	Endangered Species Act, *or* Environmentally Sensitive Area.
ESU	Evolutionarily Significant Unit
°F	Degrees Fahrenheit
GPS	global positioning system/satellite
LSMEANS	least-square estimates of the marginal means of the main effect
LWD	large woody debris
m	meters
mg/L	milligrams per liter
mm	millimeters
PT	passage transect
SGI	Source Group, Inc.
uS/cm	microsemens
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VT	velocity transect

GLOSSARY

Abundance: The total number of fish in a population, stock, or other group. Can be measured in absolute or relative terms and may be number per area or per unit fishing effort.

Adult: A sexually mature animal; a fish that has reached the length or age of first maturity.

Anadromous: Fish that migrate from saltwater to fresh water to spawn.

Barrier: An environment or physical structure that prohibits fish migration or movement among habitats.

Biological Monitoring: Collection of organisms and/or measurement of environmental parameters affecting species abundance, distribution, or habitat.

Breaching: Opening of the mouth of a lagoon or waves overtopping a sandbar.

Catch: The total number or poundage of fish captured from an area over some period of time. This includes fish that are caught but released or discarded instead of being landed. The catch may take place in an area different from where the fish are landed.

Cfs: Cubic feet per second; a measure of water velocity.

Cover: Natural items such as weeds, logs, overhanging banks, boulders, roots, etc. providing shelter for fishes.

Discharge: Flow of surface water in a stream or canal or the outflow of ground water from a flowing artesian well, ditch, or spring.

Dissolved Oxygen (DO): The oxygen freely available in water, vital to fish and other aquatic life for respiration.

Disturbance: Any event or series of events that disrupt an ecosystem, community, or population or alters the physical environment.

Diversion: The removal of water from a stream flow as water supply.

Diversion Rate:	The percentage of waste materials diverted from traditional disposal such as landfilling or incineration to be recycled, composted, or re-used.
Electrical Conductivity:	Ability of water to conduct an electrical current, a measure of salinity.
Endangered Species:	A species of animal identified by official federal and/or state agencies as being faced with the danger of extinction.
Environment:	The sum of all external conditions and influences affecting the development and life of organisms.
Evapotranspiration:	The loss of water from the soil both or waterbody by evaporation and by transpiration from the plants growing in the soil.
Flow:	The movement of water in a river or stream channel or through a sand or gravel substrate.
Fry:	A young fish at the post-larval stage. May include all fish stages from hatching to fingerling. An advanced fry is any young fish from the start of exogenous feeding after the yolk is absorbed while a sac fry is from hatching to yolk sac absorption. In *Salmonidae* the stage from end of dependence on the yolk sac as the primary source of nutrition to dispersal from the redd.
Ground Water:	Subsurface water occupying the saturated zone.
Habitat:	The place where a population (e.g. human, animal, plant, microorganism) lives and its surroundings, both living and non-living.
Hydrology:	Science that deals with the waters above and below the land surfaces of the Earth, their occurrence, circulation and distribution, both in time and space, their biological, chemical and physical properties, their reaction with their environment, including their relation to living beings.
Juvenile:	A young or sexually immature animal.
Lagoon:	Shallow body of water, often separated from the sea by coral reefs or sandbars.
Length Frequency:	A breakdown of the different lengths of a kind of fish in a population or sample.

Risk: A measure of the probability that damage to life, health, property, and/or the environment will occur as a result of a given hazard.

Salinity: The percentage of salt in water.

Salt Marsh: An area where salt water from an ocean, bay, or gulf meets fresh water from a river and salt-tolerant plants grow.

Sampling Frequency: The interval between the collection of successive samples.

Sedimentation: Deposition of material suspended in a stream system, whether in suspension (suspended load) or on the bottom (bed load).

Sensitive Species: Plant or animal species which are endangered species, or candidate species, protected bird species under endangered species laws and regulations, plant protection laws and regulations, California Department of Fish and Game codes, or species of special concern listings and policies, or species recognized by national, state, or local environmental organizations.

Spawning: Laying (and fertilizing) eggs in the process of reproduction.

Streamflow: General term for water flowing in a stream or river channel.

Substrate: Bottom materials: large boulders (>1024 mm), small boulders (256-1024 mm), stone (256-600 mm), rubble or large cobble (128-256 mm), cobble or small cobble (64-128 mm), pebble (2-64 mm), coarse gravel (32-64 mm), fine gravel (2-32 mm), sand (0.062-2.0 mm), silt (0.004-0.062) and clay (<0.004).

Summer-Run: Anadromous fish that migrate to fresh water in summer, overwinter there and spawn in spring.

Surf: Wave activity between the shore line and the outermost limit of breakers; a habitat for certain fishes.

Surface Water: All water naturally open to the atmosphere (rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc.)

Survival Rate: Number of fish alive after a specified time interval, divided by the initial number. Usually on a yearly basis.

Transect: A line on the ground along which sample plots or points are established for collecting vegetation, water quality, water depth and velocity data and in many cases, soil and hydrology data as well.

Velocity: The speed that water moves downstream.

Velocity Transect: A line on the ground along which sample plots or points are established for collecting measurements of water velocity.

Water Quality: The measurement of various constituent concentrations, such as salts, dissolved oxygen, or other parameters within a body of water.

Well Monitoring: Measurement by on-site instruments or laboratory methods of well water quality.

FIGURES

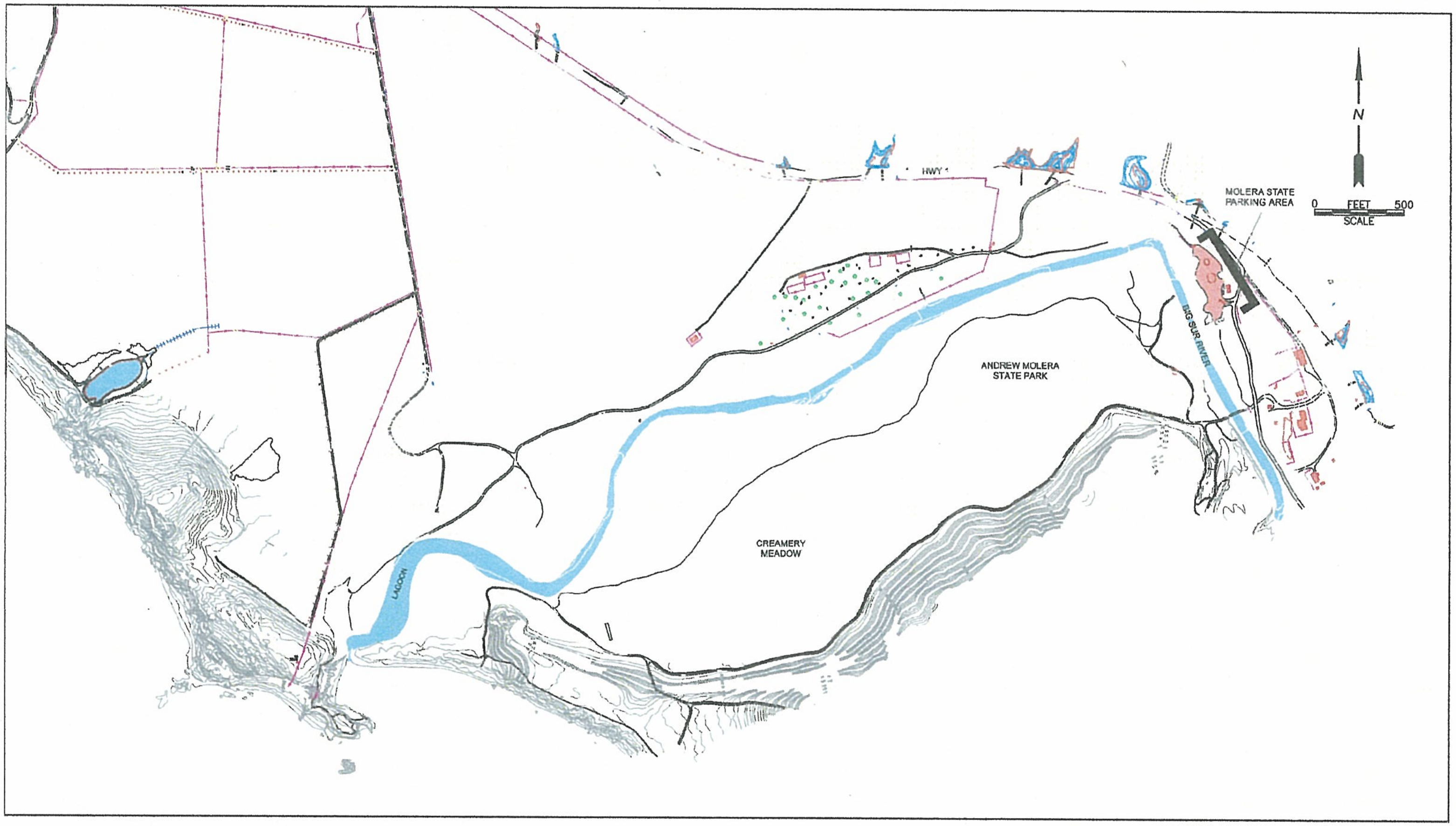

FIGURE 1. The lower Big Sur River and surrounding area.

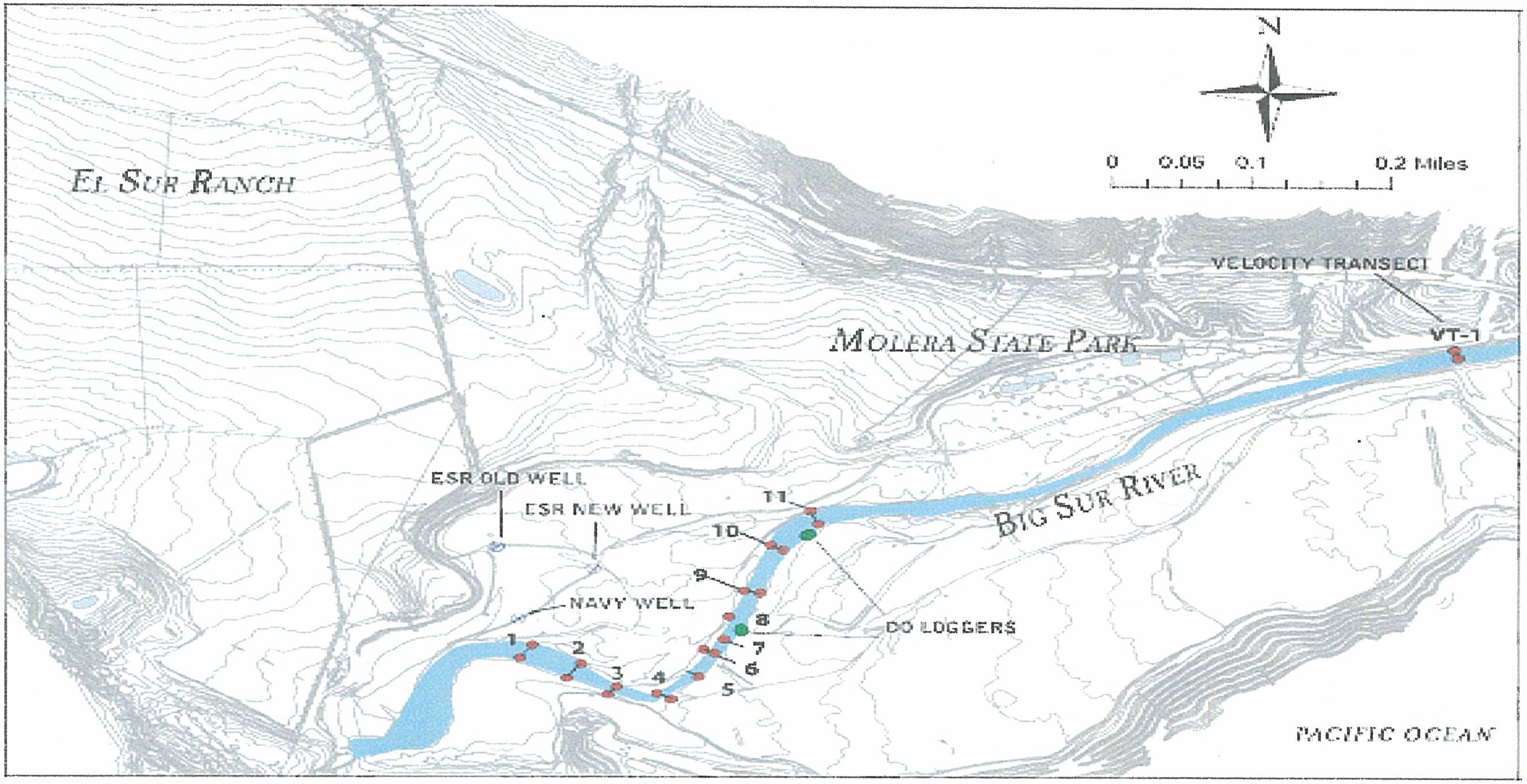

FIGURE 2. Velocity transects monitored during the 2007 study period.

FIGURE 3. Subreach locations for snorkel surveys conducted on the Big Sur River, CA. Upper subreach boundaries are shown with the subreach letter.

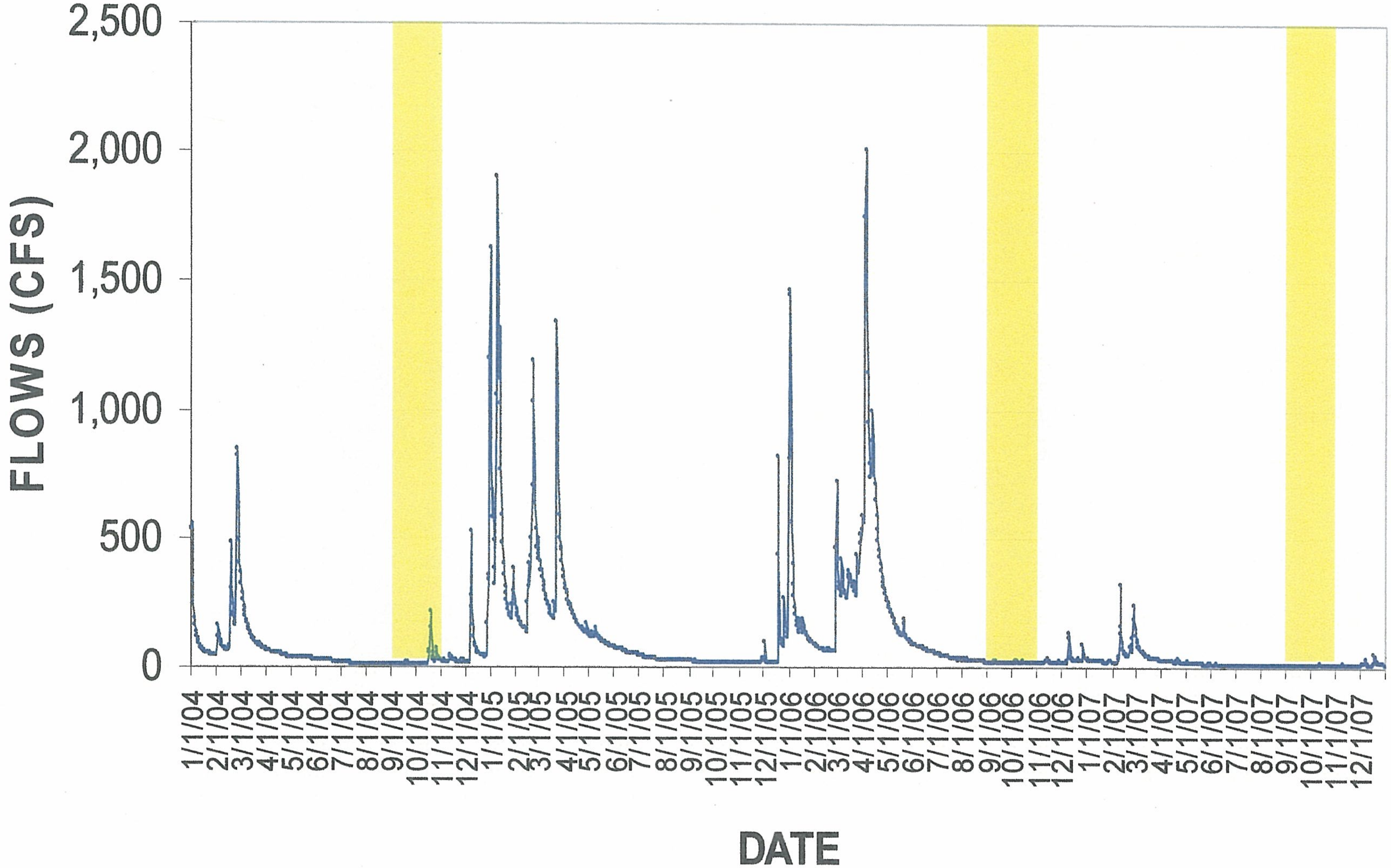

FIGURE 4. USGS Big Sur River gauging of daily flows on the Big Sur River (yellow bars indicate the 2004, 2006, and 2007 study periods) (source: USGS 2008).

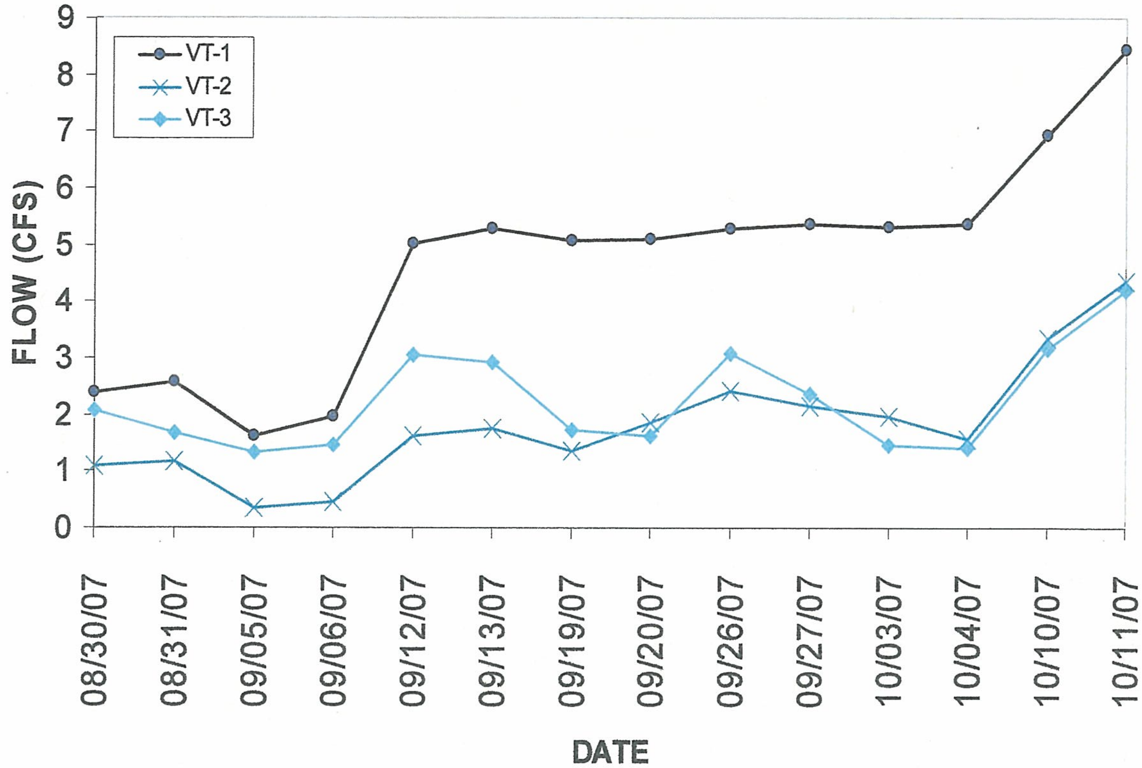

FIGURE 5. Flows (cfs) measured at VT-1, VT-2, and VT-3, August 30 – October 10, 2007 (Source: SGI 2008).

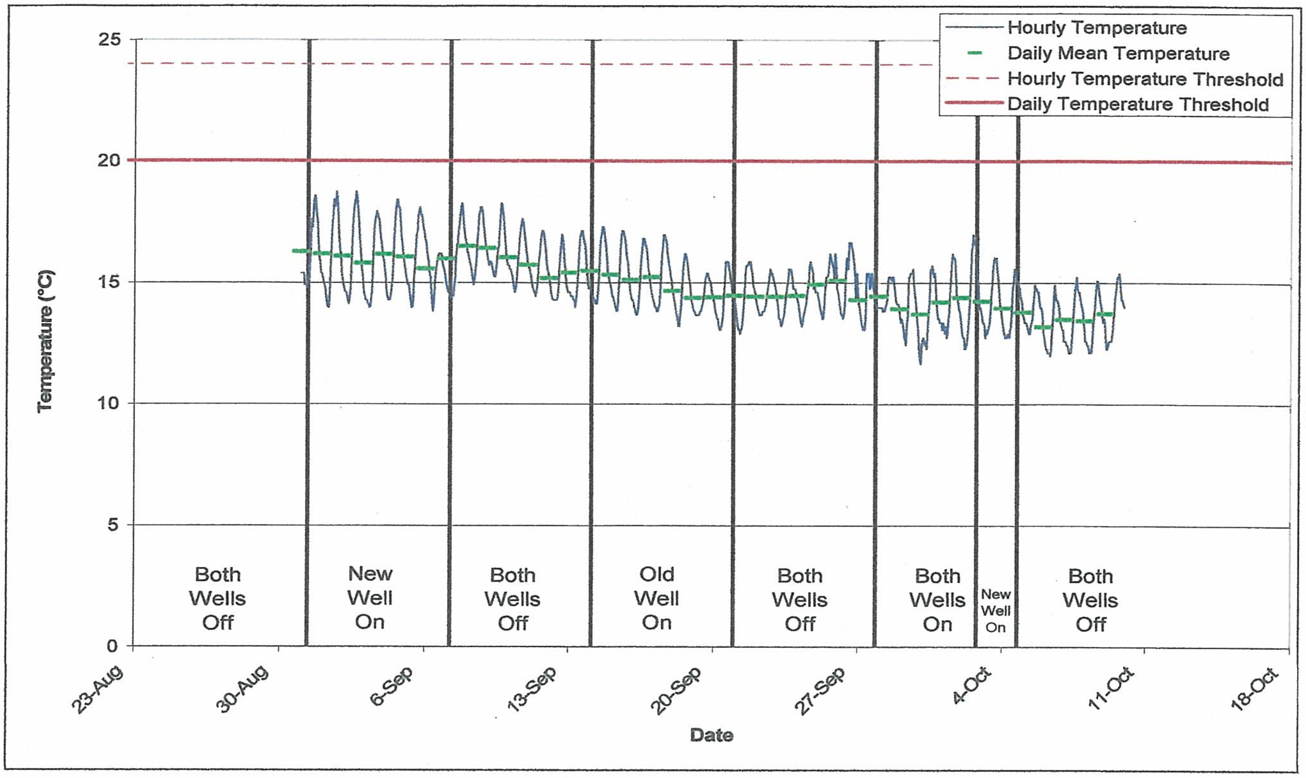

FIGURE 6. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 1, right bank.

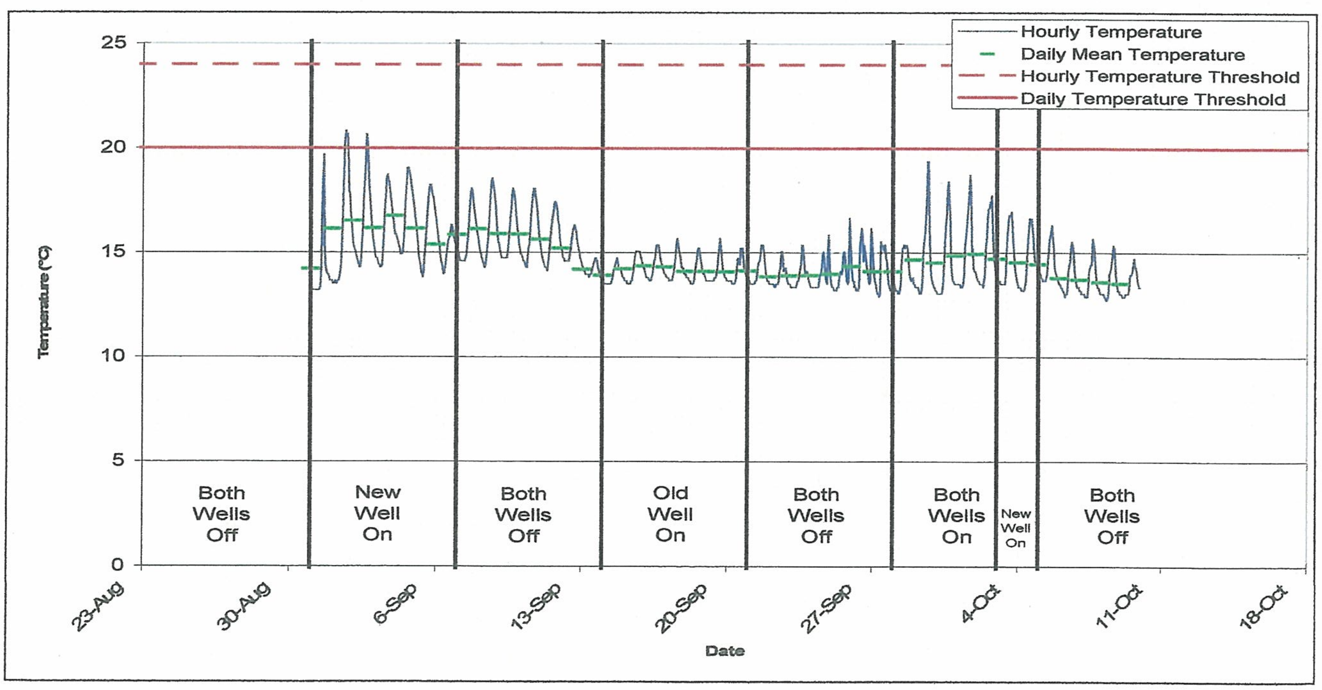

FIGURE 7. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 1, left bank.

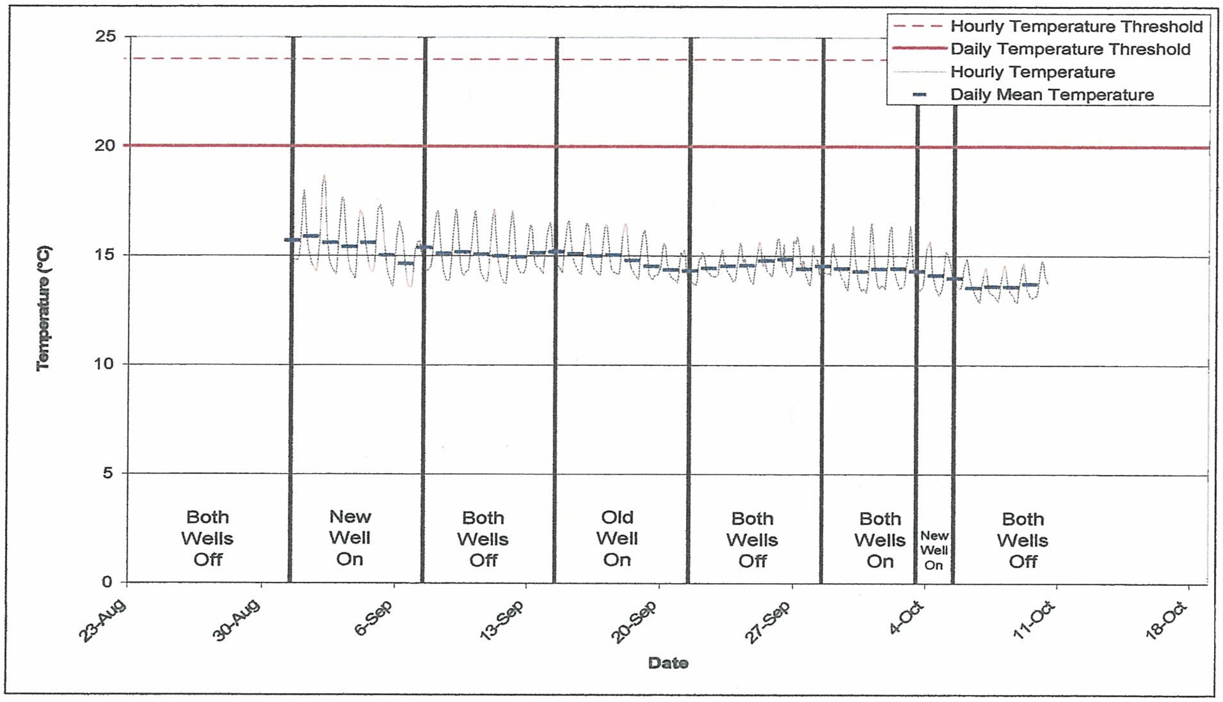

FIGURE 8. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at piezometer pair 1, left bank.

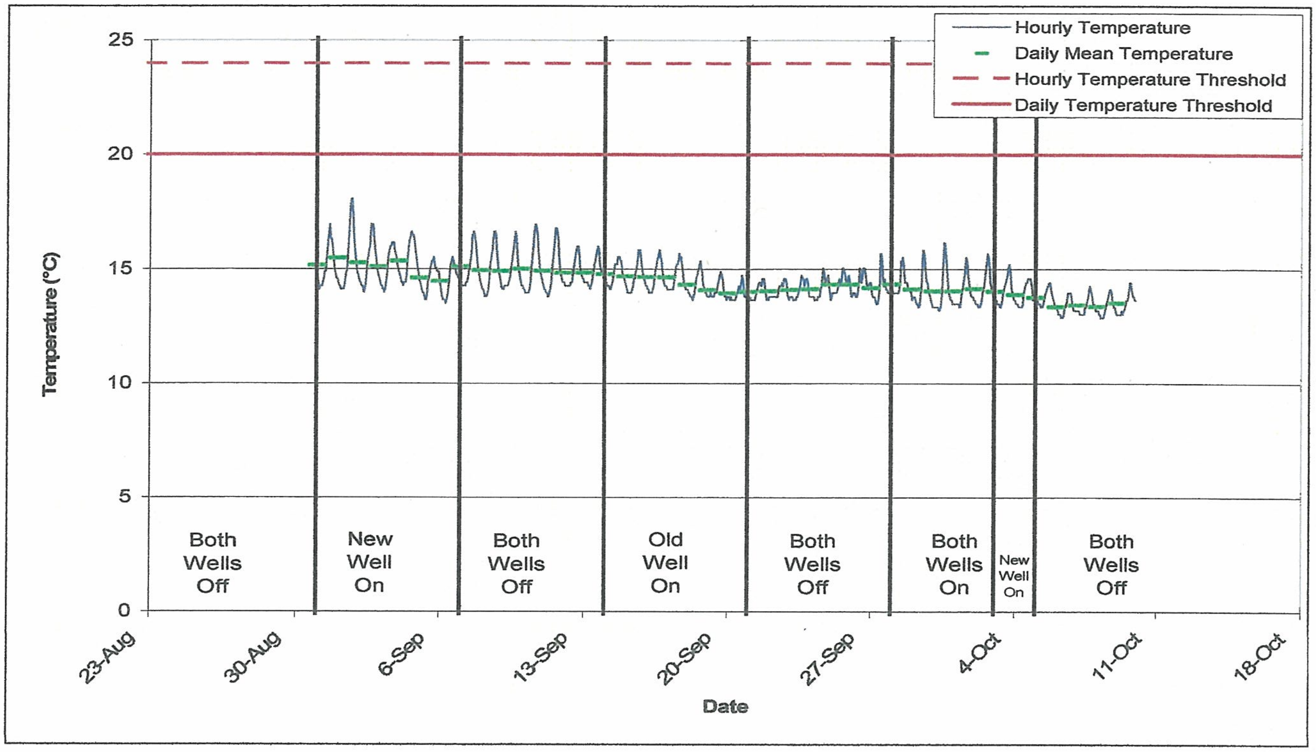

FIGURE 9. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 2, right bank.

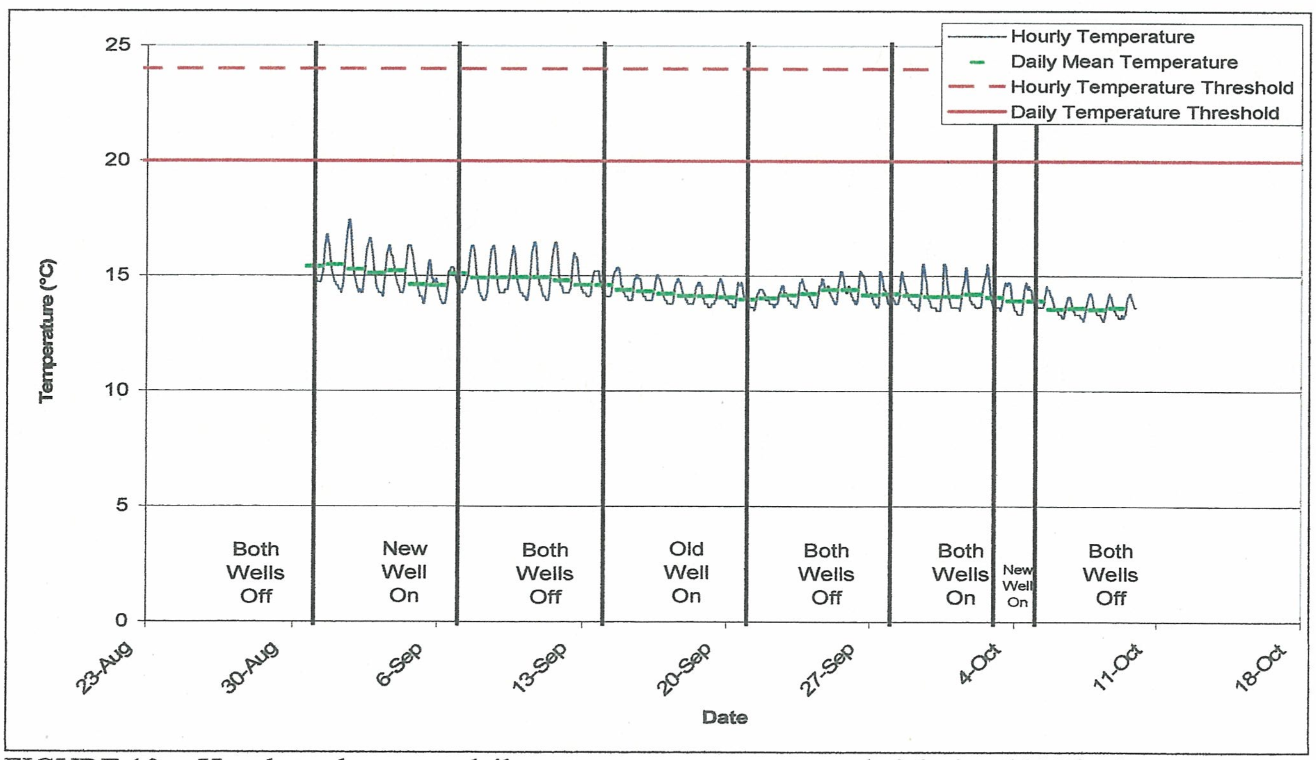

FIGURE 10. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 2, left bank.

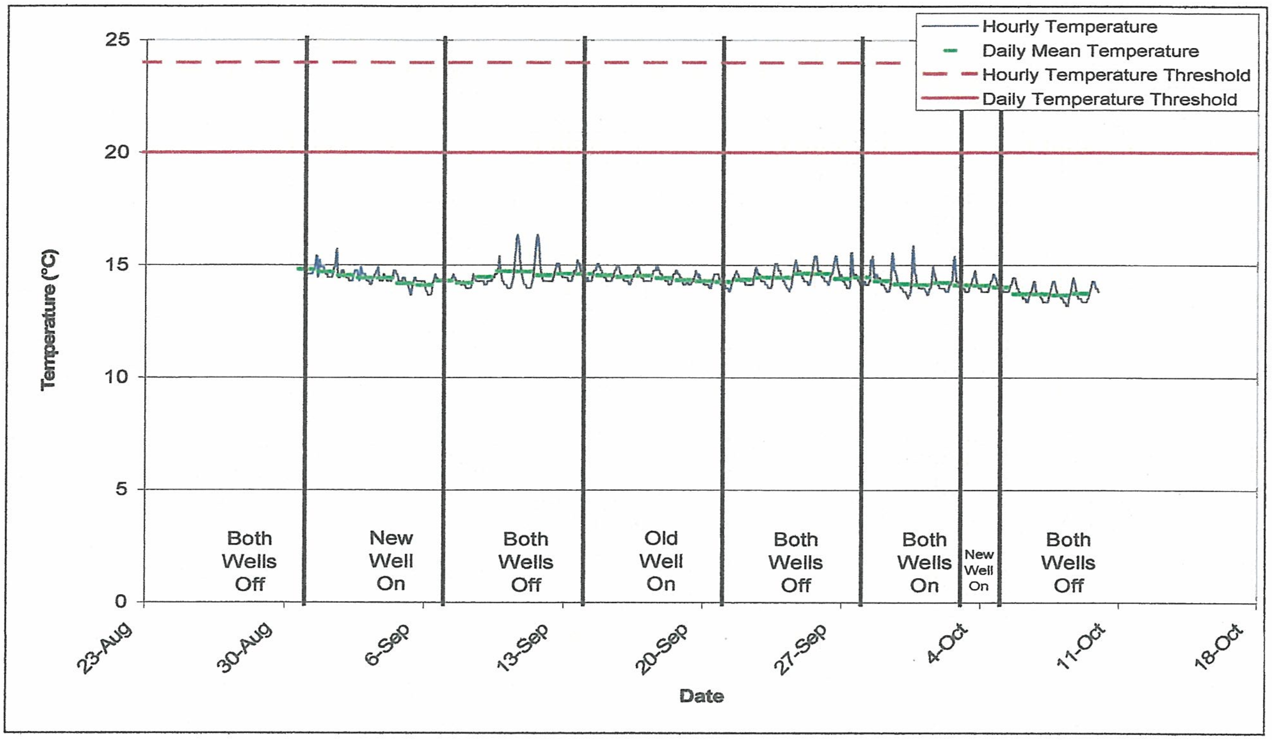

FIGURE 11. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 3, right bank.

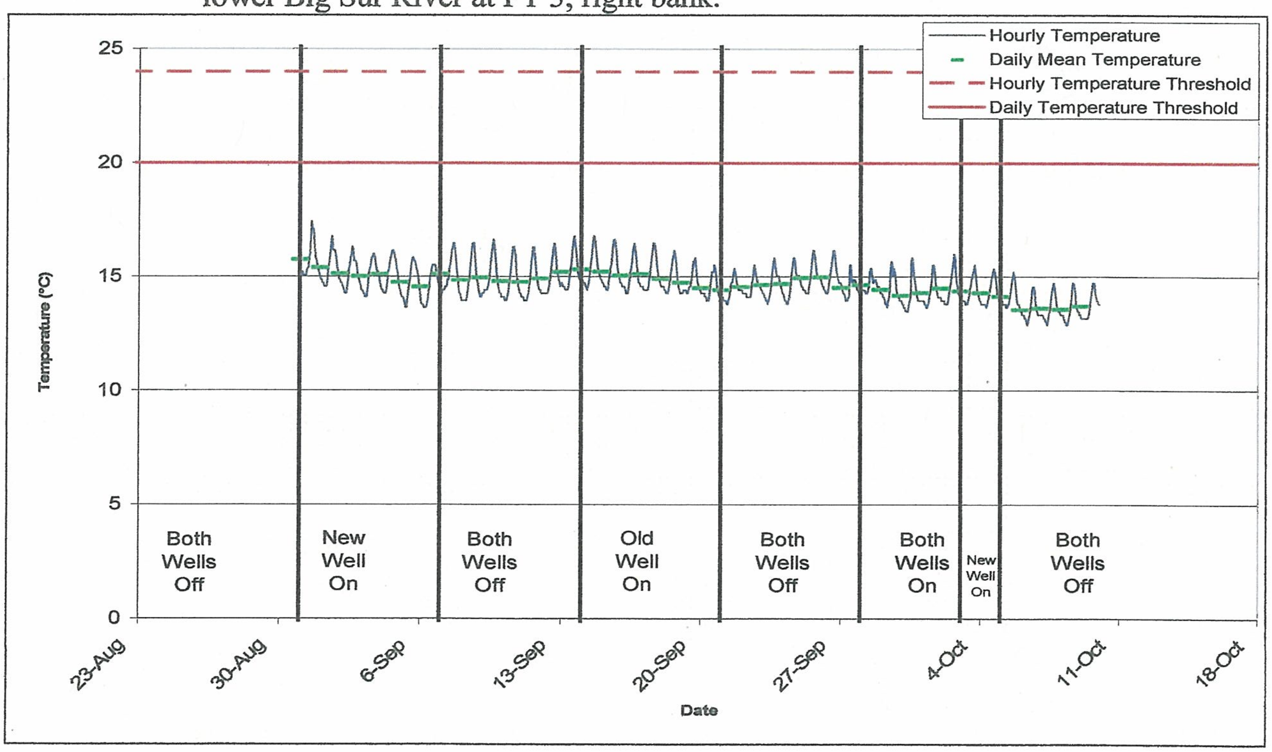

FIGURE 12. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 3, left bank.

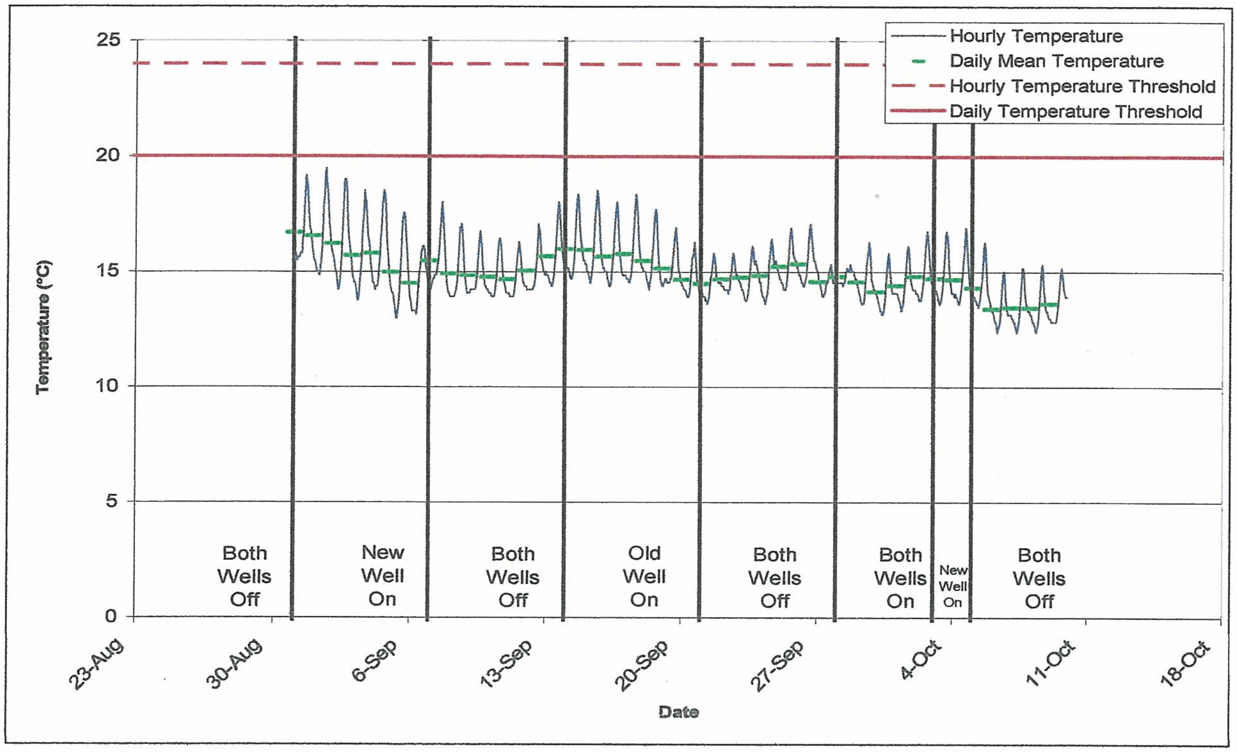

FIGURE 13. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 4, right bank.

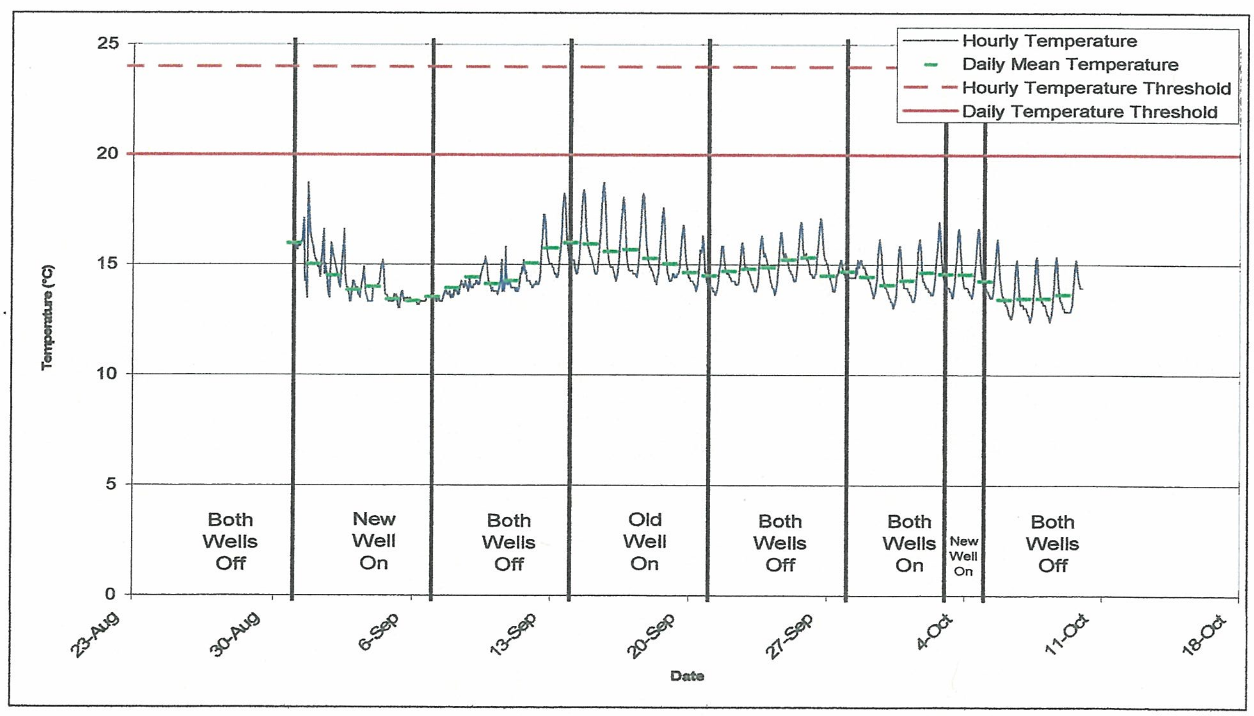

FIGURE 14. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 4, left bank.

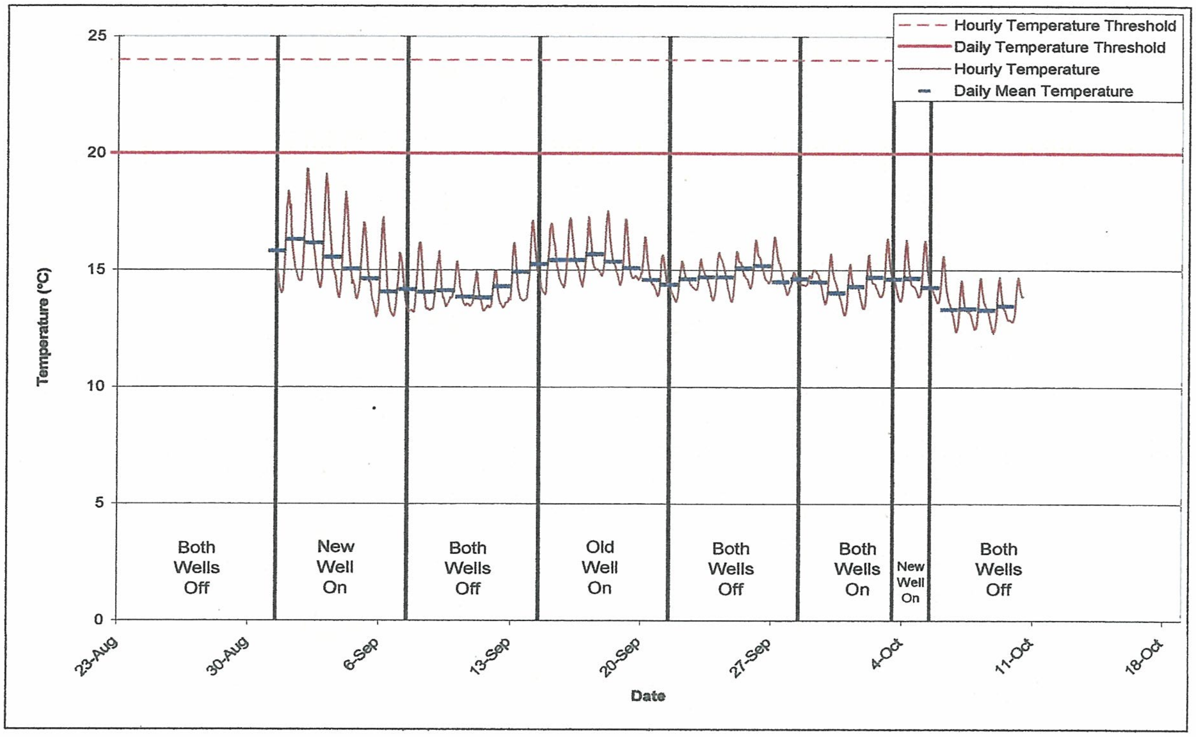

FIGURE 15. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at piezometer pair 2, right bank.

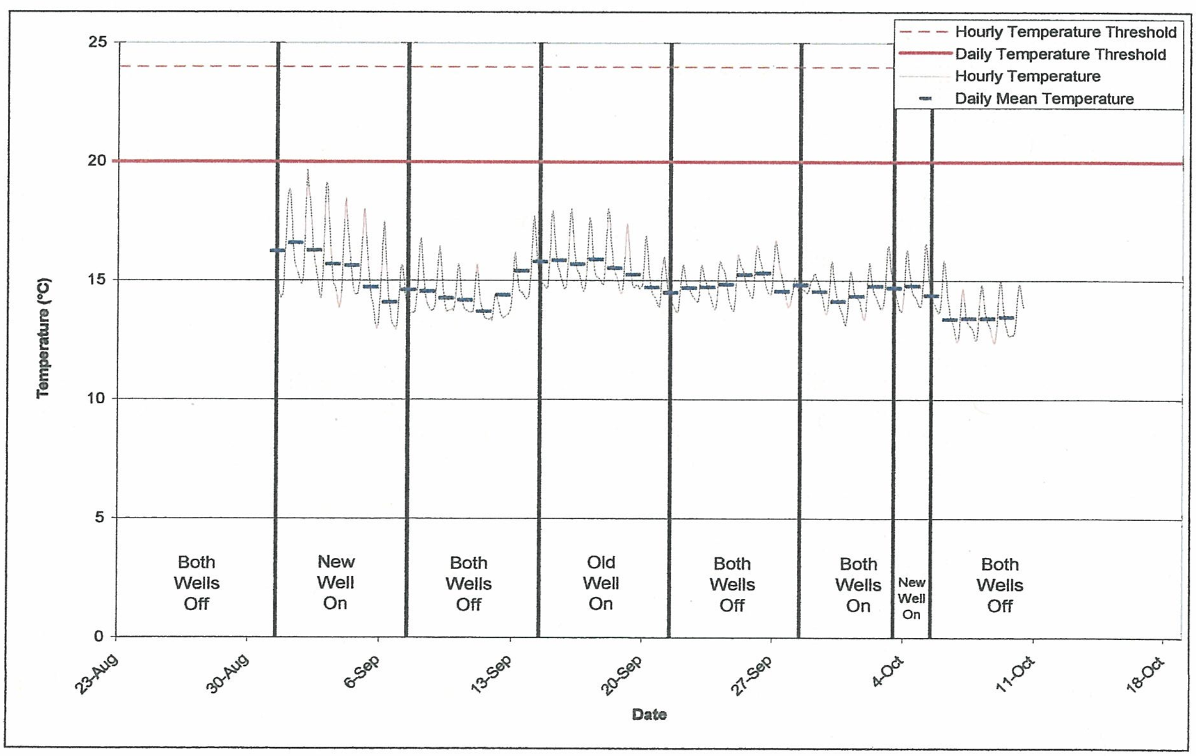

FIGURE 16. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at piezometer pair 2, left bank.

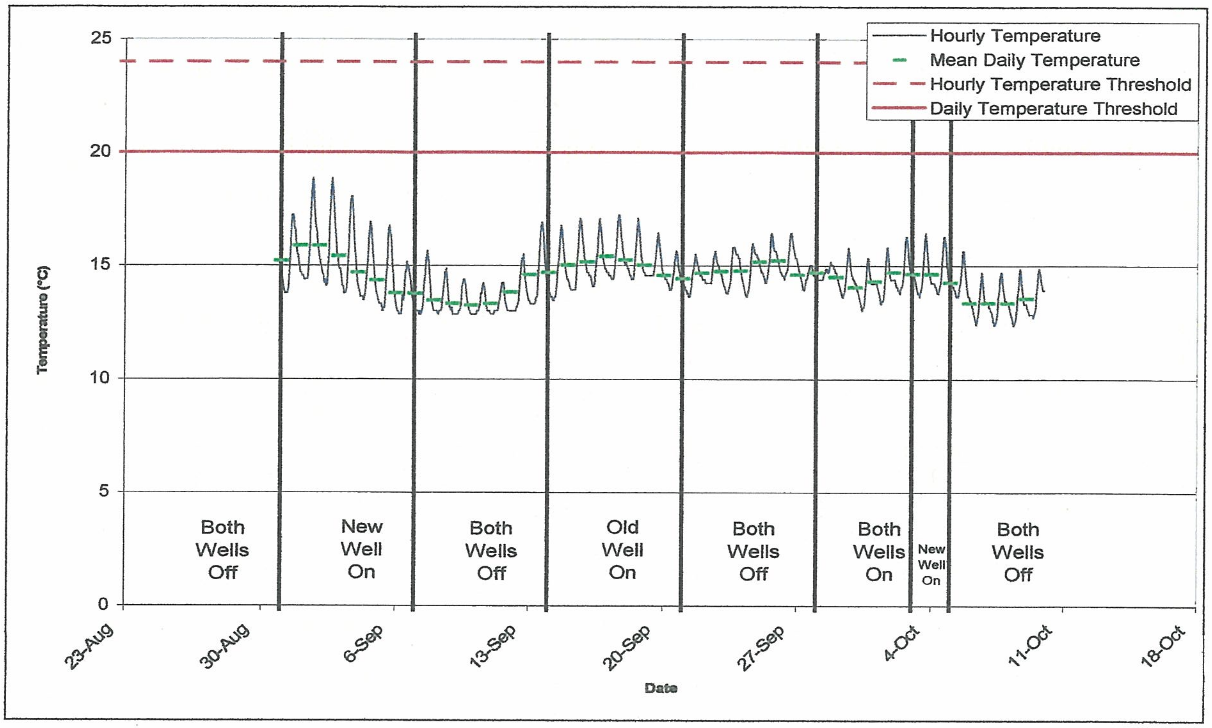

FIGURE 17. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 5, right bank.

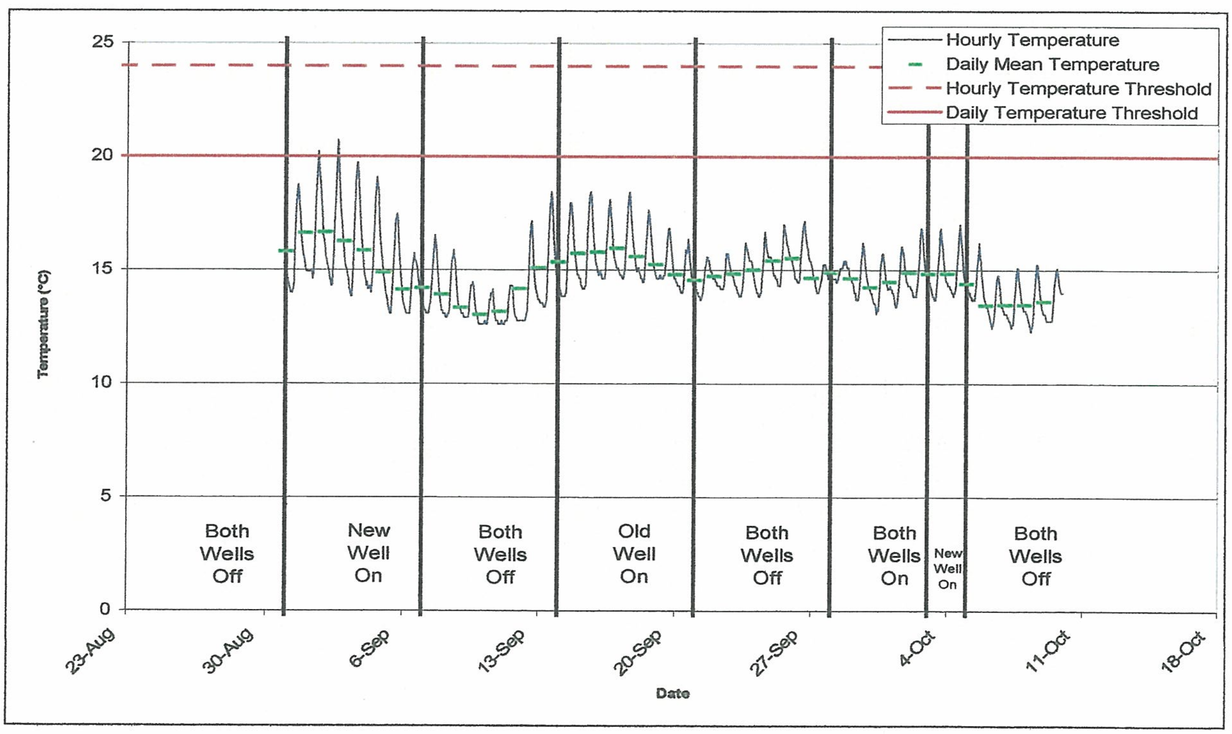

FIGURE 18. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 5, left bank.

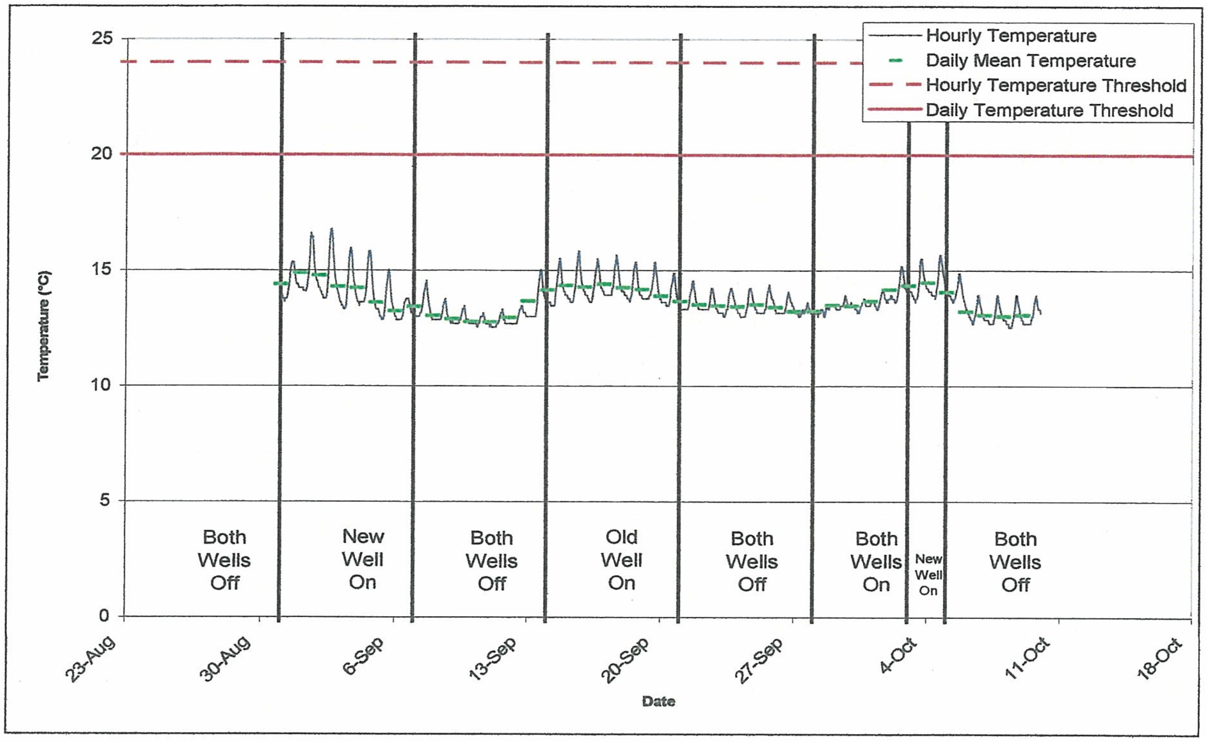

FIGURE 19. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 6, right bank.

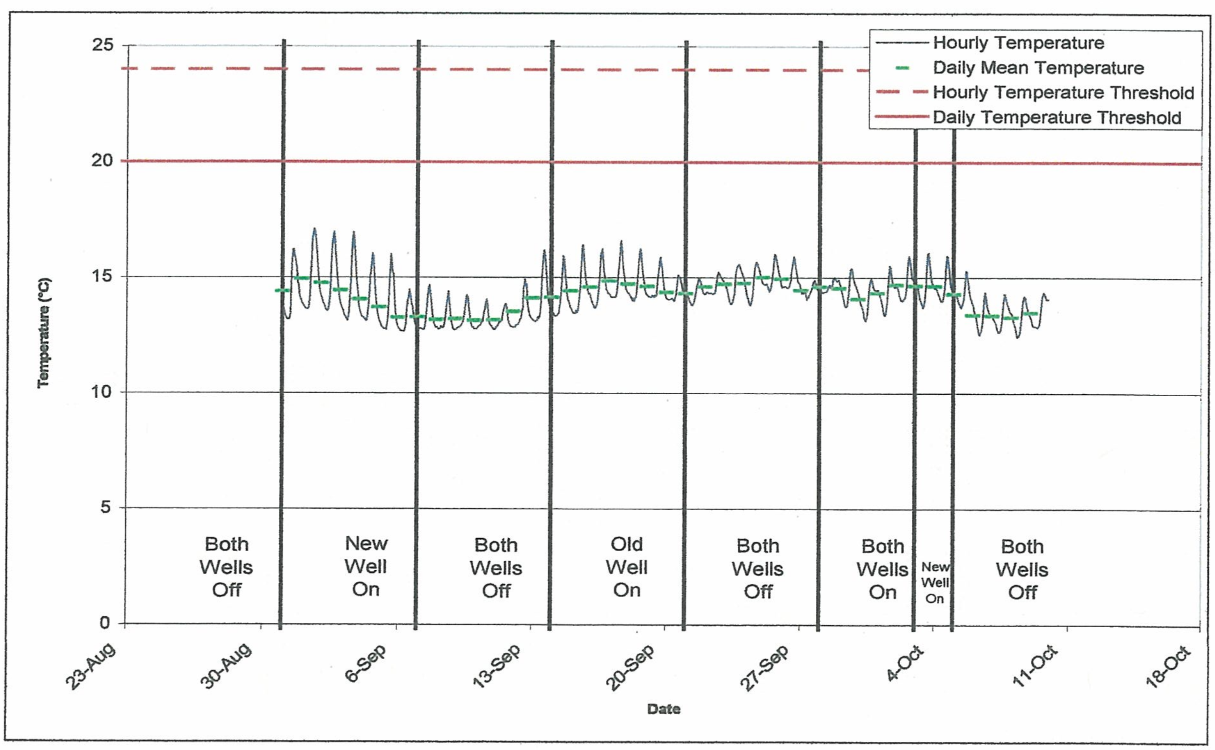

FIGURE 20. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 6, left bank.

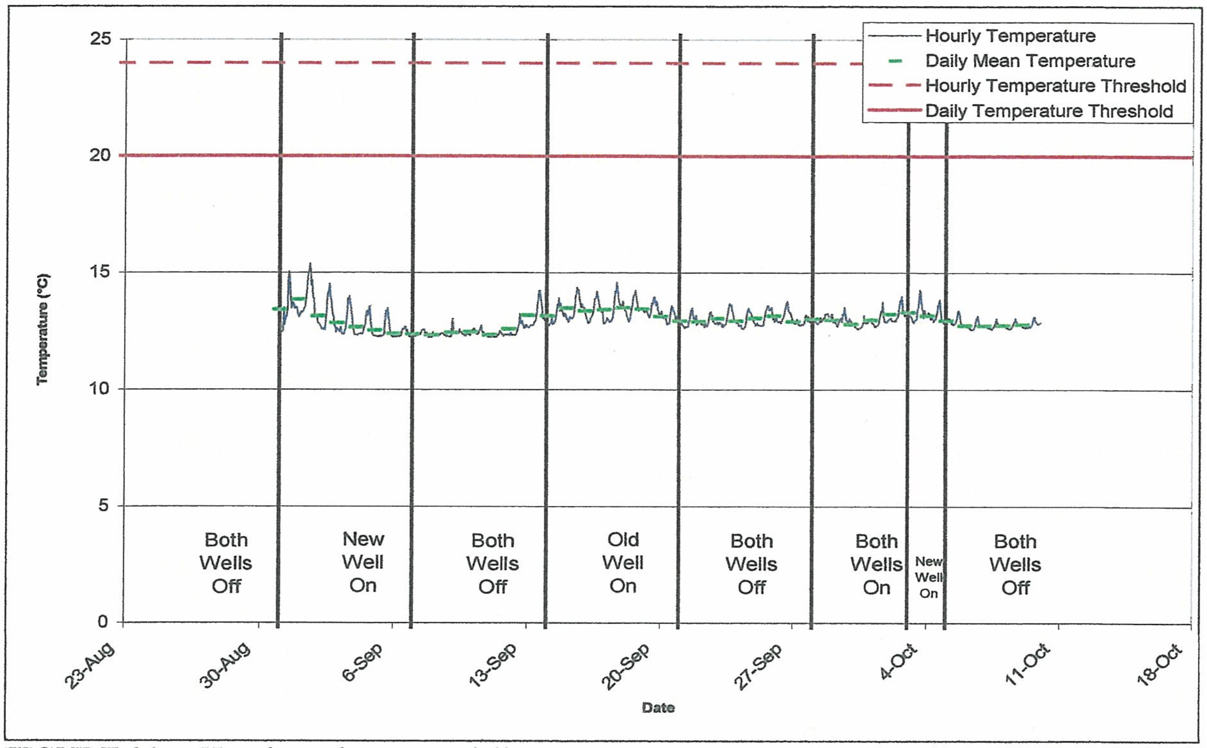

FIGURE 21. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 7, right bank.

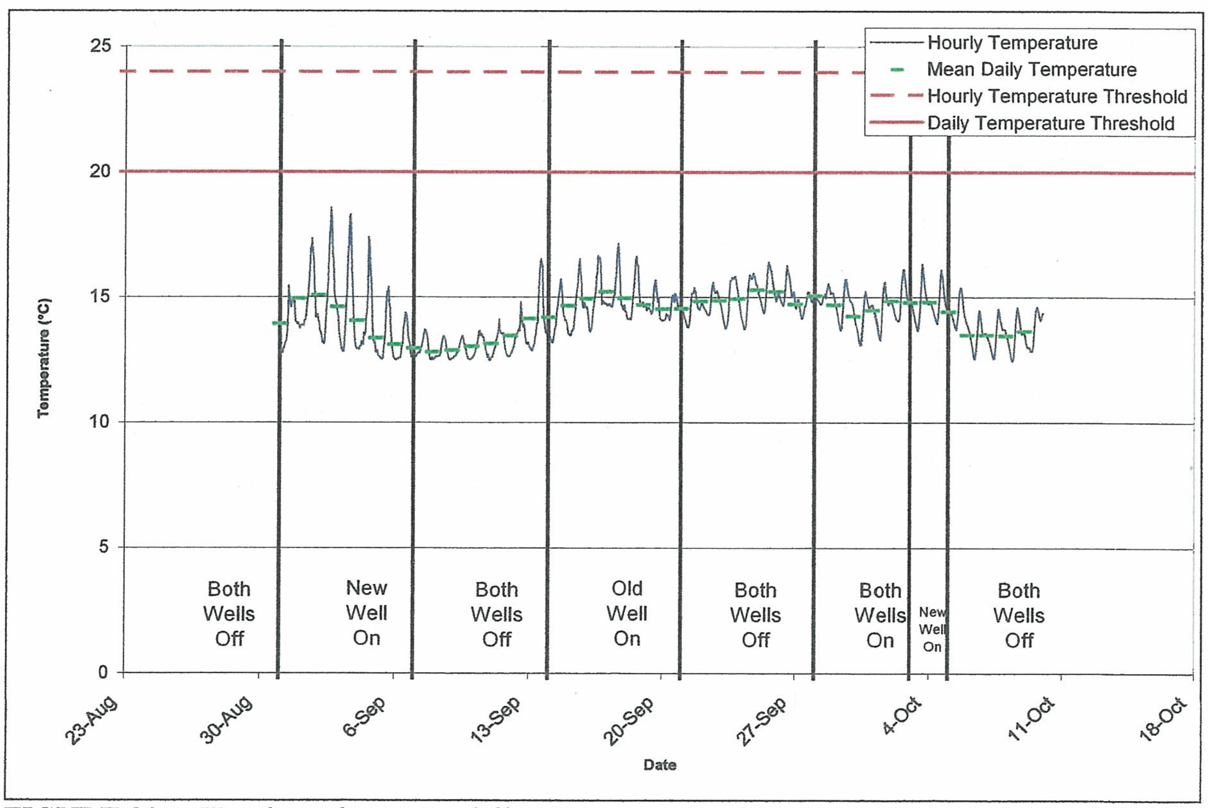

FIGURE 22. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 7, left bank.

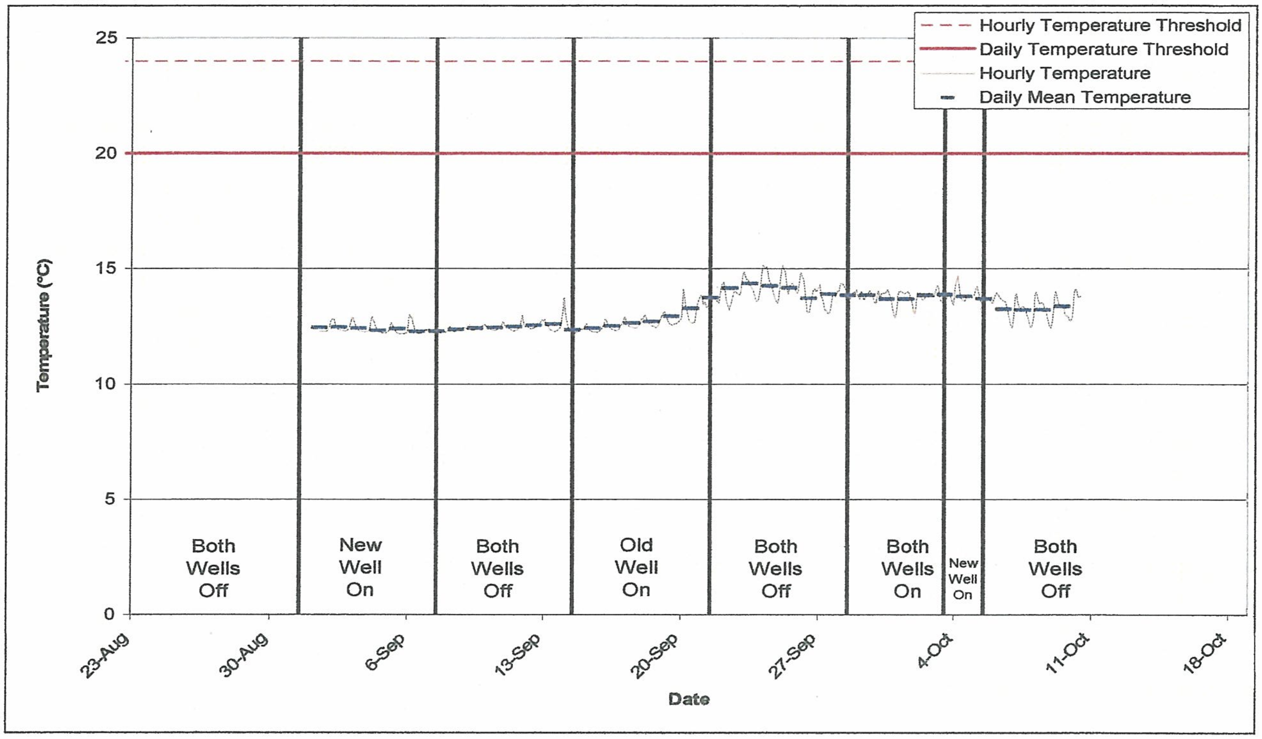

FIGURE 23. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at piezometer pair 3, right bank.

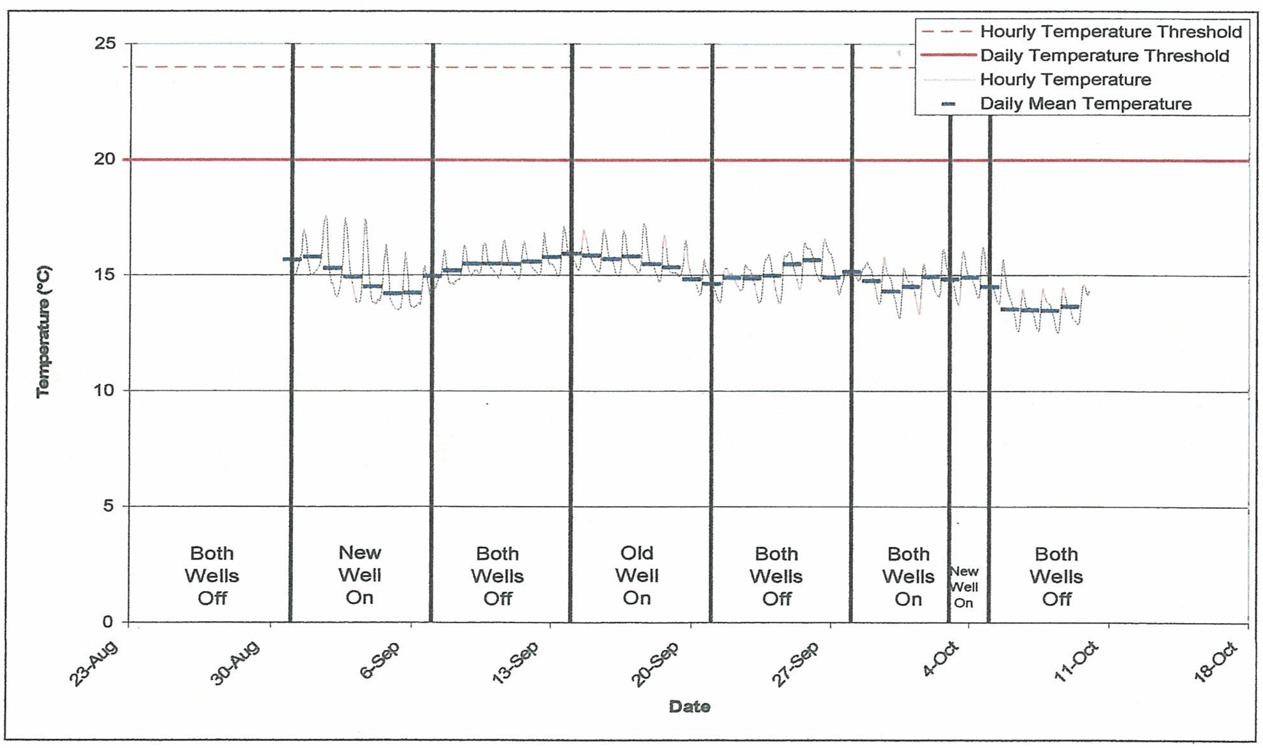

FIGURE 24. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at piezometer pair 3, left bank.

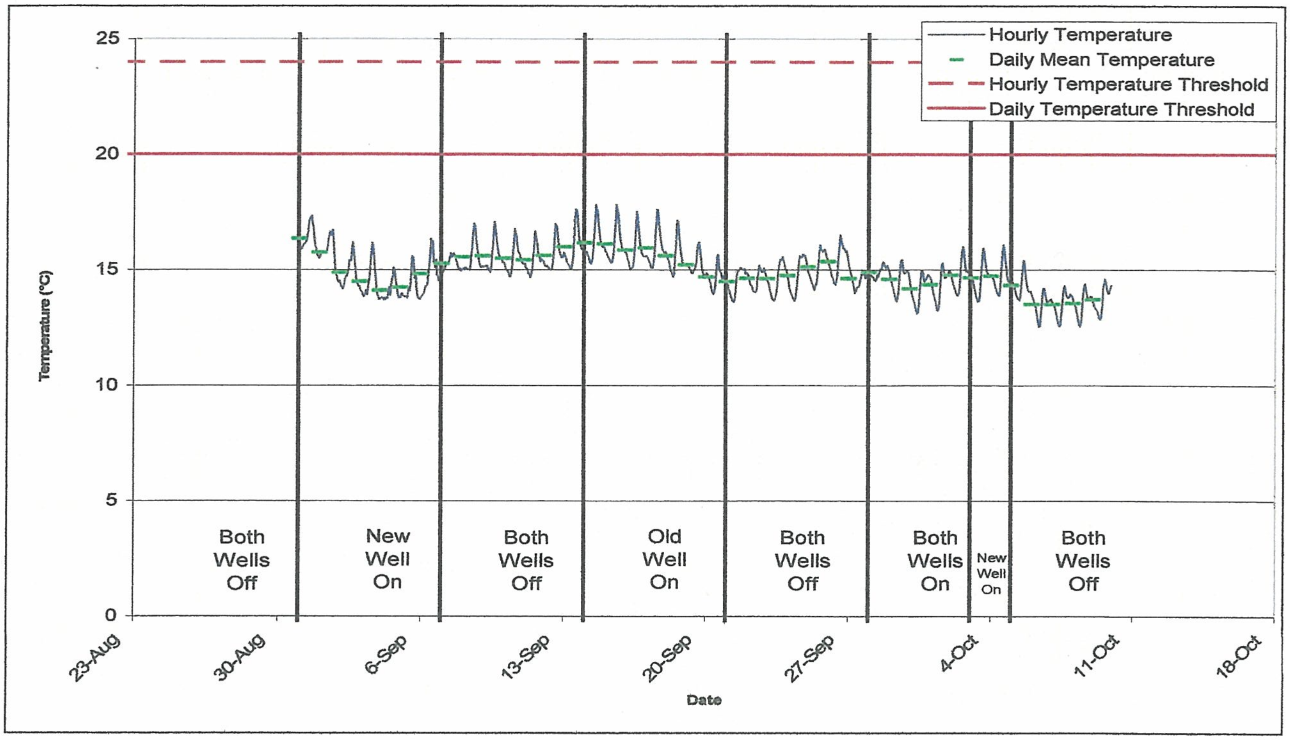

FIGURE 25. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 8, right bank.

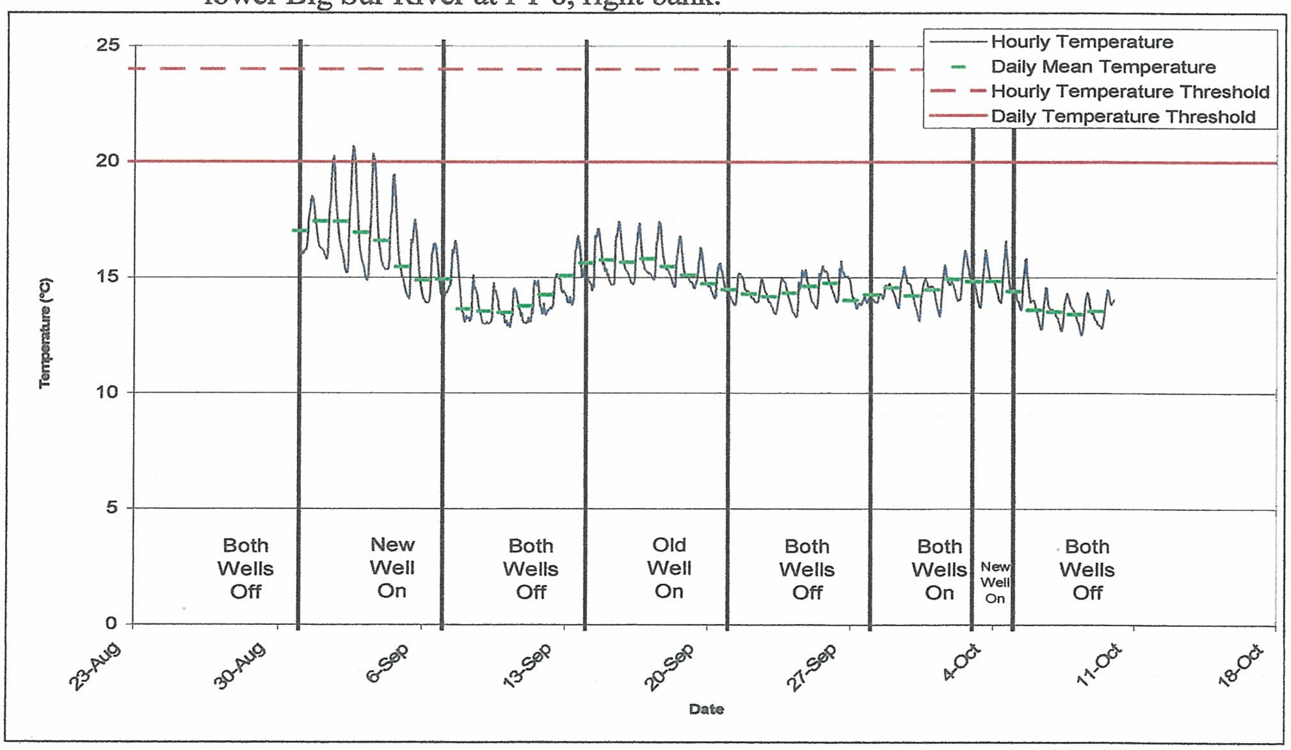

FIGURE 26. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 8, left bank.

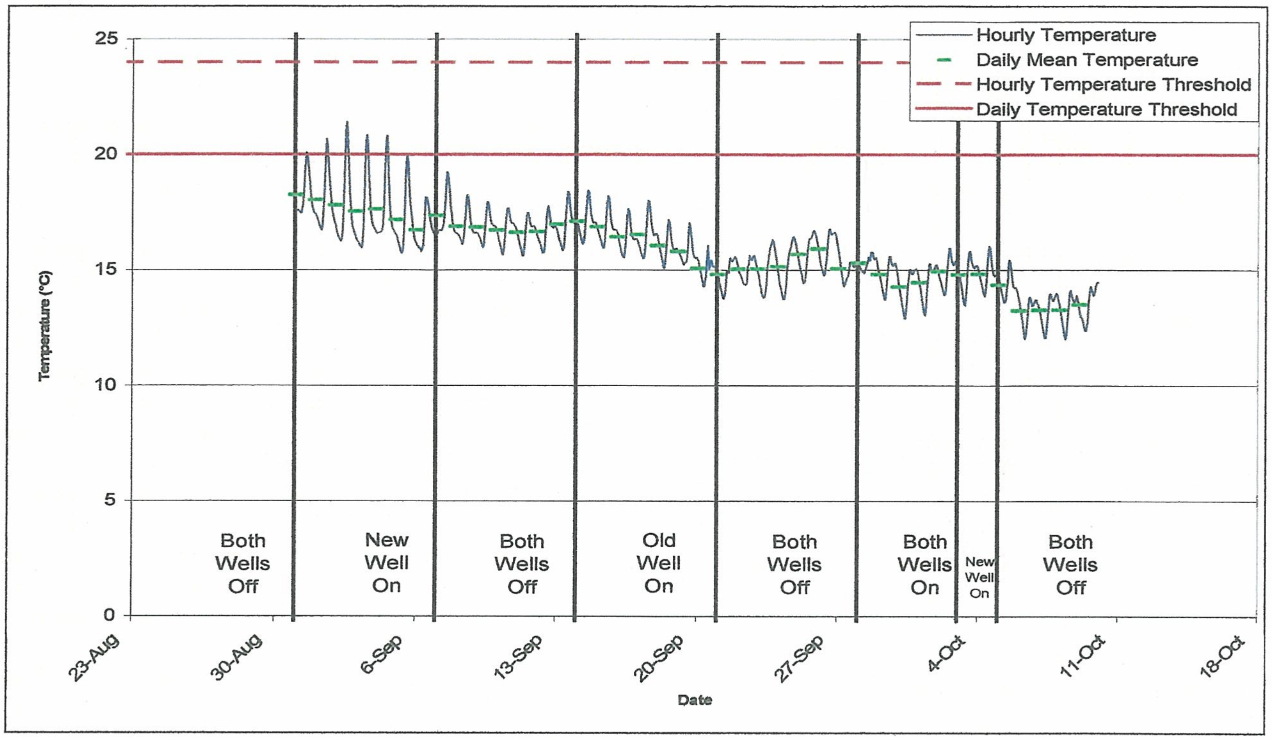

FIGURE 27. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 9, right bank.

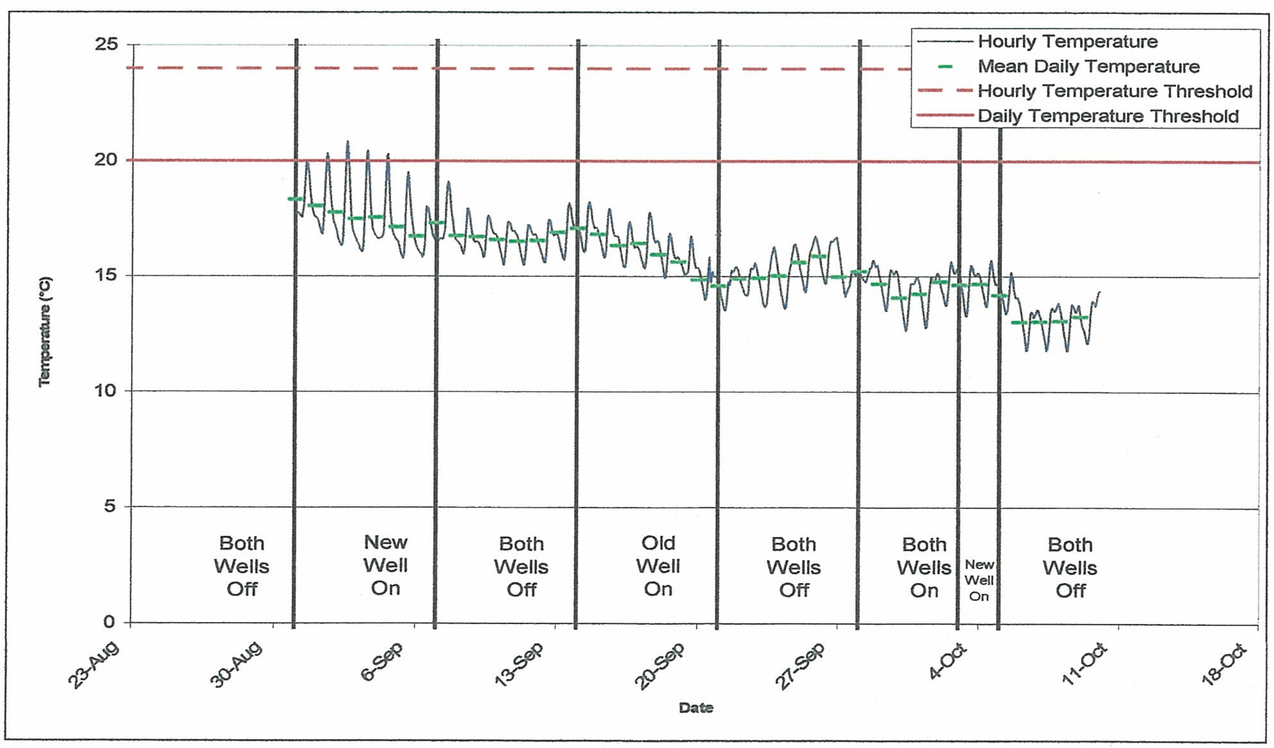

FIGURE 27. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 9, left bank.

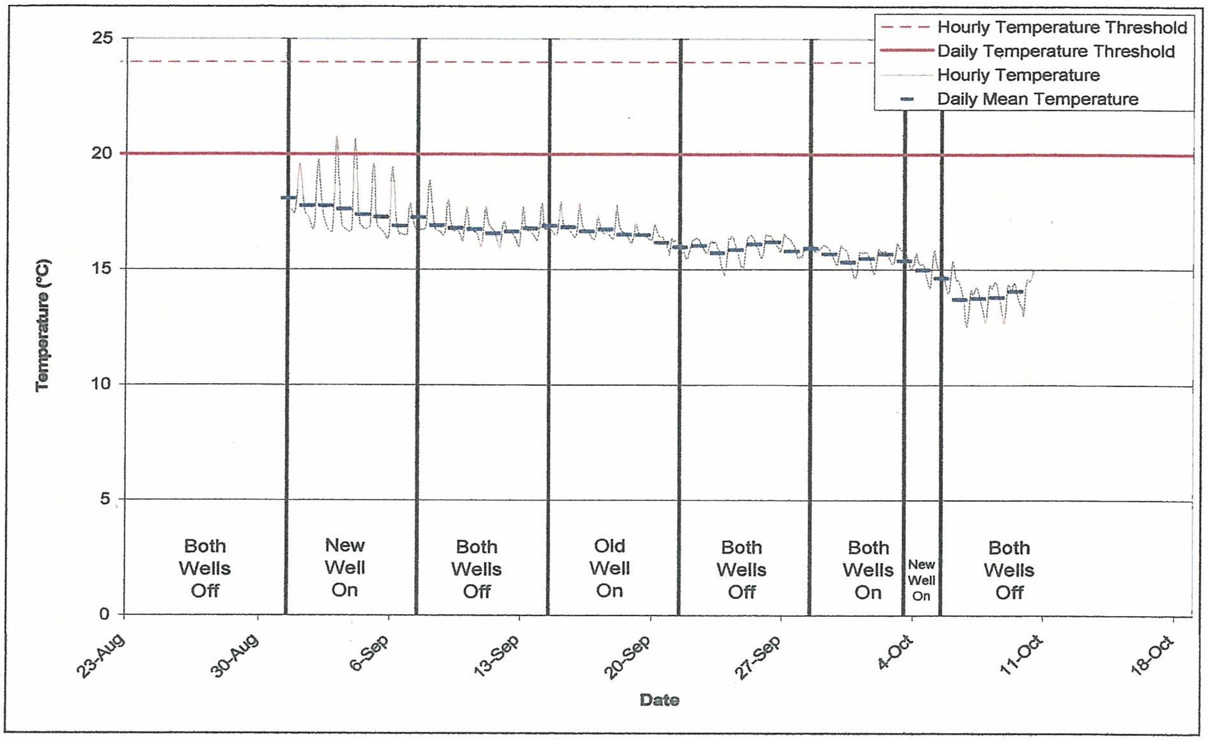

FIGURE 28. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at piezometer pair 4, right bank.

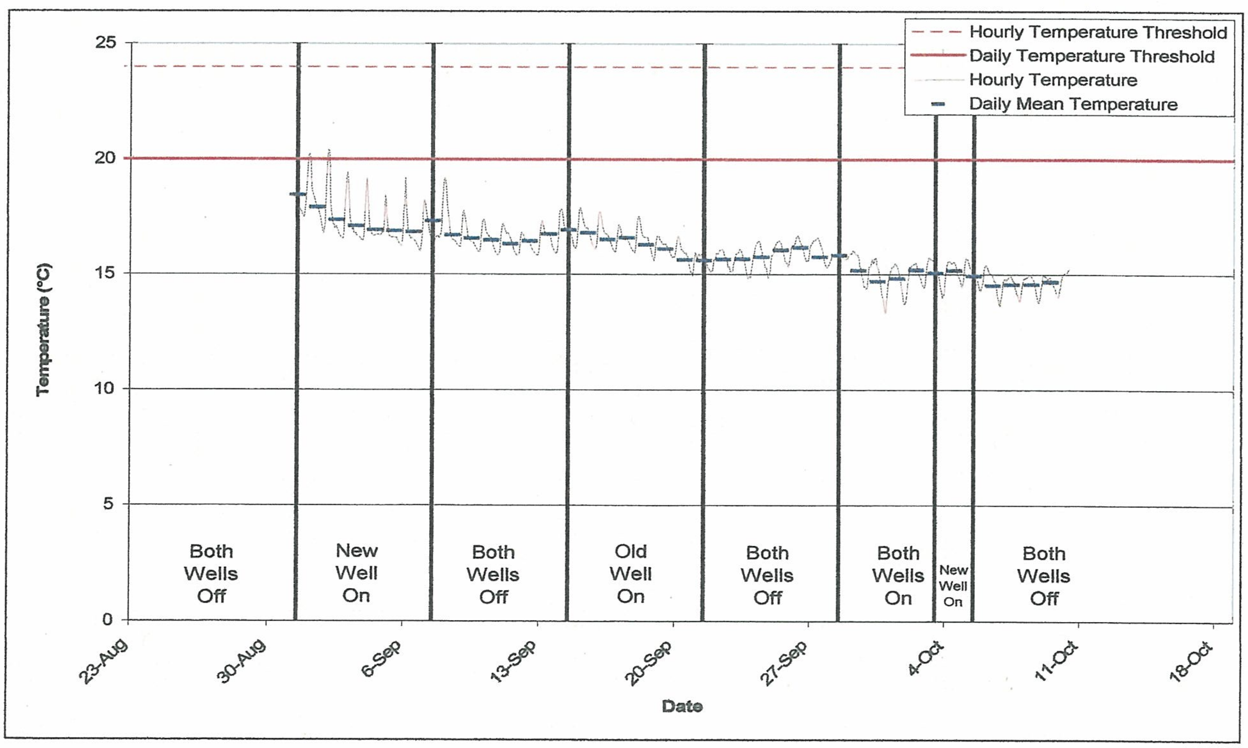

FIGURE 29. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at piezometer pair 4, left bank.

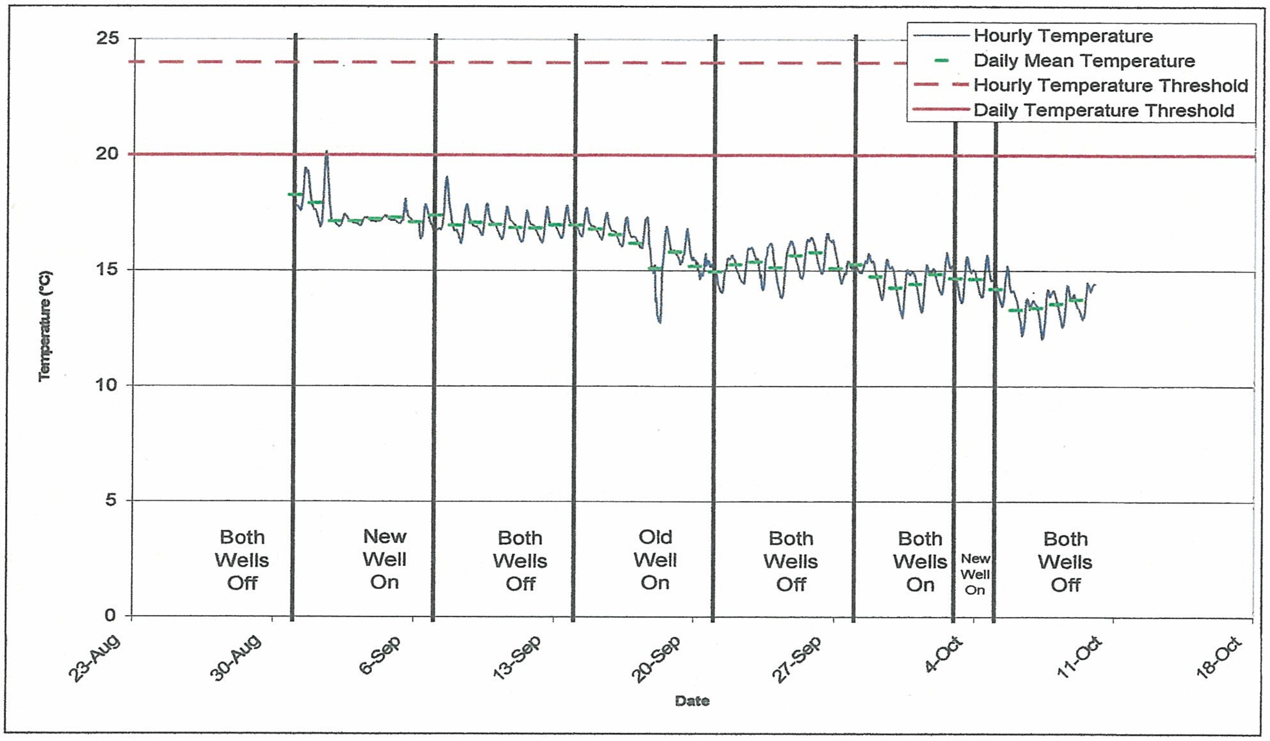

FIGURE 30. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 10, right bank.

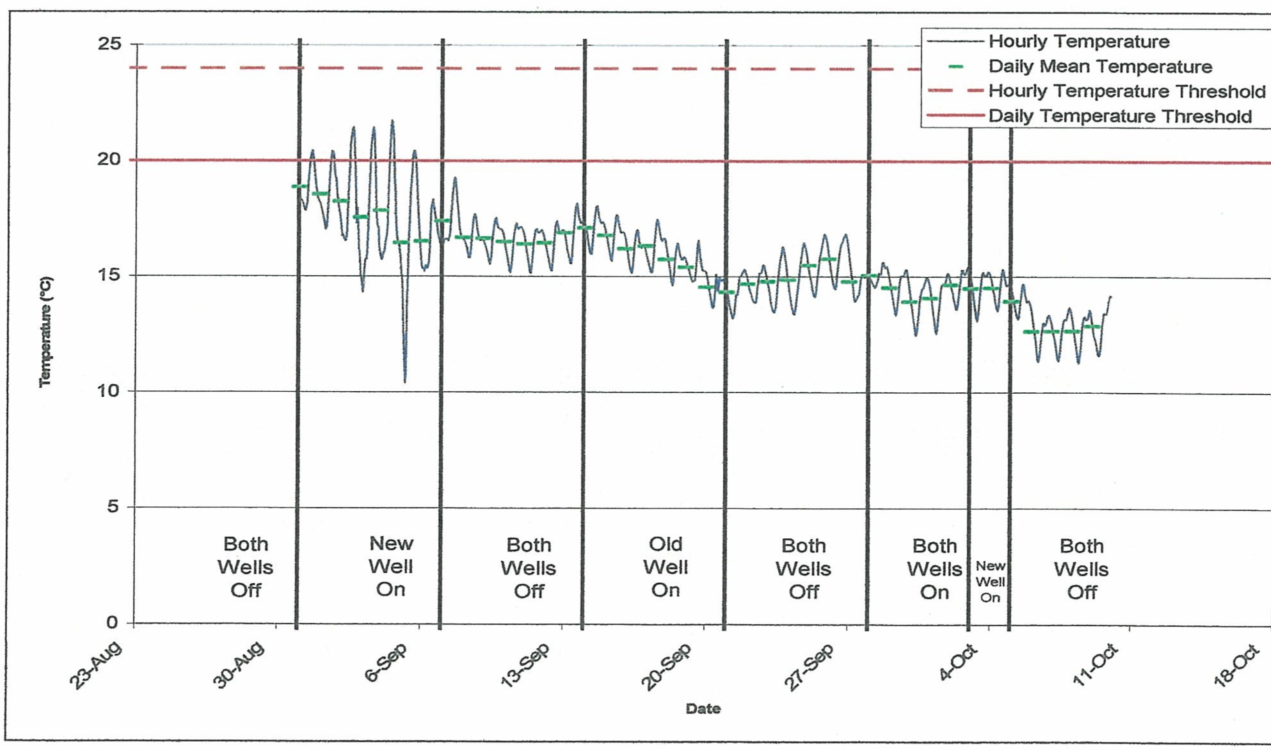

FIGURE 31. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 10, left bank.

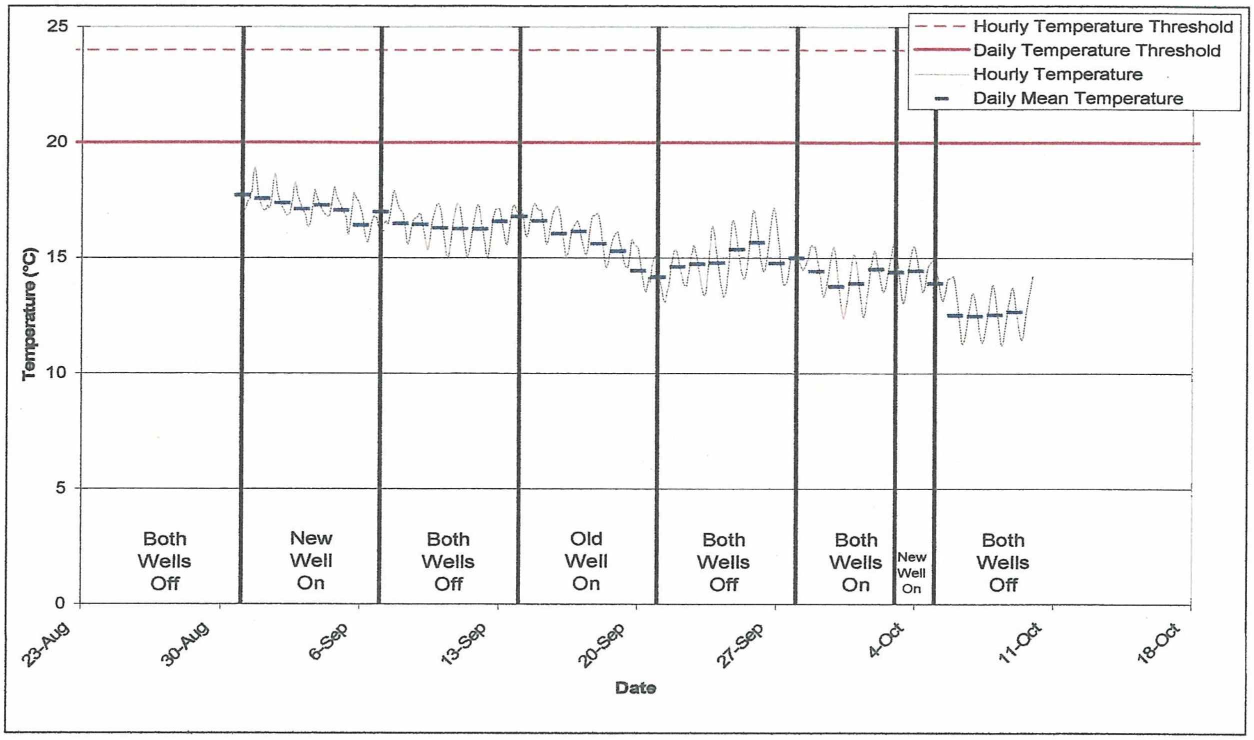

FIGURE 32. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at piezometer pair 4 upper, left bank.

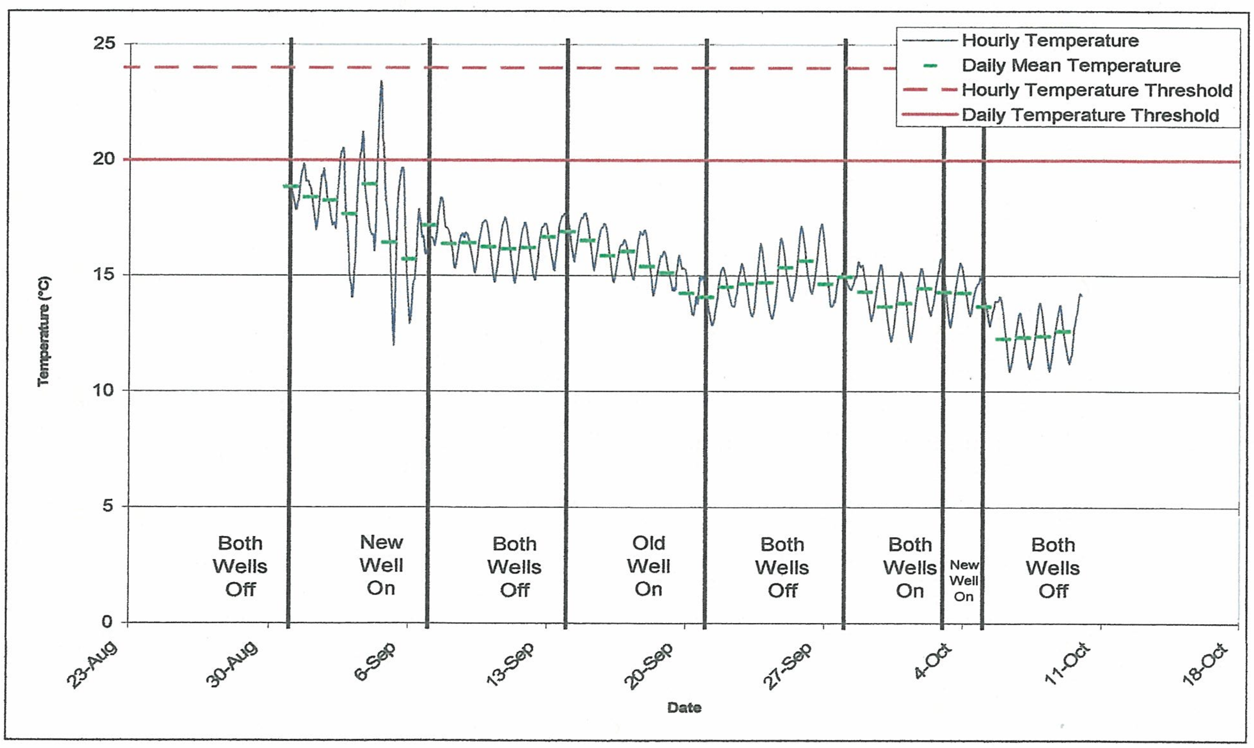

FIGURE 33. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at piezometer pair 4 upper right bank.

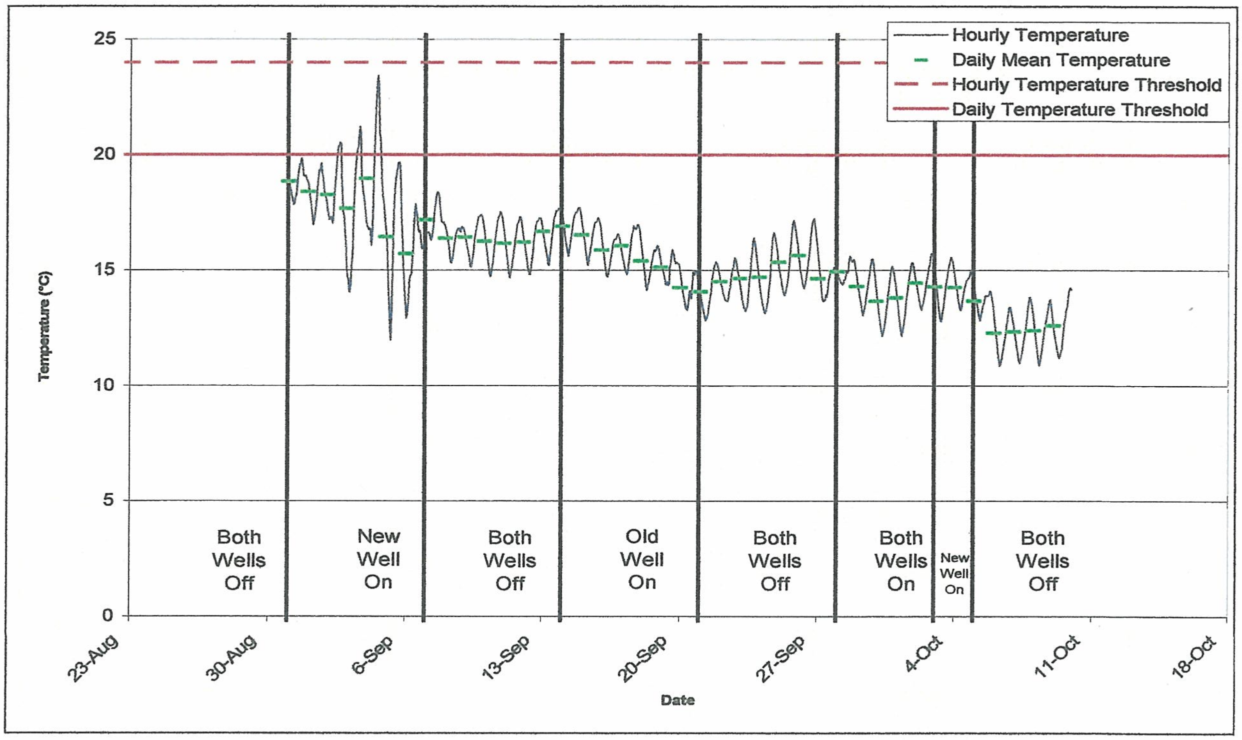

FIGURE 34. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 11, right bank.

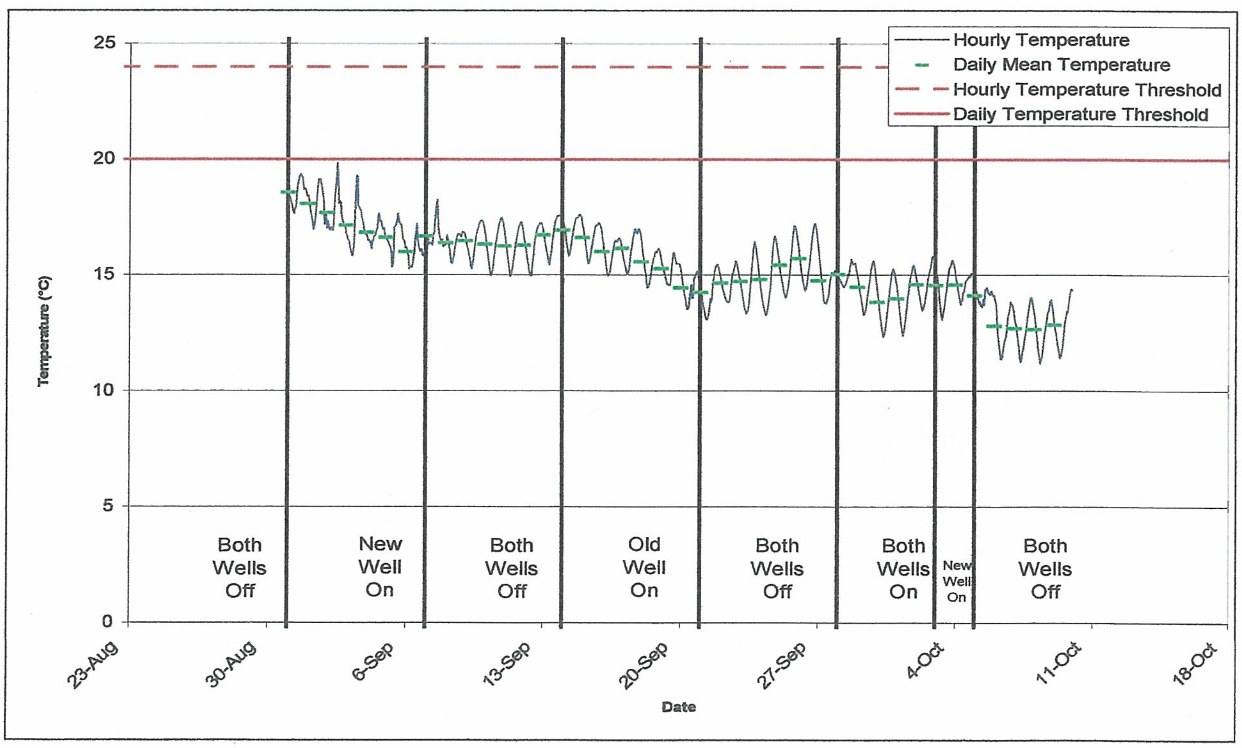

FIGURE 35. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 11, left bank.

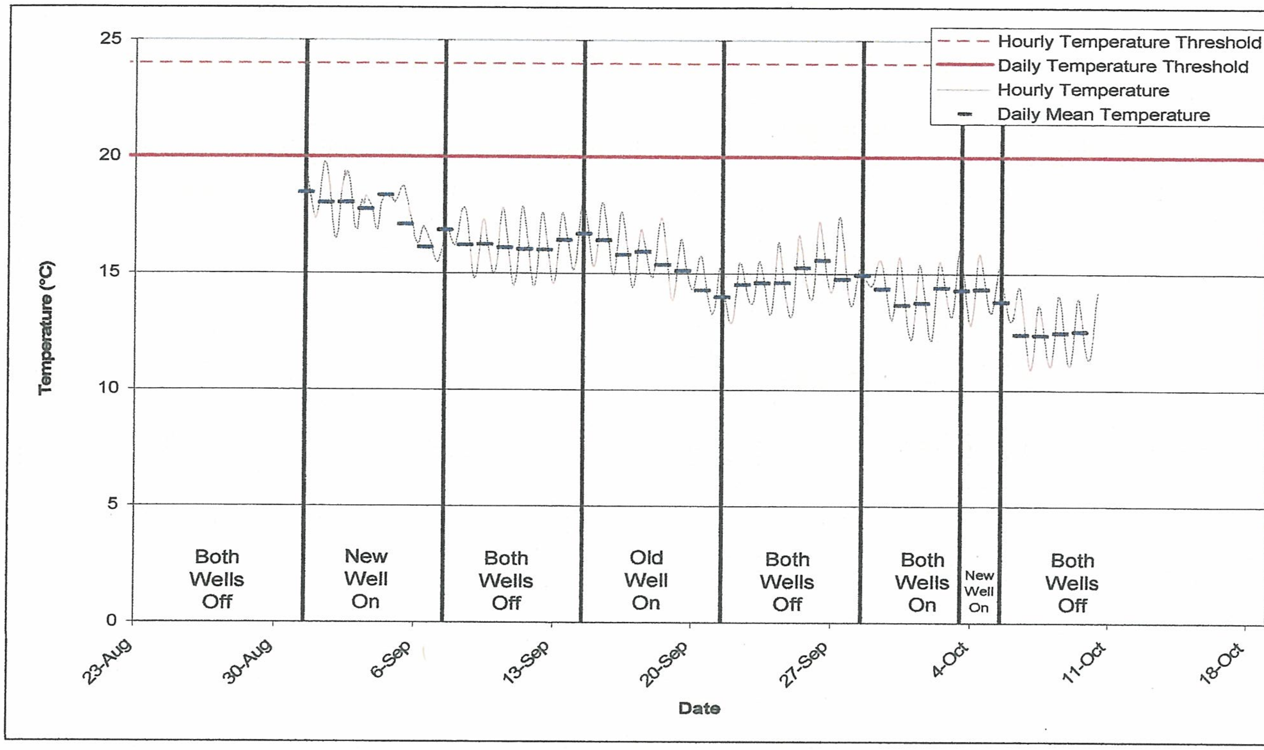

FIGURE 36. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at piezometer pair 5, left bank.

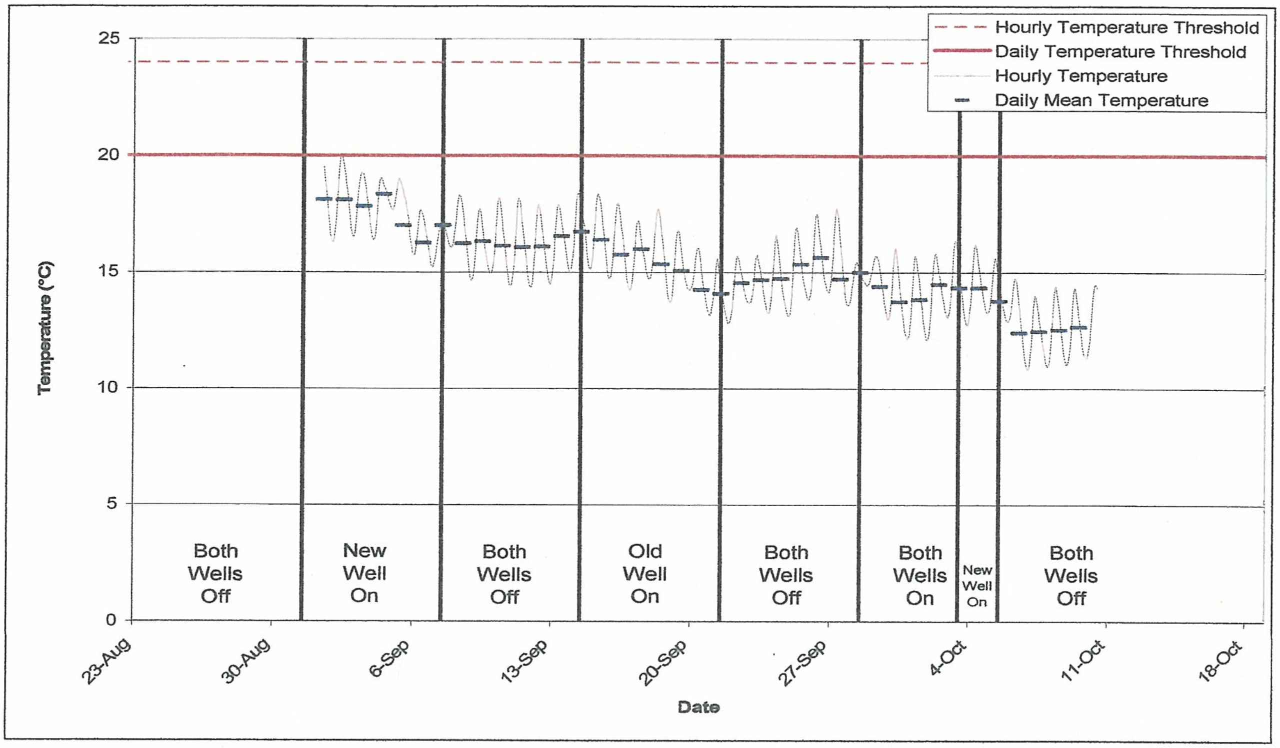

FIGURE 37. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at piezometer pair 6, left bank.

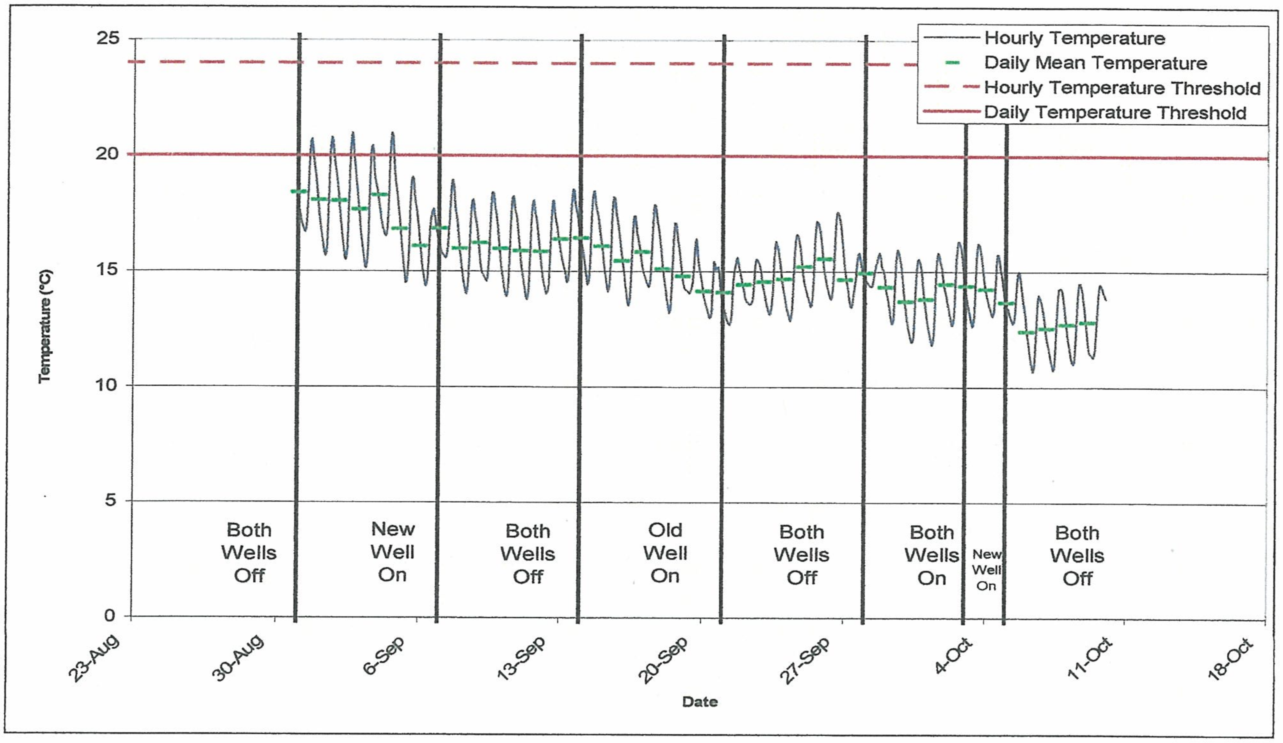

FIGURE 38. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at VT-1, right bank.

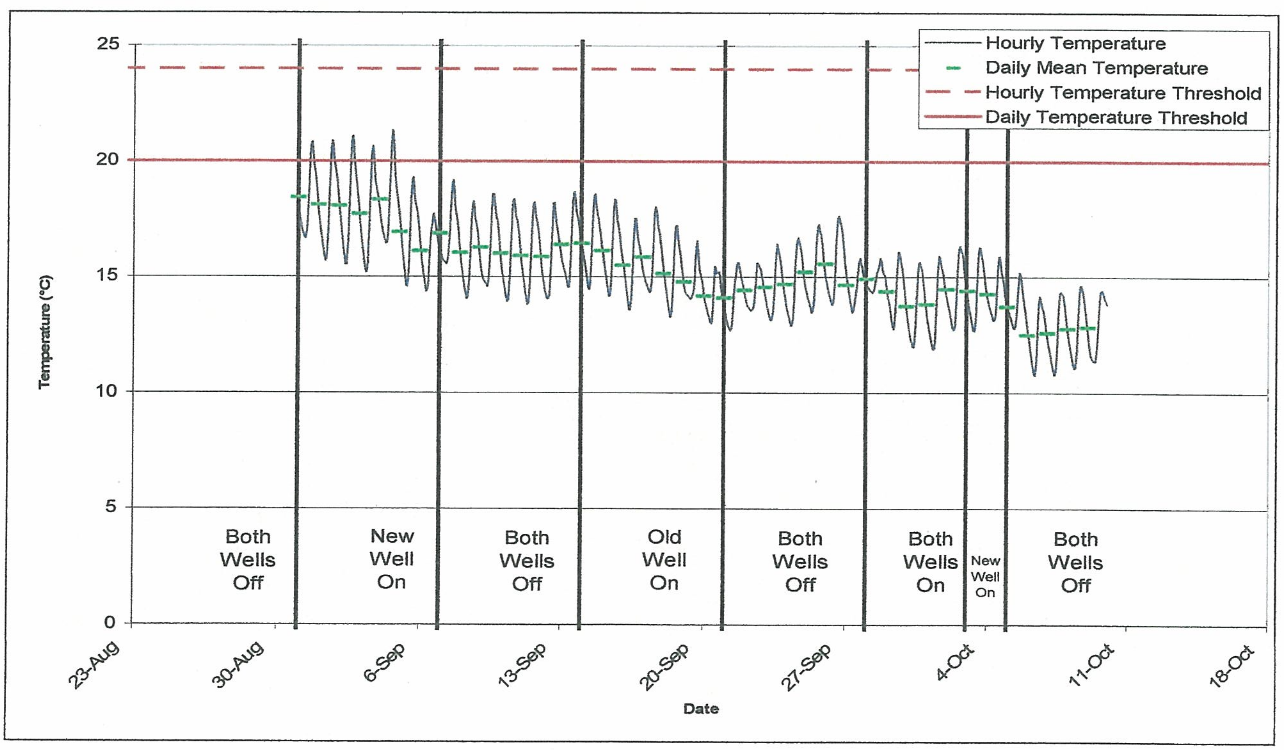

FIGURE 39. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at VT-1, left bank.

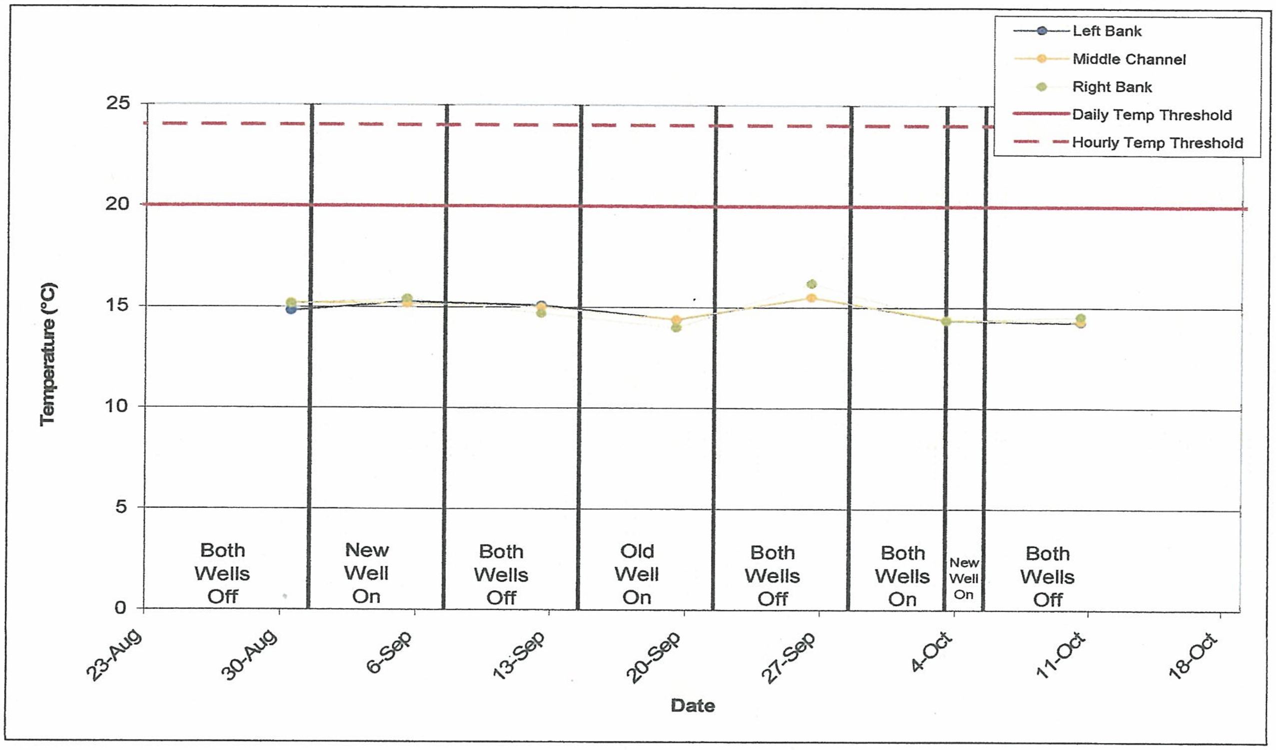

FIGURE 40. Water temperatures measured during periodic water quality surveys during 2007 in the lower Big Sur River at PT-1.

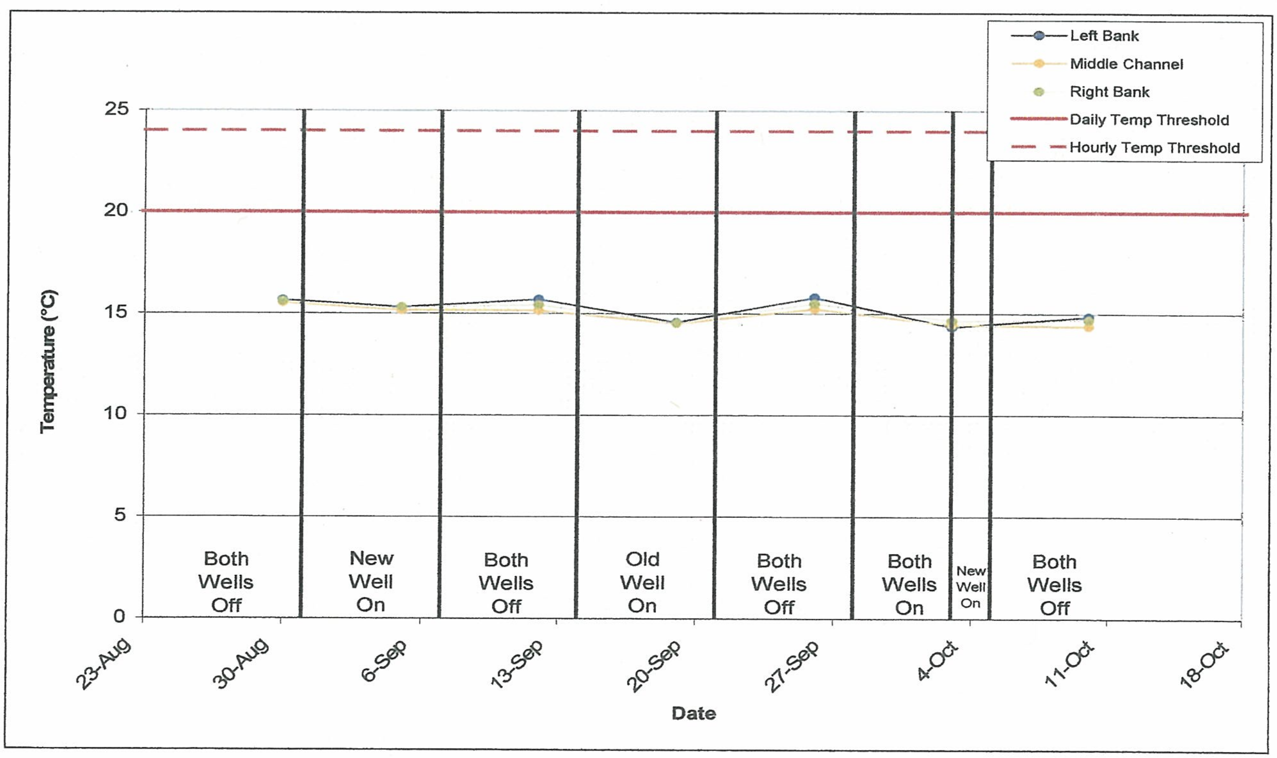

FIGURE 41. Water temperatures measured during periodic water quality surveys during 2007 in the lower Big Sur River at PT-2.

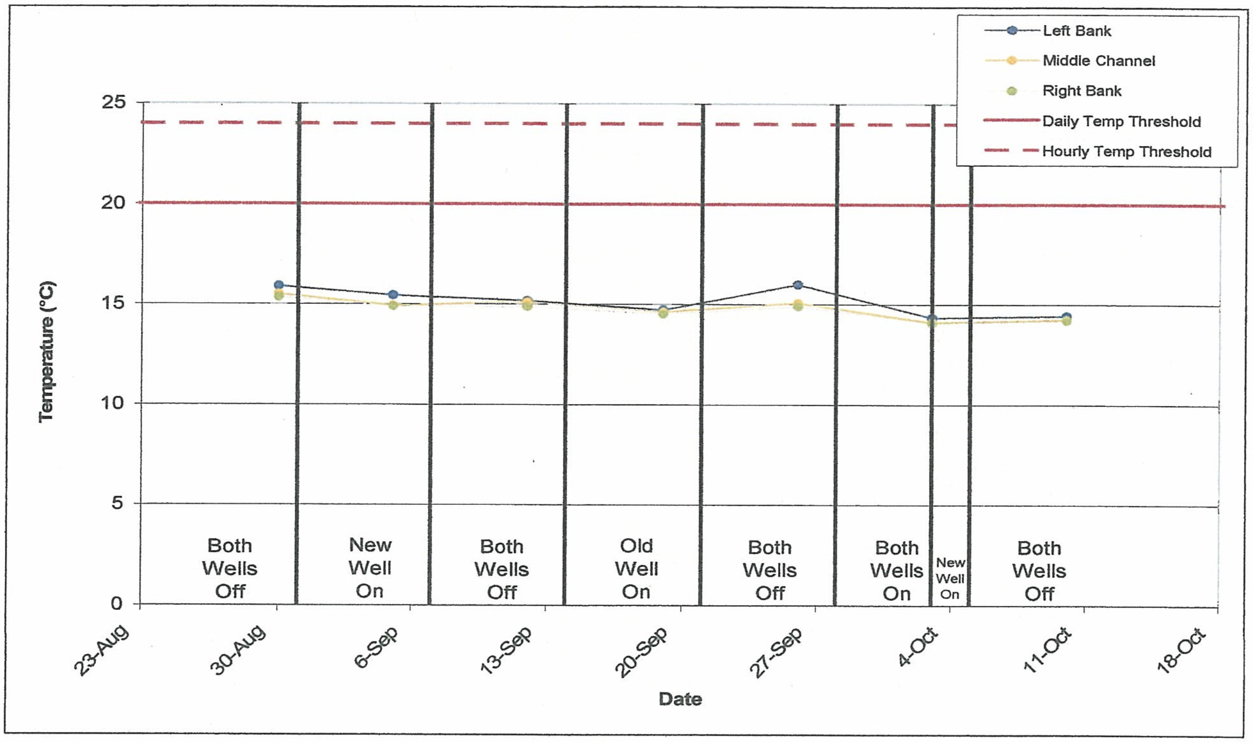

FIGURE 42. Water temperatures measured during periodic water quality surveys during 2007 in the lower Big Sur River at PT-3.

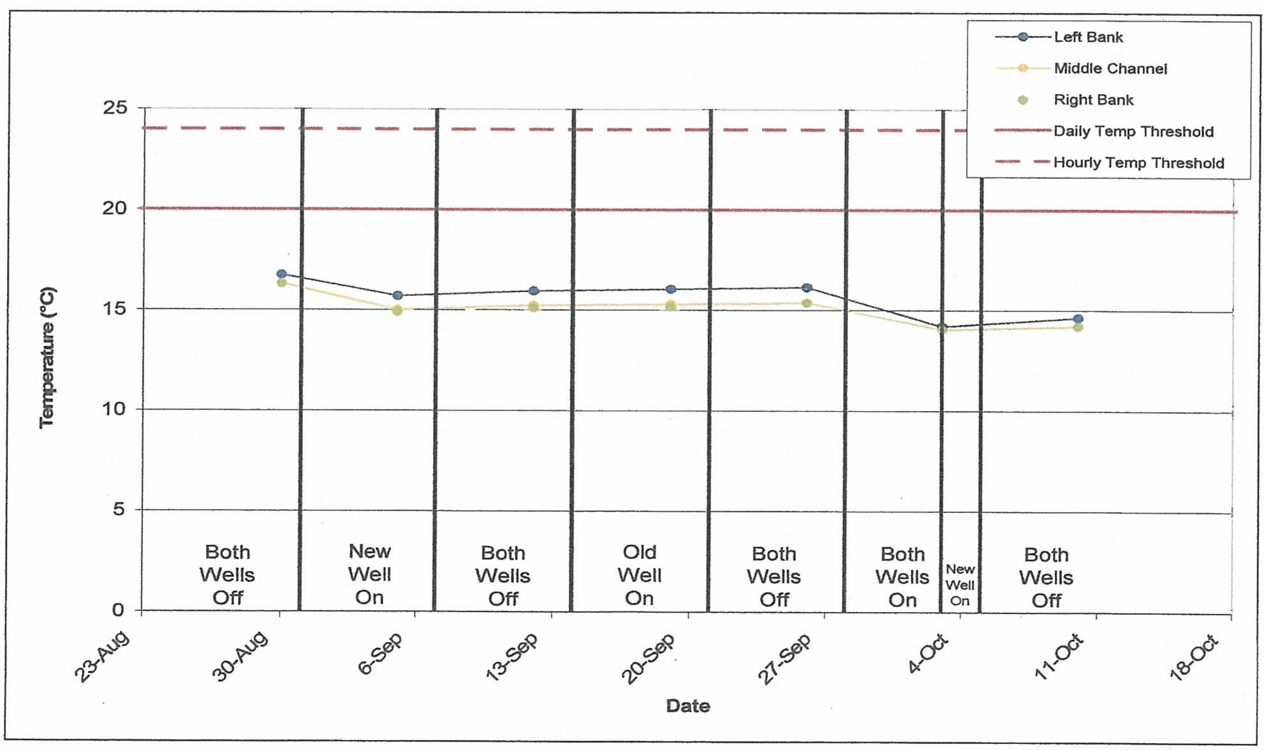

FIGURE 43. Water temperatures measured during periodic water quality surveys during 2007 in the lower Big Sur River at PT-4.

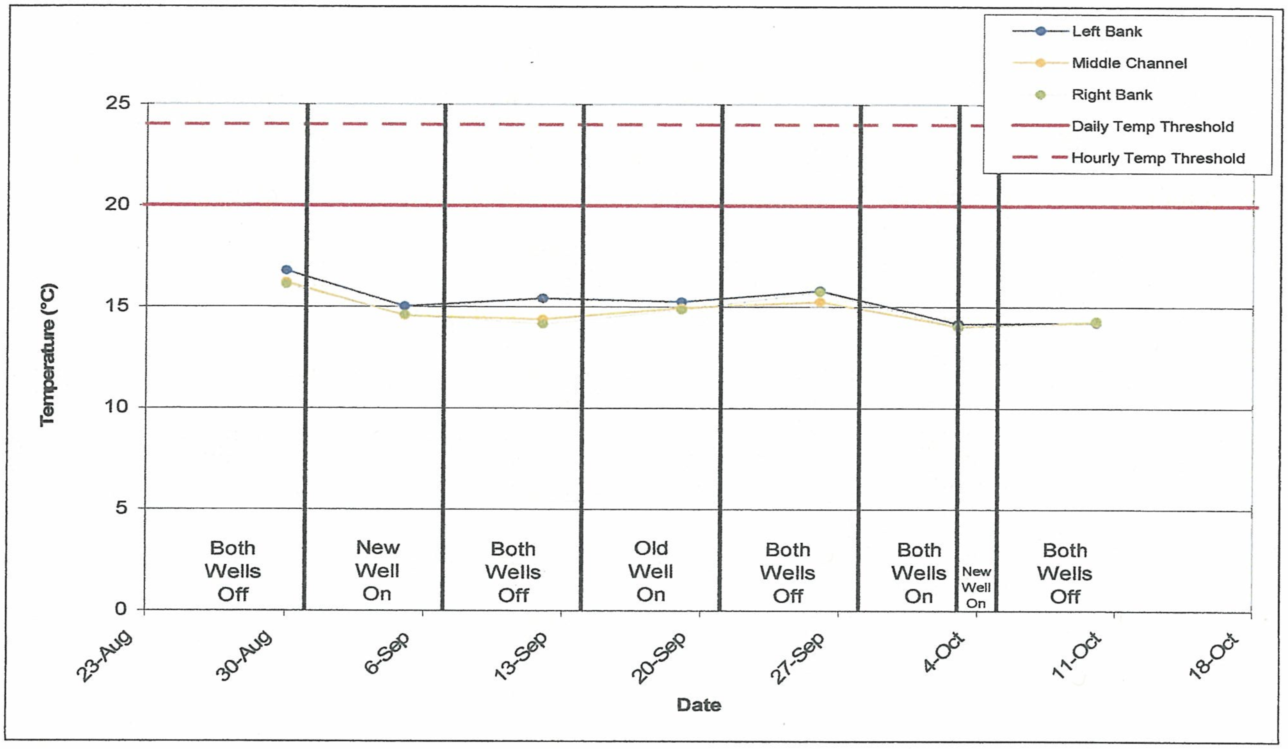

FIGURE 44. Water temperatures measured during periodic water quality surveys during 2007 in the lower Big Sur River at PT-5.

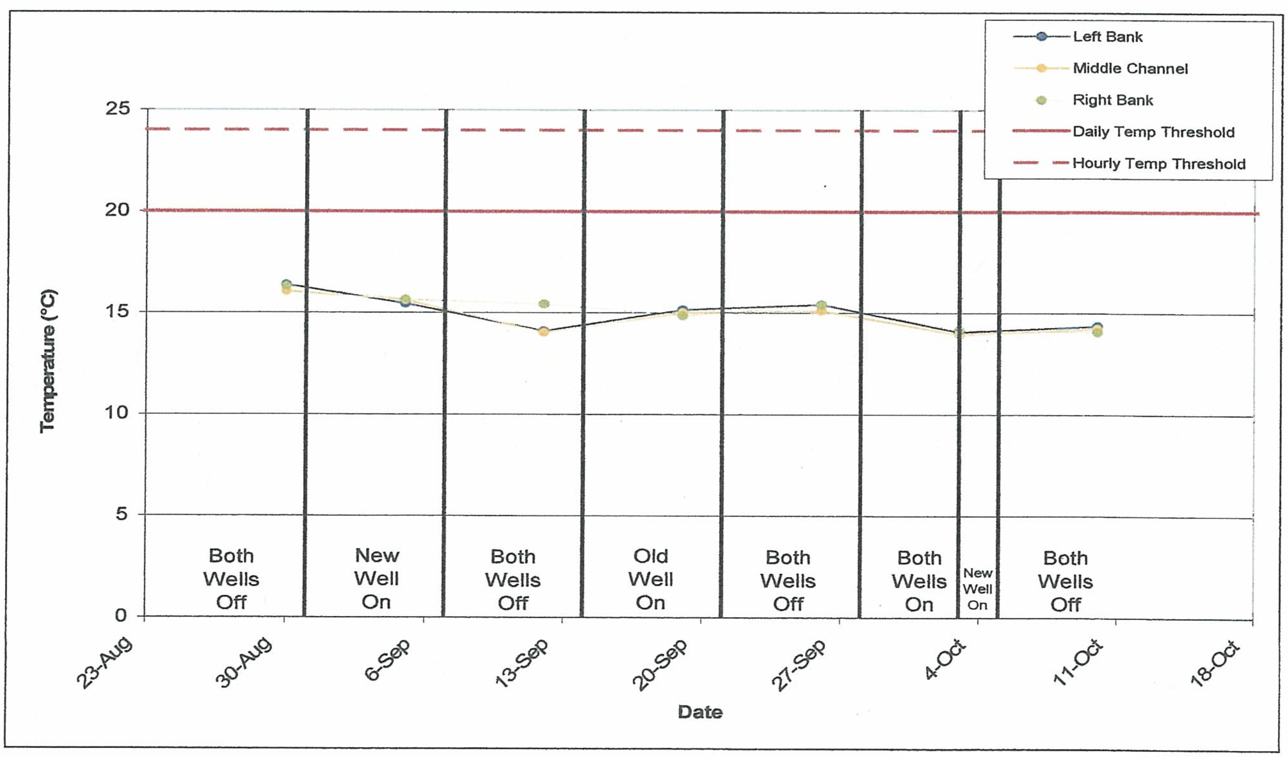

FIGURE 45. Water temperatures measured during periodic water quality surveys during 2007 in the lower Big Sur River at PT-6.

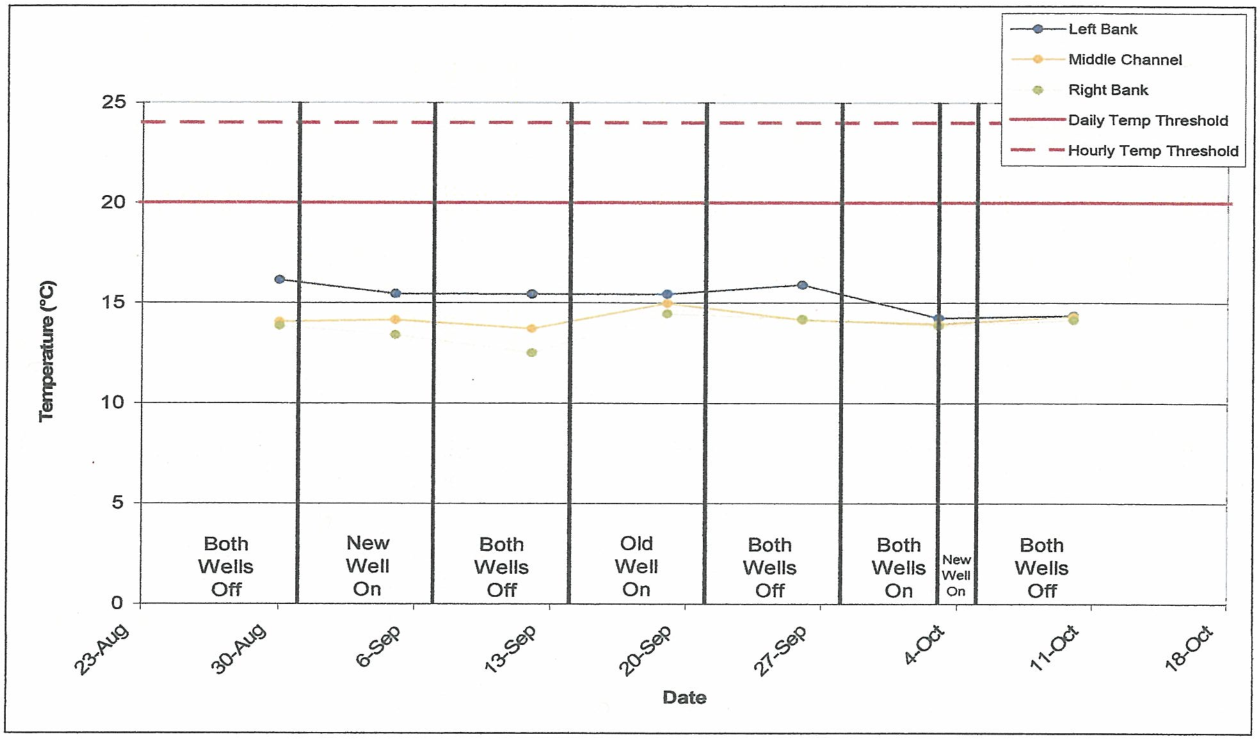

FIGURE 46. Water temperatures measured during periodic water quality surveys during 2007 in the lower Big Sur River at PT-7.

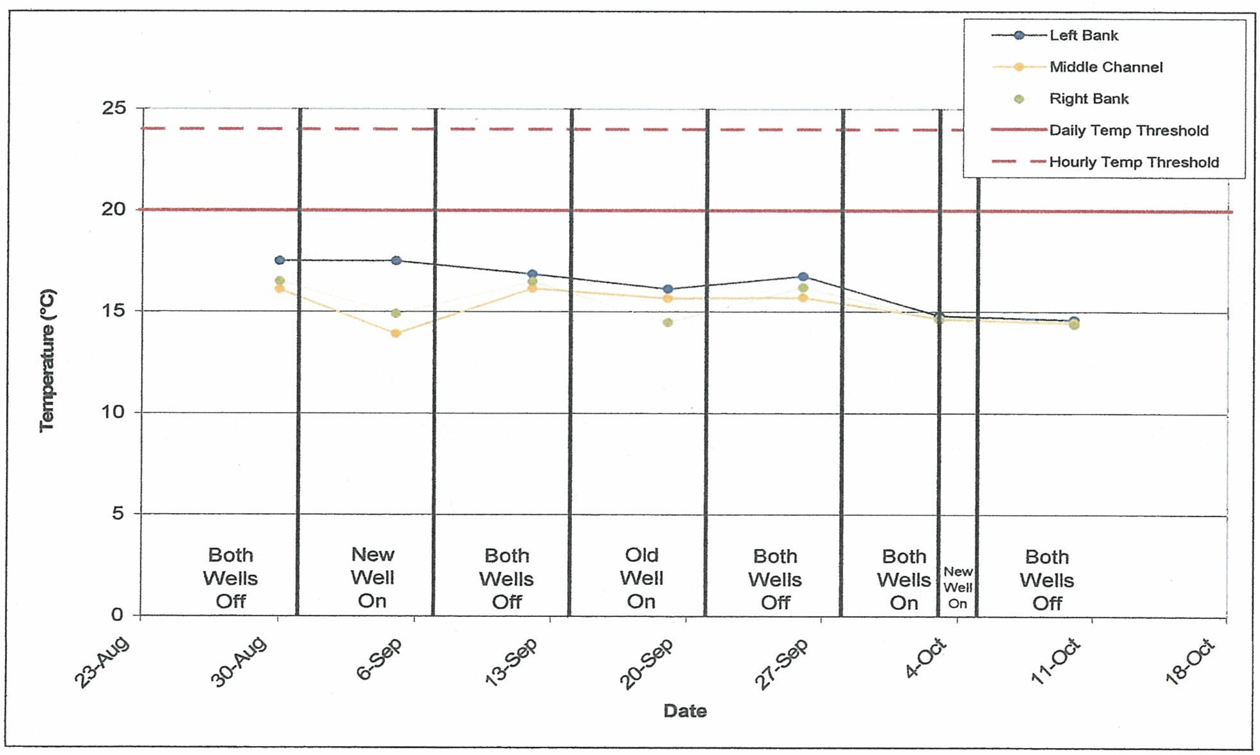

FIGURE 47. Water temperatures measured during periodic water quality surveys during 2007 in the lower Big Sur River at PT-8.

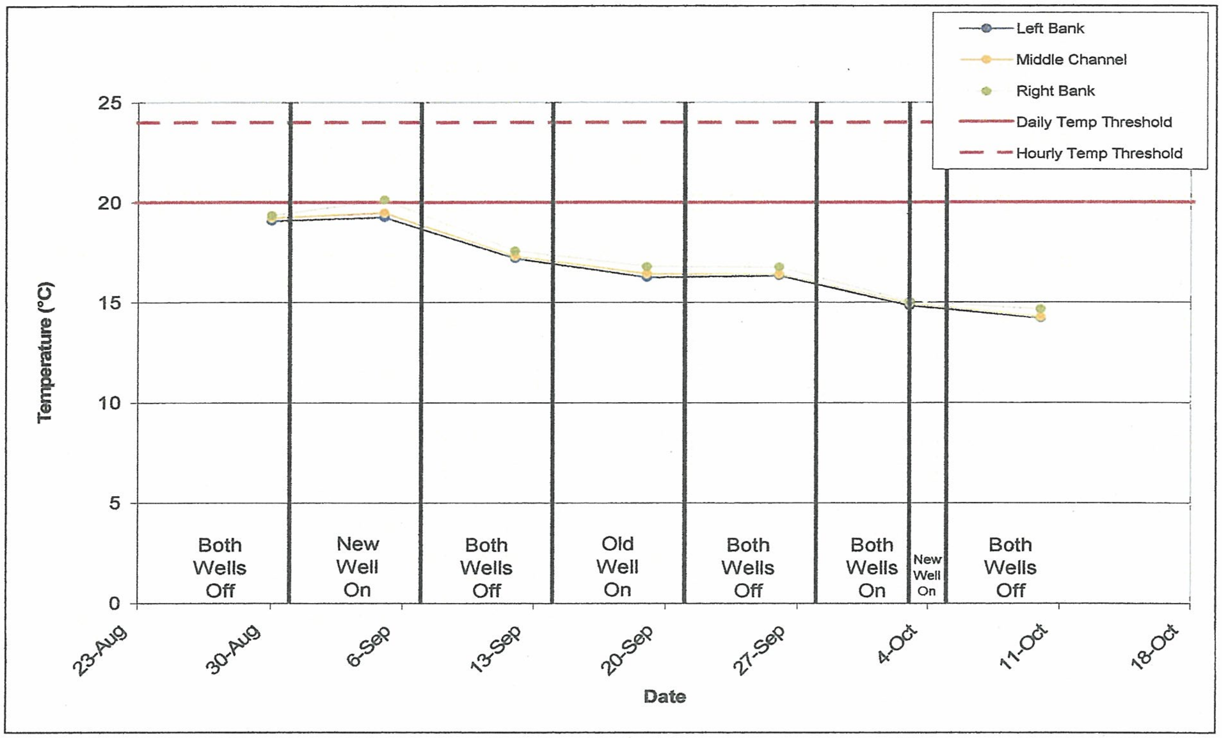

FIGURE 48. Water temperatures measured during periodic water quality surveys during 2007 in the lower Big Sur River at PT-9.

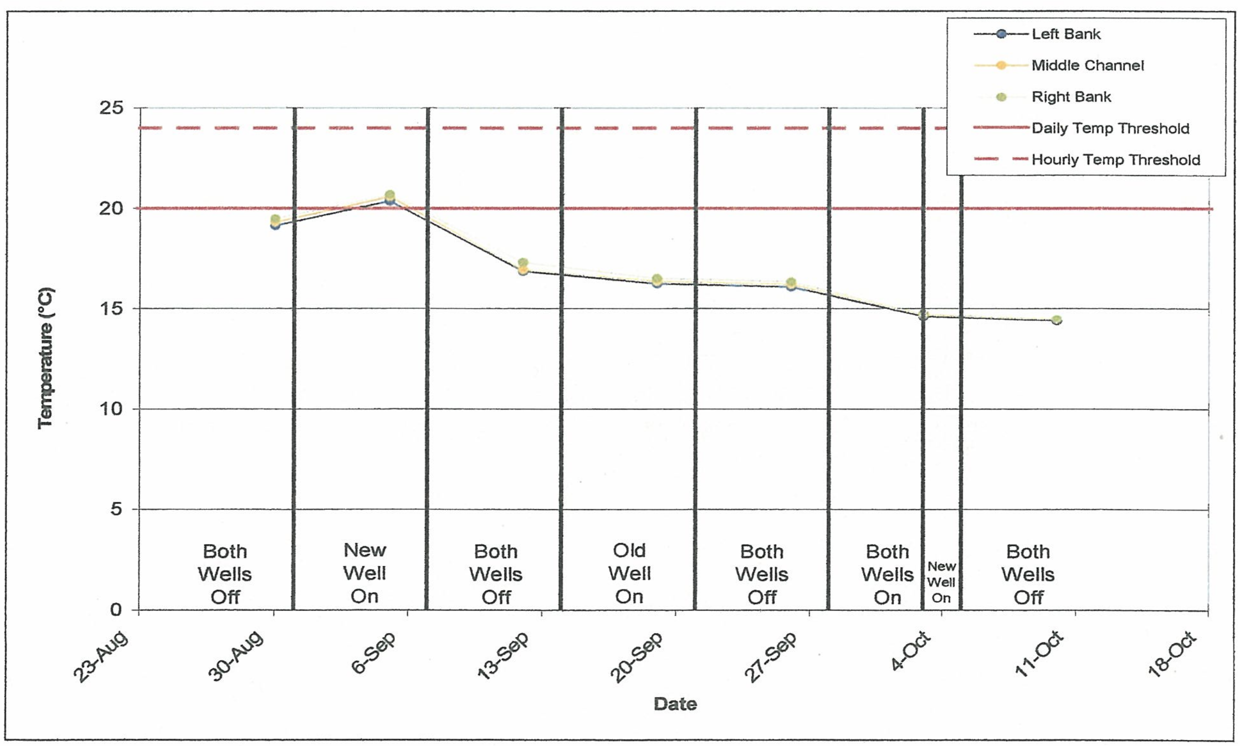

FIGURE 49. Water temperatures measured during periodic water quality surveys during 2007 in the lower Big Sur River at PT-10.

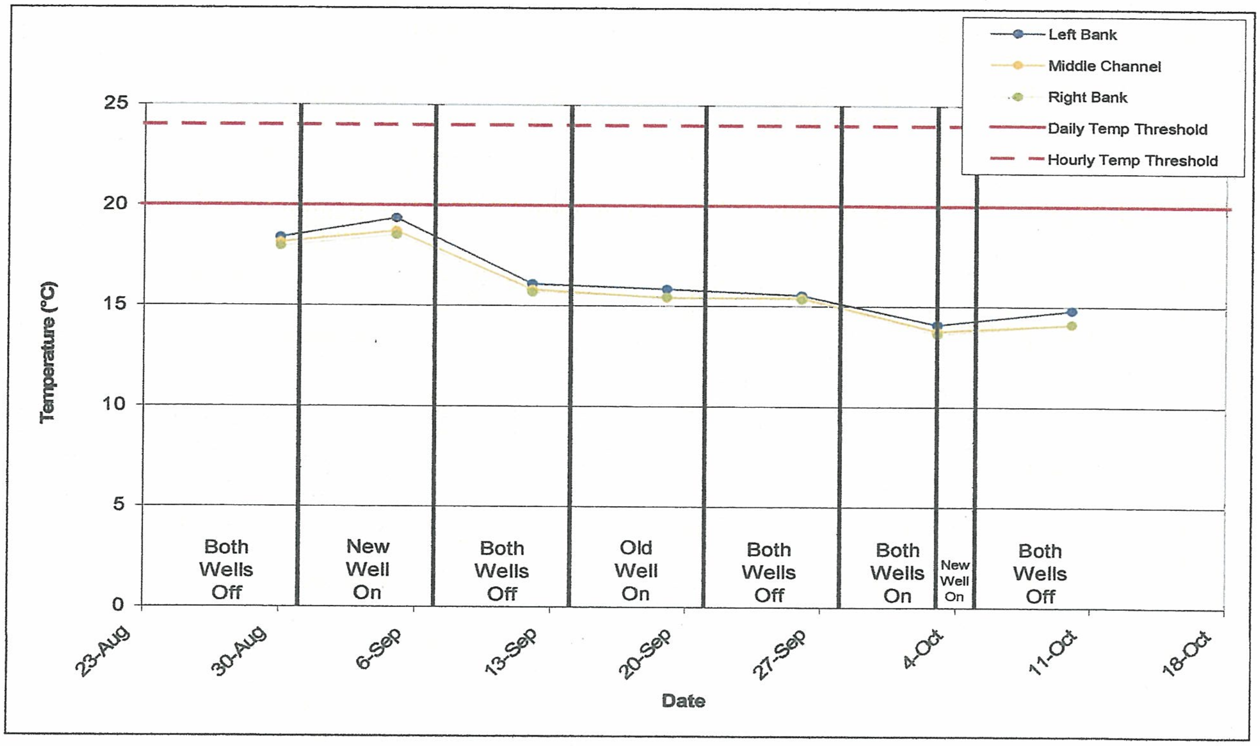

FIGURE 50. Water temperatures measured during periodic water quality surveys during 2007 in the lower Big Sur River at PT-11.

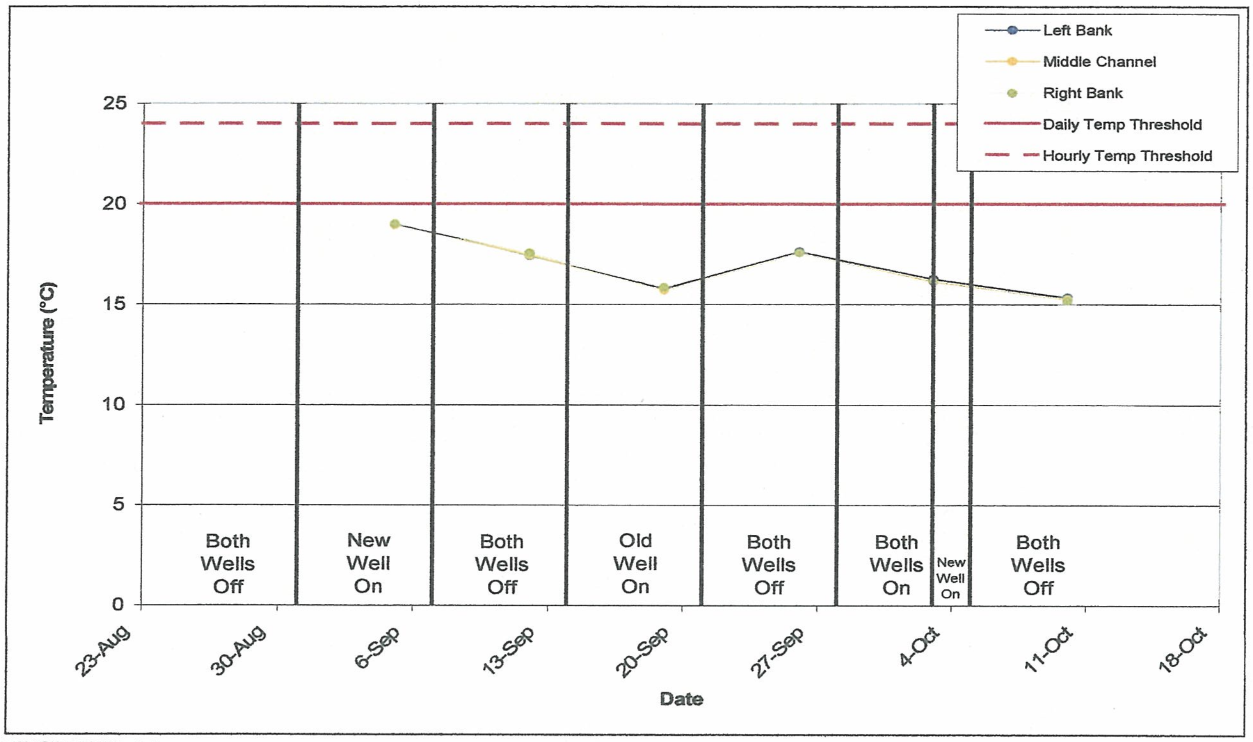

FIGURE 51. Water temperatures measured during periodic water quality surveys during 2007 in the lower Big Sur River at VT-1.

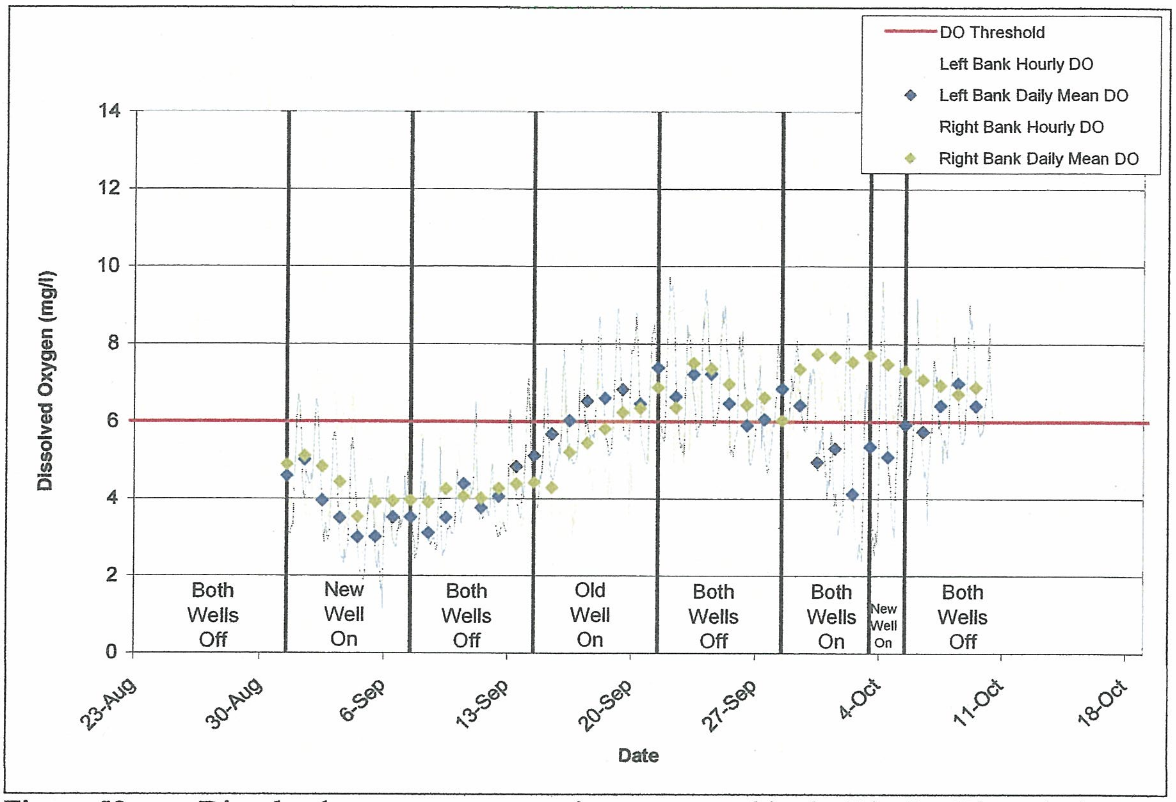

Figure 52. Dissolved oxygen concentrations measured in the Big Sur River during 2007 at piezometer pair 2, left and right banks.

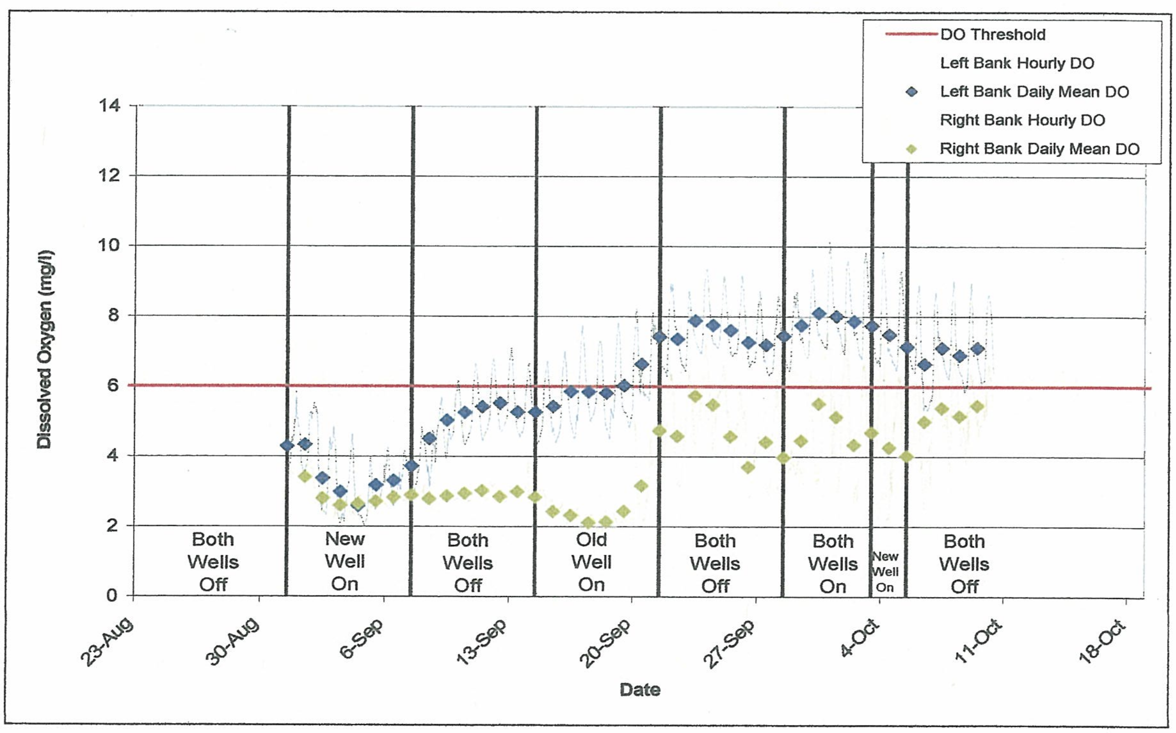

Figure 53. Dissolved oxygen concentrations measured in the Big Sur River during 2007 at piezometer pair 3, left and right banks.

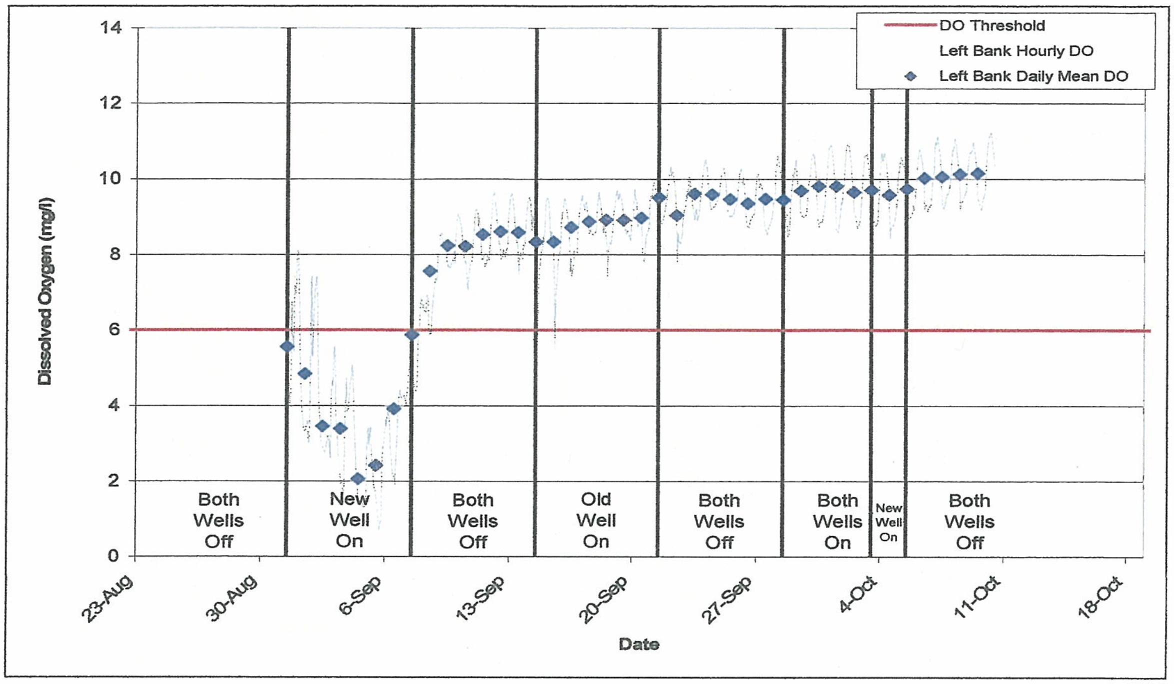

Figure 54. Dissolved oxygen concentrations measured in the Big Sur River during 2007 at piezometer pair 4, upper left bank.

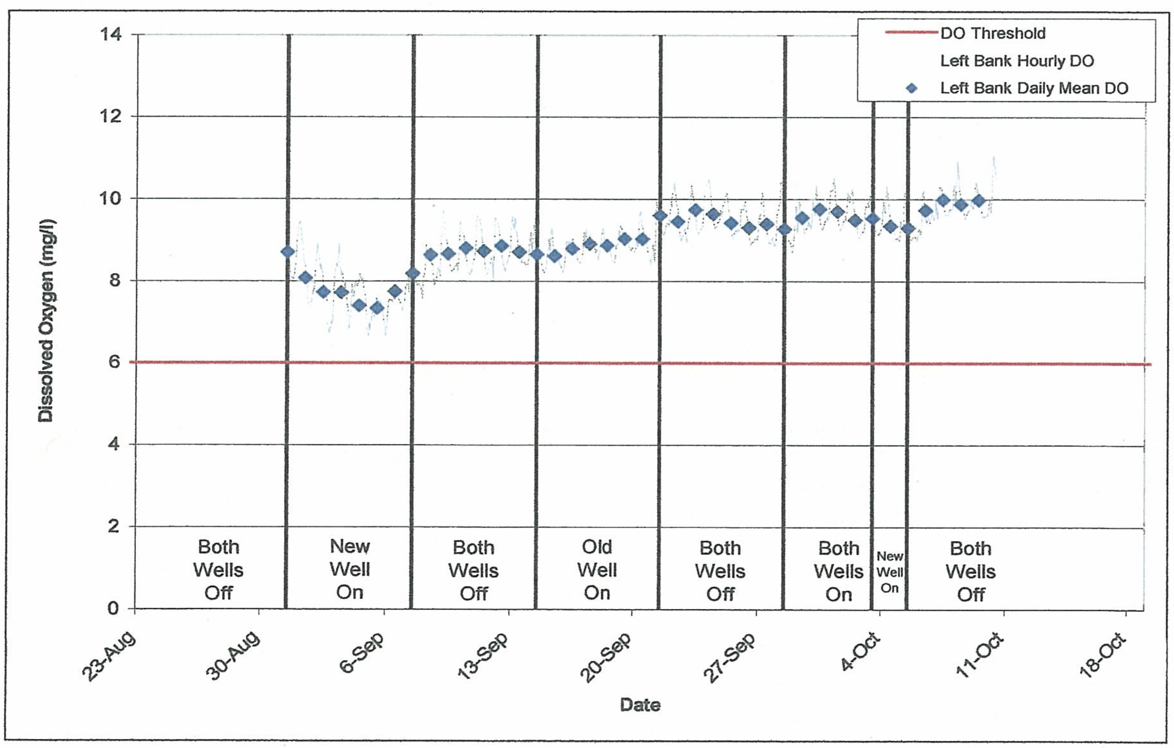

Figure 55. Dissolved oxygen concentrations measured in the Big Sur River during 2007 at piezometer pair 5, left bank.

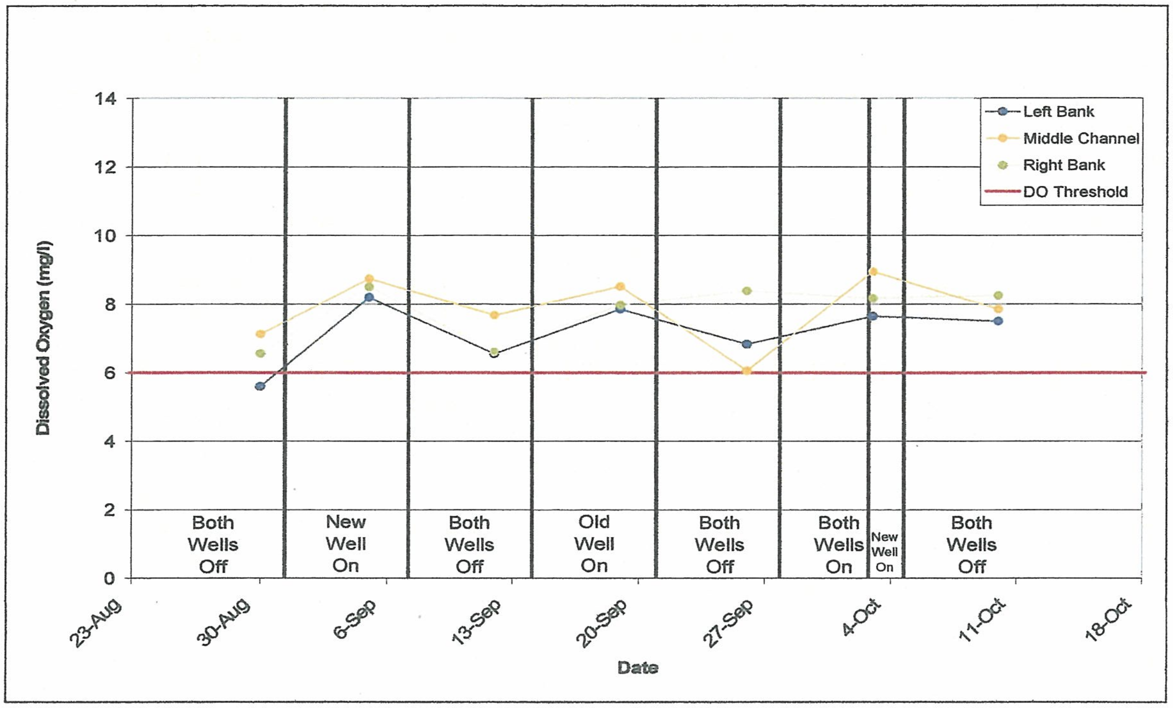

Figure 56. Dissolved oxygen concentrations measured during periodic water quality surveys in the Big Sur River during 2007 at passage transect 1.

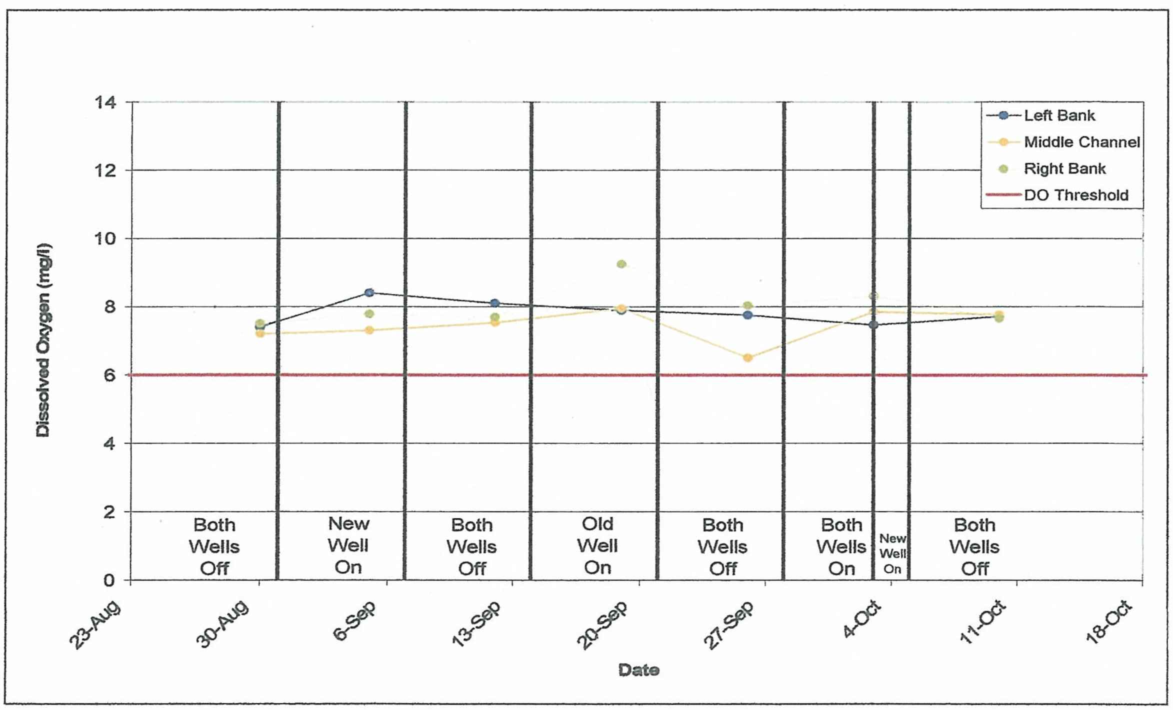

Figure 57. Dissolved oxygen concentrations measured during periodic water quality surveys in the Big Sur River during 2007 at passage transect 2.

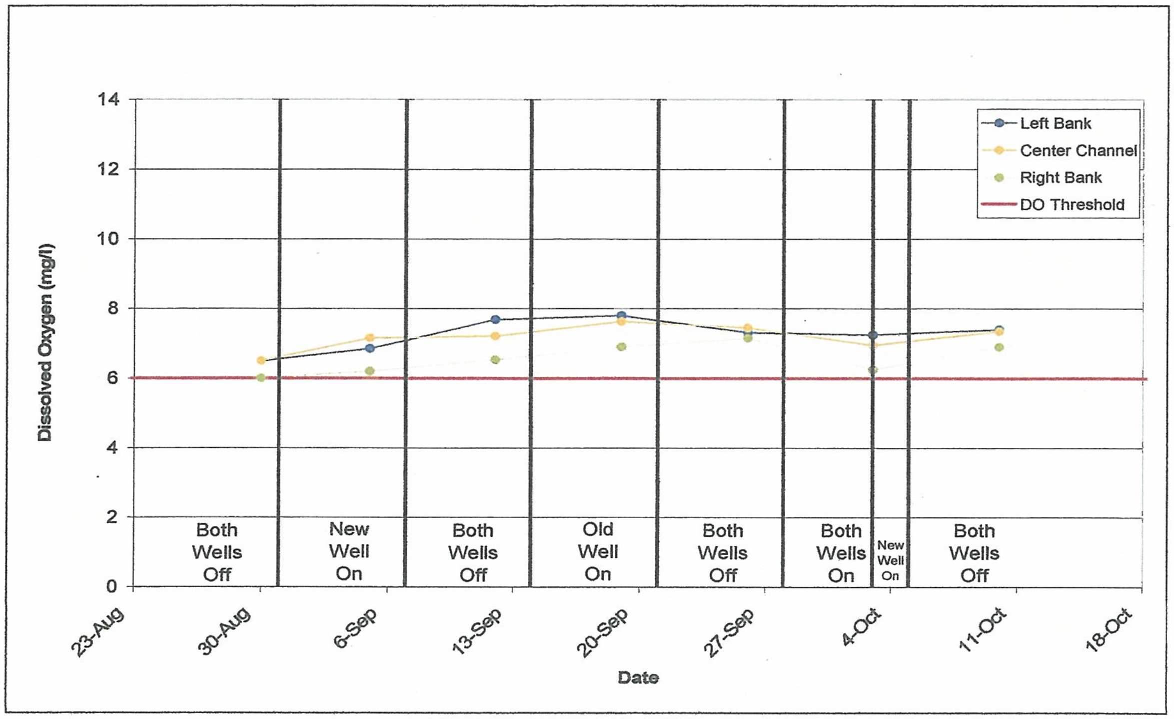

Figure 58. Dissolved oxygen concentrations measured during periodic water quality surveys in the Big Sur River during 2007 at passage transect 3.

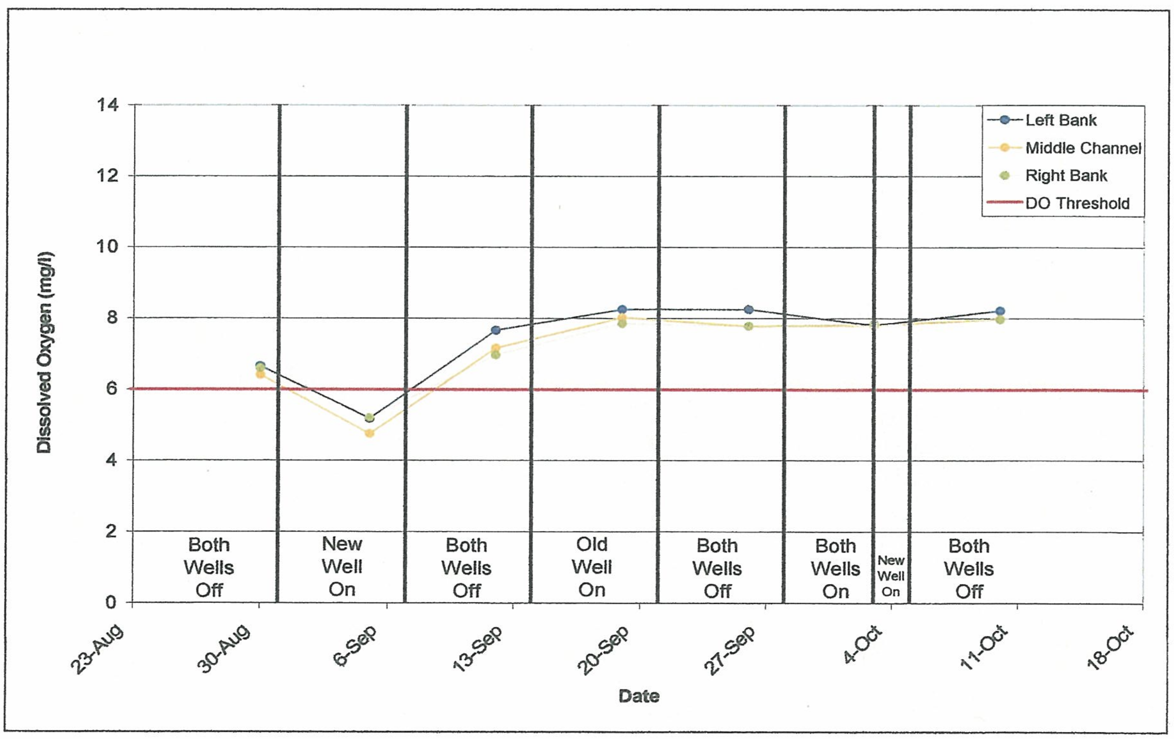

Figure 59. Dissolved oxygen concentrations measured during periodic water quality surveys in the Big Sur River during 2007 at passage transect 4.

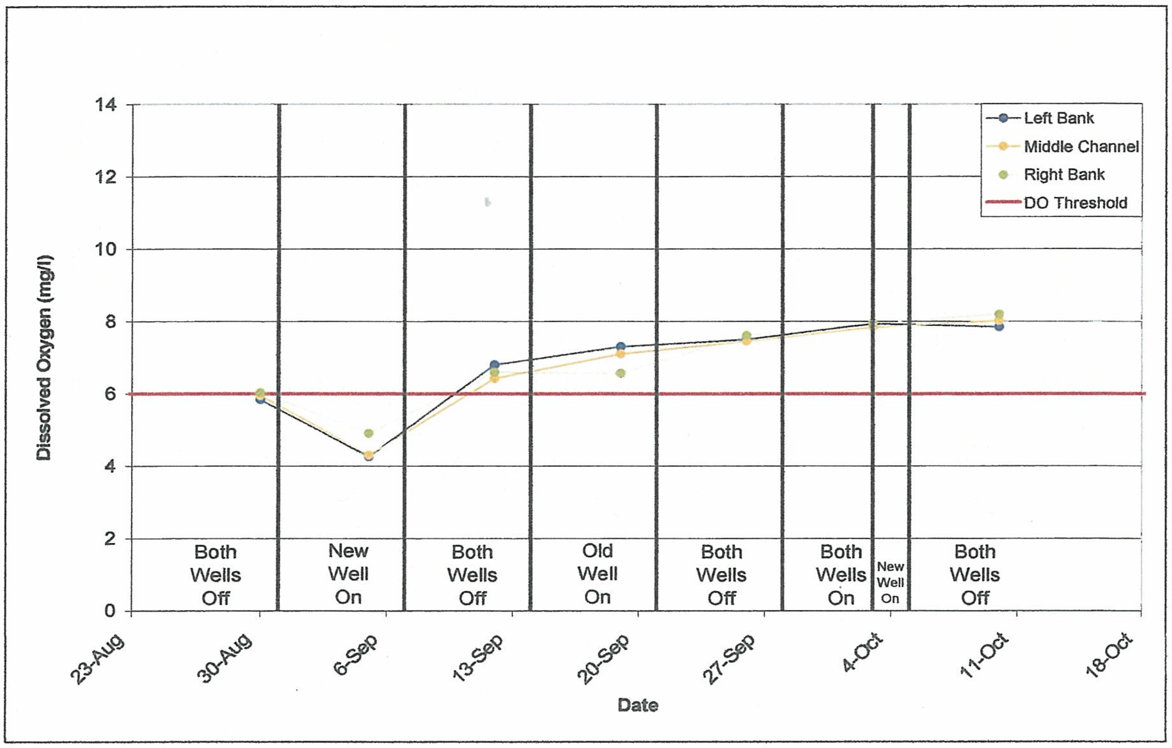

Figure 60. Dissolved oxygen concentrations measured during periodic water quality surveys in the Big Sur River during 2007 at passage transect 5.

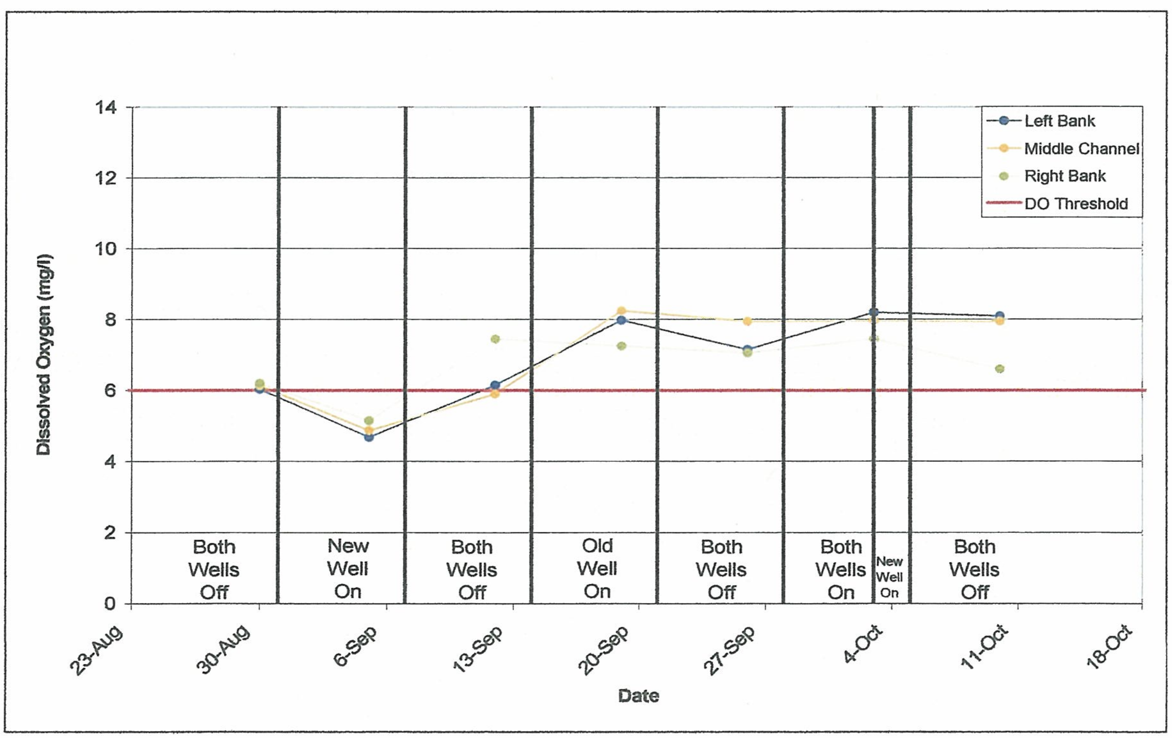

Figure 61. Dissolved oxygen concentrations measured during periodic water quality surveys in the Big Sur River during 2007 at passage transect 6.

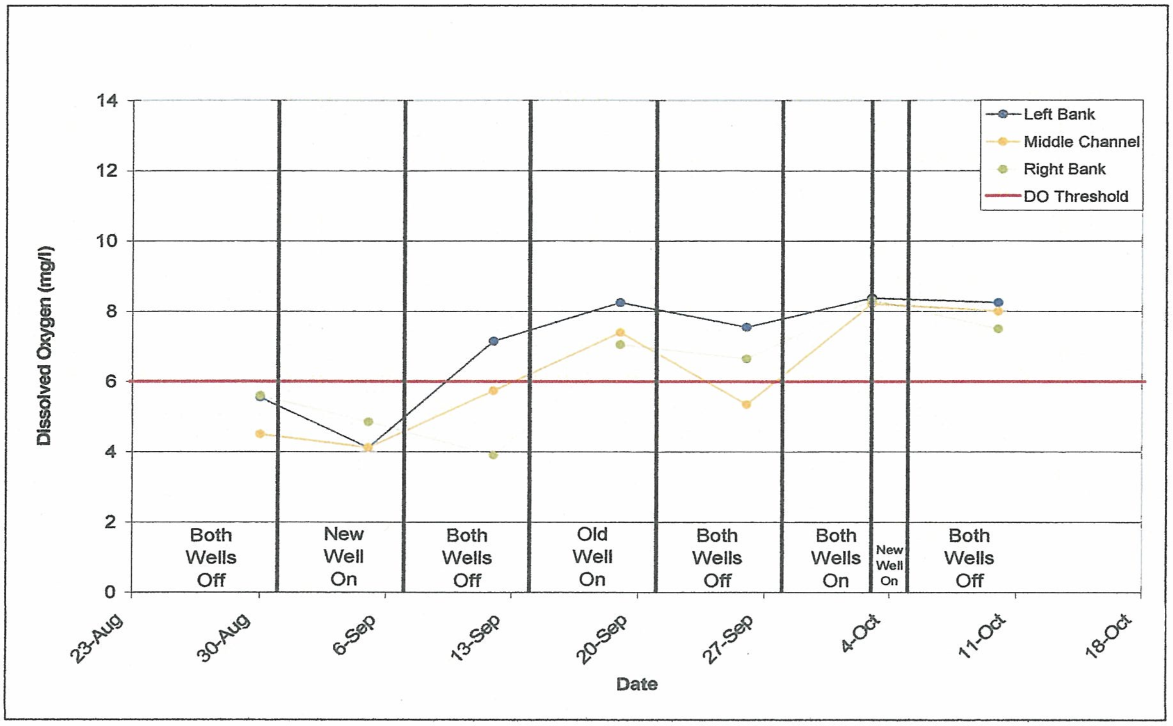

Figure 62. Dissolved oxygen concentrations measured during periodic water quality surveys in the Big Sur River during 2007 at passage transect 7.

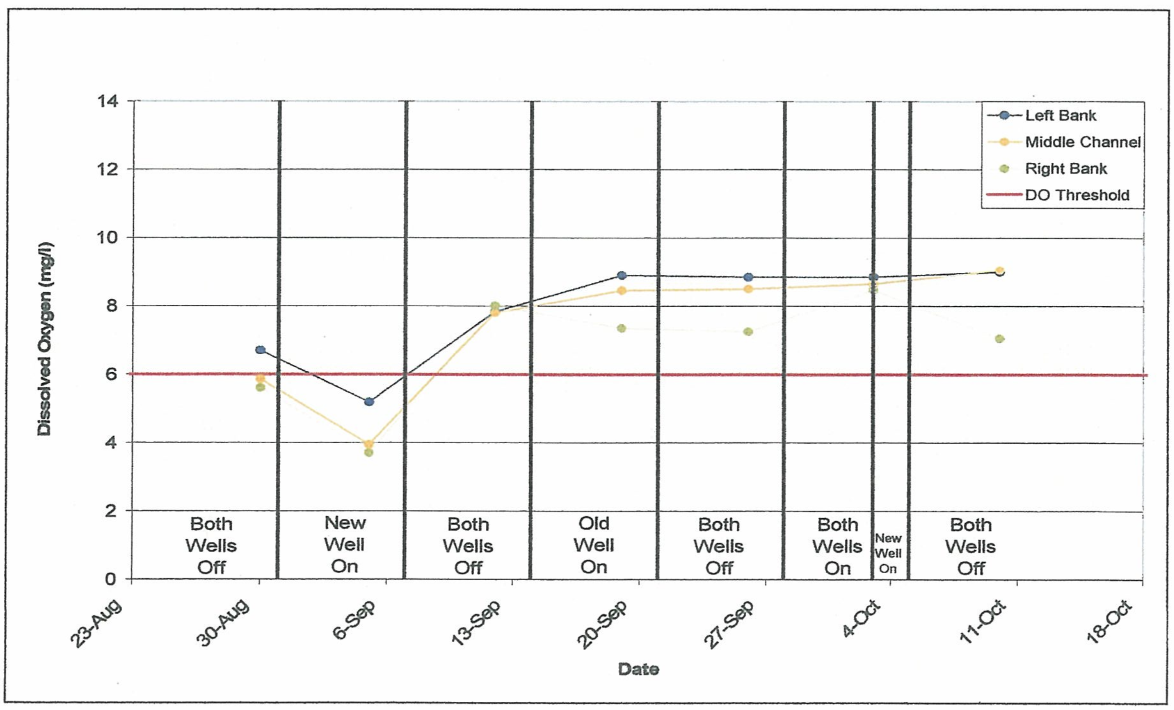

Figure 63. Dissolved oxygen concentrations measured during periodic water quality surveys in the Big Sur River during 2007 at passage transect 8.

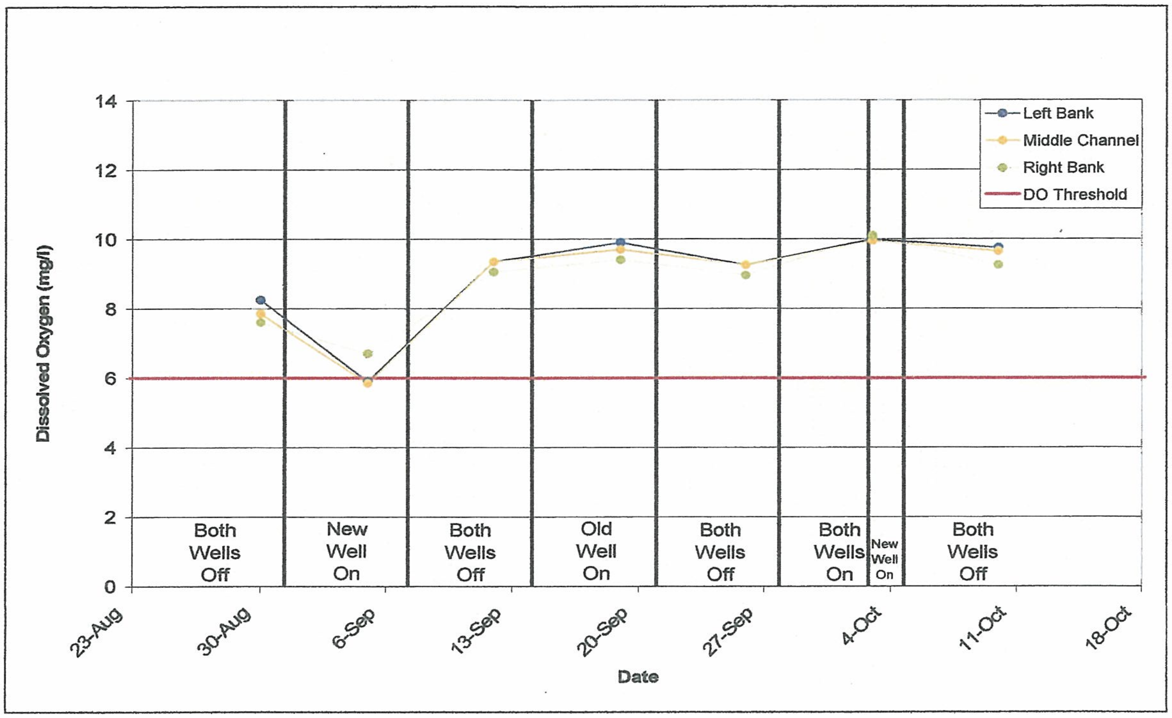

Figure 64. Dissolved oxygen concentrations measured during periodic water quality surveys in the Big Sur River during 2007 at passage transect 9.

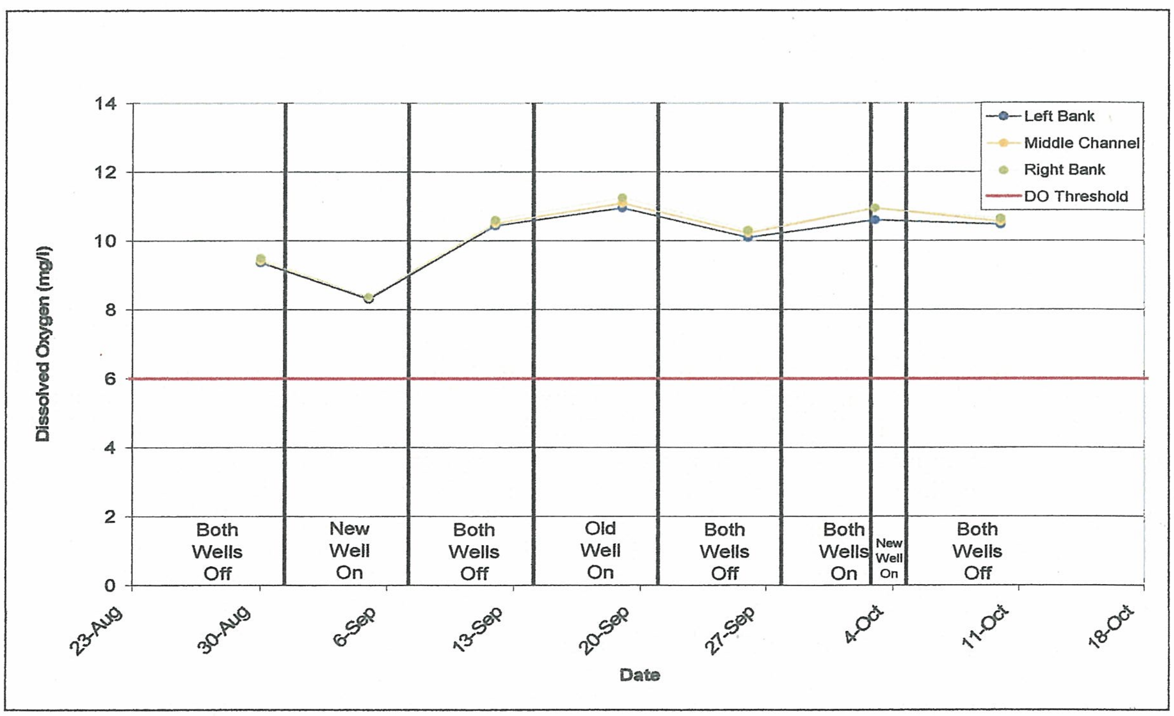

Figure 65. Dissolved oxygen concentrations measured during periodic water quality surveys in the Big Sur River during 2007 at passage transect 10.

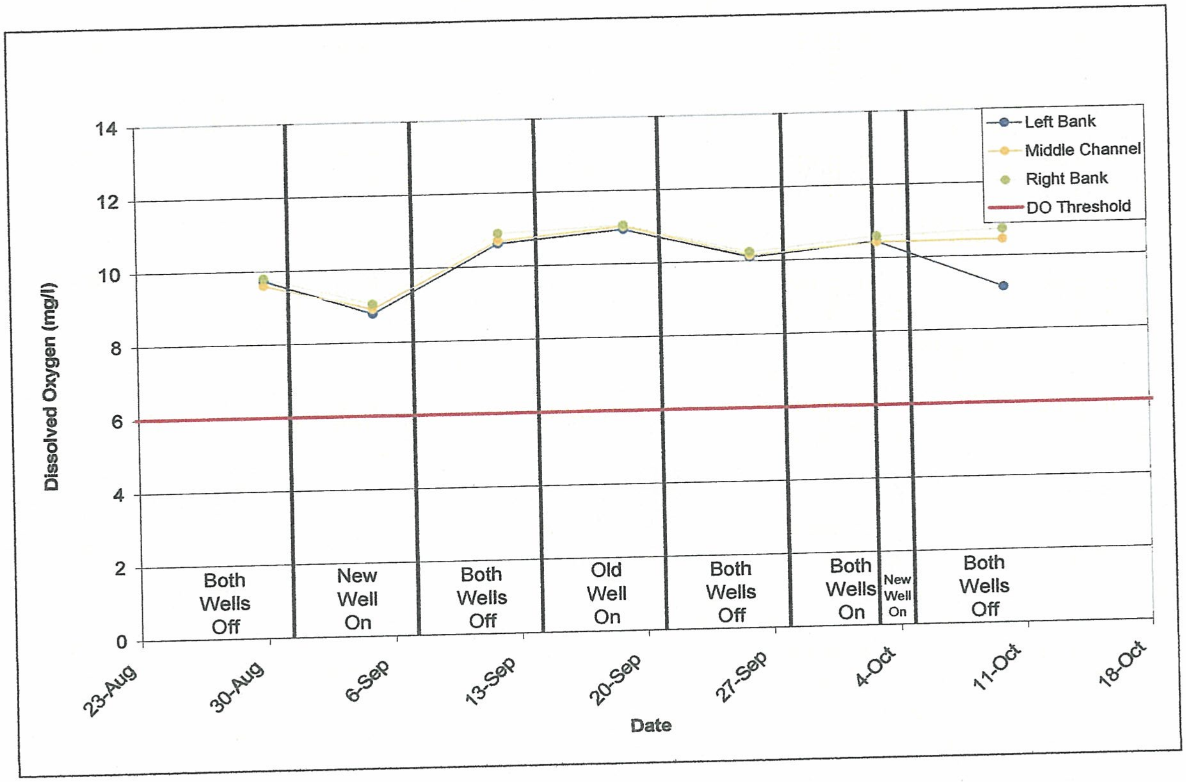

Figure 66. Dissolved oxygen concentrations measured during periodic water quality surveys in the Big Sur River during 2007 at passage transect 11.

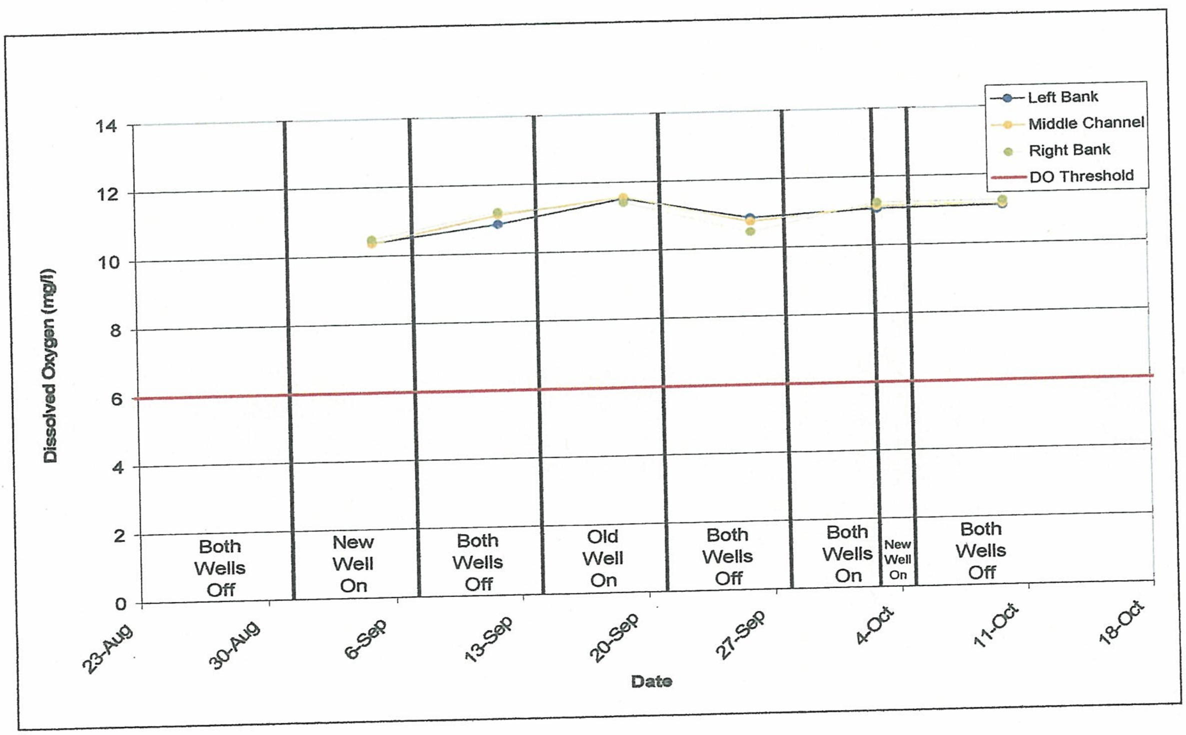

Figure 67. Dissolved oxygen concentrations measured during periodic water quality surveys in the Big Sur River during 2007 at velocity transect 1.

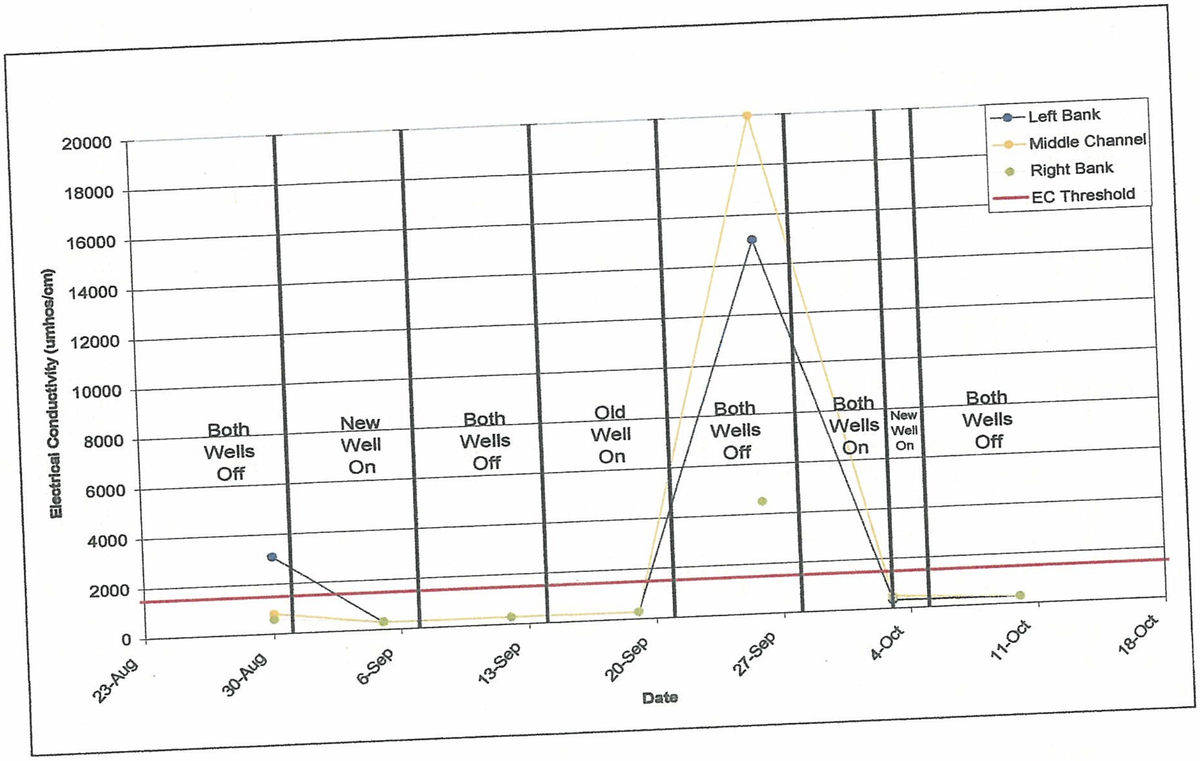

Figure 68. Electrical conductivity measured in the Big Sur River during 2007 at passage transect 1.

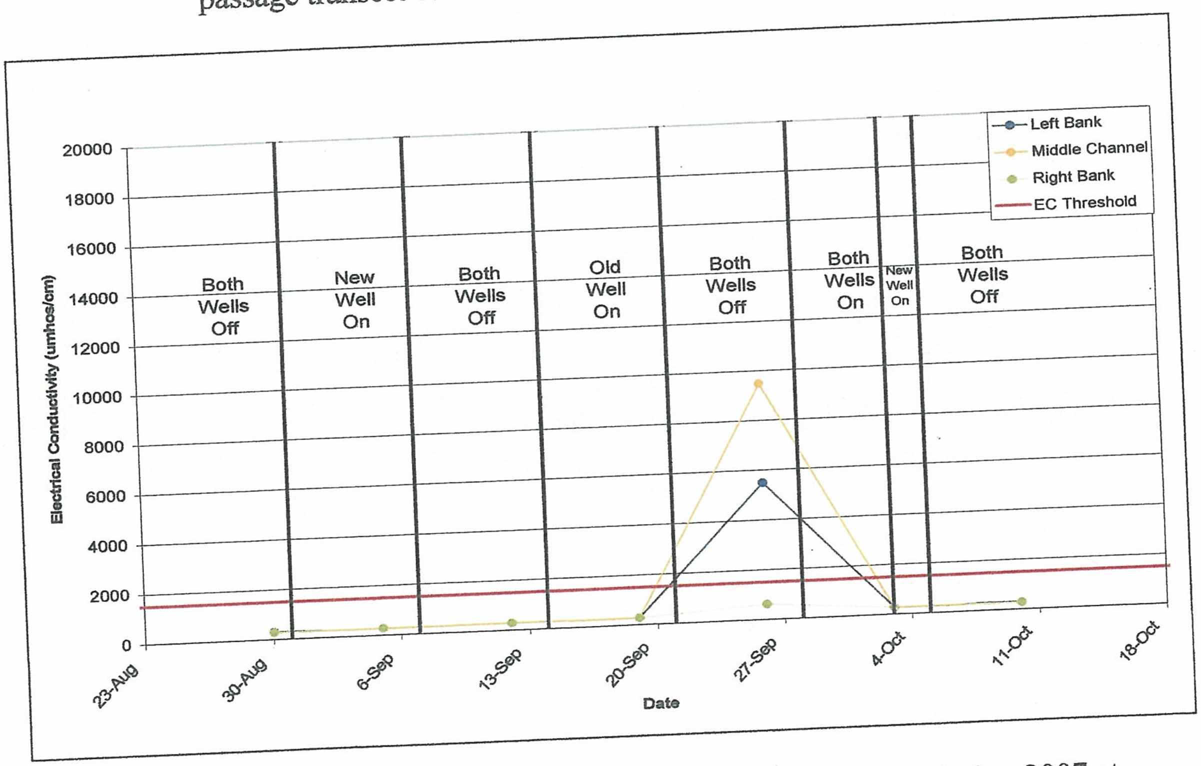

Figure 69. Electrical conductivity measured in the Big Sur River during 2007 at passage transect 2.

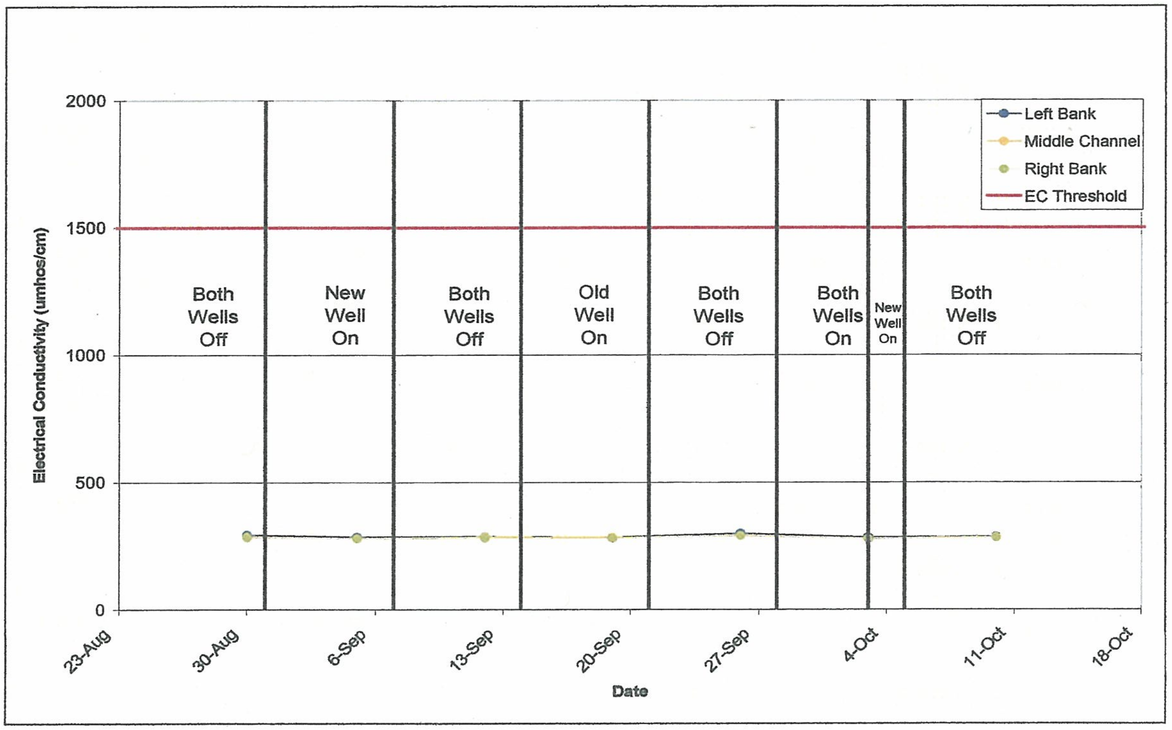

Figure 70. Electrical conductivity measured in the Big Sur River during 2007 at passage transect 3.

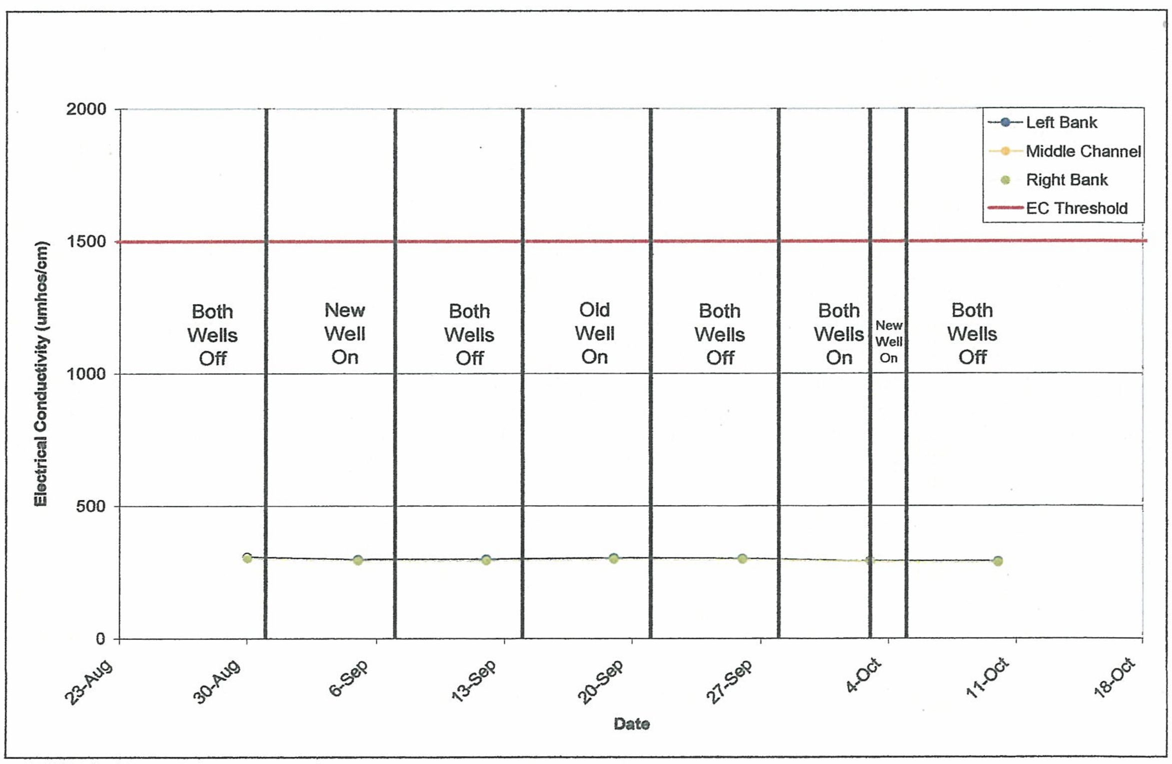

Figure 71. Electrical conductivity measured in the Big Sur River during 2007 at passage transect 4.

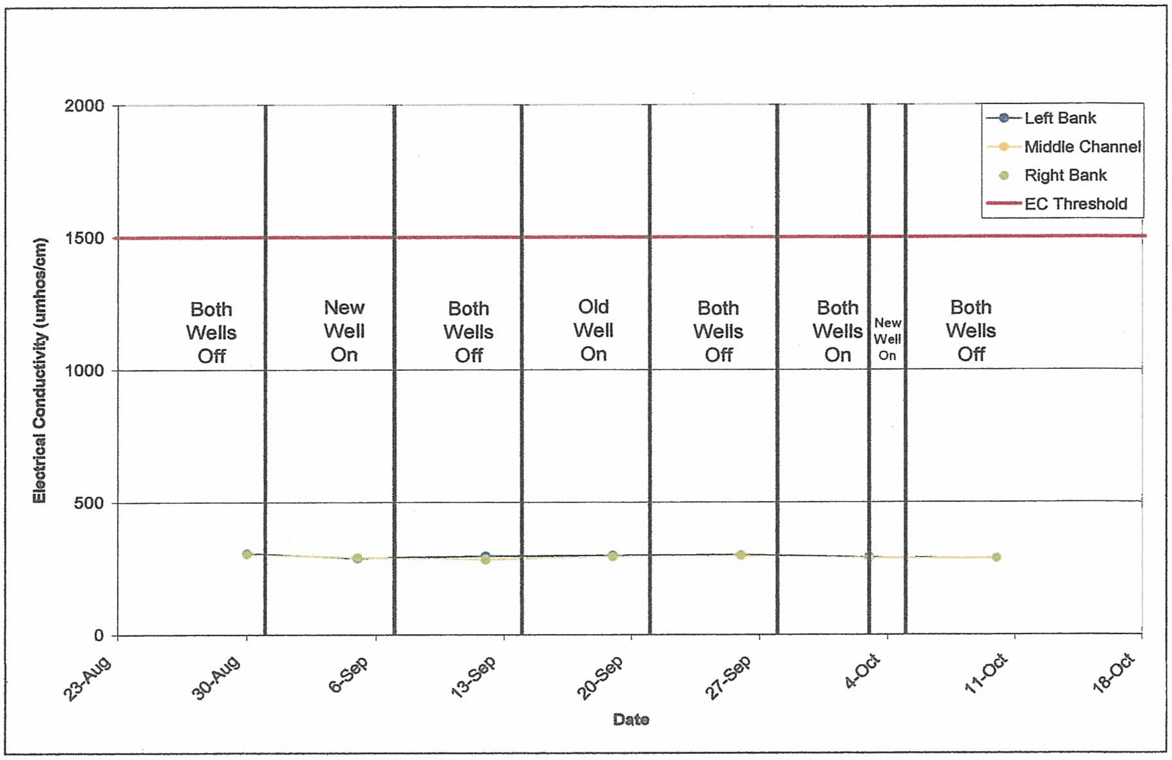

Figure 72. Electrical conductivity measured in the Big Sur River during 2007 at passage transect 5.

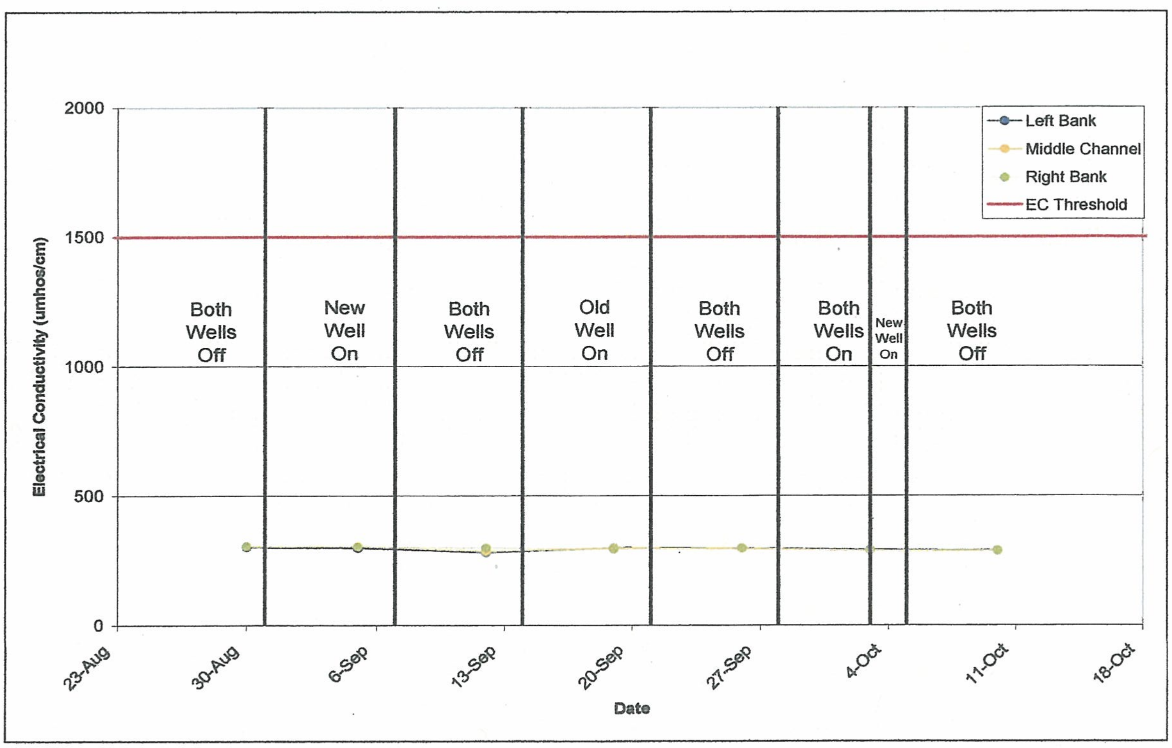

Figure 73. Electrical conductivity measured in the Big Sur River during 2007 at passage transect 6.

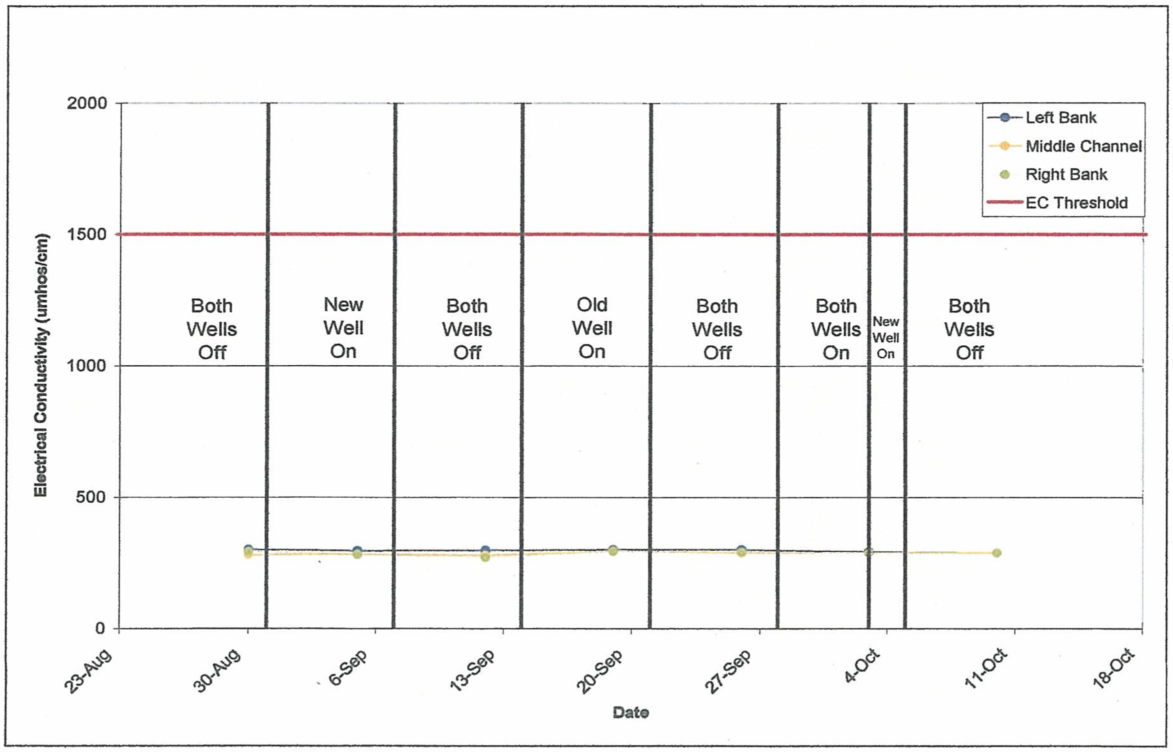

Figure 74. Electrical conductivity measured in the Big Sur River during 2007 at passage transect 7.

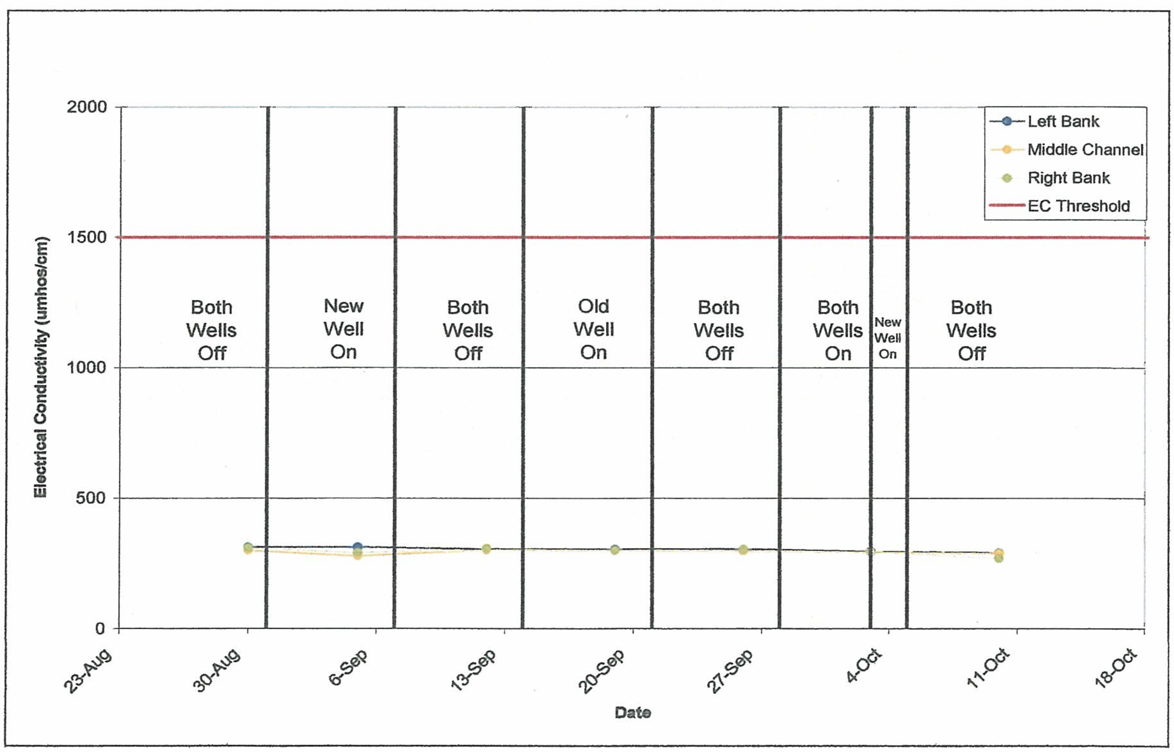

Figure 75. Electrical conductivity measured in the Big Sur River during 2007 at passage transect 8.

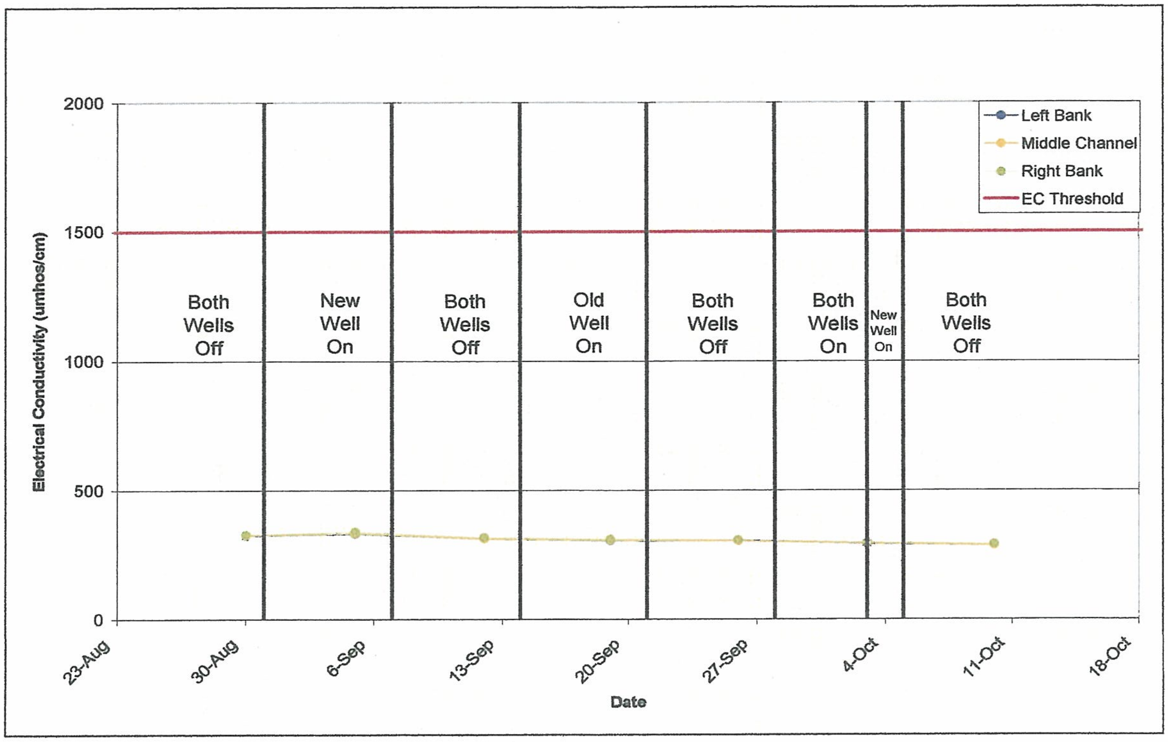

Figure 76. Electrical conductivity measured in the Big Sur River during 2007 at passage transect 9.

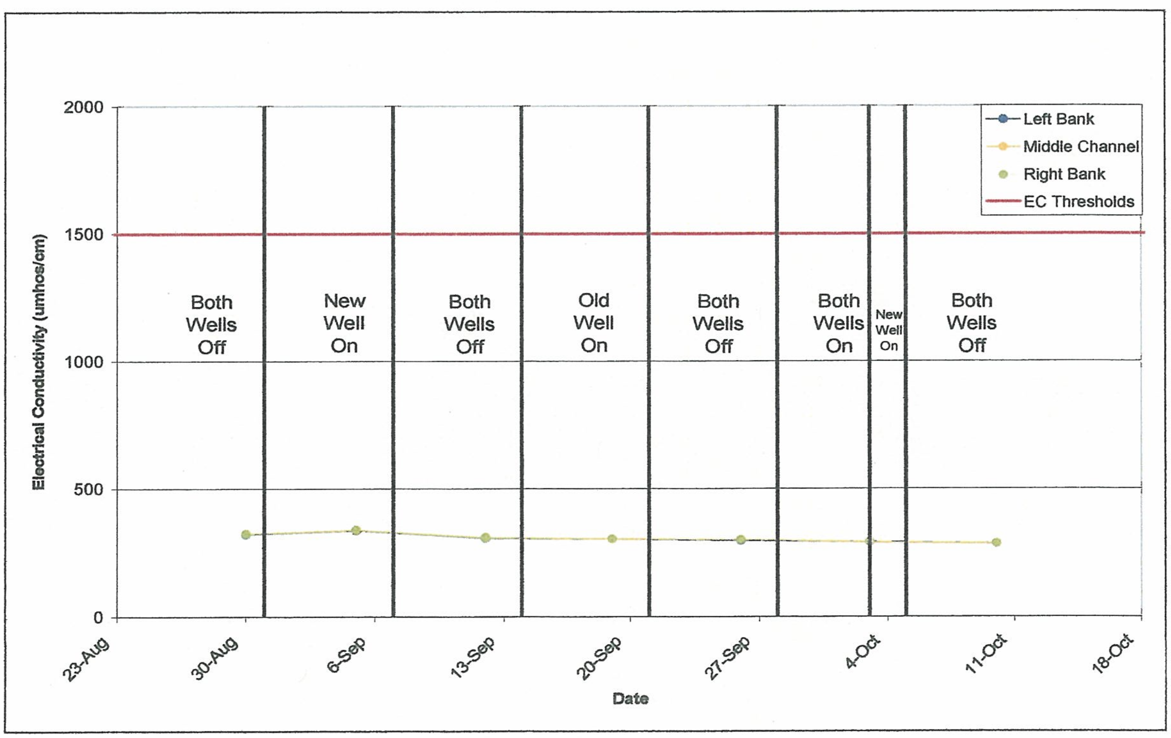

Figure 77. Electrical conductivity measured in the Big Sur River during 2007 at passage transect 10.

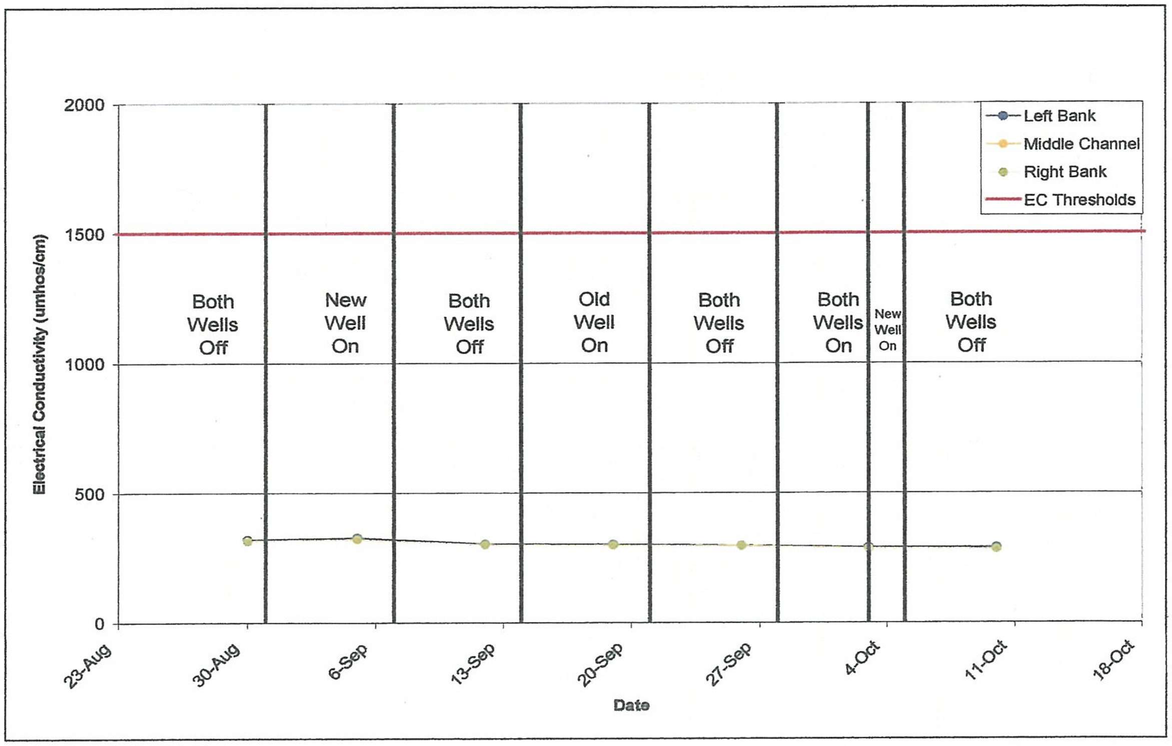

Figure 78. Electrical conductivity measured in the Big Sur River during 2007 at passage transect 11.

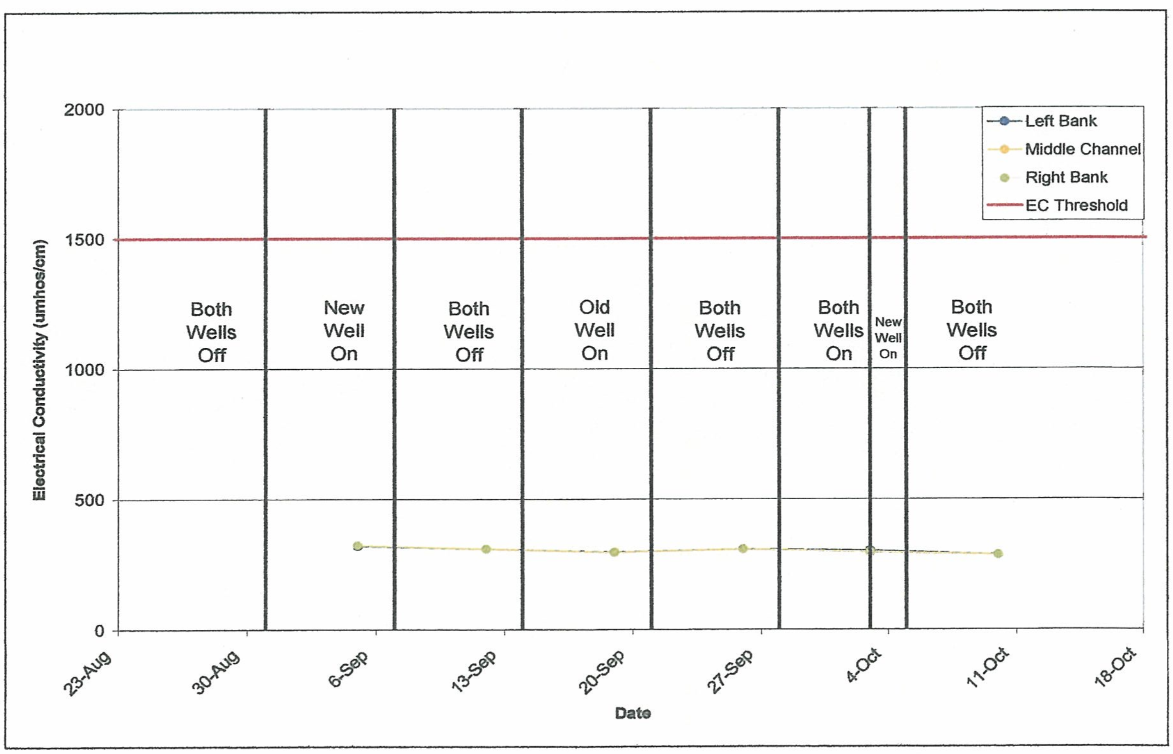

Figure 79. Electrical conductivity measured in the Big Sur River during 2007 at velocity transect 1.

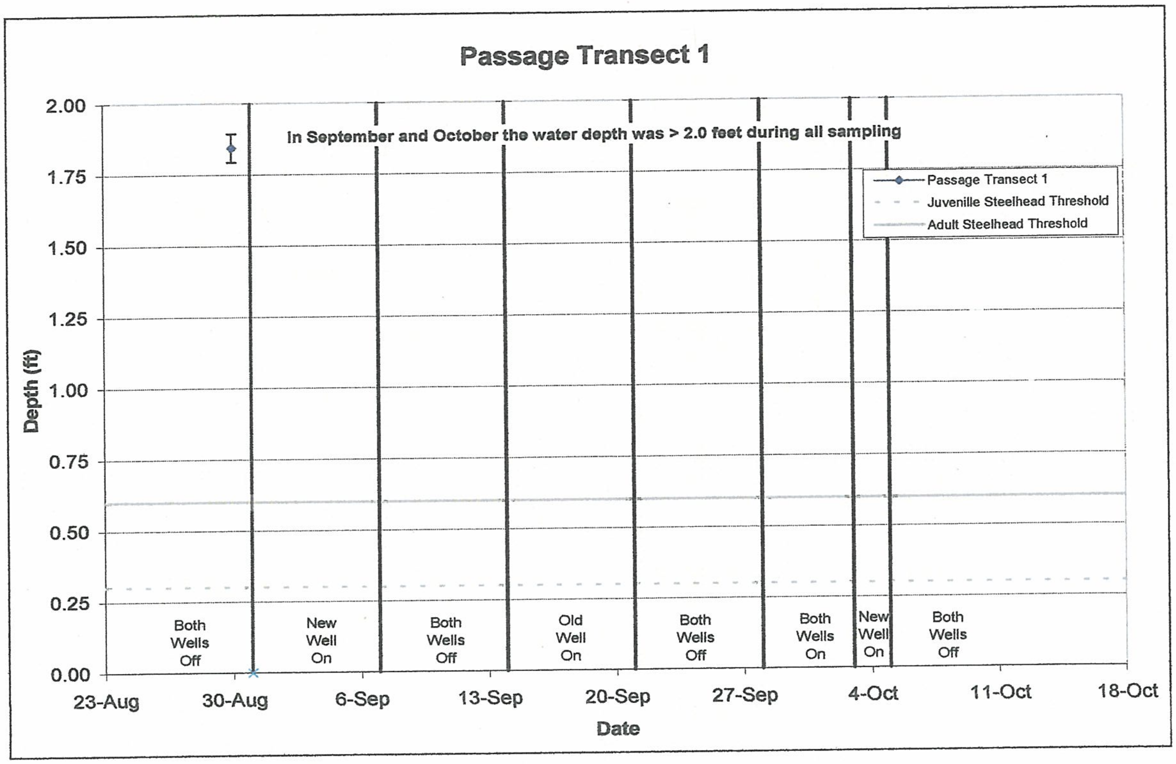

Figure 80. Average cross-sectional water depth measured in the Big Sur River during 2007 at passage transect 1.

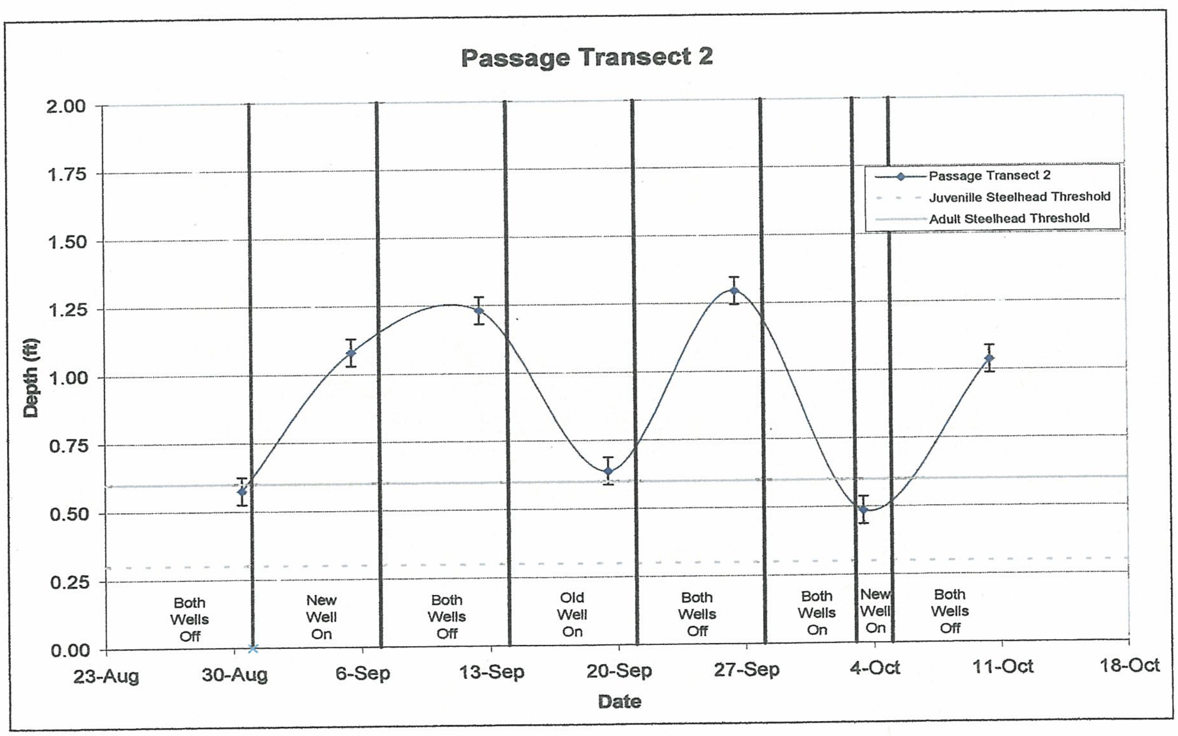

Figure 81. Average cross-sectional water depth measured in the Big Sur River during 2007 at passage transect 2.

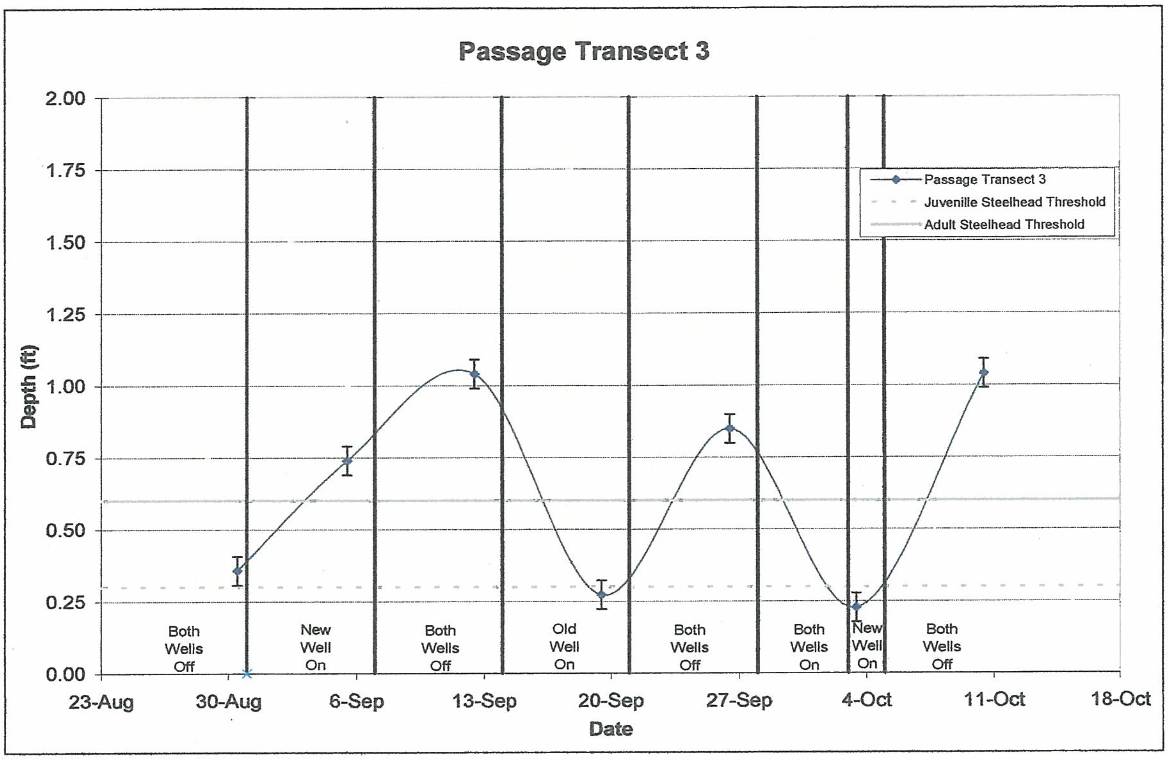

Figure 82. Average cross-sectional water depth measured in the Big Sur River during 2007 at passage transect 3.

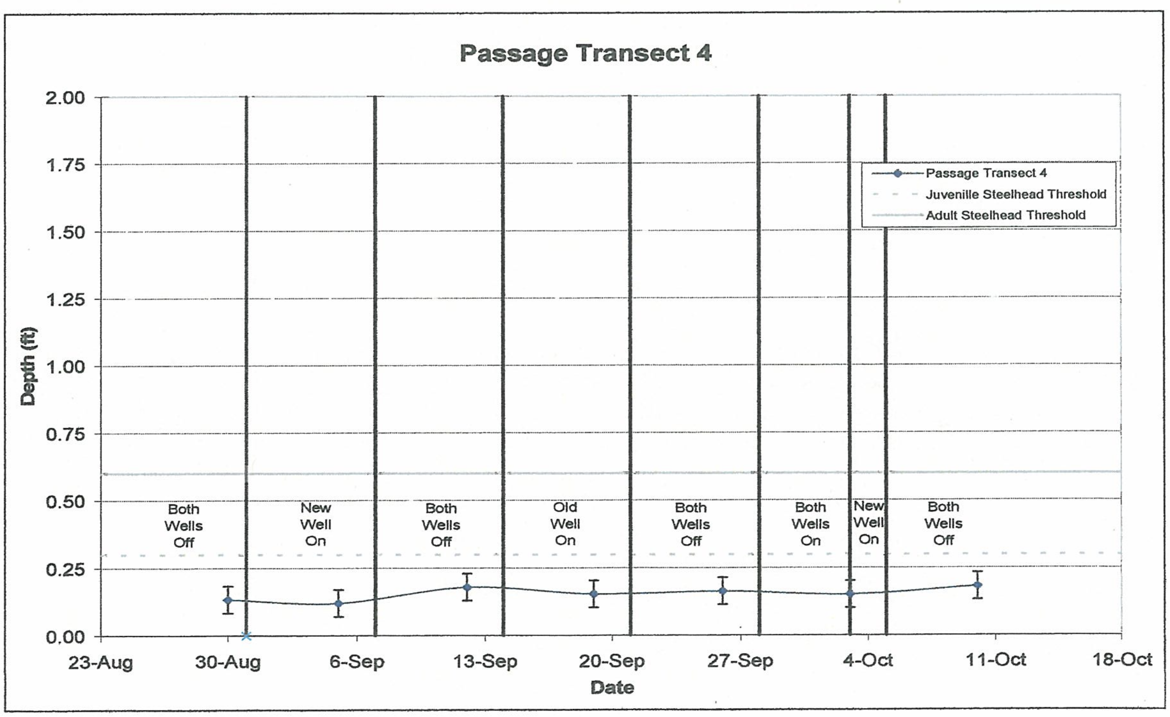

Figure 83. Average cross-sectional water depth measured in the Big Sur River during 2007 at passage transect 4.

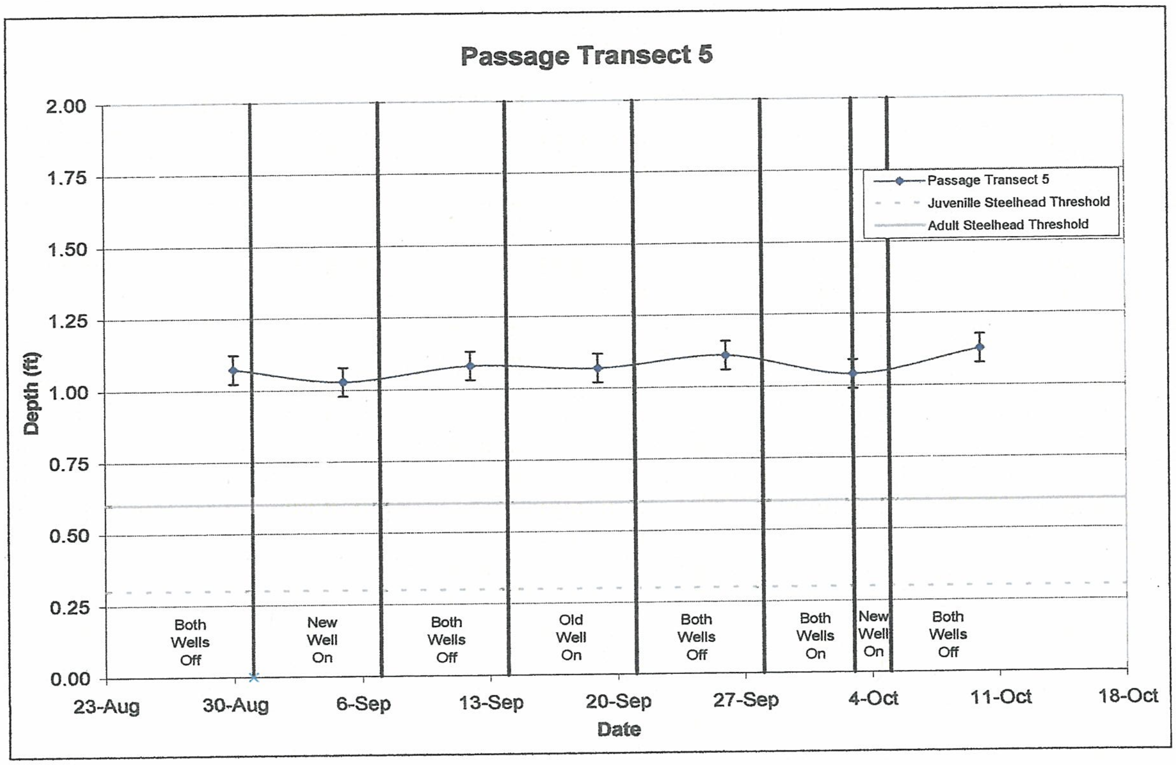

Figure 84. Average cross-sectional water depth measured in the Big Sur River during 2007 at passage transect 5.

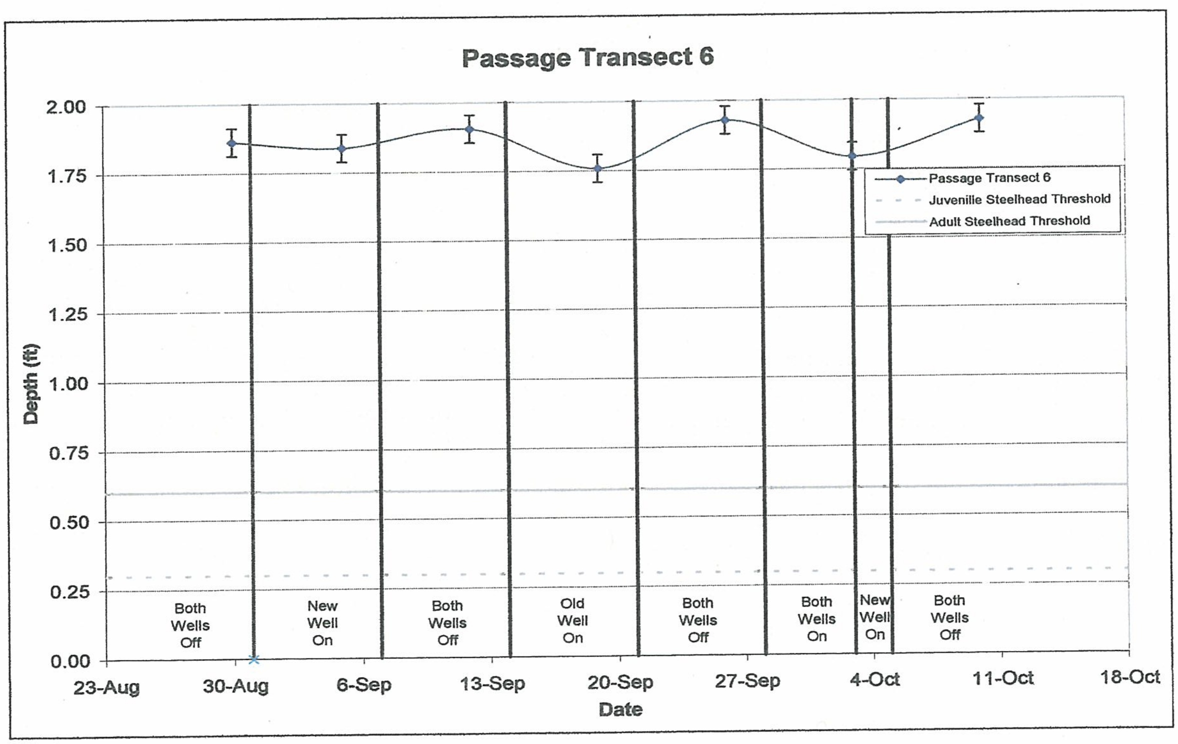

Figure 85. Average cross-sectional water depth measured in the Big Sur River during 2007 at passage transect 6.

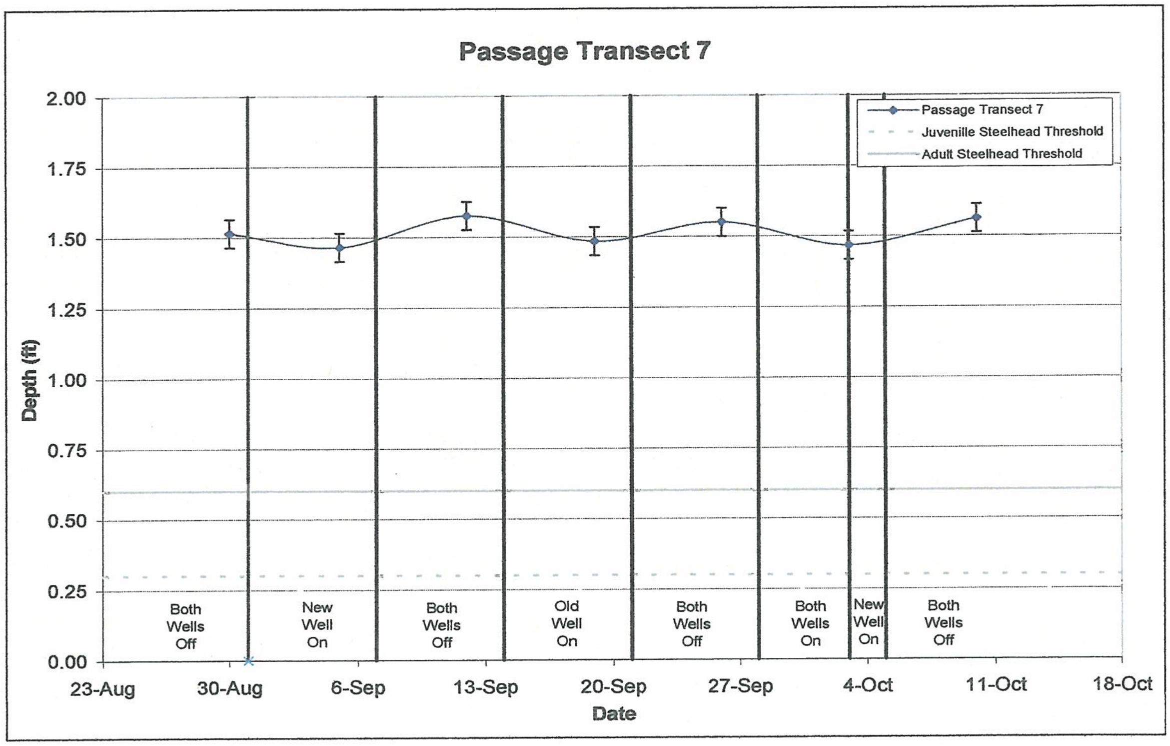

Figure 86. Average cross-sectional water depth measured in the Big Sur River during 2007 at passage transect 7.

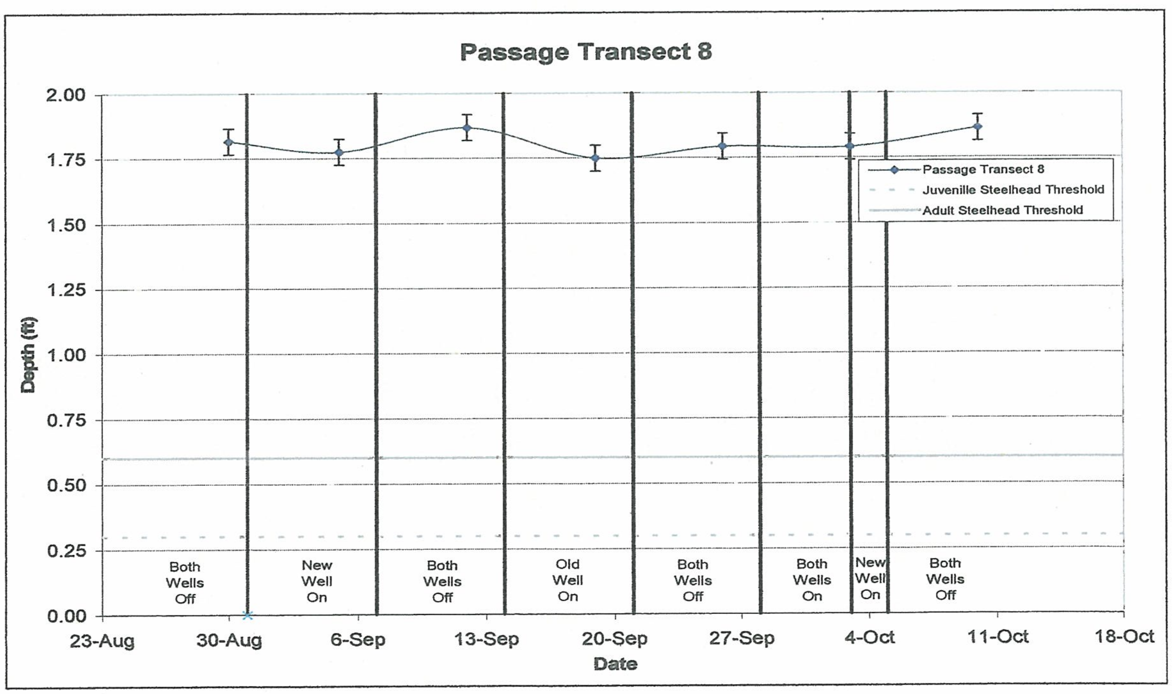

Figure 87. Average cross-sectional water depth measured in the Big Sur River during 2007 at passage transect 8.

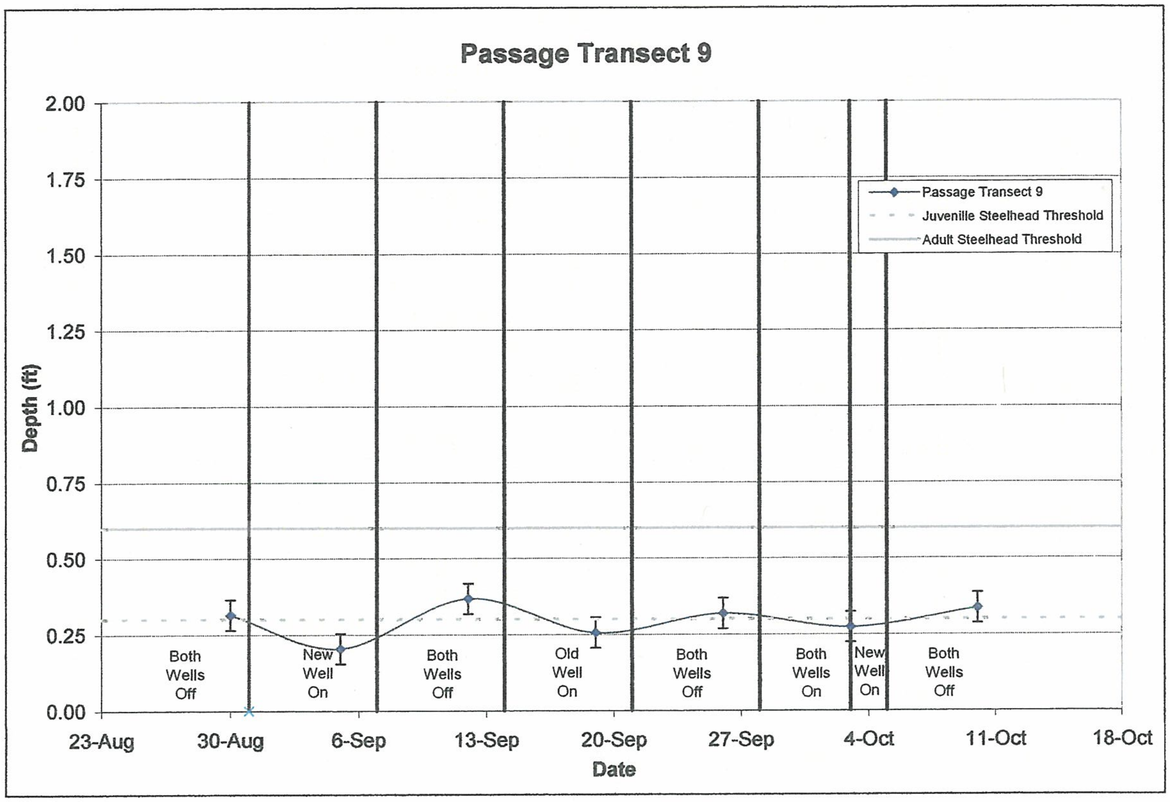

Figure 88. Average cross-sectional water depth measured in the Big Sur River during 2007 at passage transect 9.

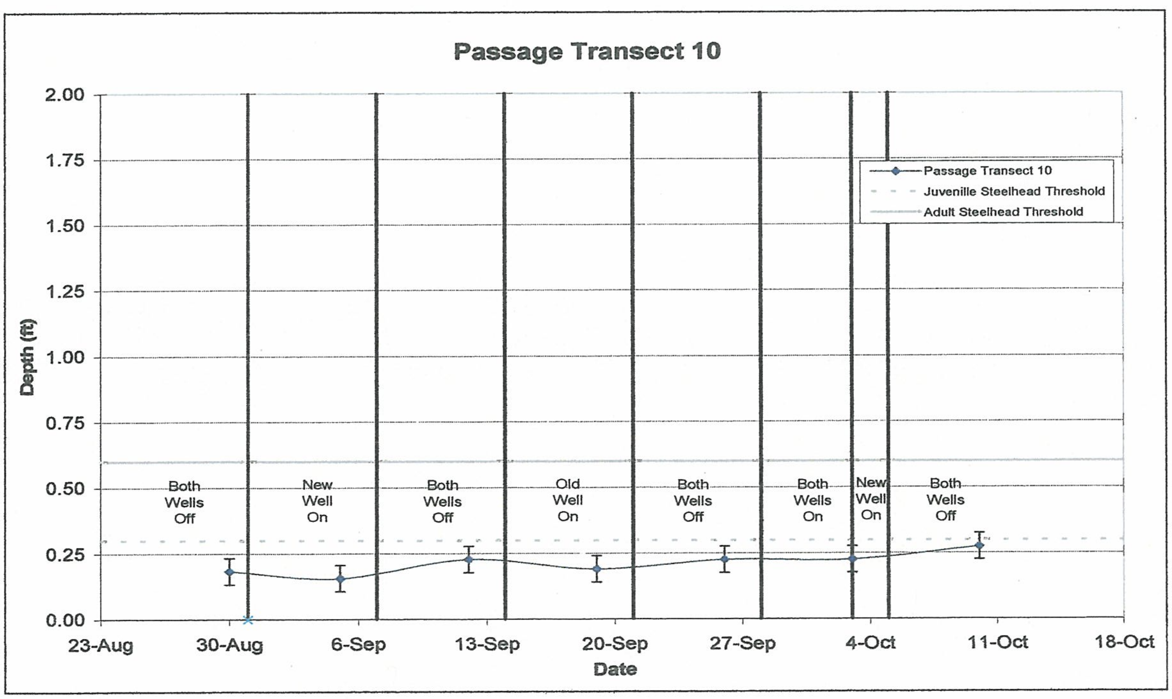

Figure 89. Average cross-sectional water depth measured in the Big Sur River during 2007 at passage transect 10.

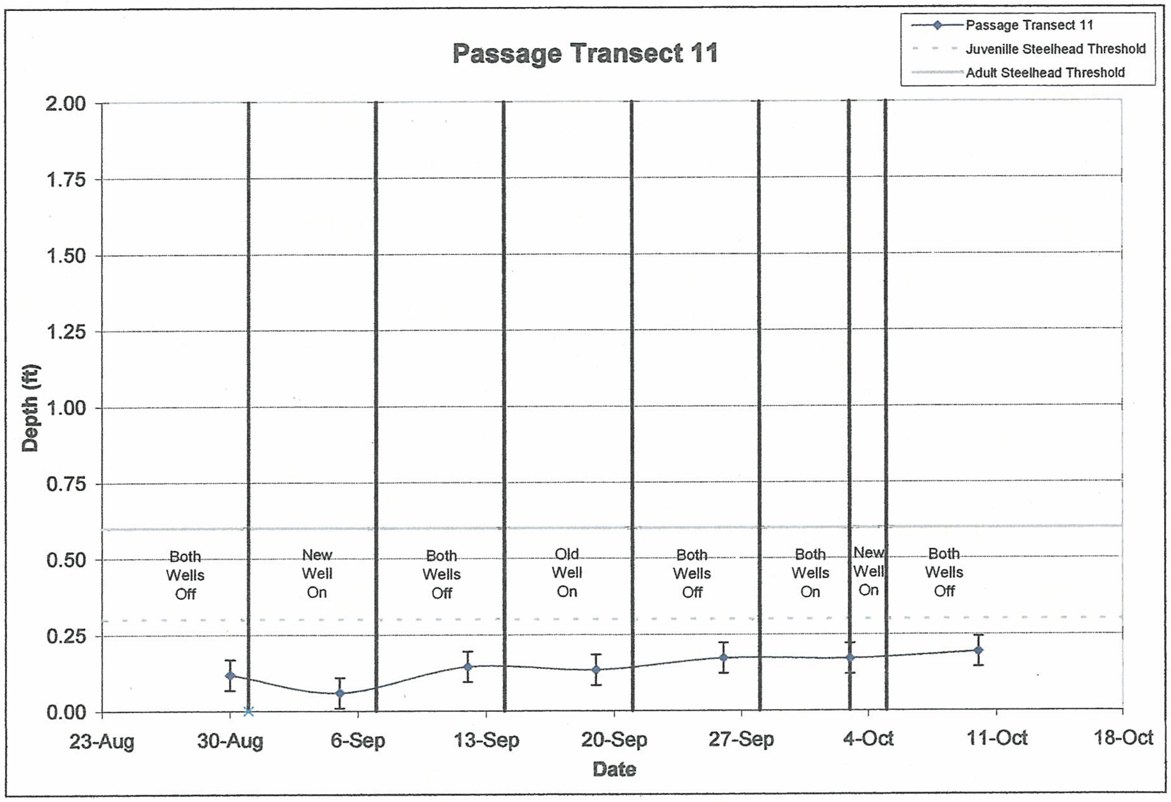

Figure 90. Average cross-sectional water depth measured in the Big Sur River during 2007 at passage transect 11.

TABLES

TABLE 1. Summary of USGS Big Sur River gauging records of average monthly river flows during April-October, 2004, 2006, and 2007 (source: USGS 2008).

AVERAGE MONTHLY FLOW (CFS)			
Month	2004	2006	2007
	Year Type		
	Dry	Wet	Critically Dry
April	50.4	751.2	24.4
May	33.7	158.2	15.8
June	23.4	72.6	11.7
July	14.6	40.5	8.6
August	12.3	26.9	7.6
September	12.2	20.6	7.5
October	13.7	20.5	9.8

TABLE 2. Summary of El Sur Ranch irrigation well operations during the 2007 study period.

Start Date	End Date	Well Operation	Water Quality Surveys*	Habitat and Passage Surveys
--	08/31/07	Both wells off	X	X
08/31/07	09/07/07	New well on	X	X
09/07/07	09/14/07	Both wells off	X	X
09/14/07	09/21/07	Old well on	X	X
09/21/07	09/28/07	Both wells off	X	X
09/28/07	10/03/07	Both wells on	X	X
10/03/07	10/05/07	New well on	X	X
10/05/07	--	Both wells off	X	X

*Temperature, electrical conductivity, and dissolved oxygen

TABLE 3. Results of habitat connectivity and passage during the 2007 study within the lower Big Sur River at passage transect 1.

Date	Flow (VT1, CFS)	Flow (VT3, CFS)	Flow (VT2, CFS)	Wetted Width	Mean Depth	Total # Cells	25% Criteria*		10% Criteria*		Meets Criteria		Pump Status
							# Cells	%	# Cells	%	25%	10%	
08/30/07	2.40	1.08	2.08	83.3	1.84	166	154	92.8%	142	85.5%	Yes	Yes	Both Wells Off
08/31/07	2.58	1.18	1.66										New Well On
09/05/07	1.62	0.35	1.34	84.2	>2	16	16	100.0%	16	100.0%	Yes	Yes	New Well On
09/06/07	1.97	0.46	1.47										New Well On
09/12/07	5.03	1.62	3.04	84	>2	Passable: Too deep to access		90.0%		90.0%	Yes	Yes	Both Wells Off
09/13/07	5.28	1.76	2.92										Both Wells Off
09/19/07	5.06	1.36	1.73	84	>2	Passable: Too deep to access		90.0%		90.0%	Yes	Yes	Old Well On
09/20/07	5.09	1.85	1.63										Old Well On
09/26/07	5.27	2.41	3.08	84	>2	Passable: Too deep to access		90.0%		90.0%	Yes	Yes	Both Wells Off
09/27/07	5.36	2.16	2.37										Both Wells Off
10/03/07	5.30	1.96	1.46	84	>2	Passable: Too deep to access		90.0%		90.0%	Yes	Yes	Both Wells On
10/04/07	5.36	1.56	1.41										New Well On
10/10/07	6.93	3.35	3.16	84	>2	Passable: Too deep to access		90.0%		90.0%	Yes	Yes	Both Wells Off
10/11/07	8.44	4.35	4.19										Both Wells Off

*25% of the channel cross-section equal to or exceeding 0.6 feet (Bjornn and Reiser 1991)
*10% contiguous section of the cross-channel having depths equal to or exceeding 0.6 feet (Bjornn and Reiser 1991)
Note: During survey of Passage Transect 1, the thalweg was consistently of a depth greater then 3.5 feet making cross channel access for survey impractical.

TABLE 4. Results of habitat connectivity and passage during the 2007 study within the lower Big Sur River at passage transect 2.

Date	Flow (VT1, CFS)	Flow (VT3, CFS)	Flow (VT2, CFS)	Wetted Width	Mean Depth	Total # Cells	25% Criteria*		10% Criteria*		Meets Criteria		Pump Status
							# Cells	%	# Cells	%	25%	10%	
08/30/07	2.40	1.08	2.08	71.9	0.57	143	87	60.8%	25	17.5%	Yes	Yes	Both Wells Off
08/31/07	2.58	1.18	1.66										New Well On
09/05/07	1.62	0.35	1.34	81	1.08	15**	13	86.7%	13	86.7%	Yes	Yes	New Well On
09/06/07	1.97	0.46	1.47										New Well On
09/12/07	5.03	1.62	3.04	98.3	1.23	143	140	97.9%	140	97.9%	Yes	Yes	Both Wells Off
09/13/07	5.28	1.76	2.92										Both Wells Off
09/19/07	5.06	1.36	1.73	68	0.64	135	101	74.8%	46	34.1%	Yes	Yes	Old Well On
09/20/07	5.09	1.85	1.63										Old Well On
09/26/07	5.27	2.41	3.08	74.3	1.30	146	142	97.3%	142	97.3%	Yes	Yes	Both Wells Off
09/27/07	5.36	2.16	2.37										Both Wells Off
10/03/07	5.30	1.96	1.46	64	0.49	127	51	40.2%	14	11.0%	Yes	Yes	Both Wells On
10/04/07	5.36	1.56	1.41										New Well On
10/10/07	6.93	3.35	3.16	82.6	1.04	165	135	81.8%	135	81.8%	Yes	Yes	Both Wells Off
10/11/07	8.44	4.35	4.19										Both Wells Off

*25% of the channel cross-section equal to or exceeding 0.6 feet (Bjornn and Reiser 1991)
*10% contiguous section of the cross-channel having depths equal to or exceeding 0.6 feet (Bjornn and Reiser 1991)
** High winds during survey on 9/5/07 mean intervals of 5ft used due to risk of surveyor tape snapping.

TABLE 5. Results of habitat connectivity and passage during the 2007 study within the lower Big Sur River at passage transect 3.

Date	Flow (VT1, CFS)	Flow (VT3, CFS)	Flow (VT2, CFS)	Wetted Width	Mean Depth	Total # Cells	25% Criteria*		10% Criteria*		Meets Criteria		Pump Status
							# Cells	%	# Cells	%	25%	10%	
08/30/07	2.40	1.08	2.08	47.2	0.36	94	5	5.3%	5	5.3%	No	No	Both Wells Off
08/31/07	2.58	1.18	1.66										New Well On
09/05/07	1.62	0.35	1.34	53.1	0.74	106	85	80.2%	74	69.8%	Yes	Yes	New Well On
09/06/07	1.97	0.46	1.47										New Well On
09/12/07	5.03	1.62	3.04	55.1	1.04	110	104	94.5%	104	94.5%	Yes	Yes	Both Wells Off
09/13/07	5.28	1.76	2.92										Both Wells Off
09/19/07	5.06	1.36	1.73	44.5	0.27	88	3	3.4%	3	3.4%	No	No	Old Well On
09/20/07	5.09	1.85	1.63										Old Well On
09/26/07	5.27	2.41	3.08	54	0.85	107	97	90.7%	96	89.7%	Yes	Yes	Both Wells Off
09/27/07	5.36	2.16	2.37										Both Wells Off
10/03/07	5.30	1.96	1.46	36	0.23	70	0	0.0%	0	0.0%	No	No	Both Wells On
10/04/07	5.36	1.56	1.41										New Well On
10/10/07	6.93	3.35	3.16	55.1	1.04	110	104	94.5%	73	66.4%	Yes	Yes	Both Wells Off
10/11/07	8.44	4.35	4.19										Both Wells Off

*25% of the channel cross-section equal to or exceeding 0.6 feet (Bjornn and Reiser 1991)
*10% contiguous section of the cross-channel having depths equal to or exceeding 0.6 feet (Bjornn and Reiser 1991)

TABLE 6. Results of habitat connectivity and passage during the 2007 study within the lower Big Sur River at passage transect 4.

Date	Flow (VT1, CFS)	Flow (VT3, CFS)	Flow (VT2, CFS)	Wetted Width	Mean Depth	Total # Cells	25% Criteria*		10% Criteria*		Meets Criteria		Pump Status
							# Cells	%	# Cells	%	25%	10%	
08/30/07	2.40	1.08	2.08	22.7	0.13	45	0	0.0%	0	0.0%	No	No	Both Wells Off
08/31/07	2.58	1.18	1.66										New Well On
09/05/07	1.62	0.35	1.34	18.6	0.12	37	0	0.0%	0	0.0%	No	No	New Well On
09/06/07	1.97	0.46	1.47										New Well On
09/12/07	5.03	1.62	3.04	25	0.18	49	0	0.0%	0	0.0%	No	No	Both Wells Off
09/13/07	5.28	1.76	2.92										Both Wells Off
09/19/07	5.06	1.36	1.73	18.6	0.15	37	0	0.0%	0	0.0%	No	No	Old Well On
09/20/07	5.09	1.85	1.63										Old Well On
09/26/07	5.27	2.41	3.08	22.7	0.16	45	0	0.0%	0	0.0%	No	No	Both Wells Off
09/27/07	5.36	2.16	2.37										Both Wells Off
10/03/07	5.30	1.96	1.46	19.2	0.15	38	0	0.0%	0	0.0%	No	No	Both Wells On
10/04/07	5.36	1.56	1.41										New Well On
10/10/07	6.93	3.35	3.16	25	0.18	49	0	0.0%	0	0.0%	No	No	Both Wells Off
10/11/07	8.44	4.35	4.19										Both Wells Off

*25% of the channel cross-section equal to or exceeding 0.6 feet (Bjornn and Reiser 1991)
*10% contiguous section of the cross-channel having depths equal to or exceeding 0.6 feet (Bjornn and Reiser 1991)

TABLE 7. Results of habitat connectivity and passage during the 2007 study within the lower Big Sur River at passage transect 4.

Date	Flow (VT1, CFS)	Flow (VT3, CFS)	Flow (VT2, CFS)	Wetted Width	Mean Depth	Total # Cells	25% Criteria*		10% Criteria*		Meets Criteria		Pump Status
							# Cells	%	# Cells	%	25%	10%	
08/30/07	2.40	1.08	2.08	22.7	0.13	45	8	17.8%	5	11.1%	No	Yes	Both Wells Off
08/31/07	2.58	1.18	1.66										New Well On
09/05/07	1.62	0.35	1.34	18.6	0.12	37	4	10.8%	2	5.4%	No	No	New Well On
09/06/07	1.97	0.46	1.47										New Well On
09/12/07	5.03	1.62	3.04	25	0.18	49	14	28.6%	10	20.4%	Yes	Yes	Both Wells Off
09/13/07	5.28	1.76	2.92										Both Wells Off
09/19/07	5.06	1.36	1.73	18.6	0.15	37	9	24.3%	4	10.8%	No	Yes	Old Well On
09/20/07	5.09	1.85	1.63										Old Well On
09/26/07	5.27	2.41	3.08	22.7	0.16	45	12	26.7%	9	20.0%	Yes	Yes	Both Wells Off
09/27/07	5.36	2.16	2.37										Both Wells Off
10/03/07	5.30	1.96	1.46	19.2	0.15	38	8	21.1%	6	15.8%	No	Yes	Both Wells On
10/04/07	5.36	1.56	1.41										New Well On
10/10/07	6.93	3.35	3.16	25	0.18	49	14	28.6%	13	26.5%	Yes	Yes	Both Wells Off
10/11/07	8.44	4.35	4.19										Both Wells Off

*25% of the channel cross-section equal to or exceeding 0.3 feet
*10% contiguous section of the cross-channel having depths equal to or exceeding 0.3 feet

TABLE 8. Results of habitat connectivity and passage during the 2007 study within the lower Big Sur River at passage transect 5.

Date	Flow (VT1, CFS)	Flow (VT3, CFS)	Flow (VT2, CFS)	Wetted Width	Mean Depth	Total # Cells	25% Criteria*		10% Criteria*		Meets Criteria		Pump Status
							# Cells	%	# Cells	%	25%	10%	
08/30/07	2.40	1.08	2.08	45.8	1.07	91	81	89.0%	81	89.0%	Yes	Yes	Both Wells Off
08/31/07	2.58	1.18	1.66										New Well On
09/05/07	1.62	0.35	1.34	45.2	1.03	90	79	87.8%	79	87.8%	Yes	Yes	New Well On
09/06/07	1.97	0.46	1.47										New Well On
09/12/07	5.03	1.62	3.04	46.9	1.08	91	80	87.9%	80	87.9%	Yes	Yes	Both Wells Off
09/13/07	5.28	1.76	2.92										Both Wells Off
09/19/07	5.06	1.36	1.73	45.6	1.07	91	81	89.0%	81	89.0%	Yes	Yes	Old Well On
09/20/07	5.09	1.85	1.63										Old Well On
09/26/07	5.27	2.41	3.08	46.2	1.11	92	83	90.2%	83	90.2%	Yes	Yes	Both Wells Off
09/27/07	5.36	2.16	2.37										Both Wells Off
10/03/07	5.30	1.96	1.46	45.4	1.04	90	80	88.9%	80	88.9%	Yes	Yes	Both Wells On
10/04/07	5.36	1.56	1.41										New Well On
10/10/07	6.93	3.35	3.16	46.7	1.13	93	82	88.2%	79	84.9%	Yes	Yes	Both Wells Off
10/11/07	8.44	4.35	4.19										Both Wells Off

*25% of the channel cross-section equal to or exceeding 0.6 feet (Bjornn and Reiser 1991)
*10% contiguous section of the cross-channel having depths equal to or exceeding 0.6 feet (Bjornn and Reiser 1991)

TABLE 9. Results of habitat connectivity and passage during the 2007 study within the lower Big Sur River at passage transect 6.

Date	Flow (VT1, CFS)	Flow (VT3, CFS)	Flow (VT2, CFS)	Wetted Width	Mean Depth	Total # Cells	25% Criteria*		10% Criteria*		Meets Criteria		Pump Status
							# Cells	%	# Cells	%	25%	10%	
08/30/07	2.40	1.08	2.08	38.5	1.86	76	69	90.8%	69	90.8%	Yes	Yes	Both Wells Off
08/31/07	2.58	1.18	1.66										New Well On
09/05/07	1.62	0.35	1.34	38.1	1.84	76	73	96.1%	73	96.1%	Yes	Yes	New Well On
09/06/07	1.97	0.46	1.47										New Well On
09/12/07	5.03	1.62	3.04	38.6	1.90	76	72	94.7%	72	94.7%	Yes	Yes	Both Wells Off
09/13/07	5.28	1.76	2.92										Both Wells Off
09/19/07	5.06	1.36	1.73	38.2	1.76	76	69	90.8%	61	80.3%	Yes	Yes	Old Well On
09/20/07	5.09	1.85	1.63										Old Well On
09/26/07	5.27	2.41	3.08	38.5	1.93	76	73	96.1%	73	96.1%	Yes	Yes	Both Wells Off
09/27/07	5.36	2.16	2.37										Both Wells Off
10/03/07	5.30	1.96	1.46	37.8	1.79	75	73	97.3%	73	97.3%	Yes	Yes	Both Wells On
10/04/07	5.36	1.56	1.41										New Well On
10/10/07	6.93	3.35	3.16	38.3	1.93	76	73	96.1%	73	96.1%	Yes	Yes	Both Wells Off
10/11/07	8.44	4.35	4.19										Both Wells Off

*25% of the channel cross-section equal to or exceeding 0.6 feet (Bjornn and Reiser 1991)
*10% contiguous section of the cross-channel having depths equal to or exceeding 0.6 feet (Bjornn and Reiser 1991)

TABLE 10. Results of habitat connectivity and passage during the 2007 study within the lower Big Sur River at passage transect 7.

Date	Flow (VT1, CFS)	Flow (VT3, CFS)	Flow (VT2, CFS)	Wetted Width	Mean Depth	Total # Cells	25% Criteria*		10% Criteria*		Meets Criteria		Pump Status
							# Cells	%	# Cells	%	25%	10%	
08/30/07	2.40	1.08	2.08	41.9	1.52	83	80	96.4%	80	96.4%	Yes	Yes	Both Wells Off
08/31/07	2.58	1.18	1.66										New Well On
09/05/07	1.62	0.35	1.34	41	1.46	82	80	97.6%	80	97.6%	Yes	Yes	New Well On
09/06/07	1.97	0.46	1.47										New Well On
09/12/07	5.03	1.62	3.04	41.5	1.58	83	81	97.6%	81	97.6%	Yes	Yes	Both Wells Off
09/13/07	5.28	1.76	2.92										Both Wells Off
09/19/07	5.06	1.36	1.73	41.5	1.48	83	80	96.4%	80	96.4%	Yes	Yes	Old Well On
09/20/07	5.09	1.85	1.63										Old Well On
09/26/07	5.27	2.41	3.08	41.5	1.55	83	81	97.6%	81	97.6%	Yes	Yes	Both Wells Off
09/27/07	5.36	2.16	2.37										Both Wells Off
10/03/07	5.30	1.96	1.46	41.4	1.47	82	79	96.3%	79	96.3%	Yes	Yes	Both Wells On
10/04/07	5.36	1.56	1.41										New Well On
10/10/07	6.93	3.35	3.16	41.7	1.56	83	81	97.6%	81	97.6%	Yes	Yes	Both Wells Off
10/11/07	8.44	4.35	4.19										Both Wells Off

*25% of the channel cross-section equal to or exceeding 0.6 feet (Bjornn and Reiser 1991)
*10% contiguous section of the cross-channel having depths equal to or exceeding 0.6 feet (Bjornn and Reiser 1991)

TABLE 11. Results of habitat connectivity and passage during the 2007 study within the lower Big Sur River at passage transect 8.

Date	Flow (VT1, CFS)	Flow (VT3, CFS)	Flow (VT2, CFS)	Wetted Width	Mean Depth	Total # Cells	25% Criteria*		10% Criteria*		Meets Criteria		Pump Status
							# Cells	%	# Cells	%	25%	10%	
08/30/07	2.40	1.08	2.08	39.5	1.82	79	67	84.8%	67	84.8%	Yes	Yes	Both Wells Off
08/31/07	2.58	1.18	1.66										New Well On
09/05/07	1.62	0.35	1.34	38.6	1.77	77	67	87.0%	67	87.0%	Yes	Yes	New Well On
09/06/07	1.97	0.46	1.47										New Well On
09/12/07	5.03	1.62	3.04	39.5	1.87	79	67	84.8%	67	84.8%	Yes	Yes	Both Wells Off
09/13/07	5.28	1.76	2.92										Both Wells Off
09/19/07	5.06	1.36	1.73	39.6	1.75	79	66	83.5%	66	83.5%	Yes	Yes	Old Well On
09/20/07	5.09	1.85	1.63										Old Well On
09/26/07	5.27	2.41	3.08	40.1	1.79	80	67	83.8%	67	83.8%	Yes	Yes	Both Wells Off
09/27/07	5.36	2.16	2.37										Both Wells Off
10/03/07	5.30	1.96	1.46	39.1	1.79	78	68	87.2%	68	87.2%	Yes	Yes	Both Wells On
10/04/07	5.36	1.56	1.41										New Well On
10/10/07	6.93	3.35	3.16	39.8	1.86	79	69	87.3%	69	87.3%	Yes	Yes	Both Wells Off
10/11/07	8.44	4.35	4.19										Both Wells Off

*25% of the channel cross-section equal to or exceeding 0.6 feet (Bjornn and Reiser 1991)
*10% contiguous section of the cross-channel having depths equal to or exceeding 0.6 feet (Bjornn and Reiser 1991)

TABLE 12. Results of adult habitat connectivity and passage during the 2007 study within the lower Big Sur River at passage transect 9.

Date	Flow (VT1, CFS)	Flow (VT3, CFS)	Flow (VT2, CFS)	Wetted Width	Mean Depth	Total # Cells	25% Criteria*		10% Criteria*		Meets Criteria		Pump Status
							# Cells	%	# Cells	%	25%	10%	
08/30/07	2.40	1.08	2.08	11.7	0.31	23	0	0.0%	0	0.0%	No	No	Both Wells Off
08/31/07	2.58	1.18	1.66										New Well On
09/05/07	1.62	0.35	1.34	11.7	0.20	23	0	0.0%	0	0.0%	No	No	New Well On
09/06/07	1.97	0.46	1.47										New Well On
09/12/07	5.03	1.62	3.04	12.4	0.37	24	0	0.0%	0	0.0%	No	No	Both Wells Off
09/13/07	5.28	1.76	2.92										Both Wells Off
09/19/07	5.06	1.36	1.73	11.3	0.26	22	0	0.0%	0	0.0%	No	No	Old Well On
09/20/07	5.09	1.85	1.63										Old Well On
09/26/07	5.27	2.41	3.08	12.3	0.32	24	0	0.0%	0	0.0%	No	No	Both Wells Off
09/27/07	5.36	2.16	2.37										Both Wells Off
10/03/07	5.30	1.96	1.46	10.9	0.27	21	0	0.0%	0	0.0%	No	No	Both Wells On
10/04/07	5.36	1.56	1.41										New Well On
10/10/07	6.93	3.35	3.16	12.7	0.34	25	0	0.0%	0	0.0%	No	No	Both Wells Off
10/11/07	8.44	4.35	4.19										Both Wells Off

*25% of the channel cross-section equal to or exceeding 0.6 feet (Bjornn and Reiser 1991)
*10% contiguous section of the cross-channel having depths equal to or exceeding 0.6 feet (Bjornn and Reiser 1991)

TABLE 13. Results of juvenile habitat connectivity and passage during the 2007 study within the lower Big Sur River at passage transect 9.

Date	Flow (VT1, CFS)	Flow (VT3, CFS)	Flow (VT2, CFS)	Wetted Width	Mean Depth	Total # Cells	25% Criteria*		10% Criteria*		Meets Criteria		Pump Status
							# Cells	%	# Cells	%	25%	10%	
08/30/07	2.40	1.08	2.08	11.7	0.31	23	17	73.9%	4	17.4%	Yes	Yes	Both Wells Off
08/31/07	2.58	1.18	1.66										New Well On
09/05/07	1.62	0.35	1.34	11.7	0.20	23	6	26.1%	4	17.4%	Yes	Yes	New Well On
09/06/07	1.97	0.46	1.47										New Well On
09/12/07	5.03	1.62	3.04	12.4	0.37	24	20	83.3%	20	83.3%	Yes	Yes	Both Wells Off
09/13/07	5.28	1.76	2.92										Both Wells Off
09/19/07	5.06	1.36	1.73	11.3	0.26	22	14	63.6%	6	27.3%	Yes	Yes	Old Well On
09/20/07	5.09	1.85	1.63										Old Well On
09/26/07	5.27	2.41	3.08	12.3	0.32	24	18	75.0%	17	70.8%	Yes	Yes	Both Wells Off
09/27/07	5.36	2.16	2.37										Both Wells Off
10/03/07	5.30	1.96	1.46	10.9	0.27	21	16	76.2%	6	28.6%	Yes	Yes	Both Wells On
10/04/07	5.36	1.56	1.41										New Well On
10/10/07	6.93	3.35	3.16	12.7	0.34	25	20	80.0%	12	48.0%	Yes	Yes	Both Wells Off
10/11/07	8.44	4.35	4.19										Both Wells Off

*25% of the channel cross-section equal to or exceeding 0.3 feet
*10% contiguous section of the cross-channel having depths equal to or exceeding 0.3 feet

TABLE 14. Results of adult habitat connectivity and passage during the 2007 study within the lower Big Sur River at passage transect 10.

Date	Flow (VT1, CFS)	Flow (VT3, CFS)	Flow (VT2, CFS)	Wetted Width	Mean Depth	Total # Cells	25% Criteria*		10% Criteria*		Meets Criteria		Pump Status
							# Cells	%	# Cells	%	25%	10%	
08/30/07	2.40	1.08	2.08	16.1	0.18	32	0	0.0%	0	0.0%	No	No	Both Wells Off
08/31/07	2.58	1.18	1.66										New Well On
09/05/07	1.62	0.35	1.34	10.4	0.16	20	0	0.0%	0	0.0%	No	No	New Well On
09/06/07	1.97	0.46	1.47										New Well On
09/12/07	5.03	1.62	3.04	16.1	0.23	32	0	0.0%	0	0.0%	No	No	Both Wells Off
09/13/07	5.28	1.76	2.92										Both Wells Off
09/19/07	5.06	1.36	1.73	15.8	0.19	30	1	3.2%	1	3.3%	No	No	Old Well On
09/20/07	5.09	1.85	1.63										Old Well On
09/26/07	5.27	2.41	3.08	16.1	0.23	32	0	0.0%	0	0.0%	No	No	Both Wells Off
09/27/07	5.36	2.16	2.37										Both Wells Off
10/03/07	5.30	1.96	1.46	15.9	0.23	31	0	0.0%	0	0.0%	No	No	Both Wells On
10/04/07	5.36	1.56	1.41										New Well On
10/10/07	6.93	3.35	3.16	17.1	0.28	34	1	2.9%	1	2.9%	No	No	Both Wells Off
10/11/07	8.44	4.35	4.19										Both Wells Off

*25% of the channel cross-section equal to or exceeding 0.6 feet (Bjornn and Reiser 1991)
*10% contiguous section of the cross-channel having depths equal to or exceeding 0.6 feet (Bjornn and Reiser 1991)

TABLE 15. Results of juvenile habitat connectivity and passage during the 2007 study within the lower Big Sur River at passage transect 10.

Date	Flow (VT1, CFS)	Flow (VT3, CFS)	Flow (VT2, CFS)	Wetted Width	Mean Depth	Total # Cells	25% Criteria*		10% Criteria*		Meets Criteria		Pump Status
							# Cells	%	# Cells	%	25%	10%	
08/30/07	2.40	1.08	2.08	16.1	0.18	32	8	25.0%	3	9.4%	Yes	No	Both Wells Off
08/31/07	2.58	1.18	1.66										New Well On
09/05/07	1.62	0.35	1.34	10.4	0.16	20	2	10.0%	1	5.0%	No	No	New Well On
09/06/07	1.97	0.46	1.47										New Well On
09/12/07	5.03	1.62	3.04	16.1	0.23	32	13	40.6%	8	25.0%	Yes	Yes	Both Wells Off
09/13/07	5.28	1.76	2.92										Both Wells Off
09/19/07	5.06	1.36	1.73	15.8	0.19	30	9	30.0%	3	10.0%	Yes	Yes	Old Well On
09/20/07	5.09	1.85	1.63										Old Well On
09/26/07	5.27	2.41	3.08	16.1	0.23	32	14	43.8%	10	31.3%	Yes	Yes	Both Wells Off
09/27/07	5.36	2.16	2.37										Both Wells Off
10/03/07	5.30	1.96	1.46	15.9	0.23	31	13	41.9%	9	29.0%	Yes	Yes	Both Wells On
10/04/07	5.36	1.56	1.41										New Well On
10/10/07	6.93	3.35	3.16	17.1	0.28	34	17	50.0%	13	38.2%	Yes	Yes	Both Wells Off
10/11/07	8.44	4.35	4.19										Both Wells Off

*25% of the channel cross-section equal to or exceeding 0.3 feet
*10% contiguous section of the cross-channel having depths equal to or exceeding 0.3 feet

TABLE 16. Results of adult habitat connectivity and passage during the 2007 study within the lower Big Sur River at passage transect 11.

Date	Flow (VT1, CFS)	Flow (VT3, CFS)	Flow (VT2, CFS)	Wetted Width	Mean Depth	Total # Cells	25% Criteria*		10% Criteria*		Meets Criteria		Pump Status
							# Cells	%	# Cells	%	25%	10%	
08/30/07	2.40	1.08	2.08	30.6	0.12	31	0	0.0%	0	0.0%	No	No	Both Wells Off
08/31/07	2.58	1.18	1.66										New Well On
09/05/07	1.62	0.35	1.34	29.7	0.06	59	0	0.0%	0	0.0%	No	No	New Well On
09/06/07	1.97	0.46	1.47										New Well On
09/12/07	5.03	1.62	3.04	30.6	0.15	61	0	0.0%	0	0.0%	No	No	Both Wells Off
09/13/07	5.28	1.76	2.92										Both Wells Off
09/19/07	5.06	1.36	1.73	30.2	0.13	60	0	0.0%	0	0.0%	No	No	Old Well On
09/20/07	5.09	1.85	1.63										Old Well On
09/26/07	5.27	2.41	3.08	30.1	0.17	60	0	0.0%	0	0.0%	No	No	Both Wells Off
09/27/07	5.36	2.16	2.37										Both Wells Off
10/03/07	5.30	1.96	1.46	29.8	0.17	59	0	0.0%	0	0.0%	No	No	Both Wells On
10/04/07	5.36	1.56	1.41										New Well On
10/10/07	6.93	3.35	3.16	30.8	0.19	61	0	0.0%	0	0.0%	No	No	Both Wells Off
10/11/07	8.44	4.35	4.19										Both Wells Off

*25% of the channel cross-section equal to or exceeding 0.6 feet (Bjornn and Reiser 1991)
*10% contiguous section of the cross-channel having depths equal to or exceeding 0.6 feet (Bjornn and Reiser 1991)

TABLE 17. Results of juvenile habitat connectivity and passage during the 2007 study within the lower Big Sur River at passage transect 11.

Date	Flow (VT1, CFS)	Flow (VT3, CFS)	Flow (VT2, CFS)	Wetted Width	Mean Depth	Total # Cells	25% Criteria*		10% Criteria*		Meets Criteria		Pump Status
							# Cells	%	# Cells	%	25%	10%	
08/30/07	2.40	1.08	2.08	30.6	0.12	31	1	3.2%	1	3.2%	No	No	Both Wells Off
08/31/07	2.58	1.18	1.66										New Well On
09/05/07	1.62	0.35	1.34	29.7	0.06	59	0	0.0%	0	0.0%	No	No	New Well On
09/06/07	1.97	0.46	1.47										New Well On
09/12/07	5.03	1.62	3.04	30.6	0.15	61	5	8.2%	2	3.3%	No	No	Both Wells Off
09/13/07	5.28	1.76	2.92										Both Wells Off
09/19/07	5.06	1.36	1.73	30.2	0.13	60	5	8.3%	2	3.3%	No	No	Old Well On
09/20/07	5.09	1.85	1.63										Old Well On
09/26/07	5.27	2.41	3.08	30.1	0.17	60	15	25.0%	5	8.3%	Yes	No	Both Wells Off
09/27/07	5.36	2.16	2.37										Both Wells Off
10/03/07	5.30	1.96	1.46	29.8	0.17	59	14	23.7%	7	11.9%	No	Yes	Both Wells On
10/04/07	5.36	1.56	1.41										New Well On
10/10/07	6.93	3.35	3.16	30.8	0.19	61	15	24.6%	2	3.3%	No	No	Both Wells Off
10/11/07	8.44	4.35	4.19										Both Wells Off

*25% of the channel cross-section equal to or exceeding 0.3 feet
*10% contiguous section of the cross-channel having depths equal to or exceeding 0.3 feet

TABLE 18. Results of juvenile habitat connectivity and passage during the 2007 study within Swiss Canyon.

DATE				DEPTH (FEET)
		SWISS CANYON UPSTREAM	SWISS CANYON MID-POINT	SWISS CANYON DOWNSTREAM
08/30/07	Both wells off	0	0	0.63
09/05/07	New Well on	0	0	0.64
09/12/07	Both wells off	0	0	0.61
09/19/07	Old Well on	0	0	0.64
09/26/07	Both wells off	0	0	0.61
10/03/07	Both wells on	0	0	0.56
10/10/07	New Well on	0	0	0.62

APPENDIX A

Snorkel Survey Locations

TABLE A-1. Locations of snorkel surveys conducted on the Big Sur River, CA, 2007.

Reach	Lower boundary (lat/long)		Upper boundary (lat/long)		Bottom (river mile)	Top (river mile)	Length (feet)
A	36 16.857	121 51.600	36 16.942	121 51.391	0.0	0.11	553
Comments: Subreach A was a lagoon characterized by deeper slow moving water and fine substrate (silt/clay/detritus). Brushy instream cover was most abundant in this reach.							
B	36 16.942	121 51.391	36 17.017	121 51.300	0.11	0.24	738
Comments: Subreach B was a glide/run complex with lateral scour and instream brush in many areas. Filamentous green algae are abundant in the margins and in the slow sections.							
C	36 17.017	121 51.300	36 17.105	121 51.237	0.24	0.43	1024
Comments: Subreach C was a four tiered riffle glide series and contained the first potential spawning habitat. Particle size dist. looked good but there were substantial fines in the gravel. The reach was less than 2 feet deep for the most part with little in the way of cover.							
D	36 17.105	121 51.237	36 17.119	121 51.134	0.43	0.47	197
Comments: Subreach D is a slow, mid stream pool with brush and LWD across the entire channel. Substrate consists of silt, sand, and detritus. Rearing habitat is abundant.							
E	36 17.119	121 51.134	36 17.183	121 50.990	0.47	0.65	950
Comments: Subreach E is a three tiered run/riffle series with small to medium substrate and no instream brush. Velocity refugia were also lacking. Riparian vegetation was more abundant than in 2004.							
F	36 17.183	121 50.990	36 17.256	121 50.778	0.65	0.87	1146
Comments: Subreach F is a three tiered glide riffle series with small to medium substrate. The river has widened in this reach and is <1 foot deep. There was little in the way of rearing habitat. Riparian vegetation has grown into the channel as compared to the 2004 surveys.							
G	36 17.256	121 50.778	36 17.273	121 50.695	0.87	0.93	312
Comments: Subreach G was a medium gradient riffle with medium to large substrate. Depths of >3feet were present in 2 lateral scour pools but there was no cover.							
H	36 17.273	121 50.695	36 17.235	121 50.660	0.93	1.04	306
Comments: Subreach H was a glide/high gradient riffle complex with predominately large substrate. Depth was >3feet below the HG riffle but very little instream brush was present.							

APPENDIX B

Fish Densities and Size Distribution Observed During 2007 Snorkel Survey

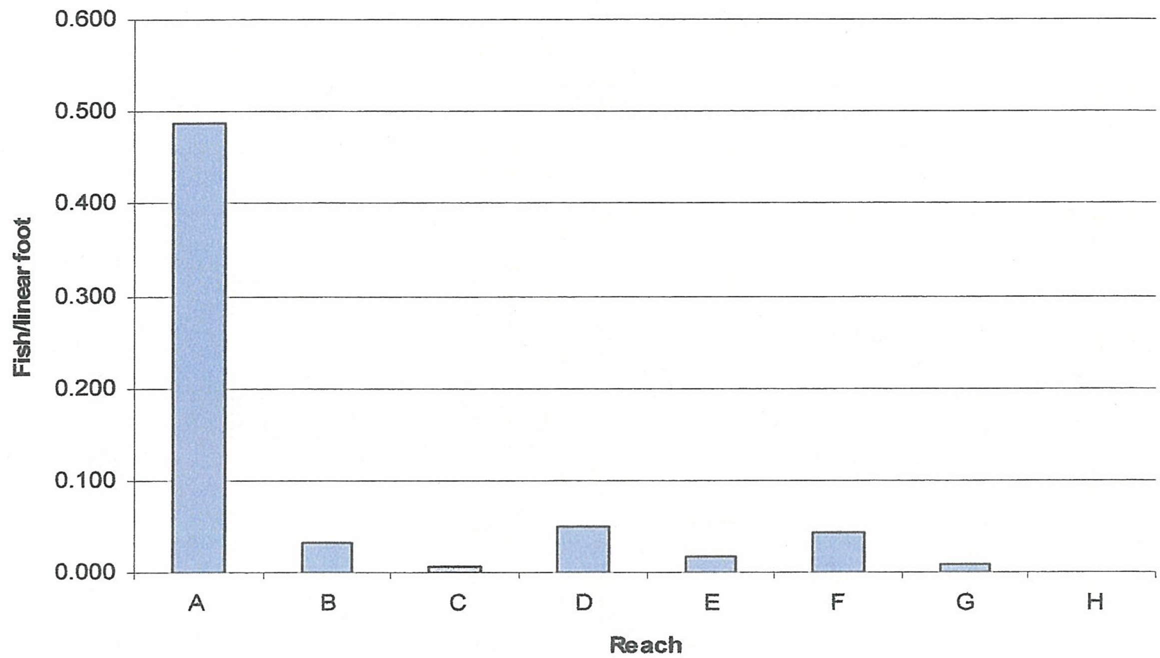

FIGURE B-1. *O. mykiss* densities by reach, Big Sur River, October, 22, 2007.

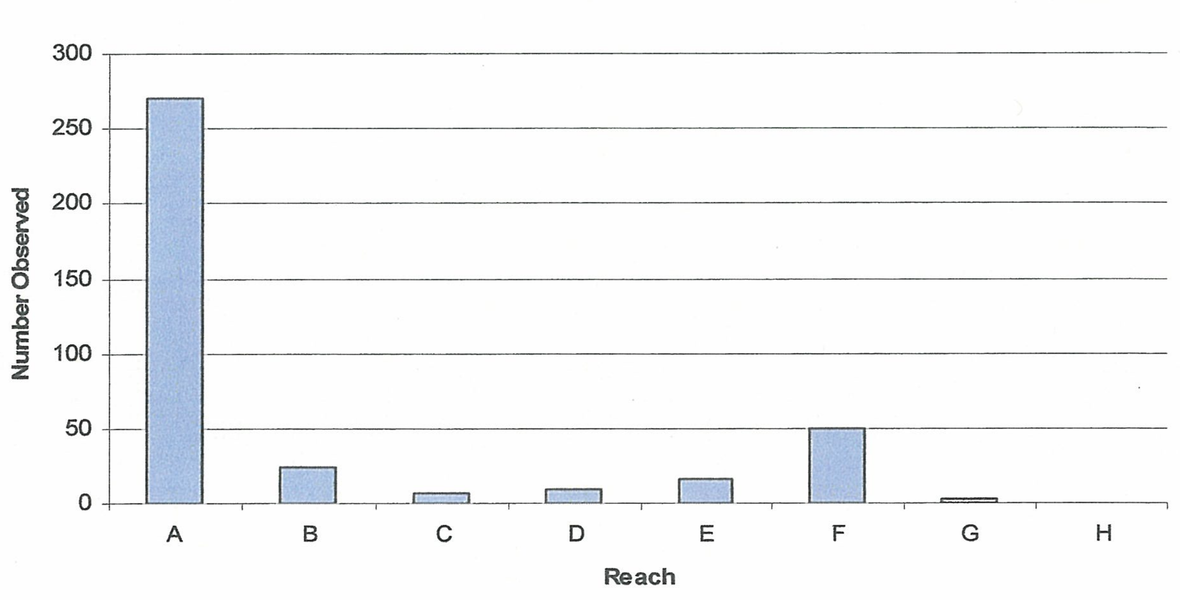

FIGURE B-2. Total *O. mykiss* by reach, Big Sur River, CA, October, 22, 2007.

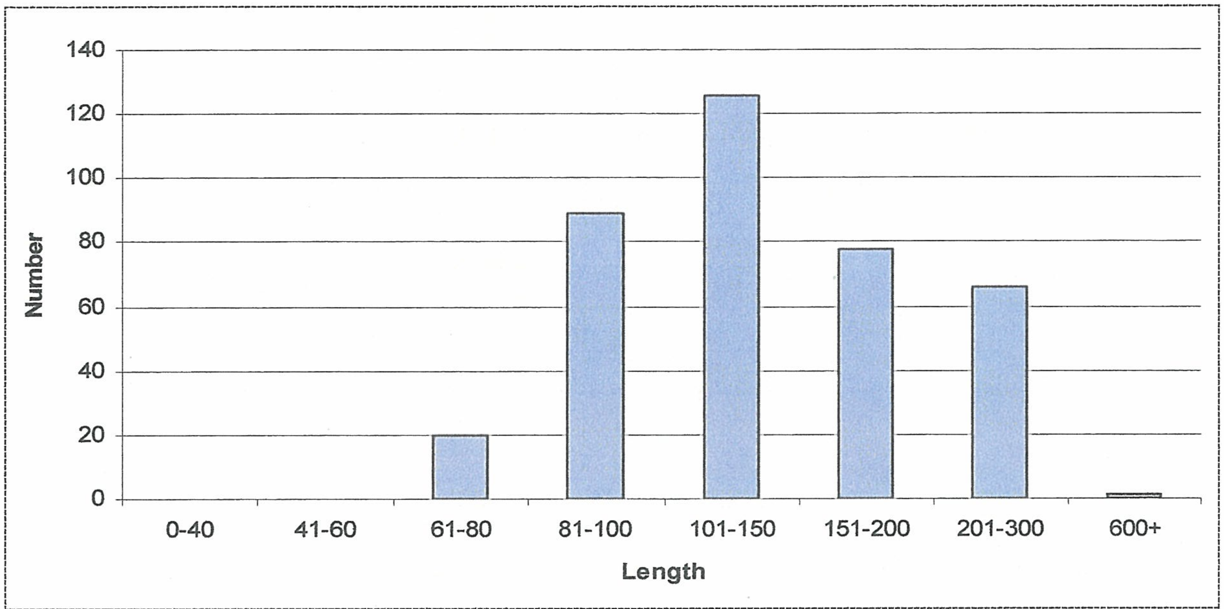

FIGURE B-3. Length frequency distribution (*O. mykiss*), Big Sur River, CA, October, 22, 2007.

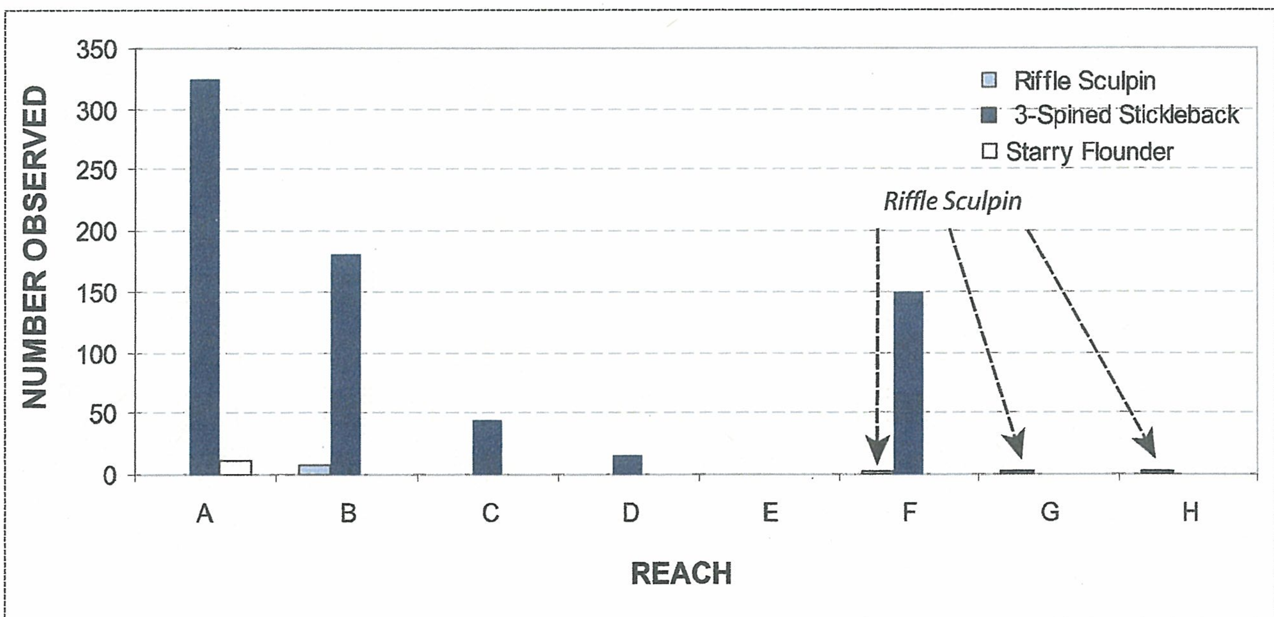

FIGURE B-4. Non salmonids species composition and abundance by reach, Big Sur River, CA, October 22, 2007.

Species Composition and Abundance by <u>subreach</u>. Big Sur River, CA (October 22, 2007).

Reach	*O. mykiss*	Riffle Sculpin	Three-Spined Stickleback	Starry Flounder
A	270	0	325	11
B	24	8	180	0
C	7	0	45	0
D	10	0	15	0
E	16	0	0	0
F	50	2	150	0
G	3	1	0	0
H	0	1	0	0

O. mykiss densities by subreach. Big Sur River, CA (October 22, 2007.

Subreach	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Total	270	24	7	10	16	50	3	0
Length (ft)	553	738	1024	197	950	1146	312	306
Fish/linear foot	0.488	0.033	0.007	0.051	0.017	0.044	0.010	0.000