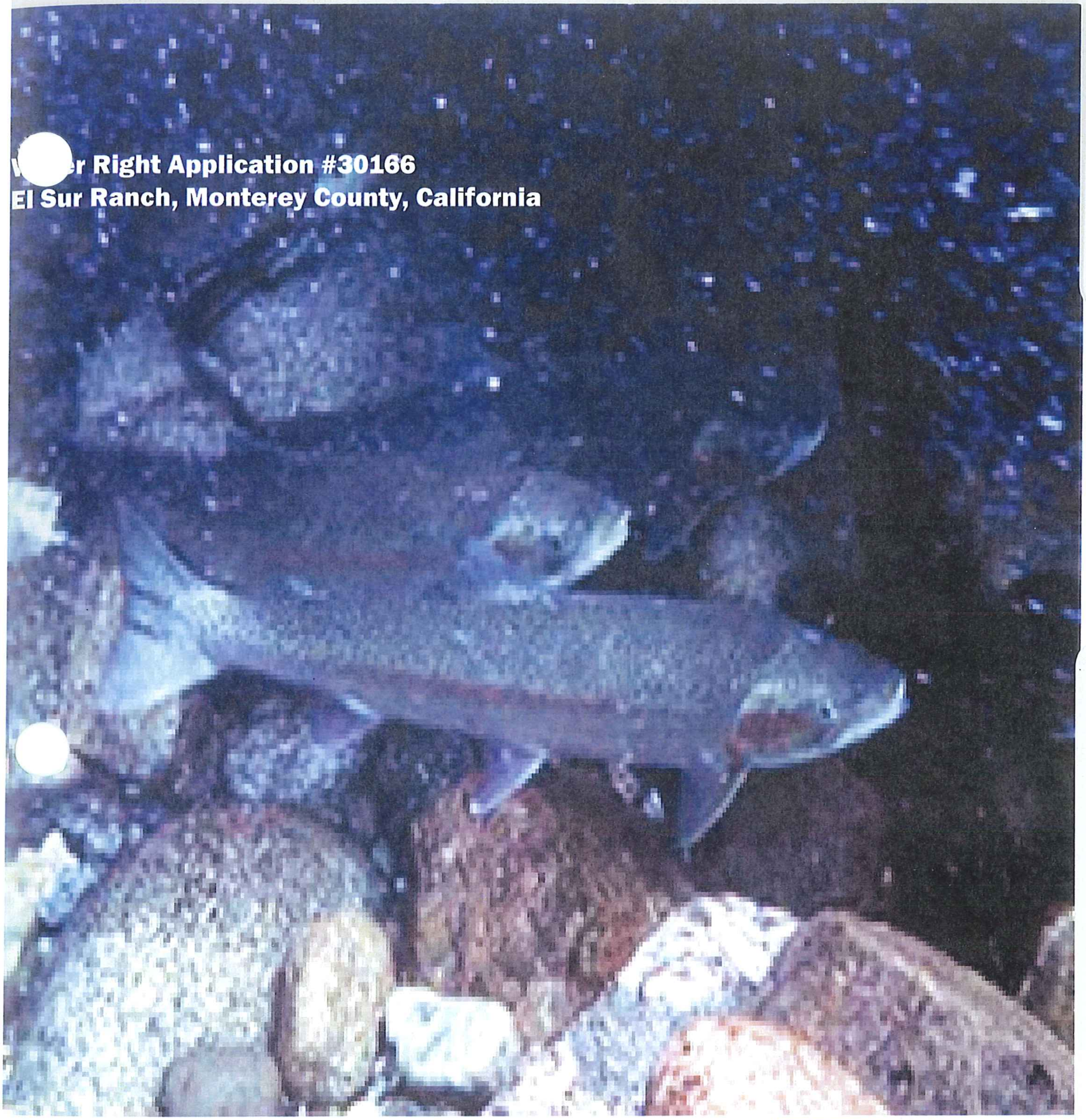
W er Right Application #30166
El Sur Ranch, Monterey County, California



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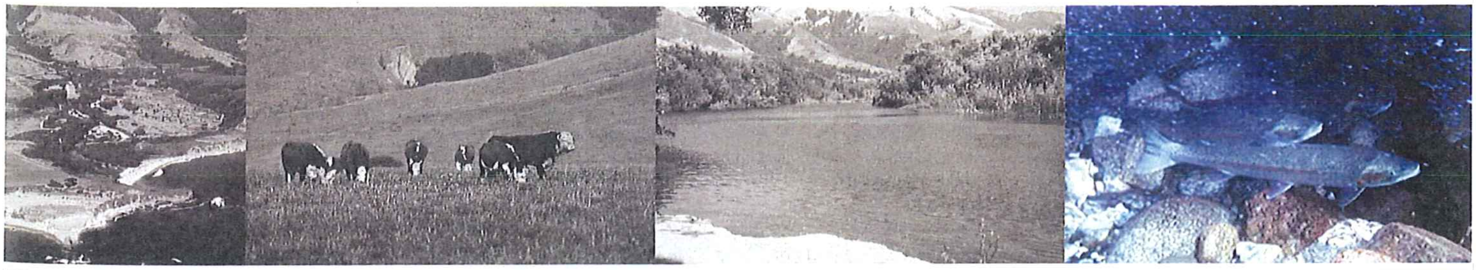

Biology

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ESR--23

EVALUATION OF THE POTENTIAL RELATIONSHIP BETWEEN EL SUR RANCH WELL OPERATIONS & AQUATIC HABITAT ASSOCIATED WITH THE BIG SUR RIVER DURING LATE SUMMER AND EARLY FALL – 2006

Prepared For

Applicant
El Sur Ranch
Monterey, CA

Prepared By

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Executive Summary

El Sur Ranch operates two irrigation wells located adjacent to the Big Sur River. The Big Sur River provides a migratory corridor, spawning and egg incubation habitat, and juvenile rearing habitat supporting a population of steelhead (*Oncorhynchus mykiss*). Steelhead inhabiting the Big Sur River have been listed as a threatened species under the Federal Endangered Species Act. Concern has been expressed regarding the potential for El Sur Ranch irrigation well operations to adversely affect habitat quality and availability for juvenile steelhead inhabiting the lower river and lagoon.

In response to a water right application submitted by El Sur Ranch to the State Water Resources Control Board (SWRCB) the California Department of Fish and Game (CDFG), National Marine Fisheries Service (NMFS), and California State Parks (DPR) identified concerns regarding the potential effects of well operations on surface and groundwater levels within the Big Sur River.

A fishery habitat investigation was designed and implemented to provide site-specific field information on instream habitat conditions within the lower reaches of the Big Sur River and the lagoon throughout the summer and early fall of 2006 under a range of manipulated El Sur Ranch irrigation well operations.

Based on resource and regulatory agency concerns regarding the potential for adverse effects to sensitive species and their habitat within the lower Big Sur River resulting from El Sur Ranch irrigation well operations, steelhead were identified as the primary target species of interest for this investigation. Potential steelhead passage and habitat quality changes within the river resulting from the range of manipulated well operations during the study period can serve as an indicator of the potential for adverse effects on habitat conditions for other sensitive and protected wildlife inhabiting the area.

A series of pilot studies were designed and implemented during 2004 that provided important information on water quality and fishery habitat within the Big Sur River, hydrogeology of surface and groundwater movement within the lower reaches of the Big Sur River watershed (Hanson 2005; SGI 2005), and information on operations of the El Sur Ranch diversion wells. Information collected from the 2004 investigations serve, in part, as the technical foundation for identifying additional monitoring and the experimental design for the investigation conducted during the late summer of 2006, specifically designed to address issues raised by CDFG and other protestants to the water right application.

The objective of the 2006 experimental investigation was to determine if El Sur Ranch diversion well operations directly cause adverse impacts to fish and wildlife habitat within and adjacent to the Big Sur River during the seasonal period of low flows and typical El Sur Ranch diversion operations. The experimental design developed to test these relationship between diversion operations and habitat connectivity and suitability included manipulation of well operations during the low flow period of 2006 (August-September) accompanied by both continuous and periodic monitoring.

Results of habitat and passage monitoring between during the 2006 study period concluded that conditions within the river, both upstream and downstream of the El Sur Ranch diversion well locations, under a range of experimental pumping regimes, remained within a suitable range for juvenile steelhead rearing throughout the summer and fall monitoring period irrespective of El Sur Ranch diversion operations.

Although variation was observed for various parameters measured during the 2006 study period, there was no evidence that well operations resulted in a consistent pattern of habitat change within the river. All parameters measured as part of this 2006 study remained within the range considered to be suitable for steelhead rearing which were independent of pump operations (0, 1, 2 pumps in service). Additional findings of the 2006 investigation include:

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

- Streamflows were sufficient to maintain connectivity among habitat units within the study reach throughout the 2006 study period;

- Water quality conditions, including water temperatures, electrical conductivity, and dissolved oxygen concentrations, were within the range considered to be suitable for juvenile steelhead/rainbow trout rearing at all times irrespective of irrigation diversion operations;

- Steelhead passage monitoring, including critical riffle habitats, concluded that no barriers/impediments to fish migration resulted from El Sur Ranch diversion operations within the study reach and no patterns were detected between passage criteria and pumping;

- Analyses incorporating results of the SGI mixing model (SGI 2007) and habitat thresholds present evidence that El Sur Ranch diversion operations cannot adversely impact steelhead habitat in the study reach by raising temperature above naturally occurring levels entering the upstream portion of the study reach;

- Analyses incorporating results of the SGI mixing model (SGI 2007 and habitat thresholds present evidence that El Sur Ranch diversion operations cannot adversely impact steelhead habitat in the study reach by depressing dissolved oxygen concentrations below naturally occurring levels;

- Results of the steelhead passage monitoring, streamflow, and water quality measurements during both the 2004 and 2006 study periods provided no evidence of adverse effects on juvenile steelhead habitat quality and connectivity or availability as a result of El Sur Ranch irrigation well operations. Similarly, the absence of adverse effects on aquatic habitat for juvenile steelhead, or any adverse effects observed, serves as an indicator that adverse effects to other sensitive and protected aquatic species inhabiting the lower Big Sur River would not be expected, based on environmental conditions and irrigation well operations that occurred during the 2004 and 2006 study period flow conditions, and;

Analyses presented show no evidence, under the conditions surveyed, that El Sur Ranch irrigation diversions adversely effect vegetation within Creamery Meadow or the areas within the range of influence of irrigation pumping.

1.0 Introduction

The El Sur Ranch operates two wells located immediately adjacent to the Big Sur River that supply water for pasture irrigation (Figure 1-1). In response to a water right application submitted by El Sur Ranch to the State Water Resources Control Board (SWRCB) the California Department of Fish and Game (CDFG), National Marine Fisheries Service (NMFS), and California State Parks (DPR) identified concerns regarding the potential effects of well operations on surface and groundwater levels within the Big Sur River. It has been hypothesized that well operations may affect instream habitat within the river for Central California Coast steelhead (*Oncorhynchus mykiss*) and other aquatic resources, in addition to riparian vegetation and associated wildlife.

The lower Big Sur River and adjacent habitat supports a variety of fish and wildlife species. Previous studies, including the 2004 investigation on the Big Sur River (Hanson 2005), have established that sensitive and protected species inhabit the area including steelhead, California red-legged frog (*Rana auropa draytonii*), western pond turtle (*Clemmys marmorata*) (Titus *et al.* 2003, BioSystems 1995, M. Green 2007) and others. Based on resource and regulatory agency concerns regarding the potential for adverse effects to sensitive species and their habitat within the lower Big Sur River resulting from El Sur Ranch irrigation well operations, steelhead were identified as the primary target species of interest for this investigation. Potential steelhead passage and habitat quality changes within the river resulting from the range of manipulated well operations during the study period can serve as an indicator of the potential for adverse effects on habitat conditions for other sensitive and protected wildlife inhabiting the area.

A series of pilot studies were designed and implemented during 2004 that provided important information on water quality and fishery habitat within the Big Sur River, hydrogeology of surface and groundwater movement within the lower reaches of the Big Sur River watershed (SGI 2005), and information on operations of the El Sur Ranch diversion wells. Information collected from the 2004 investigations serve, in part, as the technical foundation for identifying additional monitoring and the experimental design for the investigation conducted during the late summer of 2006, specifically designed to address issues raised by CDFG and other protestants to the water right application.

The objective of the 2006 experimental investigation was to determine if El Sur Ranch diversion well operations directly cause adverse impacts to fish and wildlife habitat within and adjacent to the Big Sur River during the seasonal period of low flows. The experimental design was developed to test the null hypothesis that there is no significant relationship between El Sur Ranch well operations and various indices of habitat quality and availability within the area of influence. The alternative hypotheses to be tested included (1) well operations result directly in a significant degradation of habitat, and (2) well operations result in a significant increase in habitat quality or availability. The experimental design developed to test these hypotheses included manipulation of well operations during the low flow period of 2006 (August-September) accompanied by both continuous and periodic monitoring.

1.1 Project objectives

The primary objectives of the 2006 fishery habitat investigation were to assess:

- whether the El Sur Ranch diversion well operations directly cause adverse impacts to fish and wildlife habitat within and adjacent to the Big Sur River during the seasonal period of low flows;
- whether changes in habitat quality and availability are detected within the lower river and lagoon during controlled well diversion operations, and to assess the potential effects of these diversion operations on habitat conditions for steelhead and/or sensitive wildlife;

Habitat quality and availability for steelhead within the lower Big Sur River were used as indicators of change in habitat conditions potentially affecting other sensitive or protected species. The two fundamental hypotheses being tested by the fishery habitat monitoring program include:

1) No significant relationship exists between El Sur Ranch well operations and various indices of habitat quality and availability within the area of influence.

2) No significant differences exist in habitat quality or availability for juvenile steelhead/rainbow trout rearing between habitat areas within the lower river upstream of the potential influence of the El Sur Ranch irrigation well (reference reach) when compared to habitat conditions within the Creamery Meadow reach and/or downstream within the lagoon.

Specific objectives and evaluation criteria used to assess habitat conditions as part of this survey include:

- Determine baseline reference stream flows along the longitudinal gradient from upstream areas (velocity transect [VT-1]; Figure 1-1) outside of the potential influence of the El Sur Ranch irrigation wells;
- Determine if surface water connectivity is disrupted at any location between the upper lagoon, the potential zone of influence from El Sur Ranch well diversions, and upstream reference points outside the potential influence of the El Sur Ranch irrigation wells. Loss of surface water connectivity among habitat units would adversely affect steelhead habitat by limiting 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.
- Determine if dissolved oxygen concentrations within the lower river or lagoon decrease 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;

- Determine if water temperatures within the lower river or lagoon are elevated, either seasonally or in response to specific El Sur Ranch well diversions, to a level that would represent 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 water temperatures greater than 20°C (68°F) or maximum daily (hourly) temperatures 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 pool refugia habitat that may provide suitable areas for juvenile steelhead to over-summer within the lower river and lagoon; and

- Determine if electrical conductivity (salinity) is 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 transformation when they are adapted to higher salinities in preparation for emigration to marine waters. For purposes of this habitat assessment electrical conductivities within the lower river or lagoon in excess of 1,500 µS/cm were identified as potentially stressful or unsuitable juvenile steelhead rearing habitat.

1.2 Experimental Design

Juvenile steelhead/rainbow trout have been reported by Titus *et al.* (2003), and by Hanson (2005) to inhabit the lower reaches of the Big Sur River and lagoon, which is used as foraging and rearing habitat throughout the summer and fall months. Habitat quality and availability within the lower river and lagoon for juvenile steelhead rearing is influenced by a variety of environmental factors. These factors, include, but are not limited to, seasonal patterns in instream flows, seasonal water temperatures, dissolved oxygen concentrations, electrical conductivity, surface water connectivity among habitat units, habitat diversity (e.g., the occurrence of pool: riffle complexes), instream cover (large woody 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, a fishery investigation was designed and implemented to provide site-specific field information on instream habitat conditions within the lower portions of the Big Sur River and the lagoon throughout the late summer and early fall of 2006 during a period of controlled diversion operations on the El Sur Ranch. The El Sur Ranch diversion wells were experimentally manipulated between August 30 and October 17, 2006, to include periods when no well operations occurred, Old Well operated continuously, both wells were operated continuously, and New Well operated continuously. Each of the primary experimental periods were seven days in duration with seven days of no pumping between pump operations to allow for recovery of the system to a state of equilibrium. The 2006 experimental design for irrigation well operation is shown in Figure 1-1.5.

The 2006 monitoring program included both continuous (hourly and more frequent as needed) monitoring using data loggers as well as periodic (grab sampling) monitoring scheduled to coincide with specific periods of El Sur Ranch well operations. Data loggers were used to continuously record dissolved oxygen concentrations and water temperatures within the river at upstream reference locations and at locations adjacent to the El Sur Ranch diversion wells potentially within the zone of influence. Continuous monitoring occurred over the period from August 30 through October 17 and included the following monitoring as part of the experimental design:

- Water quality parameters measured continuously using two data SONDE water quality monitoring units to measure dissolved oxygen concentration (DO) at one location within the Big Sur River located upstream of the potential El Sur Ranch diversion well zone of influence (reference area) and one location adjacent to the El Sur Ranch diversion wells in a cold-water upwelling area identified during the 2004 investigations;

- Water temperature measured at approximately 24-minute intervals at twelve (12) locations within the lower reaches of the Big Sur River extending from the lagoon upstream past the area adjacent to the El Sur Ranch diversion wells to a reference area outside the potential zone of influence. Water temperature was monitored both near the surface and near the bottom adjacent to the left and right banks.

In addition to the continuous monitoring, periodic (grab sampling) monitoring occurred within the lower reaches of the Big Sur River, which included the following:

- Steelhead passage monitoring was performed at eleven (11) transect locations selected within the reach extending from the lagoon upstream past the El Sur Ranch diversion wells to an upstream area outside the potential zone of influence (Figure 1-1). Priority was given to locations passing through surface riffle areas, where river cross-sectional measurements were made in accordance with specific well operations that include wetted channel width and water depth measured at 0.5 foot intervals across the river;

- Water quality sampling was performed at eleven (11) transect locations selected within the reach extending from the lagoon upstream past the El Sur Ranch diversion wells to an upstream area outside the potential zone of influence (Figure 1-1), using portable hand-held water quality meters to measure DO, water temperature, and EC near the surface and near the river bottom at locations adjacent to the left bank, center of the river, and right bank at each of the 11 monitoring sites during each survey. Additionally, water quality parameters were also recorded during streamflow measurements at the extreme upstream reference location (VT-1; Figure 1-1); and,

- Streamflow measurements were performed at one upstream reference location outside the potential zone of influence from El Sur Ranch diversion well operations (VT-1; Figure 1-1) in order to monitor changes to river discharge during the range of manipulated diversion well operations.

1.3 Background

1.3.1 Occurrence Of Steelhead/Rainbow Trout In The Big Sur River Drainage

Titus *et al.* (2003) compiled the most comprehensive historical summary of the occurrence of steelhead/rainbow trout within the Big Sur River drainage. The following section has been excerpted directly from Titus *et al.* (2003) to provide information on the historical occurrence and habitat conditions within the watershed.

The Big Sur River drainage is currently among the largest of those systems south of San Francisco Bay that remain mostly pristine. Within recent geological history, only the lowermost 12 km (7.5 mi.) or so of the river have been accessible to steelhead. Upstream migration beyond this point in the steep and rugged gorge section of the river has been blocked by a natural bedrock fall. This feature marks the boundary above which the river flows through the Ventana Wilderness within the Los Padres National Forest. Pfeiffer Big Sur State Park is situated immediately downstream from this point along a portion of the lower river where redwoods are a major component of the riparian zone. This far south along the California coast, fog no longer maintains the moisture climate necessary for continuous stands of redwoods, and the steep hillsides that comprise the Big Sur drainage are otherwise dominated by grassland, chaparral, and oak woodland. The lowermost 6.4 km (4 mi.) of the river flow through Andrew Molera State Park.

The following is a chronological rundown of available information on Big Sur River steelhead and resident rainbow trout. The catches of 48 anglers were checked on 1 May 1932, the opening day of the summer trout season (J. H. Wales, CDFG, unpubl. file report). A total of 451 juvenile steelhead/rainbow trout was observed, about 97% of which were age 1+ and 2+ and 10.0–15.0 cm (3.9–5.9 in.) long. The remainder of the observed catch was trout 18.0–25.0 cm (7.1–9.8 in.) in length and age 2+. Three trout about 30.5 cm (12 in.) in length were reportedly caught, as were three adult steelhead. Recently-emerged steelhead fry were abundant along the stream margins. Wales indicated that juvenile steelhead/rainbow trout were planted in the Big Sur River, but did not know when or how old the fish were at planting.

On 9 April 1940, six adult steelhead were seen in the large pool immediately below the barrier falls, and many more were reportedly seen there a few weeks earlier attempting to ascend the falls (Shapovalov 1940). On 27 March 1946, the CDFG observed a fresh run of adult steelhead in the river, again as far upstream as the barrier falls. Recently emerged steelhead fry were also seen downstream from the falls. In 1953, the CDFG began stocking catchable rainbow trout annually during May–September to support a lower river sport fishery. Prior to that time, rainbow trout fingerlings had been planted for several years. The stocking area was a 5 km (3.1 mi.) reach, mostly within Pfeiffer Big Sur State Park. Resident rainbow trout have not been planted in the Big Sur River since 1975, following adoption of the steelhead rainbow trout policy which prohibits the planting of resident fish in steelhead drainages.

About 19 km (11.8 mi.) of the Big Sur River, from the bottom of the gorge upstream to Sykes Camp in the Ventana Wilderness, were surveyed by the CDFG during July–August 1957. Most of the survey area was upstream from the impassable steelhead barrier, and thus represented the stream portion inhabited primarily by wild resident rainbow trout. The river canyon was narrow and steep-sided, and contained many migration barriers. High quality spawning areas were limited. Rearing habitat was adequate for both juvenile and adult rainbow trout. Rainbow trout, 7.5–25 cm (3–9.8 in.) long, were observed throughout the survey area. However, recruitment to the 1957 year-class was regarded as poor since few young-of-the-year (fish 5 cm (2 in.) long) were seen.

On 4 January 1961, stream flow just above the lagoon was about 0.6 m^3/s (21.19 cfs), and few adult steelhead had been reported in the river. Two steelhead, about 0.9 and 4.5 kg (2.0 and 9.9 lb.), were caught in the surf outside the lagoon. Other steelhead were also seen outside the river mouth. A 1.4 kg (3.1 lb.) steelhead was captured on 31 January 1961.

Fisher (1961) captured 338 juvenile steelhead/rainbow trout in a downstream-migrant trap in the lower Big Sur River, during 30 April–2 June 1959. The number of downstream migrants captured per day was greatest during the first 3 days of the trapping period, and then decreased sharply and fluctuated around a much lower level through the remainder of the period. Most (87%) movement occurred during the night or early morning. Most downstream migrants were believed to be 1-year-olds. Some 0+ steelhead apparently also entered the trap, although their relative abundance was probably underestimated due to a low trapping efficiency for fish that size. Stream flow in the lower Big Sur River averaged 0.7 m^3/s (24.72 cfs) during the study period, which was uncharacteristically low for the month of May. Thus, these steelhead emigration data may not be representative for normal or wet water years.

On 19 April 1961, young-of-the-year steelhead/rainbow trout were seen throughout the stream reach within Pfeiffer Big Sur State Park, and 12.5–15 cm (4.9–5.9 in.) long juveniles were common. An adult steelhead was caught in the lower river on 31 January 1962. On 28 April 1962, juvenile steelhead captured on hook-and-line in the lower river at a rate of 1.08 trout/angler hour ranged in fork length from 10 to 18 cm (3.9–7.1 in.), and averaged about 14 cm (5.5 in.) (R. N. Hinton, CDFG, intraoffice corr. of 31 May 1962). On 15 May 1962, four steelhead estimated at 61 cm (24 in.) and 1.8–2.7 kg (4–6 lb.), and one at about 36 cm (14.2 in.), were seen in a pool in the lower river area. On 22 May 1962, juvenile steelhead, 5–10 cm (2.0–3.9 in.) long, were common in abundance in pools up to the base of the barrier falls. In 1965, the CDFG estimated the annual steelhead spawning run in the Big Sur River at about 300 fish, based on the observations of local field personnel (California Department of Fish and Game 1965).

The CDFG surveyed the north and south forks of the Big Sur River in August 1978, following the Marble Cone fire of 1977 (P. Chappell, CDFG, unpubl. memo. of 11 June 1979). These headwaters were somewhat degraded due to the fire, yet resident rainbow trout were common in abundance, as determined by hook-and-line sampling. Following several attempts and much discussion over the years regarding removal of the bedrock barrier in the lower gorge, the Big Sur drainage above the barrier was surveyed by the CDFG and USFS during 14 July–4 August 1981 to determine the quantity and quality of stream habitat that would become available to steelhead for spawning and rearing (USFS stream survey reports, and summary by R. C. Benthin, CDFG, unpubl. memo. of 26 August 1981). High quality steelhead spawning and rearing habitats were observed throughout the survey area, including: the entire 21.7 km (13.5 mi.) of the main stem; the lowermost 1.6 km (1 mi.) each of the mainstem tributaries, Ventana and Lion creeks, and the lowermost 160 m (524.9 ft.) of the Ventana Creek tributary, Doolans Hole Creek; the lowermost 7.2 km (4.5 mi.) of the North Fork Big Sur River; and the lowermost 4.0 km (2.5 mi.) of the South Fork Big Sur River up to an 3.7 m (12.1 ft.) high bedrock migration barrier. So, with removal of the bedrock barrier in the lower gorge, at least 36 km (22.4 mi.) of habitat would become accessible to steelhead; an unknown proportion of another 19 km (11.8 mi.) of unsurveyed stream sections would also become available. The mainstem tributaries, Logwood and Terrace creeks, and the North Fork tributary, Cienega Creek, all had an impassable bedrock waterfall at their mouths. The North Fork tributary, Redwood Creek, was full of debris, apparently as a result of the Marble Cone fire. Resident rainbow trout, including young-of-the-year, were abundant in all stream sections surveyed, and occurred in section specific visually-estimated average densities of 40–100 trout/30 m (40-100 trout/98.4 ft.). A subsample of 50 hook-and-line captured rainbow trout averaged about 15 cm (5.9 in.) FL (overall range, 10.0–35.0 cm (3.9–13.8 in. FL)). The USFS stream survey report indicated that the CDFG had planted rainbow trout at Barlow Flat in 1948, but none since that time in the stream area above the gorge. Beginning in the fall of 1981 and through the fall of 1984, a series of modifications was carried out on the barrier to enhance steelhead passage. Six adult steelhead were observed by the CDFG on 18 March 1985 between Barlow Camp and the gorge. Adult steelhead have also been reportedly seen by anglers in upstream areas in subsequent years (K. R. Anderson, CDFG, pers. comm. of 9 July 1992).

On 7 November 1988, abundance estimates of juvenile steelhead were made by the CDFG in two sections of the lower river, each about 46 m long (150.9 ft). Fish were sampled by electrofishing, marked, released, and resampled to make Lincoln-Peterson abundance estimates. In a section just below the confluence with Post Creek, the calculated abundance was 109 trout/30 m (109 trout/98.4 ft.). These fish averaged 84 mm FL (3.3 in.) (range, 55–247 mm FL (2.2–9.7 in.)). The second section, located in Andrew Molera State Park, contained an estimated 128 trout/30 m (128 trout/98.4 ft.). Average fish length was 82 mm FL (range, 55–140 mm FL (2.2–5.5 in.)). A sample of juvenile steelhead was also collected in Molera Park by electrofishing on 17 July 1990 (D. C. Rischbieter, California Department of Parks and Recreation, unpubl. data); these fish averaged 86 mm SL (3.4 in.) (SD = 32 mm SL (1.3 in.); range, 50–175 mm SL (2.0–6.9 in.).

The largest adult steelhead reported from the Big Sur River was an illegal catch that measured 90 cm (35.43 in.) and weighed about 7 kg (15.4 lb.) (Rischbieter 1990a). During the 1992-1993 season, the reported angler catch of adult steelhead in the Big Sur included one 79 cm (31.1 in.) female and several 56 cm (22 in.) fish (M. Fitzsimmons, CDFG, pers. comm. of 13 March 1993). Recent study of juvenile steelhead habitat use in the lower Big Sur River shows that the entire area, from the lagoon to the gorge, remains highly functional for steelhead production (R. G. Titus, CDFG, unpubl. data of 1992–1994). Preliminary analysis suggests that most juveniles leave the stream after only one year of rearing, and that there is a relatively small proportion of mainstem fish that appears to be resident rainbow trout.

STATUS: Overall, the Big Sur River continues to support a healthy steelhead population, one that Nehlsen *et al.* (1991) classified as a stock of special concern.

1.3.1.1 Juan Higuera Creek

Juan Higuera Creek is the largest perennial tributary to the lower Big Sur River. The CDFG surveyed the creek on 8 August 1961. Steelhead spawning areas were lacking as stream substrate materials were cemented by calcium carbonate precipitates. Rearing habitat in the form of pools and cover also appeared limited. Several potential barriers to upstream movement of adult steelhead were identified. Two small pipe diversions removed water from the stream. No fish were seen during the survey although local residents reported that each small pool in the stream supported one catchable size (15–20 cm (5.9-7.9 in. long)) juvenile steelhead/rainbow trout. Adult steelhead reportedly migrated into Juan Higuera Creek during high flow periods in winter (R. L. Moore, CDFG, unpubl. draft memo. of August 1960).

Another long-time streamside resident and landowner corroborated historical presence of adult steelhead in Juan Higuera Creek (K. Wright for D. Fee, Big Sur, CA, pers. comm. of 4 February 1994). Steelhead were seen and captured in the creek until 1972, when the combined effects of an upslope fire and heavy flooding washed out the road crossing near the creek mouth. A culvert was subsequently installed which then created at least a partial barrier to upstream migrating adult steelhead. Recent study of juvenile steelhead habitat use in the lower Big Sur River reveals that Juan Higuera Creek is still well-populated with juvenile steelhead/rainbow trout (R. G. Titus, CDFG, unpubl. data of 1992–94). Preliminary analysis of population structure suggests that lower Juan Higuera Creek is populated by a mixture of juvenile steelhead and resident rainbow trout, as evidenced by a relatively high proportion of age 0+ fish. What is not clear is whether steelhead actually spawn in the creek and their progeny rear there, or if juvenile steelhead migrate into the creek from the Big Sur River. The population in upper Juan Higuera Creek is much sparser in comparison, and clearly characterized by a higher proportion of larger, older individuals, including mature adults, suggesting a resident rainbow trout population segment.

1.3.1.2 Post Creek

Post Creek enters the lower Big Sur River within Pfeiffer Big Sur State Park. Shapovalov (1940a) described the creek as "an inconsequential stream that is reported to go completely or nearly dry each summer", in his consideration of potential hatchery sites in the park and vicinity. In contrast, Rischbieter (1990d) noted the creek as a historically perennial stream, and when surveyed by the CDFG in 1980, the creek was identified as an important spawning and rearing area for steelhead. At that time, only the lowermost 275 m (902.2 ft.) of the creek were accessible to steelhead because of an impassable logjam. The stream habitat consisted primarily of small pools and low gradient riffles. The calculated juvenile steelhead abundance for this area was >1,000 fish, or >365 trout/100 m (>365 trout/328.1 ft) of stream.

The stream habitat at Post Creek has degraded significantly in recent years (Rischbieter 1990d). In 1986, a landslide occurred about 335 m above the creek mouth which introduced a large amount of sediment into the lower creek. The sediment filled in pools and covered spawning gravels. The lower creek went dry during the summer–fall period of the drought years 1988 and 1989. Apparently, drought effects were exacerbated by water withdrawal by the Ventana Inn and other upstream water users. Rischbieter (1990d) concluded that these conditions precluded steelhead use of the creek, and no fish were seen during a brief survey of the lower creek on 18 September 1992 (R. G. Titus, Univ. Calif., Berkeley, unpubl. field notes).

Adult steelhead spawned in lower Post Creek during the wet winter of 1992–93, and steelhead fry were seen in the creek, above the upper road crossing in the campground, on 10 June 1993 (R. G. Titus, CDFG, unpubl. memo. of 12 August 1993). On 9 July 1993, a 64 m (210 ft.) long section, from the upper road crossing to the first foot trail crossing upstream, was sampled by electrofishing. Juvenile steelhead abundance was estimated using the two-pass removal method. The estimated abundance of age 0+ steelhead was about 35 fish (54 fish/100 m (54 fish/328.1 ft.)), and that of age 1+ steelhead was 2 fish (3 fish/100 m (3 fish/328.1 ft.). Age 0+ fish comprised about 94% of the steelhead catch. The mean (± SD) length of age 0+ steelhead was 55 ± 12 mm TL (2.2 ± 0.5 in. TL) (n = 34), and the two age 1+ fish were 101 and 137 mm TL (4.0 and 5.4 in. TL). Age 0+ steelhead also occurred between the upper road crossing and the creek mouth, but no fish were found in the 50+ m (164.0+ ft.) of stream spot-checked immediately above the foot trail crossing. Several potential migration barriers for adult steelhead still exist in lower Post Creek, including the support structure for the foot trail crossing mentioned above, and several logjams that have accumulated large volumes of sediment and gravel. Post Creek has probably supported more extensive steelhead spawning and rearing, as current poor conditions for steelhead production appear to be the product of logging effects and water diversion. It is not known if resident rainbow trout persist in the upper creek area.

1.3.2 A Brief Summary Of Steelhead Life History

The National Marine Fisheries Service (NMFS) has listed steelhead inhabiting the Big Sur River as a threatened species under the federal Endangered Species Act (ESA). On August 18, 1997, NMFS listed anadromous steelhead inhabiting the South-Central California Coast evolutionarily significant unit (ESU) as a threatened species under the federal Endangered Species Act. This was reaffirmed by NMFS on January 5, 2006. The South-Central California Coast ESU (Figure 1-2) includes all naturally spawned populations of steelhead inhabiting coastal drainages from the Pajaro River (inclusive) to the Santa Maria River, including coastal areas within both Monterey and San Luis Obispo Counties. The Big Sur River falls within the South-Central California Coast ESU and therefore anadromous steelhead inhabiting the river are protected as a threatened species under the ESA. Additional information regarding the protections afforded these steelhead populations are outlined in the Federal Register final rule regarding take of steelhead (50 CFR part 223 dated

July 10, 2000). Given the listed status of anadromous steelhead within the South-Central California Coast ESU, as described in the final rules and regulations it is unlawful to harm, harass, kill, or otherwise take a naturally produced steelhead from the Big Sur River. Take is broadly defined under the ESA and includes a wide variety of potential actions that directly affect individual steelhead and/or may directly or indirectly affect their habitat.

Steelhead have not been listed for protection under the California Endangered Species Act. Steelhead have been identified by the California Fish and Game Commission as a species of special concern. The California Fish and Game Commission, which is responsible for designating listed species under the California ESA, has not been petitioned to list of steelhead under state law.

1.3.2.1 General

Steelhead are an anadromous species, living part of their life in the ocean but returning to freshwater rivers and streams to spawn and for juvenile rearing (Pauley *et al.* 1986; Figure 1-3). Adult steelhead enter freshwater rivers and streams in the winter or early spring, usually after several storm events have charged the watershed creating favorable flow conditions, including breaching the sand bar at the lagoon, and move upstream to suitable spawning areas. Spawning can occur in the winter, but more often spawning occurs in the early spring, generally at the tail of pool habitats, in some run habitats, or in riffle areas with clean coarse gravel (Pauley *et al.* 1986; Moyle 2002). During spawning, the female steelhead clears and cleans a depression in the gravel (redd) where eggs are deposited, fertilized, and incubate until hatching. After the eggs hatch, fry emerge from the gravel and disperse through the stream, typically occupying low-velocity areas along stream margins (Reiser and Bjornn 1979). Juvenile steelhead often move to deeper pools and higher velocity areas as they grow, and remain in fresh water for one to two years before migrating to the ocean (Pauley *et al.* 1986; Moyle 2002). Downstream movement of adults after spawning and juveniles migrating to the ocean usually occurs from March through May, depending on stream flow conditions. Adults can spawn more than once, although most do not spawn more than twice.

Clear, cold water, abundant instream cover, well-vegetated stream banks, relatively stable water flow, and stream features including pools and riffles generally characterize steelhead habitat. Adams *et al.* (1973) reported that prolonged exposure of juvenile steelhead to water temperatures of 15°C (59°F) inhibited the physiological transformation to smolts. Zaugg and Wagner (1973) and Zaugg (1981) observed reduced smolting as water temperatures increased above approximately 13°C (55°F). Although optimal water temperatures for steelhead in California are considered to range from approximately 10 to 15°C (50 to 59°F), habitat conditions are generally considered to be suitable for juvenile summer rearing at temperatures below 20°C (68°F) and stressful or unsuitable at higher average daily water temperatures. The 20°C (68°F) criterion represents a water temperature below which reasonable growth of steelhead/rainbow trout may be expected. Data in the literature suggest that temperatures above 21.5 °C (71°F) result in no net growth or a loss of condition in rainbow trout (Hokanson *et al.* 1977). Since the upper incipient lethal temperature for steelhead/rainbow trout is approximately 24°C (75°F; Bell 1973), a binary criterion was developed for determining habitat suitability based on the available literature, suggesting that average daily temperatures should be less than 20°C (68°F) and daily maximum temperatures should be less than 24°C (75°F) to allow acceptable steelhead/rainbow trout growth (Entrix 1995). In the absence of more definitive data on the thermal tolerance of steelhead inhabiting the southern portion of their geographic distribution, and particularly those fish inhabiting the lower Big Sur River and lagoon, the thermal tolerance criteria (frequency of average daily temperatures greater than 20°C (68°F), and frequency of maximum daily temperatures greater than 24°C (75°F) should, therefore, not be used as absolute thermal thresholds, but rather represent general guidelines for assessing the biological significance of water temperature conditions monitored during the 2006 period of these investigations.

Dissolved oxygen concentrations also affect habitat quality and use, physiological stress, and mortality for fish and other aquatic organisms. In general, dissolved oxygen concentrations less than 6 mg/l are considered to be unsuitable for most fish species, including steelhead/rainbow trout (Bell 1973).

A well-developed riparian corridor and instream cover are important components in steelhead streams. Riparian vegetation inhibits erosion of stream banks during high flows, maintains lower stream temperatures, and provides organic input to the stream. Cover, in the form of large woody debris and brush, undercut banks, and other structures (e.g., boulders) provide velocity refuges and reduce the risk of predation. Suitable spawning gravels are 1.3-7.6 cm (0.5 to 3 in.) in diameter, 20.3 cm (8 in.) in depth or more, not heavily compacted, and have low amounts of sand or silt; however, steelhead can successfully spawn in gravels not meeting these characteristics. Good rearing habitat contains low current velocities (such as behind boulders or other velocity barriers) and good cover (e.g., undercut banks, logs or brush, surface turbulence, pool depth). Cobble embeddedness (amount of sediment surrounding rocky substrate) is a measure of shelter availability for aquatic insects (food for fish) and young fish. Embeddedness also indirectly reflects habitat suitability for incubation of fish eggs and for salmonid overwintering.

Streamflow within the central California coastal steelhead range varies seasonally and annually. In California coastal drainages, droughts of one or more years can cause intermittent flow in late summer and fall with reductions in pool depths, reducing the quality and quantity of available habitat. Although steelhead can withstand substantial seasonal and annual fluctuations in stream flow and other physical conditions, prolonged drought can result in substantial mortality to juvenile fish.

1.3.2.2 Migration

Adult steelhead tend to migrate upstream from the ocean after prolonged storms have generated sufficient runoff conditions to breach a sandbar at the lagoon and provide sufficient water depths to allow fish to move upstream. The migration seldom begins earlier than December and may extend into May if late spring storms develop (Moyle 2002). In central and southern California coastal streams runoff conditions following storm events may not be sufficient to provide for migration until the months of January or February. Most adult steelhead migration and spawning has been documented during the wettest months, January through May (Moyle 2002).

Within central California coastal streams, adult steelhead may be blocked in their upstream migration by bedrock falls, surface riffles, beaver dams, and, rarely, major logjams. Man-made structures such as culverts, gaging stations, bridge abutments and dams are often significant migration impediments and/or barriers. Some barriers may completely block upstream migration, but many barriers in coastal streams are passable at higher streamflows but may remain an impediment to passage, especially when flows recede. If the barrier is not absolute, some adult steelhead may be able to pass in most years, provided they can time upstream movements to match peak flow conditions.

In coastal streams smolts (young steelhead physiologically transformed in preparation for ocean life) tend to migrate downstream to the lagoon and ocean in March through June. In streams with lagoons, such as the Big Sur River, young-of-the-year fish may migrate downstream in late spring and early summer to spend several months (typically up to one or two years) in the highly productive lagoon habitat and grow rapidly. Early closure of lagoons by sandbars may adversely affect out-migration of smolts.

1.3.2.3 Spawning

Steelhead require spawning gravels (from 0.5 to 6 inches in diameter, Flosi *et al.* 1998) having a minimum of fine material (sand and silt; Bjornn and Reiser 1991). Increases in fine materials from sedimentation, or cementing of gravels with fine materials, restrict water and oxygen flow through the redd (nest) to the fertilized eggs (Suttle *et al.* 2004). These substrate conditions increase egg mortality. In many streams, steelhead utilize substrates for spawning with high percentages of coarse sand, which may reduce hatching success and fry emergence. Large woody debris forms depositional sites for gravel and spawning habitat (J. Merz pers. comm.).

Steelhead that spawn earlier in the winter than others in the population are more likely to have their redds scoured out or buried by sediment deposited during winter storms. Monitoring within coastal streams has documented the majority of spawning and redd sites constructed between February and May, with peak spawning occurring in March and April. Late winter through early spring storms may bury redds resulting in reduced hatching success. Unless hatching success has been severely reduced, survival of eggs and larvae is usually sufficient to saturate the limited available rearing habitat in most coastal streams. Production of young-of-the year steelhead is related to spawning success, which depends on the quality of spawning conditions, ease of adult access to suitable spawning habitat, and ultimately hinges on the timing, frequency, and size of successive storm events once spawning has been completed in the mainstem river or tributaries.

1.3.2.4 Rearing Habitat

Except in streams with high food production, most juvenile steelhead require two summers of residence before reaching smolt size (Pauley *et al.* 1986). In productive systems with suitable water temperature and food availability, a high proportion of steelhead require only one summer of residence before reaching smolt size. Juvenile steelhead are identified as young-of-the-year (first year) and yearlings (second year). Young-of-the-year steelhead growth and survival appears to be regulated by available insect food, flowing water, dissolved oxygen, and water temperatures. Escape cover (hiding areas provided by undercut banks, large rocks not buried or embedded in finer substrate, surface turbulence, etc.) and water depth in pools, runs and riffles are also important, especially for larger fish. Pool and run habitats are the primary rearing areas for steelhead in summer, with pools, including lagoons, being most important. Availability of cover and cool, well-oxygenated water is an important factor affecting juvenile steelhead survival during the low-flow summer months.

Growth rates of yearling steelhead usually show a large incremental increase from March through May. As smolts mature physiologically they emigrate downstream to the ocean. For steelhead, which continue to rear in the stream over a second summer, summer growth is typically very low (or even negative in terms of weight). A growth period may also occur in fall and early winter after leaf-drop of riparian trees and before water temperatures decline or water clarity becomes too turbid for feeding.

1.3.2.5 Overwintering Habitat

Deeper pools, undercut banks, riparian vegetation, and large, unembedded rocks provide shelter for steelhead against the high flows of winter. Extreme floods may make overwintering habitat the critical factor in steelhead production in some years. In most years, if pools have sufficient larger boulders or undercut banks to provide summer rearing habitat for yearling steelhead, these elements are sufficient to protect juvenile steelhead against winter flows.

1.3.2.6 Resident Rainbow Trout

Resident rainbow trout share many of the same life history characteristics and environmental requirements as described above for anadromous steelhead. Unlike steelhead, which migrate to the ocean for a portion of their life cycle, resident rainbow trout complete their entire life cycle within freshwater environments of streams and lakes. Resident rainbow trout and anadromous steelhead have genetically been identified as the same species, which exhibit two different life history strategies. NMFS has decided that steelhead/rainbow trout that inhabit a river or stream that allows the possibility of successful migration to and from coastal marine waters will, by definition be classified as steelhead. Therefore, any *O. mykiss* present in the Big Sur River in the vicinity of the El Sur Ranch irrigation wells are considered to be anadromous steelhead.

2.0 Methods

A variety of sensitive and protected fish and wildlife species are known to inhabit the lower Big Sur River and adjacent areas (Hanson 2005; Green 2006). As part of this investigation it was assumed that steelhead and their habitat would serve as an indicator of potential changes or adverse effect on other sensitive species. Results of the 2004 fishery and aquatic habitat surveys of the lower Big Sur River (Hanson 2005) did not detect significant changes in aquatic habitat conditions that would adversely impact habitat quality or availability for steelhead or other species, other than very localized areas where water temperatures and dissolved oxygen concentrations were lower than those observed upstream or downstream of the area where groundwater upwelling occurred. Results of the 2004 investigations provided no evidence of significant changes in aquatic habitat (e.g., disruption of habitat connectivity, unsuitable water quality, etc.) resulting from El Sur Ranch irrigation well operations or adverse effects on sensitive species habitat within the lower river. Habitat thresholds for steelhead for connectivity and water quality are well established. Other protected species documented within the study reach as part of the 2004 fisheries study are generally impacted by threshold shifts beyond those affecting steelhead, hence steelhead provide a valuable indicator species for assessment of potential adverse impacts to fish habitat from El Sur Ranch diversion operations.

The experimental design for the Big Sur River fishery habitat surveys included comparative observations at eleven (11) specific locations within the lower river and lagoon (Figure 1-1) periodically throughout the summer and fall (August 30—October 17, 2006) (Table 2-1) to identify changes in habitat conditions that potentially resulted from El Sur Ranch irrigation well operations (Table 2-2), in addition to other diversion well operations within the basin, seasonal trends in evapotranspiration by riparian vegetation, and seasonal recession in instream flows within the Big Sur River.

The geographic distribution of sampling sites included a series of eleven (11) locations within (1) the lagoon, located downstream of the El Sur Ranch irrigation wells, (2) survey locations within the reach of the lower river adjacent to Creamery Meadow representing the lower river reach adjacent to the El Sur Ranch irrigation wells, and (3) a series of sampling sites located upstream of the potential zone of influence of the wells representing a reference reach. Work conducted by the Source Group in 2004 established guidelines for the El Sur Ranch zone of influence within the Big Sur River from diversion operations (SGI 2005). Upstream reference locations outside the potential zone of influence chosen to establish environmental baseline conditions within the upper river were located in consultation with the Source Group during the 2006 study period. Results of the 2006 hydrogeological study conducted by the Source Group demonstrate that the study reach in the upper river representing environmental baseline conditions is outside the 1000 ft. zone of influence of El Sur Ranch diversion operations (SGI 2007). Surveys within this upstream reference area were used to characterize habitat conditions within a reach of the river outside the potential influence of the El Sur Ranch well operations. The selection of sampling sites and design of survey methods and protocols was based, in part, on results of the 2004 study (Hanson 2005; SGI 2005) as well as hypotheses being tested as part of the 2006 Hydraulic study being conducted simultaneously by SGI.

As part of the experimental design, environmental baseline sites were established in upstream reference zones outside the potential influence of El Sur Ranch diversion operations. These reference sites provided the basis for comparison of habitat quality and connectivity between the Creamery Meadow reach of the lower Big Sur River where El Sur Ranch diversion operations potentially impact habitat (critically, the reach represented by Zones 2 through 4 by SGI, 2007) and upstream locations outside this potential influence. Work conducted by SGI in 2004 analyzed hydraulic responses of the river and aquifer to pumping rates by El Sur Ranch irrigation diversions (SGI 2005, Section 3.4.8.2). These analyses, in collaboration and consultation with SGI on the hydraulic experimental design for 2006 formed the basis of establishing the sites of the upstream reference zones outside the potential influence of El Sur Ranch diversion operations. The SGI work conducted in 2004 and results of the SGI work conducted in 2006 show the range of influence to be between 740 and 1000 feet upstream of the El Sur Ranch New Well. For water quality and passage analyses, reference site Transects 10 and 11 and VT-1 were established outside the radius of influence.

The experimental design for the Big Sur River fishery habitat surveys included both continuous (approximately hourly or more frequent where appropriate) monitoring using data loggers as well as periodic (grab sampling) monitoring scheduled to coincide with specific periods of El Sur Ranch well operations. Data loggers were used to record water elevation within each of the irrigation wells, water surface elevation within stilling wells located within the river, dissolved oxygen concentrations at an upstream reference location and at a location within the potential zone of influence of the El Sur Ranch diversion pumps, and water temperatures within the river. Continuous monitoring occurred over the period from August 30 through October 17

Elements of the fishery habitat monitoring program described below include (1) water velocity surveys to measure streamflow within the river and inflow into the lagoon (2) periodic water quality and habitat connectivity surveys; (3) continuous water temperature monitoring; and (4) continuous dissolved oxygen monitoring. The primary geographic area included in the fishery habitat investigations (transects 1 to 11; Figure 1-1) extended over a 0.35 mile reach of the river extending from the upper lagoon area of the lower Big Sur River.

2.1 Velocity And Streamflow Measurements

Streamflow represents an important factor affecting quality and availability of habitat for juvenile steelhead and other aquatic species inhabiting coastal streams. Streamflow also affects water depth and wetted channel area. Documenting streamflow within the Big Sur River on the same days habitat connectivity and fish passage surveys were conducted allows potential correlation between changes in channel depth and wetted width.

2.1.1 Survey Locations

To document streamflow during the fishery habitat investigation water velocity measurements were made at an upstream reference location (Figure 1-1 and 2-1; water velocity and stream flow transect is designated as Velocity Transect-1 or VT-1). The stream flow velocity transect location was identified by rebar posts located on the left and right river banks.

2.1.2 Survey Methods

During each survey, a tape measure was stretched across the stream channel between the rebar posts and water velocity and water depth was measured at 0.5 ft (0.15 m.) intervals across the channel. During each survey the wetted width of the channel was recorded. Water depth was measured using a top-setting depth measuring rod and recorded to 0.05 ft accuracy. Water velocity was measured using a Marsh-McBirney Model 2000 Flo-Mate portable electromagnetic velocity meter measuring water velocity (ft/sec) for each survey point on a 15 second averaging system. Water flow during each survey (cubic feet per second; cfs) was calculated based on the cross-sectional area of each 0.5 ft (0.15m.) wide cell (square feet) and the corresponding water velocity (ft/sec). The velocity meter was calibrated in accordance with manufacturer protocols. The Marsh-McBirney Flo-Mate 2000 has a zero stability of ±0.05 ft/s and is accurate to ±2% of reading + zero stability with a range of -0.5 to +20 ft/sec (-0.15 to 6 m/s).

2.1.3 Survey Frequency

Streamflow measurements were recorded at Velocity Transect 1 (VT-1) during the periodic water quality surveys. Table 2-1 summarizes the dates the streamflow monitoring occurred. A baseline reference flow condition was measured on September 1, 2006 (both El Sur Ranch pumps off). Subsequent surveys were conducted approximately twice per week during September 6 to October 12, 2006 under a range of controlled El Sur Ranch well diversions (Table 2-2).

2.2 Steelhead Passage and Habitat Connectivity

During August of 2006, a preliminary field survey was conducted along the Big Sur River corridor to identify potential fish passage transect locations in the study reach adjacent to the El Sur Ranch pumping wells. Streamflow on a given day at each of the identified passage transect locations was assumed to be consistent between adjacent transects. Instream flow at each of the designated transect points during each passage survey was calculated based on water velocity measurements made across the established reference transect (VT-1, Figure 1-1) on the same day. Changes in water surface elevation in response to instream flow rates may result in a reduction in surface water elevations, dewatering portions of a river that result in impediments and barriers to migration of fish among habitat units (connectivity), in addition to posing a risk of stranding fish within isolated pools and backwater areas.

Eleven (11) transect locations were selected within the reach extending from the lagoon upstream approximately 0.35 miles past the El Sur Ranch diversion wells, with priority given to locations passing through surface riffle habitats (Figure 1-1). At each of these transect locations, river cross-sectional measurements were made in accordance with specific El Sur Ranch well operations that include wetted channel width and water depth measured at 0.5 ft intervals across the river. Each of the transect locations were identified using re-bar posts marked with flagging tape and surveyed with a highly accurate survey-grade GPS.

2.2.1 Survey Locations

Eleven (11) steelhead passage transect locations were selected after preliminary survey of the study reach in August, 2006. Figure 1-1 summarizes the transect locations selected for steelhead passage monitoring. Preference was given to sections of the lower Big Sur River that included riffle zones or other potential passage barriers. Figures 2-2 to 2-12 show the transect locations with surrounding riparian vegetation and habitat types (riffle, pool, run). Four passage transect locations represented typical riffle habitat (Transects 4, 9, 10, 11) within the lower Big Sur River, three transect locations represented lagoon habitat (Transects 1 to 3), and four transect locations represented homogenous channel sections with deep pools and riparian cover (Transects 5 to 8). The four transect locations representing pool and run habitat types extended from down stream of the area identified as having groundwater influence through the section adjacent to the El Sur Ranch diversion wells. Table 2-3 summarizes the habitat type at each passage monitoring transect.

2.2.2 Survey Methods

Steelhead passage was monitored at 11 locations on the lower Big Sur River (Figure 1-1; Table 2-3) where measurements were made between August 30, 2006 and October 17 2006 (Table 2-1). The field sampling design included measuring water depths at each of the passage sites over a range of four El Sur Ranch diversion well pumping conditions: both Old well and New well pumps diverting water; Old well only pump diverting water; New well only diverting water, and; both pumps off. Table 2-2 summarizes El Sur Ranch diversion well operations over the study period.

Water depths at passage transect locations, identified by rebar and flagging tape, were measured by stretching a surveyor's tape across the creek at the designated transect location. Water depth was measured across the channel cross-section using a stadia rod. Water depths were measured at 0.5-foot intervals and to 0.05 feet accuracy. Wetted width was recorded during each survey to within 0.05 ft accuracy using the surveyors tape stretched across the channel cross section.

Data on the channel cross-section (e.g., water depths and wetted width across the channel) at each site were then used to iteratively determine water surface elevation (stage) that met the following passage criteria: (1) 25% of the channel cross-section equal to or exceeding 0.6 feet; and (2) a 10% contiguous section of the cross-channel having depths equal to or exceeding 0.6 feet (Bjornn and Reiser 1991). The Bjornn and Resier (1991) primary criteria for analyses of habitat connectivity is a conservative criteria in that it has been established for adult steelhead passage. The habitat connectivity requirements are for juvenile steelhead rearing within the lower Big Sur River during summer months. Therefore, the passage criteria tested present a worst case scenario in testing for loss of passage and habitat connectivity. To reflect the nature of juvenile passage, requiring depths shallower then those presented for adult passage, a secondary criteria of maintained surface water connectivity was observed during the study period. During habitat surveys, a walking inspection of the entire study reach was conducted in order to identify and record any observed areas of loss of surface water connectivity along the lower Big Sur River, similar to inspections described in the 2004 study period analyses on habitat connectivity (Hanson 2005).

2.2.3 Survey Frequency

Table 2-1 summarizes the dates on which steelhead passage transect measurements were made. Essentially, passage monitoring occurred twice a week at the eleven transect locations between August 30 and October 17, 2006. The steelhead passage monitoring surveys were timed to coincide with the El Sur Ranch well diversions to test the null hypothesis that there is no significant effect on steelhead passage from irrigation diversions during the low flow conditions of late summer and early fall of 2006.

2.3 Periodic Water Quality Surveys

Water quality parameters, including water temperature, dissolved oxygen concentrations, and electrical conductivity (salinity), affect habitat quality and availability for juvenile steelhead/rainbow trout rearing within a river and/or lagoon. Regular water quality grab sample surveys were implemented to evaluate conditions within the lower Big Sur River and lagoon, and to assess the potential effects of El Sur Ranch irrigation well operations on habitat quality and availability for juvenile steelhead/rainbow trout rearing within the lower river adjacent to the diversion pumps and the lagoon during summer and fall months.

2.3.1 Survey Locations

Based in part upon results of the 2004 study (Hanson 2005) and the preliminary survey in August 2006, eleven specific water quality survey sites (Figure 1-1), were identified at approximately equal intervals extending upstream from the lagoon and lower river, through areas of potential influence from El Sur Ranch diversion operations, to an upstream reference reach outside the potential zone of influence. Water quality parameters were also recorded at an upstream reference site, VT-1 (Figure 1-1) outside the potential zone of influence to establish baseline conditions on periodic survey dates. The periodic grab samples were conducted by taking water quality measurements using a YSI handheld multiprobe water quality meter. The YSI handheld meter was used to take grab sample data at a depth approximately 4 to 6 inches from the channel bottom at survey points adjacent to the left and right banks as well as the center of the channel at each of the eleven marked transect locations. The three sample points at each survey transect allowed variation in water quality parameters to be observed across the river channel.

The geographic distribution of individual survey sites included both locations within the lagoon as well as transects within the lower river as shown in Figure 1-1. The specific location of each individual survey site was identified by GPS coordinates and visually using rebar markers to facilitate relocating each specific survey location.

2.3.2 Survey Methods

Water quality and habitat surveys were conducted by wading the length of the entire study reach extending upstream from the lagoon to the lower river. Water quality measurements included dissolved oxygen concentrations (mg/l), water temperature (°C), and electrical conductivity (µS/cm). These parameters were measured using portable handheld water quality meter YSI 556 Multi parameter probe. Water quality meters were calibrated regularly using manufacturer protocols and standards. The YSI 556 Multi parameter probe accuracy was checked against other handheld EC and dissolved oxygen water quality meters to test for accuracy (YSI Model 33 Handheld Conductivity Meter, and YSI Model 95 Handheld Dissolved Oxygen Meter). No significant ($P>0.05$) difference was determined to exist between the various hand held water quality meters. The YSI 556 Multi parameter probe water quality monitoring parameter specifications are as follows: dissolved oxygen measured in mg/L ranging from 0 to 50 mg/L accurate within range of 0 to 20 mg/L to ± 2% of the reading or ±0.2 mg/L, whichever is greater; electrical conductivity ranging from 0 to 200 mS/cm accurate to ± 1.0% of reading or ± 0.001 mS/cm; whichever is greater; temperature ranging from -5°C to 45°C accurate to ± 0.15°C. Table 2-4 summarizes the parameters measured by survey date at the eleven transect locations within the lagoon and lower river as well as at the upstream reference site VT-1.

2.3.3 Survey Frequency

Water quality surveys were conducted at twice weekly intervals throughout the period from August 30 through October 17. Table 2-1 summarizes the water quality survey dates over the period of the monitoring operations of the Big Sur River. Table 2-4 shows the water quality parameters measured during each survey. Periodic surveys were conducted to coincide with the El Sur Ranch well operations being conducted over the test period.

2.4 Continuous Water Temperature Monitoring

Steelhead/rainbow trout, a cold-water species, are extremely sensitive to exposure to seasonally elevated water temperatures. Elevated water temperatures, particularly during late summer and early fall months, have been identified as a significant limiting factor affecting habitat quality and availability for juvenile steelhead/rainbow trout rearing within a number of southern and central California river systems. As a result of the sensitivity of juvenile steelhead/rainbow trout to seasonal water temperature conditions, continuous water temperature monitoring was performed at various locations along the longitudinal gradient of the lower river extending from the lagoon upstream through the study reach to an area outside the potential zone of influence of the El Sur Ranch irrigation diversion operations as a component of the fishery habitat monitoring program. The locations for continuous water temperature monitoring were selected, in part, based on results of the 2004 fishery habitat monitoring program (Hanson 2005). The Hanson (2005) fishery monitoring program consisted of continuous temperature monitoring of the lower Els Sur River extending upstream from the lagoon to the Andrew Molera State Park car park. The 2006 fishery habitat monitoring program consisted of a refined and more detailed recording of water temperatures within the lower Big Sur River in the reach immediately adjacent to the El Sur Ranch irrigation diversion well field and extending upstream and downstream from this zone into reference areas for baseline comparison during a range of diversion well pumping regimes.

2.4.1 Survey Locations

Eleven continuous temperature-monitoring locations, designated as Transects 1 through 10 and Transect VT-1 were identified along the longitudinal gradient of the lower river and lagoon (Figure 1-1). The eleven continuous temperature monitoring sites represent the longitudinal gradient within the study area, including upstream reference sites (Transect VT-1 and Transects 10 and 11), five temperature monitoring sites adjacent to Creamery Meadow (Transects 4 through 8), and three monitoring locations downstream within the lagoon (Transects 1 through 3). The eleven continuous temperature-monitoring sites were situated in a range of habitat types extending through the study reach including relatively deep pool habitats, surface riffle habitats, and deep homogenous run habitat. At each of the designated continuous water temperature monitoring sites, water temperature was monitored near the surface (<1 foot below the water surface) and on the bottom of the river channel (>1.5 foot where possible, on the channel bottom where depths were under 1.5 foot). Table 2-5 summarizes temperature logger placement for Transects 1 through 11 and Transect VT-1. Surface and bottom temperatures were monitored in this fashion adjacent to both the left and right banks of the entire study reach. The temperature monitoring locations were generally sited in areas that were difficult to access from hiking trails to reduce the risk of vandalism. Reference Transect VT-1 had no surface temperature recorder installed on the right bank surface location due to logger malfunction. All locations for left and right bank are oriented from facing upstream.

2.4.2 Survey Methods

Water temperature was monitored at each location described above (Transects 1 through 10 and reference Transect VT-1, Figure 1-1) using self-contained computerized temperature monitoring data loggers (Optic Stowaway temperature monitoring units). Temperature loggers were periodically calibrated, under controlled laboratory conditions, to NBS traceable standards. Results of temperature logger calibrations were used to verify the accuracy of resulting temperature data and account for instrument error/drift when developing final water temperature monitoring results.

Water temperature data were downloaded at the end of the field study from the individual data loggers into Microsoft Excel format. Data from each logger was reviewed and evaluated as part of the quality assurance program to identify potential data outliers, evaluated in accordance with the logger calibration protocol, and adjusted, if necessary, to account for instrument drift as determined by results of the laboratory calibrations. All recorders were found to be within the manufacturer's specifications (0.5°C) and therefore no adjustments to the original field temperature measurements were made. A final water temperature database was documented in tabular format, showing 24-minute temperatures at each of the designated sampling sites throughout the monitoring period. Water temperature results were also displayed in graphic format and analyzed statistically to determine potential differences in temperatures within sites (surface versus bottom temperature, left versus right bank temperature) and among monitoring sites in relationship to El Sur Ranch manipulated well diversion operations.

2.4.2 Survey Frequency

Water temperatures were monitored and recorded at 24-minute intervals from August 26 through October 10, 2006 (monitoring durations varied among sites based on the logger deployment and the loss of water temperature data from dewatering). Water temperature loggers were removed from the Big Sur River and lagoon in late October to reduce the likelihood that loggers would be lost during high flow events.

2.5 Continuous Dissolved Oxygen Concentration Monitoring

Studies conducted on the Big Sur River in 2004 (Hanson 2005) identified areas of potential groundwater upwelling within the Big Sur River within the Creamery Meadow reach and adjacent to the El Sur Ranch irrigation diversion wells. The locations of reduced dissolved oxygen levels coincide with observed reductions in water temperature and electrical conductivity. Groundwater typically has reduced dissolved oxygen concentrations when compared to aerated surface waters. Although significant differences in dissolved oxygen concentrations were detected among study reaches during the summer 2004 surveys (Hanson 2005), dissolved oxygen concentrations were within the range considered to be suitable for juvenile steelhead/rainbow trout with the exception of the localized areas adjacent to Creamery Meadow, where reduced dissolved oxygen concentrations were thought to be the result of groundwater upwelling. The observed localized reduction in dissolved oxygen concentrations associated with the Creamery Meadow sites are consistent with the hypothesis of groundwater upwelling from ground water underflow mixing within the lower Big Sur River in the area (SGI 2005).

To monitor for the potential confounding effects of groundwater upwelling on juvenile steelhead/rainbow trout habitat quality and availability within the lower river and lagoon, in conjunction with the incremental effect, if any, of irrigation well operations, dissolved oxygen concentrations were continuously recorded by placement of dissolved oxygen recording logger within the Creamery Meadow reach of the lower Big Sur River in an area identified during the 2004 study (Hanson 2005) as being an area characterized as a ground water mixing zone. A second dissolved oxygen recorder was also placed in an upstream reference location outside the potential zone of influence of ground water upwelling and El Sur Ranch irrigation well diversions.

2.5.1 Survey Locations

Two continuous dissolved oxygen concentration monitors were placed in the lower Big Sur River. One dissolved oxygen logger was placed at an upstream reference location outside the potential zone of influence from groundwater upwelling and El Sur Ranch irrigation well diversions to establish an environmental baseline (Figure 1-1). A second recorder was located within an area of recorded groundwater influence within the Creamery Meadow reach of the Big Sur River (Figure 1-1). Both recorders were situated in depths greater then 2.5 feet and were situated approximately 2 feet from the right bank as orientated facing upstream. The recorders were placed in areas of consistent flow to avoid stagnation. The recorder locations were both selected to be near the right bank to record conservative concentrations of dissolved oxygen from potential groundwater influence.

2.5.2 Survey Methods

Dissolved oxygen concentrations were recorded continuously on Troll 9500 water quality monitoring data SONDES rented from In-Situ. The multi parameter Troll 9500 data loggers were installed factory calibrated with Clarke electrode dissolved oxygen concentration probes. The Troll 9500 has 4 MB memory capacity (capable of holding 1,000,000 individual readings) and battery life good for approximately 300 days of continuous monitoring. The Clarke electrode dissolved oxygen probe recorded dissolved oxygen concentrations as mg/l with an accuracy of ± 0.2 mg/l or ± 1% and a range of 1 to 20 mg/l at depths up to 246 m.

Dissolved oxygen concentration data was downloaded periodically during the habitat monitoring survey period and a database created using Microsoft Excel for analysis of dissolved oxygen changes over the period of manipulated El Sur Ranch irrigation diversion well pumping tests. The data was analyzed for significant differences in dissolved oxygen concentrations between the upstream reference location and the downstream location in the Big Sur River study reach adjacent to the El Sur Ranch diversion wells. The data was also analyzed for significant differences in dissolved oxygen concentrations under different El Sur Ranch irrigation diversion pumping regimes over the test period.

2.5.3 Survey Frequency

Monitoring of dissolved oxygen concentrations within the lower Big Sur River was conducted between August 30 and October 16, 2006. Dissolved oxygen concentrations were recorded on an hourly basis throughout the 2006 habitat monitoring period. Monitoring was timed to coincide with manipulated El Sur Ranch irrigation well diversions.

3.0 Results

3.1 Velocity and Streamflow Measurements

The estimated streamflow measured at transect VT-1 over the period from September 1 through October 12, 2006, is summarized in Table 3-1 and Figure 3-1 based on measurements made during regularly scheduled surveys timed to coincide with a range of El Sur Ranch irrigation diversion well pumping operations. Streamflows ranged from approximately 18 to 22 cfs. Stream width ranged from approximately 39.3 to 40.3 feet with a corresponding mean depth ranging from 1.24 to 1.46 feet during all surveys. These streamflow conditions are an increase on those measured in 2004. In the 2004 study period, discharge at VT-1 was approximately 8 cfs with a mean depth of approximately 0.9 ft and a wetted width of approximately 35 ft. Results of streamflow measurements at transect VT-1 represent conditions within the reference reach of the Big Sur River located upstream of the El Sur Ranch irrigation wells (Figure 1-1). Rainfall during the study period equaled 0.1 inches during a single rainfall event between October 4 and 5, 2006. Daily air temperatures measured during the study period ranged from 12.4 to 17.7°C.

A comparison of flows measured at the velocity transect showed a general pattern of consistent flows discharging from transect VT-1 (reference location) into the downstream study reach within the river and lagoon. Habitat continuity suitable for juvenile steelhead passage to upstream habitat units from passage transects in the lower reaches (Passage Transects 1 through 11 within Zones 1 through 4 designated as the potential zone of influence by work conducted by SGI, 2007) was maintained throughout the 2006 and the 2004 study period. The continuous connectivity recorded under the differing flow years of 2006 (18 to 22 cfs) and 2004 (8 cfs) demonstrates the range of flows recorded where habitat continuity for juvenile steelhead rearing within the lower Big Sur River is maintained.

Results of the flow measurements made at the reference transect location were tested to determine if there was a significant change (reduction) in stream flows over the course of the study period that would adversely affect habitat quality or availability for juvenile steelhead rearing over the summer and early fall months independent from any El Sur Ranch irrigation diversion well pump testing.

Results of statistical analyses of the flow data showed that the median flow measured at transect VT-1 (upstream reference) was 18.91 cfs. Differences in the flows over the study period were not statistically significant ($n = 12$; $P = 0.121$) based on a T-Test for differences in discharge between periods of no irrigation diversions and either 1 or 2 pumps operating for irrigation diversions. Results of these measurements provide evidence that potential changes in flow, water depth, and fish passage potential, if any, within the lower reaches of the Big Sur River study reach, adjacent to the El Sur Ranch irrigation diversion wells, during the study period did not result from reduced stage discharge at the upstream reference location.

3.2 Steelhead Passage and Habitat Connectivity

Instream habitat conditions within the lower Big Sur River included pool, riffle, run, and glide habitat features, in addition to the pool created within the lagoon. Substrate was predominantly sand and pea gravel, although there were deposits of larger gravels associated with several of the riffles located primarily in the river reaches upstream of Creamery Meadow. The stream banks were vegetated by diverse riparian vegetation. Cover habitat was provided primarily by brush within the stream channel, overhanging riparian vegetation and large woody debris. Photographs showing the general habitat conditions along the lower Big Sur River at the eleven selected fish passage monitoring transects and at the upstream reference site transect VT-1 are presented in Figures 2-2 to 2-12. During the August 30 to October 17 survey period, surface water flows were sufficient to maintain connectivity among all habitat units within the lower river and lagoon throughout the range of El Sur Ranch irrigation diversion well pump testing.

Fish passage monitoring was conducted at eleven (11) transect locations within the lower Big Sur River representing the full range of habitat types described above (Figure 1-1). Surface riffle zones were preferentially chosen, where available, for fish passage monitoring. These critical riffle areas would present the primary barrier to fish passage under low flow conditions. Descriptions of Transects 1 through 11 habitat types are presented in Table 2-3. Results of the fish passage monitoring conducted during the survey period over a range of El Sur Ranch irrigation diversion conditions are summarized in Tables 3-2 through 3-12. Channel profiles for the fish passage monitoring transects, along with water elevation contour lines for each specific survey date are presented in Figures 3-2 to 3-12. Passage Transects 1 through 3 represented the lagoon reach, Transects 4 through 9 represented the Creamery Meadow reach, and Transects 10 and 11 represented the upstream reference area outside the potential influence of El Sur Ranch diversion pumping or groundwater upwelling influence. Within the lagoon reach, for Passage Transects 1 through 3, cross channel depths were too great for survey access on some survey dates (summarized in Tables 3-2 to 3-4). On survey dates when water levels were too high for cross channel access, channel monitoring resolution was reduced by a factor of 10 (depth measurements taken every 5 feet) and point measurements were made where access was possible. Interpolation of the remaining channel was then calculated using conservative estimates.

Passage Transects 1 through 3 represent the lagoon study reach. Passage Transect 1 (Figure 3-2, Table 3-2), the furthest downstream monitoring location within the lagoon reach, was tidally influenced and was characterized by wetted channel widths ranging from 84.1 to 85.1 feet, and mean depths ranging from 2.8 to approximately 3.5 feet. Both the 25% and 10% Bjornn and Reiser (1991) criteria were met on all survey dates under all experimental diversion pumping test conditions. Passage Transect 2 (Figure 3-3, Table 3-3), within the lagoon reach, was characterized by wetted channel widths ranging from 86.5 to 97.7. The high range of wetted channel width is due, in part, to tidal influence and to the channel left bank waters edge under summer flow conditions being characterized by low lying channel cobble bottom (Figure 2-3) that would become submerged for a distance of 4 to 6 feet at a depth of less than 6 inches. Channel mean depth ranged from 1.2 to 1.5 feet. Both the 25% and 10% Bjornn and Reiser (1991) criteria were met on all survey dates under all experimental diversion pumping test conditions. Passage Transect 3 (Figure 3-4, Table 3-4), at the upstream end of the lagoon reach, was characterized by a wetted channel width ranging from 43.9 to 98.5 feet. Like Passage Transect 2, Passage Transect 3 was tidally influenced and an extensive low lying gravel bar (Figure 2-4) would periodically become submerged, extending the channel wetted width significantly, and becoming submerged to a uniform depth of approximately less than 4 inches. Mean depths ranged from 1.27 to 1.52 feet. Both the 25% and 10% Bjornn and Reiser (1991) criteria were met on all survey dates under all experimental diversion pumping test conditions.

Passage Transects 4 through 9 represented the Creamery Meadow reach adjacent to the El Sur Ranch diversion wells. Passage Transect 4 (Figure 3-5, Table 3-5), representing a riffle habitat unit, was characterized by wetted channel widths ranging from 24.3 to 27.1 feet, and mean depths ranging from 0.34 to 0.60 feet. Both the 25% and 10% Bjornn and Reiser (1991) criteria were met on all survey dates under all experimental diversion pumping test conditions. Passage Transect 5 (Figure 3-6, Table 3-6), located at the downstream end of the Creamery Meadow reach within the ground water upwelling influence zone, was characterized by wetted channel widths ranging from 51.8 to 52.8 and mean depths ranging from 1.26 to 1.35 feet. Both the 25% and 10% Bjornn and Reiser (1991) criteria were met on all survey dates under all experimental diversion pumping test conditions. Passage Transect 6 (Figure 3-7, Table 3-7) was characterized by wetted channel widths ranging from 41.5 to 42.1 feet and men depths ranging from 2.05 to 2.22 feet. Both the 25% and 10% Bjornn and Reiser (1991) criteria were met on all survey dates under all experimental diversion pumping test conditions. Passage Transect 7 (Figure 3-8, Table 3-8), the survey location most influenced by the ground water upwelling, was characterized by wetted channel widths ranging from 41.8 to 42.9 feet and mean depths ranging from 1.78 to 2.02 feet. Both the 25% and 10% Bjornn and Reiser (1991) criteria were met on all survey dates under all experimental diversion pumping test conditions. Passage Transect 8 (Figure 3-9, Table 3-9), at the upstream end of the Creamery Meadow reach within the groundwater upwelling zone of influence, was characterized by wetted channel widths ranging from 40.7 to 41.6 feet and mean depths ranging from 2.0 to 2.1 feet. Both the 25% and 10% Bjornn and Reiser (1991) criteria were met on all survey dates under all experimental diversion pumping test conditions. Passage Transect 9 (Figure 3-10, Table 3-10), representing a riffle habitat unit in the upstream reference reach, was characterized by wetted channel widths ranging from 13.2 to 14.2 feet and mean depths ranging from 0.62 to 0.74 feet. Both the 25% and 10% Bjornn and Reiser (1991) criteria were met on all survey dates under all experimental diversion pumping test conditions.

Passage Transects 10 and 11 represented the upstream reference reach displaying environmental baseline conditions outside the zone of influence of El Sur Ranch diversion operations. Passage Transect 10 (Figure 3-11, Table 3-11), representing a riffle habitat unit in the upstream reference reach, was characterized by wetted channel widths ranging from 33.8 to 34.9 feet and mean depths ranging from 0.47 to 0.59 feet. At Passage Transect 10 the Bjornn and Reiser (1991) 25% criteria was met for all survey dates under all experimental diversion pumping test conditions. The Bjornn and Reiser (1991) 10% criteria was not met on the August 30 (8.6% of contiguous cross channel greater or equal to 0.6 foot), September 14 (8.7% of contiguous cross channel greater or equal to 0.6 foot), September 21 (8.7% of contiguous cross channel greater or equal to 0.6 foot), September 25 (8.7% of contiguous cross channel greater or equal to 0.6 foot), and October 5 (8.6% of contiguous cross channel greater or equal to 0.6 foot) survey dates. These periods of potential barrier to adult steelhead passage were present during both periods of no pump operation, 1 pump operation, and 2 pump operation. No determinable patterns were present linking irrigation diversions and potential barriers to steelhead migration. These potential barriers to fish passage occurred within the upstream reference reach and were independent of experimental El Sur Ranch irrigation pump diversions.

Passage Transect 11 (Figure 3-12, Table 3-12), representing a riffle habitat unit in the upstream reference reach, was characterized by wetted channel widths ranging from 32.9 to 33.9 feet and mean depths ranging from 0.39 to 0.48 feet. Passage Transect 11, the furthest upstream fish passage monitoring survey location, outside the zone of influence of experimental El Sur Ranch irrigation pump diversions and groundwater upwelling zones, presented the greatest potential barrier to fish passage under low flow conditions using the Bjornn and Reiser (1991) passage criteria. Fish passage was only possible for both the 25% and 10% criteria on October 5 (28.8% and 11.9% for the 25% and 10% criteria respectively) and October 12 (28.4% and 13.6% for the 25% and 10% criteria respectively) survey dates. On all other survey dates either the 25% or the 10% criteria were not met, presenting a potential barrier/impediment to steelhead passage. The periods of potential barrier to adult steelhead passage were present during both periods of no pump operation, 1 pump operation, and 2 pump operation. No determinable patterns were present linking irrigation diversions and potential barriers to steelhead migration.

Bjornn and Reiser (1991) passage criteria for 25% of the channel cross-section with a depth equal to or exceeding 0.6 feet as well as 10% contiguous section of the cross-channel having depths equal to or exceeding 0.6 feet were met for all survey dates under the range of experimental El Sur Ranch irrigation diversion pump tests between Passage Transects 1 and 9, extending from the lagoon reach through the Creamery Meadow reach. These results indicate that fish passage was not effected by the El Sur Ranch irrigation diversion pumping under the flows measured between August 30 and October 17, 2006. Passage Transects 10 and 11, within the upstream reference reach, presented a potential natural barrier/impediment to steelhead passage using the Bjornn and Reiser (1991) passage criteria under the flow conditions within the Big Sur River measured between August 30 and October 17, 2006, independent of El Sur Ranch irrigation diversion operations.

3.3 Periodic Water Quality Surveys

Water quality measurements were made twice a week at 12 sampling sites located within the 0.35 mile study reach of the river extending from the lagoon at Transect 1 upstream to Transect 11, as well as at an upstream environmental baseline reference site at Transect VT-1 near the Andrew Molera State Park car park approximately 1 mile upstream from the lower lagoon (Figure 1-1). Results of these water quality measurements were used to assess changes in conditions affecting habitat quality and availability for juvenile steelhead/rainbow trout rearing both seasonally over the late summer and early fall months coincident with the range of manipulated El Sur Ranch irrigation pumping regimes. Water quality stations included sites upstream of the influence of the El Sur Ranch irrigation wells (reference sites), within the immediate vicinity of the wells (Creamery Meadow reach), and downstream of the wells (lagoon reach). For purposes of the analysis of changes in water quality conditions, water quality monitoring Transects 10 to 11 and VT-1 were identified as upstream reference sites, Transects 4 to 9 were identified as Creamery Meadow locations adjacent to the irrigation wells, and Transects 1 to 3 were identified as downstream lagoon sites (Figure 1-1). Results of the 2006 water quality monitoring program are summarized below.

3.3.1 Water Temperature

Results of periodic water temperature measurements within the lower Big Sur River and lagoon are summarized in Figures 3-13 to 3-25. Results are summarized by Transect locations 1 through 11 and VT-1, as well as for a small groundwater spring discovered near Transect marker 6 on the right bank that appeared to have a consistent discharge rate over the period of the habitat monitoring survey (Table 2-1). Also summarized on Figures 3-13 to 3-25 are the El Sur Ranch irrigation diversion pump operations over the course of the periodic habitat water quality surveys providing a summary of potential changes to water quality throughout different stages of the pump test period of the survey. Stream discharge (cfs) measured during streamflow monitoring at Transect VT-1 is also summarized on Figures 3-13 to 3-25 for comparison of habitat quality changes, if any, to fluctuations in stream discharge over the study period.

Periodic water quality surveys conducted at Transect locations 1 through 3 represent conditions within the lagoon study reach. During the survey period between August 30 and October 17, 2006, where water quality surveys concluded on October 10, 2006, Transect 1 (Figure 3-13) was characterized by uniform temperatures across the channel from right to left bank ranging from 14.1 to 16.7°C at the left bank survey location; 14.1 to 16.6°C at the middle channel survey location, and; 14.1 to 16.9°C at the right bank survey location. Transect 2 (Figure 3-14) was characterized by uniform temperatures across the channel from right to left bank ranging from 14.1 to 16.9°C at the left bank survey location; 14.1 to 16.7°C at the middle channel survey location, and; 14.1 to 16.4°C at the right bank survey location. Transect 3 (Figure 3-15) was characterized by uniform temperatures across the channel from right to left bank ranging from 14.1 to 17.0°C at the left bank survey location; 14.1 to 16.7°C at the middle channel survey location, and; 14.1 to 16.6°C at the right bank survey location.

Periodic water quality surveys conducted at Transect locations 4 through 9 represent conditions within the Creamery Meadow study reach. Transect 4 (Figure 3-16) was characterized by uniform temperatures across the channel from right to left bank ranging from 14.1 to 17.1°C at the left bank survey location; 14.1 to 17.0°C at the middle channel survey location, and; 14.1 to 16.8°C at the right bank survey location. Transect 5 (Figure 3-17) was characterized by uniform temperatures across the channel from right to left bank ranging from 14.1 to 16.9°C at the left bank survey location; 14.1 to 16.9°C at the middle channel survey location, and; 14.0 to 16.7°C at the right bank survey location. Transect 6 (Figure 3-18) was characterized by uniform temperatures across the channel from right to left bank, but showed a slight yet consistent drop in temperature along the right bank location. Temperatures ranged from 14.1 to 16.9°C at the left bank survey location; 14.0 to 17.0°C at the middle channel survey location, and; 13.9 to 16.3°C at the right bank survey location. Transect 7 (Figure 3-19), the survey location most representative of the ground water upwelling influence within the lower Big Sur River, was characterized by uniform temperatures across the channel from middle to left bank ranging from 14.1 to 16.8°C at the left bank survey location; 14.1 to 17.0°C at the middle channel survey location, and a reduction in the water temperatures on the right bank ranging from 12.9 to 15.4°C. Transect 8 (Figure 3-20) was characterized by uniform temperatures across the channel from right to left bank ranging from 14.1 to 17.0°C at the left bank survey location; 14.1 to 17.2°C at the middle channel survey location, and; 14.1 to 16.9°C at the right bank survey location. Transect 9 (Figure 3-21) was characterized by uniform temperatures across the channel from right to left bank ranging from 14.1 to 17.2°C at the left bank survey location; 14.1 to 17.2°C at the middle channel survey location, and; 14.2 to 17.2°C at the right bank survey location.

Periodic water quality surveys conducted at Transect locations 10 and 11 and Transect VT-1 represent conditions within the upstream reference reach located outside of the zone of influence of El Sur Ranch diversion operations. Transect 10 (Figure 3-22) was characterized by uniform temperatures across the channel from right to left bank ranging from 14.1 to 17.2°C at the left bank survey location; 14.1 to 17.2°C at the middle channel survey location, and; 14.1 to 17.3°C at the right bank survey location. Transect 11 (Figure 3-23) was surveyed from September 12 to October 10, 2006 (missing the first set of periodic water quality surveys) due to being added as an additional critical riffle habitat for passage and habitat quality monitoring. Transect 11 was characterized by uniform temperatures across the channel from right to left bank ranging from 14.1 to 17.4°C at the left bank survey location; 14.1 to 17.3°C at the middle channel survey location, and; 14.1 to 17.3°C at the right bank survey location. Transect VT-1 (Figure 3-24) was surveyed from September 12 to October 10, 2006 (missing the first set of periodic water quality surveys) due to timing of the velocity monitoring transect installation during the initial project set up period. Transect VT-1 was characterized by uniform temperatures across the channel from right to left bank ranging from 13.9 to 17.1°C at the left bank survey location; 13.9 to 17.1°C at the middle channel survey location, and; 13.9 to 17.1°C at the right bank survey location.

Periodic water quality surveys of the small groundwater spring located near Transect marker 6 on the right bank showed temperatures to be consistently within the range found between Transect locations 4 through 8 localized on the right bank (Figure 3-25).

Water temperatures at all sites were within the general range of habitat conditions considered to be suitable for juvenile steelhead rearing (average daily temperatures less than 20°C (68°F) and peak daily temperatures less than 24°C (75°F). The observed decline in water temperatures observed at Transects 6 and 7 near the Creamery Meadow were hypothesized to be the result of groundwater upwelling (accretions) within the localized area of these measurement sites. At the majority of sites, there were no observed differences in water temperatures across the channel measurements beyond natural levels of variation within the river.

It was hypothesized that operation of the El Sur Ranch irrigation wells could contribute to an increase in water temperatures within the Creamery Meadow and lagoon reaches of the river that would adversely affect habitat quality for juvenile steelhead rearing. To test the hypothesis a series of statistical analyses were performed to compare potential water temperature changes monitored over the range of experimental El Sur Ranch irrigation well diversion testing between the environmental baseline reference reach (Transects 10 and 11) and the area of influence within Zones 2 through 4 (Transects 4 through 9). Transects 1 through 3 were not included within the statistical testing due to the tidal nature of the lagoon reach. The temperature variations based on tidal fluctuations within the lagoon override any detectable signal variation in temperature between periods of pumping and not pumping. In addition to this, the tidal nature of the lagoon means that pumping will not likely have an effect on temperature variations beyond the natural range, so is unlikely to adversely effect habitat within the lagoon reach.

Statistical testing was performed using both the T-Test and the Mann-Whitney Rank Sum Test. Testing was performed to determine if significant differences occurred between the environmental baseline reference reach (Transects 10 and 11) and the zone of influence (Transects 4 to 9) for each habitat quality monitoring grab sample survey date. Results of these statistical tests are summarized in Table 3-13.

Median temperature values were within the optimal range for juvenile steelhead growth at all times irrespective of irrigation diversion operations. Results were somewhat inconsistent in showing significant differences between the two reaches during times of pumping and not pumping. Significant differences were observed in temperature during periods of pumping versus periods of no pumping when comparing between the upstream reference reach (Transects 10 and 11) and the potential zone of influence (Transects 4-9). However, significant differences were also observed between the upstream reference reach and the zone of influence during periods of zero pumping. These significant differences were found to occur in periods of survey following a termination of pumping activity.

Despite some statistically significant differences between the environmental baseline reference reach and the zone of influence during periods of pump operations, it must be noted that variations in median values reported were within approximately 0.5°C. Additionally, the variation in median values showed that typically the zone of influence was a few tenths of a degree cooler then the upstream reference reach. Such an inconsistent pattern, combined with no clear signal between 0, 1, and 2 pump operations, as well as the fact that temperatures remained within optimal steelhead habitat thresholds at all times during the survey period mean that variation may have been a result of natural variation within the river, or linked to additional factors, such as time of day of sample collected. Results of statistical testing showed no evidence of a consistent pattern in observed water temperatures related to well operations.

To further understand the potential for significant impact within the zone of influence (Transects 4 to 9), further statistical testing was conducted using three-way analysis of variance (ANOVA). Testing was conducted to determine if a significant difference in temperature within the zone of influence occurred between survey dates representing the longest duration of either 0, 1, or 2 pump operations. The results of these tests are summarized in Table 3-14.

Using the three-way analysis of variance, some influence of well operations was potentially detected, but still no consistent pattern was observed between 0, 1, and 2 pump operation scenarios within the zone of influence. Any effects detected were of very low effect and indicate a high level of natural variability irrespective of pump operation. Variations in reported median temperature value for the ANOVA statistical tests were within 0.6 °C between scenarios. Results of testing between the surveys conducted on 8/30/06, representing a period of approximately 4 weeks without pump operations, and surveys conducted on 9/14/06, a period representing approximately two weeks of both pumps operating, show a significant difference in temperature. Results of testing on surveys conducted on 9/14/06 (0 pump scenario) and 9/21/06 (2 pump scenario) show a significant difference in temperatures with lower median value reported when both pumps were in operation (0.6 °C difference). Results of testing during surveys conducted on 9/21/06 (0 pump scenario) and 9/28/06 (1 pump scenario, Old Well) show a significant difference in temperatures with lower median value reported when old pump was in operation (0.6 °C difference). Results of testing during surveys conducted on 9/28/06 (1 pump scenario, Old Well) and 10/5/06 (0 pump scenario) show no significant difference in temperatures, the median values were identical.

Results of the water temperature monitoring surveys showed that during the late summer and early fall of 2006, water temperatures were within the suitable range for juvenile steelhead rearing. No apparent effect on water temperatures within the lower river or lagoon was detected from operation of the El Sur Ranch irrigation wells during the study period.

3.3.2 Electrical Conductivity

Electrical conductivity, a measure of salinity, was monitored as part of the river and lagoon water quality and fishery habitat surveys. Juvenile steelhead have been observed to inhabit rivers and estuarine lagoons having a relatively wide range of electrical conductivities. For purposes of these investigations, it was assumed that habitat conditions would be suitable for juvenile steelhead rearing if electrical conductivity was less than 1500 µmhos (approximately 0.96 ppt salinity).

Results of electrical conductivity measurements made from the lower river and lagoon during each of the 2006 surveys are summarized in Figures 3-26 to 3-38. Results are summarized by Transect locations 1 through 11 and VT-1 as well as for monitoring of water quality parameters within a small groundwater spring located at Transect marker 6 on the right bank, over the period of the habitat monitoring survey period (Table 2-1). Also summarized on Figures 3-26 to 3-38 are the El Sur Ranch irrigation diversion pump operations over the course of the periodic habitat water quality surveys, providing a summary of potential changes to water quality throughout different stages of the pump test for the survey period. Stream discharge (cfs) measured during streamflow monitoring at Transect VT-1 is also summarized on Figures 3-26 to 3-38 for comparison of habitat quality changes, if any, to fluctuations in stream discharge over the study period.

Electrical conductivities observed during the surveys were consistently less that 300 µmhos (salinity less than 0.2 ppt) and were within the range considered to be suitable for juvenile steelhead rearing. A pattern of localized reductions in electrical conductivity along the right bank of the channel cross section was observed at Transects 6 and 7. The geographic pattern in electrical conductivity was consistent with the hypothesis that these localized reductions were the result of groundwater upwelling within Zones 2 through 4 (Transects 4-9) of the lower Big Sur River (SGI 2007).

It was hypothesized that operation of the El Sur Ranch irrigation wells could contribute to an increase in water salinity within the Creamery Meadow and lagoon reaches of the river that would adversely affect habitat quality for juvenile steelhead rearing. To test the hypothesis a series of statistical analyses were performed to compare potential salinity changes monitored over the range of experimental El Sur Ranch irrigation well diversion testing between the environmental baseline reference reach (Transects 10 and 11) and the area of influence within Zones 2 through 4 (Transects 4 through 9). Transects 1 through 3 were not included within the statistical testing due to the tidal nature of the lagoon reach. The salinity variations resulting from tidal fluctuations within the lagoon override any detectable signal variation in salinity changes between periods of pumping and not pumping. In addition to this, the tidal nature of the lagoon means that pumping will not likely have an effect on salinity variations beyond the natural range, so is unlikely to adversely effect habitat within the lagoon reach.

Statistical testing was performed using both the T-Test and the Mann-Whitney Rank Sum Test. Testing was performed to determine if significant differences occured between the environmental baseline reference reach (Transects 10 and 11) and the zone of influence (Transects 4 to 9) for each habitat quality monitoring grab sample survey date. Results of these statistical tests are summarized in Table 3-13.

Median salinity values were within the optimal range for juvenile steelhead growth at all times irrespective of irrigation diversion operations. Results were somewhat inconsistent in showing significant differences between the two reaches during times of pumping and not pumping with no consistent pattern. Significant differences were observed in salinity during periods of pumping versus periods of no pumping when comparing between the upstream reference reach (Transects 10 and 11)and the potential zone of influence (Transects 4-9). However, significant differences were also observed between the upstream reference reach and the zone of influence during periods of zero pumping.

Despite some statistically significant differences between the environmental baseline reference reach and the zone of influence during periods of pump operations (9/12/06 and 9/25/06), it must be noted that variations in median values reported were well within the range of natural variations and never exceeded 300 µmhos, well under the threshold of 1500 µmhos. Such an inconsistent pattern, combined with no clear signal between 0, 1, and 2 pump operations, as well as the fact that salinities remained within optimal steelhead habitat thresholds at all times during the survey period mean that fluctuations and statistically significant differences may have been a result of natural variation within the river, or linked to additional factors, such as time of day of sample collection. Results of statistical testing showed no evidence of a consistent pattern in observed water temperatures related to well operations.

To further understand the potential for significant impact within the zone of influence (Transects 4 to 9), further statistical testing was conducted using three-way analysis of variance (ANOVA). Testing was conducted to determine if statistically significant differences in salinity within the zone of influence occurred between survey dates representing the longest duration of either 0, 1, or 2 pump operations. The results of these tests are summarized in Table 3-14.

Using the three-way analysis of variance, some influence of well operations was potentially detected for 0, 1, and 2 pump operation scenarios within the zone of influence. Any effects detected were of very low effect and indicate a high level of natural variability irrespective of pump operation. Variations in reported median salinity values for the ANOVA statistical tests were within 100 µmhos between scenarios, within the range of natural variation. Results of testing between the surveys conducted on 8/30/06, representing a period of approximately 4 weeks without pump operations, and surveys conducted on 9/14/06, a period representing approximately two weeks of both pumps operating, show a significant difference in salinity with slightly lower median salinity reported during the period of 2 pump operation. Results of testing on surveys conducted on 9/14/06 (0 pump scenario) and 9/21/06 (2 pump scenario) show a significant difference in salinity with lower median value reported when both pumps were in operation. Results of testing on surveys conducted on 9/21/06 (0 pump scenario) and 9/28/06 (1 pump scenario, Old Well) show a significant difference in salinity. Results of testing during surveys conducted on 9/28/06 (1 pump scenario, Old Well) and 10/5/06 (0 pump scenario) show a significant difference in salinity, the median values almost identical.

Based on results of these water quality comparisons it was observed that during the 2006 habitat survey monitoring, electrical conductivity remained consistently within the range of natural variation and well within established threshold limits for juvenile steelhead habitat between the monitoring locations under the range of pumping regimes.

A reduction in electrical conductivity was observed at all transect locations, within the environmental baseline reach and the reaches within Zones 1 through 4 on survey dates 9-14-06 and 9-18-06. This reduction was not determined to be in response to diversion operations and may have resulted from natural factors occurring upstream of the study area. The range of electrical conductivities recorded over the entire study period were between approximately 190 and 300 μm/cm. This falls within a similar range of electrical conductivities measured during the 2004 habitat monitoring period (Hanson 2005) (210 to 300 μm/cm) under lower flow conditions than in the 2006 study period and is thought to be within the typical range of naturally occurring salinity based on the 2004 and 2006 data periods.

Results of the electrical conductivity measurements showed that habitat conditions within the lower river and lagoon during the period of this survey were within the range considered to be suitable for juvenile steelhead rearing at all times irrespective of pump operations. There was no apparent adverse effect on electrical conductivities within the lower river or lagoon from the context of juvenile steelhead rearing habitat resulting from operation of the El Sur Ranch irrigation wells during the study period. The observed localized reduction in electrical conductivity within the Creamery Meadow reach, and the general patterns of conductivity within the reaches surveyed, are consistent with the hypothesis that groundwater upwelling (accretion) is occurring within the lower river that affect localized water quality conditions, particularly during the lower flow summer and early fall months.

3.3.3 Dissolved Oxygen

Dissolved oxygen concentrations were monitored as part of the river and lagoon water quality and fishery habitat surveys. For purposes of these investigations, it was assumed that habitat conditions would be suitable for juvenile steelhead rearing if dissolved oxygen levels were above 6 mg/l. Results of dissolved oxygen measurements made from the lower river and lagoon during the 2006 surveys are summarized in Figures 3-39 to 3-51. Results are summarized by transect locations 1 through 11 and VT-1, as well as dissolved oxygen concentration monitoring of the groundwater upwelling spring located at Transect location 6 near the right bank, over the period of the habitat monitoring survey period (Table 2-1). Also summarized on Figures 3-39 to 3-51 over the course of the periodic habitat water quality surveys are the El Sur Ranch irrigation diversion pump operations providing a summary of potential changes to water quality throughout different stages of the pump test period of the survey. Stream discharge (cfs) measured during streamflow monitoring at Transect VT-1 is also summarized on Figures 3-39 to 3-51 for comparison of habitat quality changes, if any, to fluctuations in stream discharge over the study period.

Dissolved oxygen levels observed during the surveys were consistently above 6 mg/l within the river and lagoon. Increasing degrees of separation were observed between the right and left bank with observed lower dissolved oxygen concentrations characterizing the right bank from Transects 4 through 9 (Figures 3-42 to 3-46), with the largest separation between banks occurring at Transects 6 and 7 (Figures 3-44 and 3-45). The localized reduction in dissolved oxygen concentrations associated with the Creamery Meadow sites are consistent with the hypothesis of groundwater upwelling in the area. The locations of reduced dissolved oxygen levels coincide with observed reductions in water temperature and electrical conductivity discussed above. Despite the observed lower dissolved oxygen concentrations recorded in the Creamery Meadow reach of the lower Big Sur River, no transect locations displayed dissolved oxygen concentrations below the 6 mg/l threshold for juvenile steelhead rearing habitat. The only survey point that showed dissolved oxygen concentrations to be below the 6 mg/l threshold for juvenile steelhead was the groundwater upwelling spring at Transect marker 6 on the right bank. Dissolved oxygen concentrations were consistently depressed at this point, independent of El Sur Ranch diversion operations.

However, this observed low dissolved oxygen concentration was localized specifically within the spring upwelling waters entering through a sand section of the right bank. Mixing occurred within the extreme near field area and dissolved oxygen concentrations were consistent with periodic samples taken at the right bank survey point of Transect marker 6 within 6 inches of the groundwater upwelling spring (Figure 3-51).

Periodic water quality sampling conducted at Transects 1 through 3 represented the lagoon reach. Transect 1 (Figure3-39) was characterized by dissolved oxygen concentrations across the channel from right to left bank ranging from 10.3 to 11.7 mg/l at the left bank survey location; 9.7 to 11.7 mg/l at the middle channel survey location, and; 10.3 to 11.7 mg/l at the right bank survey location. Transect 2 (Figure 3-40) was characterized by uniform dissolved oxygen concentrations across the channel from right to left bank ranging from 10.4 to 11.4 mg/l at the left bank survey location; 10.3 to 11.3 mg/l at the middle channel survey location, and; 9.7 to 11.5 mg/l at the right bank survey location. Transect 3 (Figure 3-41) was characterized by dissolved oxygen concentrations across the channel from right to left bank ranging from 9.7 to 11.3 mg/l at the left bank survey location; 9.9 to 11.3 mg/l at the middle channel survey location, and; 9.5 to 10.9 mg/l at the right bank survey location.

Periodic water quality sampling conducted at Transects 4 through 9 represented the Creamery Meadow reach. Transect 4 (Figure 3-42) was characterized by uniform dissolved oxygen concentrations across the channel from right to left bank ranging from 10.5 to 12.4 mg/l at the left bank survey location; 10.5 to 12.1 mg/l at the middle channel survey location, and; 10.0 to 11.8 mg/l at the right bank survey location. Transect 5 (Figure 3-43) was characterized by uniform dissolved oxygen concentrations, displaying some separation with consistently lower dissolved oxygen concentrations adjacent to the right bank. Dissolved oxygen concentrations across the channel from right to left bank ranged from 9.7 to 12.1 mg/l at the left bank survey location; 9.8 to 11.8 mg/l at the middle channel survey location, and; 9.3 to 10.8 mg/l at the right bank survey location. Transect 6 (Figure 3-44) was characterized by consistently recorded lower dissolved oxygen concentrations adjacent to the right bank. Dissolved oxygen concentrations ranged from 9.8 to 11.4 mg/l at the left bank survey location; 10.1 to 11.8 mg/l at the middle channel survey location, and; 7.5 to 9.2 mg/l at the right bank survey location. Transect 7 (Figure 3-45), the survey location most representative of the ground water upwelling influence within the lower Big Sur River, was characterized by the highest degree of variation in dissolved oxygen concentrations between the right and left bank. The dissolved oxygen concentrations ranged from 9.5 to 11.8 mg/l at the left bank survey location; 9.8 to 11.7 mg/l at the middle channel survey location, and the greatest reduction in dissolved oxygen concentrations were observed on the right bank ranging from 6.7 to 11.1 mg/l. Transect 8 (Figure 3-46) was characterized by uniform dissolved oxygen concentrations across the channel from right to left bank ranging from 9.5 to 11.5 mg/l at the left bank survey location; 9.7 to 11.9 mg/l at the middle channel survey location, and; 9.1 to 10.6 mg/l at the right bank survey location. Transect 9 (Figure 3-47) was characterized by uniform dissolved oxygen concentrations across the channel from right to left bank ranging from 10.2 to 12.4 mg/l at the left bank survey location; 10.3 to 12.5 mg/l at the middle channel survey location, and; 10.1 to 12.3 at the right bank survey location.

Periodic water quality sampling conducted at Transects 10 and 11 and Transect VT-1 represented the upstream reference reach outside the potential zone of influence of El Sur Ranch diversion operations reach. Transect 10 (Figure 3-48) was characterized by uniform dissolved oxygen concentrations across the channel from right to left bank ranging from 10.2 to 12.4 at the left bank survey location;10.2 to 12.4 mg/l at the middle channel survey location, and; 10.2 to 12.3 mg/l at the right bank survey location. Transect 11 (Figure 3-49) was surveyed from September 12 to October 10, 2006 (missing the first set of periodic water quality surveys) due to being added as an additional critical riffle habitat for passage and habitat quality monitoring. Transect 11 was characterized by uniform dissolved oxygen concentrations across the channel from right to left bank ranging from 10.3 to 12.3 mg/l at the left bank survey location; 9.9 to 12.4 mg/l at the middle channel survey location, and; 10.1 to 12.5 mg/l at the right bank survey location. Transect VT-1 (Figure 3-50) was surveyed from September 12 to October 10, 2006 (missing the first set of periodic water quality surveys) due to timing of the velocity monitoring transect installation during the initial project set up period. Transect VT-1 was characterized by uniform dissolved oxygen concentrations across the channel from right to left bank ranging from 9.7 to 12.2 mg/l at the left bank survey location; 9.7 to 12.3 mg/l at the middle channel survey location, and; 9.7 to 12.3 mg/l at the right bank survey location.

It was hypothesized that operation of the El Sur Ranch irrigation wells could contribute to an decrease in dissolved oxygen concentrations within the Creamery Meadow and lagoon reaches of the river that would adversely affect habitat quality for juvenile steelhead rearing. To test the hypothesis a series of statistical analyses were performed to compare potential dissolved oxygen concentration changes monitored over the range of experimental El Sur Ranch irrigation well diversion testing between the environmental baseline reference reach (Transects 10 and 11) and the area of influence within Zones 2 through 4 (Transects 4 through 9). Transects 1 through 3 were not included within the statistical testing due to the tidal nature of the lagoon reach. The dissolved oxygen variations resulting from tidal fluctuations within the lagoon override any detectable signal variation in dissolved oxygen concentration changes between periods of pumping and not pumping. In addition to this, the tidal nature of the lagoon means that pumping will not likely have an effect on dissolved oxygen variations beyond the natural range, so is unlikely to adversely effect habitat within the lagoon reach.

Statistical testing was performed using both the T-Test and the Mann-Whitney Rank Sum Test. Testing was performed to determine if significant differences occurred between the environmental baseline reference reach (Transects 10 and 11) and the zone of influence (Transects 4 to 9) for each habitat quality monitoring grab sample survey date. Results of these statistical tests are summarized in Table 3-13.

Median dissolved oxygen concentration values were within the optimal range for juvenile steelhead growth (saturated) at all times irrespective of irrigation diversion operations. Results were inconclusive in showing significant differences between the two reaches during times of pumping and not pumping at all times. Median dissolved oxygen values were up to 0.9 mg/l higher in the upstream environmental baseline reference reach for all surveys. This is consistent with hypotheses of groundwater influence within the lower river presented by SGI (2007).

To further understand the potential for significant impact within the zone of influence (Transects 4 to 9), further statistical testing was conducted using three-way analysis of variance (ANOVA). Testing was conducted to if determine if statistically significant differences in dissolved oxygen concentrations within the zone of influence occurred between survey dates representing the longest duration of either 0, 1, or 2 pump operations. The results of these tests are summarized in Table 3-14.

Using the three-way analysis of variance, some influence of well operations was potentially detected between 0, 1, and 2 pump operation scenarios within the zone of influence. Any effects detected were of very low effect and indicate a high level of natural variability irrespective of pump operation, consistent with SGI (2007) hypotheses of localized groundwater upwellings. Variations in reported median dissolved oxygen concentration values for the ANOVA statistical tests were within 1.1 mg/l between scenarios and within the range for suitable juvenile steelhead habitat at all times, irrespective of pump operations. Results of testing between the surveys conducted on 8/30/06, representing a period of approximately 4 weeks without pump operations, and surveys conducted on 9/14/06, a period representing approximately two weeks of both pumps operating, show a significant difference in dissolved oxygen concentration with slightly lower median dissolved oxygen reported during the period of 2 pump operation. Results of testing on surveys conducted on 9/14/06 (0 pump scenario) and 9/21/06 (2 pump scenario) show a significant difference in dissolved oxygen concentrations. Results of testing on surveys conducted on 9/21/06 (0 pump scenario) and 9/28/06 (1 pump scenario, Old Well) show a significant difference in dissolved oxygen concentration with lower median value reported when no pumps were in operation. Results of testing on surveys conducted on 9/28/06 (1 pump scenario, Old Well) and 10/5/06 (0 pump scenario) show a significant difference in dissolved oxygen concentration with reported median values lower during the period of no pump operation.

Results of the dissolved oxygen measurements showed that habitat conditions within the lower river and lagoon during the period of the 2006 survey period were within the range considered to be suitable for juvenile steelhead rearing at all times irrespective of irrigation diversion operations. No apparent effect on dissolved oxygen within the lower river or lagoon was detected from operation of the El Sur Ranch irrigation wells during the study period in the context of juvenile steelhead rearing habitat and statistically significant differences were inconsistent, showing some potential influence from pumping, but at very low effect level unlikely to adversely effect steelhead habitat within the lower river. The observed localized reduction in dissolved oxygen within the Creamery Meadow reach is consistent with the hypothesis that groundwater upwelling (accretion) is occurring within the lower river that affect localized water quality conditions, particularly during the lower flow summer and early fall months.

3.4 Continuous Water Temperature Monitoring

Water temperatures were measured at 24-minute intervals at 11 monitoring locations (Transects 1 through 10 and upstream reference location Transect VT-1) within the lower river, lagoon, and upstream reference zones to assess seasonal habitat conditions for juvenile steelhead rearing (Figure 1-1, Table 2-5). For purposes of these analyses, average daily water temperatures less than 20°C (68°F) and peak daily temperatures less than 24°C (75°F) were considered to provide suitable habitat for juvenile rearing during the summer and early fall months. Water temperature monitoring results are summarized in Figures 3-52 to 3-94 displaying continuous 24-minute monitoring data as well as calculated 24-hour daily means. For illustrative purposes, the figures include the 20°C (68°F) average daily and 24°C (75°F) peak daily water temperature guidelines for habitat suitability. Results of water temperature monitoring reflect the seasonal trends with increasing temperatures during the spring-summer and declining water temperatures during the fall. Water temperature monitoring results showed that habitat conditions were within the range considered to be suitable for juvenile steelhead rearing at all sites. These results are consistent with periodic water temperature monitoring results presented above.

3.5 Continuous Dissolved Oxygen Concentration Monitoring

Dissolved oxygen concentrations were measured at hourly intervals at two monitoring locations within the Creamery Meadow reach in the area identified as being most representative of groundwater upwelling and within an upstream reference area outside the potential influence of El Sur Ranch irrigation diversion well operations and ground water upwelling zones to assess seasonal habitat conditions for juvenile steelhead rearing (Figure 1, Table 2-1). For purposes of these analyses, dissolved oxygen concentrations greater than 6 mg/l were considered to provide suitable habitat for juvenile rearing during the summer and early fall months. Dissolved oxygen concentration monitoring results are summarized in Figure 3-95 displaying continuous hourly monitoring data for the two dissolved oxygen concentration loggers. Continuous dissolved oxygen concentration monitoring at the reference location and within the Creamery Meadow reach within the groundwater zone of influence and within the SGI Zone 2 portion of the study reach within the potential area of influence from El Sur Ranch diversion operations ranged from approximately 8 to 14 mg/l.

This is consistent with dissolved oxygen concentrations recorded during grab samples within reference reach and potential zone of influence (or Zone 2; SGI 2007) locations, which ranged from 8 to 12 mg/l, except in very localized locations along the right bank of Zone 2 where dissolved oxygen concentrations were recorded between 7 and 8 mg/l. Grab sampling recorded dissolved oxygen concentrations consistently within this range of concentrations. The greater range demonstrated by the continuous recorders can be explained by diurnal variation, where grab samples were conducted only during the afternoon. Also, continuous recorders were placed under thick riparian cover vegetation to aid security and reduce potential tampering by the public, where grab sampling was conducted in open channel areas. These factors contributed to the greater range of concentrations recorded by the continuous dissolved oxygen loggers when compared to the grab sample results.

For illustrative purposes, the Figure 3-95 includes the 6 mg/l threshold guideline for habitat suitability. Dissolved oxygen concentration monitoring results showed that habitat conditions were within the range considered to be suitable for juvenile steelhead rearing at all sites. These results are consistent with periodic dissolved oxygen concentration monitoring results presented above.

4.0 Discussion and Conclusions

The Big Sur River and lagoon fishery habitat surveys, including consideration of summer flows, habitat characteristics and connectivity, and water quality including water temperatures, electrical conductivity, and dissolved oxygen concentrations within the lower river and lagoon over the late summer and early fall, 2006, were designed to characterize instream conditions and potential changes to habitat quality and connectivity across a range of manipulated El Sur Ranch irrigation diversion well pumping tests to assess the potential effects of El Sur Ranch irrigation well operations on habitat quality and availability for juvenile steelhead rearing within the lower Big Sur River. Results of these fishery investigations are briefly discussed below.

4.1 El Sur Ranch Well Operations

During the late summer and early fall, 2006, period of this investigation, the El Sur Ranch irrigation well operations were manipulated as shown in Table 2-2. The range of manipulated irrigation well operations was used as the basis for assessing potential changes to instream habitat conditions potentially affecting juvenile rearing success for juvenile steelhead. Table 4-1 and Figure 4-1 presents a summary of El Sur Ranch well operations (deliveries in cfs) over the duration of the study period from August 30 to October 17, 2006, when fishery habitat surveys were performed. We hypothesized that the potential effect of irrigation well operations on fishery habitat within the lower river and lagoon would be greatest during periods when maximum diversions from both wells were occurring. The experimental design for the investigation also assumed that potential effects of well operations on fishery habitat would be greatest, if they were to occur, within the reach of the river adjacent to Creamery Meadow and downstream within the lagoon. The investigation included habitat and fishery monitoring at sites located upstream of the potential area of well diversion influence to act as a reference for comparison with downstream habitat conditions.

During the study period (August 30 to October 17, 2006), irrigation well operations were manipulated to cover a range of pumping scenarios. Both diversion pumps remained off from August 30 to September 8 to provide monitoring surveys the opportunity to record environmental baseline conditions within the study reach of the Big Sur River (Figure 1-1). Both diversion pumps (Old Well and New Well) remained on during the period September 9 to September 14 with New Well diversions ranging from 3.20 to 3.52 cfs resulting in total diversions of 40.35 acre-feet and Old Well diversions consistently pumping at 2.41 cfs for total diversions of 28.30 acre-feet. Both diversion wells remained off from September 15 to September 21 to allow the hydrologic system to return to equilibrium and to allow the opportunity to monitor potential instream habitat quality responses. Old Well diversions resumed from September 22 to September 28 at a pumping rate ranging from 2.31 to 2.57 cfs for a total diversion of 33.63 acre-feet during this period. Both diversion wells remained off from September 25 to October 5 to allow the hydrologic system to return to equilibrium and to allow the opportunity to monitor potential instream habitat quality responses. New Well diversions resumed from October 6 to October 11 at a pumping rate ranging from 2.35 to 3.39 cfs for a total diversion of 32.82 acre-feet during this period. Both diversion wells remained off from October 12 to October 17 to allow the hydrologic system to return to equilibrium and to allow the opportunity to monitor potential instream habitat quality responses. At the end of this final period, field monitoring concluded.

Data from the habitat monitoring surveys offer the opportunity to compare habitat conditions within the river during periods when both irrigation wells were operating, when Old Well only was operating, when New Well only was operating, and when no diversions were occurring.

4.2 Velocity and Streamflow Measurements

The streamflow measured at transect VT-1 over the period from July 23 through October 28, 2004, recorded during the previous fishery habitat analyses study, was based on measurements made during both day and night surveys. Streamflows during the 2004 study period ranged from approximately 6 to 10 cfs. Stream width ranged from approximately 34 to 35 ft. with a corresponding mean depth ranging from 0.86 to 0.96 ft. Results of streamflow measurements at transect VT-1 during the 2004 study represented conditions within the reference reach of the Big Sur River located upstream of the El Sur Ranch irrigation wells, as with the experimental design of the 2006 fishery study presented here.

A comparison of instream flow measurements during the August 30 to October 17, 2006, surveys, representing periods of one and two well operations as well as periods of no diversion pumping (Table 2-2) at the upstream reference site (VT-1) showed wetted channel widths ranging from 36.4 to 30.3 feet during the twelve surveys. Average channel depth ranged from 1.24 to 1.46 feet with discharge ranging from 18.31 to 21.92 cfs at the upstream reference location. Natural surface water flows entering the study reach were sufficient to maintain habitat connectivity during both the 2004 and 2006 study periods. No adverse effect on streamflows or habitat connectivity within the Creamery Meadow reach, the critical area of potential influence from El Sur Ranch diversion operations were recorded during the 2006 survey period under the range of different experimental irrigation well operating scenarios.

4.3 Steelhead Passage and Habitat Connectivity

There was no loss of surface water connectivity among habitat units within the lower river and lagoon during the period of this investigation from August 30 to October 17, 2006. There were no potential barriers/impediments to steelhead passage under the monitored experimental El Sur Ranch diversion operations between Transects 1 and 9, extending upstream from the lagoon through Creamery Meadow in a reach adjacent to the El Sur Ranch diversion wells, and into the upstream reference reach. Transects 10 and 11 presented potential natural barriers/impediments to adult steelhead passage under low flow conditions within the upstream reference reach, independent of El Sur Ranch diversion operations. However, the potential natural barrier/impediment to steelhead passage observed at Passage Transects 10 and 11 are based on thresholds for adult migration during winter flow periods. The depths recorded at these transects would likely be suitable at all times for juvenile passage during typical summer flow periods.

The monitoring results and analysis for Passage Transects 1 through 11 located within the SGI (2007) Zones 1 through 4 resulted in the following habitat impact analyses. Zone 1, or the lagoon reach containing Passage Transects 1 through 3, showed that a combination of both the daily average tide condition and fluctuations in river flow have more of an influence on water depth and potential passage within the lagoon area than does irrigation well pumping (SGI 2007). Results of habitat monitoring during the 2004 and 2006 study periods, as well as work conducted by SGI (2007), demonstrate that it is unlikely that El Sur Ranch diversion operations can directly effect habitat continuity and fish passage within the lagoon reach, especially due to the tidally influenced nature of this reach of the lower Big Sur River. The results of fishery habitat monitoring conducted within Zones 2 through 4 (SGI 2007) where Passage Transects 4 through 9 were located, as well as hydraulic analyses presented by the SGI work (SGI 2007), show that El Sur Ranch diversion operations do not impact habitat connectivity under the 2004 and 2006 flow conditions of 8 cfs and 19 cfs respectively.

It is unlikely that habitat continuity could be affected by El Sur Ranch operations within Zones 1 through 4 beyond a critical depth threshold for juvenile habitat connectivity and passage.

4.4 Water Quality

Water temperatures at all sites studied as part of the 2004 fishery study (Hanson 2005) were within the general range of habitat conditions considered to be suitable for juvenile steelhead rearing (average daily temperatures less than 20°C (68°F) and peak daily temperatures less than 24°C (75°F). The observed decline in water temperatures recorded near the Creamery Meadow reach in 2004 was hypothesized by SGI in 2004 (SGI 2005) to be the result of groundwater upwelling within the localized area of these measurement sites, consistent with further analyses conducted by SGI in 2006 (SGI 2007). Electrical conductivities and dissolved oxygen concentrations recorded as part of the 2004 fishery study were shown to be within the range suitable for juvenile steelhead rearing at all sample points along the river at all times irrespective of irrigation diversion operations. Reductions in DO and temperature were recorded in the Creamery Meadows reach localized along the right bank of Zones 2 through 4, consistent with SGI hydraulic analyses in 2004 and 2006 (SGI 2005, 2007) demonstrating groundwater inflow and mixing within the Creamery Meadow reach. This previous work by Hanson and SGI in 2004, along with collaboration with SGI in 2006 formed the basis for the refined fishery analysis conducted as part of the 2006 fishery study.

Water quality conditions within the lower river and lagoon during the 2006 fishery study were compared between survey dates at Transect locations 1 through 11 and VT-1 (Figure 1-1) from August 30 to October 17, 2006, and between survey locations representing periods of one and two irrigation well operations as well as periods of no irrigation well operations (Table 2-2). It was hypothesized that irrigation well operations could potentially contribute to an increase in water temperatures, an increase in electrical conductivity, and/or a reduction in dissolved oxygen within the Creamery Meadow and lagoon reaches when both wells were operating when compared to operation of a single irrigation well or no irrigation diversions. Water temperatures during the survey period were found to be cooler within the Creamery Meadow sites (Transects 6 and 7) along the right bank when compared to the upstream reference sites for periodic water quality grab sampling. This observed localized reduction in temperature along the right bank of the study reach adjacent to Creamery Meadow is consistent with the data presented in the hydrologic study presented by SGI in both 2004 and 2006 (SGI 2005, 2007). These results are consistent with the hypothesis that this area is a point of active groundwater influx into the lower Big Sur River.

In other respects, water temperatures were consistent along the entire study reach during the habitat monitoring survey period on given survey dates under the full range of irrigation diversion operations tested and remained within suitable habitat thresholds for juvenile steelhead at all times.

Electrical conductivities were observed to be lower within the Creamery Meadow reach (Transect 7) along the right bank under a range of irrigation pumping conditions. This observed localized reduction in electrical conductivity along the right bank of the study reach adjacent to creamery meadow is consistent with the data presented in the hydrologic study presented by SGI in both 2004 and 2006 (SGI 2005, 2007). These results are consistent with the hypothesis that this area is a point of active groundwater influx into the lower Big Sur River.

Electrical conductivities, other then those monitored adjacent to the right bank at Transect 7, were consistent on given survey dates throughout the survey period and between transect locations. At no point did salinity rise to a level that would be unsuitable for juvenile steelhead rearing (>1,500 µS/cm) and electrical conductivities remained between 150 and 300 µS/cm during the entire survey period at all survey locations under all experimental pumping operations.

Dissolved oxygen concentrations were found to be lower in the Creamery Meadow reache along the right bank (Transects 4 through 9, Zones 2 through 4), when compared to upstream reference sites (Passage Transects 10 and 11, and VT-1), or survey points within the center channel or adjacent to the left bank. This observed drop in recorded dissolved oxygen concentrations along the right bank of the study reach adjacent to Creamery Meadow is consistent with the data presented in the hydrologic study presented by SGI for both 2004 and 2006 (SGI 2005, 2007). These results are consistent with the hypothesis that this area is a point of active groundwater influx into the lower Big Sur River. Dissolved oxygen concentrations remained suitable along the entire study reach for juvenile steelhead rearing under summer flow conditions (>6 mg/l) at all survey locations despite the influence and mixing of river water and ground water inflow. The only dissolved oxygen concentrations below the 6 mg/l threshold recorded were for grab samples taken directly from an area of direct groundwater upwelling in the form of a spring. At this location, natural dissolved oxygen concentrations independent of El Sur Ranch diversion operations were recorded ranging between approximately 4 mg/l and 5 mg/l. This observed groundwater upwelling is consistent with data presented on groundwater flow pattern into the lower Big Sur River by SGI (2007). SGI hydrologic monitoring and analyses demonstrate that El Sur Ranch diversion pumping only effects the rate at which groundwater enters the lower Big Sur River under the 2004 and 2006 study flow conditions (SGI 2005, 2007).

Dissolved oxygen levels remained above the 6 mg/l threshold for juvenile steelhead rearing at all times during the irrigation well diversion testing throughout the entire survey period at Transects 1 through 11 and at upstream reference Transect VT-1. Any significantly lower dissolved oxygen concentrations within the Creamery Meadow reach were localized along the right bank and it is likely that juvenile steelhead would behaviorally avoid these zones of ground water mixing with low dissolved oxygen, especially under lower flow conditions like those observed in the 2004 study period (Hanson 2005, SGI 2005). Under lower flow conditions, groundwater inflow represents a larger percentage of the overall mixed volume within the Creamery Meadow reach and natural flow and groundwater influenced conditions can result in dissolved oxygen concentrations below the 6 mg/l habitat threshold within highly localized influence zones along the right bank of the study reach between Transects 7 and 8. El Sur Ranch irrigation diversions would result in a reduction of this groundwater inflow and therefore increase dissolved oxygen concentrations within this area (SGI 2007).

Water quality conditions within the entire study reach, including the Creamery Meadow (Zone 2 through 4, SGI 2007) and lagoon (Zone 1, SGI 2007) reaches were within the range considered to be suitable of juvenile steelhead rearing throughout the entire survey period of August 30 to October 17, 2006 across all transect locations and on all survey dates. No impacts to the established habitat thresholds were recorded anywhere within the study reach as a result of El Sur Ranch diversion operations. The fact that water temperatures, dissolved oxygen concentrations, and electrical conductivities were lower in the Creamery Meadow reach along the right bank across all survey dates is consistent with the hypothesis that groundwater upwelling and flow accretions within the lower river and lagoon contribute to changes in water quality conditions presented in hydrologic analyses conducted during the same period (SGI 2007).

4.5 Potential Habitat Response to Irrigation Diversions in Critical Low Flow Years

Hydraulic analyses conducted by SGI (SGI 2005, 2007) demonstrated that El Sur Ranch irrigation diversions can influence the Big Sur River across Zones 2 through Zone 4 (Creamery Meadow reach in vicinity of groundwater influence) within the SGI 2006 classification system for hydraulic influence by reducing the inflow of groundwater. A simple water mixing model was developed by SGI to quantify changes (SGI 2007) to dissolved oxygen concentrations and temperature levels in Zone 2 through Zone 4 under average September irrigation diversion rates under a range of flow conditions within the lower Big Sur River. The effects resulting from the reduction of groundwater inflow to the river on dissolved oxygen and daily average temperature were both explored and are discussed here in the context of steelhead habitat quality.

The mixing model developed by SGI (2007) was run for a wide variety of flow conditions, including those observed during the 2006 study and the 2004 study periods, plus the flows calculated by SGI (2007) for 20% non-exceedance dry years and 5% non-exceedance dry years. Pumping conditions tested included both no pumping scenarios, and the maximum pumping rates possible for either New Well, Old Well or both wells together. Dissolved oxygen data was used to calibrate the amount of mixing that occurred during the 2006 study, which was calculated to be approximately 35% of the channel cross section, supported by water quality grab samples collected during the 2004 and 2006 study periods (SGI 2007). Data collected during the 2004 and 2006 study periods demonstrates groundwater mixing with river water only affects DO concentrations along the right bank of the river, not the center or left bank. This indicates that groundwater mixed with only a third (33%) of the river water flowing across Zones 2 through Zones 4 and into Zone 1 (SGI 2007).

An assumption was made that temperature mixed approximately as DO did (SGI 2007). It was assumed that during lower flow dry years, the percent of river water that gets mixed with groundwater would increase due to the decreased volume of river water flowing across Zones 2 through Zone 4 under low flow conditions. The results of the mixing model are presented in Table 4-2.

Dissolved Oxygen Impacts from Irrigation Diversions

The SGI (2007) mixing model outputs for dissolved oxygen concentrations and water temperatures entering Zones 1 from Zones 2 through Zone 4 (Table 4-2) show that pumping increases the concentration of dissolved oxygen in the river. With increased pumping rates, a reduced volume of low DO concentration groundwater is available for mixing with river water. It should be noted that the SGI (2007) model results estimate that during extremely low flow years, corresponding with the 5% non-exceedance dry year condition, groundwater pumping would result in raising DO concentrations in the river above the 6 mg/L (SGI 2007) minimum required for steelhead habitat (SGI 2007).

Although low dissolved oxygen concentrations (2 mg/l) may be tolerated for short durations by steelhead under extreme low temperature conditions (Moyle 2002), concentrations close to saturation (10 mg/l) are required for growth. Monitoring within Zones 1 through 4 during the 2004 and 2006 study periods demonstrated that dissolved oxygen concentrations remained within the optimal range for steelhead growth at all times irrespective of El Sur Ranch diversion operations. Some localized reductions in dissolved oxygen were recorded along the extreme right bank of the lower river in Zones 2 through 4 where it is hypothesized that groundwater flows into the river (SGI 2007).

Research has demonstrated that juvenile steelhead will behaviorally avoid areas of sub-optimal dissolved oxygen concentration (Warren *et al.* 1973). Additionally, swimming speeds of juvenile steelhead are reduced under depressed dissolved oxygen concentration conditions, potentially impacting predator avoidance and feeding efficacy (Carter 2005). Under low flow conditions described in the SGI (2007) mixing model, lower river temperatures would likely be elevated and dissolved oxygen concentrations likely depressed. Under such a scenario, mixing model results suggest that irrigation diversions could potentially increase the dissolved oxygen concentration within portions of the lower river by 0.6 mg/l to1.3 mg/l under various low conditions for the 35% mixing rate (Table 4-2).

Protestant concerns were, in part, that operation of the El Sur Ranch irrigation wells could contribute to reduced dissolved oxygen concentrations within the Creamery Meadow and lagoon reaches of the river that would adversely affect habitat quality for juvenile steelhead rearing. Results of dissolved oxygen monitoring during the 2004 and 2006 survey periods showed that habitat conditions within the lower river and lagoon were within the range considered to be suitable for juvenile steelhead rearing at all times irrespective of diversion operations. There were no adverse effects on aquatic habitat in the context of dissolved oxygen within the lower river and lagoon resulting from operation of the El Sur Ranch irrigation wells during the 2004 and 2006 study periods under differing river flow conditions of approximately 8 cfs in 2004 and 20 cfs in 2006. Further, SGI (2007) mixing model results suggest that it is unlikely that El Sur Ranch irrigation operations could contribute to a reduction in dissolved oxygen levels within the lower Big Sur River. Therefore, it is unlikely that El Sur Ranch diversion operations could adversely affect juvenile steelhead habitat in Zones 1 through 4 in the context of dissolved oxygen levels.

Temperature Impacts from Irrigation Diversions

The results of the mixing model show that groundwater pumping has the effect of raising temperatures in the river within Zones 2 through Zone 4 to levels naturally flowing into this reach as lower temperature groundwater mixing volumes are reduced (SGI 2007). During the 2004 and the 2006 studies, the daily average temperature entering the SGI classification system Zone 4 were between 15°C and 17°C, respectively, while the temperature of the incoming groundwater was conservatively estimated at 13°C from collected data as part of grab samples taken within the area of active groundwater upwelling. Incoming groundwater mixes with the river water to lower its temperature. Reducing the inflow of groundwater will raise the temperature of the river, but not beyond the temperature the river water was at naturally as it entered Zone 4 (SGI 2007).

During drier years, temperatures in the river might be higher than those encountered during the 2004 or 2006 studies. In the SGI (2007) model, a scenario of 20°C natural river temperature was used for water flowing into Zone 4 to represent conditions that exceed habitat thresholds. The results of the SGI (2007) model show that average September pumping can raise the temperature of the 35% channel cross section mixed river water by as much as 1.1°C (SGI 2007). The daily average temperature in river water to sustain a healthy fish population should be below 20°C, as discussed above and as set as a habitat impact threshold in previous habitat monitoring work on the Big Sur River (Hanson, 2005). Based on the results of the mixing model developed by SGI (2007), incoming river water temperatures would have to be several degrees above 20°C before average September groundwater pumping would raise average mixed water temperatures above 20°C across Zones 2 through 4 (SGI 2007).

It is unlikely, based on mixing model forecasts, that irrigation diversions can result in significant impacts to juvenile steelhead during rearing within Zones 2 through 4. Juvenile steelhead typically reside in cool, clear, permanent streams with sufficient riparian vegetation providing cover. One of the key characteristics of optimal juvenile steelhead rearing habitat are cool temperatures. It has been established that optimal temperature ranges for steelhead are from 0 to 20°C (Moyle 2002). With gradual acclimation to increased temperatures, temperature highs of 24 to 27°C have been survivable for very short periods (Moyle 2002).

Optimal temperatures for juvenile steelhead rearing are between 15 and 18°C. The temperature range monitored during the 2006 study period entering Zone 4 and flowing through Zones 1 to 3 were typically within this optimal range irrespective of diversion operations carried out by El Sur Ranch. The analyses conducted by SGI (2007) on temperature effects within Zones 2 through 4 demonstrate that irrigation diversions may raise temperatures by 1°C, to a maximum of natural temperature levels entering Zone 4. The potential for impact to steelhead within the lower river is not thought to be significant under this scenario, especially given the range of deep pools, riffles, and run habitat types available with healthy riparian vegetation cover. In extreme low flow years when water levels are much reduced and natural baseline river temperatures are higher then those monitored during the 2004 and 2006 study periods, habitat connectivity will increasingly play a key role for steelhead fishery health. When temperatures become high to a stressful degree, juvenile steelhead will reside in fast moving, well oxygenated riffle zones with an abundant food supply to offset the energy requirement of living at sub-optimal temperature ranges. Therefore, fish passage and aquatic habitat connectivity are important, particularly under 5% non-exceedance dry years. Under such conditions, the greatest potential impact will come from natural dewatering of shallow riffle zones in the environmental baseline reference reach of the study area (Transects 9-11) due to lost habitat connectivity and connection to portions of the Big Sur River upstream of Zone 4. Under such a scenario, the lagoon reach in Zone 1 would provide a deep pool cool water refuge area.

It was hypothesized that operation of the El Sur Ranch irrigation wells could contribute to an increase in water temperatures within the Creamery Meadow and lagoon reaches of the river that would adversely affect habitat quality for juvenile steelhead rearing. Analyses of potential temperature impacts from El Sur Ranch irrigation diversions and habitat thresholds for juvenile steelhead suggest there is low potential for irrigation diversions to adversely effect steelhead habitat in Zones 1 through 4.

Summary of Mixing Model Findings
Habitat data collected as water quality grab samples taken during the 2004 and 2006 study periods cannot reflect the trends described by the SGI (2007) mixing model for DO or temperature due to the natural daily variations in dissolved oxygen concentrations (approximately 2 mg/l daily) and temperature levels. Variations recorded during grab sample collection may be a result of factors such as time of day sample collected, location of sample and, tidal influence at time of collection.

In the context of the SGI (2007) mixing model results, estimated effects on aquatic habitat within the lower Big Sur River in Zones 1 and 2 from El Sur Ranch average September diversion operations under various flow conditions are as follows:

- Dissolved oxygen concentrations within the mixed portion (35%) of the river channel cross section may increase by approximately 1 mg/l as a result of a reduced volume of low DO groundwater (approximately 4 mg/l) available for inflow into the river, resulting in no significant impact to habitat quality within the study reach from El Sur Ranch diversion operations;

- Temperature levels within the mixed portion (35%) of the river channel cross section may increase by approximately 1°C, to a maximum of natural background temperatures entering Zone 4, as a result of a reduced volume of low temperature groundwater (approximately 13°C) available for inflow into the river, resulting in no significant impact to habitat quality within the study reach from El Sur Ranch diversion operations.

4.6 Potential Impacts to Riparian Vegetation from Irrigation Diversions

It was hypothesized that operation of the El Sur Ranch irrigation wells could contribute to an increase in groundwater drawdown within the Creamery Meadow reaches and surrounding locations of the lower Big Sur River that would adversely affect root zone access to groundwater of local riparian vegetation and potentially impact habitat quality for juvenile steelhead and other aquatic and wildlife species in he area. Further concerns were that acute groundwater drawdown could impact the root zone of local vegetation.

Miriam Green Associates (2007) conducted vegetation assessments for visual signs of physiological stress and dieback due to lack of water, potentially from groundwater drawdown from irrigation diversions. Within the area estimated to potentially be effected from drawdown of groundwater from irrigation diversions, no signs of dieback or physiological stress were recorded during surveys conducted in June, 2006. Furthermore, these surveys recorded no stress to vegetation localized within the area immediately around the irrigation diversion pumps themselves.

Potential geographic patterns for groundwater drawdown were analyzed by SGI (2007) and contours for specific groundwater drawdown levels were produced (SGI report Figure 3-9). These analyses, conducted using continuous water level responses to pumping within local monitoring wells, show drawdown of groundwater within Creamery Meadow to range from 0.2 feet within the 1000 ft radius of influence to 0 feet beyond the potential radius of influence. These seasonal and small predicted reductions in groundwater levels would not be expected to adversely affect the Creamery Meadow vegetation.

Within the 1000 ft radius of influence outlined by SGI (2007), the potential for groundwater drawdown from irrigation diversions ranges from 4 ft of drawdown within 50 to 100 feet localized radius of both Old Well and New Well, to 0.2 ft along the immediate right bank of the lower Big Sur River.

The area of greatest potential impact to vegetation from loss of localized groundwater water within the root zones of plants from irrigation diversions are within the near field areas surrounding the diversion pumps where drawdown of groundwater was analyzed by SGI (2007) to be up to 4 ft within 100 ft of the well locations. During habitat monitoring conducted in both 2004 and 2006, involving continuous work within the areas described here, no signs of dieback or physiological stress to vegetation (e.g. wilting) were observed at any time during the studies, or on subsequent visits after study completion to dismantle monitoring apparatus in the field. In fact, vegetation densities remained at high levels throughout both the 2004 and 2006 study periods irrespective of diversion operations, to sufficient levels that local geomorphic surveying was problematic due to lack of access caused by dense vegetation barriers.

Based on the observations of vegetation by Miriam Green Associates (2005), groundwater drawdown analyses presented by SGI (2007) and field observations from the 2004 and 2006 late summer and early fall survey periods, there was no evidence, under the conditions surveyed, that El Sur Ranch irrigation diversions adversely effect vegetation within Creamery Meadow or the areas within the 1000 ft radius of influence of irrigation pumping.

5.0 Summary and Conclusions

Based upon results of the 2004 fishery investigation (Hanson 2005) it was concluded that the lower Big Sur River and lagoon provided suitable habitat for juvenile steelhead / rainbow trout rearing over the late spring, summer, and early fall period. Habitat and passage monitoring between August 30 and October 17, 2006, concluded that conditions within the river, both upstream and downstream of the El Sur Ranch diversion well locations, under a range of experimental pumping regimes, remained within a suitable range for juvenile steelhead rearing throughout the summer and fall monitoring period irrespective of El Sur Ranch diversion operations.

Although variation was observed for various parameters measured during the 2006 study period, there was no evidence that well operations resulted in a consistent pattern of habitat change within the river. All parameters measured as part of this 2006 study remained within the range considered to be suitable for steelhead rearing which were independent of pump operations (0, 1, 2 pumps in service). Additional findings and conclusions of the investigation include:

- Streamflows recorded at the upstream reference site were sufficient to maintain connectivity among habitat units throughout the study period;

- Steelhead passage monitoring, including critical riffle habitats, concluded that no barriers/impediments to fish migration criteria resulted from El Sur Ranch diversion operations within the study reach and no patterns were detected between passage transect depth variations and diversion operations for the fish passage criteria used for analysis;

- Water quality conditions, including water temperatures, electrical conductivity, and dissolved oxygen concentrations, were within the range considered to be suitable for juvenile steelhead / rainbow trout rearing at all times irrespective or irrigation diversions. For localized areas within the Creamery Meadow reach, available data recorded as part of fishery investigations and analyses presented as part of hydrologic investigations (SGI 2007) indicate that groundwater upwelling affected water quality within the river, localized specifically along the right bank of the river, where groundwater influence results in lower dissolved oxygen concentrations, temperatures, and electrical conductivity as a result of ground water and river flow mixing within the SGI designated Zones 2 through 4 section of the study reach. Habitat conditions within the study reach over the range of experimental diversion operations were within the range considered to be suitable for juvenile steelhead and there were no observed adverse effect on steelhead habitat quality as a result of El Sur Ranch diversions;

- Based on the results of the SGI mixing model (SGI 2007), it is unlikely that El Sur Ranch diversion operations can adversely impact steelhead habitat in Zones 1 through 4 by raising temperature above naturally occurring levels entering the upstream portion of the study reach at Zone 4.

- Based on the results of the SGI mixing model (SGI 2007), it is unlikely that El Sur Ranch diversion operations can adversely impact steelhead habitat in Zones 1 through 4 by depressing dissolved oxygen concentrations below naturally occurring levels.

- Results of the steelhead passage monitoring, streamflow, and water quality measurements during both the 2004 and 2006 study periods provided no evidence of adverse effects on juvenile steelhead habitat quality and connectivity or availability as a result of El Sur Ranch irrigation well operations. Similarly, the absence of adverse effects on aquatic habitat for juvenile steelhead, or any adverse effects observed, serves as an indicator that adverse effects to other sensitive and protected aquatic species inhabiting the lower Big Sur River would not be expected, based on environmental conditions and irrigation well operations that occurred during the 2004 and 2006 study period flow conditions.

- Observations of vegetation by Miriam Green Associates (2005), groundwater drawdown analyses presented by SGI (2007) and field observations from the 2004 and 2006 late summer and early fall survey periods, show no evidence, under the conditions surveyed, that El Sur Ranch irrigation diversions adversely affect vegetation within Creamery Meadow or the areas within the 1000 ft radius of influence of irrigation pumping.

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FIGURES

Figures

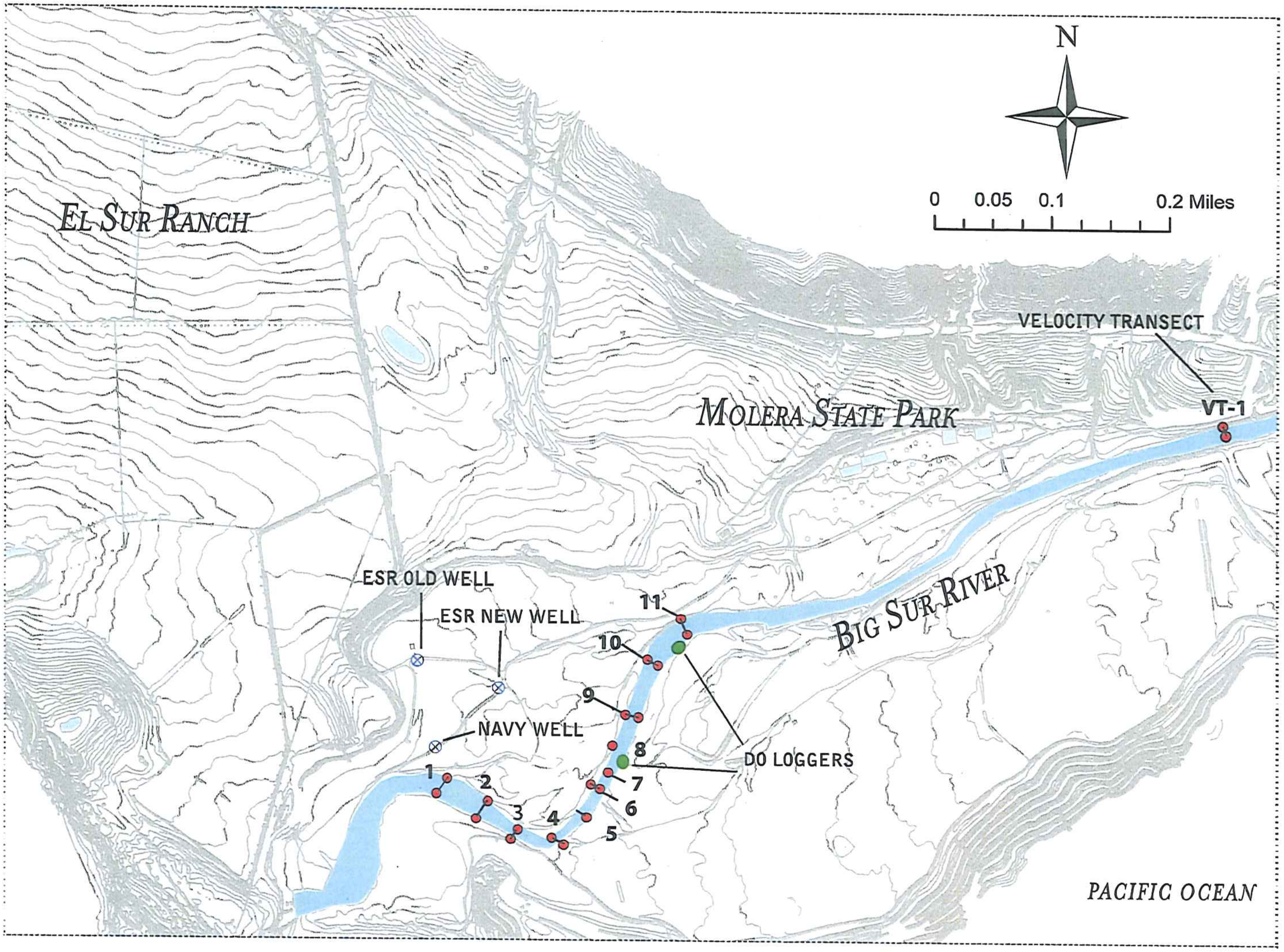

FIGURE 1-1. El Sur Ranch (ESR) irrigation diversion wells adjacent to the Big Sur River and fishery habitat study area.

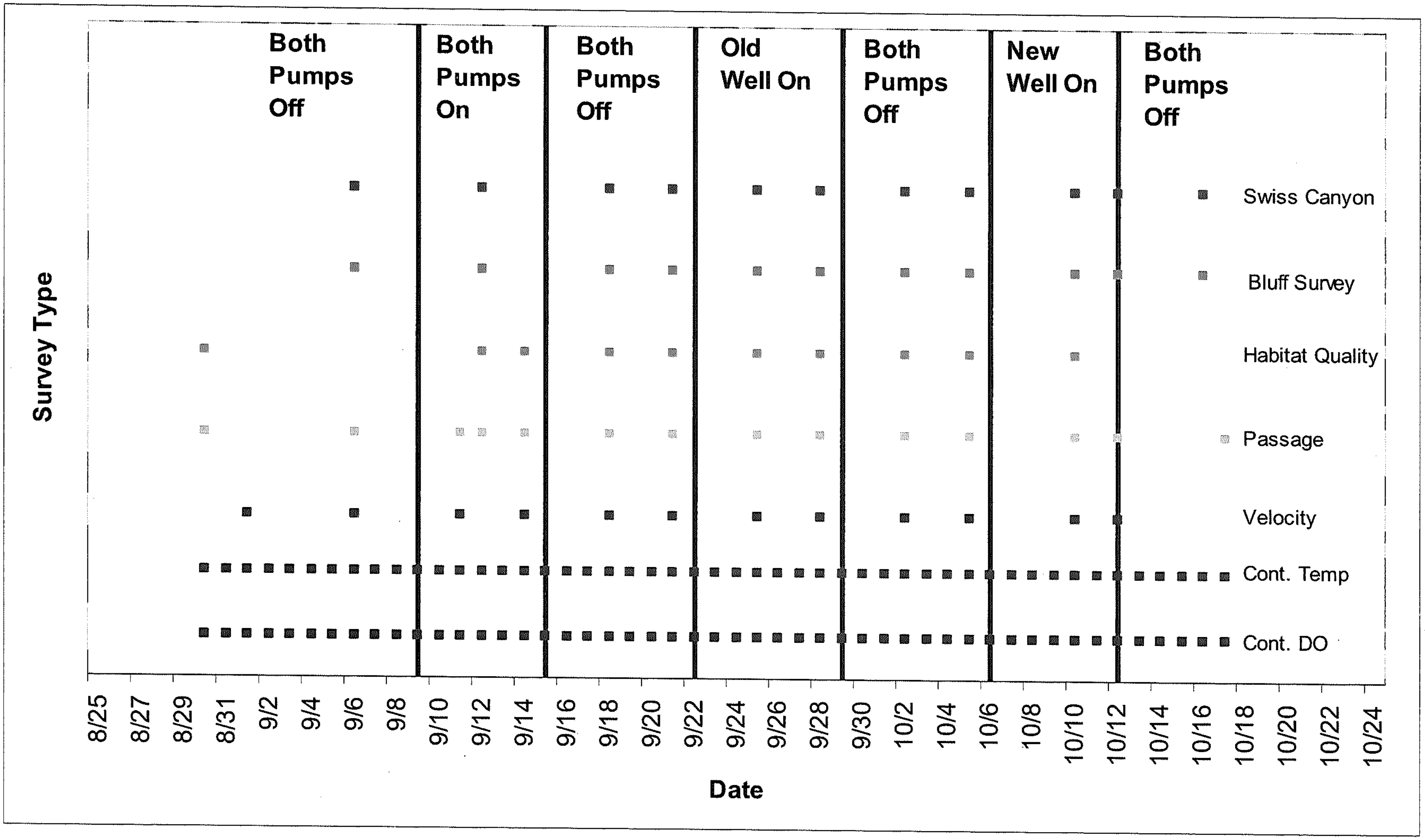

FIGURE 1-1.5. The 2006 experimental design for habitat monitoring and irrigation well operation.

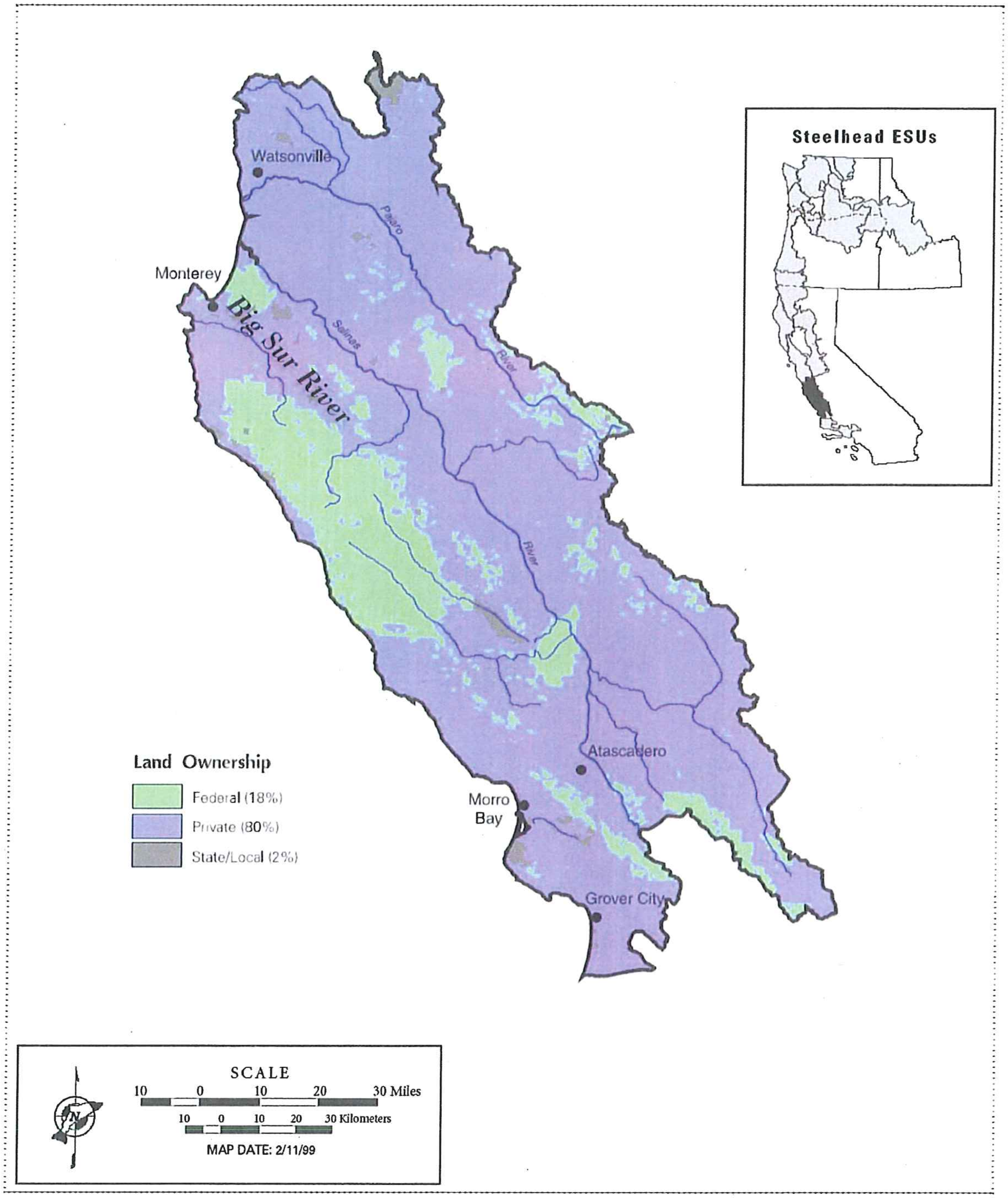

FIGURE 1-2. Steelhead Evolutionarily Significant Units (ESU) (source: NMFS 2004).

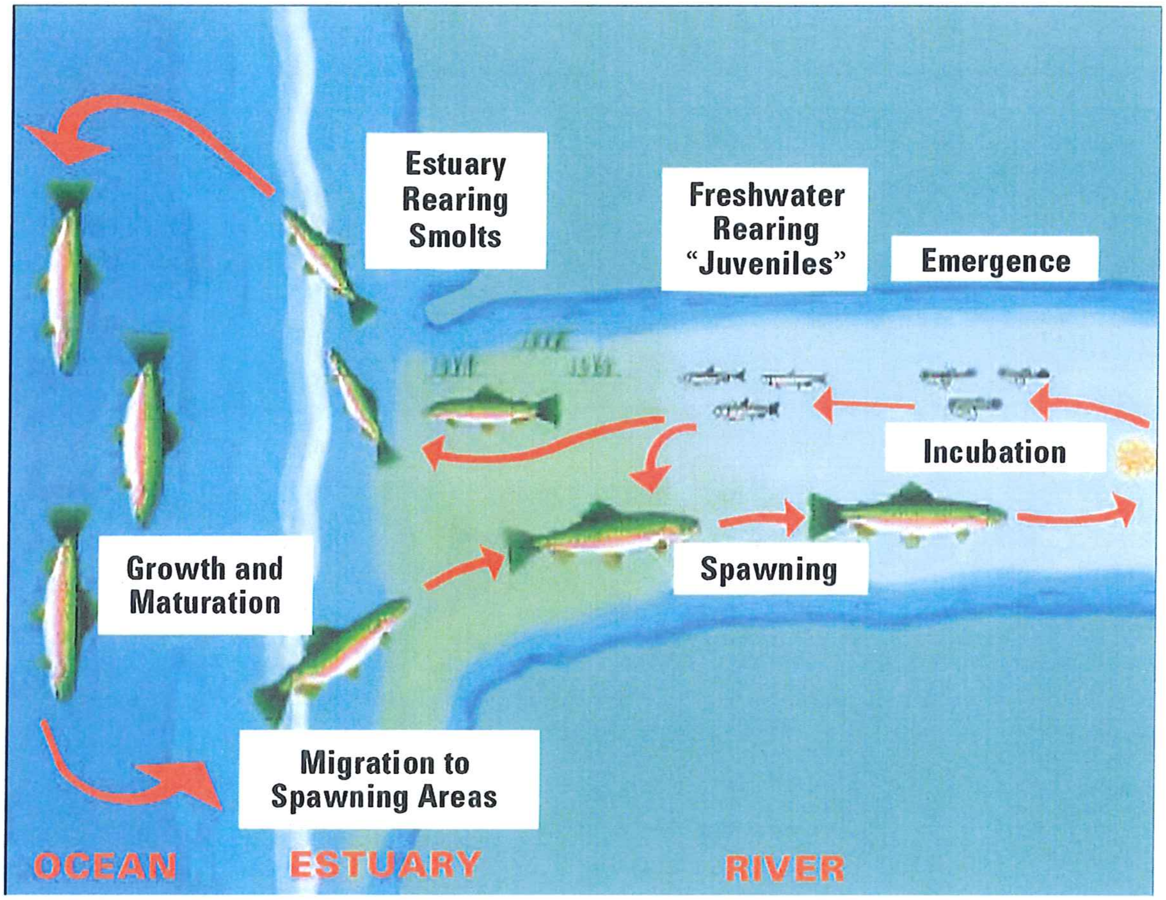

FIGURE 1-3. Life cycle of steelhead (source: Sonoma County Water Agency).

FIGURE 2-1. Velocity transect VT-1, representing the upstream reference site (9-1-06).

FIGURE 2-2. View of Passage Transect 1, downstream lagoon section.

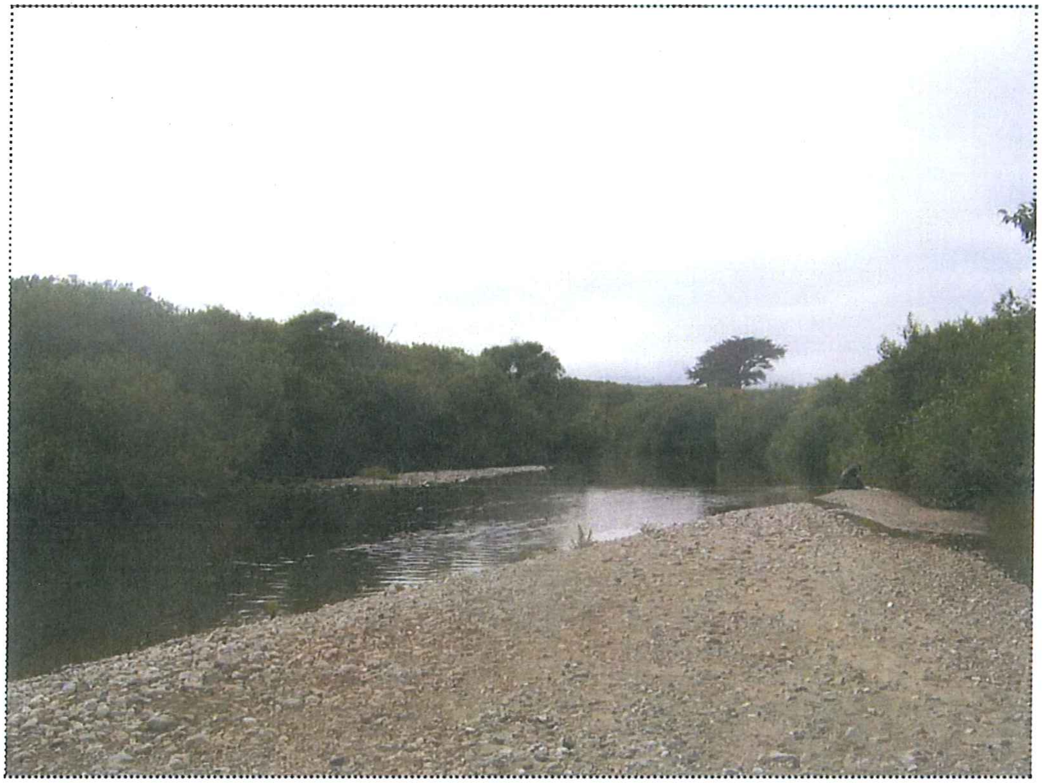

FIGURE 2-3. View of Passage Transect 2, middle lagoon section.

FIGURE 2-4. View of Passage Transect 3, upstream lagoon section.

FIGURE 2-5. View of Passage Transect 4, riffle-run section.

FIGURE 2-6. View of Passage Transect 5, deep homogenous channel section.

FIGURE 2-7. View of Passage Transect 6, downstream section adjacent to pumps and groundwater zone of influence.

FIGURE 2-8. View of Passage Transect 7, section immediately adjacent to pumps and groundwater zone of influence.

FIGURE 2-9. View of Passage Transect 8, upstream section adjacent to pumps and groundwater zone of influence.

FIGURE 2-10. View of Passage Transect 9, riffle-run section upstream of groundwater zone of influence.

FIGURE 2-11. View of Passage Transect 10, riffle run at extreme upstream point of potential zone of influence from El Sur Ranch pump operations.

FIGURE 2-12. View of Passage Transect 11, riffle run representing the upstream reference point.

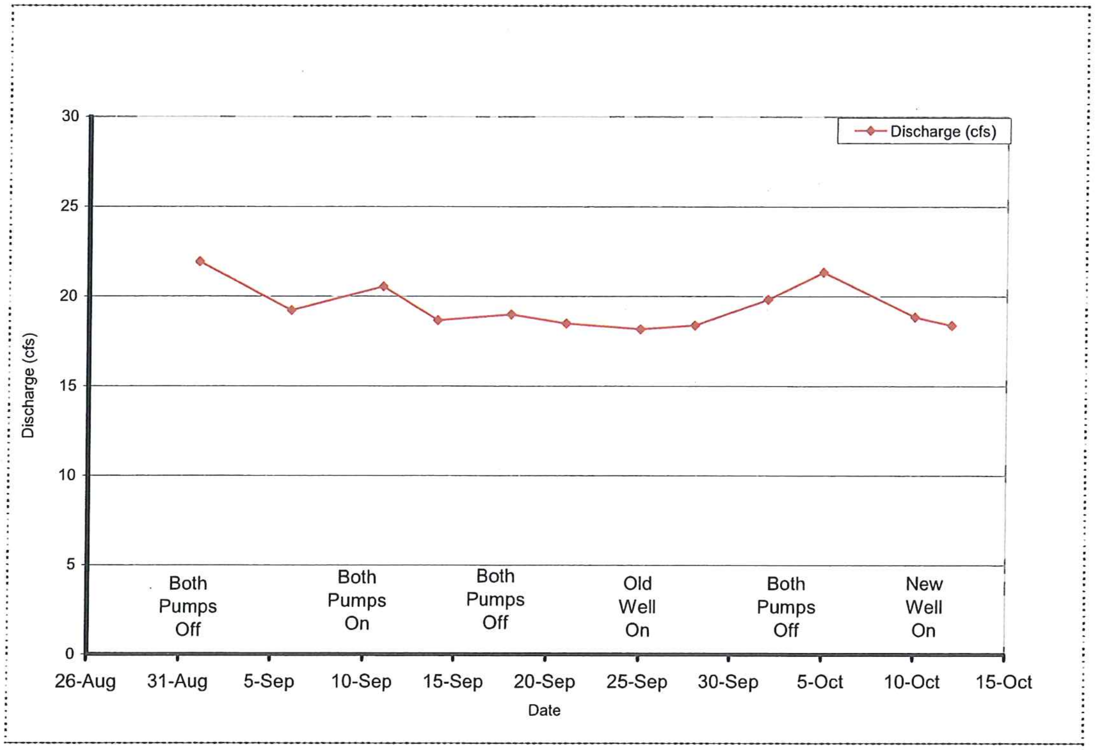

FIGURE 3-1. Estimated streamflow at transect VT-1 – upstream reference location.

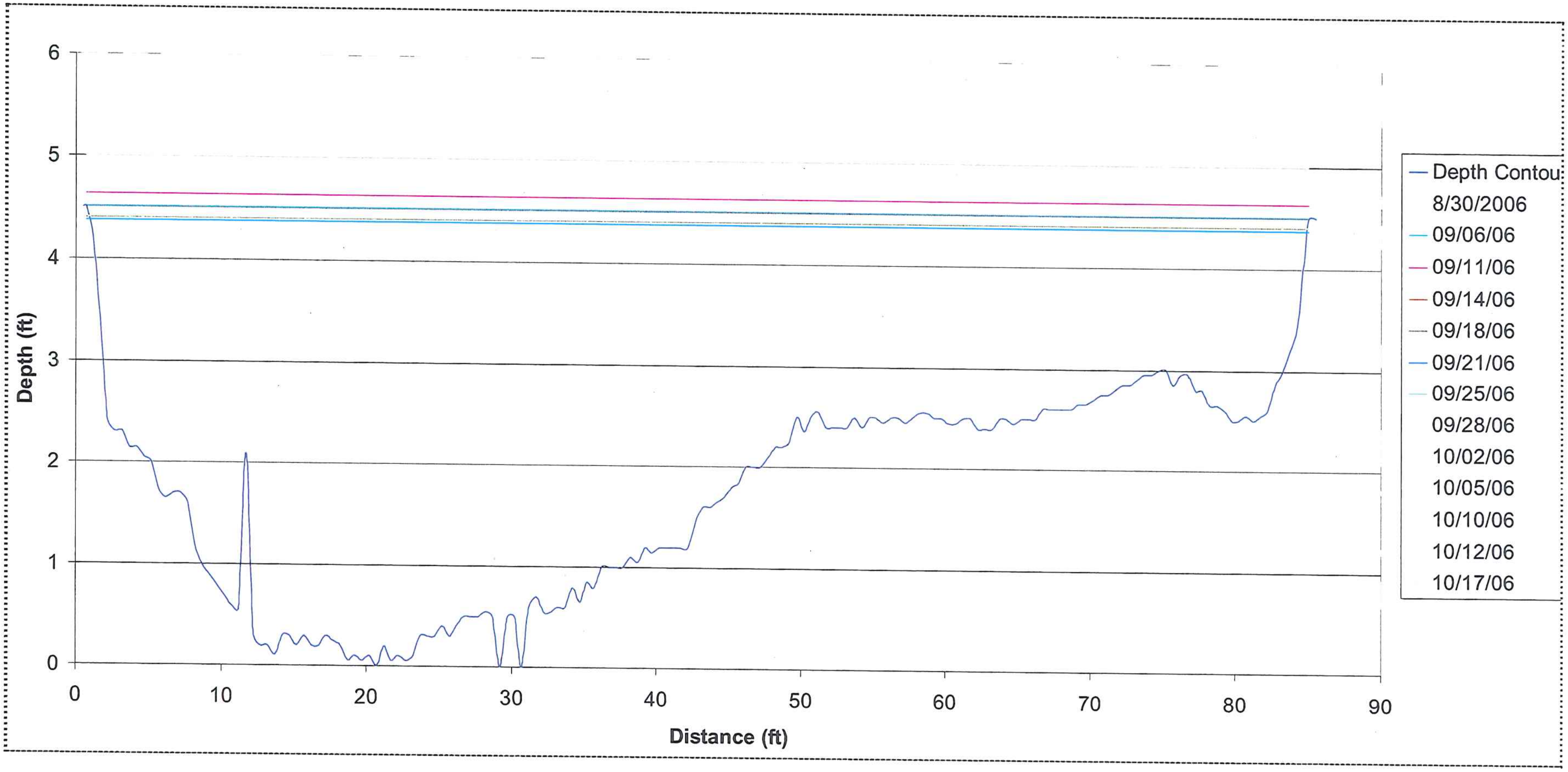

FIGURE 3-2. Passage Transect 1 depth contour and water elevation contour for habitat connectivity and fish passage survey dates.

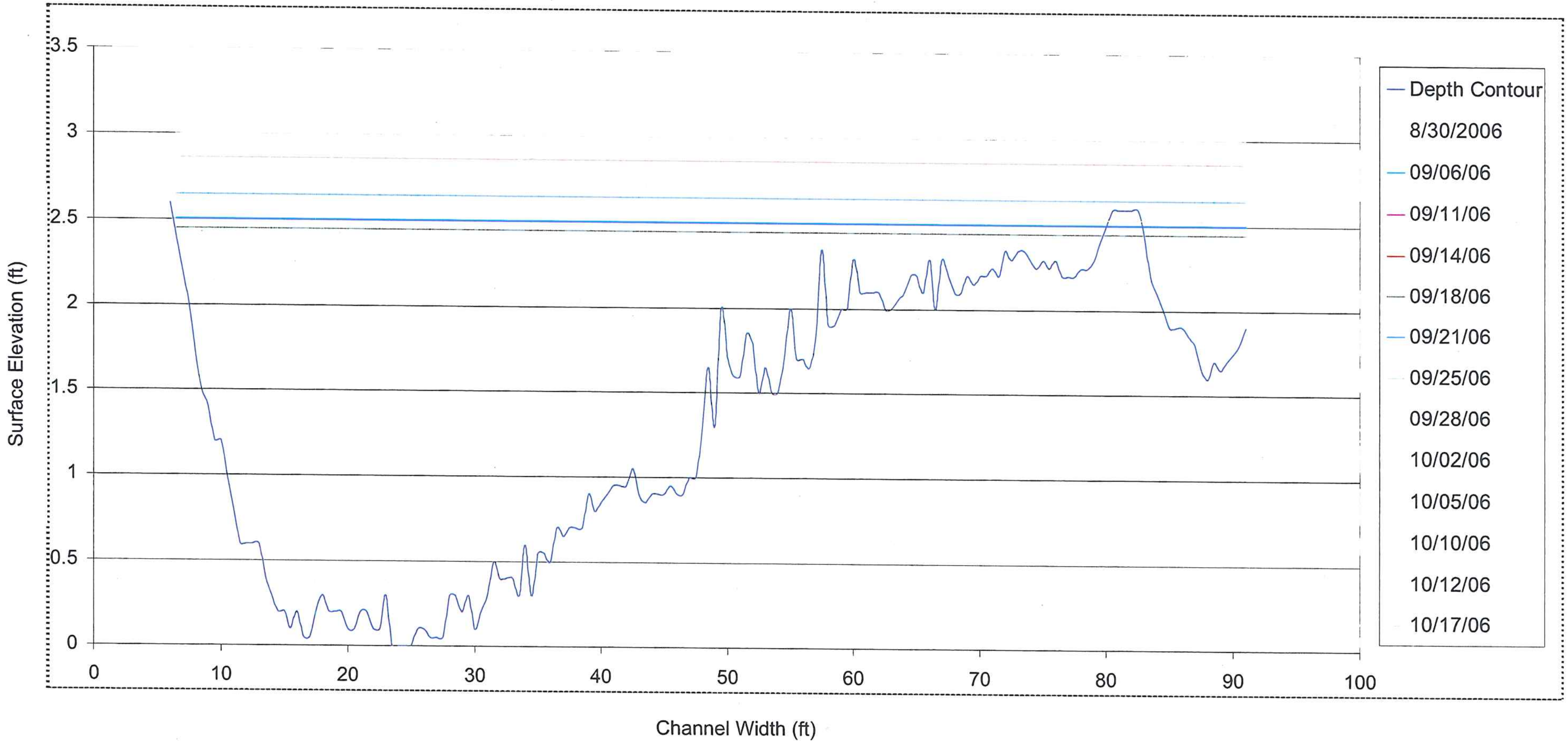

FIGURE 3-3. Passage Transect 2 depth contour and water elevation contour for habitat connectivity and fish passage survey dates.

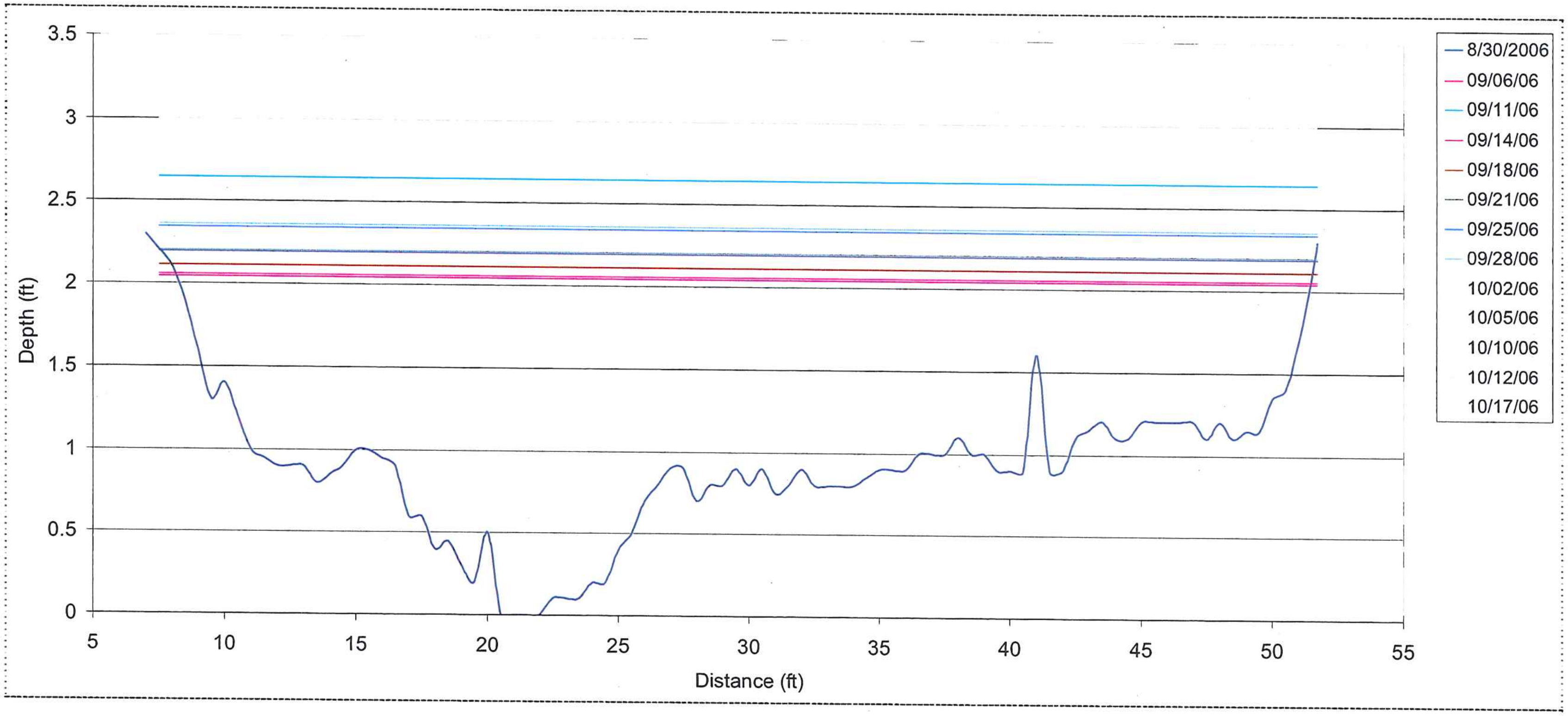

FIGURE 3-4. Passage Transect 3 depth contour and water elevation contour for habitat connectivity and fish passage survey dates.

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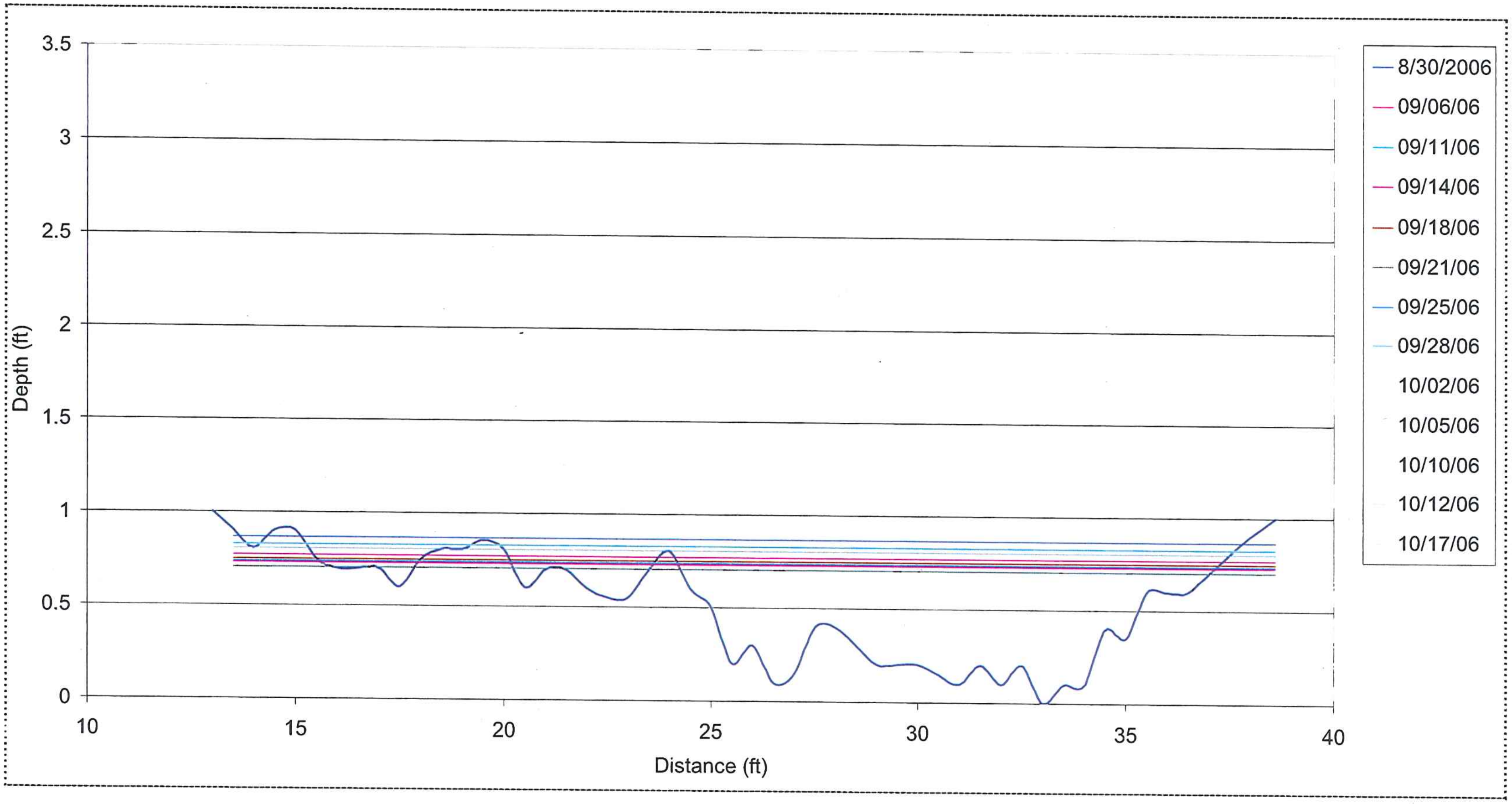

FIGURE 3-5. Passage Transect 4 depth contour and water elevation contour for habitat connectivity and fish passage survey dates.

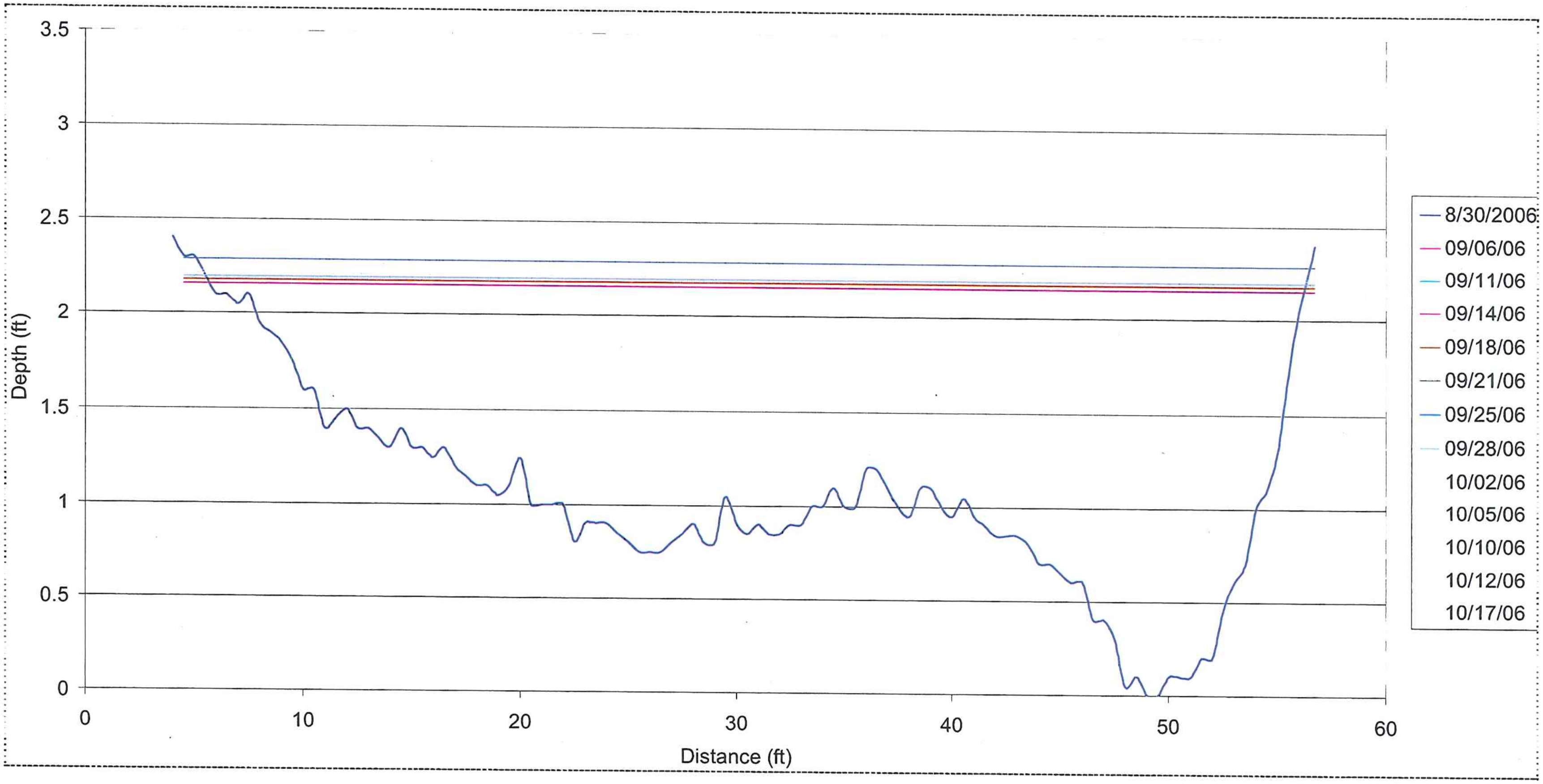

FIGURE 3-6. Passage Transect 5 depth contour and water elevation contour for habitat connectivity and fish passage survey dates.

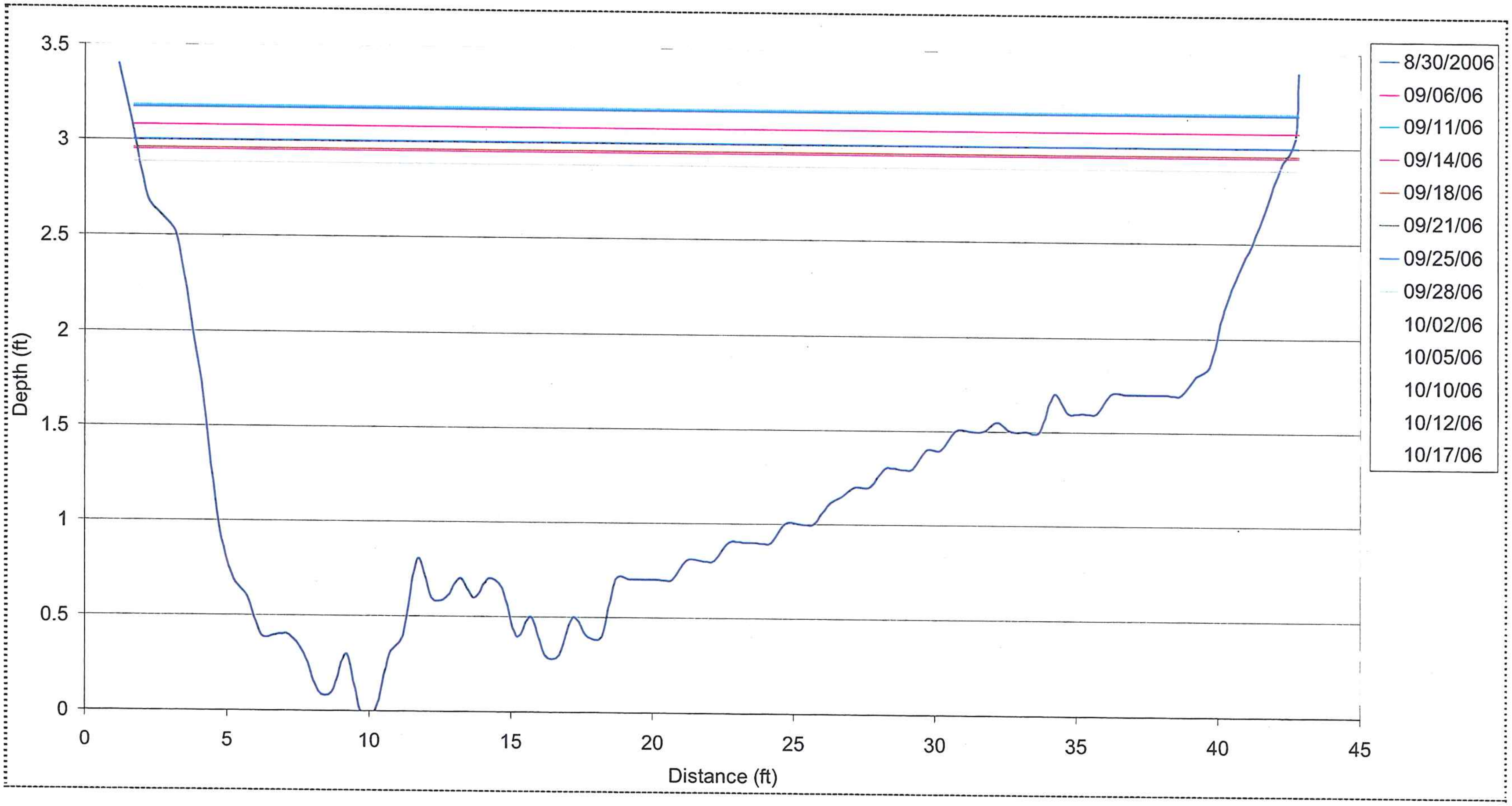

FIGURE 3-7. Passage Transect 6 depth contour and water elevation contour for habitat connectivity and fish passage survey dates.

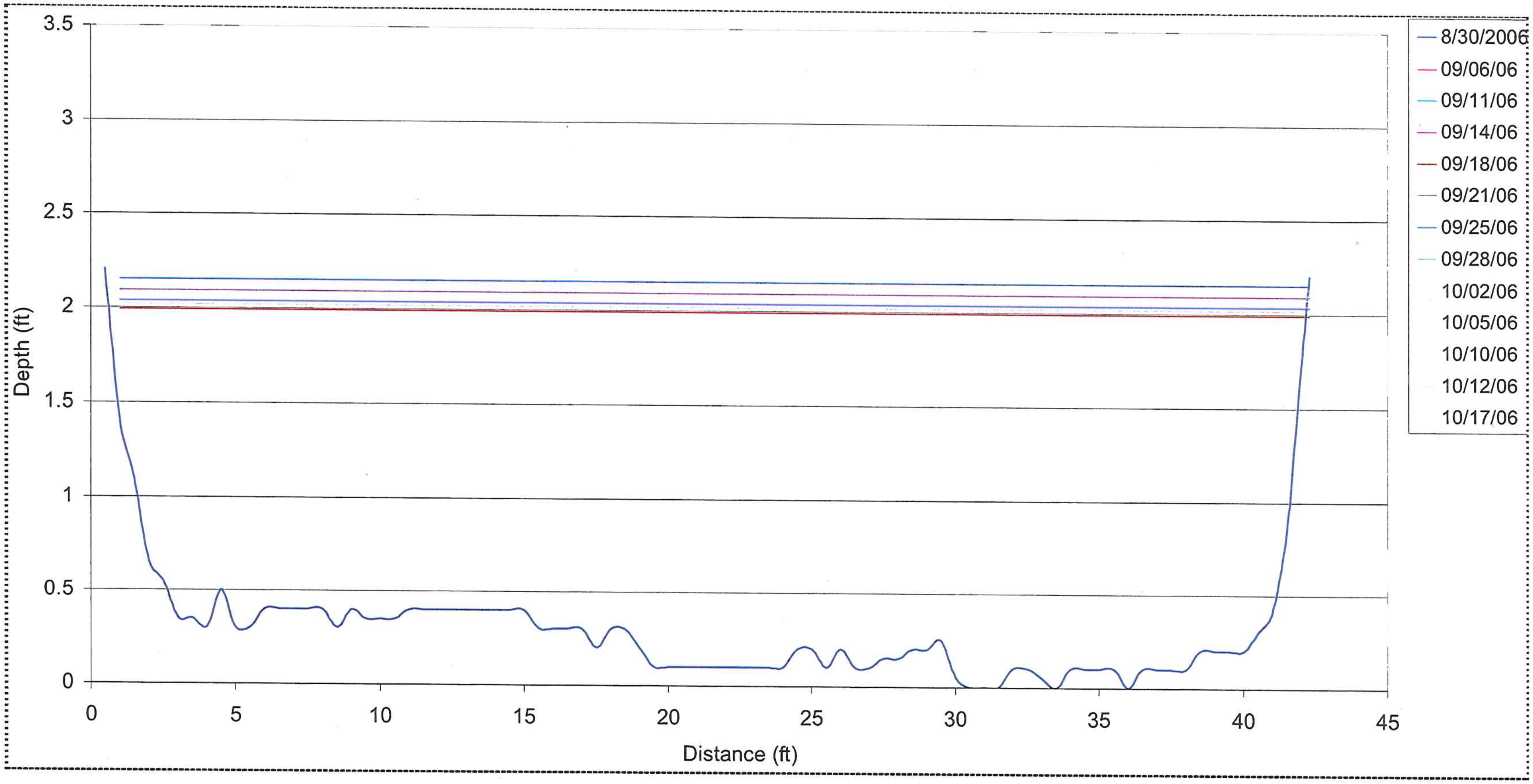

FIGURE 3-8. Passage Transect 7 depth contour and water elevation contour for habitat connectivity and fish passage survey dates.

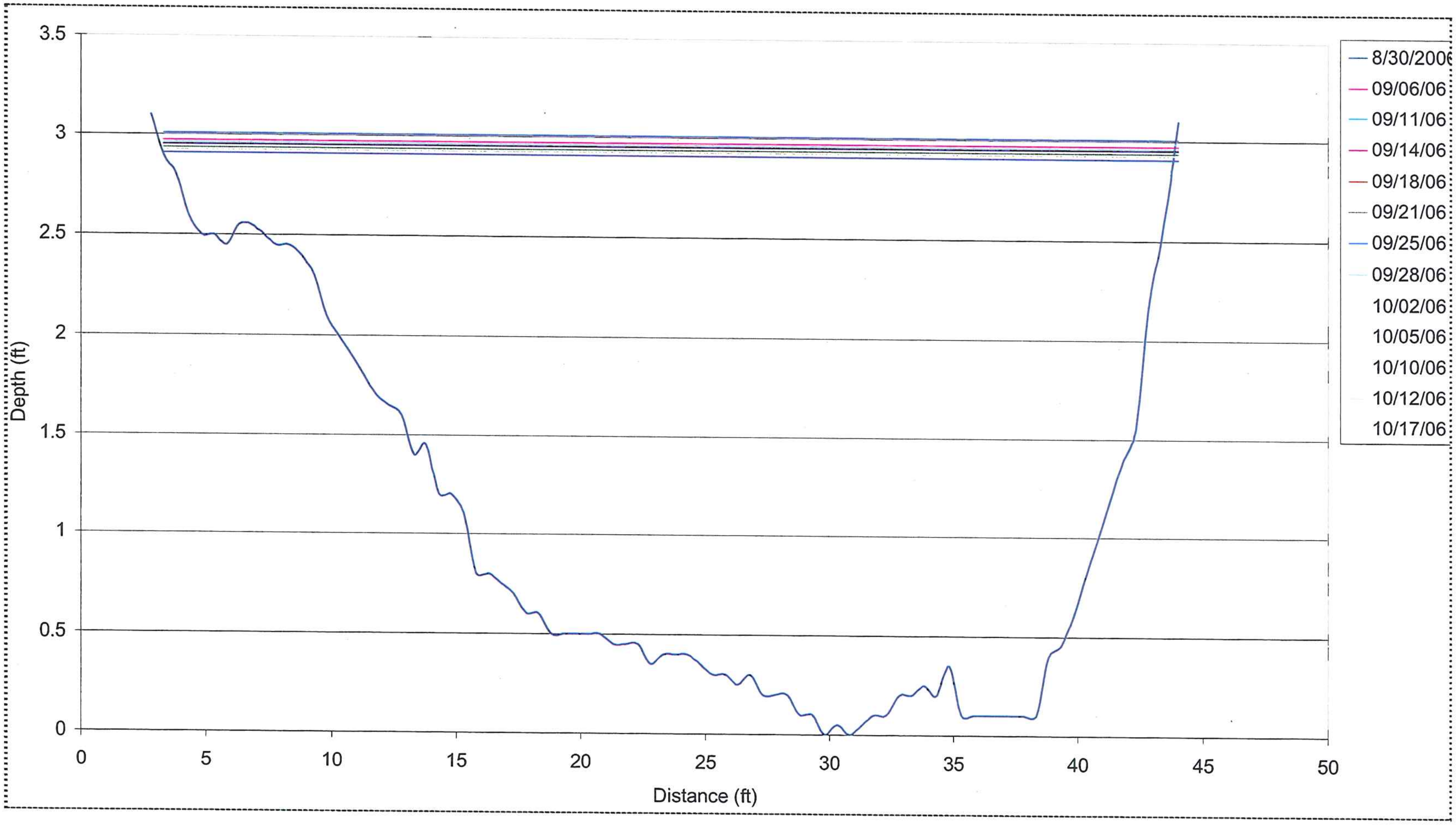

FIGURE 3-9. Passage Transect 8 depth contour and water elevation contour for habitat connectivity and fish passage survey dates.

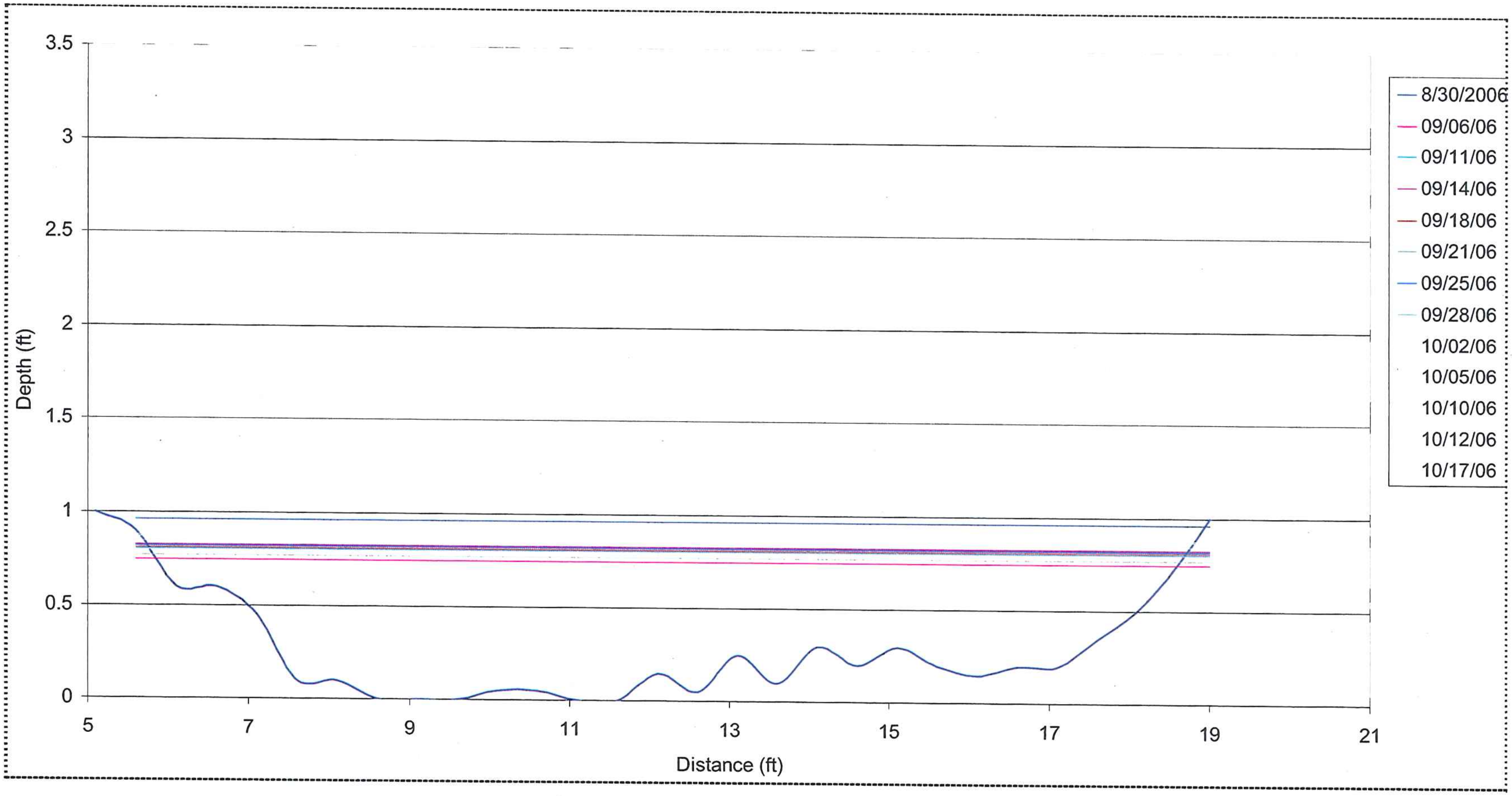

FIGURE 3-10. Passage Transect 9 depth contour and water elevation contour for habitat connectivity and fish passage survey dates.

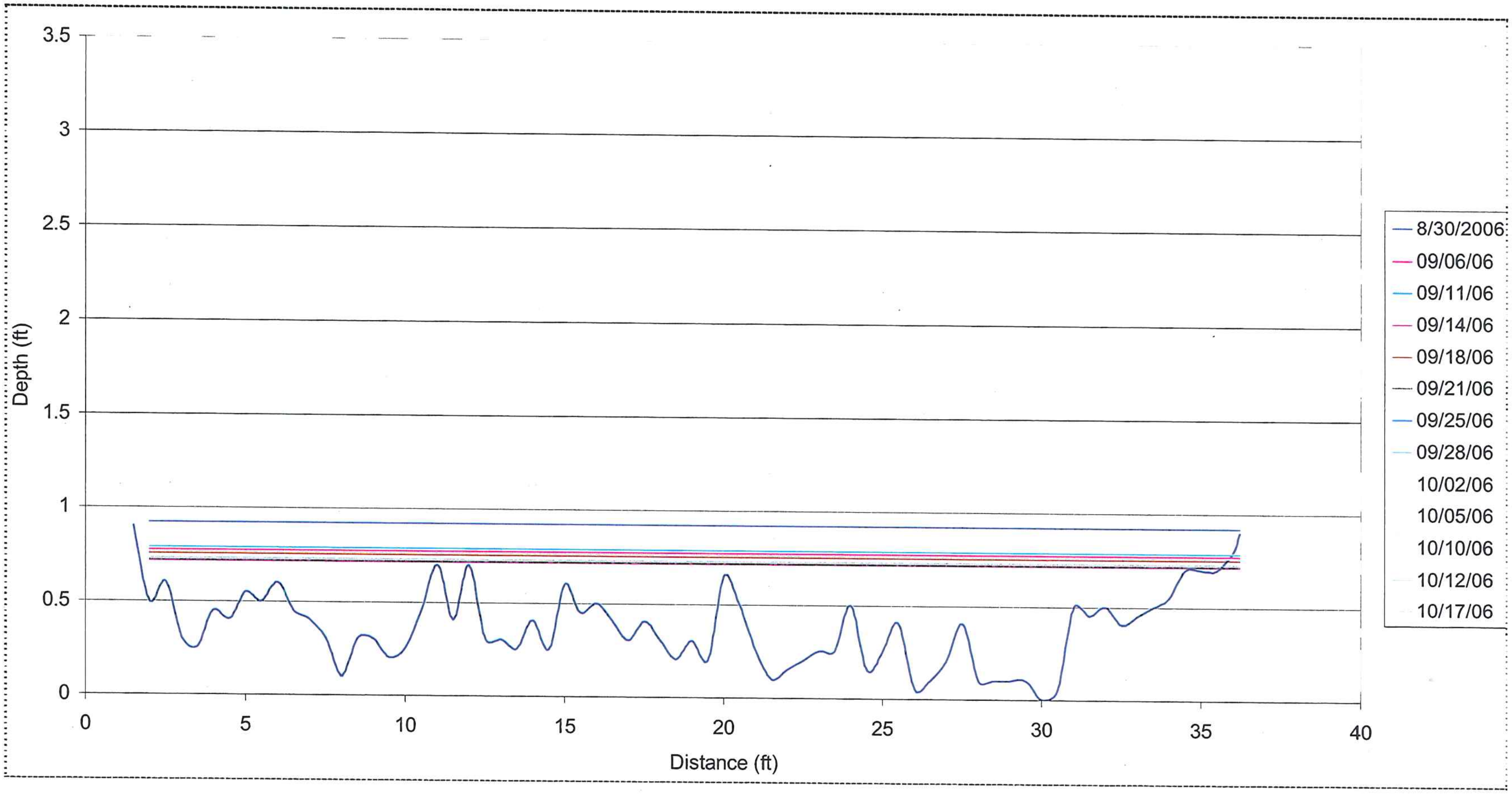

FIGURE 3-11. Passage Transect 10 depth contour and water elevation contour for habitat connectivity and fish passage survey dates.

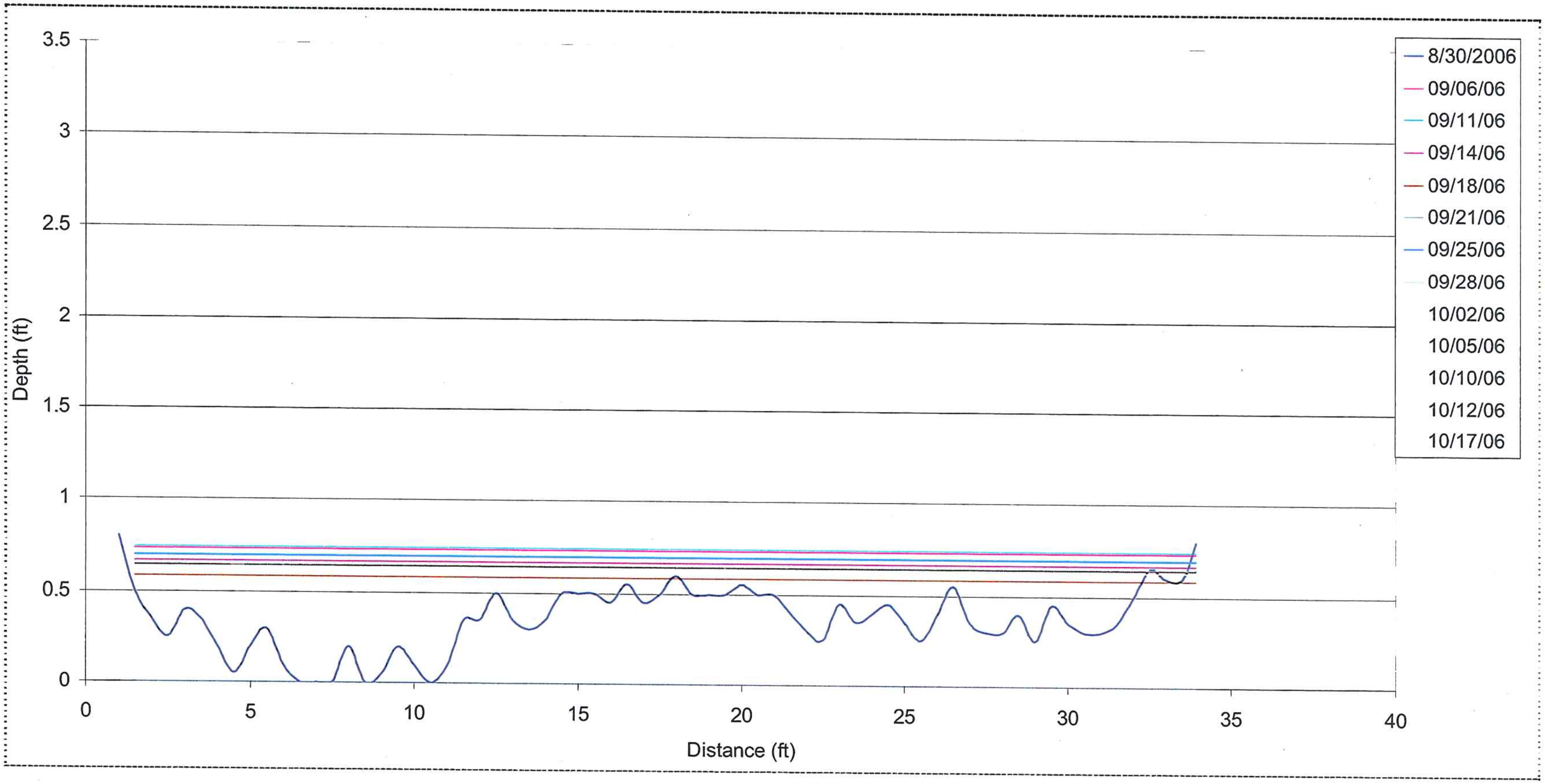

FIGURE 3-12. Passage Transect 11 depth contour and water elevation contour for habitat connectivity and fish passage survey dates.

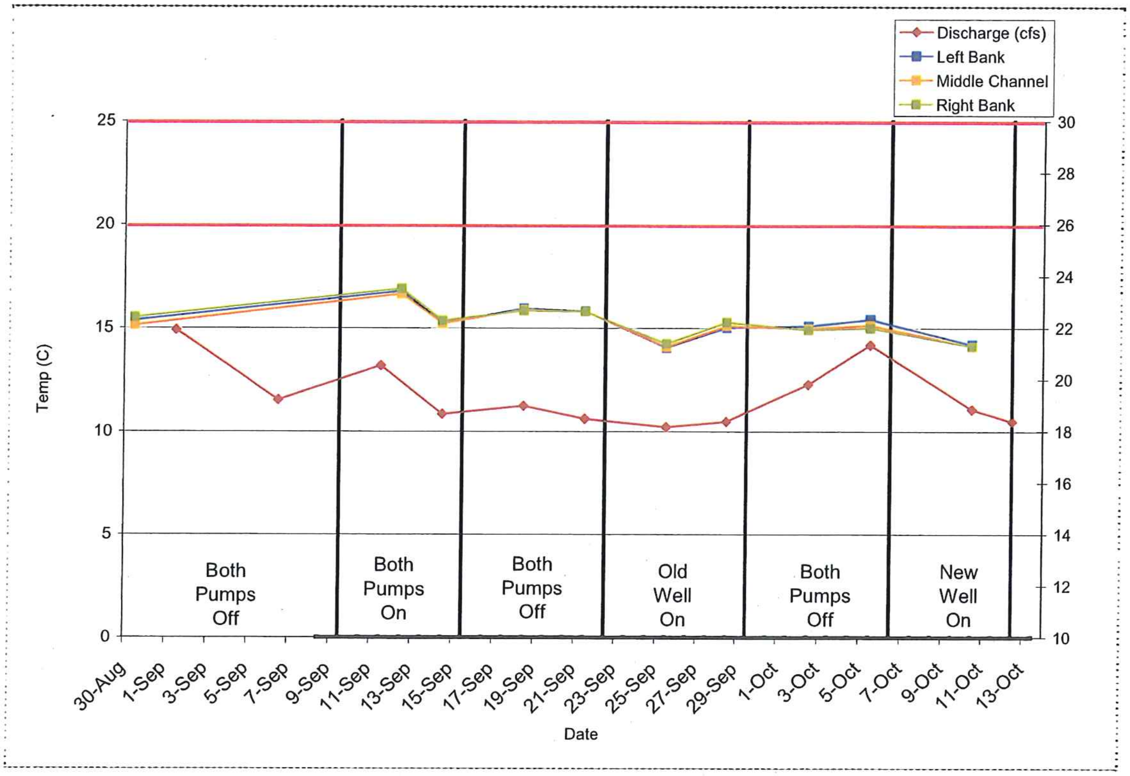

FIGURE 3-13. Transect 1 temperature (°C) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

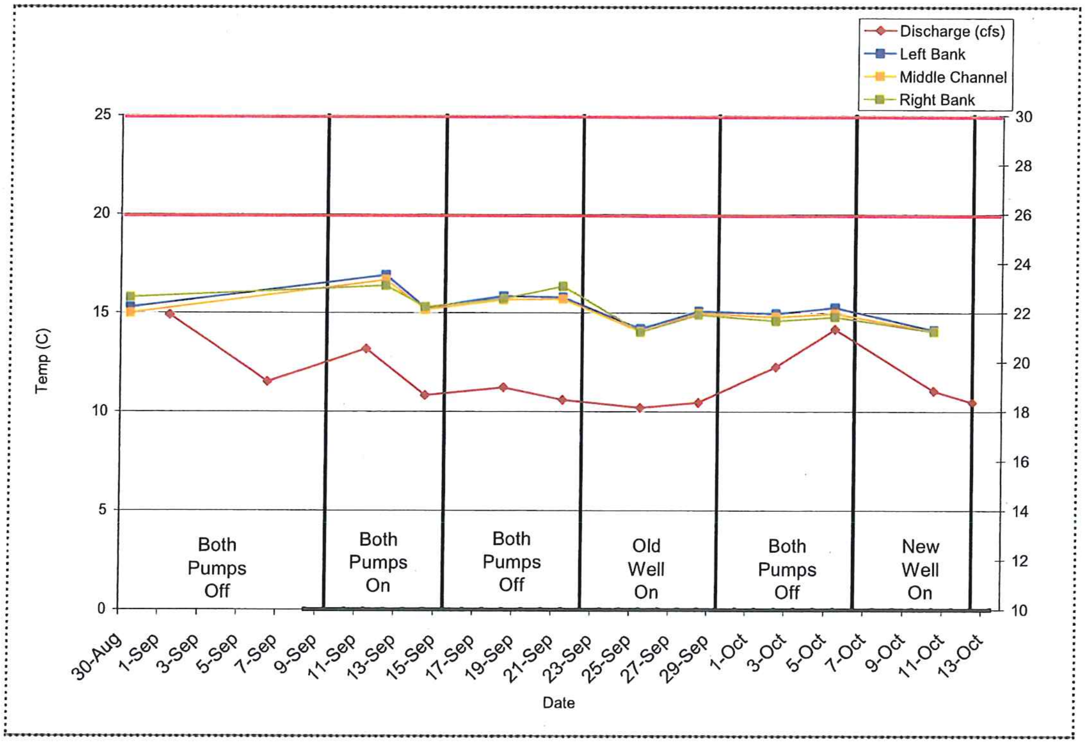

FIGURE 3-14. Transect 2 temperature (°C) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

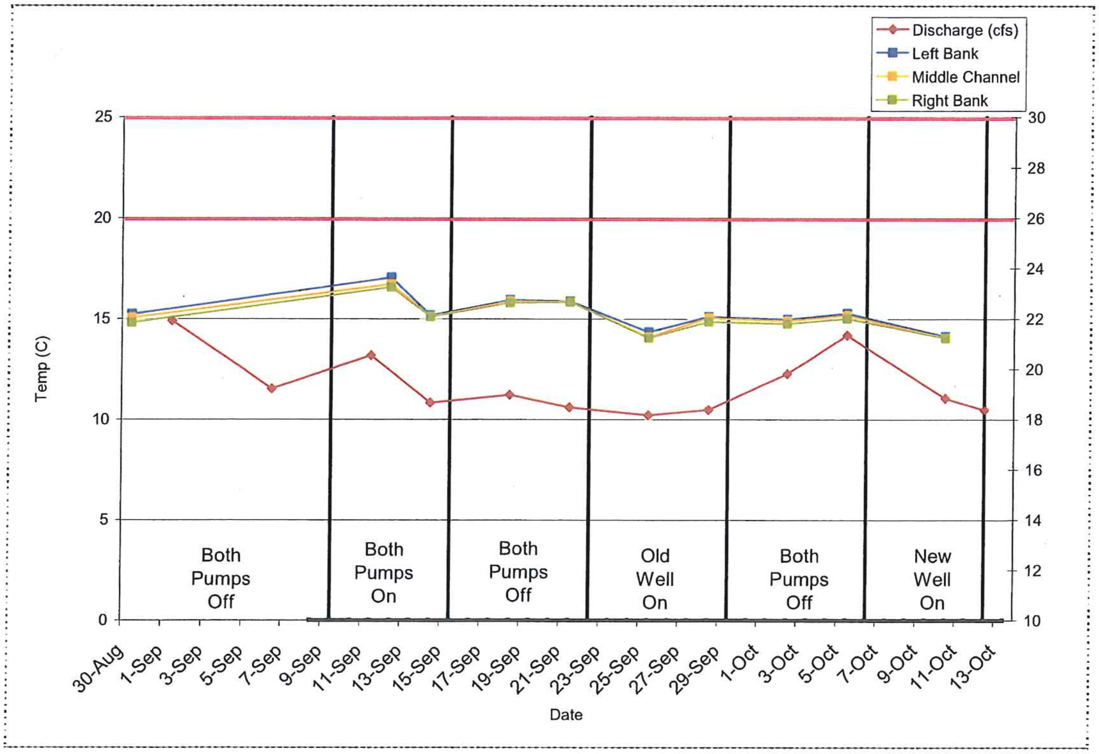

FIGURE 3-15. Transect 3 temperature (°C) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

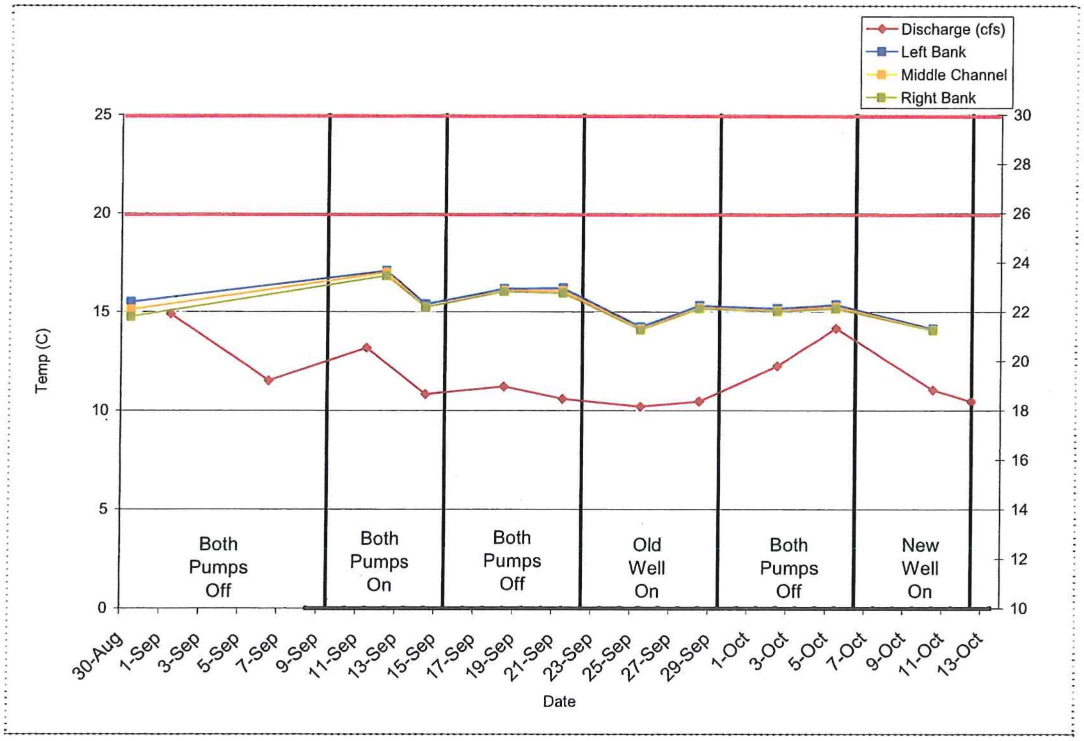

FIGURE 3-16. Transect 4 temperature (°C) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

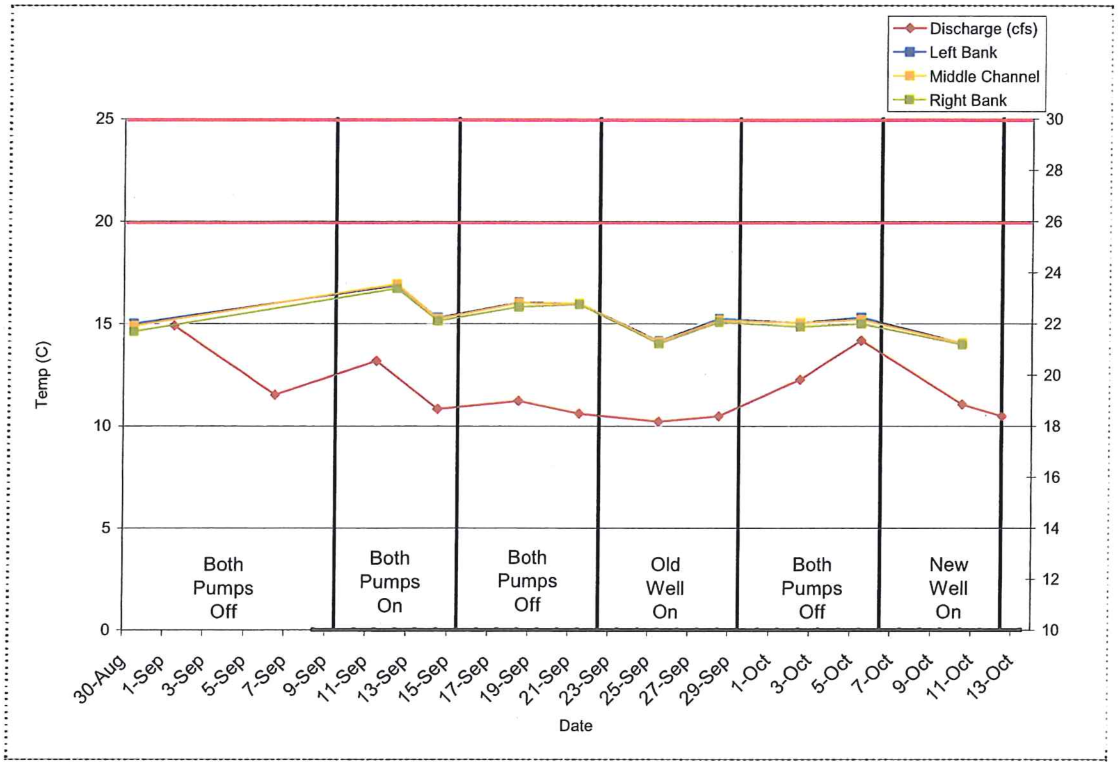

FIGURE 3-17. Transect 5 temperature (°C) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

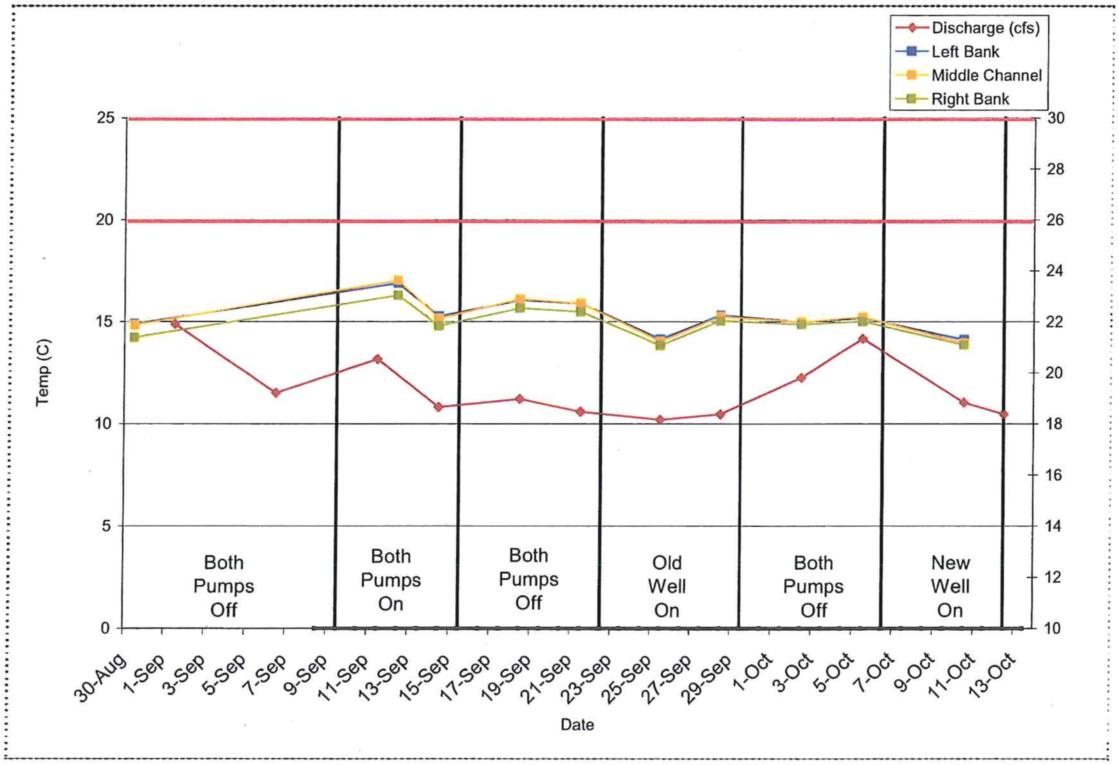

FIGURE 3-18. Transect 6 temperature (°C) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

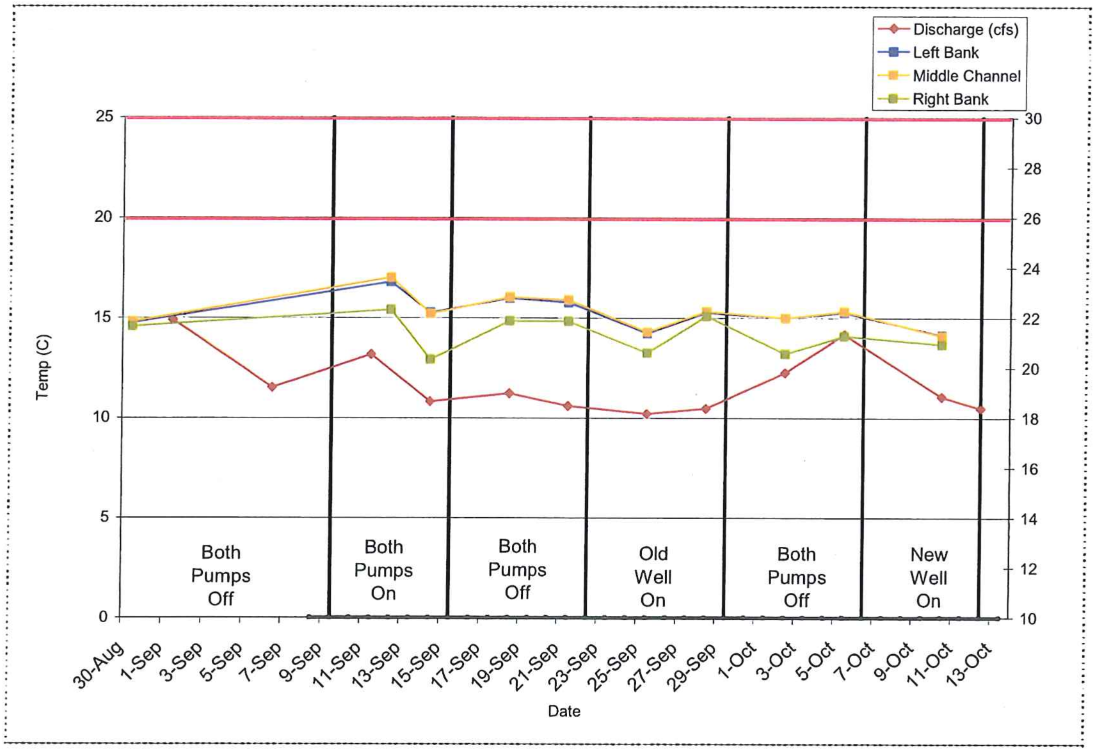

FIGURE 3-19. Transect 7 temperature (°C) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

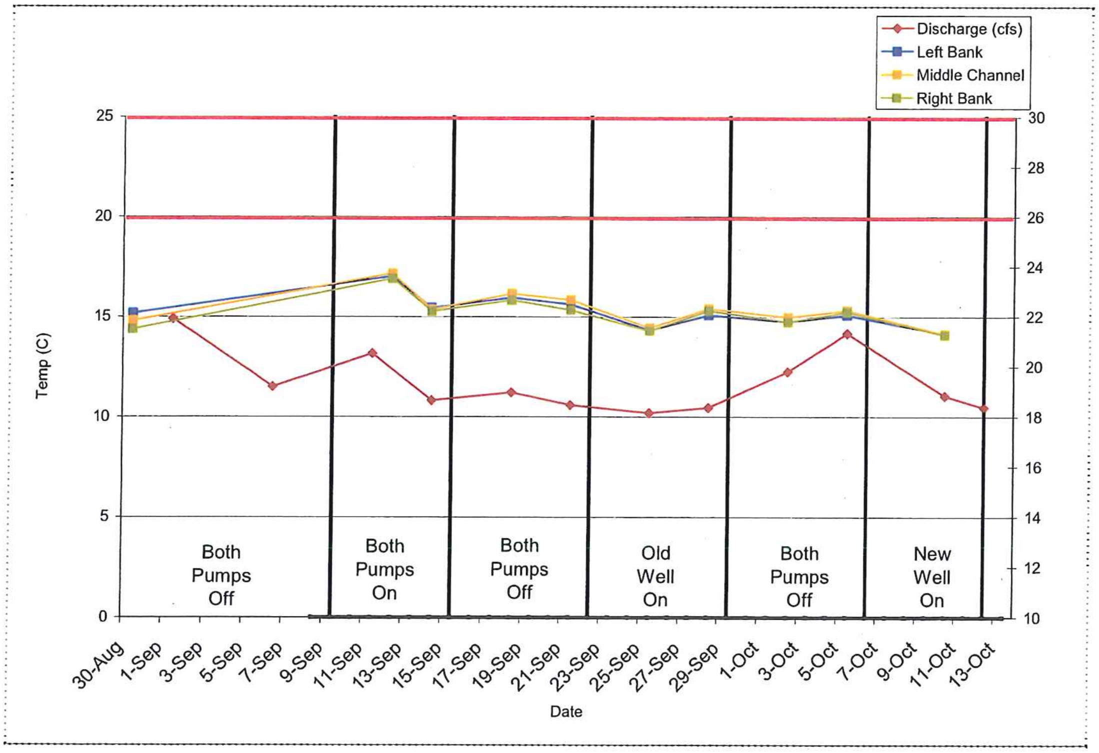

FIGURE 3-20. Transect 8 temperature (°C) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

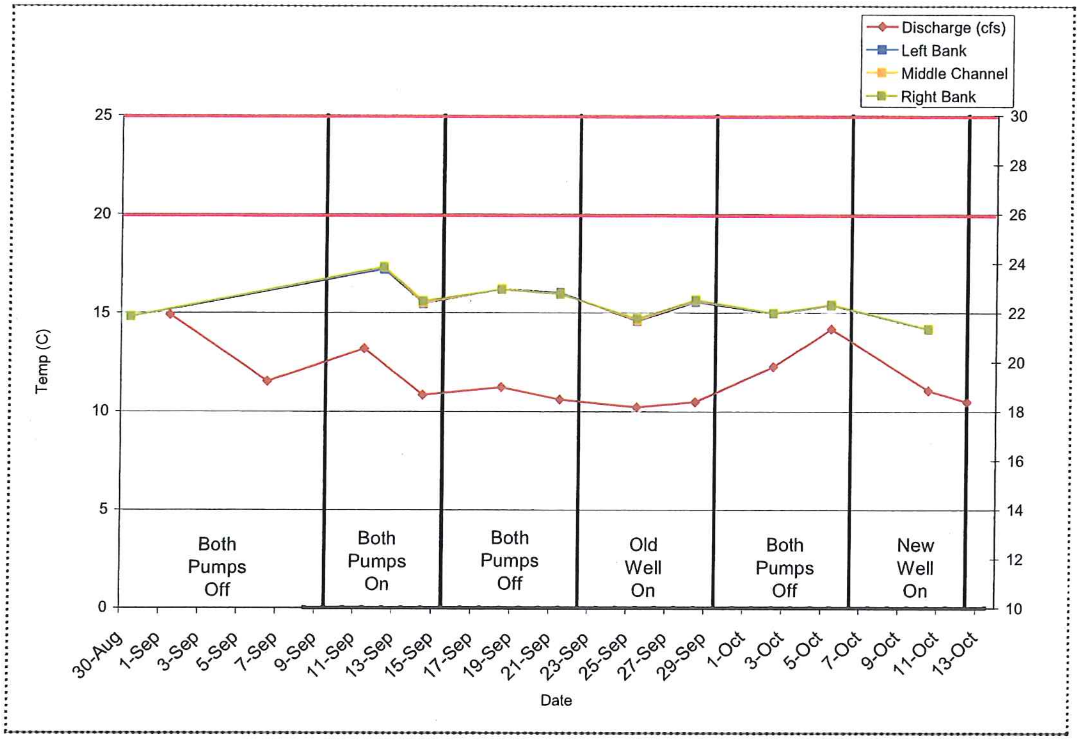

FIGURE 3-21. Transect 9 temperature (°C) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

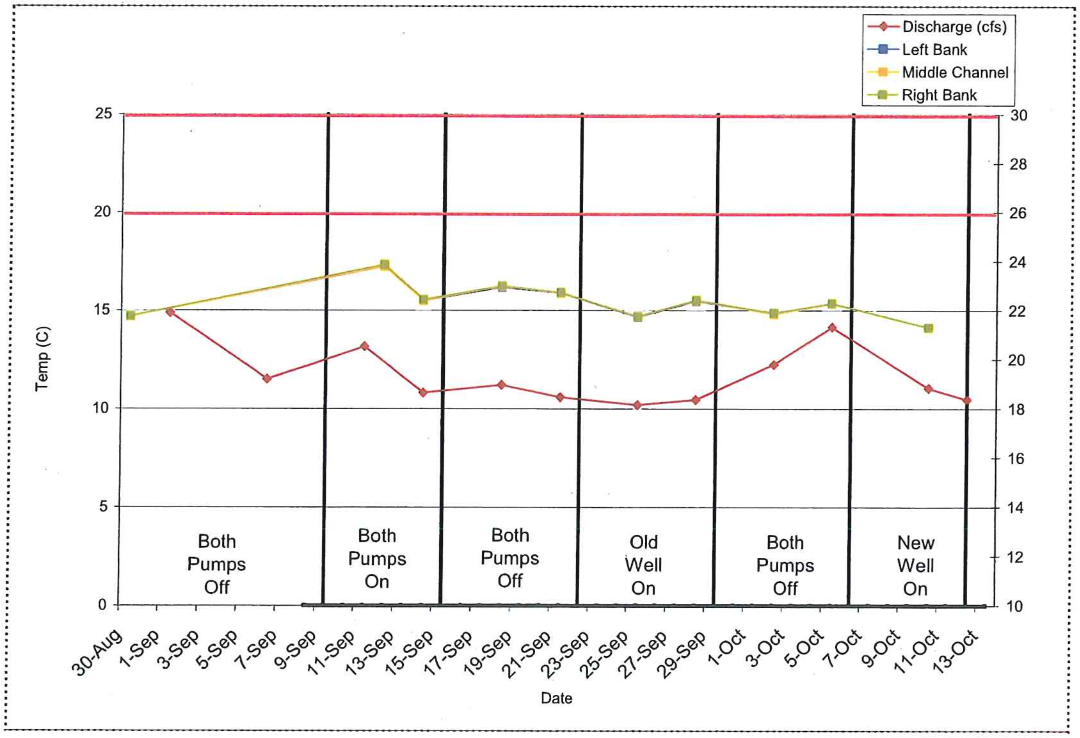

FIGURE 3-22. Transect 10 temperature (°C) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

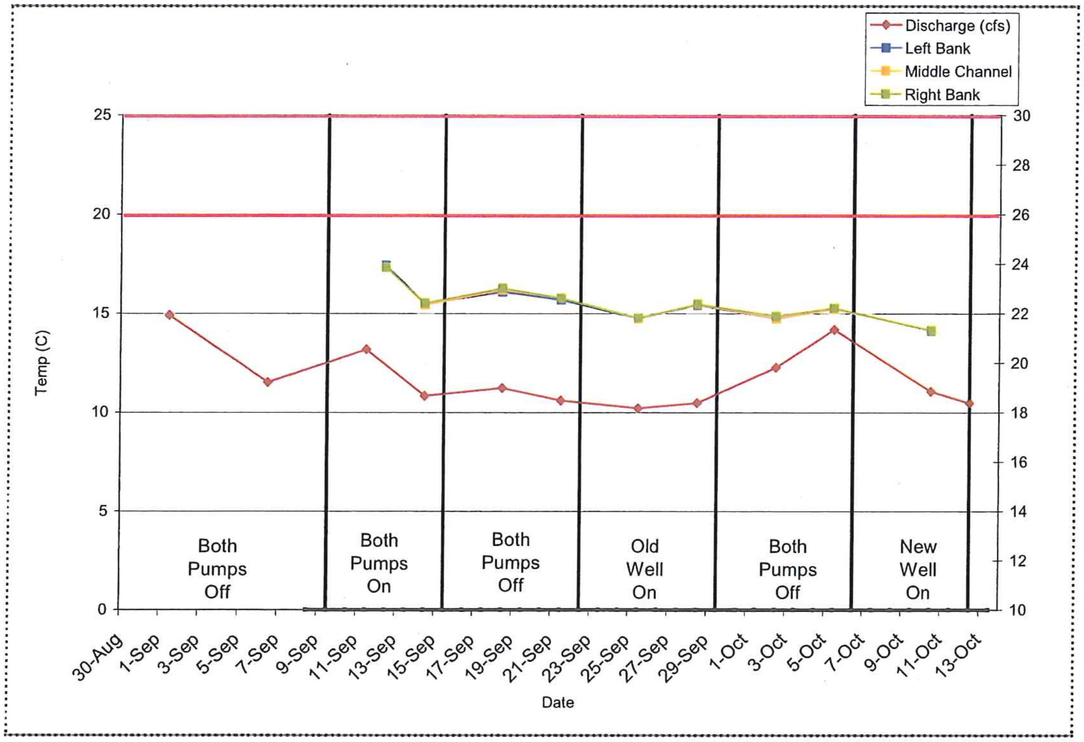

FIGURE 3-23. Transect 11 temperature (°C) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

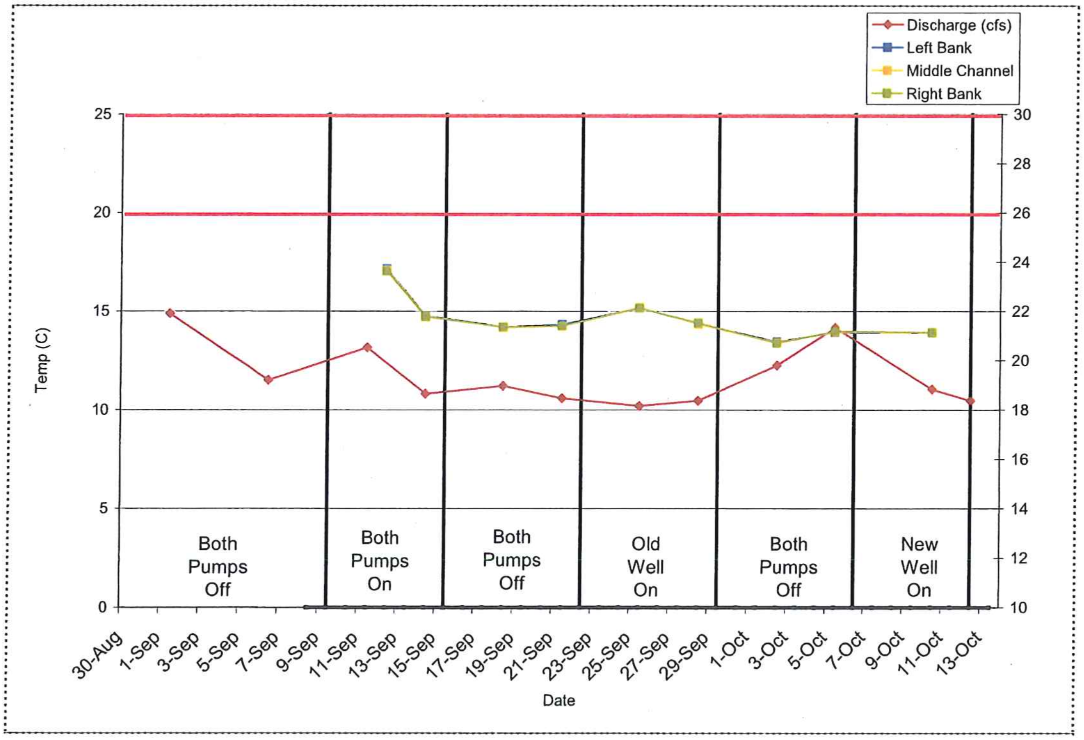

FIGURE 3-24. Transect VT-1 temperature (°C) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

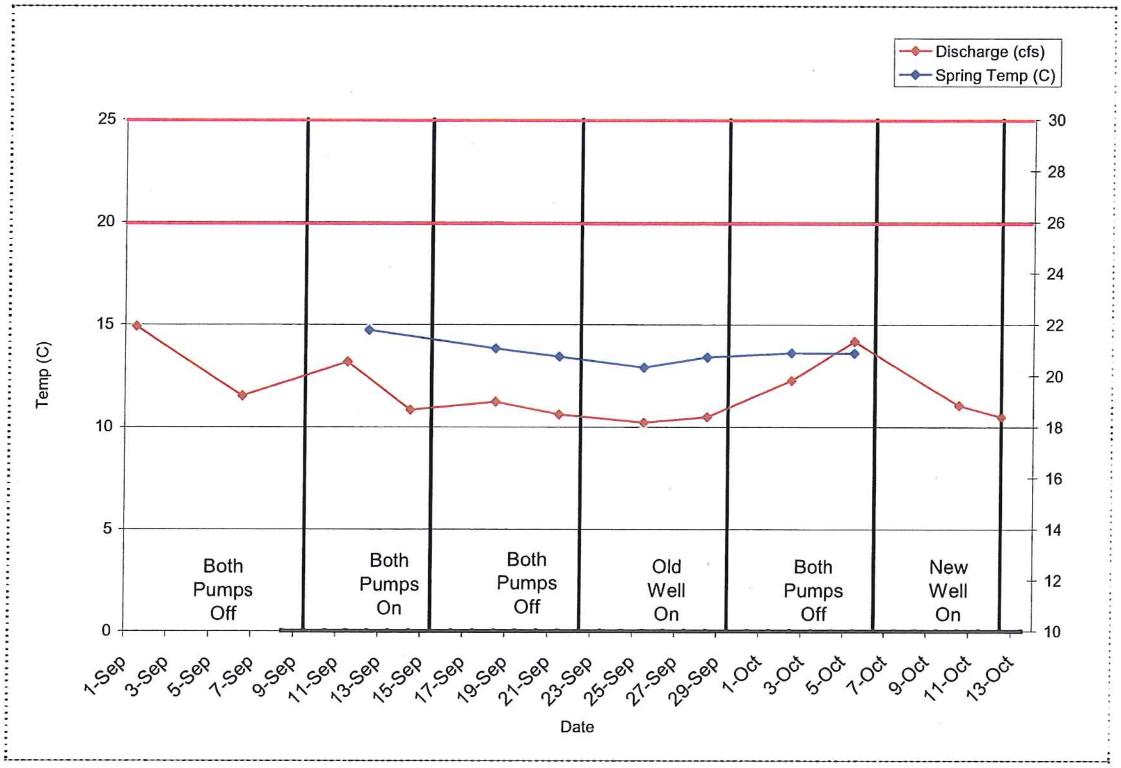

FIGURE 3-25. Spring at Transect 6 temperature (°C) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

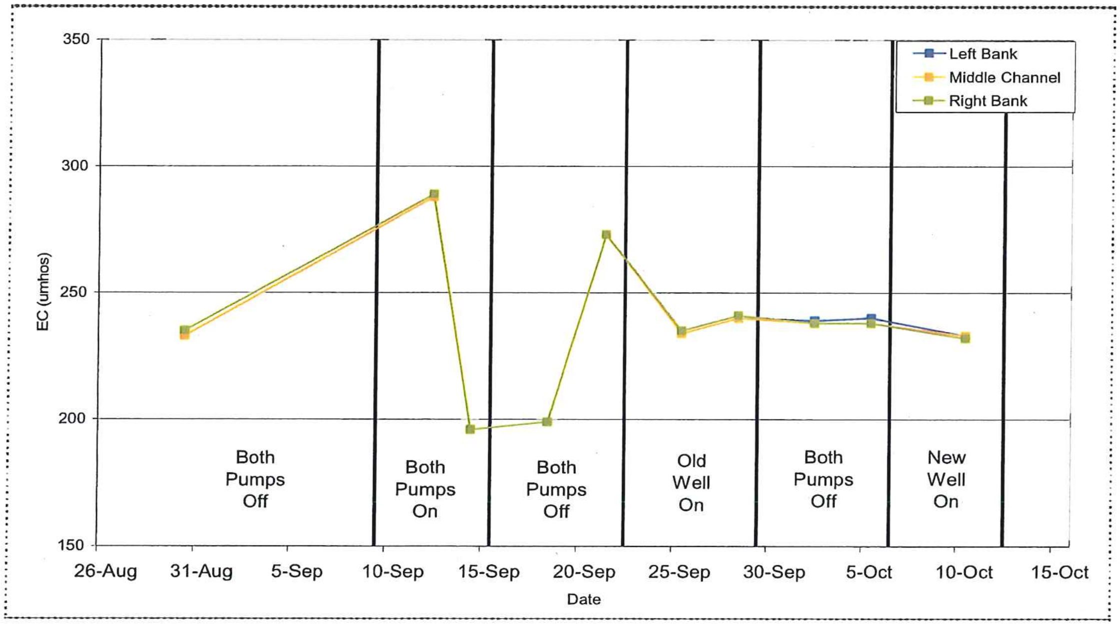

FIGURE 3-26. Transect 1 EC (uS/cm) from grab for habitat survey dates.

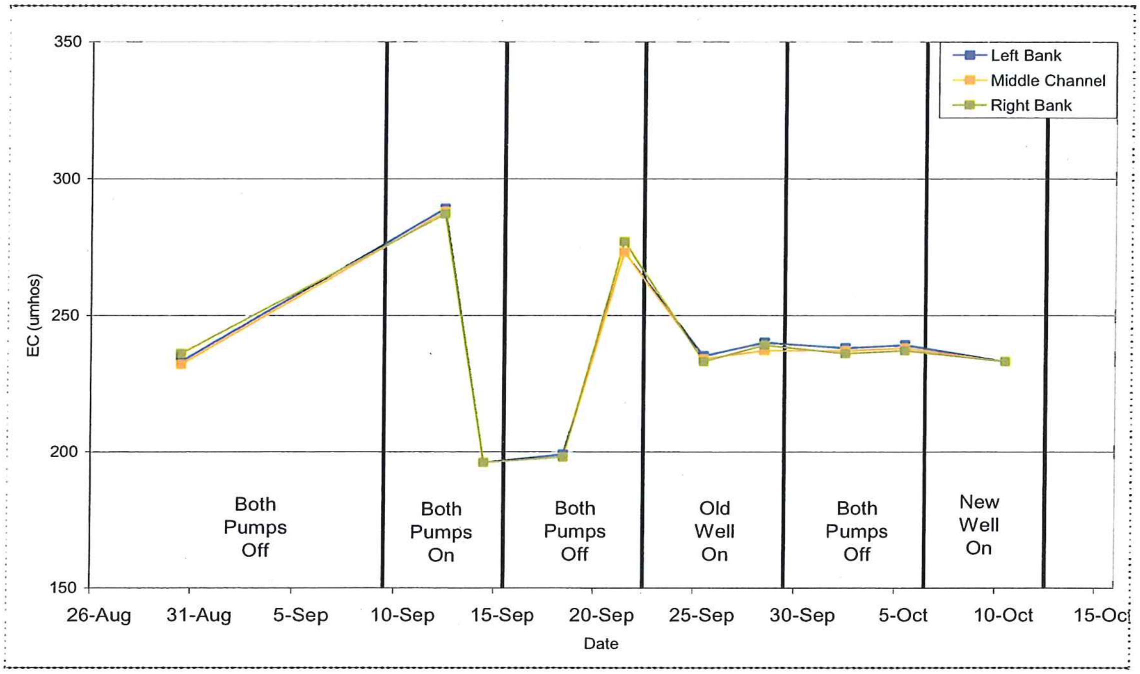

FIGURE 3-27. Transect 2 EC (uS/cm) from grab for habitat survey dates.

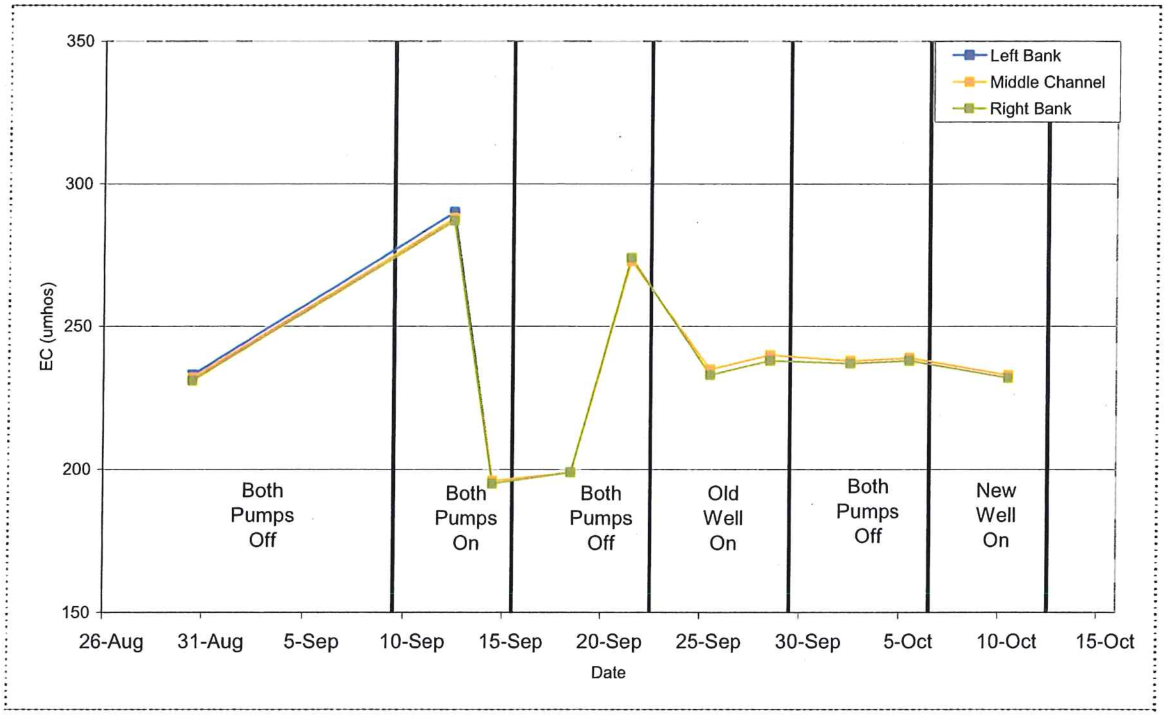

FIGURE 3-28. Transect 3 EC (uS/cm) from grab for habitat survey dates.

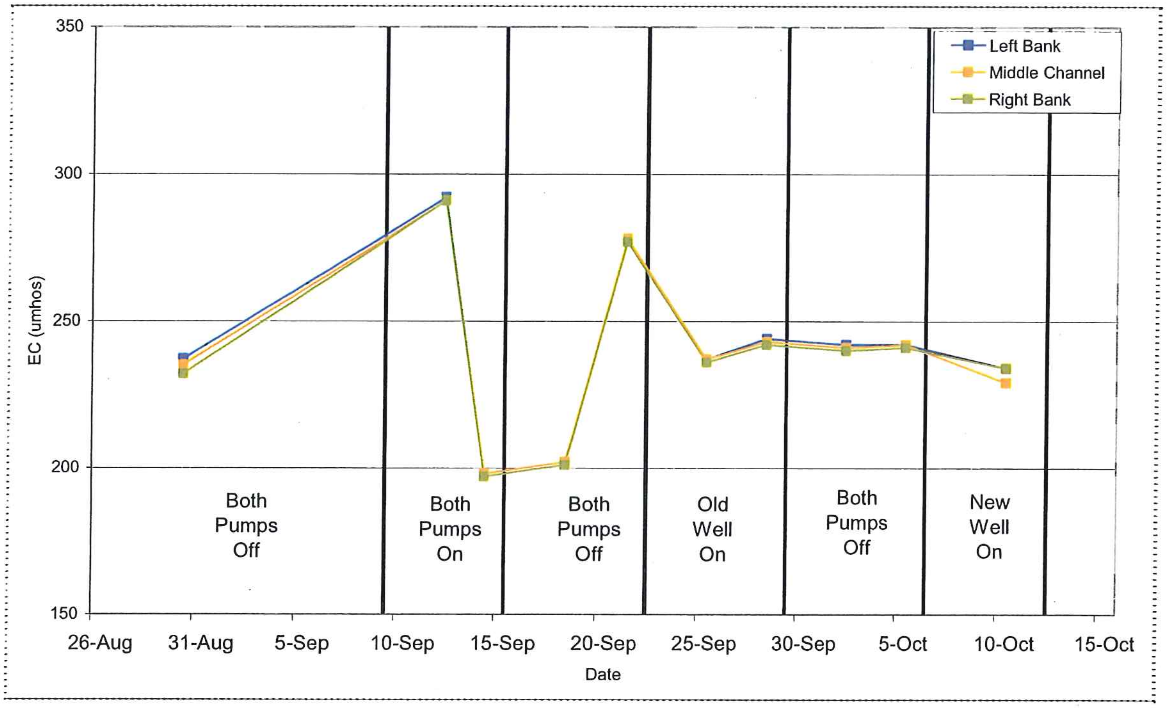

FIGURE 3-29. Transect 4 EC (uS/cm) from grab for habitat survey dates.

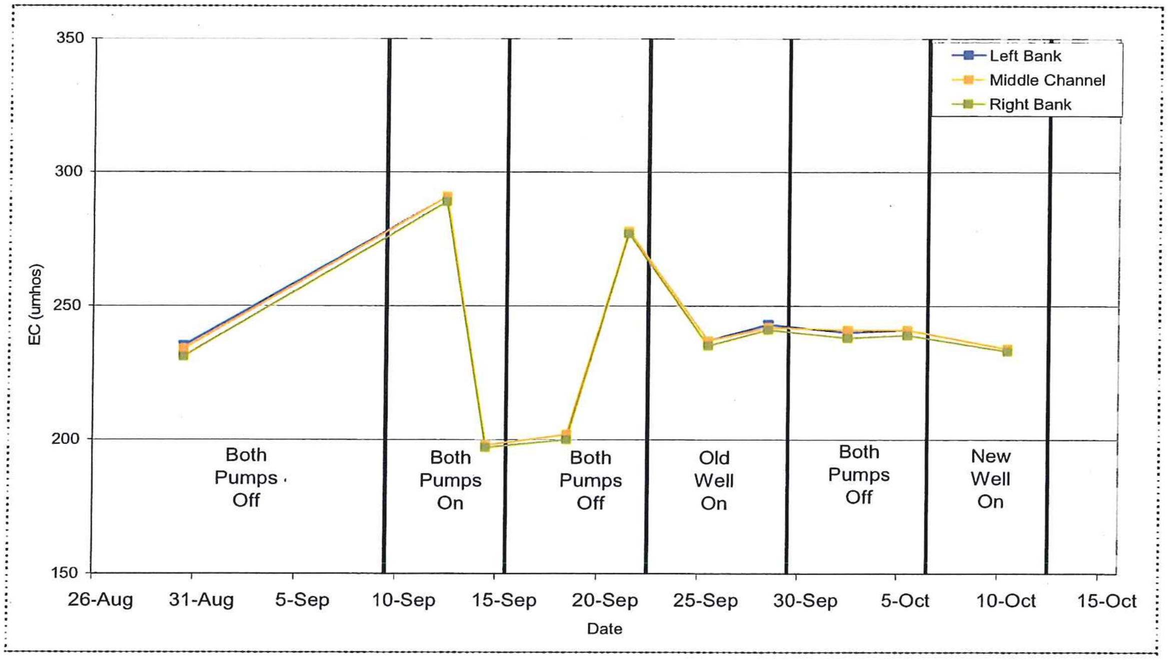

FIGURE 3-30. Transect 5 EC (uS/cm) from grab for habitat survey dates.

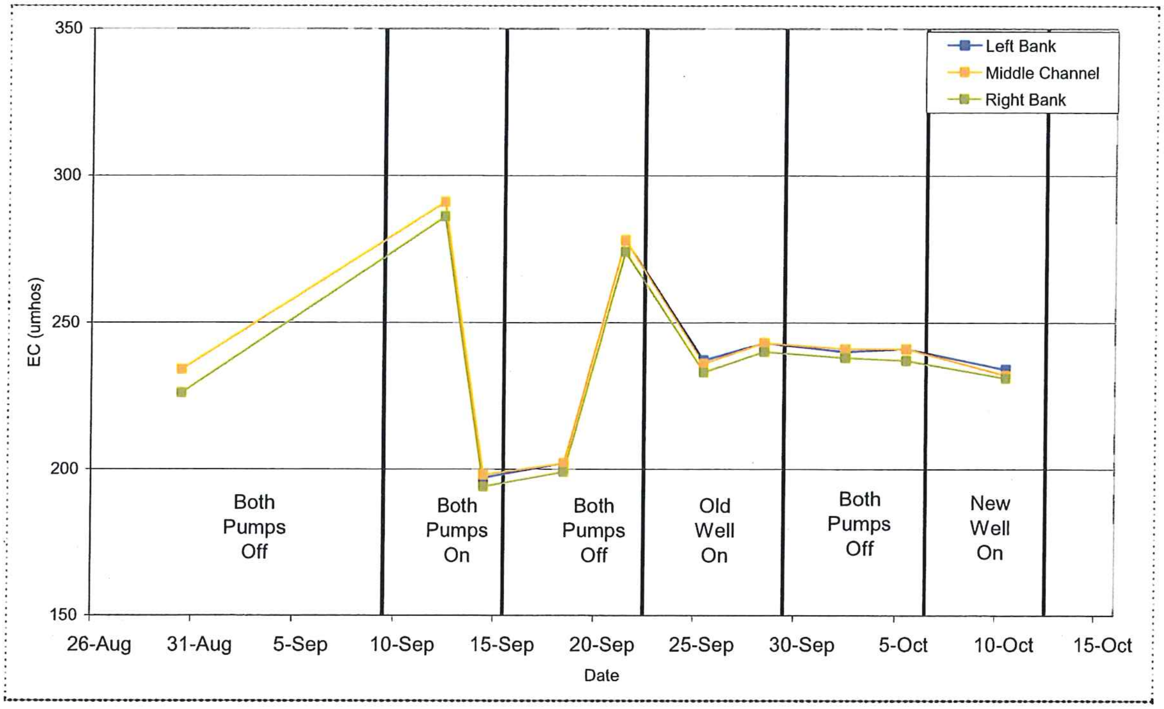

FIGURE 3-31. Transect 6 EC (uS/cm) from grab for habitat survey dates.

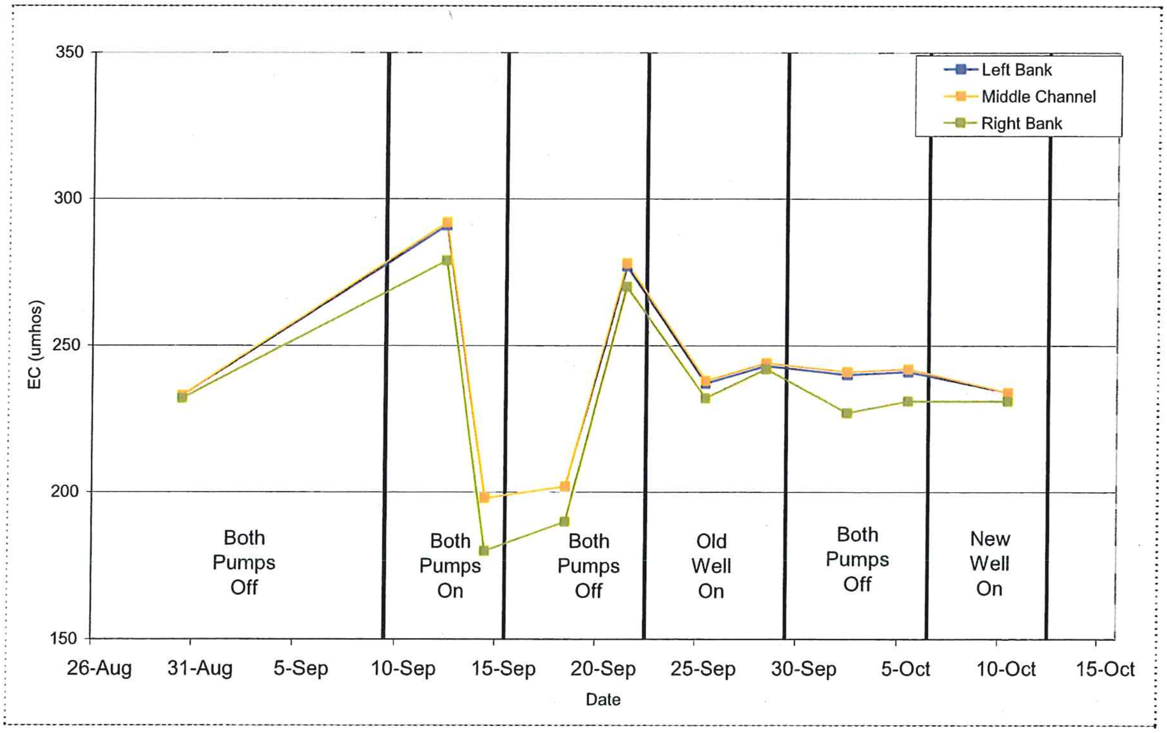

FIGURE 3-32. Transect 7 EC (uS/cm) from grab for habitat survey dates.

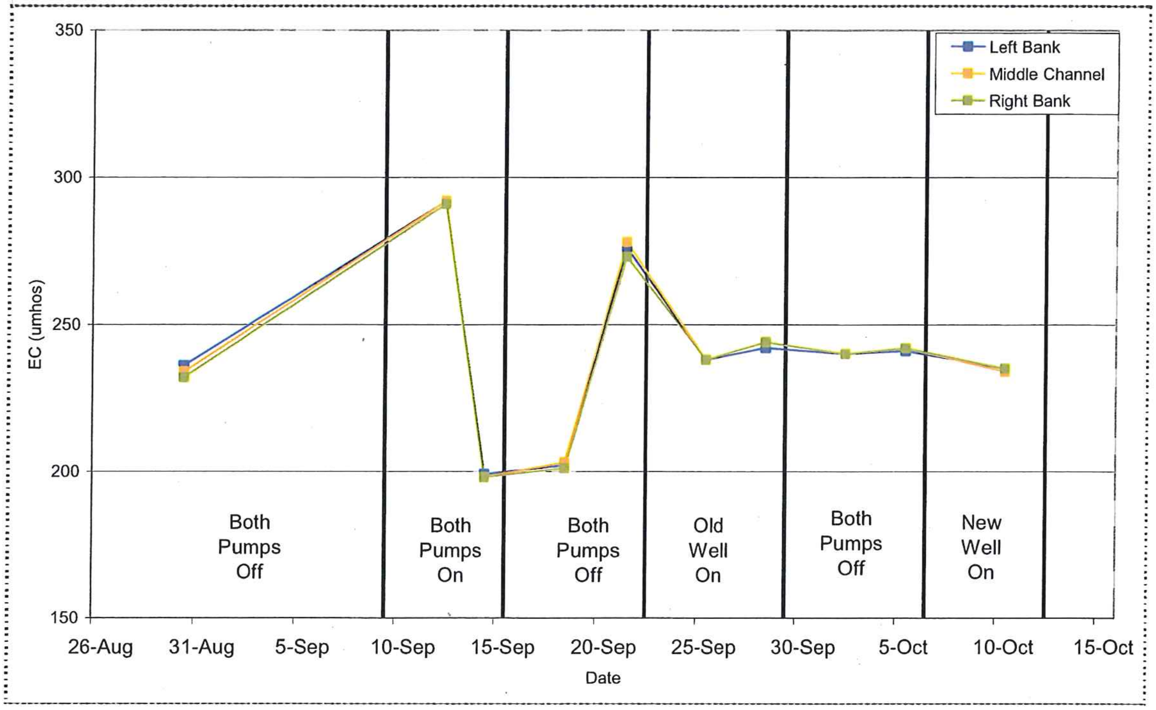

FIGURE 3-33. Transect 8 EC (uS/cm) from grab for habitat survey dates.

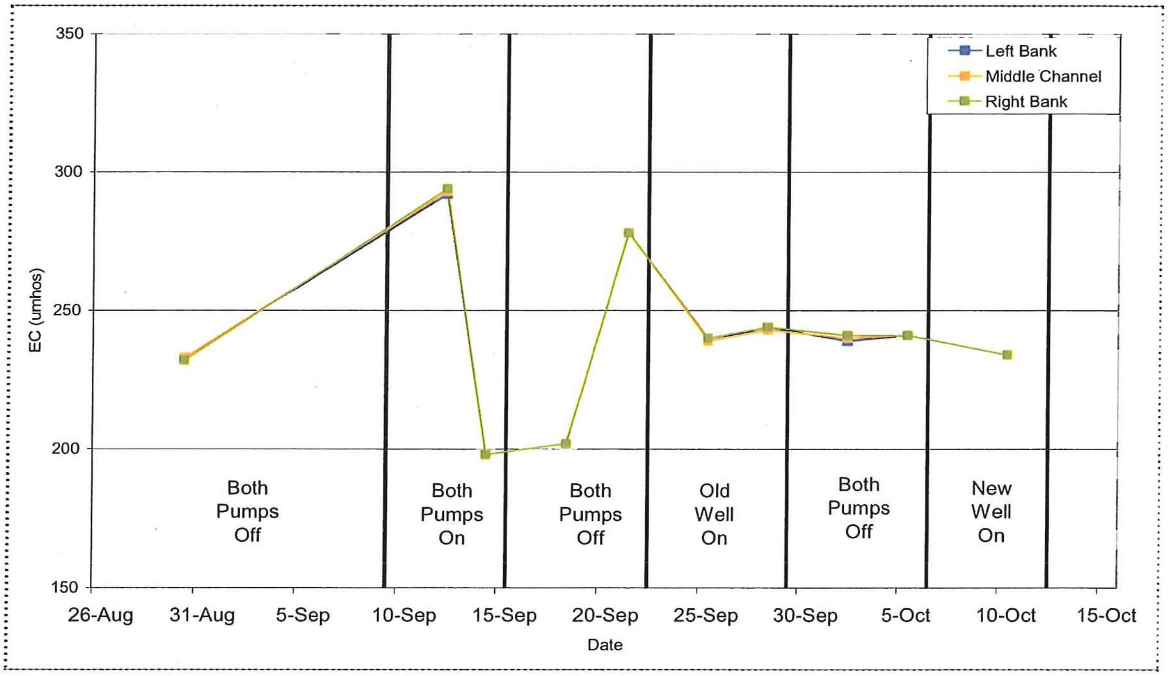

FIGURE 3-34. Transect 9 EC (uS/cm) from grab for habitat survey dates.

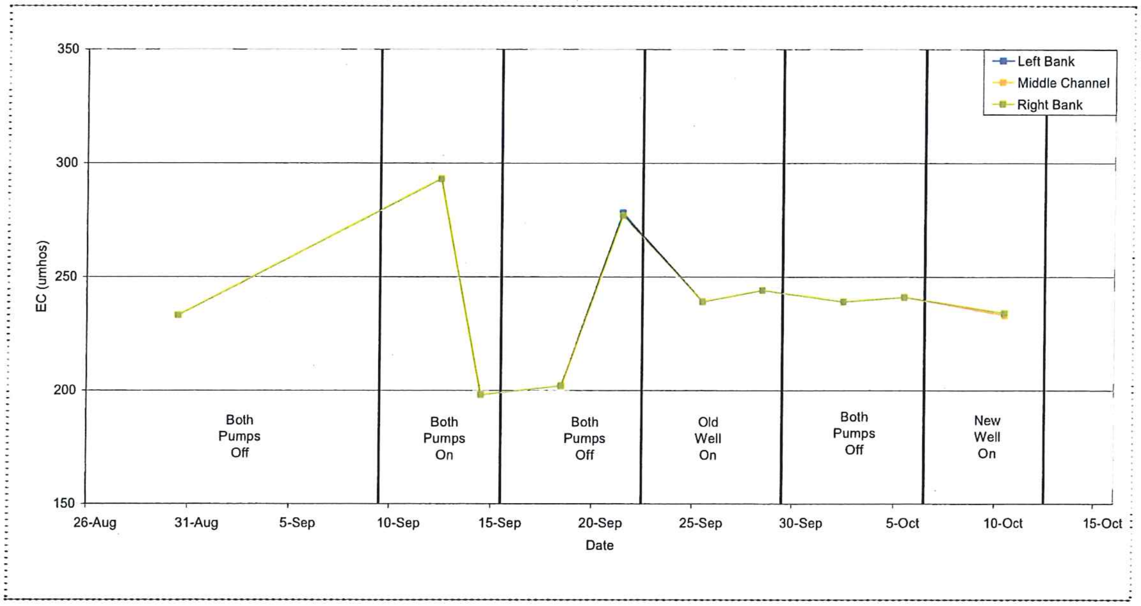

FIGURE 3-35. Transect 10 EC (uS/cm) from grab for habitat survey dates.

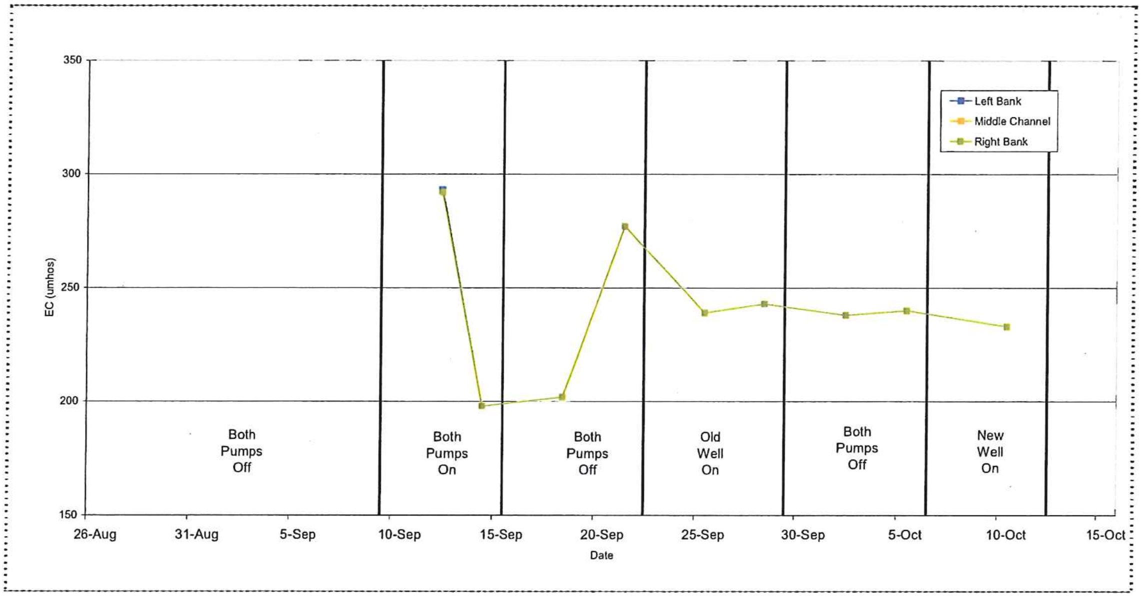

FIGURE 3-36. Transect 11 EC (uS/cm) from grab for habitat survey dates.

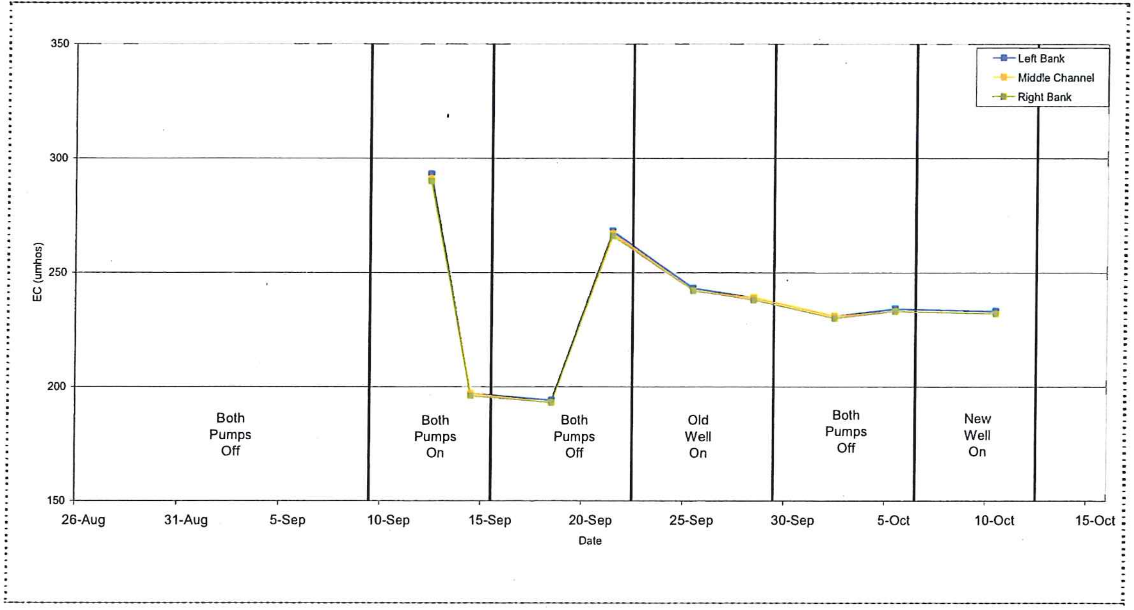

FIGURE 3-37. Transect VT-1 EC (uS/cm) from grab for habitat survey dates.

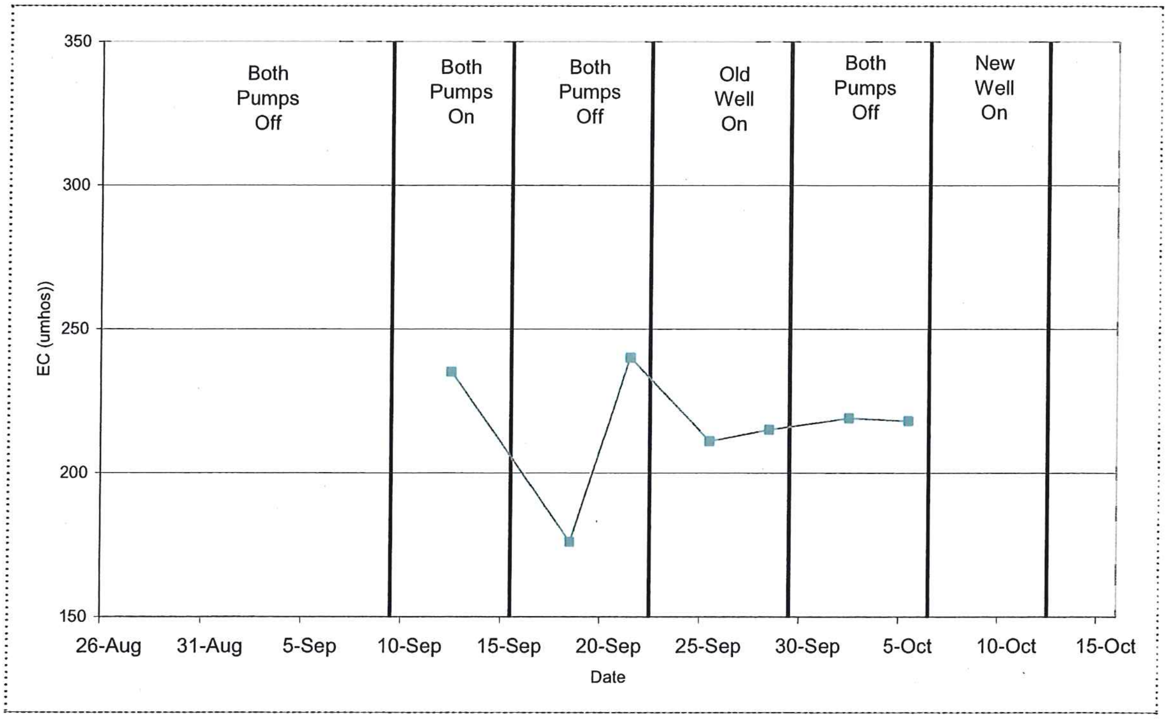

FIGURE 3-38. Spring at Transect 6 EC (uS/cm) from grab for habitat survey dates.

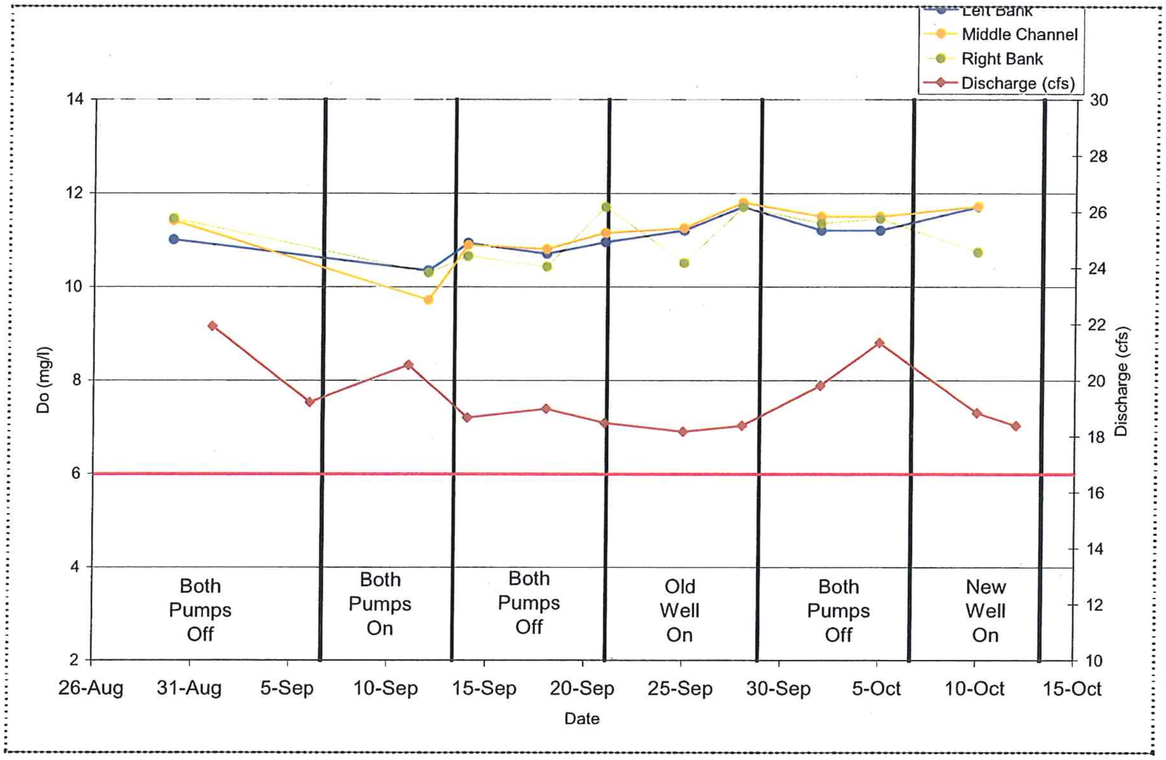

FIGURE 3-39. Transect 1 dissolved oxygen (mg/l) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

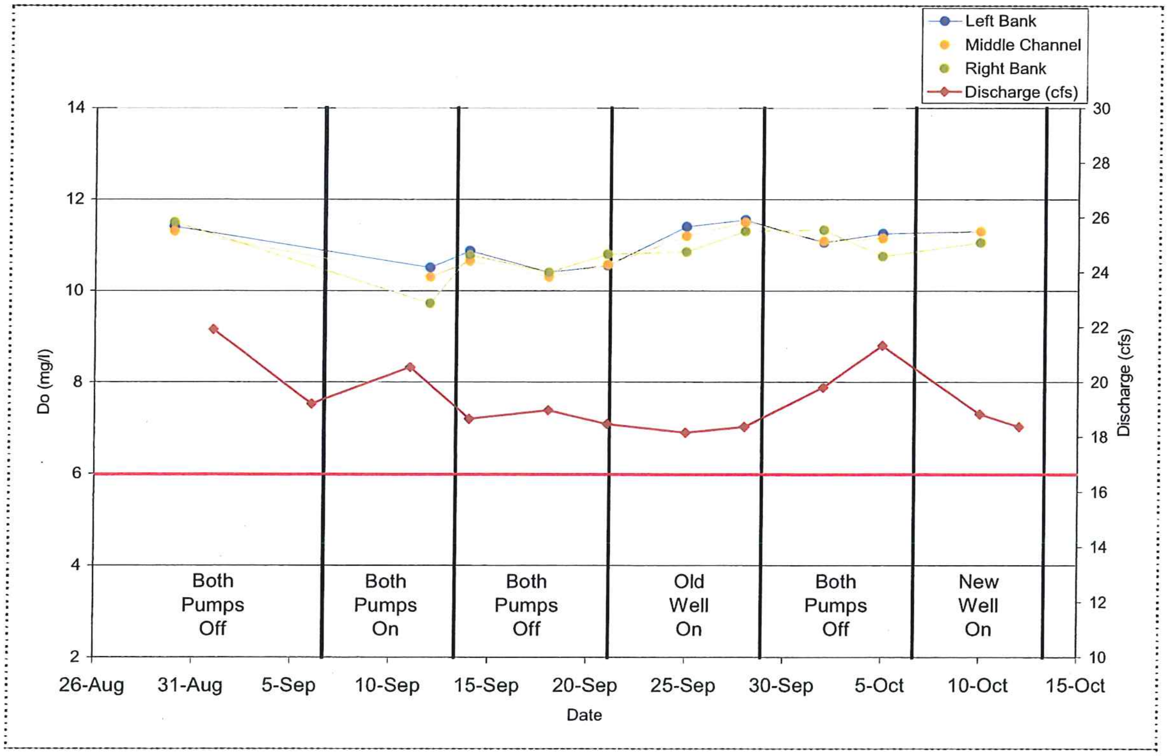

FIGURE 3-40. Transect 2 dissolved oxygen (mg/l) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

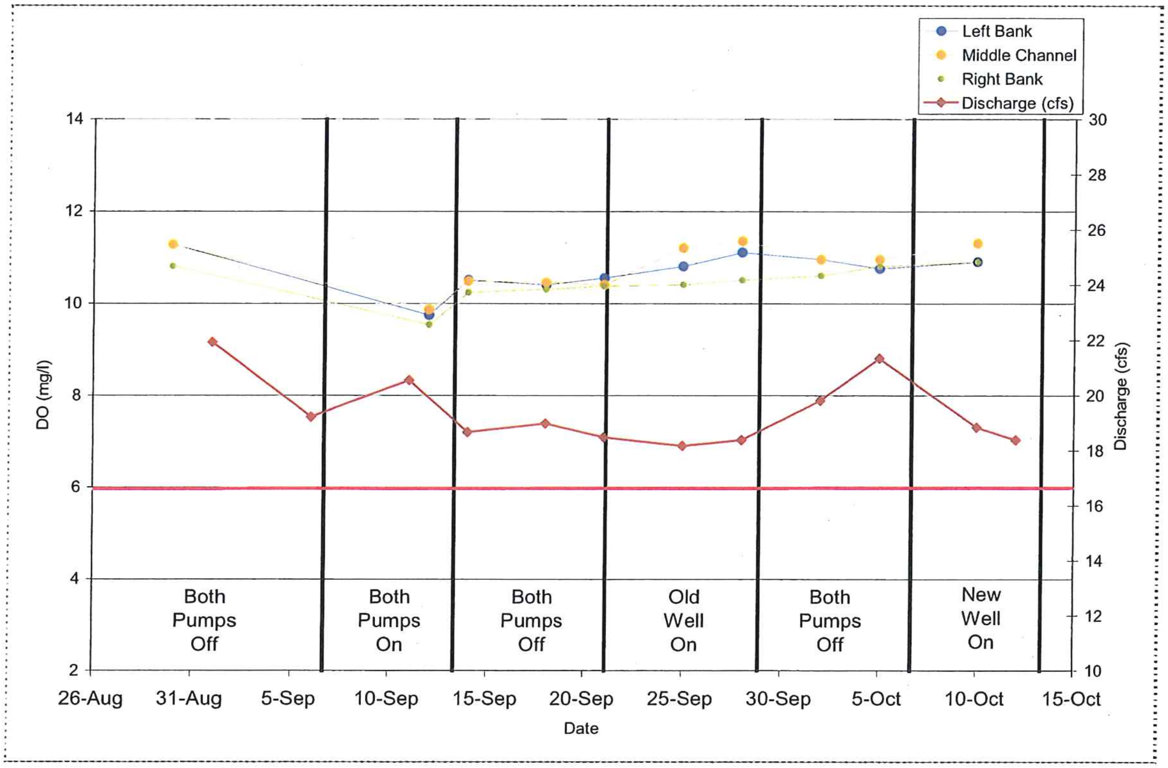

FIGURE 3-41. Transect 3 dissolved oxygen (mg/l) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

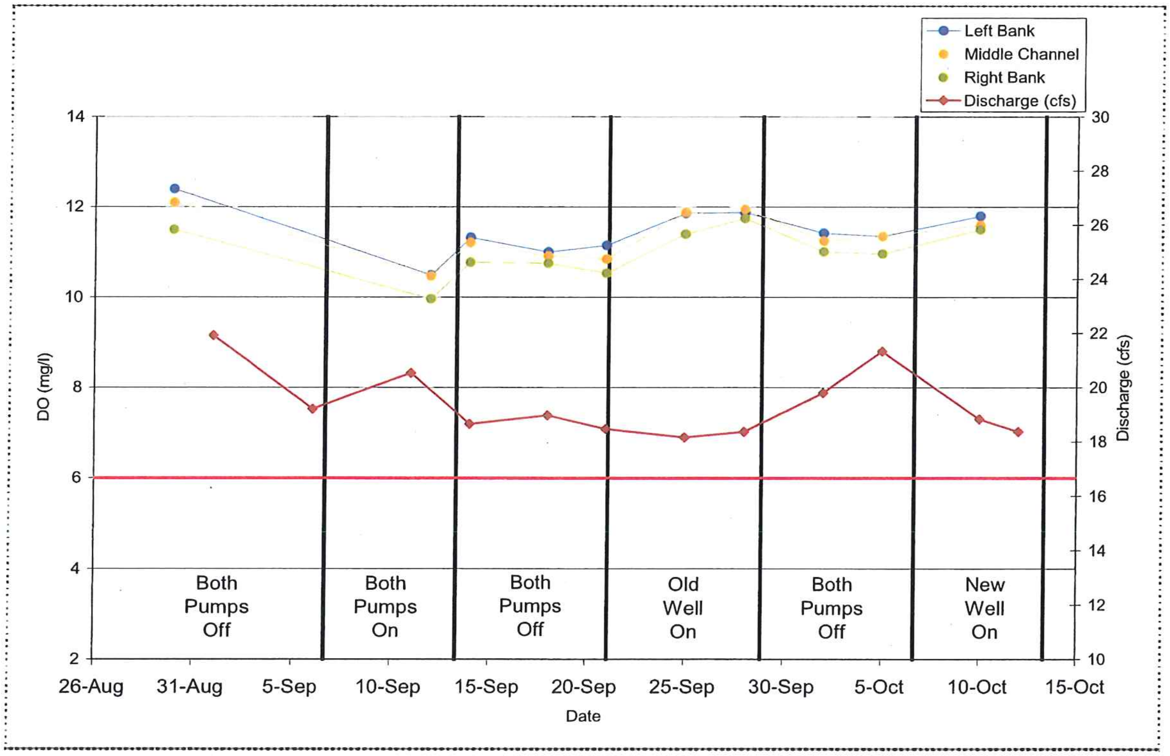

FIGURE 3-42. Transect 4 dissolved oxygen (mg/l) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

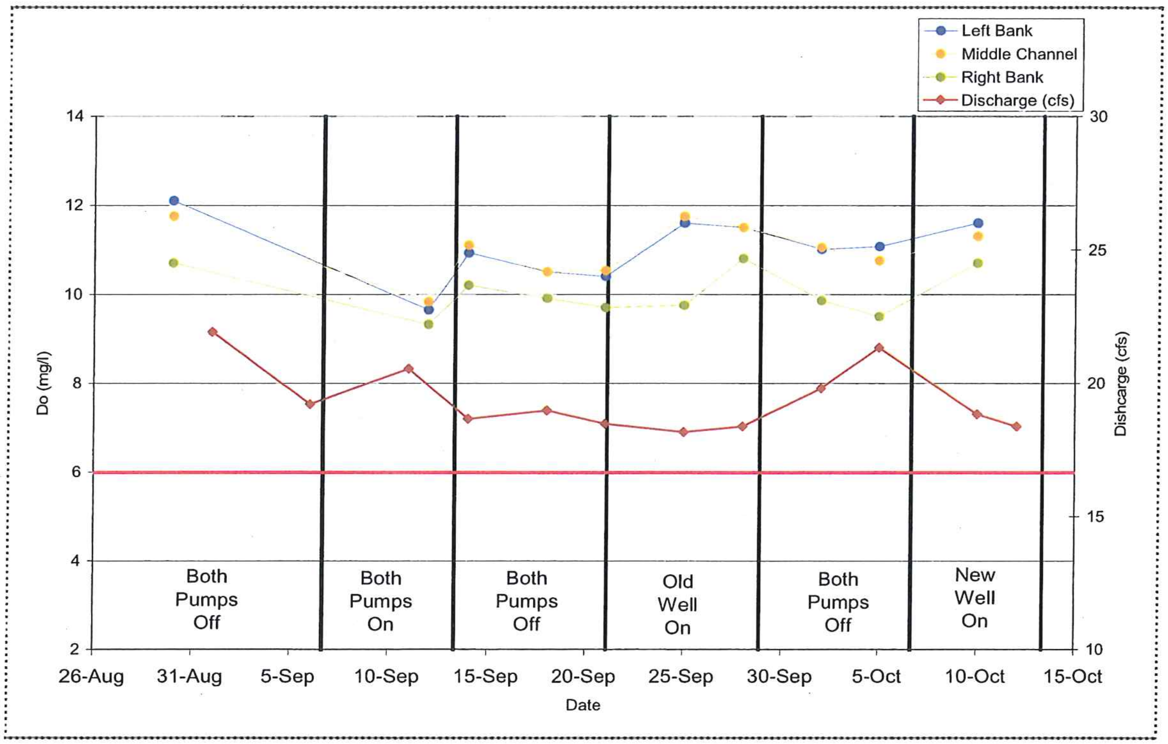

FIGURE 3-43. Transect 5 dissolved oxygen (mg/l) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

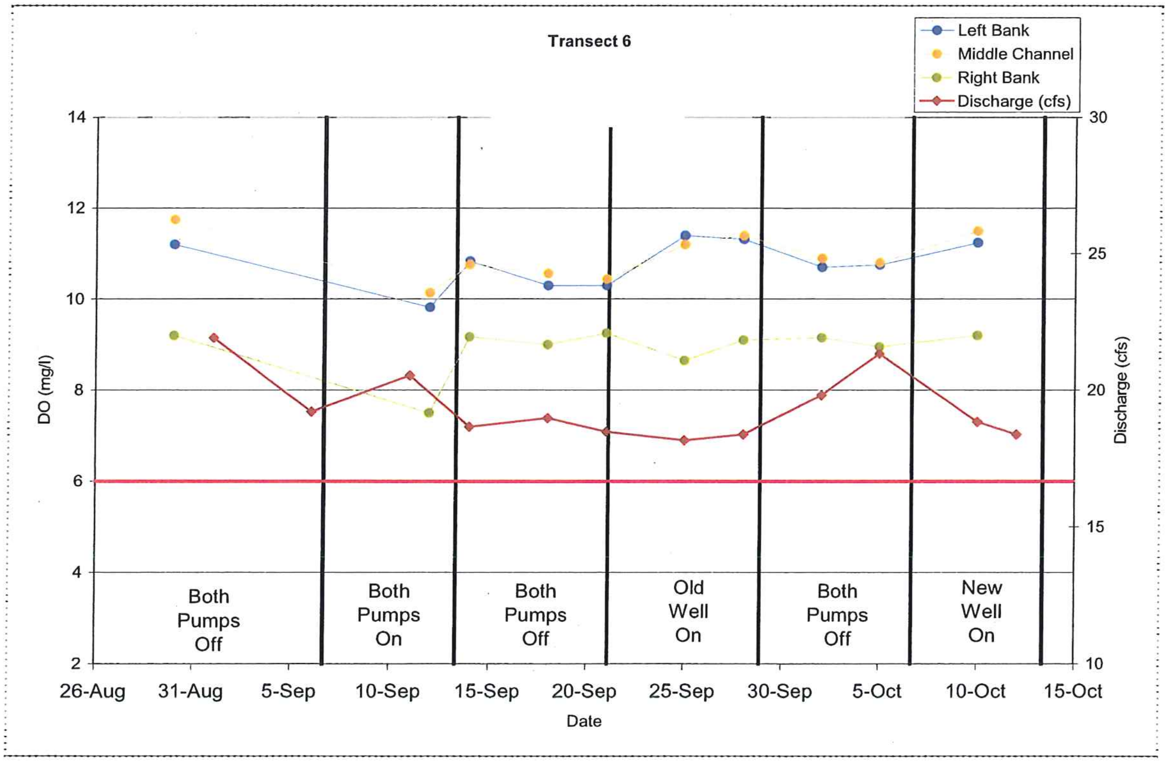

FIGURE 3-44. Transect 6 dissolved oxygen (mg/l) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

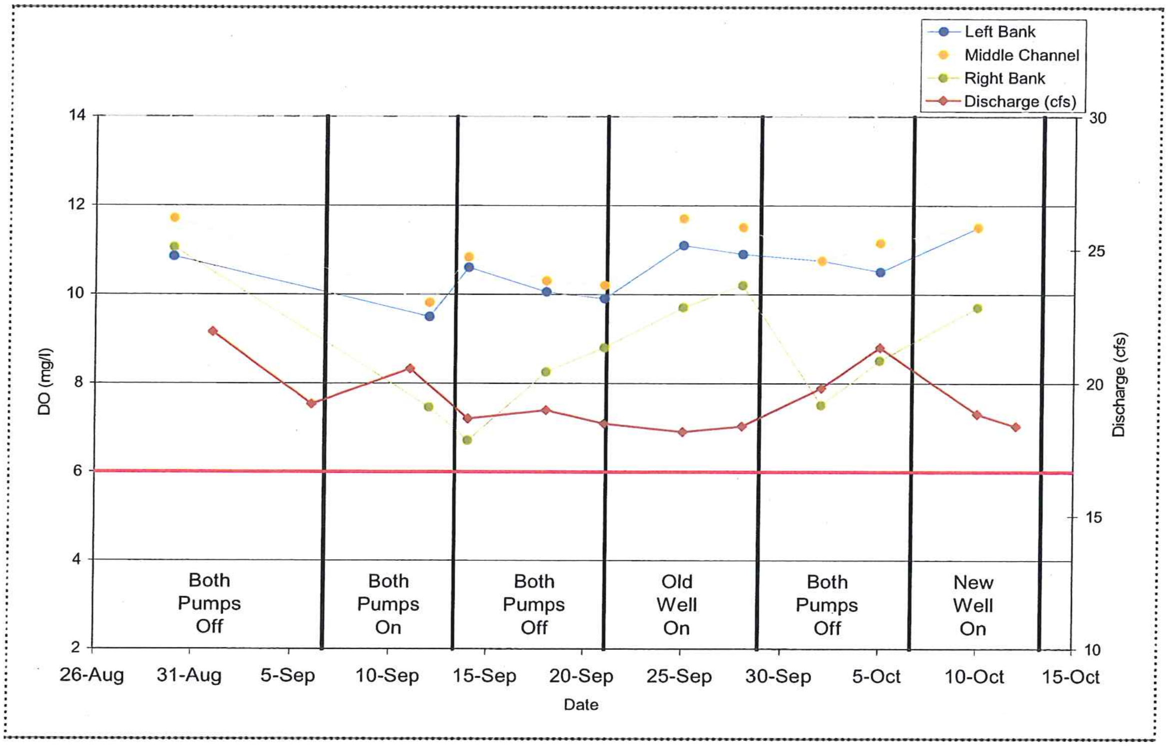

FIGURE 3-45. Transect 7 dissolved oxygen (mg/l) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

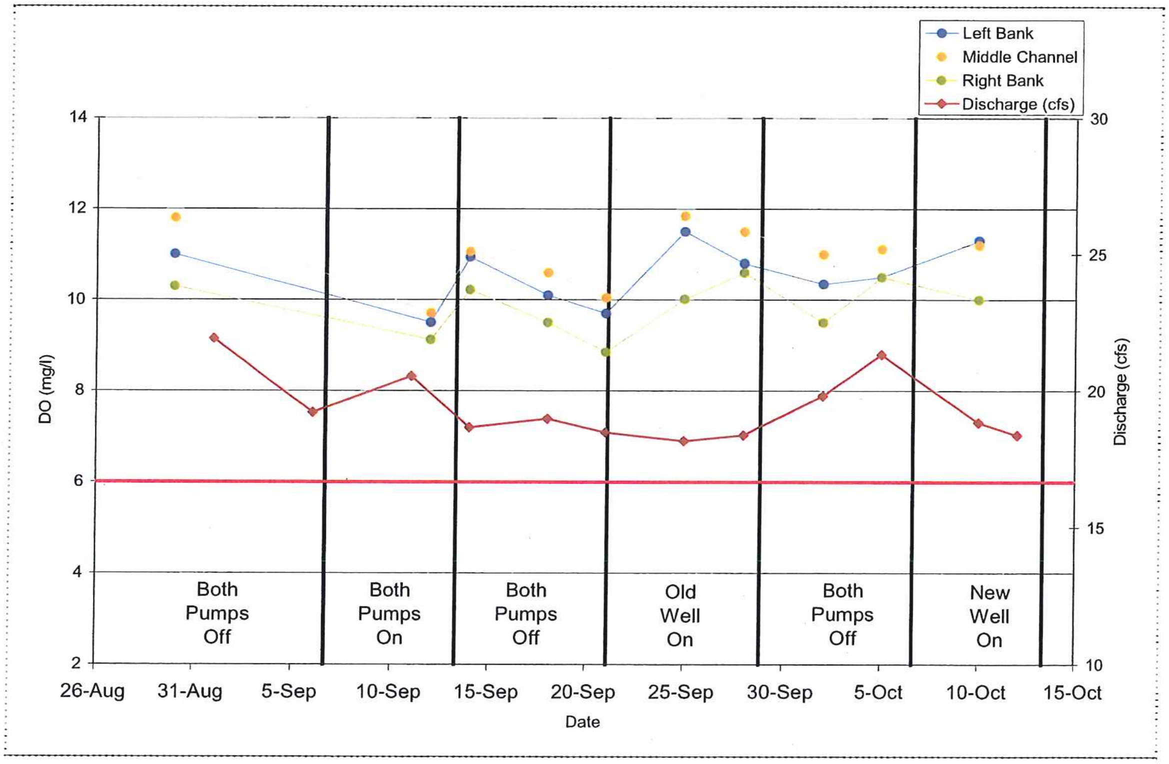

FIGURE 3-46. Transect 8 dissolved oxygen (mg/l) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

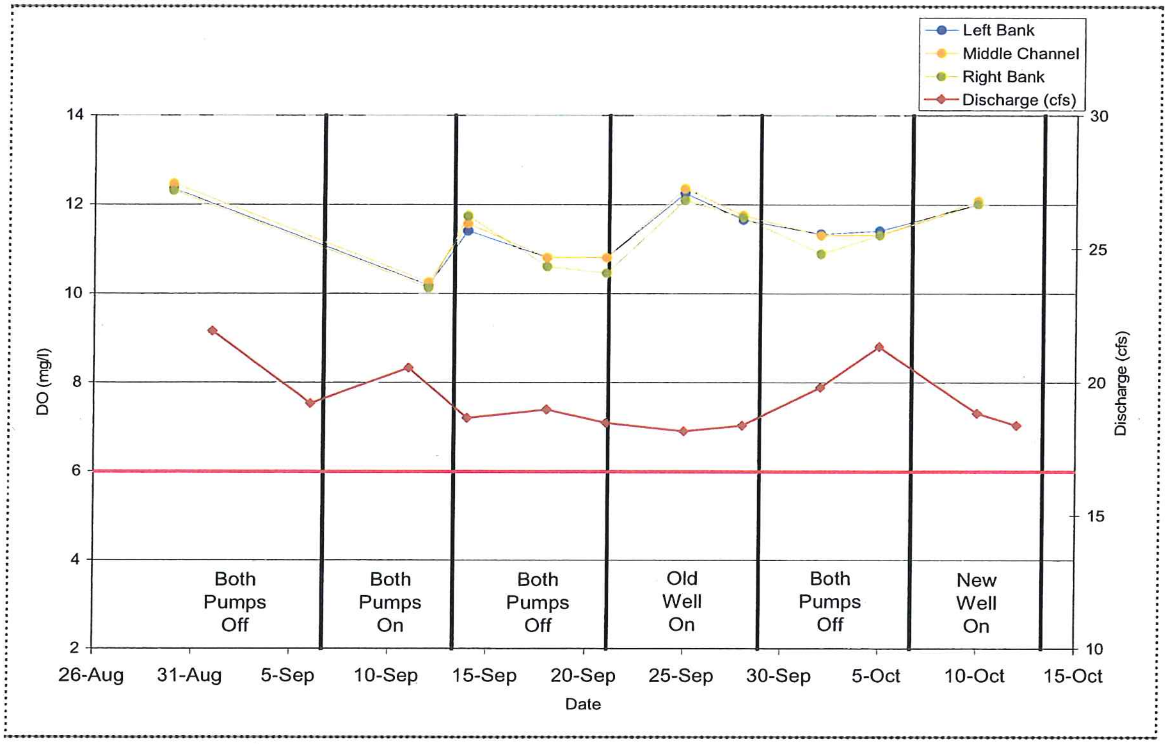

FIGURE 3-47. Transect 9 dissolved oxygen (mg/l) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

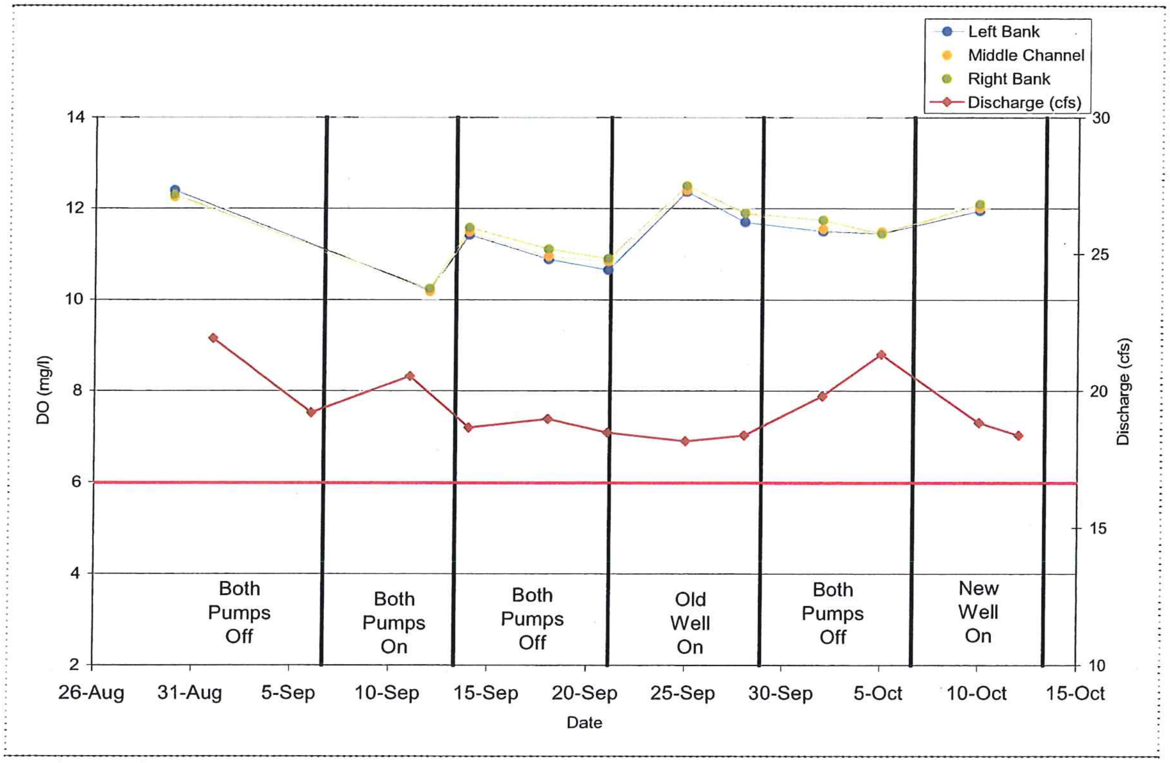

FIGURE 3-48. Transect 10 dissolved oxygen (mg/l) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

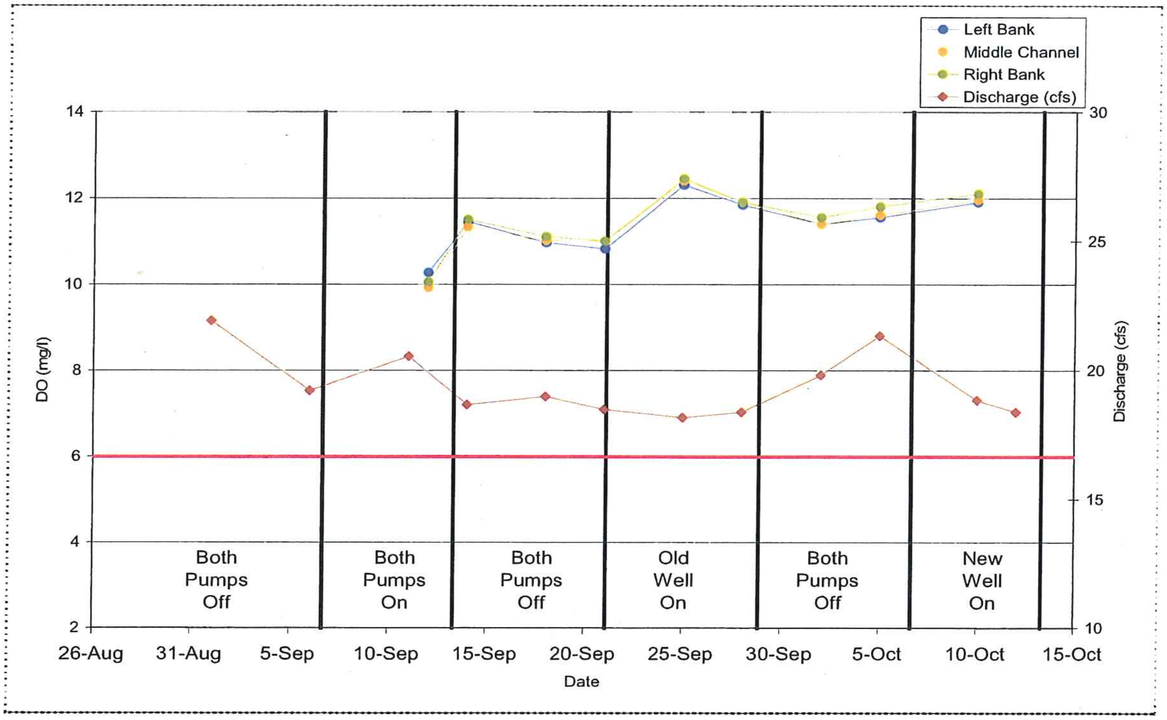

FIGURE 3-49. Transect 11 dissolved oxygen (mg/l) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

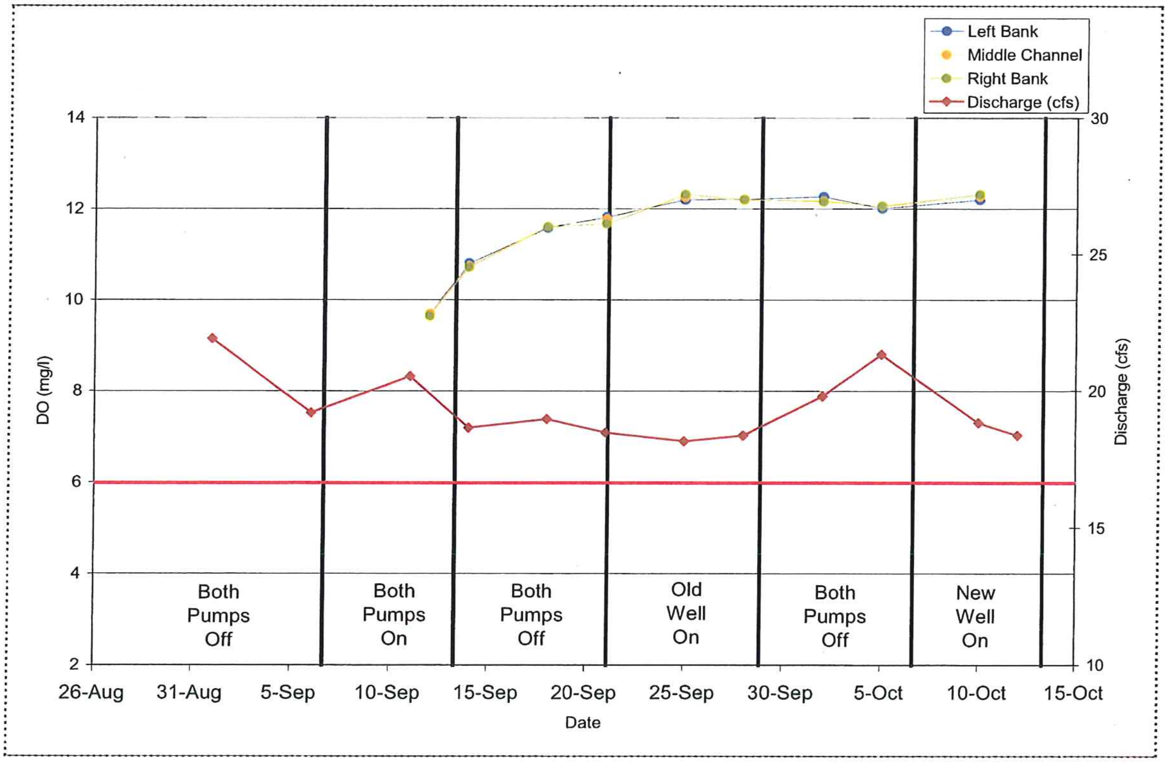

FIGURE 3-50. Transect VT-1 dissolved oxygen (mg/l) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

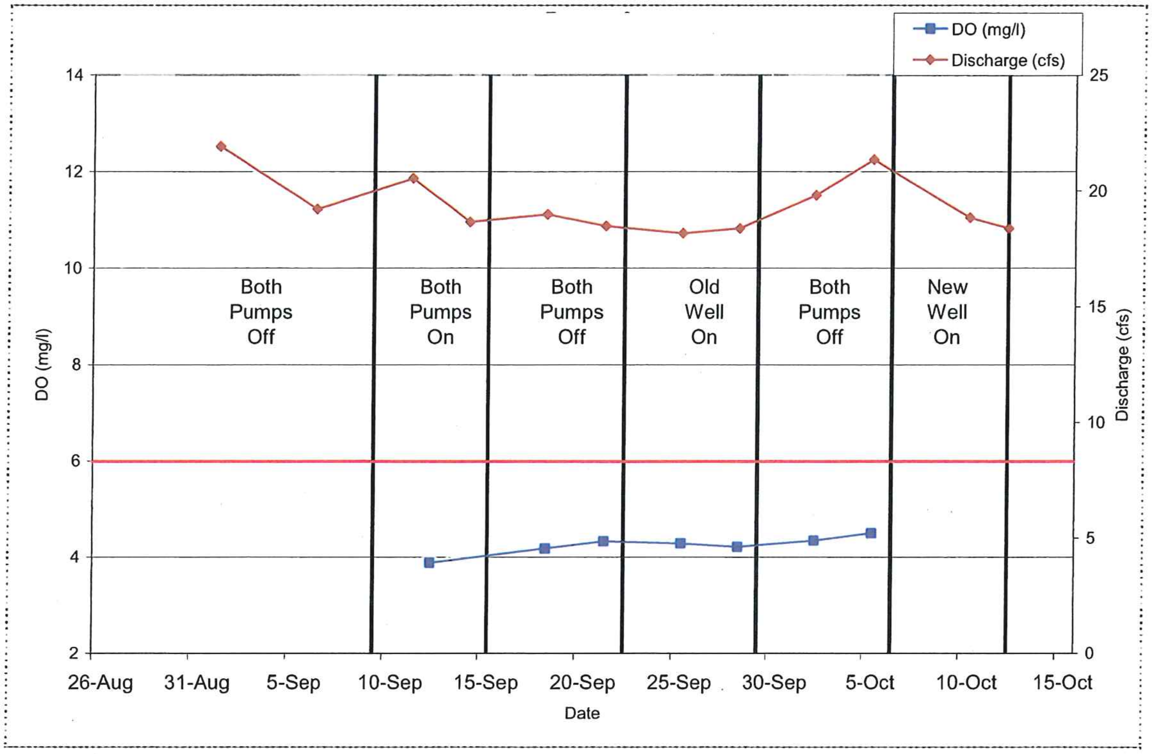

FIGURE 3-51. Spring at Transect 6 dissolved oxygen (mg/l) from grab samples and VT-1 discharge (cfs) for habitat survey dates.

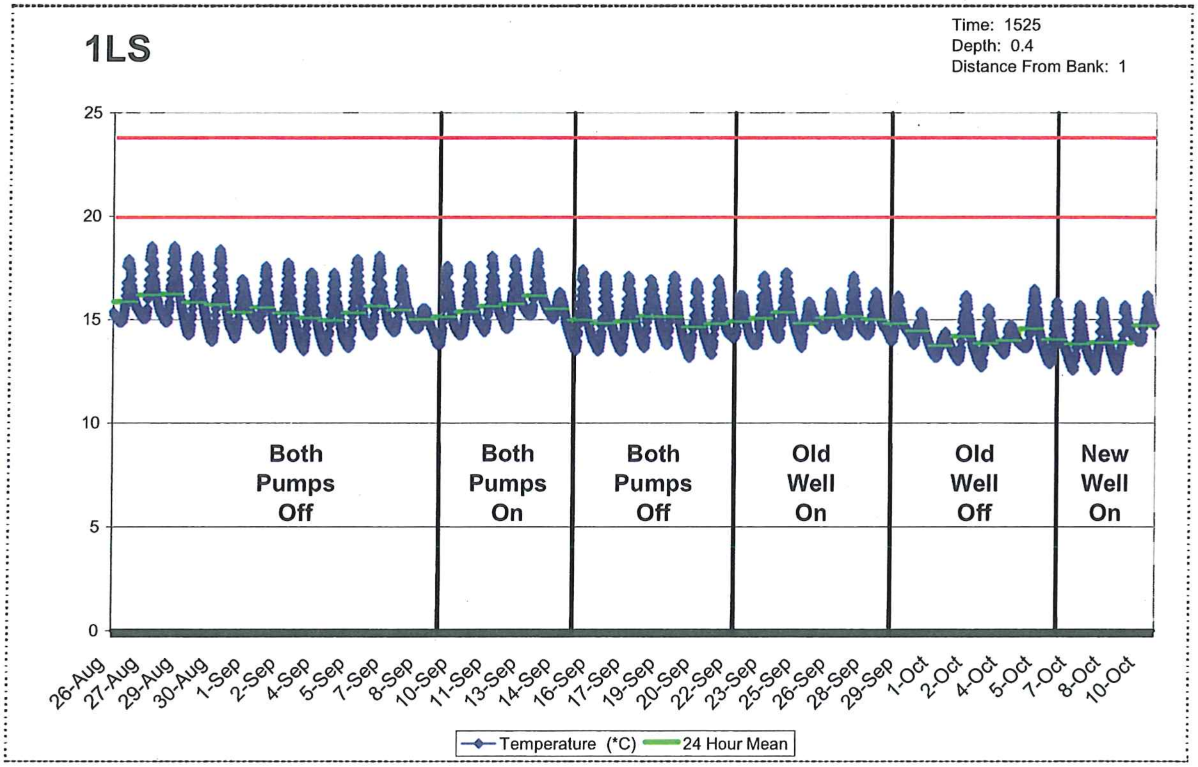

FIGURE 3-52. 24 minute and daily average mean temperature recorded at Transect 1, left bank, surface.

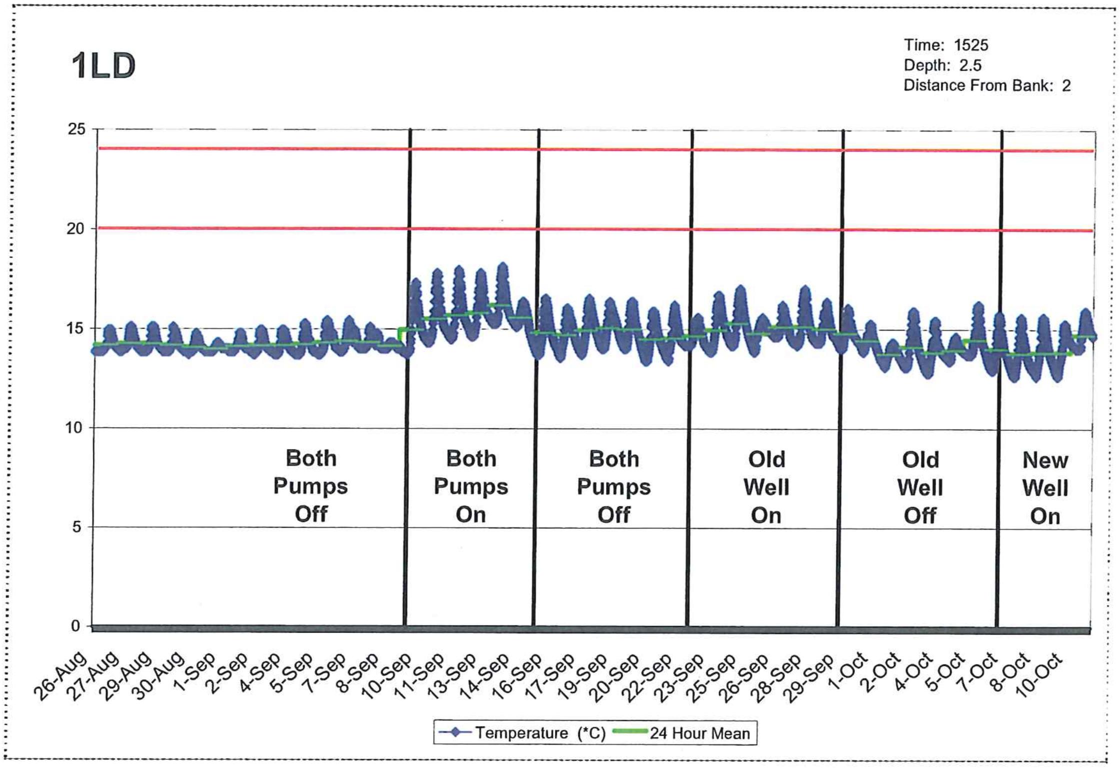

FIGURE 3-53. 24 minute and daily average mean temperature recorded at Transect 1, left bank, deep.

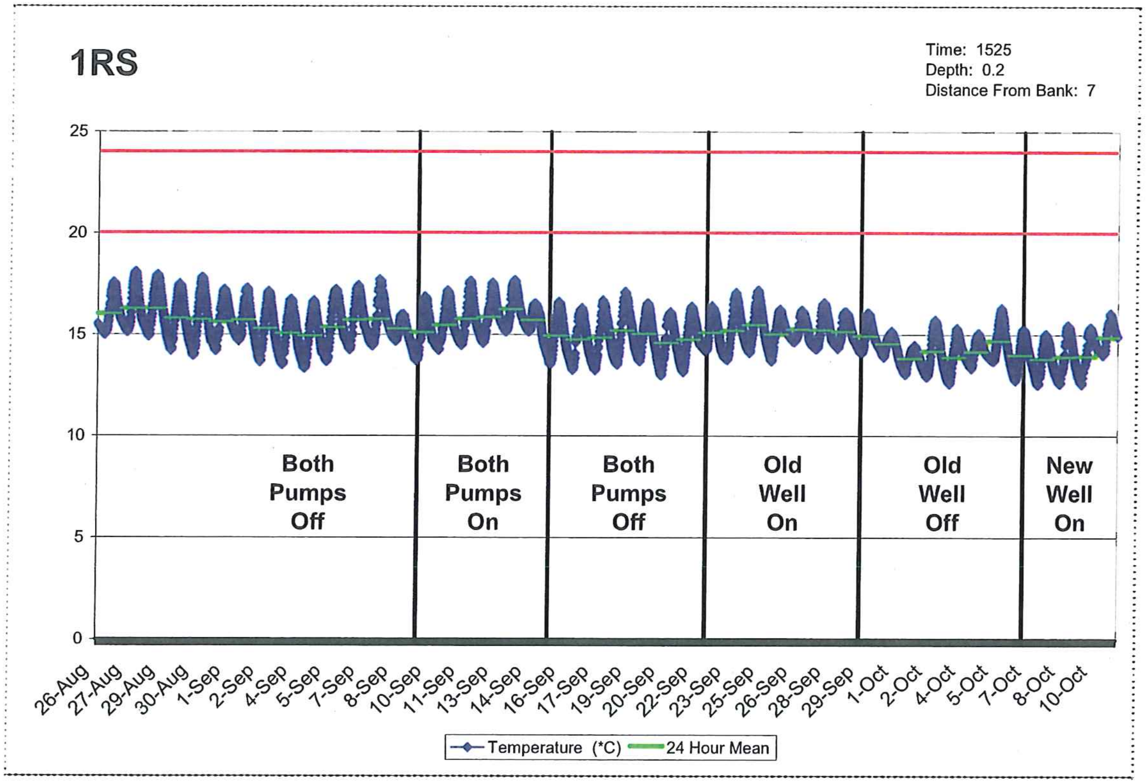

FIGURE 3-54. 24 minute and daily average mean temperature recorded at Transect 1, right bank, surface.

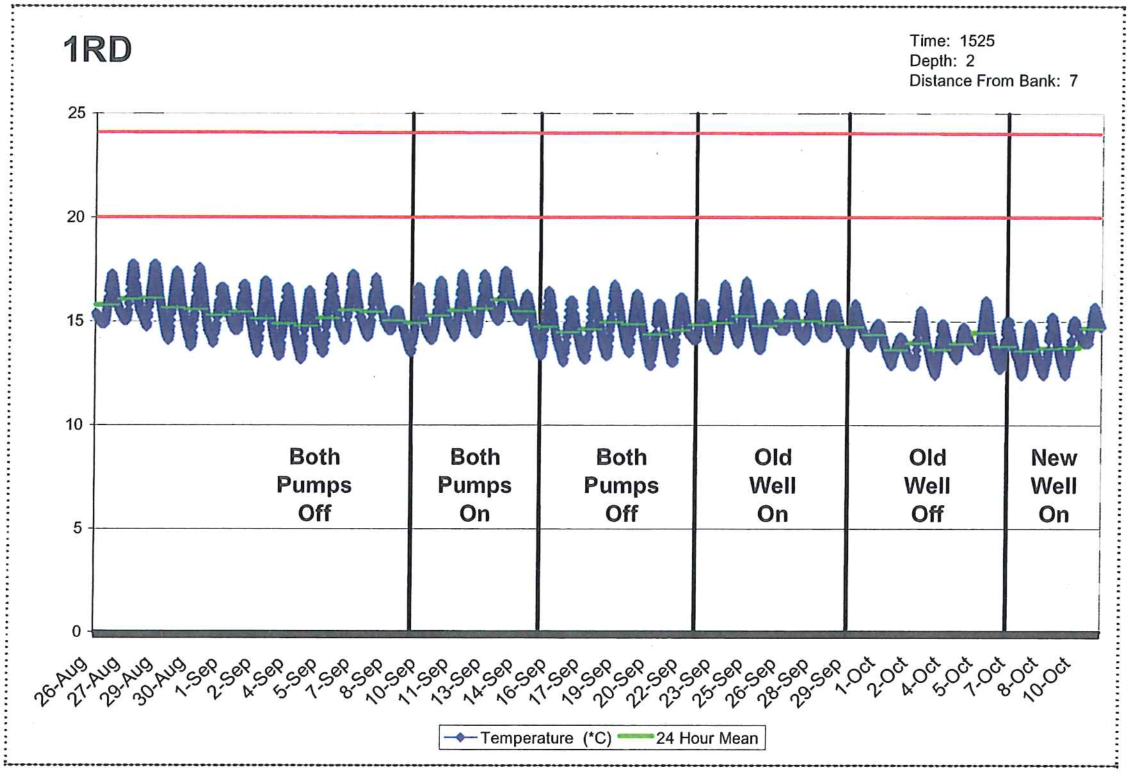

FIGURE 3-55. 24 minute and daily average mean temperature recorded at Transect 1, right bank, deep.

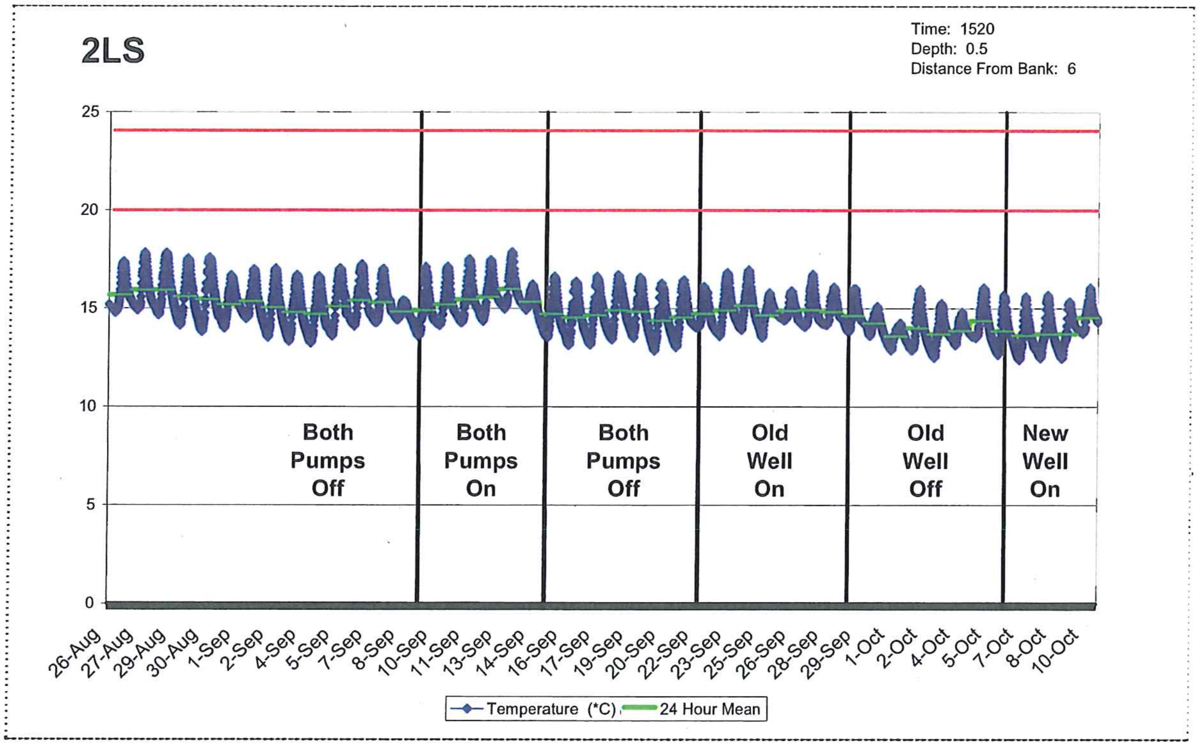

FIGURE 3-56. 24 minute and daily average mean temperature recorded at Transect 2, left bank, surface.

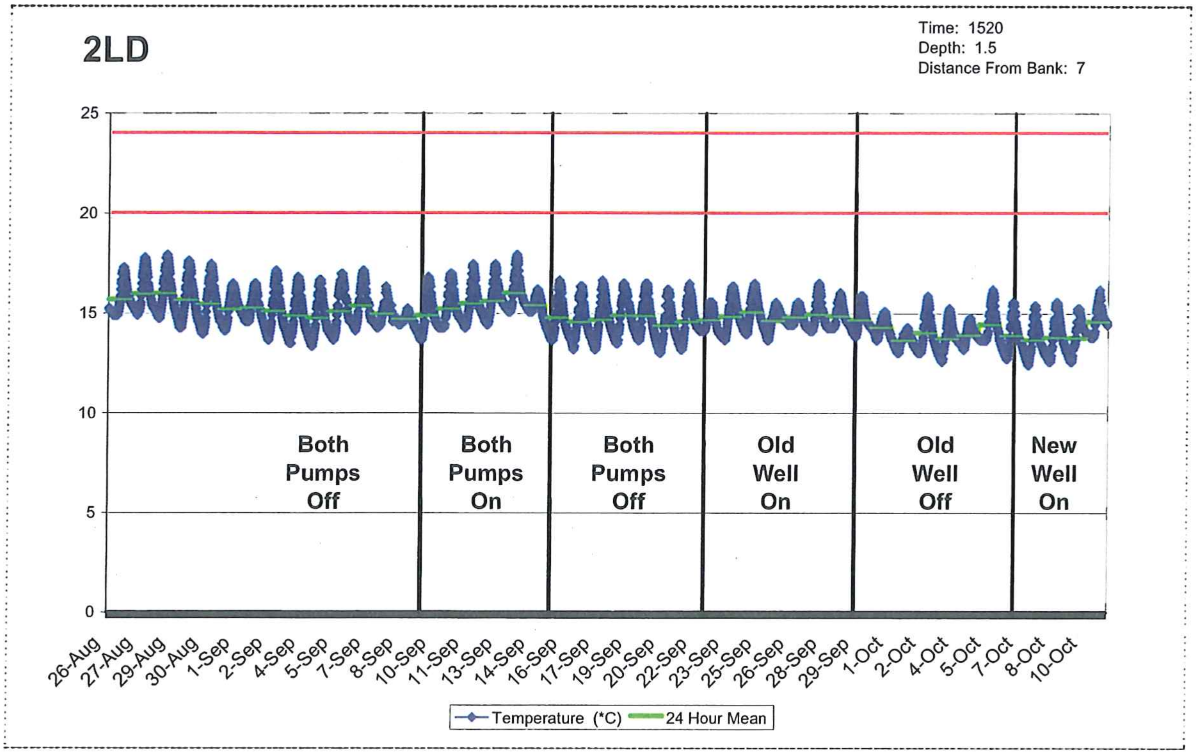

FIGURE 3-57. 24 minute and daily average mean temperature recorded at Transect 2, left bank, deep.

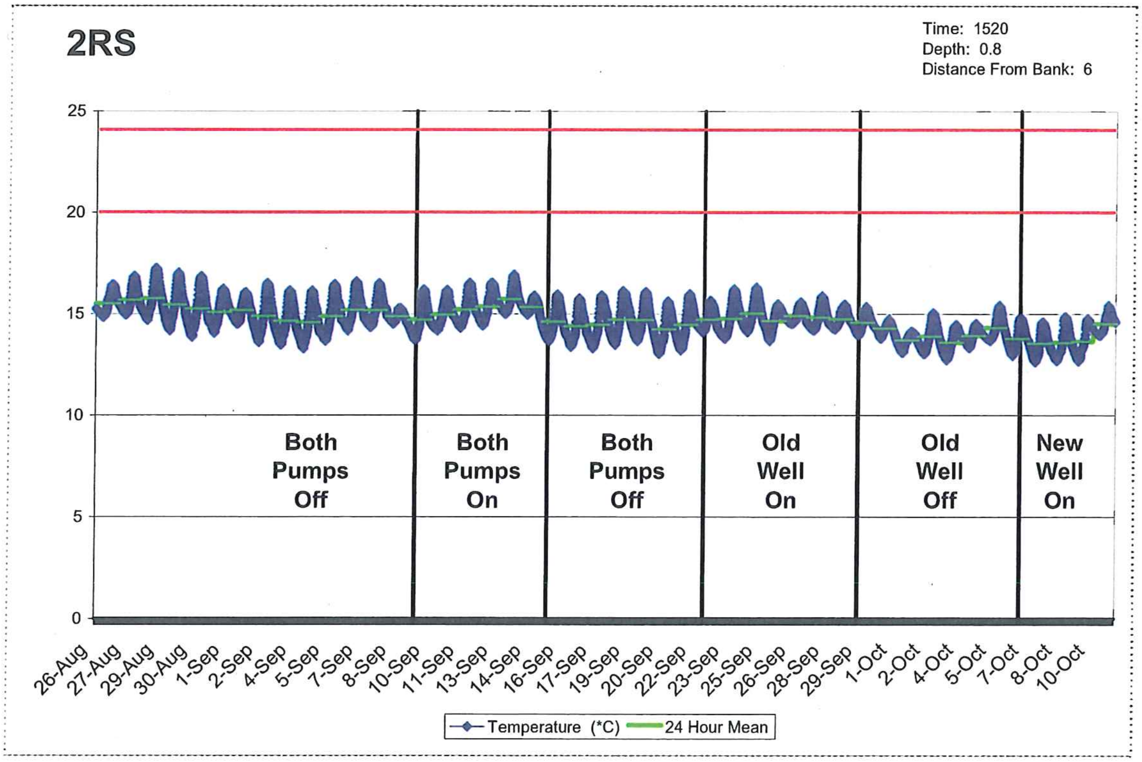

FIGURE 3-58. 24 minute and daily average mean temperature recorded at Transect 2, right bank, surface.

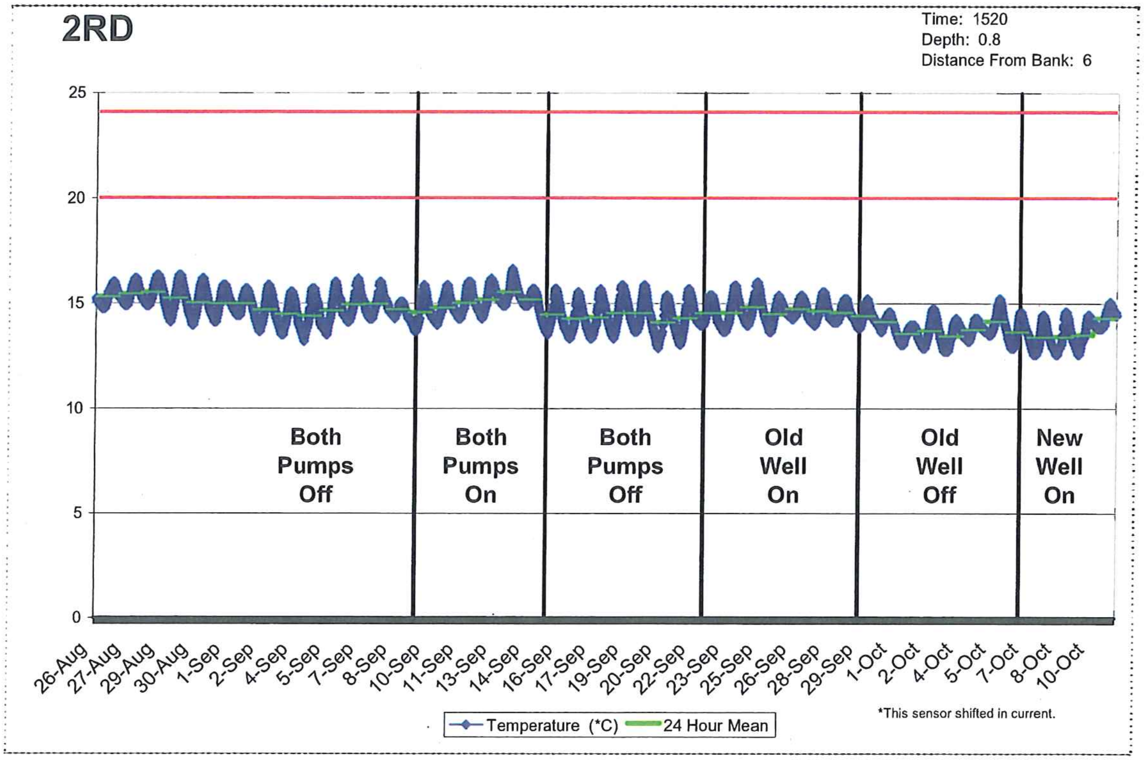

FIGURE 3-59. 24 minute and daily average mean temperature recorded at Transect 2, right bank, deep.

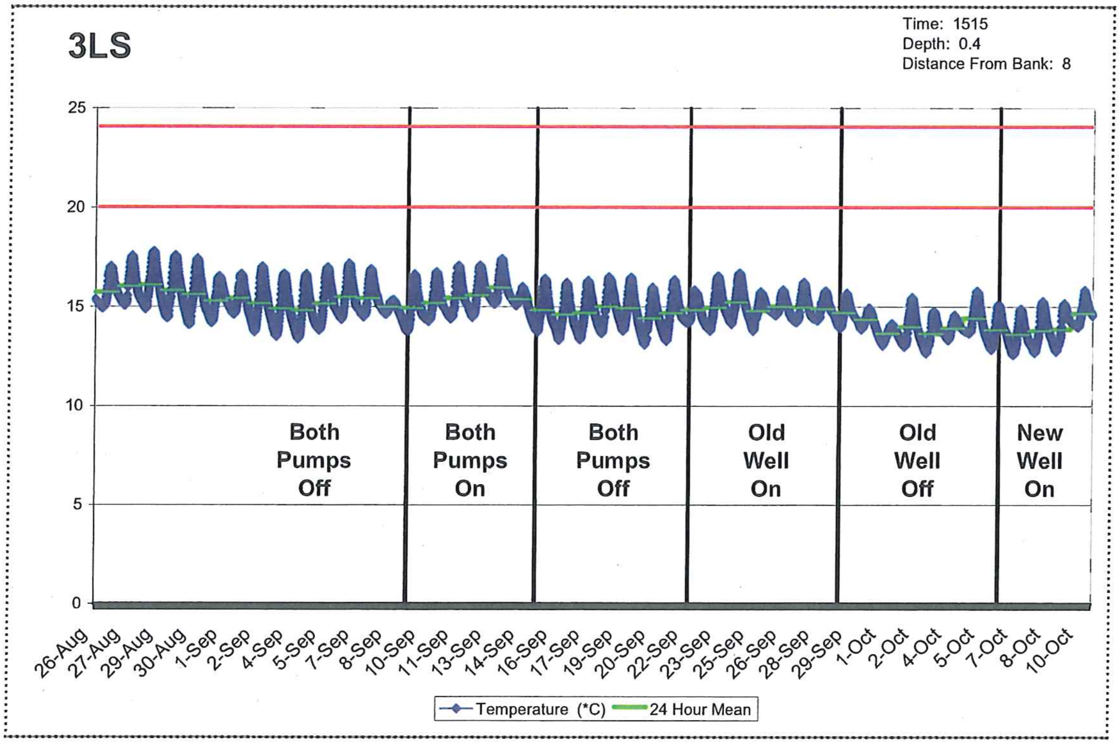

FIGURE 3-60. 24 minute and daily average mean temperature recorded at Transect 3, left bank, surface.

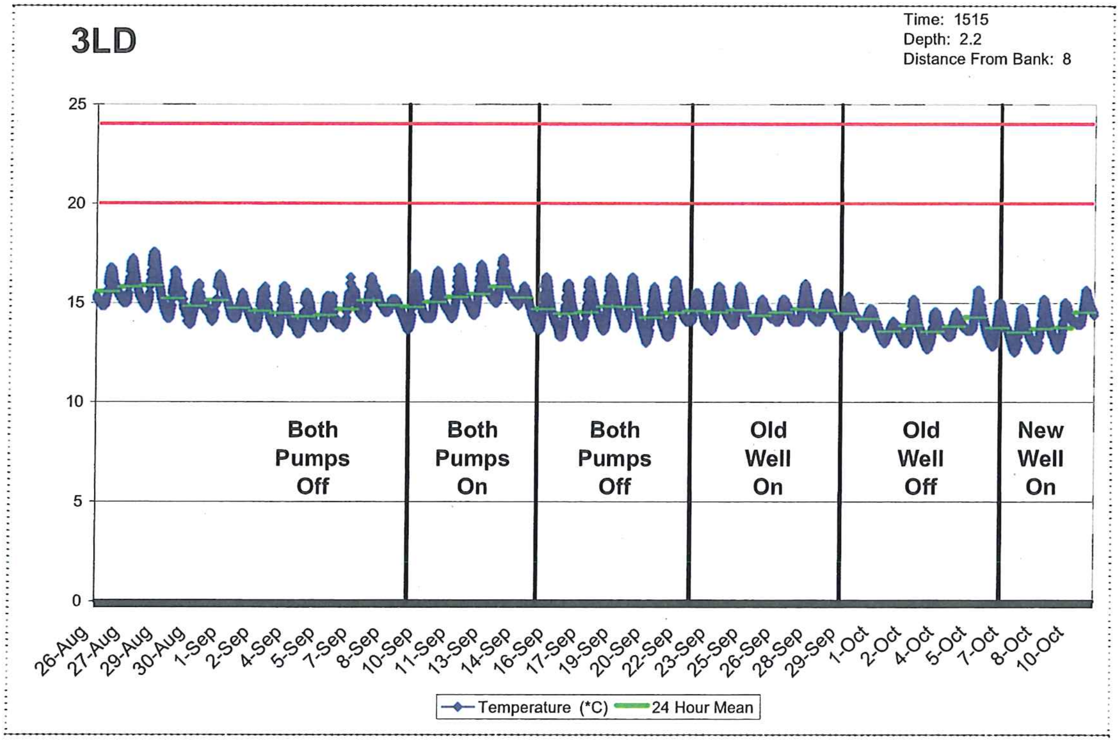

FIGURE 3-61. 24 minute and daily average mean temperature recorded at Transect 3, left bank, deep.

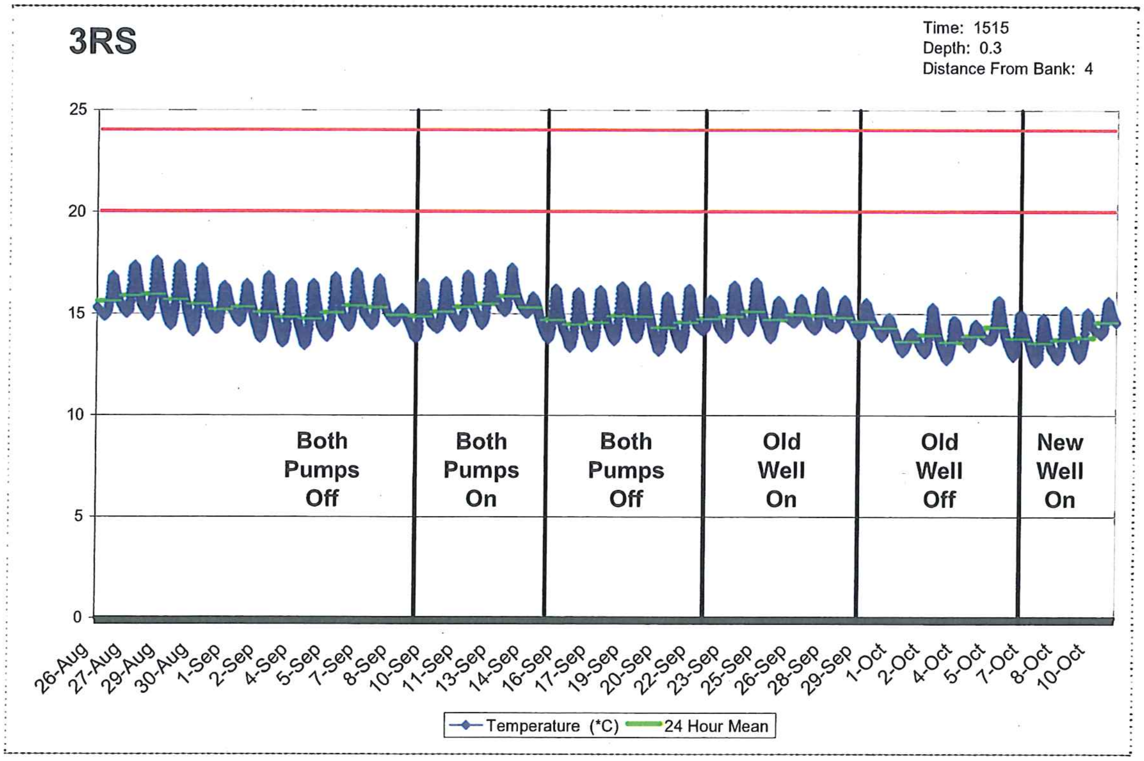

FIGURE 3-62. 24 minute and daily average mean temperature recorded at Transect 3, right bank, surface.

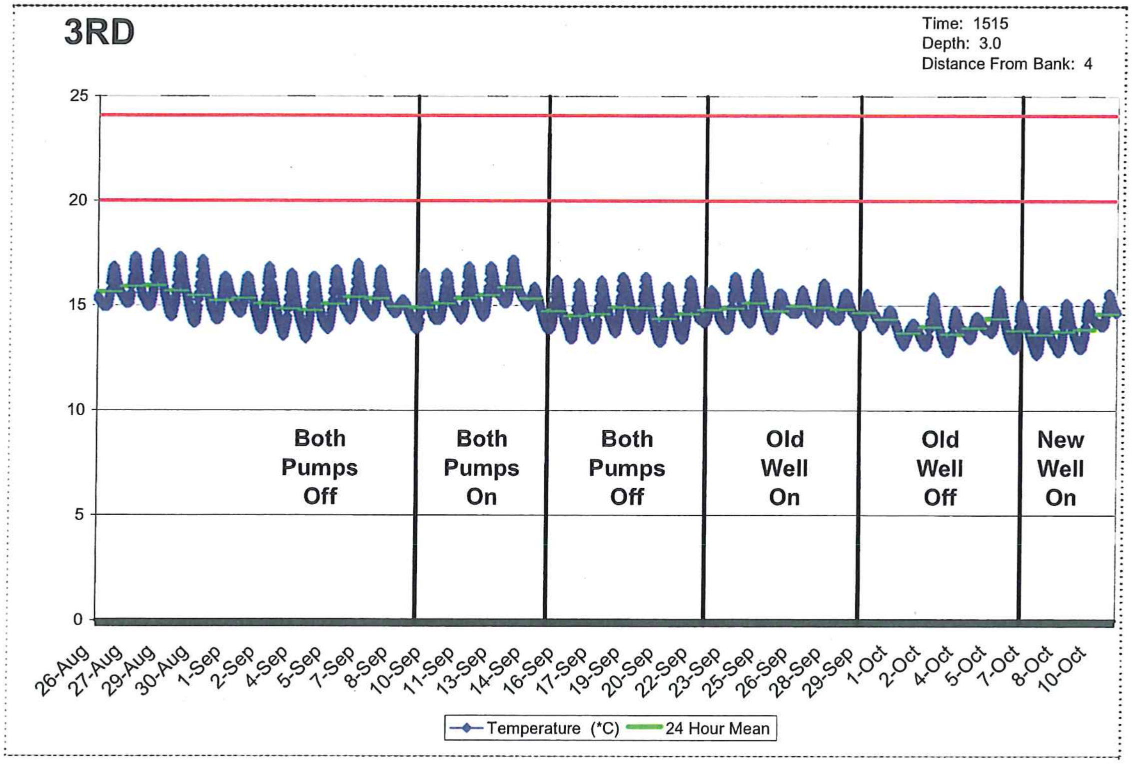

FIGURE 3-63. 24 minute and daily average mean temperature recorded at Transect 3, right bank, deep.

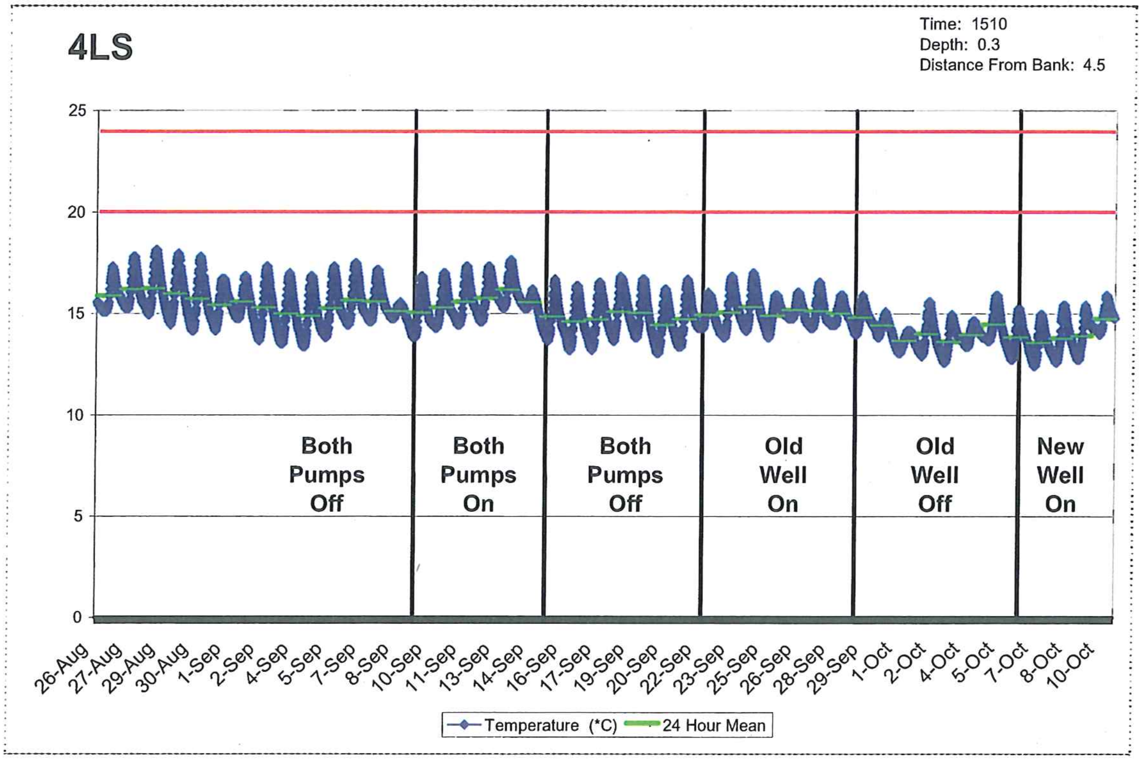

FIGURE 3-64. 24 minute and daily average mean temperature recorded at Transect 4, left bank, surface.

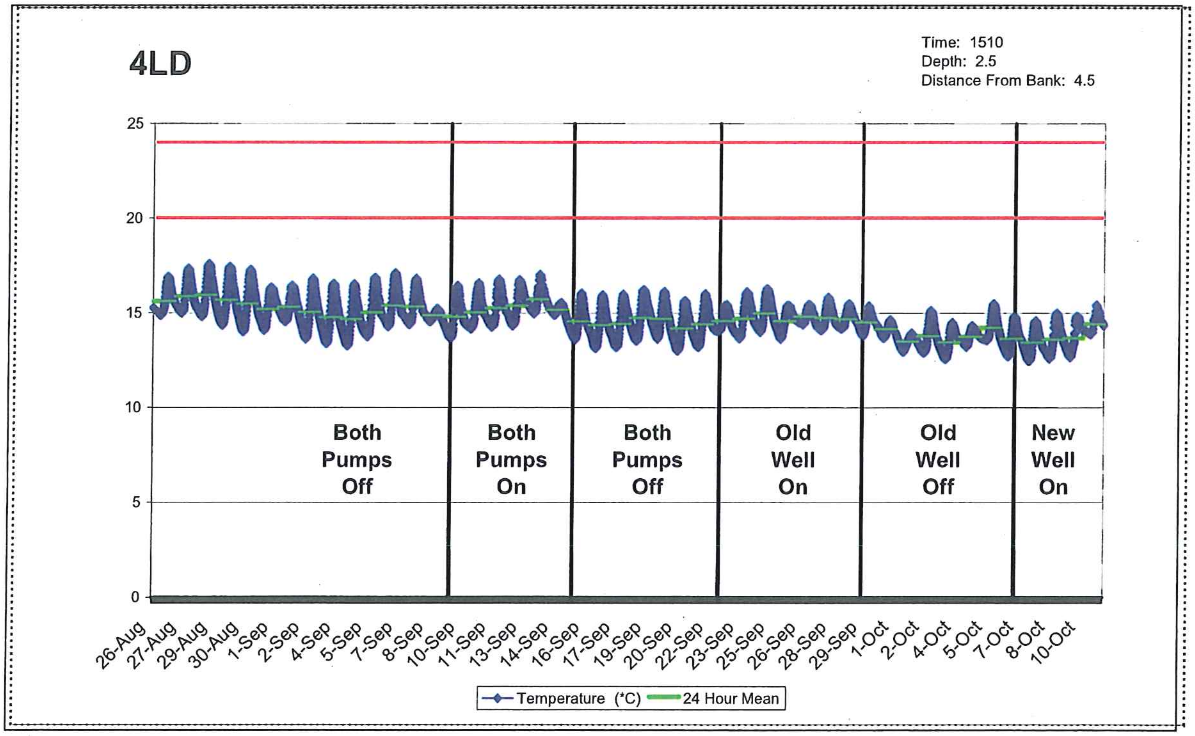

FIGURE 3-65. 24 minute and daily average mean temperature recorded at Transect 4, left bank, deep.

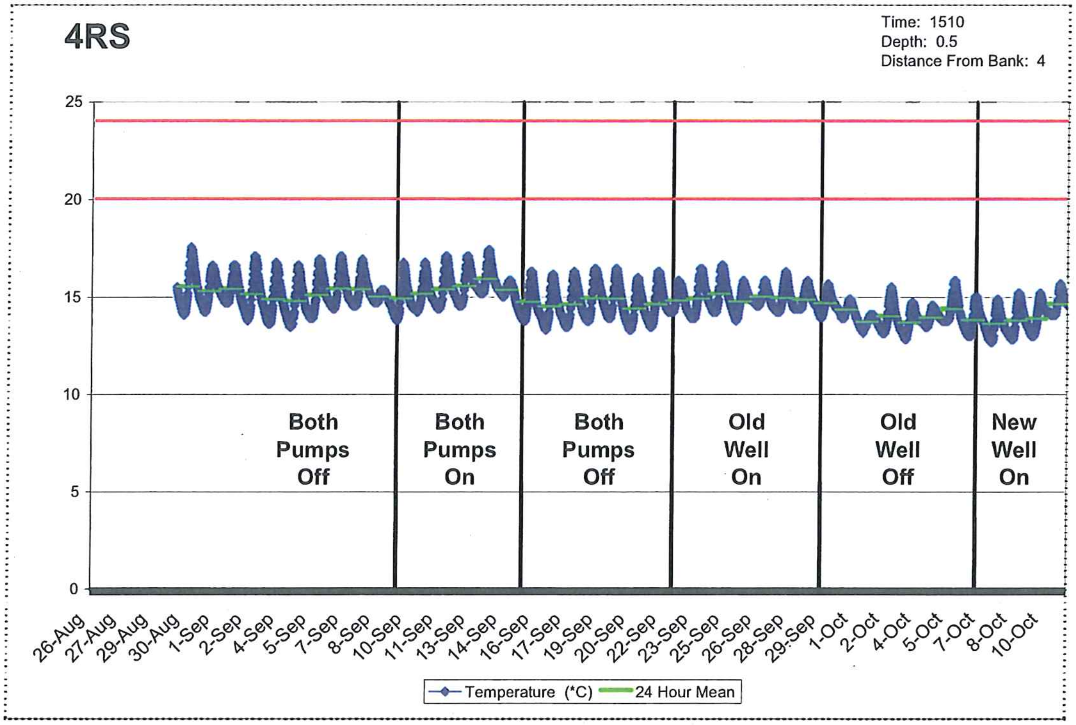

FIGURE 3-66. 24 minute and daily average mean temperature recorded at Transect 4, right bank, surface.

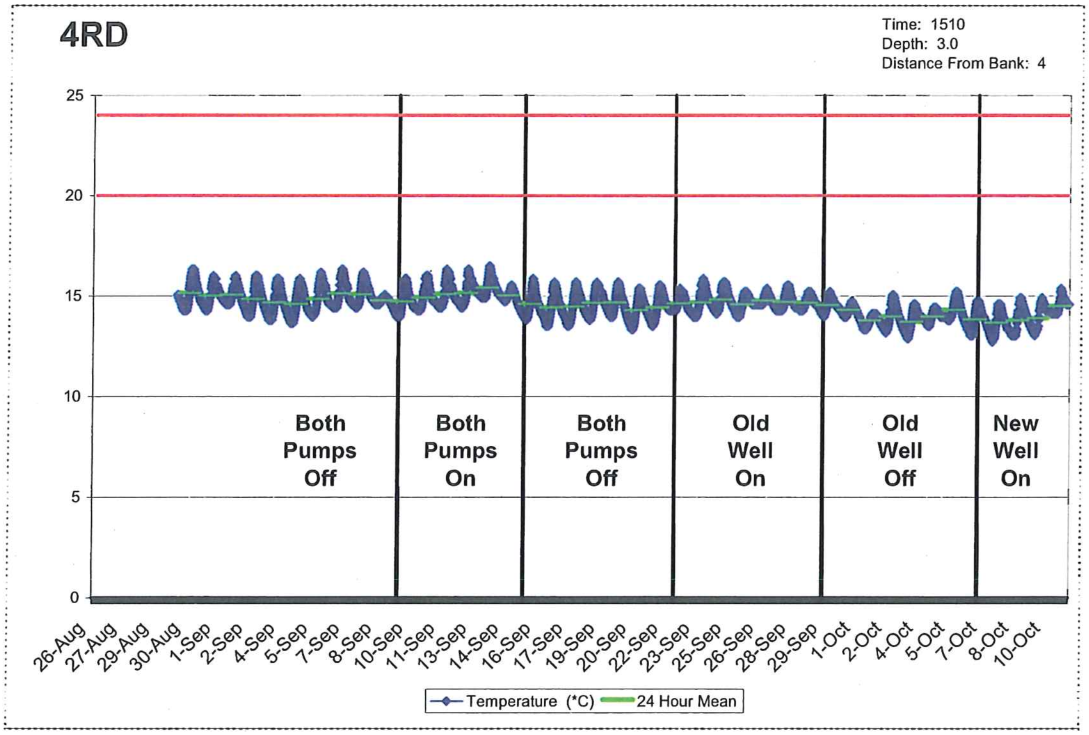

FIGURE 3-67. 24 minute and daily average mean temperature recorded at Transect 4, right bank, deep.

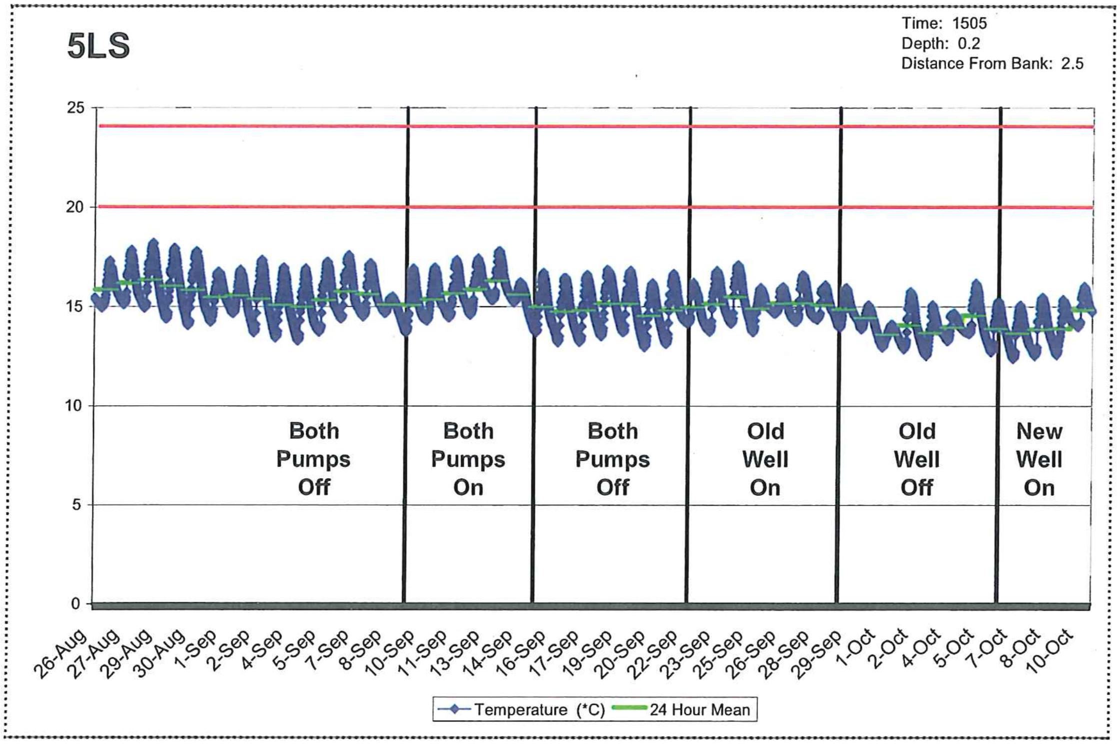

FIGURE 3-68. 24 minute and daily average mean temperature recorded at Transect 5, left bank, surface.

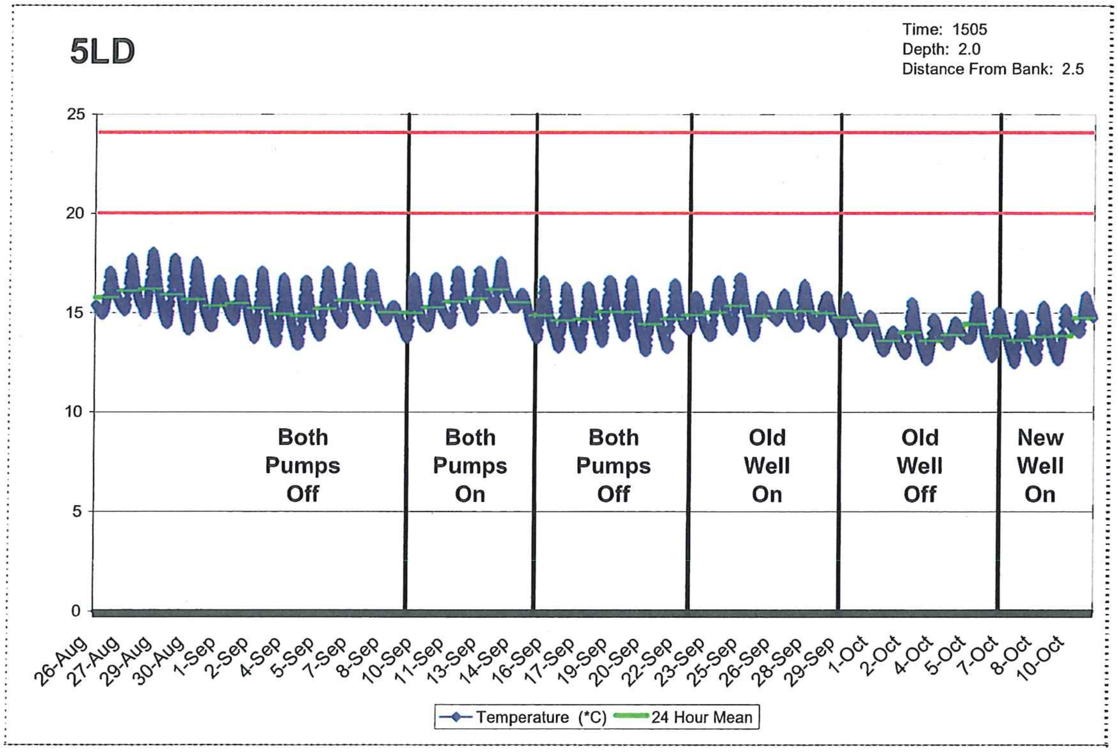

FIGURE 3-69. 24 minute and daily average mean temperature recorded at Transect 5, left bank, deep.

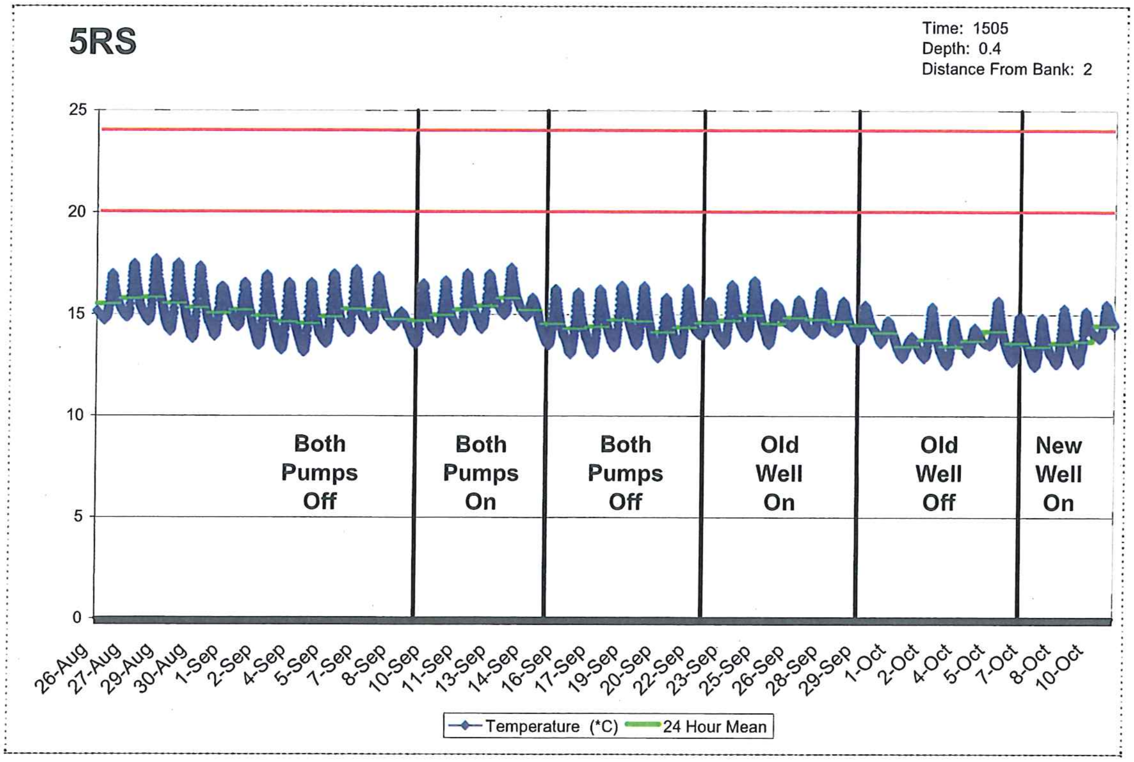

FIGURE 3-70. 24 minute and daily average mean temperature recorded at Transect 5, right bank, surface.

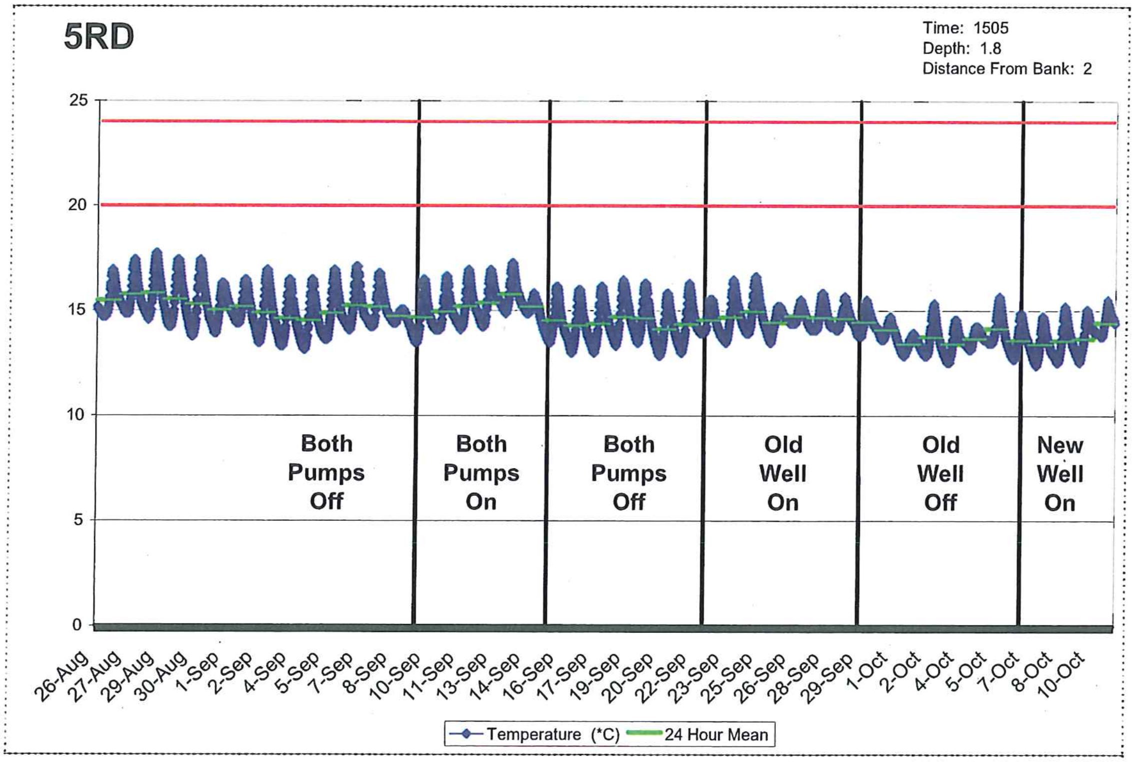

FIGURE 3-71. 24 minute and daily average mean temperature recorded at Transect 5, right bank, deep.

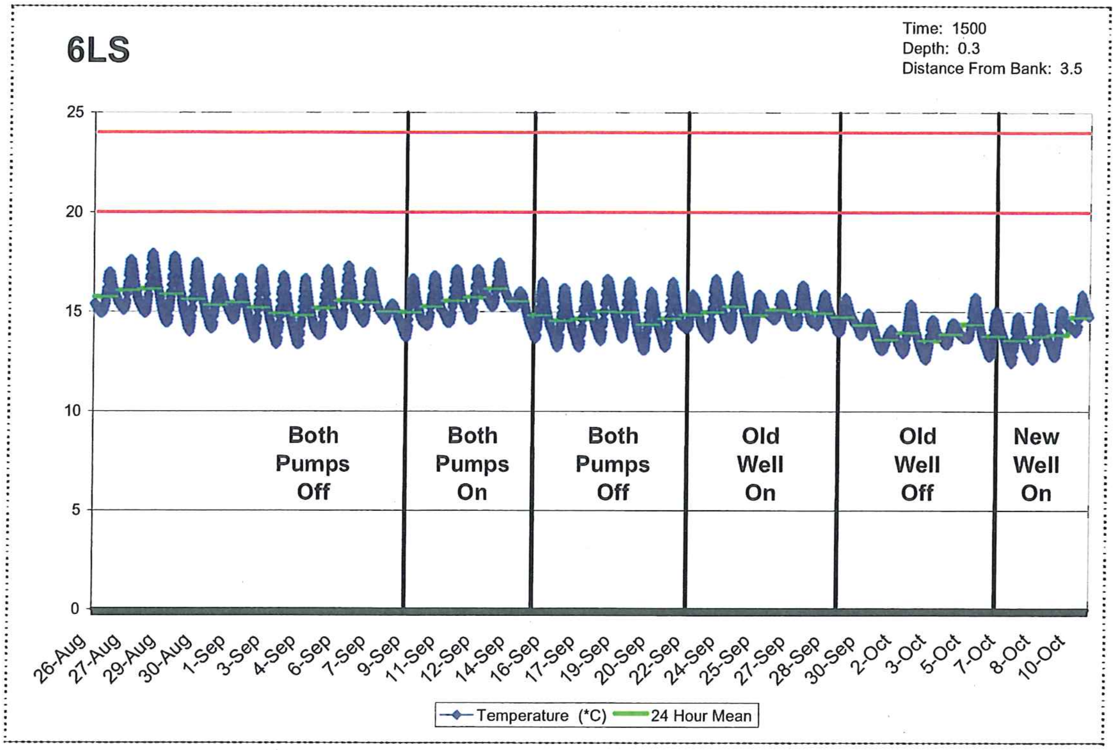

FIGURE 3-72. 24 minute and daily average mean temperature recorded at Transect 6, left bank, surface.

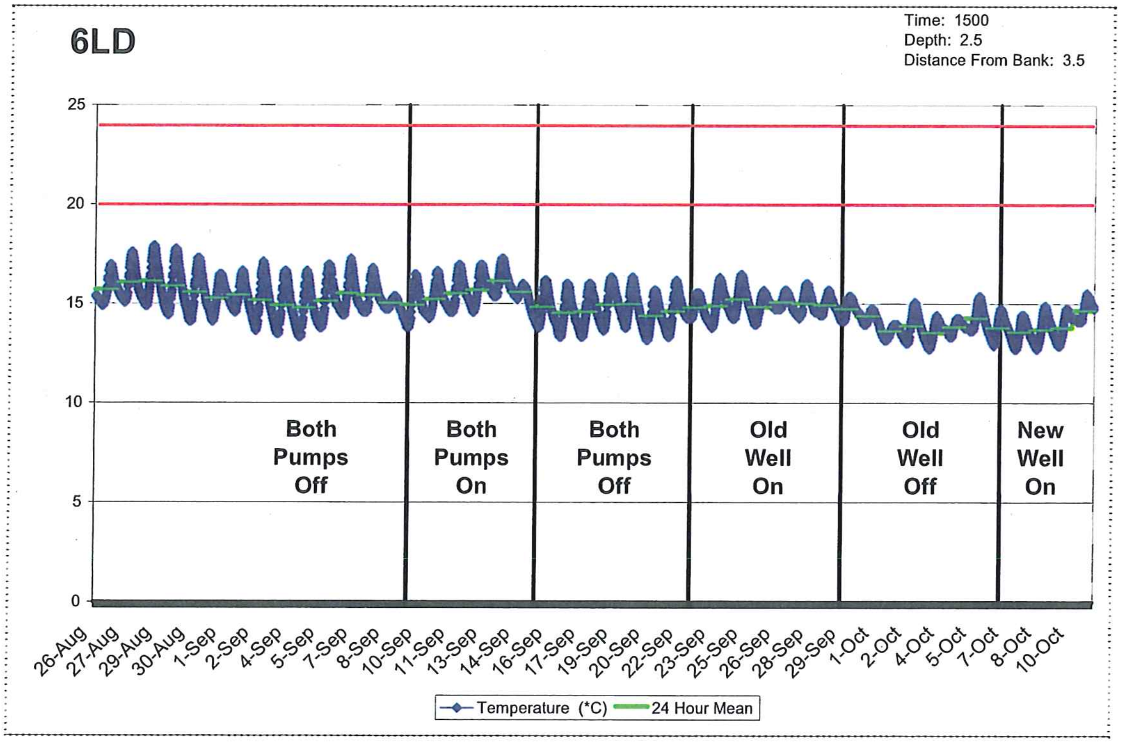

FIGURE 3-73. 24 minute and daily average mean temperature recorded at Transect 6, left bank, deep.

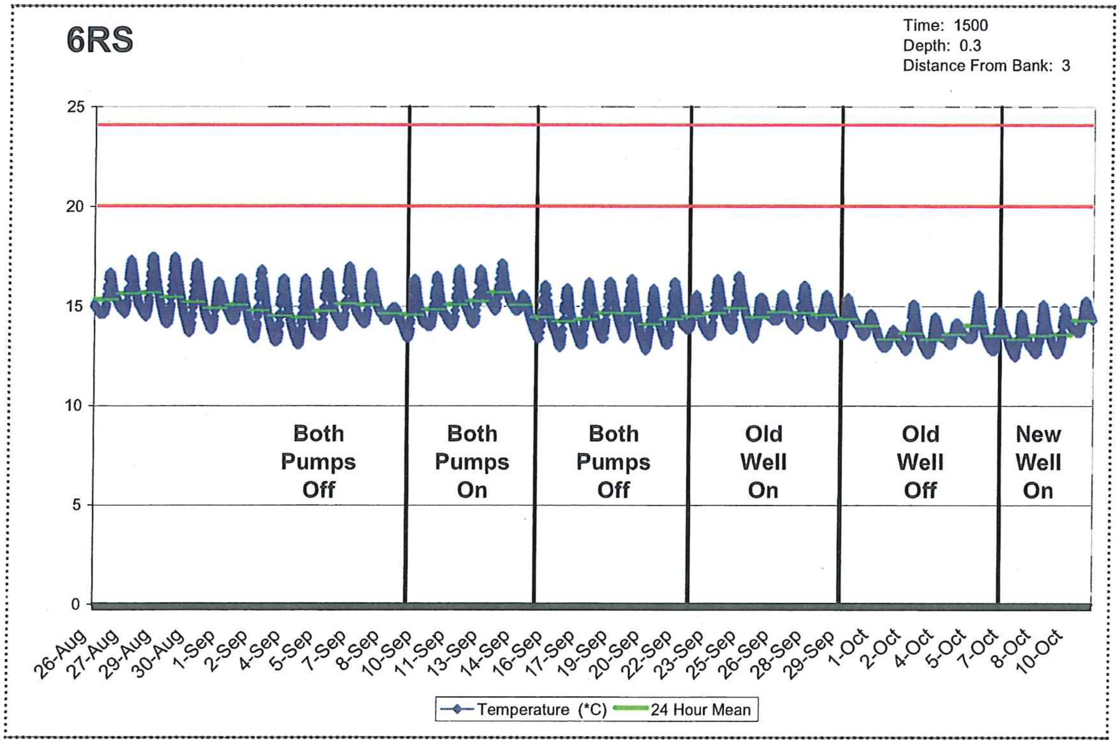

FIGURE 3-74. 24 minute and daily average mean temperature recorded at Transect 6, right bank, surface.

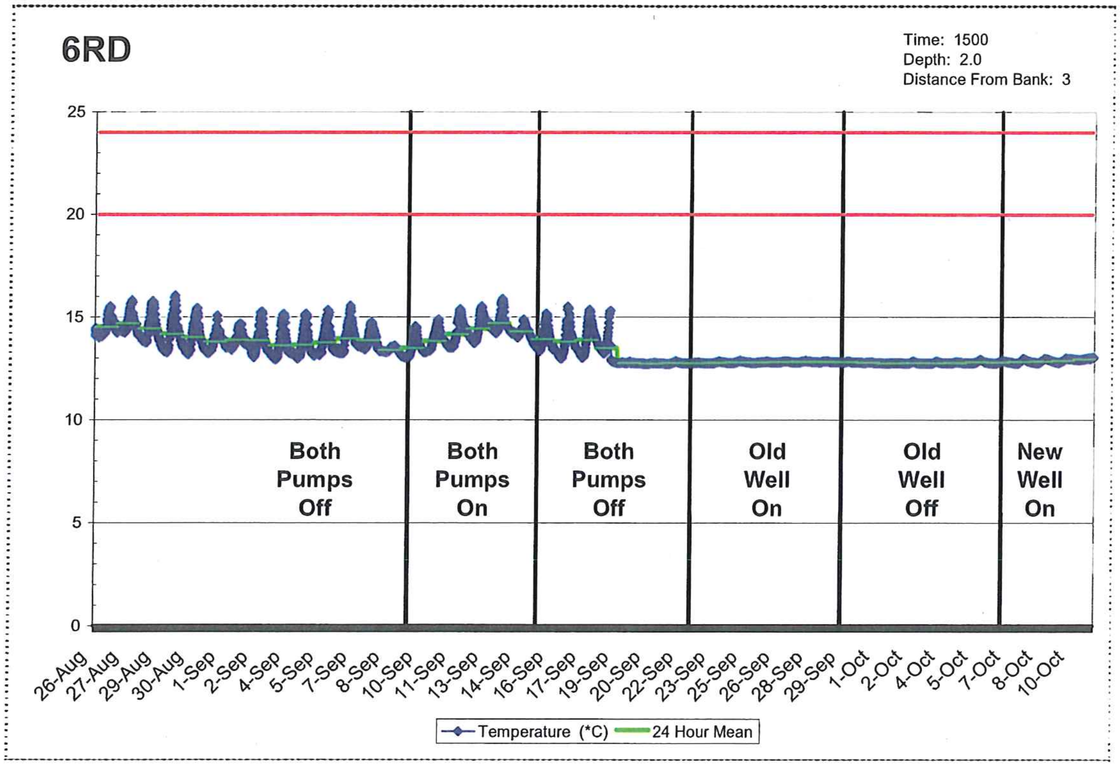

FIGURE 3-75. 24 minute and daily average mean temperature recorded at Transect 6, right bank, deep. (Note: Logger potentially malfunctioned on 9-18-06).

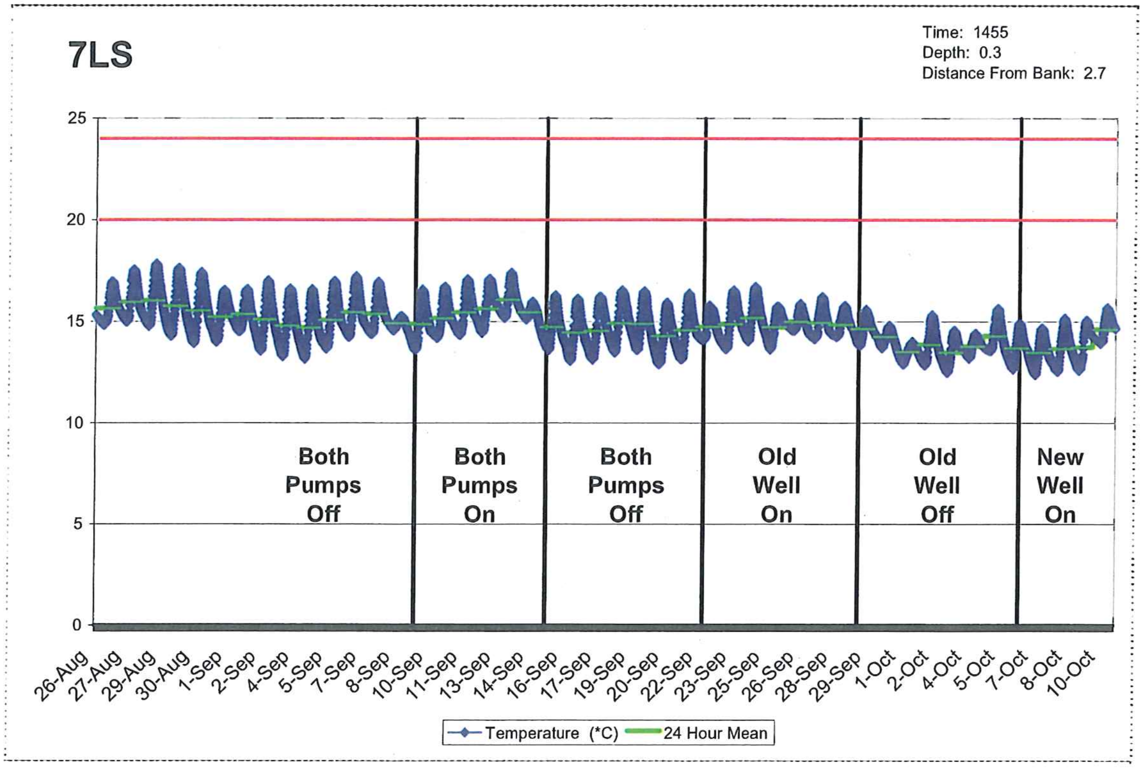

FIGURE 3-76. 24 minute and daily average mean temperature recorded at Transect 7, left bank, surface.

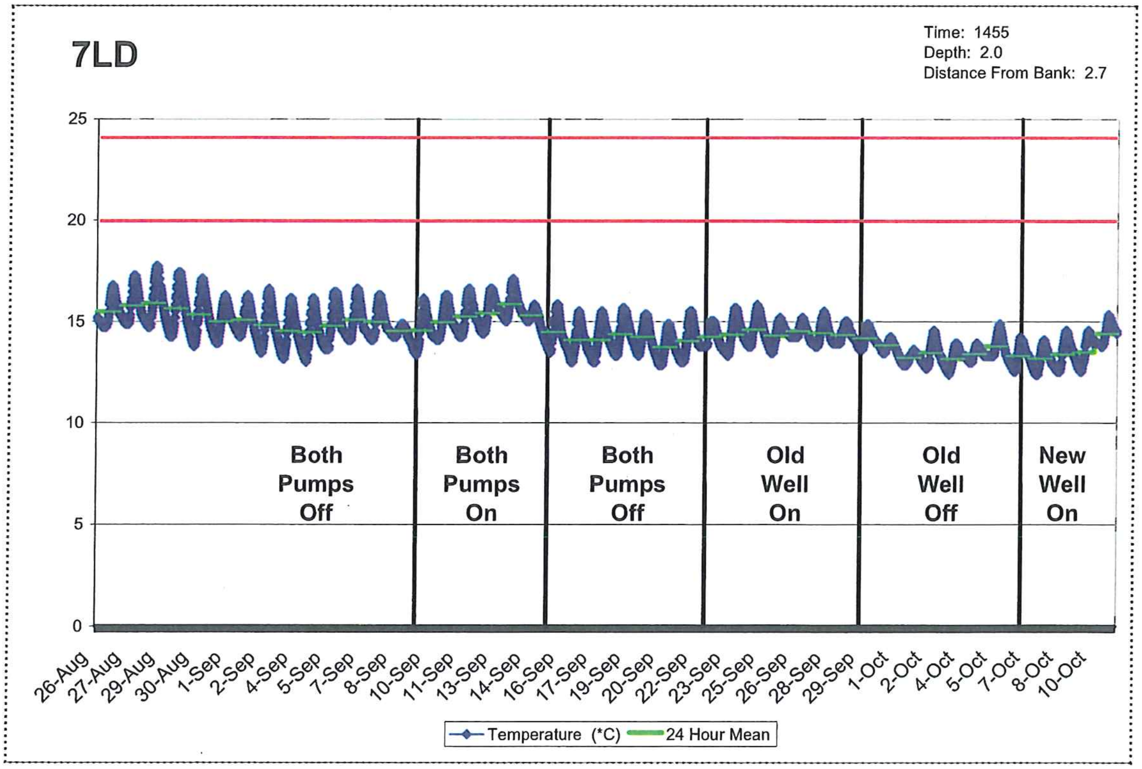

FIGURE 3-77. 24 minute and daily average mean temperature recorded at Transect 7, left bank, deep.

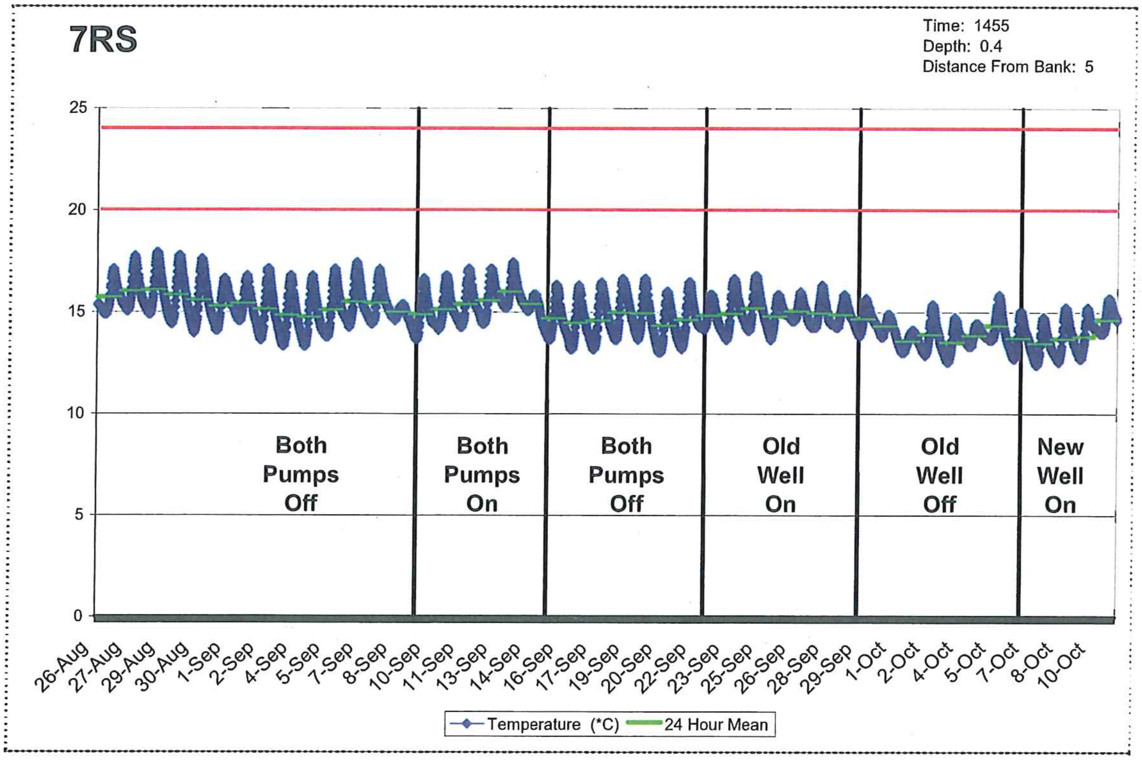

FIGURE 3-78. 24 minute and daily average mean temperature recorded at Transect 7, right bank, surface.

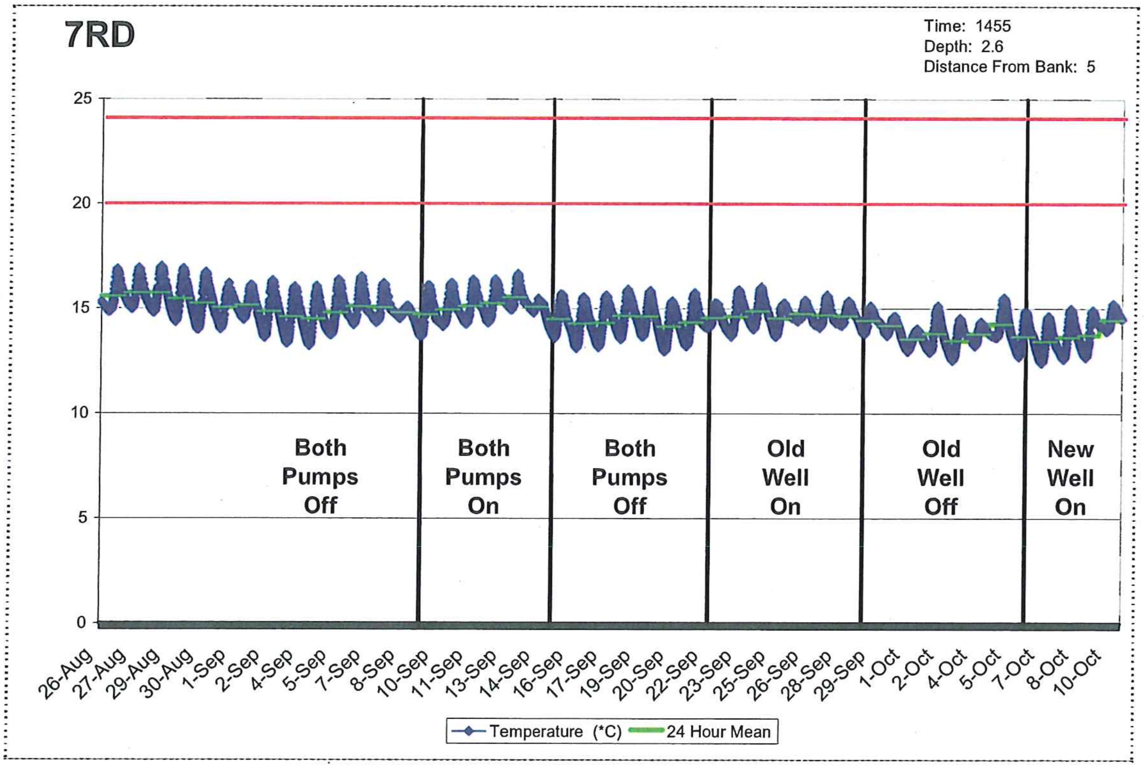

FIGURE 3-79. 24 minute and daily average mean temperature recorded at Transect 7, right bank, deep.

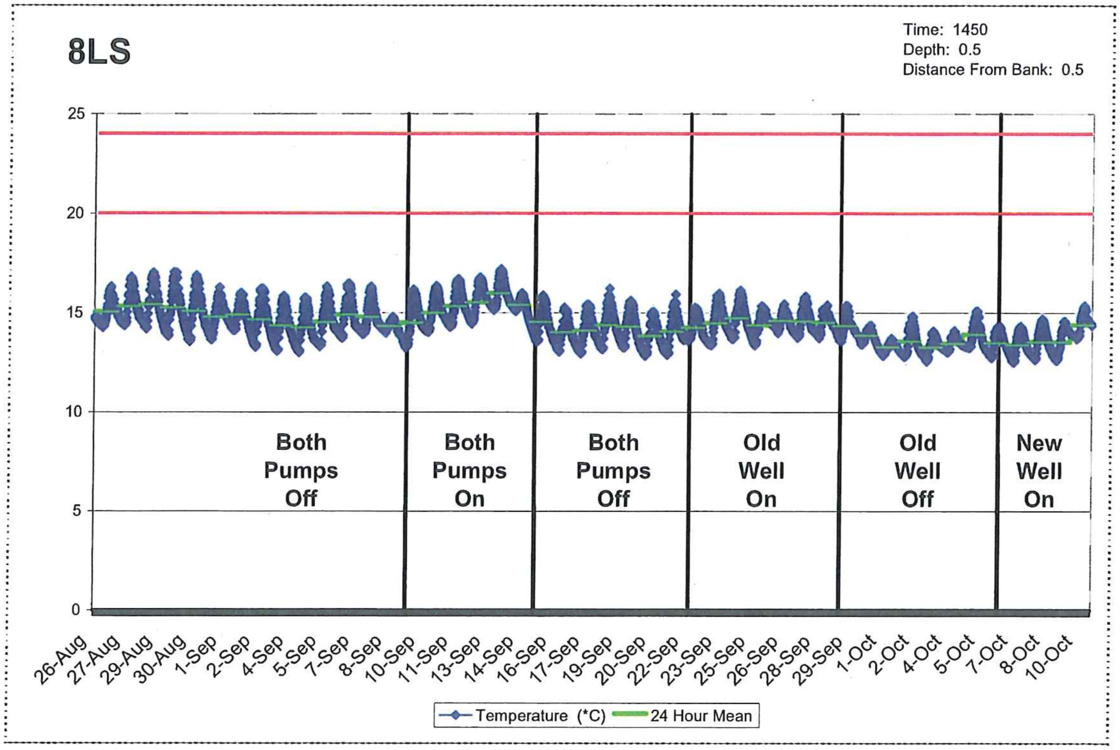

FIGURE 3-80. 24 minute and daily average mean temperature recorded at Transect 8, left bank, surface.

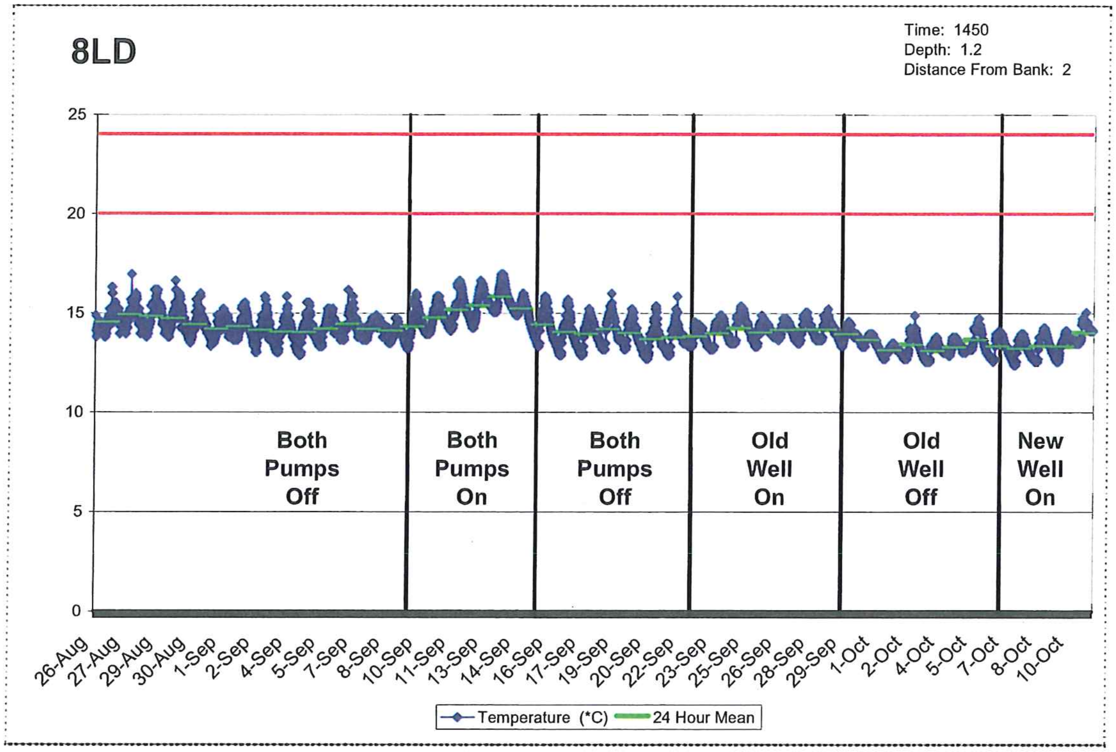

FIGURE 3-81. 24 minute and daily average mean temperature recorded at Transect 8, left bank, deep.

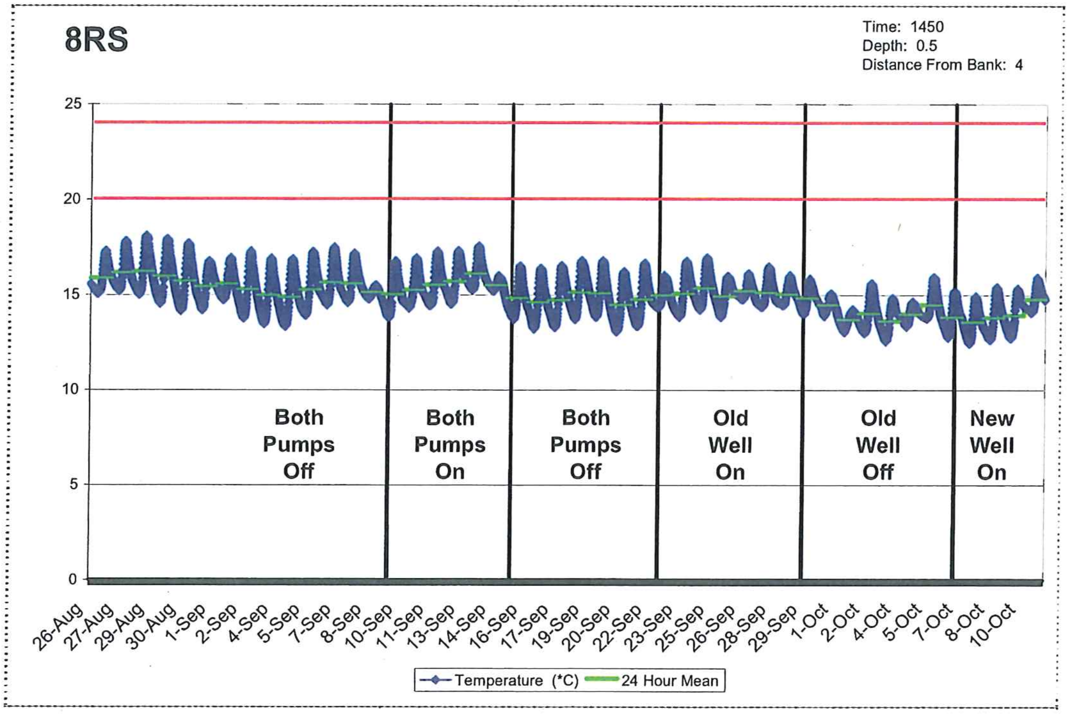

FIGURE 3-82. 24 minute and daily average mean temperature recorded at Transect 8, right bank, surface.

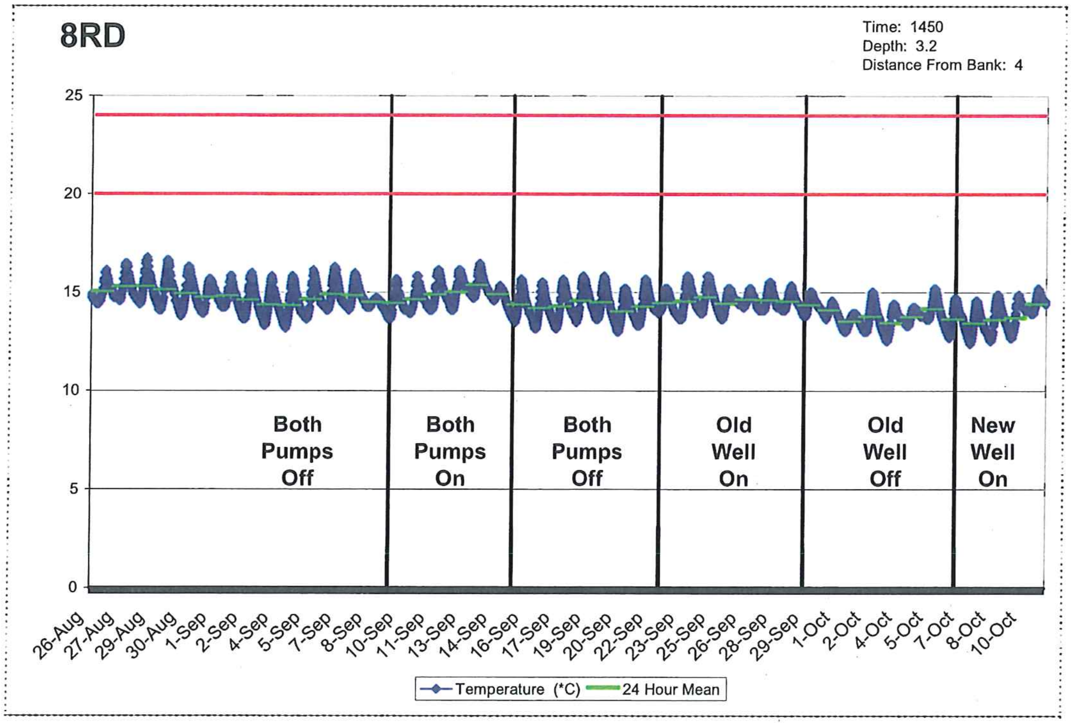

FIGURE 3-83. 24 minute and daily average mean temperature recorded at Transect 8, right bank, deep.

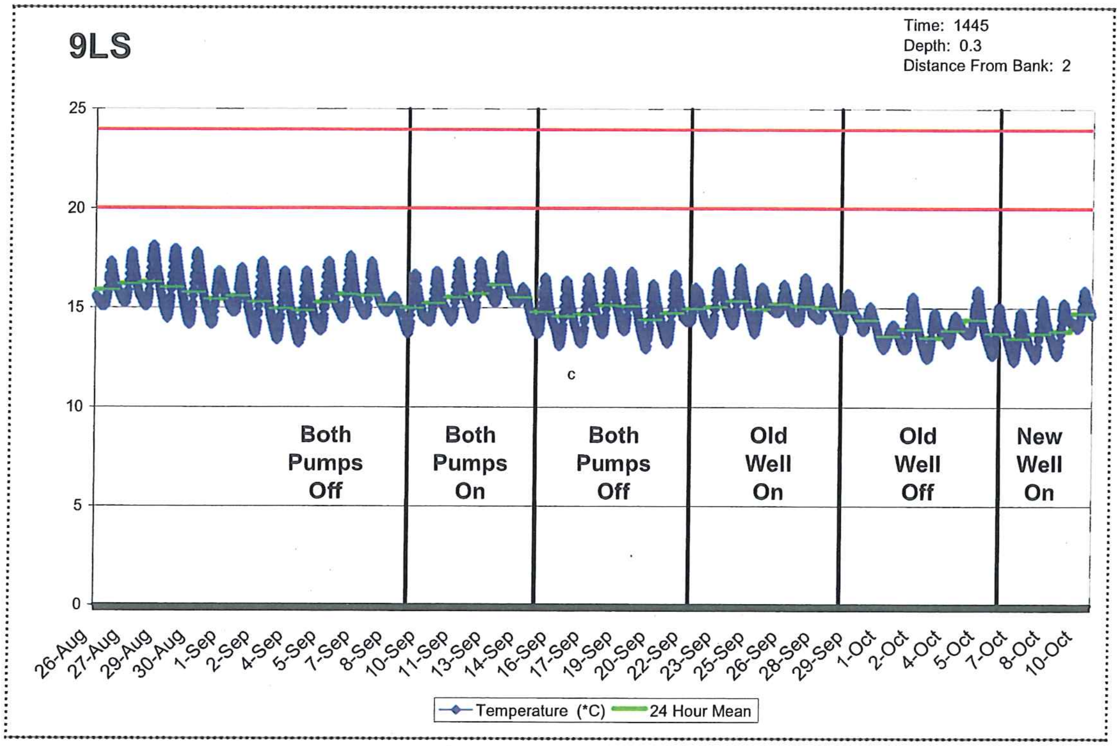

FIGURE 3-84. 24 minute and daily average mean temperature recorded at Transect 9, left bank, surface.

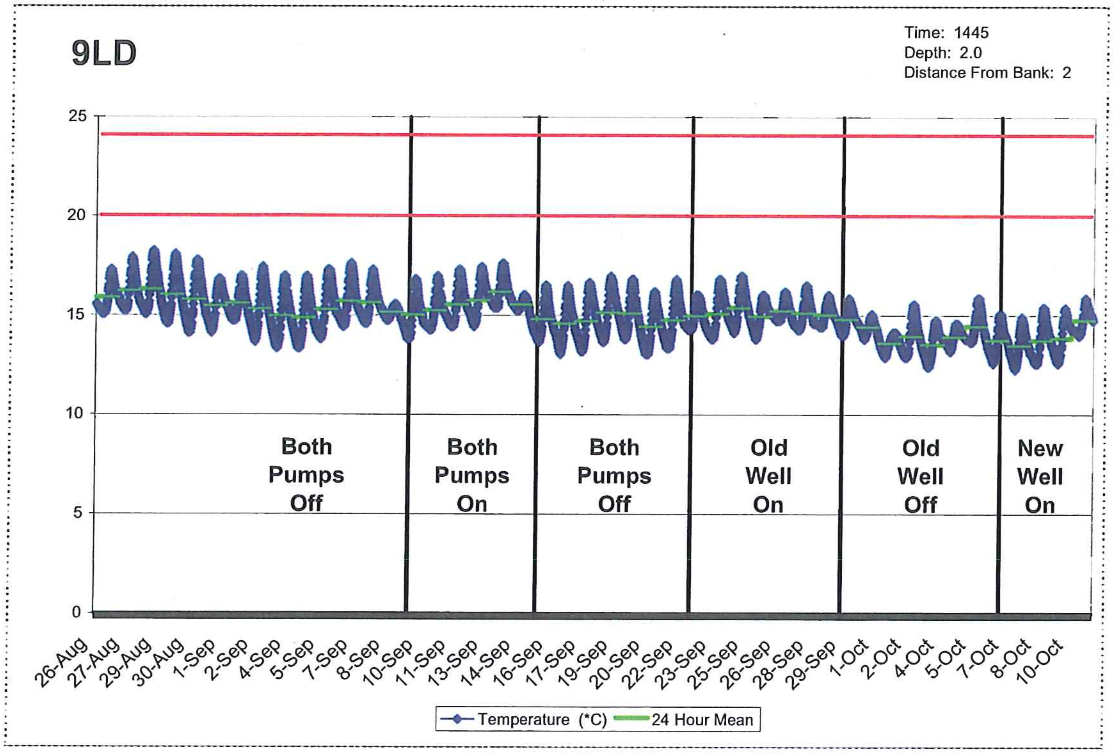

FIGURE 3-85. 24 minute and daily average mean temperature recorded at Transect 9, left bank, deep.

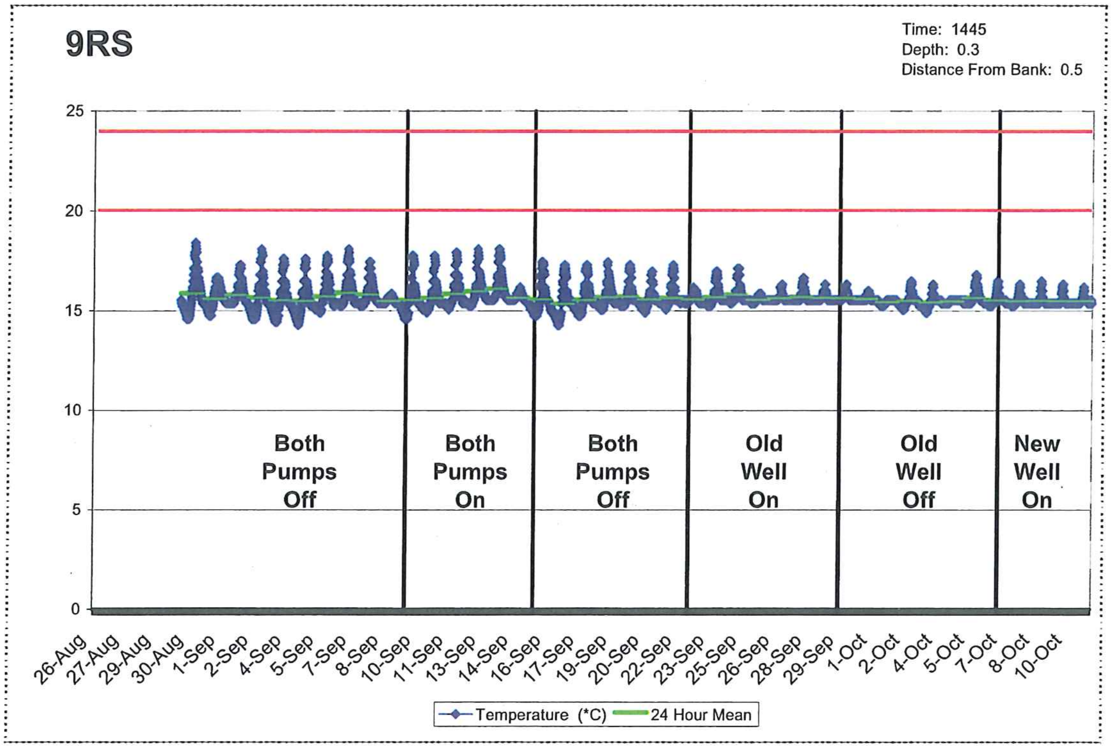

FIGURE 3-86. 24 minute and daily average mean temperature recorded at Transect 9, right bank, surface.

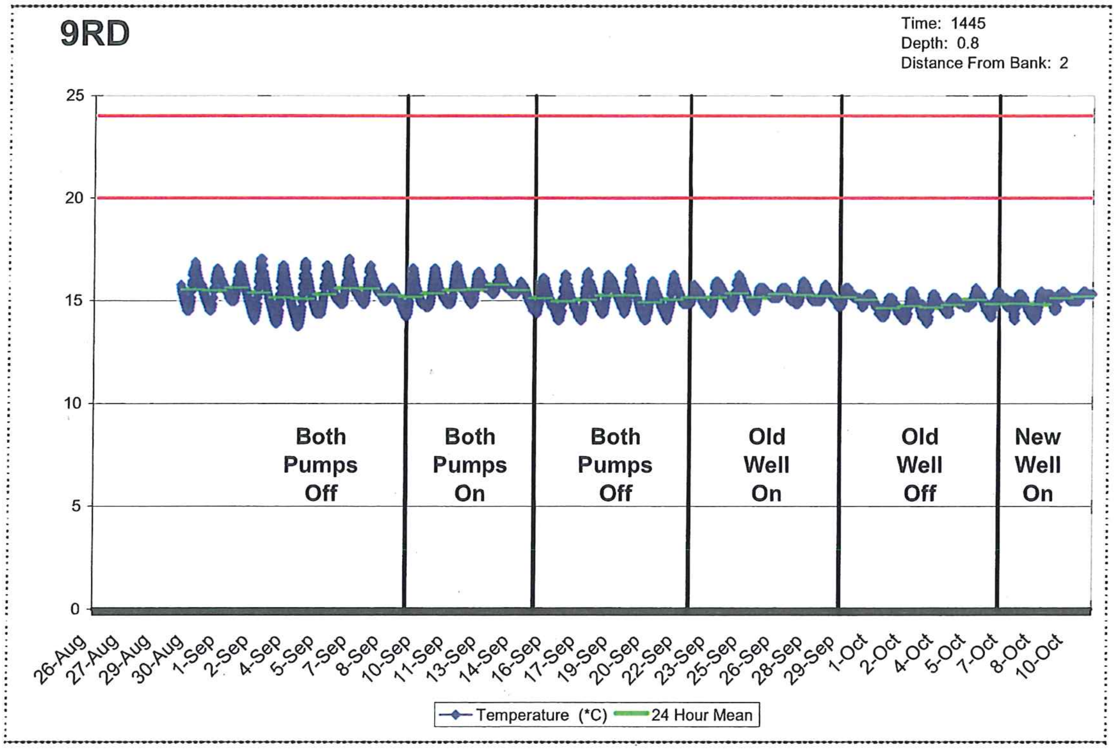

FIGURE 3-87. 24 minute and daily average mean temperature recorded at Transect 9, right bank, deep.

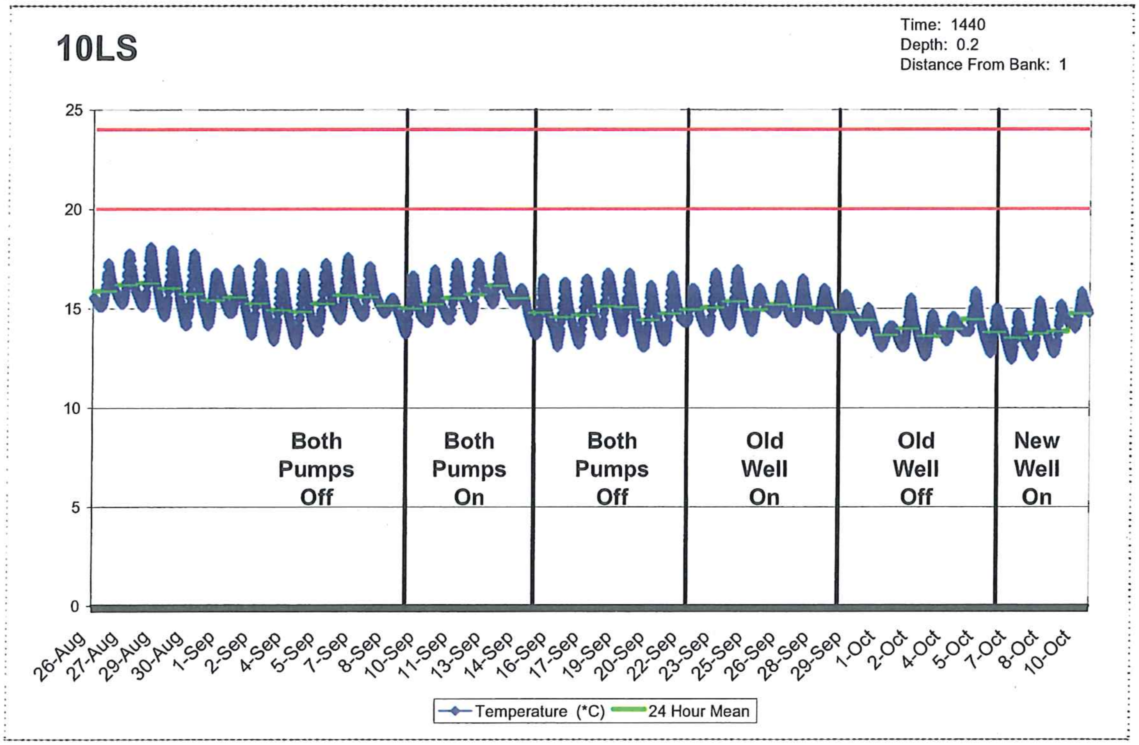

FIGURE 3-88. 24 minute and daily average mean temperature recorded at Transect 10, left bank, surface.

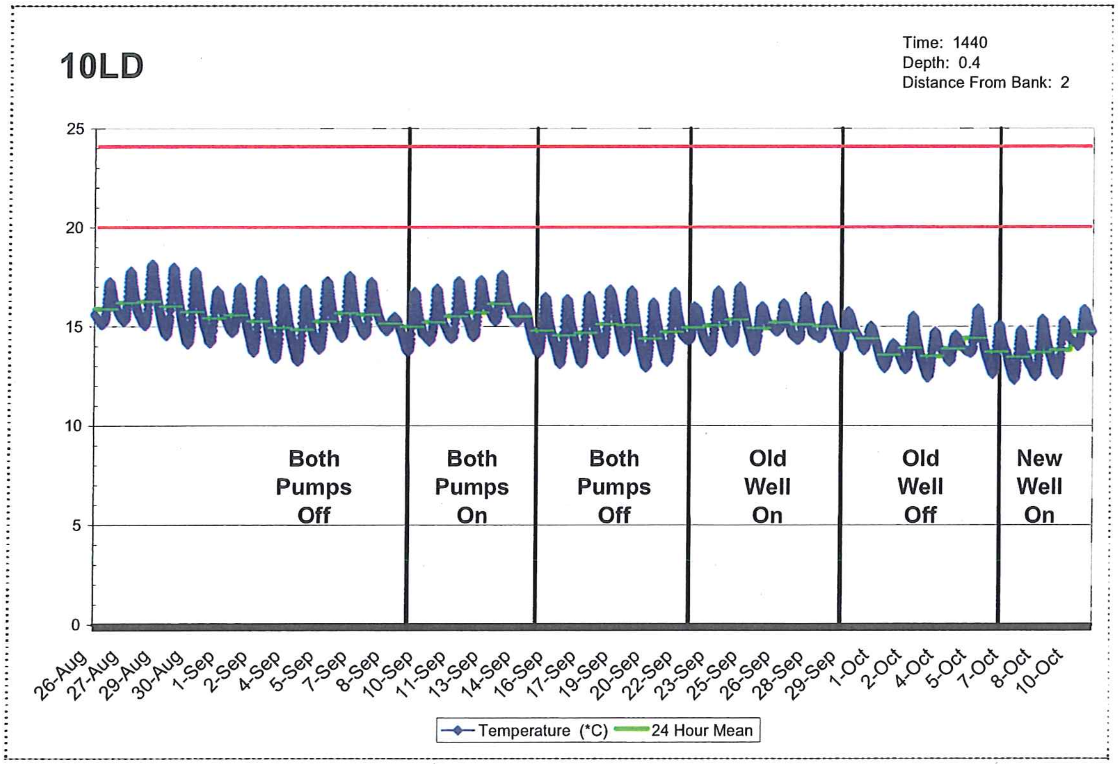

FIGURE 3-89. 24 minute and daily average mean temperature recorded at Transect 10, left bank, deep.

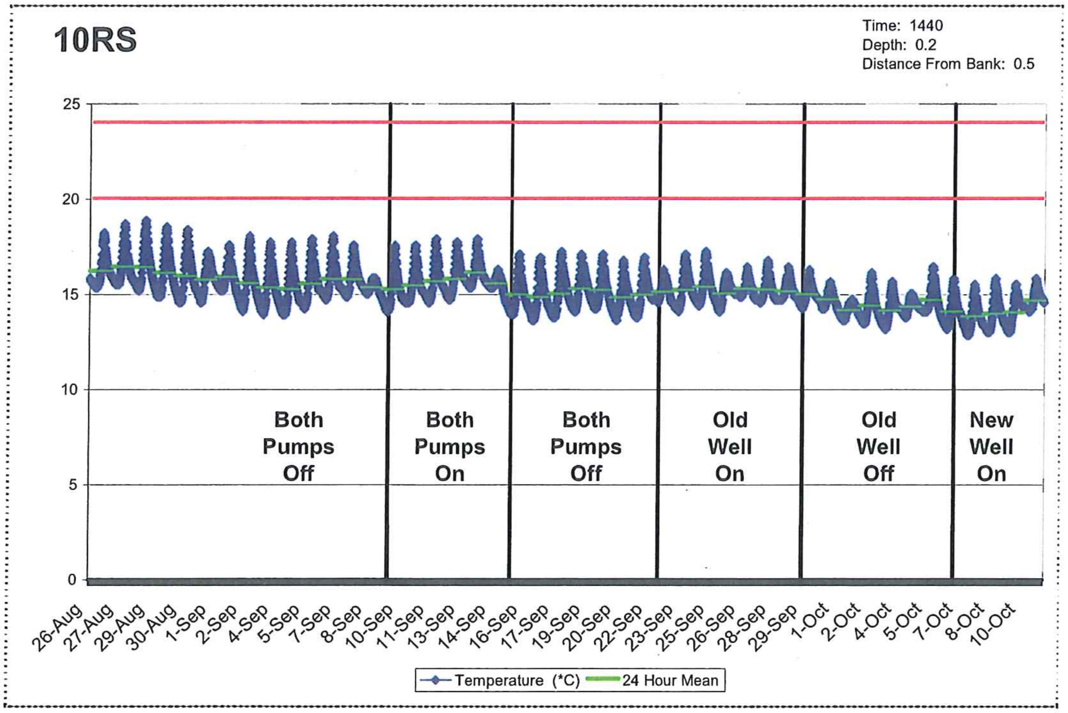

FIGURE 3-90. 24 minute and daily average mean temperature recorded at Transect 10, right bank, surface.

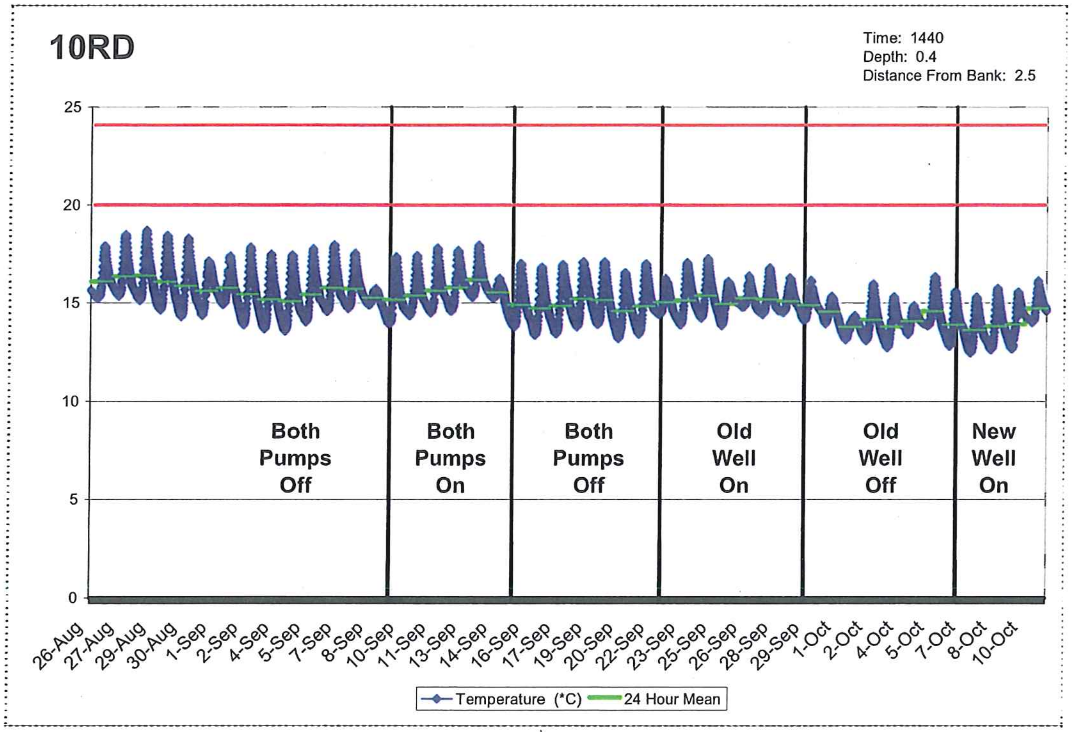

FIGURE 3-91. 24 minute and daily average mean temperature recorded at Transect 10, right bank, deep.

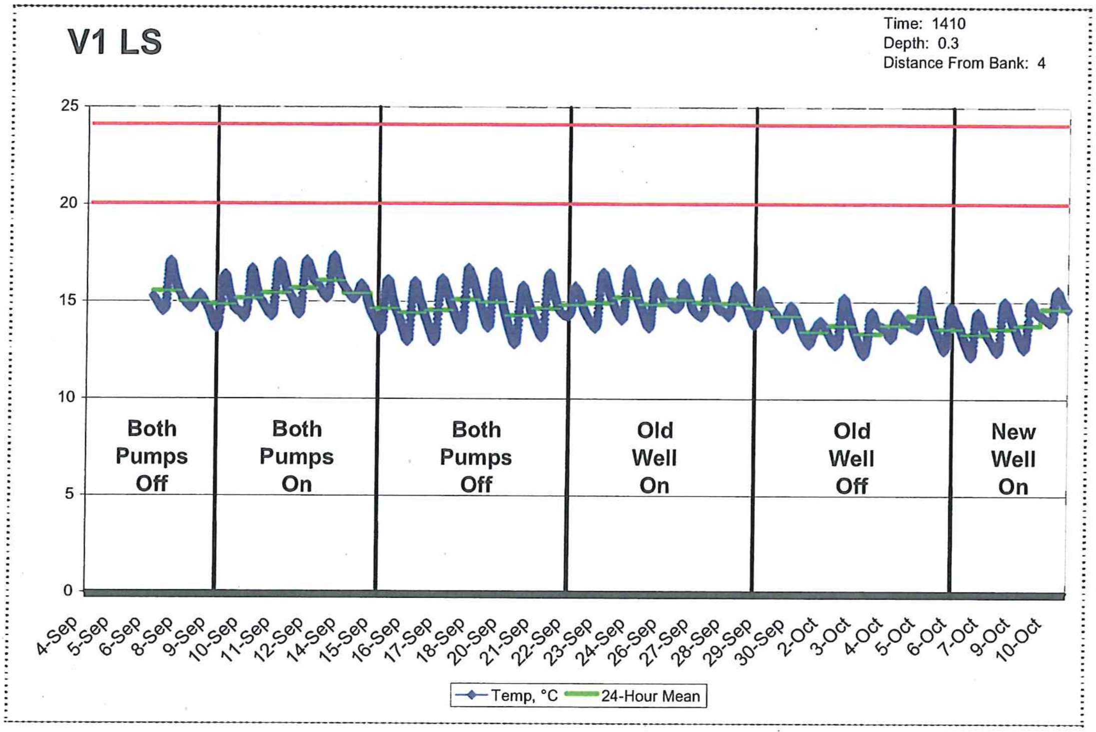

FIGURE 3-92. 24 minute and daily average mean temperature recorded at Transect VT-1, left bank, surface.

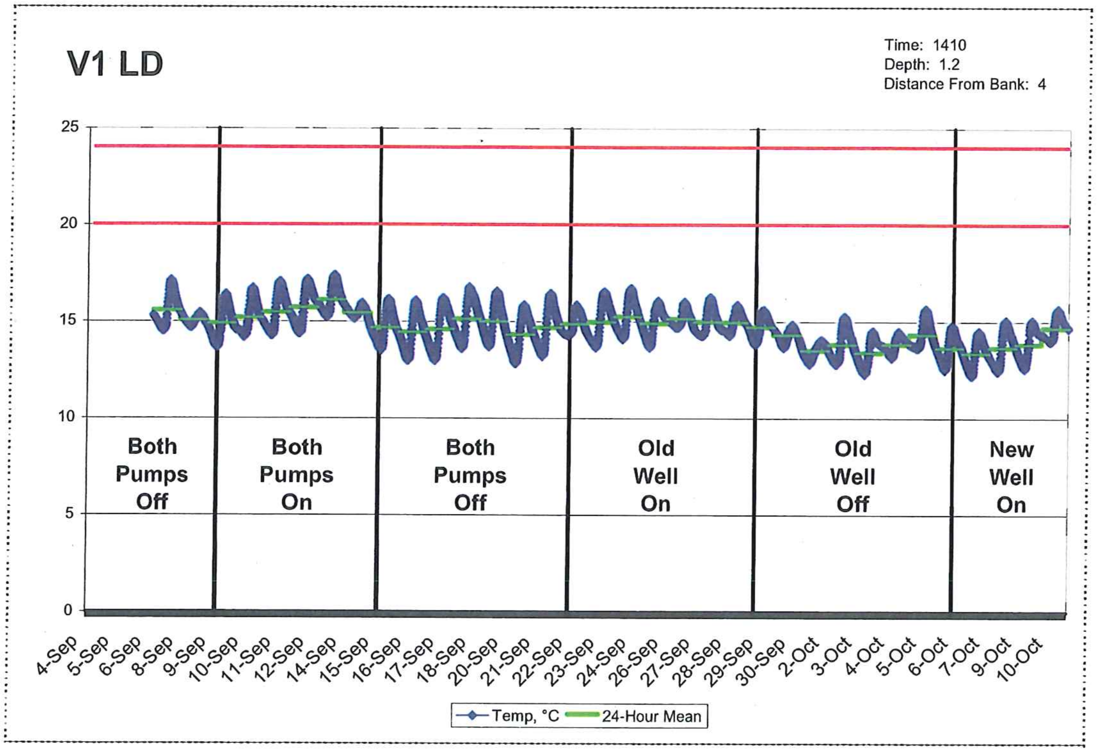

FIGURE 3-93. 24 minute and daily average mean temperature recorded at Transect VT-1, left bank, deep.

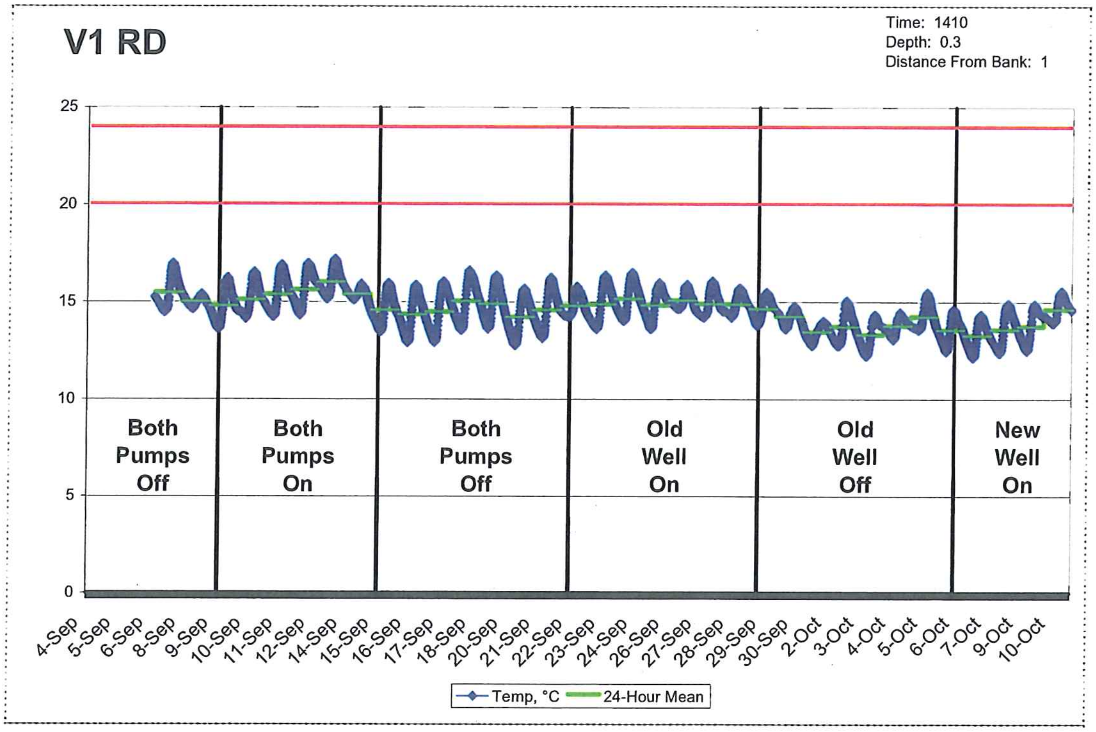

FIGURE 3-94. 24 minute and daily average mean temperature recorded at Transect VT-1, right bank, deep.

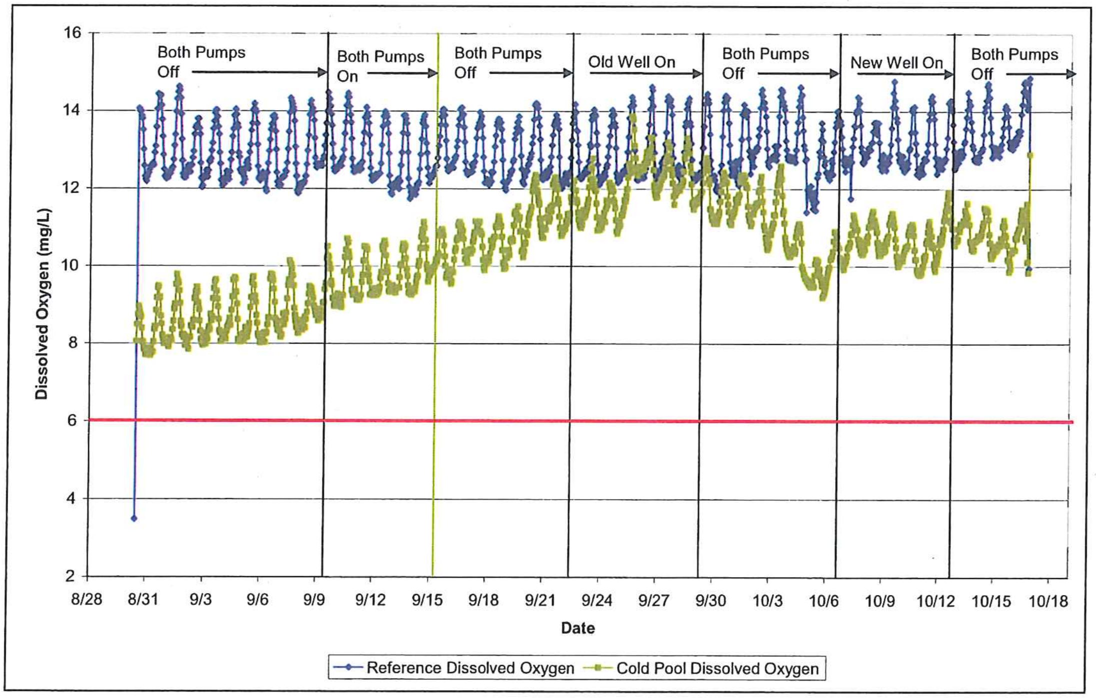

FIGURE 3-95. Continuous dissolved oxygen monitoring at upstream reference site and within area of "cold pool" groundwater upwelling adjacent to El Sur Ranch diversion wells.

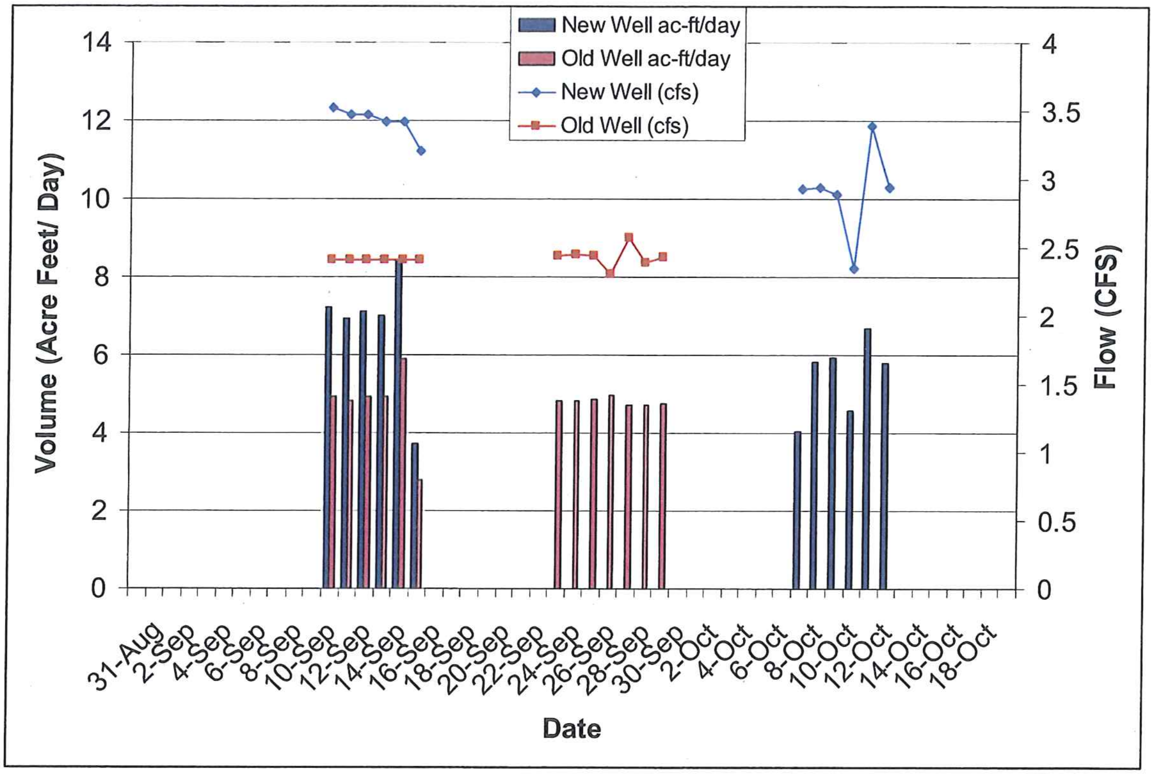

FIGURE 4-1. Daily pump test volumes and velocities.

TABLES

TABLE 2-1. Summary of the 2006 Big Sur River fishery habitat and water quality surveys.

SURVEY DATE	WATER VELOCITY AND STREAM FLOW	HABITAT CONDITIONS AND FISH PASSAGE	PERIODIC HABITAT WATER QUALITY MEASUREMENTS	CONTINUOUS WATER TEMPERATURE	CONTINUOUS DISSOLVED OXYGEN
08/30/06		X	X	Continuous – 24 min	Continuous - Hour
09/01/06	X			Continuous – 24 min	Continuous - Hour
09/06/06	X	X		Continuous – 24 min	Continuous - Hour
09/11/06	X	X		Continuous – 24 min	Continuous - Hour
09/12/06		X	X	Continuous – 24 min	Continuous - Hour
09/13/06				Continuous – 24 min	Continuous - Hour
09/14/06	X	X	X	Continuous – 24 min	Continuous - Hour
09/18/06	X	X	X	Continuous – 24 min	Continuous - Hour
09/21/06	X	X	X	Continuous – 24 min	Continuous - Hour
09/25/06	X	X	X	Continuous – 24 min	Continuous - Hour
09/28/06	X	X	X	Continuous – 24 min	Continuous - Hour
10/02/06	X	X	X	Continuous – 24 min	Continuous - Hour
10/05/06	X	X	X	Continuous – 24 min	Continuous - Hour
10/10/06	X	X	X	Continuous – 24 min	Continuous - Hour
10/12/06	X	X		Continuous – 24 min	Continuous - Hour
10/17/06		X		Continuous – 24 min	Continuous - Hour

TABLE 2-2. El Sur Ranch pump operations schedule.

PUMP STATUS	DATE	TIME
Both Pumps Off	09/01/06	N/A
Both Pumps On	09/09/06	8:24
Both Pumps Off	09/15/06	6:35
Old Well On	0 9/22/06	8:39
Both Pumps Off	09/29/06	8:10
New Well On	10/06/06	15:51
Both Pumps Off	10/12/06	17:41

N/A = not applicable; project start date.

TABLE 2-3 . Summary of water quality and fish passage monitoring locations.

TRANSECT ID	LOCATION DESCRIPTION
Transect 1	Downstream Deep Lagoon
Transect 2	Middle Deep Lagoon
Transect 3	Upstream Deep Lagoon
Transect 4	Riffle
Transect 5	Deep Homogenous Channel
Transect 6	Downstream Adjacent to Pumps and Groundwater Zone of Influence
Transect 7	Adjacent to Pumps and Groundwater Zone of Influence
Transect 8	Upstream Adjacent to Pumps and Groundwater Zone of Influence
Transect 9	Riffle
Transect 10	Riffle
Transect 11	Riffle
Velocity Transect 1	Velocity Transect

TABLE 2-4. Summary of water quality parameters surveyed, 2006.

DATE	WATER TEMPERATURE [°C]	ELECTRICAL CONDUCTIVITY [EC]	DISSOLVED OXYGEN [DO]
08/30/06	X	X	X
09/12/06	X	X	X
09/14/06	X	X	X
09/18/06	X	X	X
09/21/06	X	X	X
09/25/06	X	X	X
09/28/06	X	X	X
10/02/06	X	X	X
10/05/06	X	X	X
10/10/06	X	X	X

TABLE 2-5. Continuous water temperature monitoring locations.

TRANSECT ID	LEFT BANK - SURFACE	LEFT BANK - DEEP	RIGHT BANK - SURFACE	RIGHT BANK - DEEP
Transect 1	X	X	X	X
Transect 2	X	X	X	X
Transect 3	X	X	X	X
Transect 4	X	X	X	X
Transect 5	X	X	X	X
Transect 6	X	X	X	X
Transect 7	X	X	X	X
Transect 8	X	X	X	X
Transect 9	X	X	X	X
Transect 10	X	X	X	X
Transect 11	X	X	X	X
Velocity Transect 1	X	X		X

TABLE 3-1. Summary of flow and channel measurements made at the upstream reference transect VT-1.

DATE	WETTED WIDTH [FT]	MEAN DEPTH [FT]	DISCHARGE [CFS]
09/01/06	39.9	1.31	21.92
09/06/06	40.0	1.26	19.21
09/11/06	39.9	1.26	20.54
09/14/06	39.9	1.25	18.66
09/18/06	39.6	1.25	18.98
09/21/06	40.3	1.24	18.48
09/25/06	39.9	1.24	18.17
09/28/06	39.5	1.25	18.38
10/02/06	39.7	1.25	19.81
10/05/06	39.8	1.30	21.34
10/10/06	39.4	1.46	18.84
10/12/06	39.6	1.25	18.38

TABLE 3-2. Passage Transect 1 summary.

DATE	FLOW (CFS)	WETTED WIDTH (FT)	MEAN DEPTH (FT)	TOTAL # CELLS	25% CRITERIA		10% CRITERIA		MEETS CRITERIA*		PUMP STATUS
					# CELLS	%	# CELLS	%	25%	10%	
08/30/06	NF	84.3	2.80	167	166	99%	166	99%	Yes	Yes	Both Pumps Off
09/06/06	21.92	84.2	2.82	168	167	99%	167	99%	Yes	Yes	Both Pumps Off
09/11/06	19.21	84.6	3.03	168	166	99%	166	99%	Yes	Yes	Both Pumps On
09/14/06	20.54	84.1	>3	Passable: Too deep to access		99%		99%	Yes	Yes	Both Pumps On
09/18/06	18.66	84.1	2.78	16 - 5 ft resolution	16	100%	16	100%	Yes	Yes	Both Pumps Off
09/21/06	18.98	84.1	3.27	17 - 5 ft resolution	17	100%	17	100%	Yes	Yes	Both Pumps Off
09/25/06	18.48	84.3	2.95	168	167	99%	167	99%	Yes	Yes	Old Well On
09/28/06	18.17	84.6	3.07	17 - 5 ft resolution	17	100%	17	100%	Yes	Yes	Old Well On
10/02/06	18.38	84.4	3.02	16 - 5 ft resolution	16	100%	16	100%	Yes	Yes	Both Pumps Off
10/05/06	19.81	85	>3	Passable: Too deep to access		99%		99%	Yes	Yes	Both Pumps Off
10/10/06	21.34	85	>3	Passable: Too deep to access		99%		99%	Yes	Yes	New Well On
10/12/06	18.84	85.1	>3	Passable: Too deep to access		99%		99%	Yes	Yes	New Well On
10/17/06	NF	84.1	>3	Passable: Too deep to access		99%		99%	Yes	Yes	Both Pumps 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)
NF = no flow reading taken

TABLE 3-3. Passage Transect 2 summary.

DATE	FLOW (CFS)	WETTED WIDTH (FT)	MEAN DEPTH (FT)	TOTAL # CELLS	25% CRITERIA		10% CRITERIA		MEETS CRITERIA*		PUMP STATUS
					# CELLS	%	# CELLS	%	25%	10%	
08/30/06	NF	86.5	1.26	174	121	70%	100	57%	Yes	Yes	Both Pumps Off
09/06/06	21.92	86.7	1.20	175	120	69%	99	57%	Yes	Yes	Both Pumps Off
09/11/06	19.21	97.5	1.51	198	163	82%	143	72%	Yes	Yes	Both Pumps On
09/14/06	20.54	94	>1.5	Passable: Too deep to access					Yes	Yes	Both Pumps On
09/18/06	18.66	87.3	1.28	17	14	82%	12	71%	Yes	Yes	Both Pumps Off
09/21/06	18.98	88.1	1.48	17	14	82%	13	76%	Yes	Yes	Both Pumps Off
09/25/06	18.48	88.9	1.35	178	137	77%	102	57%	Yes	Yes	Old Well On
09/28/06	18.17	97.4	1.50	19 - 5 ft resolution	17	89%	15	79%	Yes	Yes	Old Well On
10/02/06	18.38	88.9	1.39	179	147	82%	102	57%	Yes	Yes	Both Pumps Off
10/05/06	19.81	97.6	>1.5	Passable: Too deep to access		89%		79%	Yes	Yes	Both Pumps Off
10/10/06	21.34	98.5	>1.5	Passable: Too deep to access		89%		79%	Yes	Yes	New Well On
10/12/06	18.84	97.7	1.47	197	163	83%	137	70%	Yes	Yes	New Well On
10/17/06	NF	87.4	>1.5	Passable: Too deep to access		89%		79%	Yes	Yes	Both Pumps 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)
NF = no flow reading taken

TABLE 3-4. Passage Transect 3 summary.

DATE	FLOW (CFS)	WETTED WIDTH (FT)	MEAN DEPTH (FT)	TOTAL # CELLS	25% CRITERIA		10% CRITERIA		MEETS CRITERIA*		PUMP STATUS
					# CELLS	%	# CELLS	%	25%	10%	
08/30/06	NF	44.70	1.38	89	85	96%	85	96%	Yes	Yes	Both Pumps Off
09/06/06	21.92	44.40	1.27	88	83	94%	83	94%	Yes	Yes	Both Pumps Off
09/11/06	19.21	55.75	1.54	112	90	80%	90	80%	Yes	Yes	Both Pumps On
09/14/06	20.54	43.90	1.25	87	84	97%	84	97%	Yes	Yes	Both Pumps On
09/18/06	18.66	44.40	1.33	88	85	97%	85	97%	Yes	Yes	Both Pumps Off
09/21/06	18.98	44.70	1.36	89	84	94%	84	94%	Yes	Yes	Both Pumps Off
09/25/06	18.48	46.60	1.46	93	85	91%	85	91%	Yes	Yes	Old Well On
09/28/06	18.17	46.40	1.51	92	86	93%	86	93%	Yes	Yes	Old Well On
10/02/06	18.38	45.80	1.46	91	86	95%	86	95%	Yes	Yes	Both Pumps Off
10/05/06	19.81	46.90	1.47	93	85	91%	85	91%	Yes	Yes	Both Pumps Off
10/10/06	21.34	98.5	>1.5	Passable: Too deep to access		93%		93%	Yes	Yes	New Well On
10/12/06	18.84	49.20	1.52	98	86	88%	86	88%	Yes	Yes	New Well On
10/17/06	NF	87.4	>1.5	Passable: Too deep to access		93%		93%	Yes	Yes	Both Pumps 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)
NF = no flow reading taken

TABLE 3-5. Passage Transect 4 summary.

DATE	FLOW (CFS)	WETTED WIDTH (FT)	MEAN DEPTH (FT)	TOTAL # CELLS	25% CRITERIA		10% CRITERIA		MEETS CRITERIA*		PUMP STATUS
					# CELLS	%	# CELLS	%	25%	10%	
08/30/06	NF	25.60	0.48	51	20	39%	20	39%	Yes	Yes	Both Pumps Off
09/06/06	21.92	24.30	0.43	49	19	39%	19	39%	Yes	Yes	Both Pumps Off
09/11/06	19.21	26.30	0.44	53	18	34%	18	34%	Yes	Yes	Both Pumps On
09/14/06	20.54	25.40	0.40	51	18	35%	18	35%	Yes	Yes	Both Pumps On
09/18/06	18.66	24.80	0.40	50	17	34%	17	34%	Yes	Yes	Both Pumps Off
09/21/06	18.98	25.40	0.34	51	16	31%	9	18%	Yes	Yes	Both Pumps Off
09/25/06	18.48	25.20	0.37	51	18	35%	18	35%	Yes	Yes	Old Well On
09/28/06	18.17	24.90	0.41	50	19	38%	19	38%	Yes	Yes	Old Well On
10/02/06	18.38	24.30	0.43	49	17	35%	17	35%	Yes	Yes	Both Pumps Off
10/05/06	19.81	25.40	0.42	51	18	35%	18	35%	Yes	Yes	Both Pumps Off
10/10/06	21.34	27.10	0.60	54	29	54%	27	50%	Yes	Yes	New Well On
10/12/06	18.84	25.80	0.41	52	18	35%	18	35%	Yes	Yes	New Well On
10/17/06	NF	24.70	0.39	50	19	38%	19	38%	Yes	Yes	Both Pumps 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)
NF = no flow reading taken

TABLE 3-6. Passage Transect 5 summary.

DATE	FLOW (CFS)	WETTED WIDTH (FT)	MEAN DEPTH (FT)	TOTAL # CELLS	25% CRITERIA		10% CRITERIA		MEETS CRITERIA*		PUMP STATUS
					# CELLS	%	# CELLS	%	25%	10%	
08/30/06	NF	52.70	1.35	106	93	88%	93	88%	Yes	Yes	Both Pumps Off
09/06/06	21.92	52.00	1.31	104	92	88%	92	88%	Yes	Yes	Both Pumps Off
09/11/06	19.21	52.80	1.29	105	91	87%	91	87%	Yes	Yes	Both Pumps On
09/14/06	20.54	51.90	1.26	104	91	88%	91	88%	Yes	Yes	Both Pumps On
09/18/06	18.66	51.90	1.28	104	92	88%	92	88%	Yes	Yes	Both Pumps Off
09/21/06	18.98	52.50	1.26	105	91	87%	91	87%	Yes	Yes	Both Pumps Off
09/25/06	18.48	52.50	1.27	105	91	87%	91	87%	Yes	Yes	Old Well On
09/28/06	18.17	51.80	1.29	104	91	88%	91	88%	Yes	Yes	Old Well On
10/02/06	18.38	52.70	1.30	106	93	88%	93	88%	Yes	Yes	Both Pumps Off
10/05/06	19.81	52.60	1.32	106	93	88%	93	88%	Yes	Yes	Both Pumps Off
10/10/06	21.34	52.70	1.28	106	92	87%	92	87%	Yes	Yes	New Well On
10/12/06	18.84	52.80	1.27	106	93	88%	93	88%	Yes	Yes	New Well On
10/17/06	NF	52.70	1.28	106	93	88%	93	88%	Yes	Yes	Both Pumps 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)
NF = no flow reading taken

TABLE 3-7. Passage Transect 6 summary.

DATE	FLOW (CFS)	WETTED WIDTH (FT)	MEAN DEPTH (FT)	TOTAL # CELLS	25% CRITERIA		10% CRITERIA		MEETS CRITERIA*		PUMP STATUS
					# CELLS	%	# CELLS	%	25%	10%	
08/30/06	NF	41.60	2.22	84	80	95%	80	95%	Yes	Yes	Both Pumps Off
09/06/06	21.92	41.70	2.13	84	79	94%	79	94%	Yes	Yes	Both Pumps Off
09/11/06	19.21	41.90	2.11	84	79	94%	79	94%	Yes	Yes	Both Pumps On
09/14/06	20.54	41.50	2.07	83	79	95%	78	94%	Yes	Yes	Both Pumps On
09/18/06	18.66	41.70	2.07	84	80	95%	80	95%	Yes	Yes	Both Pumps Off
09/21/06	18.98	41.70	2.06	84	80	95%	80	95%	Yes	Yes	Both Pumps Off
09/25/06	18.48	41.80	2.07	84	80	95%	80	95%	Yes	Yes	Old Well On
09/28/06	18.17	41.90	2.11	84	80	95%	80	95%	Yes	Yes	Old Well On
10/02/06	18.38	42.00	2.13	84	80	95%	80	95%	Yes	Yes	Both Pumps Off
10/05/06	19.81	42.10	2.15	85	80	94%	80	94%	Yes	Yes	Both Pumps Off
10/10/06	21.34	41.90	2.09	84	79	94%	79	94%	Yes	Yes	New Well On
10/12/06	18.84	42.10	2.05	85	79	93%	79	93%	Yes	Yes	New Well On
10/17/06	NF	42.10	2.10	85	79	93%	79	93%	Yes	Yes	Both Pumps 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)
NF = no flow reading taken

TABLE 3-8. Passage Transect 7 summary.

DATE	FLOW (CFS)	WETTED WIDTH (FT)	MEAN DEPTH (FT)	TOTAL # CELLS	25% CRITERIA		10% CRITERIA		MEETS CRITERIA*		PUMP STATUS
					# CELLS	%	# CELLS	%	25%	10%	
08/30/06	NF	41.8	1.90	84	82	98%	82	98%	Yes	Yes	Both Pumps Off
09/06/06	21.92	42.3	1.80	84	82	98%	82	98%	Yes	Yes	Both Pumps Off
09/11/06	19.21	42.4	1.83	85	83	98%	83	98%	Yes	Yes	Both Pumps On
09/14/06	20.54	42.1	2.02	85	84	99%	84	99%	Yes	Yes	Both Pumps On
09/18/06	18.66	41.9	1.79	84	82	98%	82	98%	Yes	Yes	Both Pumps Off
09/21/06	18.98	42.0	1.79	84	83	99%	83	99%	Yes	Yes	Both Pumps Off
09/25/06	18.48	42.3	1.80	85	82	96%	82	96%	Yes	Yes	Old Well On
09/28/06	18.17	42.5	1.79	85	84	99%	84	99%	Yes	Yes	Old Well On
10/02/06	18.38	42.4	1.84	85	84	99%	84	99%	Yes	Yes	Both Pumps Off
10/05/06	19.81	42.3	1.88	85	84	99%	84	99%	Yes	Yes	Both Pumps Off
10/10/06	21.34	42.3	1.80	85	84	99%	84	99%	Yes	Yes	New Well On
10/12/06	18.84	42.9	1.78	86	84	98%	84	98%	Yes	Yes	New Well On
10/17/06	NF	42.8	1.80	86	84	98%	84	98%	Yes	Yes	Both Pumps 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)
NF = no flow reading taken

TABLE 3-9. Passage Transect 8 summary.

DATE	FLOW (CFS)	WETTED WIDTH (FT)	MEAN DEPTH (FT)	TOTAL # CELLS	25% CRITERIA		10% CRITERIA		MEETS CRITERIA*		PUMP STATUS
					# CELLS	%	# CELLS	%	25%	10%	
08/30/00	NF	41.2	2.10	83	76	92%	73	88%	Yes	Yes	Both Pumps Off
09/06/06	21.92	41.3	2.06	83	73	88%	71	86%	Yes	Yes	Both Pumps Off
09/11/06	19.21	41.6	2.05	84	75	89%	75	89%	Yes	Yes	Both Pumps On
09/14/06	20.54	40.9	2.00	81	69	85%	69	85%	Yes	Yes	Both Pumps On
09/18/06	18.66	40.7	2.06	82	70	85%	70	85%	Yes	Yes	Both Pumps Off
09/21/06	18.98	40.9	2.03	82	70	85%	70	85%	Yes	Yes	Both Pumps Off
09/25/06	18.48	41.3	2.03	83	71	86%	70	84%	Yes	Yes	Old Well On
09/28/06	18.17	41.4	2.06	83	73	88%	71	86%	Yes	Yes	Old Well On
10/02/06	18.38	41.3	2.03	83	75	90%	75	90%	Yes	Yes	Both Pumps Off
10/05/06	19.81	41.2	2.09	83	78	94%	78	94%	Yes	Yes	Both Pumps Off
10/10/06	21.34	41.3	2.07	83	74	89%	71	86%	Yes	Yes	New Well On
10/12/06	18.84	41.5	2.03	83	77	93%	77	93%	Yes	Yes	New Well On
10/17/06	NF	41.2	2.05	83	71	86%	71	86%	Yes	Yes	Both Pumps 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)
NF = no flow reading taken

TABLE 3-10. Passage Transect 9 summary.

DATE	FLOW (CFS)	WETTED WIDTH (FT)	MEAN DEPTH (FT)	TOTAL # CELLS	25% CRITERIA		10% CRITERIA		MEETS CRITERIA*		PUMP STATUS
					# CELLS	%	# CELLS	%	25%	10%	
08/30/06	NF	13.9	0.74	28	21	75%	21	75%	Yes	Yes	Both Pumps Off
09/06/06	21.92	13.4	0.65	27	21	78%	21	78%	Yes	Yes	Both Pumps Off
09/11/06	19.21	13.9	0.67	28	23	82%	23	82%	Yes	Yes	Both Pumps On
09/14/06	20.54	13.3	0.72	27	23	85%	23	85%	Yes	Yes	Both Pumps On
09/18/06	18.66	13.2	0.67	27	22	81%	22	81%	Yes	Yes	Both Pumps Off
09/21/06	18.98	13.3	0.62	27	17	63%	17	63%	Yes	Yes	Both Pumps Off
09/25/06	18.48	13.8	0.63	28	19	68%	15	54%	Yes	Yes	Old Well On
09/28/06	18.17	13.7	0.63	28	20	71%	13	46%	Yes	Yes	Old Well On
10/02/06	18.38	13.4	0.70	27	22	81%	22	81%	Yes	Yes	Both Pumps Off
10/05/06	19.81	13.7	0.74	28	24	86%	24	86%	Yes	Yes	Both Pumps Off
10/10/06	21.34	13.9	0.69	28	23	82%	23	82%	Yes	Yes	New Well On
10/12/06	18.84	14.2	0.64	29	22	76%	22	76%	Yes	Yes	New Well On
10/17/06	NF	14.2	0.66	29	23	79%	23	79%	Yes	Yes	Both Pumps 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)
NF = no flow reading taken

TABLE 3-11. Passage Transect 10 summary.

DATE	FLOW (CFS)	WETTED WIDTH (FT)	MEAN DEPTH (FT)	TOTAL # CELLS	25% CRITERIA		10% CRITERIA		MEETS CRITERIA*		PUMP STATUS
					# CELLS	%	# CELLS	%	25%	10%	
08/30/06	NF	34.7	0.59	70	35	50%	6	9%	Yes	**No**	Both Pumps Off
09/06/06	21.92	34.9	0.52	70	39	56%	16	23%	Yes	Yes	Both Pumps Off
09/11/06	19.21	34.9	0.51	70	32	46%	8	11%	Yes	Yes	Both Pumps On
09/14/06	20.54	34.4	0.50	69	29	42%	6	9%	Yes	**No**	Both Pumps On
09/18/06	18.66	34.4	0.49	69	30	43%	12	17%	Yes	Yes	Both Pumps Off
09/21/06	18.98	34.2	0.47	69	27	39%	6	9%	Yes	**No**	**Both Pumps Off**
09/25/06	18.48	34.5	0.47	69	28	41%	6	9%	Yes	**No**	**Old Well On**
09/28/06	18.17	33.8	0.49	68	28	41%	11	16%	Yes	Yes	Old Well On
10/02/06	18.38	34.3	0.49	69	26	38%	9	13%	Yes	Yes	Both Pumps Off
10/05/06	19.81	34.7	0.54	70	33	47%	6	9%	Yes	**No**	Both Pumps Off
10/10/06	21.34	34.7	0.48	70	28	40%	13	19%	Yes	Yes	New Well On
10/12/06	18.84	34.4	0.50	69	32	46%	13	19%	Yes	Yes	New Well On
10/17/06	NF	34.2	0.53	69	36	52%	12	17%	Yes	Yes	Both Pumps 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)
NF = no flow reading taken

TABLE 3-12. Passage Transect 11 summary.

DATE	FLOW (CFS)	WETTED WIDTH (FT)	MEAN DEPTH (FT)	TOTAL # CELLS	25% CRITERIA		10% CRITERIA		MEETS CRITERIA*		PUMP STATUS
					# CELLS	%	# CELLS	%	25%	10%	
08/30/06	NF										Both Pumps Off
09/06/06	21.92	32.9	0.45	66	14	21%	11	17%	**No**	Yes	Both Pumps Off
09/11/06	19.21	33.9	0.45	68	16	24%	11	16%	**No**	Yes	Both Pumps On
09/14/06	20.54	32.9	0.45	66	13	20%	7	11%	**No**	Yes	Both Pumps On
09/18/06	18.66	32.9	0.39	66	11	17%	6	9%	**No**	**No**	Both Pumps Off
09/21/06	18.98	33.1	0.40	67	11	16%	6	9%	**No**	**No**	Both Pumps Off
09/25/06	18.48	33.2	0.39	67	12	18%	11	16%	**No**	Yes	Old Well On
09/28/06	18.17	33.7	0.42	68	13	19%	6	9%	**No**	**No**	Old Well On
10/02/06	18.38	33.5	0.42	67	12	18%	6	9%	**No**	**No**	Both Pumps Off
10/05/06	19.81	33.2	0.48	67	19	28%	8	12%	Yes	Yes	Both Pumps Off
10/10/06	21.34	33.9	0.41	68	14	21%	6	9%	**No**	**No**	New Well On
10/12/06	18.84	33.4	0.45	66	19	29%	9	14%	Yes	Yes	New Well On
10/17/06	NF	33.2	0.43	67	16	24%	8	12%	**No**	Yes	Both Pumps 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)
NF = no flow reading taken

TABLE 3-13. Results of statistical tests for significance for water quality parameters between environmental baseline reference reach and within the zone of influence for periods of both pumping and not pumping.

Parameter:			DO				Temperature				EC			
Date	No. Pumps	Pump Operations	transects 4-9	transects 10-11*	significant	*P* value	transects 4-9	transects 10-11*	significant	*P* value	transects 4-9	transects 10-11*	significant	*P* value
			median	median			median	median			median	median		
8/30/06	0	Pumps off	11.5	12.3	yes	0.006	14.8	14.8	no	0.622	234	233	no	0.393
9/12/06	**2**	**Both Pumps On**	**9.8**	**10.2**	**no**	**0.053**	**17.0**	**17.3**	**yes**	**0.001**	**291**	**293**	**yes**	**0.010**
9/14/06	2	Both Pumps On	10.9	11.5	yes	0.006	15.3	15.5	yes	0.004	198	198	no	0.439
9/18/06	0	Pumps off	10.5	11.0	yes	<0.001	16.0	16.2	yes	0.007	202	202	no	0.439
9/21/06	0	Pumps off	10.4	10.9	yes	0.018	15.9	15.8	no	0.243	278	277	no	0.367
9/25/06	1	Old Pump	11.6	12.4	yes	<0.001	14.2	14.7	yes	<0.001	237	239	yes	0.006
9/28/06	1	Old Pump	11.9	11.5	yes	0.040	15.3	15.5	yes	0.017	243	244	no	0.189
10/2/06	0	Pumps off	10.9	11.5	yes	<0.001	15.0	14.8	yes	0.015	240	238	yes	0.014
10/5/06	0	Pumps off	10.9	11.9	yes	<0.001	15.3	14.7	no	0.089	241	237	yes	0.006
10/10/06	1	New Pump	11.5	12.0	yes	0.004	14.1	14.1	no	0.152	234	233	no	0.332

* transect 11 not sampled on 8/30/06

TABLE 3-14. Results of statistical tests for significance within the zone of influence between periods of pumping and not pumping.

Parameter:			DO			Temperature			EC		
Date	No. Pumps	Pump Operations	transects 4-9	significant	*P* value	transects 4-9	significant	*P* value	transects 4-9	significant	*P* value
			median			median			median		
8/30/06	0	Pumps off	11.5			14.8			234		
9/14/06	2	Both Pumps On	10.9			15.3			198		
ANOVA				**YES**	**0.006**		**YES**	**0.031**		**YES**	**<0.001**
9/14/06	2	Both Pumps On	10.9			15.3			198		
9/21/06	0	Pumps off	10.4			15.9			278		
ANOVA				**YES**	**0.016**		**YES**	**<0.001**		**YES**	**0.002**
9/21/06	0	Pumps off	10.4			15.9			278		
9/28/06	1	Old Pump	11.9			15.3			243		
ANOVA				**YES**	**<0.001**		**YES**	**<0.001**		**YES**	**<0.001**
9/28/06	1	Old Pump	11.9			15.3			243		
10/5/06	0	Pumps off	10.9			15.3			241		
ANOVA				**YES**	**<0.001**		**NO**	**0.085**		**YES**	**<0.001**

TABLE 4-1. Daily El Sur Ranch diversions during the 2006 habitat monitoring surveys.

Date	New Well ac-ft/day	New Well (cfs)	Old Well ac-ft/day	Old Well (cfs)
08/30/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
08/31/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
09/01/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
09/02/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
09/03/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
09/04/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
09/05/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
09/06/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
09/07/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
09/08/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
09/09/06	**7.21**	**3.52**	**4.93**	**2.41**
09/10/06	**6.94**	**3.47**	**4.81**	**2.41**
09/11/06	**7.11**	**3.47**	**4.94**	**2.41**
09/12/06	**6.99**	**3.42**	**4.92**	**2.41**
09/13/06	**8.38**	**3.42**	**5.90**	**2.41**
09/14/06	**3.72**	**3.20**	**2.80**	**2.41**
09/15/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
09/16/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
09/17/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
09/18/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
09/19/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
09/20/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
09/21/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
09/22/06	*Pumps Off*	*Pumps Off*	**4.81**	**2.44**
09/23/06	*Pumps Off*	*Pumps Off*	**4.84**	**2.45**
09/24/06	*Pumps Off*	*Pumps Off*	**4.86**	**2.44**
09/25/06	*Pumps Off*	*Pumps Off*	**4.97**	**2.31**
09/26/06	*Pumps Off*	*Pumps Off*	**4.70**	**2.57**
09/27/06	*Pumps Off*	*Pumps Off*	**4.72**	**2.39**
09/28/06	*Pumps Off*	*Pumps Off*	**4.74**	**2.43**
09/29/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
09/30/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
10/01/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
10/02/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
10/03/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
10/04/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
10/05/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
10/06/06	**4.02**	**2.93**	*Pumps Off*	*Pumps Off*
10/07/06	**5.81**	**2.94**	*Pumps Off*	*Pumps Off*
10/08/06	**5.94**	**2.89**	*Pumps Off*	*Pumps Off*
10/09/06	**4.59**	**2.35**	*Pumps Off*	*Pumps Off*
10/10/06	**6.68**	**3.39**	*Pumps Off*	*Pumps Off*
10/11/06	**5.78**	**2.94**	*Pumps Off*	*Pumps Off*
10/12/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
10/13/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
10/14/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
10/15/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
10/16/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*
10/17/06	*Pumps Off*	*Pumps Off*	*Pumps Off*	*Pumps Off*

TABLE 4-2. Potential habitat response to critical low flow years (used with permission; SGI 2007).

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

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

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

APPENDIX A

Appendix A

Results of the Statistical Analysis

ANOVA Tests

8/30/06 (pumping off) vs. 9/14/06 (both pumps on) DO

Three Way Analysis of Variance   Monday, March 26, 2007, 18:28:16

Data source: Data 1 in Notebook

Balanced Design (No Interactions)

Dependent Variable: 9-28-dooff

Normality Test: Failed (P = 0.002)

Equal Variance Test: Passed (P = 1.000)

```
Source of Variation   DF    SS     MS     F      P
9-28-oldpumpon        1     6.401  6.401  12.235 0.006
9-28-loc       2      9.816  4.908  9.381  0.005
9-28-tras      5      12.136 2.427  4.640  0.019
Residual       10     5.232  0.523
Total   35     40.911 1.169
```

The difference in the mean values among the different levels of 9-28-oldpumpon are greater than would be expected by chance after allowing for the effects of differences in 9-28-loc and 9-28-tras. There is a statistically significant difference (P = 0.006). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of 9-28-loc are greater than would be expected by chance after allowing for the effects of differences in 9-28-oldpumpon and 9-28-tras. There is a statistically significant difference (P = 0.005). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of 9-28-tras are greater than would be expected by chance after allowing for the effects of differences in 9-28-oldpumpon and 9-28-loc. There is a statistically significant difference (P = 0.019). To isolate which group(s) differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor: 9-28-oldpumpon

```
Comparison    Diff of Means p     q      P      P<0.050
0.000 vs. 2.000       0.843  2    4.947  0.006  Yes
```

Comparisons for factor: 9-28-loc

Comparison	Diff of Means	p	q	P	P<0.050
M vs. R	1.187	3	5.683	0.006	Yes
M vs. L	0.180	3	0.862	0.818	No
L vs. R	1.007	3	4.821	0.017	Yes

Comparisons for factor: 9-28-tras

Comparison	Diff of Means	p	q	P	P<0.050
9.000 vs. 7.000	1.678	6	5.684	0.022	Yes
9.000 vs. 6.000	1.482	6	5.018	0.045	Yes
9.000 vs. 8.000	1.080	6	3.657	0.187	No
9.000 vs. 5.000	0.837	6	2.833	0.403	Do Not Test
9.000 vs. 4.000	0.417	6	1.411	0.909	Do Not Test

8/30/06 (pumping off) vs. 9/14/06 (both pumps on) EC

Three Way Analysis of Variance Monday, March 26, 2007, 18:27:10

Data source: Data 1 in Notebook

Balanced Design (No Interactions)

Dependent Variable: 9-28-ecoff

Normality Test: Failed (P = <0.001)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	DF	SS	MS	F	P
9-28-oldpumpon	1	11953.778	11953.778	1080.703	<0.001
9-28-loc	2	111.056	55.528	5.020	0.031
9-28-tras	5	68.889	13.778	1.246	0.358
Residual	10	110.611	11.061		
Total	35	12359.556	353.130		

The difference in the mean values among the different levels of 9-28-oldpumpon are greater than would be expected by chance after allowing for the effects of differences in 9-28-loc and 9-28-tras. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of 9-28-loc are greater than would be expected by chance after allowing for the effects of differences in 9-28-oldpumpon and 9-28-tras. There is a statistically significant difference (P = 0.031). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of 9-28-tras are not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in 9-28-oldpumpon and 9-28-loc. There is not a statistically significant difference (P = 0.358).

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor: 9-28-oldpumpon

Comparison	Diff of Means	p	q	P	P<0.050
0.000 vs. 2.000	36.444	2	46.491	<0.001	Yes

Comparisons for factor: 9-28-loc

Comparison	Diff of Means	p	q	P	P<0.050
L vs. R3.917	3	4.080	0.040	Yes	
L vs. M	0.417 3	0.434	0.950	No	
M vs. R	3.500 3	3.646	0.065	No	

Power of performed test with alpha = 0.0500: for 9-28-oldpumpon : 1.000
Power of performed test with alpha = 0.0500: for 9-28-loc : 0.575
Power of performed test with alpha = 0.0500: for 9-28-tras : 0.0861

Least square means for 9-28-oldpumpon :

Group	Mean
2.000	196.667
0.000	233.111

8/30/06 (pumping off) vs. 9/14/06 (both pumps on) Temperature (°C)

Three Way Analysis of Variance Monday, March 26, 2007, 18:25:56

Data source: Data 1 in Notebook

Balanced Design (No Interactions)

Dependent Variable: 9-28-toff

Normality Test: Failed (P = <0.001)

Equal Variance Test: Passed (P = 1.000)

```
Source of Variation   DF    SS      MS      F      P
9-28-oldpumpon        1     1.040   1.040   6.254  0.031
9-28-loc      2       1.626  0.813  4.889  0.033
9-28-tras     5       1:579  0.316  1.898  0.182
Residual      10      1.664  0.166
Total   35    8.185   0.234
```

The difference in the mean values among the different levels of 9-28-oldpumpon are greater than would be expected by chance after allowing for the effects of differences in 9-28-loc and 9-28-tras. There is a statistically significant difference (P = 0.031). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of 9-28-loc are greater than would be expected by chance after allowing for the effects of differences in 9-28-oldpumpon and 9-28-tras. There is a statistically significant difference (P = 0.033). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of 9-28-tras are not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in 9-28-oldpumpon and 9-28-loc. There is not a statistically significant difference (P = 0.182).

All Pairwise Multiple Comparison Procedures (Tukey Test):

```
Comparisons for factor: 9-28-oldpumpon
Comparison    Diff of Means p      q      P      P<0.050
2.000 vs. 0.000       0.340  2     3.537  0.032  Yes
```

```
Comparisons for factor: 9-28-loc
Comparison    Diff of Means p      q      P      P<0.050
L vs. R0.492  3       4.183  0.035  Yes
L vs. M       0.1000 3       0.849  0.823  No
M vs. R       0.393  3       3.334  0.093  No
```

Power of performed test with alpha = 0.0500: for 9-28-oldpumpon : 0.540
Power of performed test with alpha = 0.0500: for 9-28-loc : 0.560

Power of performed test with alpha = 0.0500: for 9-28-tras : 0.205

```
Least square means for 9-28-oldpumpon :
Group  Mean
2.000  15.157
0.000  14.817
```

9/14/06 (both pumps on) vs. 9/21/06 (pumping off): Temperature (°C)

Three Way Analysis of Variance   Monday, March 26, 2007, 17:54:16

Data source: Data 1 in Notebook

Balanced Design (No Interactions)

Dependent Variable: 9-28-toff

Normality Test: Passed (P > 0.200)

Equal Variance Test: Passed (P = 1.000)

```
Source of Variation   DF    SS     MS     F      P
9-28-oldpumpon        1     3.822  3.822  64.407 <0.001
9-28-loc      2       1.421  0.711  11.977 0.002
9-28-tras     5       2.274  0.455  7.663  0.003
Residual      10      0.593  0.0593
Total   35      11.356 0.324
```

The difference in the mean values among the different levels of 9-28-oldpumpon are greater than would be expected by chance after allowing for the effects of differences in 9-28-loc and 9-28-tras. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of 9-28-loc are greater than would be expected by chance after allowing for the effects of differences in 9-28-oldpumpon and 9-28-tras. There is a statistically significant difference (P = 0.002). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of 9-28-tras are greater than would be expected by chance after allowing for the effects of differences in 9-28-

oldpumpon and 9-28-loc. There is a statistically significant difference (P = 0.003). To isolate which group(s) differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Tukey Test):

```
Comparisons for factor: 9-28-oldpumpon
Comparison    Diff of Means p      q       P      P<0.050
0.000 vs. 2.000        0.652  2      11.350 <0.001 Yes
```

```
Comparisons for factor: 9-28-loc
Comparison    Diff of Means p      q       P      P<0.050
L vs. R0.430  3       6.115  0.004  Yes
L vs. M       0.0175 3       0.249  0.983  No
M vs. R       0.412  3       5.866  0.005  Yes
```

```
Comparisons for factor: 9-28-tras
Comparison    Diff of Means p      q       P      P<0.050
9.000 vs. 7.000       0.763  6      7.676  0.003  Yes
9.000 vs. 6.000       0.317  6      3.184  0.295  No
9.000 vs. 8.000       0.253  6      2.547  0.505  Do Not Test
9.000 vs. 5.000       0.147  6      1.475  0.893  Do Not Test
9.000 vs. 4.000       0.0550 6      0.553  0.998  Do Not Test
```

9/14/06 (both pumps on) vs. 9/21/06 (pumping off): EC

Three Way Analysis of Variance   Monday, March 26, 2007, 17:55:52

Data source: Data 1 in Notebook

Balanced Design (No Interactions)

Dependent Variable: 9-28-ecoff

Normality Test: Failed (P = 0.009)

Equal Variance Test: Passed (P = 1.000)

```
Source of Variation    DF     SS       MS       F       P
9-28-oldpumpon         1      57760.111     57760.111     14106.947     <0.001
```

```
9-28-loc       2       96.056 48.028 11.730 0.002
9-28-tras      5       83.556 16.711 4.081  0.028
Residual       10      40.944 4.094
Total   35     58157.222      1661.635
```

The difference in the mean values among the different levels of 9-28-oldpumpon are greater than would be expected by chance after allowing for the effects of differences in 9-28-loc and 9-28-tras. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of 9-28-loc are greater than would be expected by chance after allowing for the effects of differences in 9-28-oldpumpon and 9-28-tras. There is a statistically significant difference (P = 0.002). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of 9-28-tras are greater than would be expected by chance after allowing for the effects of differences in 9-28-oldpumpon and 9-28-loc. There is a statistically significant difference (P = 0.028). To isolate which group(s) differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Tukey Test):

```
Comparisons for factor: 9-28-oldpumpon
Comparison    Diff of Means p      q        P      P<0.050
0.000 vs. 2.000         80.111 2   167.970         <0.001 Yes
```

```
Comparisons for factor: 9-28-loc
Comparison    Diff of Means p      q        P      P<0.050
M vs. R       3.583  3      6.135  0.004  Yes
M vs. L       0.250  3      0.428  0.951  No
L vs. R3.333  3      5.707  0.006  Yes
```

```
Comparisons for factor: 9-28-tras
Comparison    Diff of Means p      q      P      P<0.050
9.000 vs. 7.000      4.500  6      5.447  0.028  Yes
9.000 vs. 6.000      1.500  6      1.816  0.787  No
9.000 vs. 8.000      1.000  6      1.211  0.949  Do Not Test
9.000 vs. 5.000      0.333  6      0.404  1.000  Do Not Test
9.000 vs. 4.000      0.333  6      0.404  1.000  Do Not Test
```

9/14/06 (both pumps on) vs. 9/21/06 (pumping off): DO

Three Way Analysis of Variance   Monday, March 26, 2007, 17:50:38

Data source: Data 1 in Notebook

Balanced Design (No Interactions)

Dependent Variable: 9-28-dooff

Normality Test: Passed (P = 0.138)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	DF	SS	MS	F	P
9-28-oldpumpon	1	2.069	2.069	8.383	0.016
9-28-loc	2	8.677	4.339	17.580	<0.001
9-28-tras	5	10.808	2.162	8.758	0.002
Residual	10	2.468	0.247		
Total	35	31.873	0.911		

The difference in the mean values among the different levels of 9-28-oldpumpon are greater than would be expected by chance after allowing for the effects of differences in 9-28-loc and 9-28-tras. There is a statistically significant difference (P = 0.016). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of 9-28-loc are greater than would be expected by chance after allowing for the effects of differences in 9-28-oldpumpon and 9-28-tras. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of 9-28-tras are greater than would be expected by chance after allowing for the effects of differences in 9-28-oldpumpon and 9-28-loc. There is a statistically significant difference (P = 0.002). To isolate which group(s) differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor: 9-28-oldpumpon

Comparison	Diff of Means	p	q	P	P<0.050
2.000 vs. 0.000	0.479	2	4.095	0.016	Yes

```
Comparisons for factor: 9-28-loc
Comparison    Diff of Means p       q       P       P<0.050
M vs. R       1.085   3       7.566   0.001   Yes
M vs. L       0.0933 3        0.651   0.891   No
L vs. R0.992  3       6.915   0.002   Yes
```

```
Comparisons for factor: 9-28-tras
Comparison    Diff of Means p       q       P       P<0.050
9.000 vs. 7.000       1.618   6       7.980   0.002   Yes
9.000 vs. 6.000       0.998   6       4.922   0.050   Yes
9.000 vs. 8.000       0.987   6       4.865   0.053   No
9.000 vs. 5.000       0.647   6       3.189   0.294   Do Not Test
9.000 vs. 4.000       0.152   6       0.748   0.994   Do Not Test
```

9/21/06 (pumping off) vs. 9/28/06 (Old Pump on): Temperature (°C)

Three Way Analysis of Variance   Monday, March 26, 2007, 18:19:26

Data source: Data 1 in Notebook

Balanced Design (No Interactions)

Dependent Variable: 9-28-toff

Normality Test: Passed (P = 0.043)

Equal Variance Test: Passed (P = 1.000)

```
Source of Variation   DF      SS      MS      F       P
9-28-oldpumpon        1       2.486   2.486   143.118         <0.001
9-28-loc      2       0.401   0.200   11.541 0.003
9-28-tras     5       0.719   0.144   8.280   0.003
Residual      10      0.174   0.0174
Total   35    4.784   0.137
```

The difference in the mean values among the different levels of 9-28-oldpumpon are greater than would be expected by chance after allowing for the effects of differences in 9-28-loc and 9-28-tras. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of 9-28-loc are greater than would be expected by chance after allowing for the effects of differences in 9-28-oldpumpon and 9-28-tras. There is a statistically significant difference (P = 0.003). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of 9-28-tras are greater than would be expected by chance after allowing for the effects of differences in 9-28-oldpumpon and 9-28-loc. There is a statistically significant difference (P = 0.003). To isolate which group(s) differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Tukey Test):

```
Comparisons for factor: 9-28-oldpumpon
Comparison    Diff of Means p     q        P      P<0.050
0.000 vs. 1.000       0.526  2     16.919 <0.001 Yes
```

```
Comparisons for factor: 9-28-loc
Comparison    Diff of Means p     q        P      P<0.050
M vs. R       0.238   3       6.264   0.003   Yes
M vs. L       0.0325 3        0.854   0.821   No
L vs. R0.206  3       5.410   0.009   Yes
```

```
Comparisons for factor: 9-28-tras
Comparison    Diff of Means p     q        P      P<0.050
9.000 vs. 7.000       0.427  6     7.930  0.002  Yes
9.000 vs. 8.000       0.345  6     6.412  0.010  Yes
9.000 vs. 6.000       0.295  6     5.483  0.027  Yes
9.000 vs. 5.000       0.225  6     4.182  0.109  No
9.000 vs. 4.000       0.125  6     2.323  0.592  Do Not Test
```

9/21/06 (pumping off) vs. 9/28/06 (Old Pump on): EC

Three Way Analysis of Variance   Monday, March 26, 2007, 18:20:16

Data source: Data 1 in Notebook

Balanced Design (No Interactions)

Dependent Variable: 9-28-ecoff

```
Normality Test:        Passed (P > 0.200)

Equal Variance Test:  Passed (P = 1.000)

Source of Variation    DF     SS       MS       F       P
9-28-oldpumpon      1       10370.028     10370.028     7436.673       <0.001
9-28-loc       2       31.056 15.528 11.135 0.003
9-28-tras      5       13.806 2.761  1.980  0.167
Residual       10      13.944 1.394
Total   35     10477.639      299.361
```

The difference in the mean values among the different levels of 9-28-oldpumpon are greater than would be expected by chance after allowing for the effects of differences in 9-28-loc and 9-28-tras. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of 9-28-loc are greater than would be expected by chance after allowing for the effects of differences in 9-28-oldpumpon and 9-28-tras. There is a statistically significant difference (P = 0.003). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of 9-28-tras are not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in 9-28-oldpumpon and 9-28-loc. There is not a statistically significant difference (P = 0.167).

All Pairwise Multiple Comparison Procedures (Tukey Test):

```
Comparisons for factor: 9-28-oldpumpon
Comparison    Diff of Means p       q       P       P<0.050
0.000 vs. 1.000        33.944 2     121.956       <0.001 Yes


Comparisons for factor: 9-28-loc
Comparison    Diff of Means p       q       P       P<0.050
M vs. R       2.083  3       6.112  0.004  Yes
M vs. L       0.250  3       0.733  0.864  No
L vs. R1.833  3       5.378  0.009  Yes
```

Power of performed test with alpha = 0.0500: for 9-28-oldpumpon : 1.000
Power of performed test with alpha = 0.0500: for 9-28-loc : 0.946
Power of performed test with alpha = 0.0500: for 9-28-tras : 0.221

Least square means for 9-28-oldpumpon :

Group	Mean
1.000	242.833
0.000	276.778

9/21/06 (pumping off) vs. 9/28/06 (Old Pump on): DO

Three Way Analysis of Variance Monday, March 26, 2007, 18:20:52

Data source: Data 1 in Notebook

Balanced Design (No Interactions)

Dependent Variable: 9-28-dooff

Normality Test: Passed (P = 0.086)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	DF	SS	MS	F	P
9-28-oldpumpon	1	10.134	10.134	154.414	<0.001
9-28-loc	2	5.375	2.688	40.952	<0.001
9-28-tras	5	7.376	1.475	22.478	<0.001
Residual	10	0.656	0.0656		
Total	35	26.494	0.757		

The difference in the mean values among the different levels of 9-28-oldpumpon are greater than would be expected by chance after allowing for the effects of differences in 9-28-loc and 9-28-tras. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of 9-28-loc are greater than would be expected by chance after allowing for the effects of differences in 9-28-oldpumpon and 9-28-tras. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of 9-28-tras are greater than would be expected by chance after allowing for the effects of differences in 9-28-oldpumpon and 9-28-loc. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

```
All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor: 9-28-oldpumpon
Comparison   Diff of Means p      q      P      P<0.050
1.000 vs. 0.000        1.061  2      17.574 <0.001 Yes


Comparisons for factor: 9-28-loc
Comparison   Diff of Means p      q      P      P<0.050
M vs. R      0.895   3      12.103 <0.001 Yes
M vs. L      0.181   3      2.445  0.242  No
L vs. R0.714 3       9.657  <0.001 Yes


Comparisons for factor: 9-28-tras
Comparison   Diff of Means p      q      P      P<0.050
4.000 vs. 8.000        1.102  6      10.534 <0.001 Yes
4.000 vs. 7.000        1.102  6      10.534 <0.001 Yes
4.000 vs. 6.000        1.050  6      10.040 <0.001 Yes
4.000 vs. 5.000        0.613  6      5.865  0.018  Yes
4.000 vs. 9.000        0.160  6      1.530  0.878  No
```

9/28/06 (Old Pump on) vs. 10/5/06 (pumping off): Temperature (°C)

Three Way Analysis of Variance   Monday, March 26, 2007, 18:14:01

Data source: Data 1 in Notebook

Balanced Design (No Interactions)

Dependent Variable: 10-5-toff

Normality Test: Failed (P = 0.005)

Equal Variance Test: Passed (P = 1.000)

```
Source of Variation    DF    SS     MS     F     P
10-5-Pumps-off         1     0.0961 0.0961 3.642 0.085
10-5-loc        2      0.308 0.154  5.830  0.021
10-5-tras       5      0.652 0.130  4.946  0.015
Residual        10     0.264 0.0264
Total   35      2.154  0.0615
```

The difference in the mean values among the different levels of 10-5-Pumps-off are not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in 10-5-loc and 10-5-tras. There is not a statistically significant difference (P = 0.085).

The difference in the mean values among the different levels of 10-5-loc are greater than would be expected by chance after allowing for the effects of differences in 10-5-Pumps-off and 10-5-tras. There is a statistically significant difference (P = 0.021). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of 10-5-tras are greater than would be expected by chance after allowing for the effects of differences in 10-5-Pumps-off and 10-5-loc. There is a statistically significant difference (P = 0.015). To isolate which group(s) differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Tukey Test):

```
Comparisons for factor: 10-5-loc
Comparison    Diff of Means p    q     P     P<0.050
M vs. R       0.210  3      4.479 0.025 Yes
M vs. L       0.0317 3      0.675 0.883 No
L vs. R0.178  3      3.803  0.055 No
```

```
Comparisons for factor: 10-5-tras
Comparison      Diff of Means p      q      P      P<0.050
9.000 vs. 7.000        0.438  6      6.610  0.008  Yes
9.000 vs. 5.000        0.337  6      5.077  0.042  Yes
9.000 vs. 6.000        0.318  6      4.801  0.056  No
9.000 vs. 8.000        0.255  6      3.845  0.155  Do Not Test
9.000 vs. 4.000        0.245  6      3.695  0.180  Do Not Test
4.000 vs. 7.000        0.193  6      2.916  0.375  No
4.000 vs. 5.000        0.0917 6      1.382  0.915  Do Not Test
4.000 vs. 6.000        0.0733 6      1.106  0.965  Do Not Test
4.000 vs. 8.000        0.01000       6      0.151  1.000  Do Not Test
8.000 vs. 7.000        0.183  6      2.765  0.426  Do Not Test
8.000 vs. 5.000        0.0817 6      1.232  0.945  Do Not Test
```

9/28/06 (Old Pump on) vs. 10/5/06 (pumping off): EC

```
Three Way Analysis of Variance      Monday, March 26, 2007, 18:15:01

Data source: Data 1 in Notebook

Balanced Design (No Interactions)

Dependent Variable: 10-5-ecoff

Normality Test:         Passed (P = 0.087)

Equal Variance Test:  Passed (P = 1.000)

Source of Variation    DF    SS      MS      F       P
10-5-Pumps-off         1     53.778 53.778 24.694 <0.001
10-5-loc        2      29.556 14.778 6.786  0.014
10-5-tras       5      23.222 4.644  2.133  0.144
Residual        10     21.778 2.178
Total   35      194.556         5.559
```

The difference in the mean values among the different levels of 10-5-Pumps-off are greater than would be expected by chance after allowing for the effects of differences in 10-5-loc and 10-5-tras. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of 10-5-loc are greater than would be expected by chance after allowing for the effects of differences in 10-5-Pumps-off and 10-5-tras. There is a statistically significant difference (P = 0.014). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of 10-5-tras are not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in 10-5-Pumps-off and 10-5-loc. There is not a statistically significant difference (P = 0.144).

All Pairwise Multiple Comparison Procedures (Tukey Test):

```
Comparisons for factor: 10-5-Pumps-off
Comparison    Diff of Means p       q       P       P<0.050
1.000 vs. 0.000         2.444  2       7.028   <0.001 Yes
```

```
Comparisons for factor: 10-5-loc
Comparison    Diff of Means p       q       P       P<0.050
M vs. R       2.000   3       4.695   0.019   Yes
M vs. L       0.167   3       0.391   0.959   No
L vs. R1.833  3       4.304   0.031   Yes
```

Power of performed test with alpha = 0.0500: for 10-5-Pumps-off : 0.995
Power of performed test with alpha = 0.0500: for 10-5-loc : 0.747
Power of performed test with alpha = 0.0500: for 10-5-tras : 0.252

```
Least square means for 10-5-Pumps-off :
Group  Mean
1.000  242.833
0.000  240.389
```

9/28/06 (Old Pump on) vs. 10/5/06 (pumping off): DO

Three Way Analysis of Variance   Monday, March 26, 2007, 18:16:00

Data source: Data 1 in Notebook

Balanced Design (No Interactions)

Dependent Variable: 10-5-dooff

```
Normality Test:         Failed  (P = <0.001)

Equal Variance Test:  Passed (P = 1.000)

Source of Variation     DF      SS      MS      F       P
10-5-Pumps-off          1       2.806   2.806   38.625 <0.001
10-5-loc        2       6.954   3.477   47.867 <0.001
10-5-tras       5       7.491   1.498   20.626 <0.001
Residual        10      0.726   0.0726
Total   35      23.556 0.673
```

The difference in the mean values among the different levels of 10-5-Pumps-off are greater than would be expected by chance after allowing for the effects of differences in 10-5-loc and 10-5-tras. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of 10-5-loc are greater than would be expected by chance after allowing for the effects of differences in 10-5-Pumps-off and 10-5-tras. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of 10-5-tras are greater than would be expected by chance after allowing for the effects of differences in 10-5-Pumps-off and 10-5-loc. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Tukey Test):

```
Comparisons for factor: 10-5-Pumps-off
Comparison    Diff of Means p       q       P       P<0.050
1.000 vs. 0.000         0.558   2       8.789   <0.001 Yes


Comparisons for factor: 10-5-loc
Comparison    Diff of Means p       q       P       P<0.050
M vs. R         1.017   3       13.078 <0.001 Yes
M vs. L         0.204   3       2.624   0.202   No
L vs. R0.813    3       10.454 <0.001 Yes


Comparisons for factor: 10-5-tras
Comparison    Diff of Means p       q       P       P<0.050
4.000 vs. 6.000         1.153   6       10.482 <0.001 Yes
```

4.000 vs. 7.000	1.082	6	9.831	<0.001	Yes
4.000 vs. 8.000	0.703	6	6.392	0.010	Yes
4.000 vs. 5.000	0.687	6	6.241	0.012	Yes
4.000 vs. 9.000	0.0233	6	0.212	1.000	No

t-tests

Velocity VT-1

Normality Test: Failed (P = 0.005)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test Thursday, March 08, 2007, 10:34:26

Data source: Data 1 in Notebook

Group	N	Missing	Median	25%	75%
vt-1	12	0	2454002.000	2453991.500	2454012.500
discharge	12	0	18.910	18.430	20.175

T = 222.000 n(small)= 12 n(big)= 12 (P = <0.001)

The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (P = <0.001)

Velocity VT-1

```
t-test    Thursday, March 08, 2007, 10:41:48

Data source: Data 1 in Notebook

Normality Test:         Passed (P = 0.043)

Equal Variance Test:  Passed (P = 0.270)

Group Name              N      Missing          Mean   Std Dev         SEM
discharge-pumping       6      0                18.828 0.871           0.356
discharge-no-pumping 6      0                19.957 1.377           0.562

Difference       -1.128

t = -1.696  with 10 degrees of freedom. (P = 0.121)

95 percent confidence interval for difference of means: -2.611 to 0.354

The difference in the mean values of the two groups is not great enough to reject the
possibility that the difference is due to random sampling variability. There is not a
statistically significant difference between the i  nput groups (P = 0.121).

Power of performed test with alpha = 0.050: 0.226

The power of the performed test (0.226) is below the desired power of 0.800.
You should interpret the negative findings cautiously.
```

8/30/06: DO

Normality Test: Passed (P > 0.200)

Equal Variance Test: Passed (P = 0.079)

Group Name	*N*	Missing	Median	Mean	Std Dev	SEM
dooff	18	0		11.108	0.860	0.203
dooff1	3	0		12.317	0.0764	0.0441

Difference -1.208

t = -2.381 with 19 degrees of freedom. (P = 0.028)

95 percent confidence interval for difference of means: -2.270 to -0.146

The difference in the mean values of the two groups is greater than would be expected by chance; there is a statistically significant difference between the input groups (P = 0.028).

Power of performed test with alpha = 0.050: 0.530

The power of the performed test (0.530) is below the desired power of 0.800.
You should interpret the negative findings cautiously.

8/30/06: Temperature (°C)

Normality Test: Failed (P = <0.001)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test Monday, March 26, 2007, 15:41:58

Data source: Data 1 in Notebook

Group	*N*	Missing	Median	25%	75%
toff	18	0	14.870	14.750	15.170
toff1	3	0	14.710	14.710	14.710

T = 18.000 n(small)= 3 n(big)= 18 (P = 0.145)

The difference in the median values between the two groups is not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.145)

8/30/06: EC

```
Normality Test:        Failed  (P = <0.001)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test        Monday, March 26, 2007, 15:45:18

Group       N      Missing       Median       25%        75%
ecoff       18     0             234.000      232.000    236.000
ecoff1      3      0             233.000      233.000    233.000

T = 24.000  n(small)= 3  n(big)= 18  (P = 0.393)

The difference in the median values between the two groups is not great enough to
exclude the possibility that the difference is due to random sampling variability; there is
not a statistically significant difference  (P = 0.393)
```

9/12/06: DO

Normality Test: Failed (P = 0.002)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test Monday, March 26, 2007, 15:48:59

Group	*N*	Missing	Median	25%	75%
doon	18	0	9.815	9.490	10.140
doon1	6	0	10.190	10.050	10.240

T = 104.500 n(small)= 6 n(big)= 18 (P = 0.053)

The difference in the median values between the two groups is not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.053)

9/12/06: Temperature (°C)

Normality Test: Failed (P = <0.001)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test Monday, March 26, 2007, 15:47:14

Group	*N*	Missing	Median	25%	75%
ton	18	0	16.960	16.830	17.070
ton1	6	0	17.320	17.240	17.340

T = 124.000 n(small)= 6 n(big)= 18 (P = 0.001)

The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (P = 0.001)

9/12/06: EC

```
Normality Test:        Failed  (P = <0.001)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test        Monday, March 26, 2007, 15:50:21

Group        N     Missing      Median       25%          75%
econ         18    0            291.000      291.000      292.000
econ1        6     0            293.000      292.000      293.000

T = 114.000  n(small)= 6  n(big)= 18  (P = 0.010)

The difference in the median values between the two groups is greater than would be
expected by chance; there is a statistically significant difference  (P = 0.010)
```

9/14/06: DO

```
Normality Test:        Failed  (P = <0.001)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test        Monday, March 26, 2007, 15:54:53


Group        N     Missing      Median       25%          75%
doon         18    0            10.880       10.600       11.210
doon1        6     0            11.465       11.420       11.500

T = 117.000  n(small)= 6  n(big)= 18  (P = 0.006)

The difference in the median values between the two groups is greater than would be
expected by chance; there is a statistically significant difference  (P = 0.006)
```

9/14/06: Temperature (°C)

Data source: Data 1 in Notebook

Normality Test: Failed (P = <0.001)

Mann-Whitney Rank Sum Test Monday, March 26, 2007, 15:56:44

Data source: Data 1 in Notebook

Group	*N*	Missing	Median	25%	75%
ton	18	0	15.265	15.210	15.380
ton1	6	0	15.510	15.470	15.510

T = 118.500 n(small)= 6 n(big)= 18 (P = 0.004)

The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (P = 0.004)

9/14/06: EC

Normality Test: Failed (P = <0.001)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test Monday, March 26, 2007, 15:57:43

Group	N	Missing	Median	25%	75%
econ	18	0	198.000	197.000	198.000
econ1	6	0	198.000	198.000	198.000

T = 87.000 n(small)= 6 n(big)= 18 (P = 0.439)

The difference in the median values between the two groups is not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.439)

9/18/06: DO

```
Data source: Data 1 in Notebook

Normality Test:        Failed  (P = 0.007)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test       Monday, March 26, 2007, 16:01:20

Group        N     Missing      Median      25%        75%
dooff        18    0            10.500      10.050     10.750
dooffl       6     0            10.985      10.950     11.100

T = 125.000  n(small)= 6  n(big)= 18  (P = <0.001)

The difference in the median values between the two groups is greater than would be
expected by chance; there is a statistically significant difference  (P = <0.001)
```

9/18/06: Temperature (°C)

```
Normality Test:        Failed  (P = 0.001)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test       Monday, March 26, 2007, 15:59:03

Group        N     Missing      Median      25%        75%
toff         18    0            16.030      15.950     16.160
toffl        6     0            16.215      16.160     16.260

T = 116.000  n(small)= 6  n(big)= 18  (P = 0.007)

The difference in the median values between the two groups is greater than would be
expected by chance; there is a statistically significant difference  (P = 0.007)
```

9/18/06: EC

```
Data source: Data 1 in Notebook

Normality Test:        Failed  (P = <0.001)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test       Monday, March 26, 2007, 16:00:12

Group        N      Missing       Median        25%          75%
ecoff        18     0             202.000       201.000      202.000
ecoff1       6      0             202.000       202.000      202.000

T = 87.000  n(small)= 6  n(big)= 18  (P = 0.439)

The difference in the median values between the two groups is not great enough to
exclude the possibility that the difference is due to random sampling variability; there is
not a statistically significant difference  (P = 0.439)
```

9/21/06: DO

```
Normality Test:          Passed (P > 0.200)

Equal Variance Test:  Passed (P = 0.045)

Group Name  N      Missing       Median        Mean          Std Dev       SEM
dooff       18     0             10.350        10.150        0.672         0.158
dooff1      6      0             10.870        10.868        0.132         0.0537

Difference      -0.718

t = -2.564  with 22 degrees of freedom. (P = 0.018)

95 percent confidence interval for difference of means: -1.299 to -0.137

The difference in the mean values of the two groups is greater than would be expected by
chance; there is a statistically significant difference between the input groups (P = 0.018).

Power of performed test with alpha = 0.050: 0.616

The power of the performed test (0.616) is below the desired power of 0.800.
You should interpret the negative findings cautiously.
```

9/21/06: Temperature (°C)

Normality Test: Failed (P = 0.003)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test Monday, March 26, 2007, 16:06:23

Group	*N*	Missing	Median	25%	75%
toff	18	0	15.915	15.760	15.970
toff1	6	0	15.825	15.760	15.890

T = 57.000 n(small)= 6 n(big)= 18 (P = 0.243)

The difference in the median values between the two groups is not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.243)

9/21/06: EC

Normality Test: Failed (P = <0.001)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test Monday, March 26, 2007, 16:07:36

Group	*N*	Missing	Median	25%	75%
ecoff	18	0	278.000	277.000	278.000
ecoff1	6	0	277.000	277.000	277.000

T = 61.000 n(small)= 6 n(big)= 18 (P = 0.367)

The difference in the median values between the two groups is not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.367)

9/25/06: DO

Normality Test: Failed (P = <0.001)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test Monday, March 26, 2007, 16:11:14

Group	*N*	Missing	Median	25%	75%
doon	18	0	11.550	11.100	11.860
doon1	6	0	12.400	12.370	12.450

T = 128.000 n(small)= 6 n(big)= 18 (P = <0.001)

The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (P = <0.001)

9/25/06: Temperature (°C)

Normality Test: Passed (P = 0.026)

Equal Variance Test: Passed (P = 0.049)

Group Name	*N*	Missing	Median	Mean	Std Dev	SEM
ton	18	0	14.190	14.195	0.323	0.0760
ton1	6	0	14.715	14.710	0.0276	0.0113

Difference -0.515

t = -3.849 with 22 degrees of freedom. (P = <0.001)

95 percent confidence interval for difference of means: -0.792 to -0.238

The difference in the mean values of the two groups is greater than would be expected by chance; there is a statistically significant difference between the input groups (P = <0.001).

Power of performed test with alpha = 0.050: 0.958

9/25/06: EC

Normality Test: Failed (P = <0.001)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test Monday, March 26, 2007, 16:12:55

Group	N	Missing	Median	25%	75%
econ	18	0	237.000	236.000	238.000
econ1	6	0	239.000	239.000	239.000

T = 117.000 n(small)= 6 n(big)= 18 (P = 0.006)

The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (P = 0.006)

9/28/06: DO

Normality Test: Passed (P = 0.017)

Equal Variance Test: Passed (P = 0.098)

Group Name	*N*	Missing	Median	Mean	Std Dev	SEM
dooff	18	0	11.900	11.211	0.714	0.168
dooff1	6	0	11.500	11.858	0.0816	0.0333

Difference -0.647

t = -2.182 with 22 degrees of freedom. (P = 0.040)

95 percent confidence interval for difference of means: -1.262 to -0.0322

The difference in the mean values of the two groups is greater than would be expected by chance; there is a statistically significant difference between the input groups (P = 0.040).

Power of performed test with alpha = 0.050: 0.447

The power of the performed test (0.447) is below the desired power of 0.800.
You should interpret the negative findings cautiously.

9/28/06: Temperature (°C)

Normality Test: Passed (P = 0.012)

Equal Variance Test: Passed (P = 0.044)

Group Name	*N*	Missing	Median	Mean	Std Dev	SEM
toff	18	0	15.270	15.283	0.180	0.0423
toffl	6	0	15.480	15.477	0.0418	0.0171

Difference -0.194

t = -2.586 with 22 degrees of freedom. (P = 0.017)

95 percent confidence interval for difference of means: -0.349 to -0.0384

The difference in the mean values of the two groups is greater than would be expected by chance; there is a statistically significant difference between the input groups (P = 0.017).

Power of performed test with alpha = 0.050: 0.626

The power of the performed test (0.626) is below the desired power of 0.800.
You should interpret the negative findings cautiously.

9/28/06: EC

Normality Test: Passed (P = 0.027)

Equal Variance Test: Passed (P = 0.317)

Group Name	*N*	Missing	Median	Mean	Std Dev	SEM
ecoff	18	0	243.000	242.833	1.150	0.271
ecoffl	6	0	243.500	243.500	0.548	0.224

Difference -0.667

t = -1.354 with 22 degrees of freedom. (P = 0.189)

95 percent confidence interval for difference of means: -1.688 to 0.354

The difference in the mean values of the two groups is not great enough to reject the possibility that the difference is due to random sampling variability. There is not a statistically significant difference between the input groups (P = 0.189).

Power of performed test with alpha = 0.050: 0.132

The power of the performed test (0.132) is below the desired power of 0.800.
You should interpret the negative findings cautiously.

10/2/06: DO

Normality Test: Failed (P = <0.001)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test Monday, March 26, 2007, 17:03:16

Group	*N*	Missing	Median	25%	75%
dooff	18	0	10.890	10.350	11.050
dooff1	6	0	11.525	11.390	11.550

T = 127.000 n(small)= 6 n(big)= 18 (P = <0.001)

The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (P = <0.001)

10/2/06: Temperature (°C)

Normality Test: Failed (P = <0.001)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test Monday, March 26, 2007, 16:59:40

Group	*N*	Missing	Median	25%	75%
toff	18	0	14.990	14.860	15.020
toff1	6	0	14.840	14.730	14.850

T = 38.000 n(small)= 6 n(big)= 18 (P = 0.015)

The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (P = 0.015)

10/2/06: EC

```
Normality Test:        Failed  (P = <0.001)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test        Monday, March 26, 2007, 17:00:54

Group        N     Missing      Median       25%        75%
ecoff        18    0            240.000      240.000    241.000
ecoff1       6     0            238.500      238.000    239.000

T = 37.500  n(small)= 6  n(big)= 18  (P = 0.014)

The difference in the median values between the two groups is greater than would be
expected by chance; there is a statistically significant difference  (P = 0.014)
```

10/5/06: DO

```
Data source: Data 1 in Notebook

Normality Test:        Failed  (P = 0.003)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test        Monday, March 26, 2007, 18:40:11

Group        N     Missing      Median       25%        75%
dooff        18    0            10.880       10.500     11.300
dooff1       6     0            11.875       11.600     12.010

T = 129.000  n(small)= 6  n(big)= 18  (P = <0.001)

The difference in the median values between the two groups is greater than would be
expected by chance; there is a statistically significant difference  (P = <0.001)
```

10/5/06: Temperature (°C)

Normality Test: Passed (P = 0.015)

Equal Variance Test: Failed (P = 0.001)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test Monday, March 26, 2007, 17:05:48

Group	*N*	Missing	Median	25%	75%
toff	18	0	15.255	15.170	15.320
toff1	6	0	14.680	14.140	15.240

T = 49.000 n(small)= 6 n(big)= 18 (P = 0.089)

The difference in the median values between the two groups is not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.089)

10/5/06: EC

Normality Test: Failed (P = <0.001)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test Monday, March 26, 2007, 17:07:34

Data source: Data 1 in Notebook

Group	*N*	Missing	Median	25%	75%
ecoff	18	0	241.000	241.000	242.000
ecoff1	6	0	237.000	234.000	240.000

T = 33.000 n(small)= 6 n(big)= 18 (P = 0.006)

The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (P = 0.006)

10/10/06: DO

```
Data source: Data 1 in Notebook

Normality Test:        Failed  (P = <0.001)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test        Monday, March 26, 2007, 17:16:42

Data source: Data 1 in Notebook

Group          N      Missing       Median        25%         75%
dooff          18     0             11.500        11.200      11.600
dooff1         6      0             11.980        11.950      12.100

T = 119.000  n(small)= 6  n(big)= 18  (P = 0.004)

The difference in the median values between the two groups is greater than would be
expected by chance; there is a statistically significant difference  (P = 0.004)
```

10/10/06: TEMPERATURE (°C)

```
Normality Test:        Failed  (P = <0.001)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test        Monday, March 26, 2007, 17:13:37

Group          N      Missing       Median        25%         75%
toff           18     0             14.090        14.050      14.140
toff1          6      0             14.140        14.130      14.140

T = 97.000  n(small)= 6  n(big)= 18  (P = 0.152)

The difference in the median values between the two groups is not great enough to
exclude the possibility that the difference is due to random sampling variability; there is
not a statistically significant difference  (P = 0.152)
```

10/10/06: EC

```
Data source: Data 1 in Notebook

Normality Test:        Failed  (P = <0.001)

Test execution ended by user request, Rank Sum Test begun

Mann-Whitney Rank Sum Test        Monday, March 26, 2007, 17:15:02

Group         N    Missing       Median      25%        75%
ecoff         18   0             234.000     233.000    234.000
ecoff1        6    0             233.000     233.000    234.000

T = 60.000  n(small)= 6  n(big)= 18  (P = 0.332)

The difference in the median values between the two groups is not great enough to
exclude the possibility that the difference is due to random sampling variability; there is
not a statistically significant difference  (P = 0.332)
```

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

Prepared For
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Monterey, CA

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Appendix A

Introduction

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

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

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

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

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

Concerns have been raised that irrigation operations on El Sur Ranch pastures may adversely affect water levels and habitat conditions for protected species, such as the red legged frog, within the creek running through Swiss Canyon (Figure 1). To study the potential effect of rainfall runoff and El Sur Ranch surface irrigation operations on Swiss Canyon Creek, a monitoring program was implemented involving fixed station monitoring of water levels at three points within Swiss Canyon on a twice weekly basis between September 9 and October 16, 2006, during experimental well diversion operations.

Methods

Three fixed monitoring locations were selected within Swiss Canyon for routine inspection. Figure 1 summarizes the locations of Stations 1 through 3 in Swiss Canyon. Table 1 summarizes the descriptions for the fixed point routine monitoring locations. Stations were selected at the mid point of the center channel within the streamflow observed in Swiss Canyon. Stations were marked by driving temporary rebar marker posts into the three monitoring station points.

Once stations were selected, they were marked with flagging tape and GPS co-ordinates were recorded to ensure return inspections were at the same location. Stations 1 through 3 were inspected and documented by photographic record at twice weekly intervals between September 9 and October 16, 2006. Table 2 summarizes the survey dates for Stations 1 through 3. Inspection of each station included visual observation of differences in water height and flow conditions as well as specific water depth measured at the same point by surveyors tape at the same location during each survey at each of the station markers for Stations 1 through 3.

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

Appendix A, Stations 1 through 3, present photographic documentation of the survey stations taken during twice weekly inspections. No photographs exist for the survey conducted on September 28, 2006, due to digital camera failure.

Results and Discussion

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

Irrigation during the study period is summarized in Table 3. Fields 1, 2, 3, and 4 are situated to the east and west of the Swiss Canyon study area. Surface irrigation on these fields could potentially result in surface flow reaching lower portions of the Swiss Canyon monitoring area, and especially irrigation excess flow on Fields 2 and 3. During the study period, Field 1 was irrigated from September 9 through September 11, 2006, at a rate of between 6.94 and 7.21 acre feet per day by New Well and at a rate of between 4.81 and 4.94 acre feet per day by Old Well. Field 3 was irrigated between September 12 and September 13 at a rate of between 6.99 and 8.38 acre feet per day by New Well and 4.92 and 5.90 acre feet per day by Old Well. Field 4 was irrigated between September 13 and September 15 at a rate of between 8.38 and 3.72 acre feet per day by New Well and 5.90 and 2.80 acre feet per day by Old Well. Field 2 was irrigated between September 22 and September 25, 2006, at a rate of between 4.81 and 4.86 acre feet per day by Old Well. Field 3 was irrigated between September 26 and September 27 at a rate of between 4.70 and 4.72 acre feet per day by Old Well. Field 4 was irrigated between September 28 and September 29 at a rate of 4.74 acre feet per day by Old Well. Field 7 was irrigated between October 8 and October 11 at a rate of between 4.59 and 6.68 acre feet per day by New Well. Following are the results and observations for Stations 1 through 3 for the monitoring conducted between September 9 and October 16, 2006:

Station 1

Results for Station 1 surveys are summarized in Figure 3 and Table 5. Photographic documentation recorded during the survey periods are presented in Appendix A, Station 1. No survey was conducted at this location on September 25, 2006, due to calving occurring in close proximity to the station marker. Water depths recorded at Station 1 showed a drop in surface elevation from 0.25 ft to 0.20 ft between September 6 and September 13, 2006. Surveys conducted from September 14 to October 16, 2006, show water surface elevation to remain at approximately 0.30 ft at this location.

Station 2

Results for Station 2 surveys are summarized in Figure 4 and Table 5. Photographic documentation recorded during the survey periods are presented in Appendix A, Station 2. Water depths recorded at Station 2 showed a drop in surface elevation from 0.17 ft to 0.10 ft between September 6 and September 14, 2006. Surveys conducted from September 18 to October 16, 2006, recorded a completely dry creek bed in Swiss Canyon at Station 2. Water surface elevation at this location remained at 0 ft from September 18 through to the end of the study on October 16, 2006.

Station 3

Results for Station 3 surveys are summarized in Figure 5 and Table 5. Photographic documentation recorded during the survey periods are presented in Appendix A, Station 3. Water depths recorded at Station 3 showed a consistent surface elevation between 0.18 ft to 0.20 ft between September 6 and September 14, 2006. Surveys conducted from September 18 to October 16, 2006, recorded a completely dry creek bed in Swiss Canyon at Station 3. Water surface elevation at this location remained at 0 ft from September 18 through to the end of the study on October 16, 2006.

Swiss Canyon Survey

The consistent water depth of approximately 0.3 ft at Swiss Canyon monitoring Station 1 from September 14 through to the end of the study on October 16, 2006, differed from the dry creek bed recorded at stations 2 and 3 during the same period further upstream. This prompted an investigation of the entire length of the creek bed along Swiss Canyon from Station 3 at Highway 1 to the beach downstream of Station 1. Results of this survey, conducted on October 16, 2006, are summarized in Figure 6. Inspection of Swiss Canyon along the creek bed revealed that the creek remained dry from Station 3 to a point of ground water upwelling approximately 0.1 miles upstream of Station 1. There was also some standing water recorded within the creek bed in the vicinity of irrigation pipe repair and testing downstream of Station 2 between Fields 2 and 3. This irrigation pipe repair and pump testing resulted in water discharging from the irrigation pipe into the Swiss Canyon creek. This extent of this standing water was recorded by GPS and is summarized on Figure 6 upstream of the point of Groundwater Upwelling.

A point of groundwater upwelling was recorded upstream of Station 1 and is summarized on Figure 6. This location showed characteristically uniform flowing upwelling of groundwater entering the creek from the creek bed. Water quality was recorded at this point at a depth of 0.4 ft. Dissolved oxygen at this point was 2.82 mg/l, temperature was 11.24 degrees Celsius, and electrical conductivity was 587 um/cm. Ground water parameters measured on the same day at Station 1 recorded dissolved oxygen at 8.5 mg/l, temperature at 11.8 degrees Celsius, and electrical conductivity at 642 um/cm.

Conclusions

The Swiss Canyon water depth monitoring survey conducted from September 9 through October 16, 2006, at Stations 1 through 3 ranging from the beach at the southern extreme of Swiss Canyon to Highway 1 at the northern extreme of Swiss Canyon showed that, under the irrigation pattern described and with the recorded irrigation volumes and lack of rainfall during the study period, Swiss Canyon was characteristically dry upstream of the groundwater influence entering the creek through the streambed. Well diversion records show that irrigation did not occur in the North and South Pasture during the monitoring period. Stations 2 and 3 were located upstream of the fields irrigated during the monitoring period and outside the influence of any potential surface irrigation excess runoff.

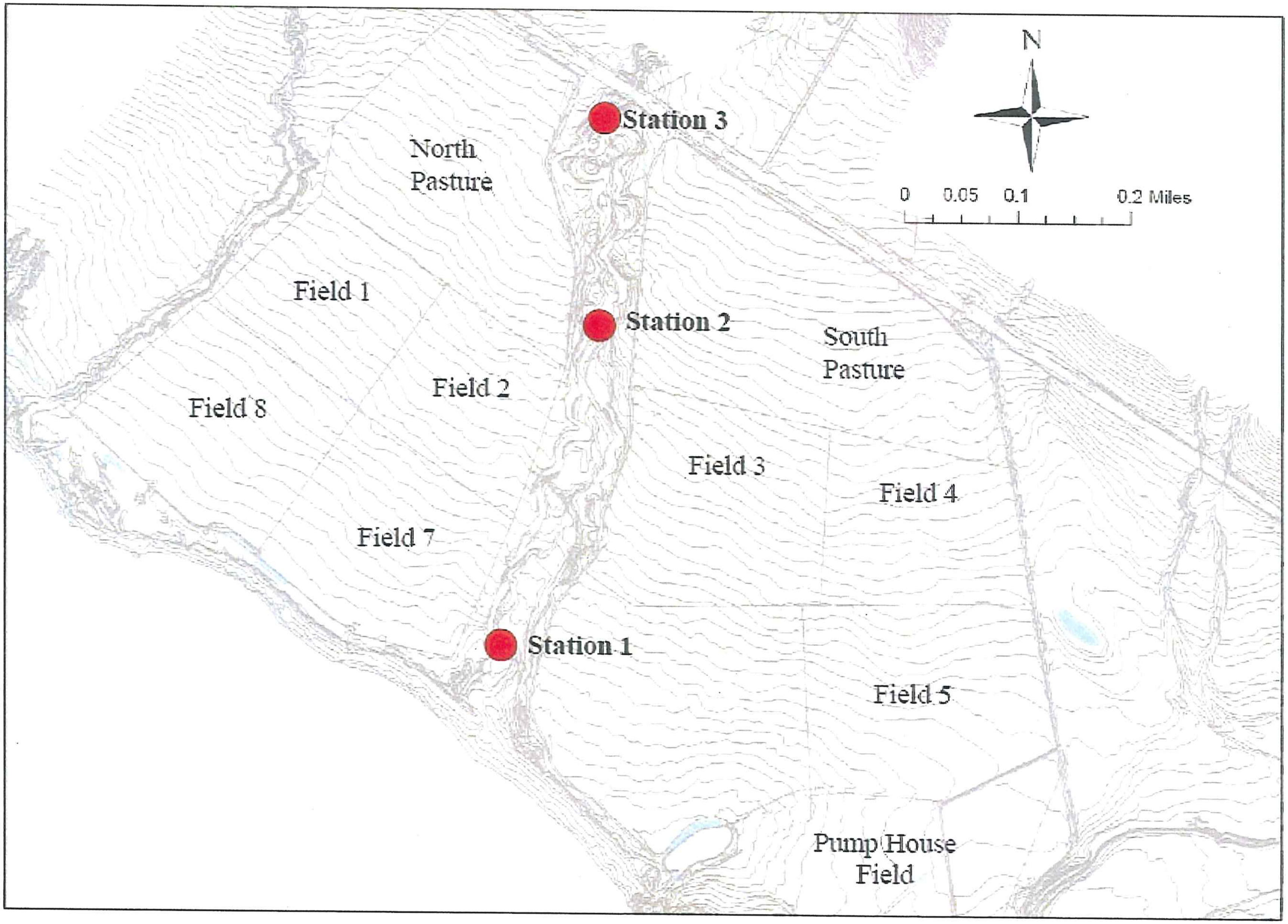


Figure 1: Map of El Sur Ranch Swiss Canyon Survey Points.

Figure 2. Surface irrigation on El Sur Ranch pastures

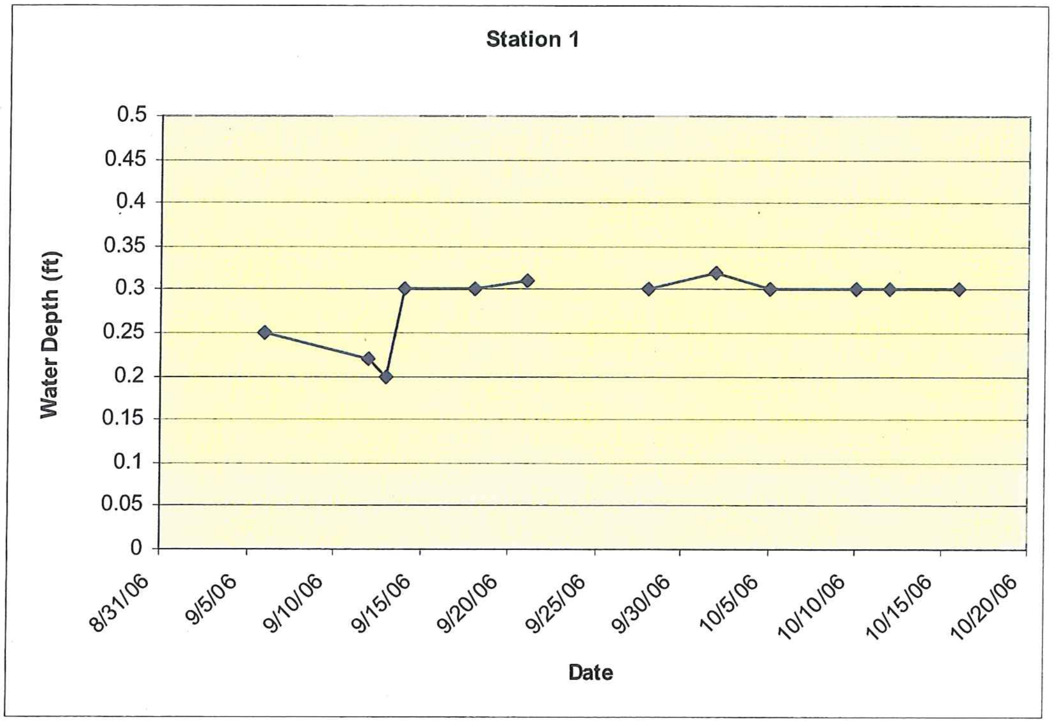


Figure 3. Water depth in Swiss Canyon at Station 1 during monitoring period.

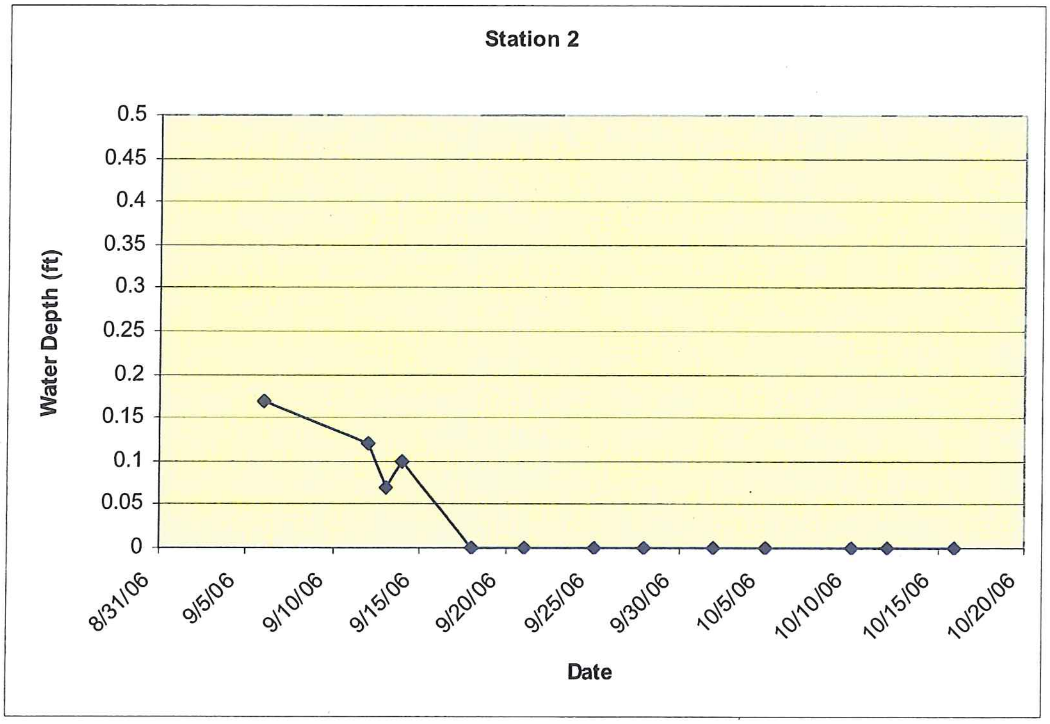


Figure 4. Water depth in Swiss Canyon at Station 2 during monitoring period.

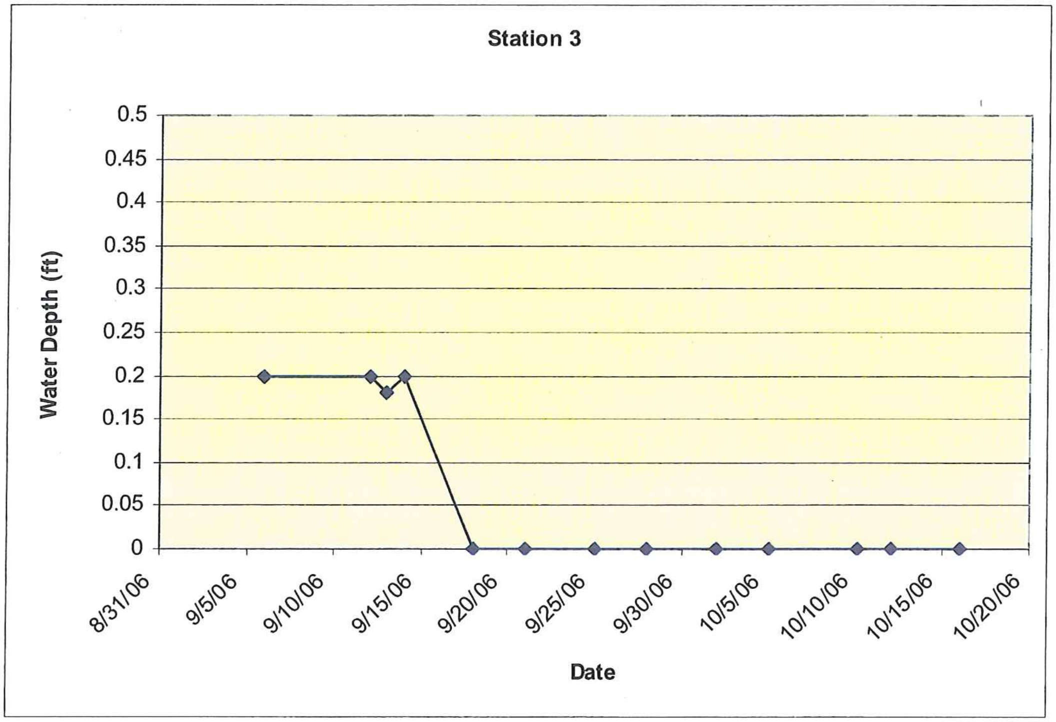


Figure 5. Water depth in Swiss Canyon at Station 1 during monitoring period.

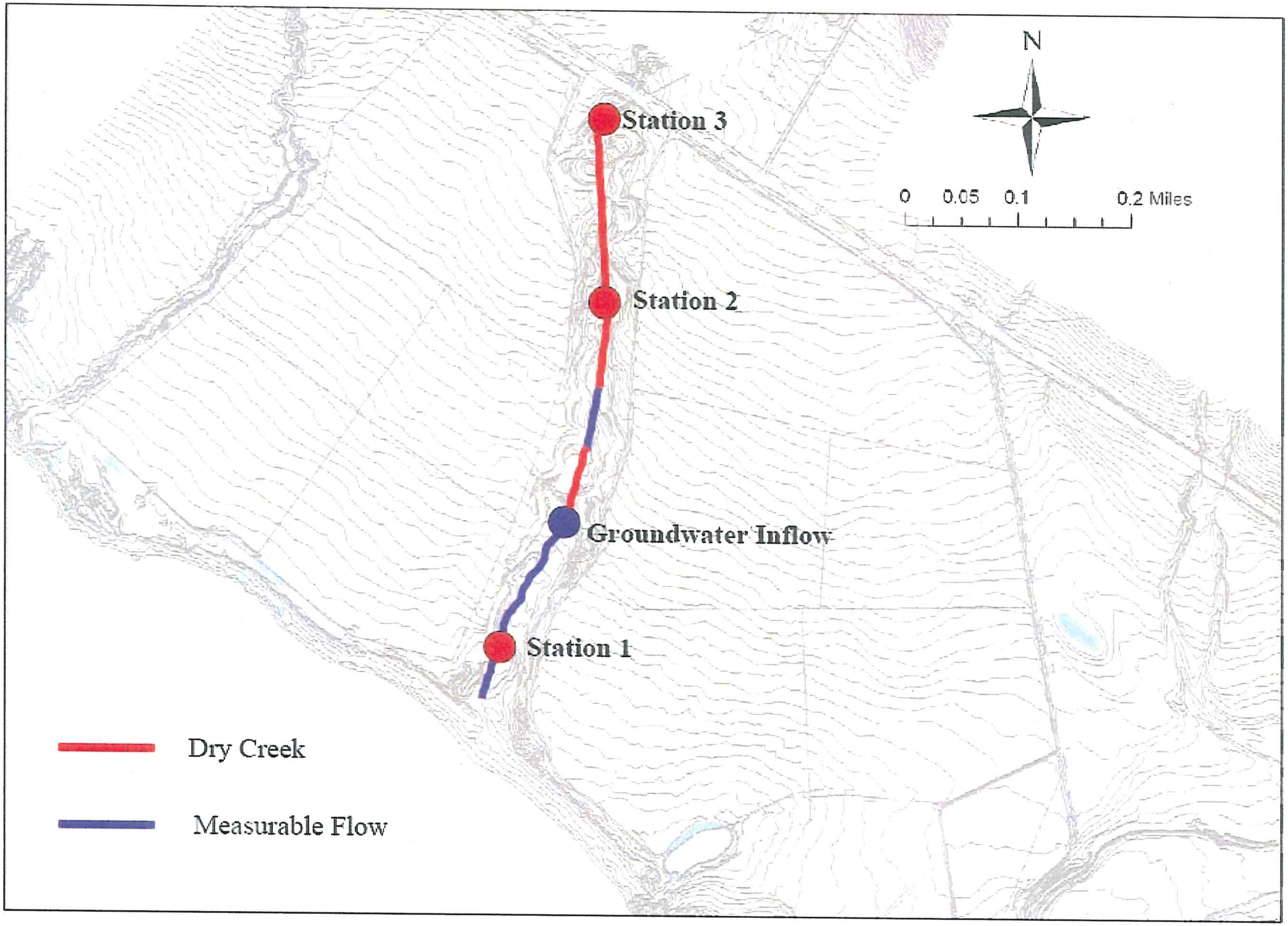


Figure 6. Map of El Sur Ranch Swiss Canyon Survey Points with Groundwater Upwelling Location and Creek Survey Results.

Table 1. Monitoring station descriptions.

Station #	Station Description
1	Upstream station at northern boundary of US Highway 1
2	Mid point of Swiss Canyon
3	Downstream point of Swiss Canyon near beach. Downstream of zone of recorded groundwater influence into Swiss Canyon.

Table 2. Dates of water level monitoring for all stations within Swiss Canyon.

Survey	Station		
Date	#1	#2	#3
9-6-06	X	X	X
9-12-06	X	X	X
9-13-06	X	X	X
9-14-06	X	X	X
9-18-06	X	X	X
9-21-06	X	X	X
9-25-06	X	X	X
9-28-06	X	X	X
10-2-06	X	X	X
10-5-06	X	X	X
10-10-06	X	X	X
10-12-06	X	X	X
10-16-06	X	X	X

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

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

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

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

Table 5. Results of water depth monitoring at Stations 1 through 3 in Swiss Canyon.

Station 1			Station 2			Station 3		
Date	Time	Depth	Date	Time	Depth	Date	Time	Depth
9/6/2006	9:15	0.25	9/6/2006	9:05	0.17	9/6/2006	8:50	0.20
9/12/2006	12:05	0.22	9/12/2006	12:00	0.12	9/12/2006	11:05	0.20
9/13/2006	15:05	0.20	9/13/2006	14:50	0.07	9/13/2006	14:40	0.18
9/14/2006	11:05	0.30	9/14/2006	11:00	0.10	9/14/2006	10:55	0.20
9/18/2006	13:10	0.30	9/18/2006	13:05	0	9/18/2006	13:10	0
9/21/2006	13:25	0.31	9/21/2006	13:20	0	9/21/2006	13:15	0
9/25/2006	17:00		9/25/2006	16:40	0	9/25/2006	16:35	0
9/28/2006	13:10	0.30	9/28/2006	13:05	0	9/28/2006	13:00	0
10/2/2006	13:30	0.32	10/2/2006	13:20	0	10/2/2006	13:10	0
10/5/2006	13:30	0.30	10/5/2006	13:20	0	10/5/2006	13:10	0
10/10/2006	13:15	0.30	10/10/2006	13:10	0	10/10/2006	13:05	0
10/12/2006	8:30	0.30	10/12/2006	8:40	0	10/12/2006	8:50	0
10/16/2006	11:30	0.30	10/16/2006	10:30	0	10/16/2006	10:25	0

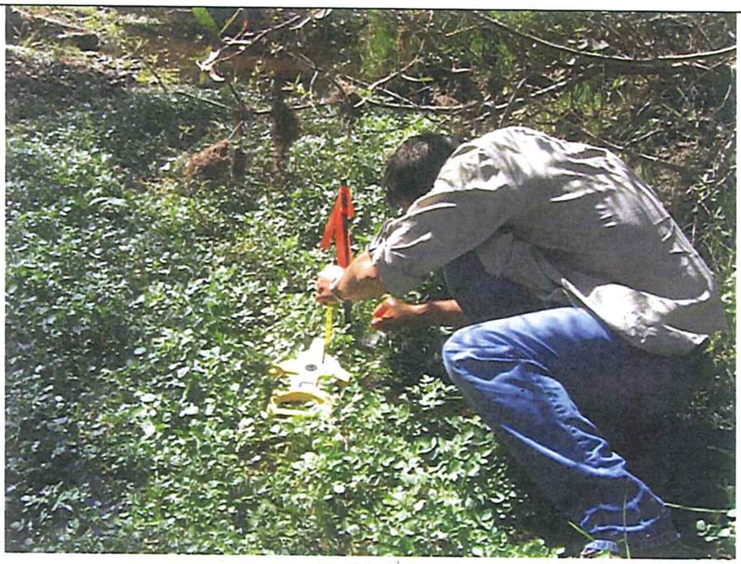
Appendix A

Photographic documentation of water level monitoring in Swiss Canyon at Stations 1 through 3.

Monitoring conducted from September 9 through October 16, 2006.

Station 1

9-6-06



9-13-06

9-18-06

9-21-06

Station 1 (continued)

9-25-06	9-28-06
 10-2-06	 10-5-06

Station 1 (continued)

10-10-06

10-16-06

Station 2


9-6-06


9-13-06


9-18-06


9-21-06

Station 2 (continued)

9-25-06

9-28-06

10-2-06

10-5-06

Station 2 (continued)

10-10-06

10-16-06

Station 3

9-6-06

9-13-06

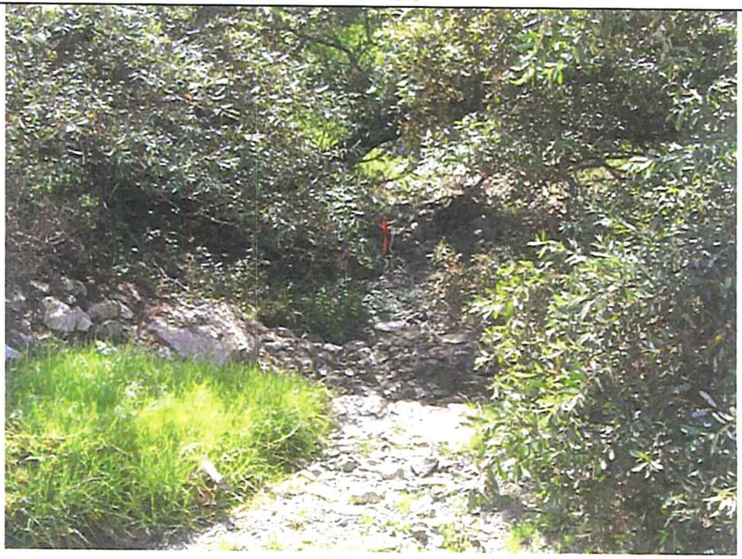
9-18-06

9-21-06

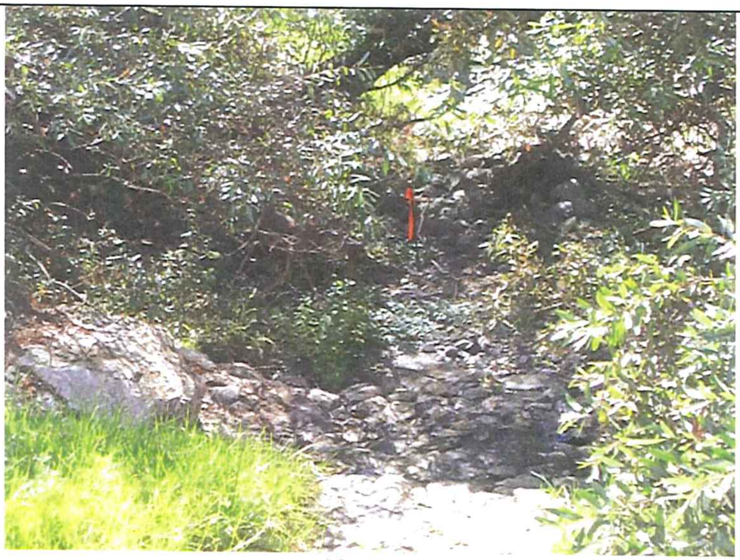
Station 3 (continued)

9-25-06

9-28-06

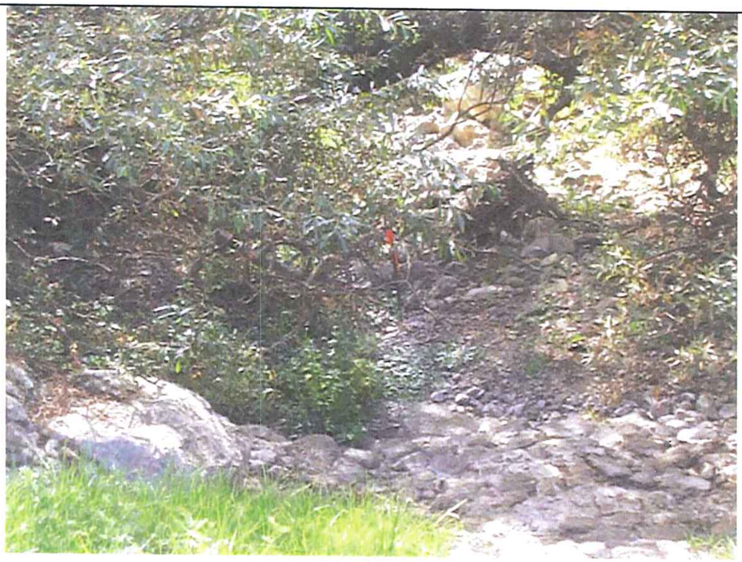


10-2-06



10-5-06

Station 3 (continued)



10-10-06

10-16-06

BIOLOGIC SURVEYS

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

Biologic Surveys

RESULTS OF BIOLOGICAL SURVEYS
IN THE
EL SUR RANCH STUDY AREA
MONTEREY COUNTY, CALIFORNIA

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December 21, 2006

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RESULTS OF BIOLOGICAL SURVEYS ON THE EL SUR RANCH STUDY AREA, MONTEREY COUNTY, CALIFORNIA

Executive Summary

Biological surveys were conducted of the El Sur Ranch proper and the westernmost portion of Andrew Molera State Park to gain baseline information on plant communities and wildlife resources in the area. This information is intended to inform the CEQA process and public trust analysis associated with a pending Water Right Application. Collectively, the two areas comprise the "Study Area" that is referred to in this report. The potential for special-status plant and wildlife species, including federally- and state-listed species, to occur in the Study Area also was evaluated. Reconnaissance surveys were conducted in May, 2006. More in-depth surveys were conducted in June and September 2006.

Aside from collecting baseline information on biological resources for CEQA purposes, another reason for conducting the surveys was to determine for public trust purposes whether the El Sur Ranch's existing long-time irrigation practices and use of well water are having adverse impacts on vegetation and/or wildlife in the Study Area.

No federally- or state-listed plants were observed in the Study Area during 2006 surveys. Two plants that are tracked by the California Native Plant Society (CNPS) were observed in the Study Area: Arroyo Seco bushmallow (*Malacothamnus palmeri* var. l*ucianus*) and Monterey Indian paint brush (*Casteilleja latifolia*).

Although not observed during our surveys, the California red-legged frog (*Rana aurora draytonii*), a federally-threatened species, was recorded in the Big Sur River in the early 1990s and in Swiss Canyon in 2006 by researchers conducting fisheries surveys. The southwestern pond turtle (*Emys marmorata pallida*), a California species of special concern, was also observed during the early 1990s in the Big Sur River. The reclamation pond in the Study Area provides suitable habitat for both species.

No other listed species were observed in the Study Area during 2006 surveys although suitable habitat is present for two other federally-listed species, Smith's blue butterfly (*Euphilotes enoptes smithi*) and California tiger salamander (*Ambystoma californiense*). Suitable habitat is also present in the Study Area for 11 California species of special concern and/or fully protected species, including the Monterey dusky-footed woodrat (*Neotoma macrotis luciana*), ringtail (*Bassariscus astutus*), American badger (*Taxidea taxus*), pallid bat (*Antrozous pallidus*), golden eagle (*Aquila chrysaetos*), northern harrier (*Circus cyaneus*), white-tailed kite (*Elanus leucurus*), long-billed curlew (*Numenius americanus*), California horned lark (*Eremophila alpestris actia*), Coast horned lizard (*Phrynosoma coronatum frontale*), and Coast Range newt (*Toricha torosa torosa*). Of these species only the golden eagle, Cooper's hawk, northern harrier, white-tailed kite, long-billed curlew, and California horned lark were observed during 2006 surveys.

Both beneficial and adverse effects of existing baseline ranch operations were evident, especially in Swiss Canyon, although the adverse effects did not appear to be significant. Adverse effects of cattle include overgrazing, trampling, soil compaction, and erosion within the riparian corridor. Even with these impacts, Swiss Canyon benefits from the ranching operation because of the irrigation seepage that sustains a diverse riparian corridor and sufficient aquatic habitat to support amphibians such as the federally-listed California red-legged frog and more common Pacific chorus frog (*Pseudacris regilla*). Irrigation seepage allows the structural diversity of the vegetation to be maintained, as evidenced by the presence of a diverse avian community. Swiss Canyon also provides valuable habitat for other amphibian species, as well as reptiles and mammals.

One component of our work was to conduct a visual survey within the estimated area of drawdown surrounding the wells to determine whether the vegetation exhibited visual signs of physiological stress or dieback due to lack of water from groundwater pumping. No signs of dieback or physical stress were observed within the Study Area boundary during our surveys.

Introduction

Miriam Green Associates was retained by Hanson Environmental, Inc. to conduct biological surveys of the El Sur Ranch proper and the westernmost portion of the Andrew Molera State Park, between the eastern ranch boundary and the Big Sur River, in Big Sur, Monterey County, California. Collectively, the two areas are referred to as the Study Area. Existing site conditions, and a description of the plant communities and the wildlife that they support, are described in this report. The potential for special-status plant and animal species to occur in the Study Area is evaluated. A preliminary survey of the area of estimated drawdown from the two existing wells was also conducted.

Tables 1 and 2 that are referred to in the text have been placed at the end of the narrative portion of the report due to their length. Figures 1 through 13 follow the tables.

Location

The El Sur Ranch Study Area is located adjacent to the Big Sur Coast in Monterey County, California, approximately 1½ miles south of the Point Sur Lighthouse (Figure 1). The Study Area is bounded to the north by Highway 1 and the Santa Lucia Mountains, to the south by the Pacific Ocean, to the west by an adjacent portion of the El Sur Ranch, and to the east by Andrew Molera State Park. The Study Area consists of approximately 292 acres of irrigated pasture including Swiss Canyon, which is located within the El Sur Ranch and separates Pastures 1, 2, 6, and 7 and the North Pasture from Pastures 3, 4, 5, and 6, the South Pasture, and the Pump House Field (Figure 2). The Study Area also includes the westernmost portion of the Andrew Molera State Park up to the lower reach of the Big Sur River. Specifically, it can be located in Township 19 South, Range 1 East of the Big Sur United States Geological Survey (USGS) 7.5-minute topographic quadrangle map.

Methods

Prior to conducting field surveys, computer searches of the California Native Plant Society (CNPS) On-Line Inventory and the California Natural Diversity Database (CNDDB) (data dated June 2, 2006) were conducted to determine whether any special-status plant or animal species had been reported from the general area. USGS quadrangles searched included Big Sur and the surrounding 7.5-minute topographic quadrangles – Carmel Valley, Ventana Cones, Partington Ridge, Mt. Carmel, Soberanes Point, Point Sur, and Pfeiffer Point. The search produced 29 plant species and 15 wildlife species. Additional special-status wildlife species were included in Table 2 that were known or observed in the area during field surveys and that either were not included in the CNDDB printout or that are not tracked by the CNDDB. Table 1 identifies the special-status plant species that may occur in the Study Area and includes information on their legal status, habitat requirements, bloom time, and potential for occurrence. Table 2 identifies the special-status wildlife species that could occur in the Study Area and provides information on their legal status, habitat requirements, and potential for occurrence.

Plants

Botanical surveys were conducted by John Hale, M.S., Botany. Preliminary field surveys were conducted on May 30 and 31, 2006. Additional surveys were conducted on June 19, 20, and 21, 2006 to describe plant communities and check for special-status plants that could occur in the Study Area.

The entire Study Area was walked where possible and focused surveys were conducted in areas of suitable habitat for special-status plants (see Table 1). All plants observed were identified to species. In addition, the area of estimated drawdown from the two existing wells was surveyed where accessible on foot. Appendix A contains a list of the vascular plants observed during the 2006 field surveys.

Wildlife

An assessment of wildlife habitats in the Study Area was conducted on May 30 and 31, and September 21 and 22, 2006 by Heather L. Johnson, M.S., Biology. Avian surveys in the Study Area were conducted September 21 and 22, 2006 by Waldo Holt, Biology. Surveys consisted of walking through all habitats to document species present as well as to search for raptor nests and potential habitat for other special-status species.

While all wildlife species observed during field surveys were recorded, the emphasis of our work was on locating special-status species or potential supporting habitat for these species in the Study Area. Special-status species include the following:

- Species listed as threatened or endangered by the U.S. Fish and Wildlife Service (USFWS) and California Department of Fish and Game (CDFG),
- California species of special concern, and
- Species that are fully protected under the California Fish and Game Code.

It should be noted that the September avian surveys were conducted after the conclusion of the nesting season and many of the neo-tropical migrants had already left the area for their wintering grounds. Our surveys were able to identify several species that winter in the area, but do not nest there, and we were able to observe many of the year-round residents. Appendix B contains a list of all wildlife species observed during the 2006 field surveys.

Results

The Study Area encompasses the irrigated pastures within the El Sur Ranch including Swiss Canyon which bisects the pasture land from north to south and part of the Andrew Molera State Park within the lower reach of the Big Sur River watershed. The pastures slope and drain from the north to the south and vary in elevation between 120 feet to 20 feet above sea level. The pastures, including Swiss Canyon, are being grazed on a rotational basis. The surrounding land use is a mixture of cattle grazing on private land and recreational on state park land.

Twelve natural communities occur within the Study Area. They include: irrigated pasture, marginal coastal prairie, non-native annual grassland, eucalyptus woodland, northern coastal foredunes, coyote bush scrub, central coast cottonwood-sycamore riparian forest, central coast arroyo willow riparian forest, coast live oak forest, coastal and valley freshwater marsh, northern coastal bluff scrub, and central coastal scrub. The names and descriptions of plant communities follow Holland (1988) and Sawyer and Keeler-Wolf (1995); they are also consistent with those used in the Andrew Molera State Park Resource Inventory (California Department of Parks and Recreation 1990). The community of "irrigated pasture" has been added to this discussion because neither reference includes this habitat type. Representative photographs of the various plant communities are included at the end of the narrative as Figures 3 through 12. A map of the natural communities in the Study Area is included as Figure 13.

IRRIGATED PASTURE - The 11 irrigated pastures within the El Sur Ranch are comprised mostly of non-native perennial grasses and annual forbs (Figure 3). Dominant grass species include velvet grass (*Holcus lanatus*), Harding grass (*Phalaris aquatica*), orchard grass (*Dactylis glomerata*), and tall fescue (*Festuca arundinacea*). Dominant forbs include various clovers (*Trifolium* spp.), filaree (*Erodium* spp.), long-beaked hawkbit (*Leontodon taraxacoides* ssp. *taraxacoides*), and narrow-leaved flax (*Linum bienne*).

Common wildlife species such as wild pig (*Sus scrofa*), coyote (*Canis latrans*), and black-tailed deer (*Odocoileus hemionus*) are likely to use these habitats as long as vegetative cover is nearby. One example of this would be the pastures adjacent to Swiss Canyon. The irrigated pasture, marginal coastal prairie, and non-native annual grassland habitats appear to be suitable for the American badger as the soils are friable and preferred small mammal prey is available. No potential badger dens were observed during 2006 surveys. Special-status birds observed foraging in the irrigated pastures during our surveys include the golden eagle, northern harrier, white-tailed kite, tri-colored blackbird (*Agelaius tricolor*), and loggerhead shrike (*Lanius ludovicianus*). Of these species, only the northern harrier and white-tailed kite would be expected to nest in the Study Area. Common avian species that use the irrigated pastures for foraging include turkey vultures (*Cathartes aura*), robins (*Turdus migratorius*), sparrows, and blackbirds.

MARGINAL COASTAL PRAIRIE - A small area of marginal coastal terrace prairie habitat is found outside the gate leading from the El Sur Ranch to the wells, along the west edge of Andrew Molera State Park extending slightly to the north (Figure 4). Dominant species include California oat grass (*Danthonia californica*), meadow barley (*Hordeum brachyantherum* ssp. *brachyantherum*), velvet grass, Douglas iris (*Iris douglasiana*), western rush (*Juncus occidentalis*), brown-headed rush (*Juncus phaeocephalus* var. *phaeocephalus*), and spreading rush (*Juncus patens*). Isolated pockets of native bunchgrass, including purple needlegrass (*Nassella pulchra*) and foothill needlegrass (*Nassella lepida*), are found on both the El Sur Ranch, along Swiss Canyon, and on the western edge of Andrew Molera State Park.

NON-NATIVE ANNUAL GRASSLAND - Non-native annual grassland is found scattered within portions of the Study Area (Figure 5). It is dominated by European species including soft chess (*Bromus hordeaceus*), ripgut brome (*Bromus diandrus*), wild oat (*Avena* spp.), annual ryegrass (*Lolium multiflorum*), hare barley (*Hordeum murinum* ssp. *leporinum*), six-weeks fescue (*Vulpia bromoides*), milk thistle (*Silybum marianum*), sheep sorrel (*Rumex acetosella*), Italian thistle (*Carduus pycnocephalus*), and filaree.

It is worth noting that Andrew Molera State Park initiated a native plant revegetation project in Creamery Meadow, which is located south of the Big Sur River, within the Study Area. Approximately 3,000 trees and shrubs were planted in Creamery Meadow from 1995 through 1998. Species planted included coast live oak (*Quercus agrifolia*), black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), California bay (*Umbellularia californica*), western sycamore (*Platanus racemosa*), buckeye (*Aesculus californica*), Coast redwood (*Sequoia sempervirens*), willow (*Salix* spp.), blue elderberry (*Sambucus mexicana*), and California coffeeberry (*Rhamnus californica*). Prior to restoration efforts this area consisted of disturbed annual grassland. Although no quantitative data was available to evaluate the success of this restoration effort, it appears that survivorship is good based on visual observations of tree height, vigor, and canopy coverage.

EUCALYPTUS WOODLAND - Eucalyptus woodland is located in Andrew Molera State Park adjacent to Cooper's cabin, north of the Big Sur River (Figure 6). Understory is minimal. This small grove of introduced blue gum (*Eucalyptus globulus*) provides unique structure (i.e., wind protection and height) for nesting passerine birds and raptors; red-shouldered hawks (*Buteo lineatus*) and red-tailed hawks (*Buteo jamaicensis*) are known to nest there. The flowering trees provide nectar for wintering birds and insects; the ruby-crowned kinglet (*Regulus calendula*) and Townsend's warbler (*Dendroica townsendi*) use the eucalyptus woodland as a nectar source. This grove provides important wintering habitat for migratory monarch butterflies (*Danaus plexippus*) that amass in the tens of thousands in communal roosts along the California and Mexican coast, a globally recognized phenomenon. In addition, black swifts (*Cypseloides niger*) are known to forage in the grove. However, the only known nesting location for black swifts in the vicinity is at the Point Sur Lighthouse Reservation operated by the U.S. Coast Guard. Approximately 10 pairs were observed during a 1972 study; however, it is not known whether this colony still exists (CNDDB 2006).

NORTHERN COASTAL FOREDUNES - Northern coastal foredunes habitat is found in isolated areas along the southern edge of the El Sur Ranch west of the bluffs and near the mouth of the Big Sur River (Figure 7). This community lies at the base of the bluffs in areas of sand accumulation. Dominant species include beach sagewort (*Artemisia pycnocephala*), Hottentot-fig (*Carpobrotus edulis*), beach evening-primrose (*Camissonia cheiranthifolia*), beach dunegrass (*Leymus mollis*), sea rocket (*Cakile maritima*), yellow sand verbena (*Abronia latifolia*), and silver beach lupine (*Lupinus chamissonis*). The dune habitat appears to be suitable for the globose dune beetle (*Coelus globosus*); however, the habitat preferences of this beetle species are not fully understood. It has been found buried in sand that is stabilized by vegetation such as sea rocket.

Avian species observed in the dune habitat and along the shoreline include gulls, long-billed curlew, marbled godwit (*Limosa fedoa*), and black turnstone (*Arenaria melanocephala*).

COYOTE BUSH SCRUB - A significant section of the Study Area in the west end of Andrew Molera State Park, north of the Big Sur River and south of Highway 1, is best described as coyote bush scrub. This rectangular-shaped shrub community is dominated primarily by coyote bush (*Baccharis pilularis*), with lesser amounts of fennel (*Foeniculum vulgare*), poison hemlock (*Conium maculatum*), Italian thistle, and Harding grass.

RIPARIAN FOREST - Riparian habitat is found along both the Big Sur River (Figure 8) and within Swiss Canyon (Figure 9). Two riparian series are represented: central coast cottonwood-sycamore riparian forest and central coast arroyo willow riparian forest. Swiss Canyon, within the irrigated pastures of the El Sur Ranch, is a more deeply incised channel with steep banks and is grazed (Figure 10). It is best characterized as central coast arroyo willow riparian forest. Dominant trees include arroyo willow (*Salix lasiolepis*), black cottonwood, and coast live oak. Isolated wind-pruned coast redwood is also found in this plant community. The understory is dominated by poison hemlock, poison oak, and California blackberry (*Rubus ursinus*).

The lower reach of the Big Sur River riparian community, within Andrew Molera State Park, is a more developed and species-rich riparian habitat. It is best characterized as a combination of central coast cottonwood-sycamore riparian forest and central coast arroyo willow riparian forest. Dominant trees include western sycamore, willow (*Salix* spp.), alder (*Alnus* spp.), black cottonwood, and scattered coast redwood. Understory vegetation is mainly dominated by California blackberry and poison oak. Other understory components include mugwort (*Artemisia douglasiana*), hoary nettle (*Urtica dioica* ssp. *holosericea*) and giant horsetail (*Equisetum telmatiea* ssp. *braunii*).

The Swiss Canyon and Big Sur River corridors are suitable for ringtail, although none was observed during 2006 surveys. Scat and tracks from other wildlife species with similar habitat needs, such as bobcat (*Lynx rufus*), coyote (*Canis latrans*), fox, and raccoon (*Procyon lotor*) were observed in the Study Area. Habitat aspects found in these riparian corridors such as large mature trees, structural diversity of the vegetation, and open, slow-moving water are likely to provide roosting and foraging habitat for the pallid bat. A woodrat stick nest was found next to the Old Pump, which likely belongs to the desert woodrat (*Neotoma fuscipes*) or the Monterey dusky-footed subspecies (*Neotoma macrotis luciana*) (Henson and Usner 1993). Avian species observed in the riparian habitat include the acorn woodpecker (*Melanerpes formicivorus*), black phoebe (*Sayornis nigricans*), Wilson's warbler (*Wilsonia pusilla*), and yellow warbler (*Dendroica petechia*).

California red-legged frogs (*Rana aurora draytonii*) were observed in the Big Sur River during fisheries surveys conducted by CDFG in 1993 and 1994 (Biosystems 1995) and in Swiss Canyon during 2006 fisheries studies by Hanson Environmental (C. Hanson personal communication). The riparian habitat also appears suitable for the Coast Range newt. Common amphibian and reptile species that occur in this community include the ensatina (*Ensatina eschscholtzii*), arboreal salamander (*Aneides lugubris*), and Pacific chorus frog.

COAST LIVE OAK FOREST - Coast live oak forest is found in limited distribution within the Study Area along the northern edge of Pfeiffer Ridge. Dominant trees include coast live oak interspersed with California bay. Understory includes California hedge-nettle (*Stachys bullata*), coast morning-glory (*Calystegia macrostegia* ssp. *cyclostegia*), cleavers (*Galium aparine*), and common hedge-parsley (*Torilis arvensis* ssp. *arvensis*). The western gray squirrel (*Sciurus griseus)* inhabits trees in this habitat and the riparian habitats of the Study Area. Common reptile species that occur here include the western fence lizard (*Sceloporus occidentalis*) and southern alligator lizard (*Gerrhonotus multicarinatus*). Avian species that are found in coast live oak forest include Hutton's vireo (*Vireo huttoni*) and Nuttall's woodpecker (*Picoides nuttallii*).

FRESHWATER MARSH - Coastal and valley freshwater marsh is found in areas where emergent wetland vegetation is present. The reclamation pond located in the southeast corner of the El Sur Ranch contains patches of common tule (*Scirpus acutus* var. *occidentalis*) (Figure 11). At the mouth of Swiss Canyon, a small freshwater lagoon is dominated by obligate wetland species including common three-square (*Scirpus pungens*), broad-leaved cattail (*Typha latifolia*), and Pacific silver-weed (*Potentilla anserina* ssp. *pacifica*). Small patches of emergent vegetation are also visible along the Big Sur River near its mouth.

The reclamation pond appears to be suitable for California tiger salamander, California red-legged frog, and southwestern pond turtle (Figure 11). An active California ground squirrel (*Spermophilus beecheyi*) colony was observed in the adjacent upland, which could provide subterranean aestivation habitat for amphibians and reptiles. No fish, crayfish, or bullfrogs were observed during a cursory examination of the aquatic habitat. Avian species observed sheltering and feeding in the marsh included black-crowned night-heron (*Nycticorax nycticorax*), American coot (*Fulica americana*), pied-billed grebe (*Podilymbus podiceps*), and mallard (*Anas platyrhynchos*).

NORTHERN COASTAL BLUFF SCRUB - Northern coastal bluff scrub is found scattered along the ocean bluff edge of the El Sur Ranch and on the bluff, west of the lagoon near the mouth of the Big Sur River. Dominant plants in this community include beach sagewort (*Artemisia pycnocephala*), yellow yarrow (*Eriophyllum confertiflorum* var. *confertiflorum*), tree lupine (*Lupinus arboreus*), lizard tail (*Eriophyllum staechadifolium*), coast buckwheat (*Eriogonum latifolium*), dune buckwhat (*Eriogonum parvifolium*), mock heather (*Ericameria ericoides*), and poison oak (*Toxicodendron diversilobum*).

CENTRAL COASTAL SCRUB - Central coastal scrub intergrades with areas of non-native grassland and coastal bluff scrub within the Study Area (Figure 12). Dominant shrubs include California sage (*Artemisia californica*), sticky monkey flower (*Mimulus aurantiacus*), black sage (*Salvia mellifera*), and poison oak. The dense herbaceous understory of the bluff scrub and coastal scrub provides habitat for small mammals like the Trowbridge shrew (*Sorex trowbridgei*), pocket gopher (*Thomomys bottae*), and brush mouse (*Peromyscus boylei*); and medium-sized mammals including the desert cottontail (*Sylvilagus audubonii*), striped skunk (*Mephitis mephitis*), badger, gray fox (*Urocyon cinereoargenteus*), bobcat, and coyote. In the Big Sur area these predators are described as 'not uncommon' and ringtails and long-tailed weasels (*Mustela frenata*) are occasionally observed (Henson and Usner 1993). This habitat also appears to be suitable for Coast horned lizard due to the availability of friable soil and insect prey. Avian species such as the endemic California thrasher (*Toxostoma redivivum*) and wrentit (*Chamaea fasciata*) also inhabit the coastal scrub.

In general, birds are not usually closely associated with a single plant community due to their mobility and often highly transient habits. Their habitat preferences may change over the course of a day and preferred foraging habitats may differ from their nesting habitat. Avian species that nest in the Study Area but had left the area by the time of the September 2006 surveys include Allen's hummingbird (*Selasphorus sasin*), western wood-pewee (*Contopus sordidulus*), olive-sided flycatcher (*Contopus cooperi*), ash-throated flycatcher (*Myiarchus cinerascens*), Cassin's vireo (*Vireo cassinii*), purple martin (*Progne subis*), Swainson's thrush (*Catharus ustulatus*), and black-headed grosbeak (*Pheucticus melanocephalus*). Some of the wintering avian species observed during September surveys include loggerhead shrike, Townsend's warbler, and tri-colored blackbird, and golden-crowned sparrow (*Zonothrichia albicollis*).

Special-Status Species

Plants

Special-status plant species that may occur in the Study Area are listed in Table 1. Of these species, the known CNDDB occurrence for the Arroyo Seco bushmallow (*Malacothamnus palmeri* var. *lucianus*), CNPS List 1B, was observed at the south edge of the entrance road to Andrew Molera State Park, south of Highway 1. This small population was established from fill dirt that was placed along the side of the road. No other populations of this plant were observed elsewhere within the Study Area during 2006 surveys.

Scattered occurrences of Monterey Indian paint brush (*Castilleja latifolia*), CNPS List 4, were observed in the coastal bluff scrub along the south portion of the El Sur Ranch and west of the lagoon near the mouth of the Big Sur River.

No other special-status plants were observed during the 2006 surveys. It is important to note that the survey timing was too late in the year for observing two target species: fragrant fritillary (*Fritillaria liliaceae*) and adobe sanicle (*Sanicula maritima*). Both are included in CNPS List 1B. The fragrant fritillary has the potential to occur in open grassland such as in the coastal prairie and coastal scrub and blooms from February through April. The adobe sanicle has the potential to occur on heavy soils also in the coastal prairie habitat and blooms February through May.

One other special-status species that may occur in the Study Area is compact cobwebby thistle (*Cirsium occidentale* var. *compactum*), included on CNPS List 1B. Suitable habitat is available in the coastal dunes, coastal scrub, and coastal prairie. This plant blooms from April through June and differs from the more common variety by its low, rounded growth form.

Wildlife

Special-status wildlife species that may occur in the Study Area are listed in Table 2. Of these species, six are federally-listed as threatened or endangered, and 27 are CDFG species of special concern or fully protected species known or expected to occur in the Study Area. The latter group includes three mammalian species (Monterey dusky-footed woodrat, ringtail, and pallid bat); 21 avian species only six of which may nest in the Study Area; two reptile species (southwestern pond turtle and coast horned lizard); and one amphibian species (Coast Range newt). It should be noted that many of the avian species listed in Table 2 occur as winter residents or migrants and do not nest in the Big Sur area.

One federally-listed endangered invertebrate species, Smith's blue butterfly, may occur in the Study Area. This observation is based upon the recorded presence of its host plant, buckwheat

(*Eriogonum*), which occurs in portions of the Study Area supporting coastal bluff scrub, and to a lesser extent, on some of the more stable dunes, especially above the mouth of the Big Sur River.

As stated earlier in this report California red-legged frogs were observed in the Big Sur River during fisheries surveys conducted by CDFG in 1993 and 1994 (Biosystems 1995). In 2006, at least 20 adult frogs were observed in pools in Swiss Canyon during fisheries studies conducted by Hanson Environmental (C. Hanson personal communication). Swiss Canyon is the recipient of irrigation water which provides aquatic habitat for the red-legged frog. The Study Area contains suitable habitat for this species in the reclamation pond and in the riparian habitats.

The southwestern pond turtle was recorded from the Big Sur River in 1993 and 1994 (Biosystems 1995) and suitable habitat is present for this species on the El Sur Ranch, although no individuals were observed during 2006 surveys. It should be noted that ranch operations maintain this aquatic habitat.

Survey Within the Estimated Area of Drawdown

A survey within the estimated area of drawdown was conducted by foot where it was accessible. Vegetation was assessed for any visual signs of physiological stress or dieback due to lack of water from existing baseline groundwater pumping. No signs of dieback or physical stress were observed within the area boundary during June surveys.

It has been suggested that permanent transects be constructed within this estimated area of drawdown to establish some baseline monitoring on the vegetation. Having observed the vegetation composition and structure within this boundary, the almost impenetrable undergrowth consisting of California blackberry and poison oak within most of this area may make this a very difficult, if not impossible task, unless swaths of vegetation could be cleared and these clearings maintained for the duration of the study.

Discussion

The El Sur Ranch has been in the cattle ranching business for 180 years, which has included maintaining irrigated pastures for more than 50 years. It is the largest of the remaining working cattle ranches that once existed on the coast between San Simeon and Monterey. The irrigation water for the ranch land is provided by two wells located within easements on land currently owned by the State Department of Parks and Recreation and operated as Andrew Molera State Park.

Diverted water has been delivered to ranch lands for surface irrigation since the 1950s. Diverted water from the two wells is currently conveyed to the irrigated lands through a pipeline system with valves to deliver water to the 11 pastures (see Figure 2), Most of the pipeline is 14-inch concrete with valves placed at 28-foot spacing across the pastures. The El Sur Ranch irrigation system is operated manually by opening and adjusting valves at the head of the 14-foot-wide borders, with one valve serving two borders. A border is a strip of land running approximately perpendicular to the slope of the field that is bound by earth ridges used to control the surface irrigation. The number of valves that are opened is determined by the irrigator based on his experiences in consideration of: the available flow from the wells, the length of the border, the dryness of the soil, the length and condition of the grass, and the irrigation set time. The tailwater (i.e., water exiting the pasture on the down slope side) from all but the bottom set of pastures flows onto the next set of downstream pastures, which provides for an efficient irrigation system. The pastures on the El Sur Ranch are irrigated on a rotating schedule.

The pending Water Right Application does not seek to alter the above circumstances or otherwise significantly modify historical operating practices premised on perceived irrigation needs of the pasture crop. The Water Right Application indicates that there has been some under-irrigation of pastures in the past, either because it is not always desirable to optimize pasture crop production or because pumping was generally stopped in the Old Well when a salinity threshold was met that is well below the salinity tolerance of the pasture. Changes in those operational practices in the future could therefore result in increases in water use over baseline conditions described in this survey. However, it is beyond the scope of this report to describe potential biological impacts associated with possible variation of the historic operational practices. That task is the providence of the ongoing CEQA process.

Part of the scope of work for the 2006 biological surveys was to make biological observations concerning baseline uses relative to public trust values. Accordingly, any noticeable effects of existing ranch operations and maintenance, including cattle grazing, irrigation, vegetation clearing, and underground water pumping were noted. Both beneficial and adverse effects were evident, although the adverse effects did not appear to be significant.

Swiss Canyon is both beneficially and adversely affected by the existing ranch operations. Historic cattle grazing, with its associated trampling and resting within the riparian corridor, results in an adverse effect to the habitat that is supported by pasture irrigation. In places the water-saturated ground is deeply pocked by trampling and some trees showed evidence of trimming by browsing or by the new growth having been broken off when the cattle habitually pass by or rest beneath the trees. Evidence of tree trimming and brush clearing by ranch employees also was noted. Brush is often piled before it is removed or burned. The banks of the channel were marked with wide trails for the passage of cattle and humans, both of which contribute to soil erosion. Grazing also accelerates the invasion of weedy vegetation into riparian areas (J. Hale personal observations).

Even with these adverse impacts of cattle ranching, Swiss Canyon provides valuable habitat for a variety of amphibians, reptiles, birds, and mammals. Its historical and current habitat suitability is likely inextricably tied to continued irrigation of the pastures. The structural diversity of the vegetation is maintained, as evidenced by the presence of a diverse avian community. The tree trimming by ranch employees does not appear to have a significant effect on the vegetation and probably both contributes and detracts from available cover for small mammals, reptiles, and amphibians. While cattle browsing undoubtedly reduces the recruitment and growth of tree seedlings and affects some shrub growth, it may attract wildlife that prefer more open areas and deter colonization by wildlife species that prefer more closed canopies. The canyon provides cattle with refuge from predators and the strong prevailing winds, shelter for cows when calving, and gated access between Pastures 6 and 7-8 on either side of the canyon. (El Sur Ranch reports that the only other feasible access between these pastures adds approximately 2 hours to the transit time and requires considerable staffing.)

Although portions of the water channel within Swiss Canyon appear to be degraded by livestock trampling, suitable habitat remains for California red-legged frog and Pacific chorus frog reproduction (e.g., standing pools with shade) and upland aestivation (e.g., under logs and detritus). Adult frogs and tadpoles were present in the channels and pools in July and September. Clearly, if irrigation run-off was removed from the hydrologic cycle of the channel this habitat would be drastically altered. Our access to Swiss Canyon was limited due to the calving season (i.e., aggressive cows with newborn calves); therefore, our observations of the aquatic habitat were limited to isolated areas where there were no cows. Unfortunately, a more quantitative evaluation of habitat degradation within Swiss Canyon was not possible during our 2006 surveys.

Some erosion may be caused by the runoff of irrigation water over the edge of the bluffs; however, this was indistinguishable to the surveyors from natural erosion from the coastal elements, which is of a far greater magnitude than runoff irrigation.

No apparent stress to the vegetation was noted that could have been evidence of existing underground water pumping. The pump houses themselves provide suitable day and night roosting habitat for bats.

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TABLE 1. SPECIAL-STATUS PLANT SPECIES POTENTIALLY OCCURRING IN THE EL SUR RANCH STUDY AREA

Scientific Name (Common Name)	Status[1] Federal/State/CNPS	Habitat, Elevation, and Bloom Time	Potential for Occurrence
Observed in Study Area			
Castilleja latifolia Monterey Indian paintbrush	--/--/4	Closed-cone coniferous forest, cismontane woodland (openings), coastal dunes, coastal scrub, sandy 0 - 607 feet February-September	Known occurrences along Monterey coast; suitable habitat present within Study Area; observed during 2006 surveys
Malacothamnus palmeri var. *lucianus* Arroyo Seco bushmallow	--/--/1B	Chaparral, meadows and seeps 33 - 3,002 feet May-August	Known NDDB occurrence from Big Sur quad; suitable habitat present within Study Area; observed during 2006 surveys
Suitable Habitat Present, Not Observed			
Arctostaphylos edmundsii Little Sur manzanita	--/--/1B	Coastal bluff scrub, chaparral / sandy 98 - 344 feet November-April	Known NDDB occurrences from Big Sur, Soberanes Point, Point Sur, and Pfeiffer Point quads; suitable habitat present within Study Area; not observed during 2006 surveys
Arctostaphylos hookeri ssp. *hookeri* Hooker's manzanita	--/--/1B	Closed-cone coniferous forest, chaparral, cismontane woodland, coastal scrub / sandy 279 - 984 feet February-June	Known NDDB occurrence from Soberanes Point quad; suitable habitat present within Study Area; not observed during 2006 surveys
Cirsium occidentale var. *compactum* Compact cobwebby thistle	--/--/1B	Chaparral, coastal dunes, coastal prairie, coastal scrub 16 - 492 feet April-June	Known NDDB occurrence from Point Sur quad; suitable habitat present within Study Area; not observed during 2006 surveys
Clarkia jolonensis Jolon clarkia	--/--/1B	Chaparral, cismontane woodland, coastal scrub 66 - 2,165 feet April-June	Suitable habitat present within Study Area; not observed during 2006 surveys
Cordylanthus rigidus ssp. *littoralis* Seaside bird's beak	--/E/1B	Closed-cone coniferous forest, chaparral (maritime), cismontane woodland, coastal dunes, coastal scrub / sandy, often disturbed sites 0 - 705 feet May-October	Suitable habitat present within Study Area; not observed during 2006 surveys
Corethogyne leucophylla Branching beach aster	--/--/3	Closed-cone coniferous forest, coastal dunes 10 - 197 feet May-December	Suitable habitat present within Study Area; not observed during 2006 surveys

Table 1. Special-Status Plant Species Pote ally Occurring in the El Sur Ranch Study Area

Scientific Name (Common Name)	Status[1] Federal/State/CNPS	Habitat, Elevation, and Bloom Time	Potential for Occurrence
Delphinium hutchinsoniae Hutchinson's larkspur	--/--/1B	Broadleaved upland forest, chaparral, coastal prairie, coastal scrub 0 – 1,312 feet March-June	Known NDDB occurrences from Big Sur, Partington Ridge, Soberanes Point, Point Sur, and Pfeiffer Point quads; suitable habitat present within Study Area; not observed during 2006 surveys
Ericameria fasciculate Eastwood's goldenbush	--/--/1B	Closed-cone coniferous forest, chaparral (maritime), coastal dunes, coastal scrub / sandy, openings 98 - 902 feet July-October	Known NDDB occurrences from Carmel Valley and Mt. Carmel quads; suitable habitat present within Study Area; not observed during 2006 surveys
Fritillaria liliacea Fragrant fritillary	--/--/1B	Cismontane woodland, coastal prairie, coastal scrub, valley and foothill grassland / often serpentinite 10 – 1,345 feet February-April	Known NDDB occurrences from Big Sur and Pfeiffer Point quads; suitable habitat present within Study Area; however, 2006 surveys were conducted too late in season to determine presence or absence
Grindelia hirsutula var. *maritima* San Francisco gumplant	--/--/1B	Coastal bluff scrub, coastal scrub, valley and foothill grassland / sandy or serpentinite 49 - 1,312 feet August-September	Suitable habitat present within Study Area; not observed during 2006 surveys; species would have been identifiable in June by growth form had it been present
Malacothamnus palmeri var. *involucratus* Carmel Valley bushmallow	--/--/1B	Chaparral, cismontane woodland, coastal scrub 98 - 3,609 feet May-October	Known NDDB occurrences from Carmel Valley and Mt. Carmel quads; suitable habitat present within Study Area; not observed during 2006 surveys
Pedicularis dudleyii Dudley's lousewort	--/R/1B	Chaparral (maritime), cismontane woodland, North Coast coniferous forest, valley and foothill grassland 197 - 2,953 feet April-June	Known NDDB occurrence from Big Sur quad; suitable habitat present within Study Area; not observed area during 2006 surveys
Piperia yadonii Yadon's rein orchid	E/--/1B	Coastal bluff scrub, Closed-cone coniferous forest, chaparral (maritime) / sandy 33 - 1,362 feet May-August	Known NDDB occurrence from Soberanes Point quad; suitable habitat present within Study Area; not observed during 2006 surveys

Table 1. Special-Status Plant Species Pote[illegible]ally Occurring in the El Sur Ranch Study Area

Scientific Name (Common Name)	Status[1] Federal/State/CNPS	Habitat, Elevation, and Bloom Time	Potential for Occurrence
Sanicula maritima Adobe sanicle	R/--/1B	Chaparral, coastal prairie, meadows and seeps, valley and foothill grassland / clay, serpentinite 98 - 787 feet February-May	Known NDDB occurrence from Big Sur quad; suitable habitat present within Study Area; 2006 surveys conducted too late in season to determine presence or absence
Sidalcea malachroides Maple-leaved checkerbloom	--/--/1B	Broadleaved upland forest, coastal prairie, coastal scrub, North Coast coniferous forest / often in disturbed areas 7 – 2,297 feet April-August	Known NDDB occurrences from Big Sur, Mt. Carmel, Soberanes Point, and Point Sur quads; suitable habitat present within Study Area; not observed during 2006 surveys
No Suitable Habitat Present, Not Observed			
Eriogonum nortonii Pinnacles buckwheat	--/--/1B	Chaparral, valley and foothill grassland / sandy, often on recent burns 984 - 3,199 feet May-June	Known NDDB occurrence from Soberanes Point quad; no suitable habitat present within Study Area; not observed during 2006 surveys
Fritillaria falcata Talus fritillary	--/--/1B	Chaparral, cismontane woodland, lower montane coniferous forest / serpentinite, often talus 984 - 5,003 feet March-May	Known NDDB occurrence from Ventana Cones quad; no suitable habitat present within Study Area; not observed during 2006 surveys
Galium californicum ssp. *luciense* Cone Peak bedstraw	--/--/1B	Broadleaved upland forest, chaparral, cismontane woodland, lower montane coniferous forest 1,312 – 5,003 feet March-September	Known NDDB occurrences from Ventana Cones and Partington Ridge quads; no suitable habitat present within Study Area; not observed during 2006 surveys
Galium clementis Santa Lucia bedstraw	--/--/1B	Lower montane coniferous forest, upper montane coniferous forest / granitic or serpentinite, rocky 3,707 - 5,840 feet May-July	No suitable habitat present within Study Area; not observed during 2006 surveys
Lupinus albifrons var. *abramsii* Abrams's lupine	--/--/3	Broadleaved upland forest, lower montane coniferous forest 1,476 - 6,562 feet April-June	No suitable habitat present within Study Area; not observed during 2006 surveys
Malacothrix saxatilis var. *arachnoidea* Carmel Valley malacothrix	--/--/1B	Chaparral (rocky) 82 - 1,099 feet March-December	Known NDDB occurrences from Carmel Valley and Mt. Carmel quads; no suitable habitat present within Study Area; not observed during 2006 surveys
Monardella antonina ssp. *antonina* San Antonio Hills monardella	--/--/3	Chaparral, cismontane woodland 1,640 - 3,281 feet June-August	No suitable habitat present within Study Area; not observed during 2006 surveys

TABLE 1. SPECIAL-STATUS PLANT SPECIES POTENTIALLY OCCURRING IN THE EL SUR RANCH STUDY AREA

Scientific Name **(Common Name)**	**Status[1] Federal/State/CNPS**	**Habitat, Elevation, and Bloom Time**	**Potential for Occurrence**
Pinus radiata Monterey pine	--/--/1B	Closed-cone coniferous forest, cismontane woodland 82 - 607 feet	Known NDDB occurrence from Soberanes Point quad; no suitable habitat present within Study Area; not observed during 2006 surveys
Plagiobothrys uncinatus Hooked popcorn flower	--/--/1B	Chaparral (sandy), cismontane woodland, valley and foothill grassland 984 - 2,395 feet April-May	Known NDDB occurrence from Carmel Valley quad; no suitable habitat present within Study Area; not observed during 2006 surveys
Tortula californica California screw-moss	--/--/1B	Chenopod scrub, valley and foothill grassland / sandy 33 - 328 feet	No suitable habitat present within Study Area; not observed during 2006 surveys

<u>(1) Legal Status Codes</u>:

E = Federally or State listed as Endangered
T = Federally or State listed as Threatened
R = State listed as Rare
1B = CNPS List 1B: Plants rare, threatened or endangered in California and elsewhere
2 = CNPS List 2: Plants rare, threatened or endangered in California, but more common elsewhere
3 = CNPS List 3: Plants about which we need more information – a review list
4 = CNPS List 4: Plants of limited distribution – a watch list

LE 2. SPECIAL-STATUS WILDLIFE SPECIES POTENTIALLY OCCURRING IN THE EL SUR RANCH STUDY AREA

Common Name **(*Scientific Name*)**	**Legal Status* Federal/State**	**Habitat Requirements**	**Potential for Occurrence**
MAMMALS			
Monterey dusky-footed woodrat (*Neotoma macrotis luciana*)	-- / CSC	Found in dense chaparral, coastal sage-scrub, pinyon-juniper, oak and riparian woodlands, and mixed conifer forest habitats that have a well-developed understory; species appears to favor brushy habitat or woodland with a live oak component	Suitable habitat present in Study Area; stick house observed in oak woodland along Big Sur River; potential habitat in Swiss Canyon; however, area was not accessible to survey
Ringtail (*Bassariscus astutus*)	-- / FP	Occurs in a variety of wooded and rocky habitats; dens in tree hollows and rock cavities; hunts in riparian drainages and avoids open ground	Potential habitat in the oak woodland and riparian habitats; known to occur in Andrew Molera State Park; not observed during 2006 surveys
American badger (*Taxidea taxus*)	-- / CSC	Inhabits grasslands and woodlands; creates large subterranean dens.	Potential habitat in Study Area; no dens or individuals observed during 2006 surveys
Pallid bat (*Antrozous pallidus*)	-- / CSC	Occurs in woodlands; roosts in crevices and cavities found in trees, rocks, and buildings; forages in grasslands, riparian corridors, and agricultural areas	Potential foraging habitat throughout Study Area; potential roosting habitat in trees in the riparian and oak woodland habitats and in ranch buildings; not observed during 2006 surveys
BIRDS			
California brown pelican – nesting colony and communal roosts (*Pelecanus occidentalis californicus*)	E / E, FP	Open coastal habitats; nests on islands without mammalian predators; forages on small schooling fish, primarily anchovies; rarely strays from ocean environment	Common post-breeding visitor to Study Area; formerly nested in Monterey County but declined due to DDT use and demise of local anchovy stocks; species is making a comeback and may resume nesting in County, but not in Study Area; observed bathing and roosting at mouth of Big Sur River during 2006 surveys
Double-crested cormorant – rookery (*Phalacrocorax auritus*)	-- / CSC	Rivers, lakes, swamps, sea coasts, along coastal cliffs; nests in colonies in trees or on ground; eats small schooling fish	Does not nest in Study Area; however, species is resident in vicinity and is known to nest offshore on a rocky island
California condor (*Gymnogyps californianus*)	E / E	Wanders widely over enormous tracts of land; feeds on animal carcasses; nests in isolated country on cliff ledges or tall snags; at least 18 captive-bred individuals have been released into the Ventana Wilderness; these constitute a local Monterey County population	None observed during 2006 surveys; however, individuals may be observed occasionally soaring at a distance overhead; may feed on cattle carcasses within Study Area; has been recorded feeding on whale and other sea mammal carcasses that have washed ashore

ommon Name (*Scientific Name*)	Legal Status* Federal/State	Habitat Requirements	Potential for Occurrence
Golden eagle (*Aquila chrysaetos*)	-- / CSC, FP	Rare in grasslands and other open country; nests on cliff ledges and less often in tall trees; consumes a wide variety of mammalian prey	Observed hunting ground squirrels in irrigated pastures on El Sur Ranch during 2006 surveys
Cooper's hawk - nesting (*Accipiter cooperii*)	-- / CSC	Inhabits dense wooded areas with snags for perching, typically near water; preys primarily upon smaller birds taken in flight	Suitable nesting habitat in riparian woodlands along the drainages; observed during 2006 surveys
Sharp-shinned hawk - nesting (*Accipiter striatus*)	-- / CSC	Inhabits dense wooded areas with snags for perching, typically near water; preys primarily on smaller birds taken in flight	Suitable nesting habitat in riparian woodlands along the drainages but not likely to nest in Study Area; not observed during 2006 surveys, but is a regular visitor to area during non-breeding season
Ferruginous hawk - wintering (*Buteo regalis*)	--/ CSC	Inhabits open country, prairies, plains, and badlands; preys primarily upon small mammals such as rabbits, hares, and ground squirrels	Irregular winter visitor along coast; may occasionally forage for small mammals in irrigated pasture, prairie, and scrub habitats in Study Area; not observed during 2006 surveys
Osprey - nesting (*Pandion haliaetus*)	--/ CSC	Nests along rivers, lakes, and coastal areas; stick nests are typically in trees over water; nests often become perennial and very large; diet is primarily fish	Not known to nest along Big Sur coast; not observed during 2006 surveys
Merlin - wintering (*Falco columbarius*)	-- / CSC	Open habitats and woodlands; preys upon birds that it catches in flight	Uncommon in winter along coast where they hunt in areas frequented by shorebirds; may occasionally visit Big Sur River mouth; not observed during 2006 surveys
Prairie falcon - nesting (*Falco mexicanus*)	-- / CSC	Rare resident of dry, open country, mountainous regions, and short-grass prairie; feeds on a wide variety of birds and small mammals; nests on cliffs	Found only rarely in non-breeding season; no nesting in vicinity of Study Area; not observed during 2006 surveys
Peregrine falcon - nesting (*Falco peregrinus*)	-- / FP	Open habitats; including sea coasts and mountains; preys upon a wide variety of birds: doves, pigeons, shorebirds, waterfowl, passerines, etc.; nests on cliffs and occasionally on tall buildings in cities	A few nesting pairs along Big Sur coast; does not nest in Study Area; routinely observed in non-breeding season at coastal estuaries where shorebirds congregate; not observed during 2006 surveys
Northern harrier (*Circus cyaneus*)	-- / CSC	Frequents meadows, grasslands, and open rangelands; nests on the ground in shrubby vegetation, often near marshes; preys mainly on voles and a wide variety of other items	Observed during 2006 surveys in Study Area; irrigated pastures, prairie, and scrub habitats provide suitable foraging and nesting habitats
White-tailed kite (*Elanus leucurus*)	-- / FP	Nests in low foothill or valley areas with oaks, riparian areas, and marshlands; forages in open grasslands or fields	Observed during 2006 surveys foraging in irrigated pastures and annual grasslands; likely nests in or near Study Area

Common Name (*Scientific Name*)	Legal Status* Federal/State	Habitat Requirements	Potential for Occurrence
Western snowy plover - nesting (*Charadrius alexandrinus nivosus*)	T / CSC	Beaches, mud or salt flats; margins of rivers, lakes, and ponds; forages upon insects and other invertebrates; nest is a scrape with some twigs, debris, etc.	Nests at scattered locations on beaches and estuaries in Monterey County, but does not nest at mouth of Big Sur River or in Study Area; not observed during 2006 surveys
Long-billed curlew - wintering (*Numenius americanus*)	-- / CSC	Inhabits prairies, grassy meadows, usually near water; winters along beaches; forages upon insects, worms, burrow-dwelling crustaceans, etc.	Observed during 2006 surveys on beach but also may forage in irrigated pastures
Laughing gull – nesting colony (*Larus atricilla*)	-- / CSC	Nests in colonies of thousands of birds, often with terns, black skimmers, other gulls; breeding range is Atlantic seaboard, Gulf of Mexico, and Central America; post-breeding visitor to Gulf of California and Salton Sea; eats fish, eggs, nestlings, etc.	Does not nest in Study Area; species is included in this table due to the observation of one individual during Sept. 2006 surveys. This sighting, however, is of a vagrant bird that is perhaps only the second fall record of the species in Monterey County (Roberson 2002)
California gull – nesting colony (*Larus californicus*)	-- / CSC	Inland breeder in western North America; large colony at Mono Lake; nests colonially on isolated sand bars, shores, and islands; eats worms, mice, eggs, garbage, fish crabs, etc.	Observed during 2006 surveys; winters in Study Area but does not nest in Monterey County
Burrowing owl (*Athene cunicularia*)	-- / CSC	Occupies abandoned mammal burrows (esp. ground squirrels) along fence lines and in open grasslands with sparse vegetation	May winter in Study Area, possibly in ground squirrel holes in irrigated pastures; however, this species is not known to nest in Big Sur area (Davis and Roberson 2000)
Black swift – nesting (*Cypseloides niger*)	-- / CSC	Nests on sheer cliffs and under waterfalls; forages on insects taken while in flight	Does not nest in Study Area; not observed during 2006 surveys
Loggerhead shrike (*Lanius ludovicianus*)	-- / CSC	Frequents open habitats with sparse shrubs and trees and/or other suitable perches, bare ground, and low or sparse herbaceous cover	Observed during 2006 surveys; however, individual observed is likely a fall or winter visitor. While suitable habitat does exist in Study Area, this species is not known to nest in Big Sur area (Davis and Roberson 2000)
California horned lark (*Eremophila alpestris actia*)	-- / CSC	Frequents grasslands and other open habitats with low, sparse vegetation	Suitable habitat exists in Study Area; nesting is possible; not observed during 2006 surveys
Purple martin – nesting (*Progne subis*)	-- / CSC	Usually nests colonially, often in cavities in trees, near water; winters in South America; competes with starlings for nest cavities; forages on insects, usually taken in flight	A small colony is known to nest in sycamore grove in Andrew Molera State Park; not observed during 2006 surveys
Tri-colored blackbird – nesting colony (*Agelaius tricolor*)	-- / CSC	Typically nests colonially in dense stands of cattails and tules, or in upland sites with blackberries, nettles, or thistles	Observed in Study Area during Sept. 2006 surveys; species does not nest in Big Sur area (Davis and Roberson 2000)

Common Name (*Scientific Name*)	Legal Status* Federal/State	Habitat Requirements	Potential for Occurrence
REPTILES			
Southwestern pond turtle (*Emys* [=*Clemmys*] *marmorata pallida*)	-- / CSC	Occurs near a variety of aquatic habitats (e.g., ponds, marshes, sloughs, irrigation ditches, and wetlands) providing adequate basking sites from which turtles may readily escape to the water; females have been found to nest as far as 0.5 km from water	Potential habitat in reclamation pond on El Sur Ranch; adults and juveniles observed in Big Sur River in 1993 and 1994 (BioSystems 1995); not observed during 2006 surveys
Coast (California) horned lizard (*Phrynosoma coronatum frontale*)	-- / CSC	Occurs in open scrubland, grassland, coniferous forests, and broadleaf woodlands providing adequate open areas for basking, loose soils for burrowing, and abundant ant and insect prey	Potential habitat in scrub, grassland, and woodland habitats in Study Area; not observed during 2006 surveys
AMPHIBIANS			
California tiger salamander (*Ambystoma californiense*)	T / CSC	Typically found in annual grasslands of lower hills and valleys; breeds in temporary and permanent ponds and in streams; uses rodent burrows and other subterranean retreats in surrounding uplands for shelter; appears to be absent in waters containing predatory game fish	Suitable breeding habitat in reclamation pond on El Sur Ranch and aestivation habitat in adjacent grassy uplands (i.e., ground squirrel colony) in Pump House field; not observed during 2006 surveys
California red-legged frog (*Rana aurora draytonii*)	T / CSC	Inhabits permanent, cool waters of ponds, lakes, reservoirs, and streams offering dense shrubbery and emergent vegetation; may disperse far from water following breeding; larvae typically require 4 to 5 months to attain metamorphosis	Observed in Big Sur River in 1993 and 1994 (Biosystems 1995) and in Swiss Canyon during 2006 fisheries surveys (C. Hanson pers. comm.); Study Area contains suitable habitat in reclamation pond and riparian habitats
Coast Range newt *Toricha torosa torosa*)	-- / CSC	Frequents grassland, woodland, and forest in the open or under rocks, logs, bark, and in rotten wood. Breeds in ponds, reservoirs, and slowly flowing streams from Monterey County south	Portions of Study Area provide suitable habitat; not observed during 2006 surveys
INVERTEBRATES			
Smith's blue butterfly (*Euphilotes enoptes smithi*)	E / --	Most commonly associated with coastal dunes and coastal sage scrub plant communities in Monterey and Santa Cruz counties; buckwheats (*Eriogonum latifolium* and *Eriogonum parvifolium*) serve as both larval and adult food plants	Collected in chaparral habitat on cliffs at "Big Sur, NW of Pfeiffer Big Sur State Park" in 1975 (NDDB 2006); both host plants occur in Study Area in coastal bluff scrub and to a lesser extent on some of the more stable dunes, especially above mouth of Big Sur River on bluffs at southeast corner of El Sur Ranch; not observed during 2006 surveys

Common Name (*Scientific Name*)	Legal Status* Federal/State	Habitat Requirements	Potential for Occurrence
Globose dune beetle (*Coelus globosus*)	-- / --	Burrowing beetle that inhabits coastal foredunes immediately bordering the sea; usually no more than 50 m above median high tide; historical records include Big Sur, Little Sur, and Carmel	Dune habitat appears to be suitable; however, no surveys were conducted for this species in 2006
Dolloff cave spider (*Meta dolloff*)	-- / --	Orb weaver spider found in region of caves from cave mouth extending inside to deep twilight zone; known from caves in the Santa Cruz area	1982 record for "Ghost Cave E face of Pico Blanco"; identification is tentative until males are collected since males exhibit diagnostic characters and only females collected on Pico Blanco; no suitable habitat in Study Area
Monarch butterfly (*Danaus plexippus*)	-- / --	Winter roosts in wind-protected tree groves (eucalyptus, Monterey pine, and cypress) with nectar and water sources nearby	Records for the El Sur Ranch in 1984, 1985-1986, 1996, and 1998 approximately one mile south of the turn-off to Point Sur lighthouse; monarchs roosting in Monterey pines and planted cypress rows in a downcut streambed on the coastal terrace; records for eucalyptus grove around Cooper's Cabin in 1982-1986, 1996, and 1998; maximum number of monarchs observed on ranch was 35,000 in 1998; clusters do not persist through winter every year; in September 2006 prior to migration small numbers incidentally observed in state park eucalyptus grove; ranch grove not surveyed since outside of Study Area boundary

***Legal Status Definitions**

Federal

E = listed as endangered under the federal Endangered Species Act
T = listed as threatened under the federal Endangered Species Act
-- = no designation

State

E = listed as endangered under the California Endangered Species Act
T = listed as threatened under the California Endangered Species Act
CSC = California Species of Special Concern
FP = fully protected under the California Fish and Game Code (fully protected species may not be taken or possessed without a permit from the Fish and Game Commission and/or the Department of Fish and Game)
-- = no designation

APPENDIX A

Vascular Plants Observed During May 30, 31 and June 19, 20, 21, 2006 Field Surveys of the El Sur Ranch, Monterey County, California

Scientific Name	**Common Name**	**Family**
Abronia latifolia	Yellow sand verbena	Nyctaginaceae
Acacia decurrens	Green wattle	Fabaceae
Acer macrophyllum	Big-leaved maple	Aceraceae
Achillea millefolium	Yarrow	Asteraceae
Agrostis densiflora	California bent-grass	Poaceae
Aira caryophyllea	Silver European hairgrass	Poaceae
Alnus rhombifolia	White alder	Betulaceae
Alnus rubra	Red alder	Betulaceae
Ambrosia chamissonis	Bur-sage	Asteraceae
Anagallis arvensis	Scarlet pimpernel	Primulaceae
Anaphalis margaritaceae	Pearly-everlasting	Asteraceae
Arctostaphylos uva-ursi	Bearberry	Ericaceae
Artemisia californica	California sage	Asteraceae
Artemisia douglasiana	Mugwort	Asteraceae
Artemisia pycnocephala	Beach sagewort	Asteraceae
Avena barbata	Slender wild oat	Poaceae
Avena fatua	Wild oat	Poaceae
Baccharis pilularis	Coyote-brush	Asteraceae
Brassica nigra	Black mustard	Brassicaceae
Briza maxima	Rattlesnake grass	Poaceae
Briza minor	Little rattlesnake grass	Poaceae
Brodiaea terrestris ssp. *terrestris*	Terrestrial brodiaea	Liliaceae
Bromus carinatus var. *carinatus*	California brome	Poaceae
Bromus catharticus	Rescue grass	Poaceae
Bromus diandrus	Rip-gut brome	Poaceae
Bromus hordeaceus	Soft chess	Poaceae
Cakile maritima	Sea rocket	Brassicaceae
Calystegia macrostegia ssp. *cyclostegia*	Coast morning-glory	Convolvulaceae
Calystegia occidentalis	Western morning-glory	Convolvulaceae
Camissonia cheiranthifolia	Beach evening primrose	Onagraceae
Carduus pycnocephalus	Italian thistle	Asteraceae
Carex obnupta	Slough sedge	Cyperaceae
Carpobrotus edulis	Hottentot-fig	Aizoaceae
Castilleja ambigua ssp. *ambigua*	Johnny nip	Scrophulariaceae
Castilleja latifolia	Monterey Indian paint-brush	Scrophulariaceae
Ceanothus griseus	Carmel ceanothus	Rhamnaceae
Ceanothus thyrsiflorus	Blue blossom	Rhamnaceae
Centaurea solstitialis	Yellow starthistle	Asteraceae
Cerastium fontanum ssp. *vulgare*	Larger mouse-eared chickweed	Caryophyllaceae
Chamomilla suaveolens	Pineapple weed	Asteraceae
Chenopodium murale	Nettle-leaved goosefoot	Chenopodiaceae
Chlorogalum pomeridianum var. *divaricatum*	Soap plant	Liliaceae
Cirsium occidentale var. *occidentale*	Cobweb thistle	Asteraceae
Cirsium quercetorum	Brownie thistle	Asteraceae
Cirsium vulgare	Bull thistle	Asteraceae
Claytonia perfoliata	Miner's lettuce	Portulacaceae
Conium maculatum	Poison hemlock	Apiaceae
Convolvulus arvensis	Field bindweed	Convolovulaceae
Cortaderia jubata	Pampas grass	Poaceae

Vascular Plants Observed During May 30, 31 and June 19, 20, 21, 2006 Field Surveys of the El Sur Ranch, Monterey County, California

Scientific Name	**Common Name**	**Family**
Cotula coronopifolia	Brass buttons	Asteraceae
Cupressus macrocarpa	Monterey cypress	Cupressaceae
Cynodon dactylon	Bermuda grass	Poaceae
Cyperus eragrostis	Nut sedge	Cyperaceae
Dactylis glomerata	Orchard grass	Poaceae
Danthonia californica	California oat-grass	Poaceae
Delairea odorata	Cape ivy	Asteraceae
Dudleya caespitosa	Sea lettuce	Crassulaceae
Ehrharta erecta	Panic veldtgrass	Poaceae
Elymus glaucus ssp. *glaucus*	Blue wild-rye	Poaceae
Epilobium ciliatum ssp. *ciliatum*	Fringed willowherb	Onagraceae
Equisetum arvense	Common horsetail	Equisetaceae
Equisetum telmateia ssp. *braunii*	Giant horsetail	Equisetaceae
Ericameria ericoides	Mock heather	Asteraceae
Erigeron glaucus	Seaside daisy	Asteraceae
Eriogonum latifolium	Coast buckwheat	Polygonaceae
Eriogonum parvifolium	Dune buckwheat	Polygonaceae
Eriophyllum confertifolium var. *confertifolium*	Yellow yarrow	Asteraceae
Eriophyllum staechadifolium	Lizard-tail	Asteraceae
Erodium botrys	Broad-leaved filaree	Geraniaceae
Erodium cicutarium	Red-stemmed filaree	Geraniaceae
Eschscholzia californica	California poppy	Papaveraceae
Eucalyptus globulus	Blue gum	Myrtaceae
Euphorbia peplus	Petty spurge	Euphorbiaceae
Festuca arundinacea	Tall fescue	Poaceae
Filago californica	California filago	Asteraceae
Foeniculum vulgare	Fennel	Apiaceae
Fragaria chiloensis	Beach strawberry	Rosaceae
Galium aparine	Cleavers	Rubiaceae
Genista monspessulana	French broom	Fabaceae
Geranium carolinianum	Carolina geranium	Geraniaceae
Geranium dissectum	Cut-leaved geranium	Geraniaceae
Geranium molle	Dove's-foot geranium	Geraniaceae
Gnaphalium californicum	Green everlasting	Asteraceae
Gnaphalium canescens ssp. *beneolens*	Fragrant everlasting	Asteraceae
Gnaphalium purpureum	Purple cudweed	Asteraceae
Gnaphalium ramosissimum	Pink cudweed	Asteraceae
Grindelia stricta var. *platyphylla*	Pacific gum-plant	Asteraceae
Hazardia squarrosa	Saw-toothed goldenbush	Asteraceae
Heracleum lanatum	Cow-parsnip	Asteraceae
Hirschfeldia incana	Mediterranean hoary-mustard	Brassicaceae
Holcus lanatus	Common velvetgrass	Poaceae
Hordeum brachyantherum ssp. *brachyantherum*	Meadow barley	Poaceae
Hordeum marinum ssp. *gussoneanum*	Mediterranean barley	Poaceae
Hordeum murinum ssp. *leporinum*	Hare barley	Poaceae
Hypochaeris glabra	Smooth cat's ear	Asteraceae
Hypochaeris radicata	Rough cat's ear	Asteraceae
Iris douglasiana	Douglas iris	Iridaceae

Vascular Plants Observed During May 30, 31 and June 19, 20, 21, 2006 Field Surveys of the El Sur Ranch, Monterey County, California

Scientific Name	**Common Name**	**Family**
Juncus balticus	Baltic rush	Juncaceae
Juncus bufonius var. *bufonius*	Common toad rush	Juncaceae
Juncus effusus var. *pacificus*	Pacific rush	Juncaceae
Juncus occidentalis	Western rush	Juncaceae
Juncus patens	Speading rush	Juncaceae
Juncus phaeocephalus var. *phaeocephalus*	Brown-headed rush	Juncaceae
Juncus xiphioides	Iris-leaved rush	Juncaceae
Leontodon taraxacoides ssp. *taraxacoides*	Long-beaked hawkbit	Asteraceae
Lepidium campestre	English pepper-grass	Brassicaceae
Lessingia filaginifolia var. *californica*	California beach-aster	Asteraceae
Leymus condensatus	Giant ryegrass	Poaceae
Leymus mollis	American dune grass	Poaceae
Linum bienne	Narrow-leaved flax	Linaceae
Lolium multiflorum	Italian ryegrass	Poaceae
Lotus corniculatus	Bird's-foot trefoil	Fabaceae
Lotus humistratus	Short-podded lotus	Fabaceae
Lotus scoparius	Deer weed	Fabaceae
Lupinus albifrons	Silver bush lupine	Fabaceae
Lupinus arboreus	Tree lupine	Fabaceae
Lupinus bicolor	Dwarf lupine	Fabaceae
Lupinus chamissonis	Silver beach lupine	Fabaceae
Lythrum hyssopifolium	Hyssop loosestrife	Lythraceae
Madia gracilis	Slender tarweed	Asteraceae
Malacothamnus palmeri var. *lucianus*	Arroyo Seco bushmallow	Malvaceae
Marah fabaceus	Wild cucumber	Cucurbitaceae
Marrubium vulgare	Hoarhound	Lamiaceae
Medicago polymorpha	Bur-clover	Fabaceae
Melica sp.	Melic grass	Poaceae
Melilotus indica	Yellow melilot	Fabaceae
Microseris bigelovii	Coast microseris	Asteraceae
Mimulus aurantiacus	Sticky monkey flower	Scrophulariaceae
Mimulus guttatus	Common monkey flower	Scrophulariaceae
Myoporum laetum	Myoporum	Myoporaceae
Myrica californica	Wax myrtle	Myricaceae
Nassella lepida	Foothill needlegrass	Poaceae
Nassella pulchra	Purple needlegrass	Poaceae
Oenothera elata ssp. *hookeri*	Hooker's evening primrose	Onagraceae
Oxalis albicans ssp. *pilosa*	Pilose wood-sorrel	Oxalidaceae
Oxalis oregana	Redwood sorrel	Oxalidaceae
Pennisetum clandestinum	Kikuyu grass	Poaceae
Phacelia malvifolia	Stinging phacelia	Hydrophyllaceae
Phalaris aquatica	Harding grass	Poaceae
Phlox gracilis	Slender phlox	Polemoniaceae
Picris echioides	Bristly ox-tongue	Asteraceae
Piptatherum miliaceum	Smilo grass	Poaceae
Plantago coronopus	Cutleaf plantain	Plantaginaceae
Plantago erecta	California plantain	Plantaginaceae
Plantago lanceolata	English plantain	Plantaginaceae

Vascular Plants Observed During May 30, 31 and June 19, 20, 21, 2006 Field Surveys of the El Sur Ranch, Monterey County, California

Scientific Name	**Common Name**	**Family**
Plantago major	Common plantain	Plantaginaceae
Platanus racemosa	Western sycamore	Platanaceae
Poa annua	Annual bluegrass	Poaceae
Polygonum arenastrum	Prostrate knotweed	Polygonaceae
Polypodium californicum var. *californicum*	California polypody	Polypodiaceae
Polypogon monspeliensis	Annual beardgrass	Poaceae
Polystichum munitum	Sword fern	Dryopteridaceae
Populus balsamifera ssp. *trichocarpa*	Black cottonwood	Salicaceae
Potentilla anserina ssp. *pacifica*	Pacific silver-weed	Rosaceae
Prunella vulgaris var. *lanceolata*	Self-heal	Lamiaceae
Pteridium aquilinum var. *pubescens*	Western bracken fern	Dennstaedtiaceae
Quercus agrifolia	Coast live oak	Fagaceae
Raphanus sativus	Wild radish	Brassicaceae
Rhamnus californica	California coffeeberry	Rhamnaceae
Ribes menziesii	Canyon gooseberry	Grossulariaceae
Rorippa nasturtium-aquaticum	Watercress	Brassicaceae
Rubus parviflorus	Thimbleberry	Rosaceae
Rubus ursinus	California blackberry	Rosaceae
Rumex acetosella	Sheep sorrel	Polygonaceae
Rumex conglomeratus	Green dock	Polygonaceae
Rumex crispus	Curly dock	Polygonaceae
Rumex pulcher	Fiddle dock	Polygonaceae
Rumex salcifolius var. *salcifolius*	Willow dock	Polygonaceae
Salix exigua	Sandbar willow	Salicaceae
Salix laevigata	Red willow	Salicaceae
Salix lasiolepis var. *lasiolepis*	Arroyo willow	Salicaceae
Salix lucida ssp. *lasiandra*	Yellow willow	Salicaceae
Salix sitchensis	Sitka willow	Salicaceae
Salvia mellifera	Black sage	Lamiaceae
Sambucus mexicana	Blue elderberry	Caprifoliaceae
Sanicula crassicaulis	Pacific sanicle	Apiaceae
Sanicula laciniata	Coast sanicle	Apiaceae
Satureja douglasii	Yerba buena	Lamiaceae
Scirpus acutus var. *occidentalis*	Common tule	Cyperaceae
Scirpus microcarpus	Small-fruited bulrush	Cyperaceae
Scirpus pungens	Common three-square	Cyperaceae
Scrophularia californica	Coast figwort	Scropulariaceae
Senecio vulgaris	Groundsel	Asteraceae
Sequoia sempervirens	Redwood	Taxodiaceae
Sidalcea malvaeflora ssp. *malvaeflora*	Checker bloom	Malvaceae
Silene gallica	Windmill pink	Caryophyllaceae
Silybum marianum	Milk thistle	Asteraceae
Sisyrinchium bellum	Blue-eyed-grass	Iridaceae
Solanum americanum	Small-flowered nightshade	Solanaceae
Sonchus asper ssp. *asper*	Spiny-leaved sow-thistle	Asteraceae
Sonchus oleraceus	Common sow-thistle	Asteraceae
Spergularia bocconii	Bocconi's sand-spurry	Caryophyllaceae
Stachys ajugoides var. *rigida*	Rigid hedge-nettle	Lamiaceae
Stachys bullata	California hedge-nettle	Lamiaceae

Vascular Plants Observed During May 30, 31 and June 19, 20, 21, 2006 Field Surveys of the El Sur Ranch, Monterey County, California

Scientific Name	**Common Name**	**Family**
Stellaria media	Common chickweed	Caryophyllaceae
Symphoricarpos albus var. *laevigatus*	Snowberry	Caprifoliaceae
Taraxacum officinale	Dandelion	Asteraceae
Torilis arvensis ssp. *arvensis*	Common hedge-parsley	Apiaceae
Toxicodendron diversilobum	Poison oak	Anacardiaceae
Trifolium angustifolium	Narrow-leaved clover	Fabaceae
Trifolium campestre	Hop clover	Fabaceae
Trifolium hirtum	Rose clover	Fabaceae
Trifolium repens	White clover	Fabaceae
Trifolium subterraneum	Subterranean clover	Fabaceae
Triteleia ixioides ssp. *ixioides*	Pretty face	Liliaceae
Typha latifolia	Broad-leaved cattail	Typhaceae
Umbellularia californica	California bay	Lauraceae
Urtica dioica ssp. *holosericea*	Hoary nettle	Urticaceae
Verbena bracteata	Bracted vervain	Verbenaceae
Veronica americana	American brooklime	Scrophulariaceae
Vicia benghalensis	Red-flowered vetch	Fabaceae
Vicia sativa ssp. *sativa*	Spring vetch	Fabaceae
Vinca major	Periwinkle	Apocynaceae
Vulpia bromoides	Six-weeks fescue	Poaceae
Vulpia myuros var. *myuros*	Rattail fescue	Poaceae

APPENDIX B

Wildlife [or its sign] Observed During May, June, and September 2006 Field Surveys of the El Sur Ranch, Monterey County, California

Common Name	**Scientific Name**
MAMMALS	
Myotis bat	*Myotis* sp.
Brush rabbit	*Sylvilagus bachmani*
Desert cottontail	*Sylvilagus audubonii*
California ground squirrel	*Spermophilus beecheyi*
Western gray squirrel	*Sciurus griseus*
Botta's pocket gopher (earthen mounds)	*Thomomys bottae*
Woodrat (nest)	*Neotoma* sp.
Coyote	*Canis latrans*
Gray fox	*Urocyon cinereoargenteus*
Raccoon	*Procyon lotor*
Bobcat	*Lynx rufus*
Wild pig	*Sus scrofa*
Black-tailed deer	*Odocoileus hemionus*
BIRDS	
Pied-billed grebe	*Podilymbus podiceps*
Brown pelican	*Pelicanus occidentalis*
Brandt's cormorant	*Phalacrocorax penicillatus*
Double-crested cormorant	*Phalacrocorax auritus*
Pelagic cormorant	*Phalacrocorax peligicus*
Great blue heron	*Ardea herodias*
Great egret	*Phalacrocorax auritus*
Black-crowned night-heron	*Nycticorax nycticorax*
Turkey vulture	*Cathartes aura*
Mallard	*Anas platyrhynchos*
White-tailed kite	*Elanus leucurus*
Northern harrier	*Circus cyaneus*
Sharp-shinned hawk	*Accipiter striatus*
Red-shouldered hawk	*Buteo lineatus*
Golden eagle	*Aquila chrysaetos*
American kestrel	*Falco sparverius*
California quail	*Callipepla californica*
American coot	*Fulica americana*
Killdeer	*Charadrius vociferus*
Whimbrel	*Numenius phaeopus*
Long-billed curlew	*Numenius americanus*
Marbled godwit	*Limosa fedoa*
Black turnstone	*Arenaria melanocephala*
Sanderling	*Calidris alba*
Laughing gull	*Larus atricilla*
Heermann's gull	*Larus heermanni*
California gull	*Larus californicus*
Western gull	*Larus occidentalis*
Mourning dove	*Zenaida macroura*
Anna's hummingbird	*Calypte anna*
Belted kingfisher	*Ceryle alcyon*
Acorn woodpecker	*Melanerpes formicivorus*
Nuttall's woodpecker	*Picoides nuttallii*
Northern flicker	*Colaptes auratus*
Black phoebe	*Sayornis nigricans*

Wildlife [or its sign] Observed During May, June, and September 2006 Field Surveys of the El Sur Ranch, Monterey County, California

Common Name	**Scientific Name**
Say's phoebe	*Sayornis saya*
Western kingbird	*Tyrannus verticalis*
Loggerhead shrike	*Lanius ludovicianus*
Hutton's vireo	*Vireo huttoni*
Warbling vireo	*Vireo gilvus*
Western scrub-jay	*Aphelocoma californica*
American crow	*Corvus brachyrhynchos*
Barn swallow	*Hirundo rustica*
Chestnut-backed chickadee	*Poecile rufescens*
Oak titmouse	*Baeolophus inornatus*
Bushtit	*Psaltriparus minimus*
Bewick's wren	*Thryomanes bewickii*
American dipper	*Cinculus mexicanus*
Hermit thrush	*Catharus guttatus*
American robin	*Turdus migratorius*
Wrentit	*Chamaea fasciata*
California thrasher	*Toxostoma redivivum*
European starling	*Sturnus vulgaris*
Orange-crowned warbler	*Vermivora celata*
Yellow warbler	*Dendroica petechia*
Black-throated gray warbler	*Dendroica nigrescens*
Townsend's warbler	*Dendroica townsendi*
MacGillvray's warbler	*Oporornus tolmiei*
Common yellowthroat	*Geothlypis trichas occidentalis*
Wilson's warbler	*Wilsonia pusilla*
Western tanager	*Piranga ludoviciana*
Spotted towhee	*Pipilo maculatus*
California towhee	*Pipilo crisalis*
Chipping sparrow	*Spizella passerina*
Clay-colored sparrow	*Spizella pallida*
Song sparrow	*Melospiza melodia*
Lincoln's sparrow	*Melospiza lincolnii*
White-crowned sparrow	*Zonotrichia leucophrys*
Golden-crowned sparrow	*Zonothrichia albicollis*
Dark-eyed junco	*Junco hyemalis*
Lazuli bunting	*Passerina amoena*
Red-winged blackbird	*Agelaius phoeniceus*
Tri-colored blackbird	*Agelaius tricolor*
Brewer's blackbird	*Euphagus cyanocephalus*
Brown-headed cowbird	*Molothrus ater*
House finch	*Carpodacus mexicanus*
Pine siskin	*Carduelis pinus*
Lesser goldfinch	*Carduelis psaltria*
American goldfinch	*Carduelis tristis*
REPTILES	
Western fence lizard	*Sceloporus occidentalis*
Southern alligator lizard	*Gerrhonotus multicarinatus*
Coast garter snake	*Thamnophis elegans terrestris*
AMPHIBIANS	
Pacific chorus frog	*Pseudacris (=Hyla) regilla*
California red-legged frog	*Rana aurora draytonii*

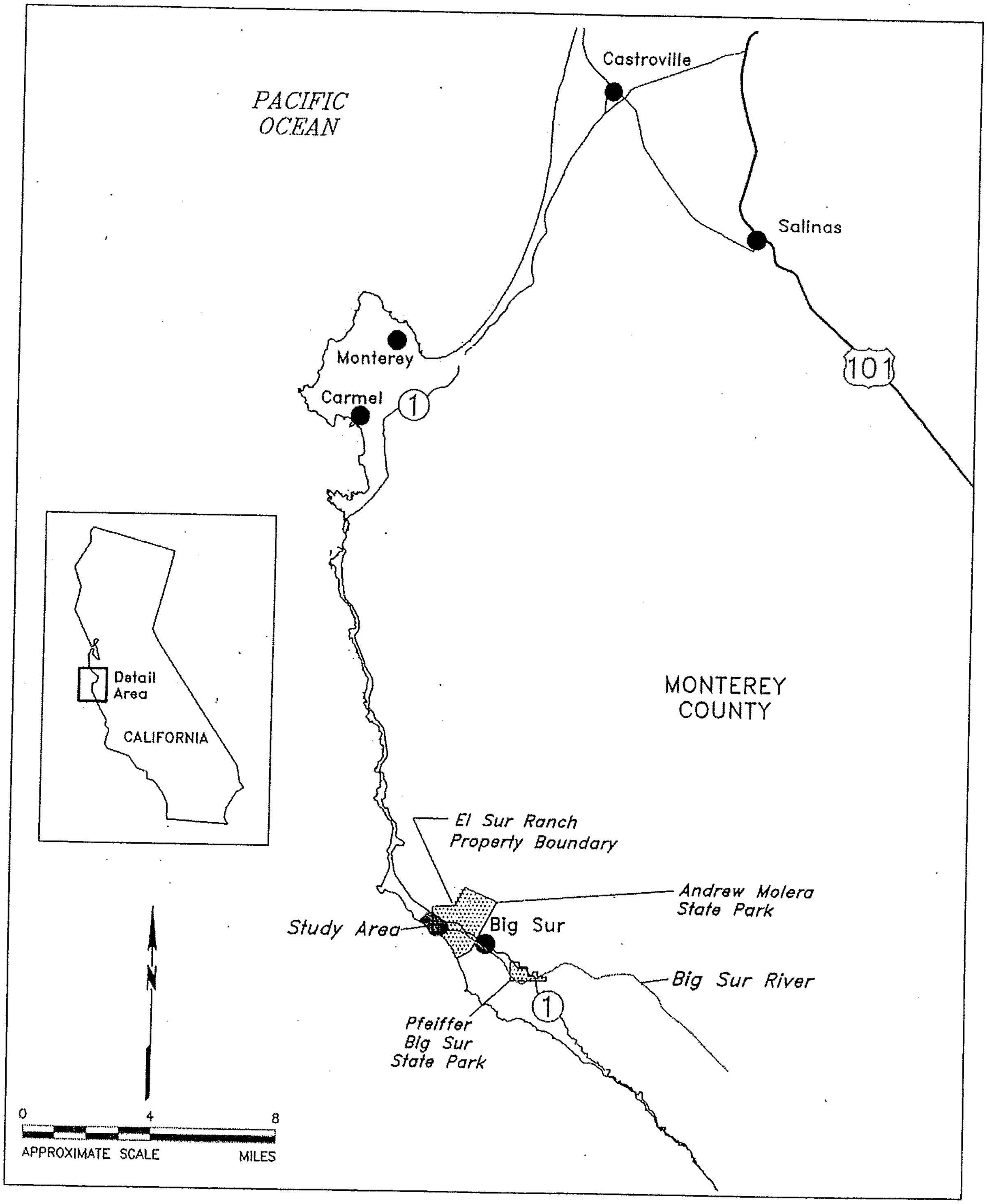


Figure 1. Location Map

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

ORT SOURCE:

THE SOURCE GROUP, MAY 2005

EL SUR RANCH
BIG SUR, CALIFORNIA

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

FIGURE 2

SITE PLAN

Figure 3. Irrigated pasture, El Sur Ranch.

Figure 4. Coastal prairie in the mid-ground, Andrew Molera State Park.

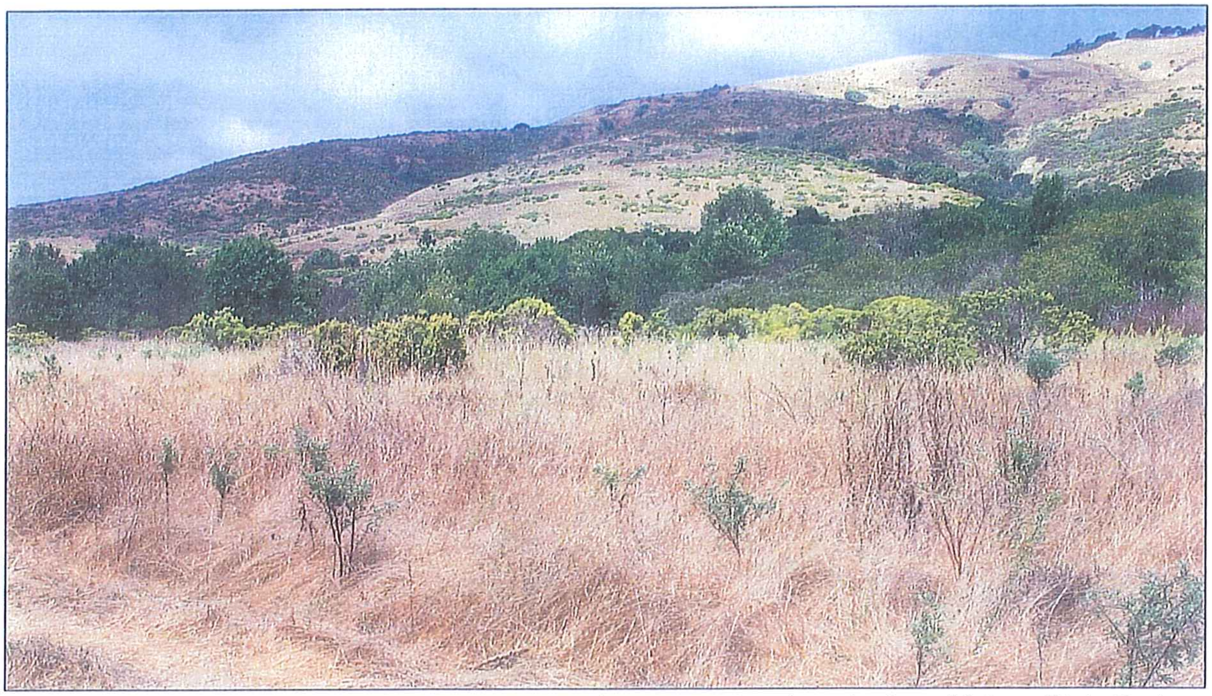


Figure 5. Non-native grassland in foreground, Creamery Meadow, Andrew Molera State Park.

Figure 6. Eucalyptus grove in mid-ground adjacent to coyote bush scrub, Andrew Molera State Park.

Figure 7. Coastal dune habitat below the bluffs at the western edge of El Sur Ranch.

Figure 8. Riparian habitat along the Big Sur River, Andrew Molera State Park.

Figure 9. Riparian habitat in Swiss Canyon, El Sur Ranch.

Figure 10. View of Swiss Canyon, an incised channel bisecting the irrigated pastures.

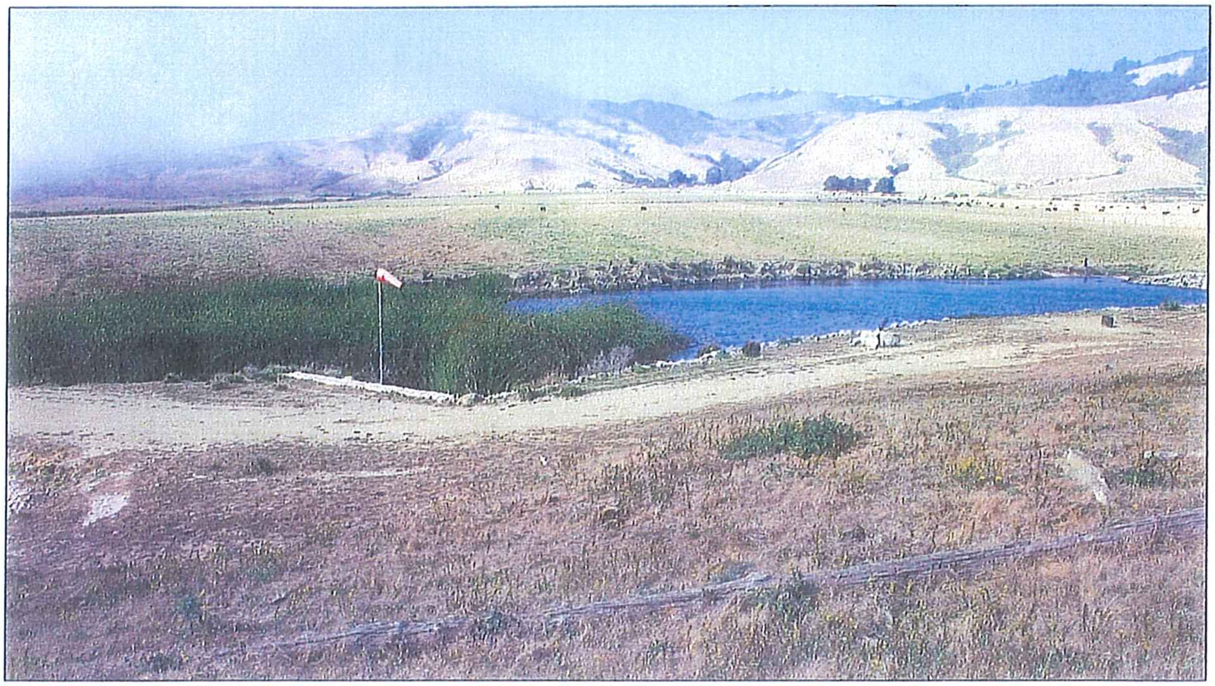


Figure 11. Freshwater emergent wetland and adjacent upland in Pump House Field, El Sur Ranch.

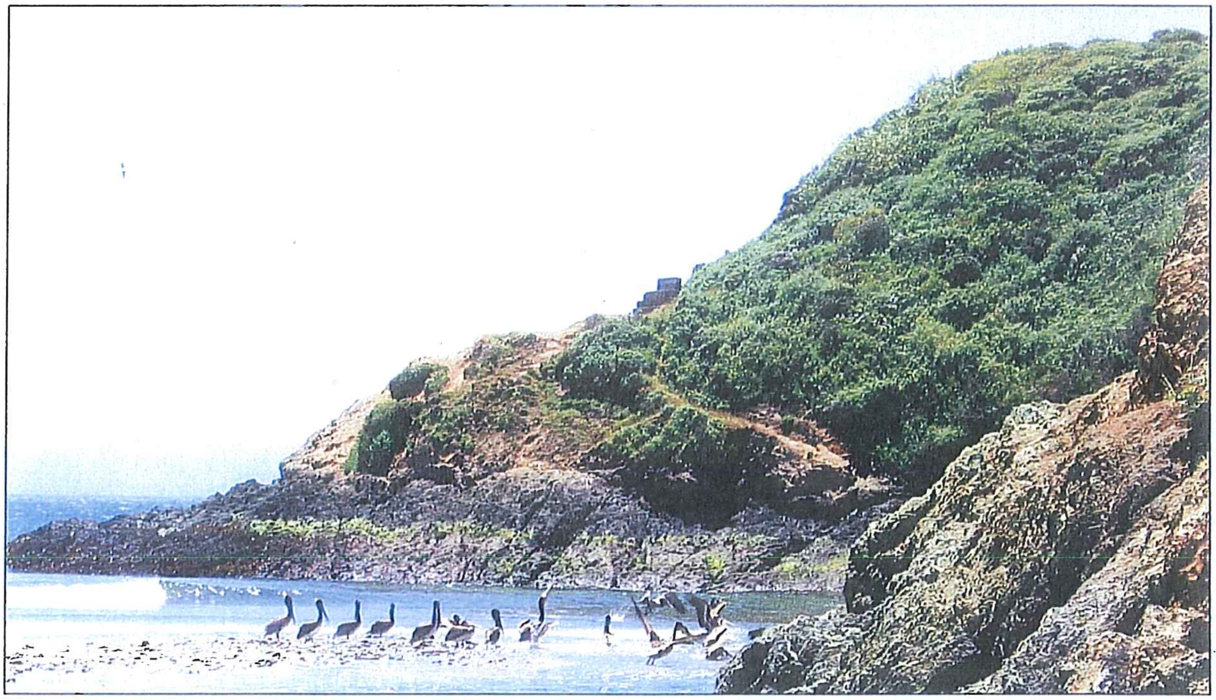
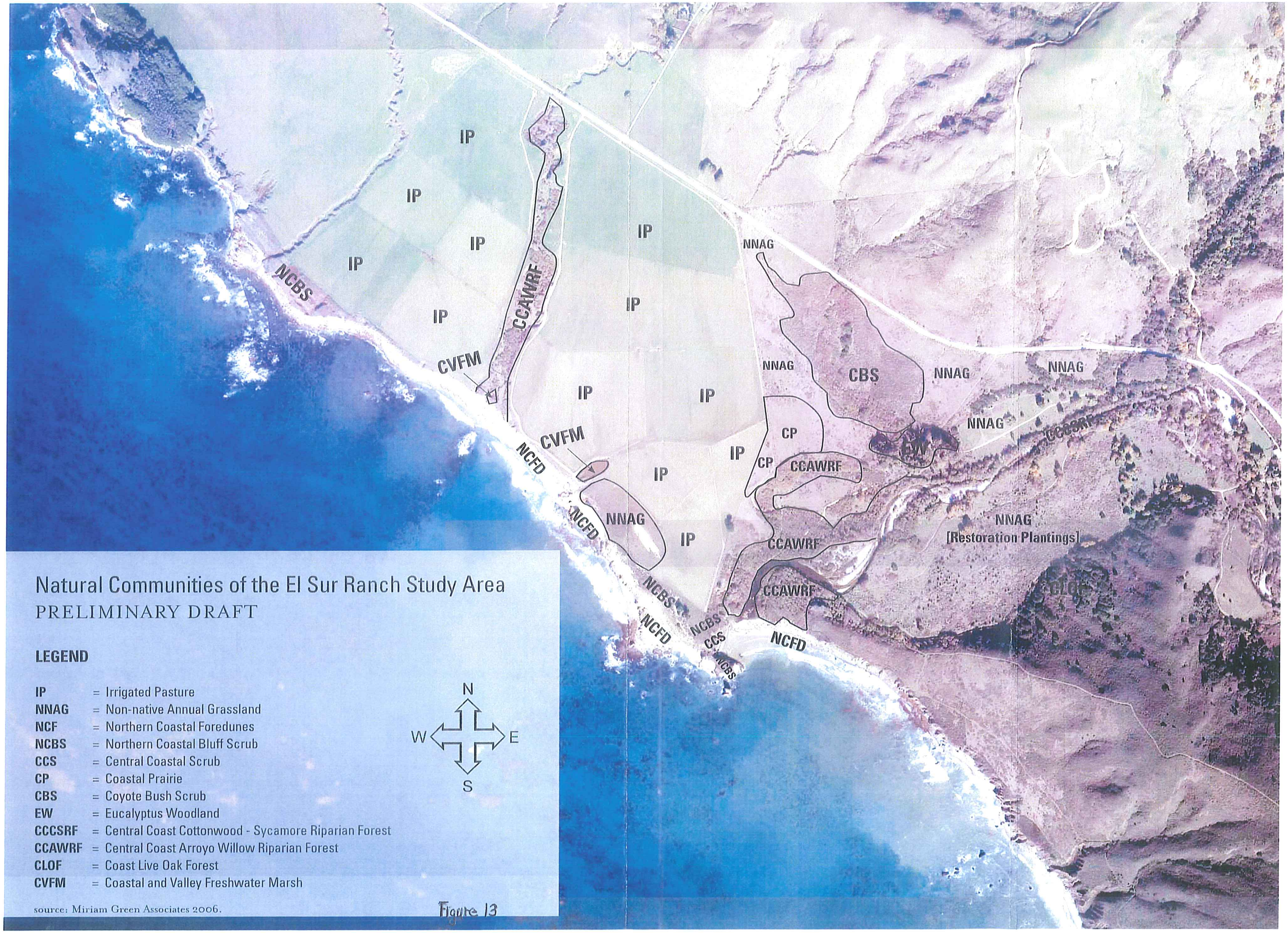


Figure 12. Coastal scrub adjacent to mouth of Big Sur River, Andrew Molera State Park.



Natural Communities of the El Sur Ranch Study Area

PRELIMINARY DRAFT

LEGEND

IP = Irrigated Pasture
NNAG = Non-native Annual Grassland
NCF = Northern Coastal Foredunes
NCBS = Northern Coastal Bluff Scrub
CCS = Central Coastal Scrub
CP = Coastal Prairie
CBS = Coyote Bush Scrub
EW = Eucalyptus Woodland
CCCSRF = Central Coast Cottonwood - Sycamore Riparian Forest
CCAWRF = Central Coast Arroyo Willow Riparian Forest
CLOF = Coast Live Oak Forest
CVFM = Coastal and Valley Freshwater Marsh

source: Miriam Green Associates 2006.

Figure 13