Water Quality and Streamflow Monitoring of San Francisquito and Los Trancos Creeks at Piers Lane, and Bear Creek at Sand Hill Road, Water Year 2006, Long-term Monitoring and Assessment Program

San Mateo and Santa Clara Counties, California

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SUMMARY AND CONCLUSIONS

San Francisquito Creek is currently listed by the California State Water Resources Control Board as being impaired by sediment and by the organophosphate pesticide, diazinon. Water quality in the creek is of particular concern because the creek is habitat for steelhead trout, a federally-listed threatened species. This study reports results of water year 2006 stream gaging and water quality sampling conducted as part of the Long-Term Monitoring and Assessment Program (LTMAP), a water-quality sampling program sponsored by Stanford University and the City of Palo Alto. Water year 2006 was the fifth year of monitoring at the Los Trancos Creek and San Francisquito Creek stations at Piers Lane, and the third year of monitoring at the Bear Creek at Sand Hill Road station. Measurements and observations will continue during water year 2007, though on a limited scale at the Bear Creek at Sand Hill Road station.

Since fall 2001, Balance Hydrologics, Inc. has operated for LTMAP two automated water-quality sampling stations on San Francisquito Creek and Los Trancos Creek at Piers Lane, just above their confluence. In fall 2003, Kinnetic Labs (Santa Cruz) installed another automated sampling station, located on Bear Creek at Sand Hill Road, along the northern border of the Jasper Ridge Biological Preserve. The station, which is now also operated by Balance Hydrologics, is configured similarly to the other stations with a datalogger, several probes, and a programmable pumping unit. As in previous years, the electronic records were combined with manual measurements to create flow records for each stream. Measurements of temperature, specific conductance, dissolved oxygen and pH were made manually.

Three sets of comprehensive, composite water-quality samples were collected on each stream during the water year using time-paced sampling. A fourth set of samples was collected during the dry-season as grab samples. The same storms were sampled at all three stations. Samples for particular constituents requiring special preservation methods (i.e., ammonia and mercury) were collected as grab samples during the composite sampling intervals. Suspended-sediment samples were collected during and between storms and used to estimate annual suspended-sediment yields. Results were compared to water quality objectives established by the San Francisco Bay office (Region 2) of the California Regional Water Quality Control Board (“Regional Board” or “RWQCB”). Our conclusions are presented below, together with citations to the relevant text subsections, tables and figures:

1. Rainfall and streamflow totals for water year 2006 were above average. Based on USGS provisional streamflow data for San Francisquito Creek, the peak flow for the year

corresponds to about a 19-year recurrence-interval flood, equivalent to a 5.2 percent chance of being exceeded in any year. *(Sections 4.1 to 4.3; Table 4; Figures 2 to 5)*

2. Specific conductance values *(Section 6.2; Tables 1 to 3; Figures 8 to 10)* and pH values (*Section 6.7; Tables 1 to 3; Figure 14*) in all three streams were within the range of previous sampling results during water year 2006. Dissolved oxygen concentrations *(Section 6.8; Tables 1 to 3; Figures 15 to 17)* were occasionally low (in some cases as low as 20 percent saturation) in late summer or fall -- particularly in San Francisquito Creek – a condition which may prove limiting for certain biota.

3. We noted various high-temperature spikes on Los Trancos Creek and Bear Creek at multiple times throughout the water year. Water temperatures rose in late July, in response to a major summer heat wave. For the first time since LTMAP measurements began in fall 2001, maximum daily temperatures in San Francisquito Creek and Bear Creek exceeded 25˚C and mean daily water temperatures in all three streams exceeded the 21˚C upper threshold of optimal steelhead habitat. *(Sections 4.4 and 6.6; Tables 1 to 3; Figures 11 to 13).*

4. As in prior years, organophosphate pesticide concentrations were below detectable limits in all three streams on all dates sampled in water year 2006 *(Section 6.4; Tables 5 and 6).* Given the small number of total samplings to-date, relative to the sample set required for consideration of de-listing, further sampling should be performed before concluding when or if these pesticides are present or absent in the three streams.

5. Ammonia-nitrogen was not detected at any stations during water year 2006. Nitrate-nitrogen was detected at moderate concentrations in all samples from the three streams. Levels of nitrate-nitrogen were within the range of previous sampling results and typical of those observed in other streams in the Santa Cruz Mountains where urban and agricultural land uses occur *(Section 6.3; Tables 5 and 6).*

6. Total mercury concentrations in wet-season grab samples were high in all three streams in water year 2006 and often exceeded the chronic toxicity objective. Dissolved mercury concentrations in all samples were well below the regulatory standard *(Section 6.5.7; Tables 5 and 6).*

7. Dissolved copper concentrations in all three streams in water year 2006 were similar to prior years. Although copper concentrations in composite samples were slightly below the regulatory objectives, acute standards may actually have been exceeded at some point during the storm events when copper concentrations were higher and hardness levels were lower. *(Section 6.5.5; Tables 5 and 6).* As suggested in the water year 2005 report, we recommend that multiple grab samples be collected in water year 2007 to investigate this issue further.

8. Fluctuations in flow and specific conductance during baseflow periods were most noticeable at the Bear Creek station, but also propagated downstream to San Francisquito Creek at Piers Lane. In addition, various artificial alterations seem to have occurred in Los Trancos Creek. Upstream diversions and other flow alterations may significantly and quickly affect summer baseflows and, therefore, aquatic habitat. Besides the volumetric changes to flow, water quality may also be altered by the apparent additions to creek flow *(Sections 4.4; Figures 3, 6, and 11 to 13).*

9. Sediment-transport measurements and qualitative observations of bed conditions at all three stations indicate that sediment conditions during water year 2006 were typical of previous years and other gaging stations operated by Balance in the San Francisquito watershed *(Section 6.9.3; Table 4; Figures 18 and 19).*

1. INTRODUCTION

This report presents the results of surface water monitoring in the San Francisquito Creek watershed by Balance Hydrologics, Inc. ("Balance"), on behalf of the Stanford University Utilities Division, Jasper Ridge Biological Preserve, Stanford Management Company, Stanford Linear Accelerator Center (all, "Stanford") and the City of Palo Alto. Stanford is a participant in the San Francisquito Watershed Council, which is managing the Long-Term Monitoring and Assessment Program (LTMAP). The LTMAP was originally created by a subcommittee of the San Francisquito Creek Coordinated Resource Management and Planning (CRMP) Steering Committee, the group now known as the San Francisquito Watershed Council. The LTMAP was established primarily to monitor and assess current (i.e., baseline) conditions, analyze trends, and evaluate watershed management. Three LTMAP monitoring stations in the lower San Francisquito Creek watershed have been monitored since fall 2001 (water year 2002[1]); monitoring at a fourth station higher in the watershed began in fall 2003.

The San Francisquito Creek watershed is located on the San Francisco Peninsula, and includes the northwestern portion of Santa Clara County and the southeastern portion of San Mateo County (Figure 1). Los Trancos Creek and (below their confluence) San Francisquito Creek form the boundary between the two counties. The watershed encompasses approximately 45 square miles, of which about 37 square miles lie upstream from the two Piers Lane stations, and includes a wide diversity of urbanized, rural and natural habitats. The 11.7-square mile Bear Creek sub-watershed encompasses the northwestern headwaters of San Francisquito Creek, covering approximately 25 percent of its watershed. Los Trancos Creek has a sub-watershed area of 7.8 square miles.

The first three LTMAP automated sampling stations were installed in fall 2001. City of Palo Alto Regional Water Quality Control Plant staff are operating the lowermost station on San Francisquito Creek at Newell Road, a short distance upstream of Highway 101 and near the head of tidewater. Balance staff are operating the other two stations, on San Francisquito Creek and Los Trancos Creek at Piers Lane, a short distance downstream (north) of Interstate 280 and immediately upstream of the confluence of the two creeks. A fourth LTMAP station was installed on Bear Creek at Sand Hill Road in fall 2003. This station, which is also operated by Balance, is about 2.5 miles upstream from Piers Lane.

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[1] Most hydrologic and geomorphic monitoring occurs for a period defined as a water year, which begins on October 1 and ends on September 30 of the named year. For example, water year 2004 (WY2004) began on Oct. 1, 2003 and concluded on September 30, 2004.

Data and findings from the initial two years of monitoring the Piers Lane stations are presented in the prior annual monitoring reports (Owens and others, 2003; Owens and others, 2004). To better integrate findings from the three stations currently monitored by Balance staff, results were summarized in a single report beginning with water year 2004, the third year of monitoring the two Piers Lane stations and the initial year of monitoring the Bear Creek at Sand Hill Road station (Owens and others, 2005) and continuing in water year 2005 (Owens and others, 2006). This report similarly presents results of water year 2006 monitoring at all three stations. Measurement and observations will continue during water year 2007 (WY2007), though on a limited scale at the Bear Creek at Sand Hill Road station.

2. BACKGROUND

Surface-water monitoring for this project is being implemented to assess known and potential pollutant concentrations as part of the Long-Term Monitoring and Assessment Program (LTMAP). The LTMAP was originally created by a subcommittee of the San Francisquito Creek Coordinated Resource Management and Planning (CRMP) Steering Committee, the group now known as the San Francisquito Watershed Council. The goals of the LTMAP are to provide a comprehensive framework for organizing and coordinating monitoring and assessment activities in the San Francisquito Creek watershed.

As part of the LTMAP, surface water data are being collected for use in describing constituents which might adversely affect water quality in the watershed, under storm runoff and low-flow conditions, in major part as they affect the full range of steelhead life stages. To assist the LTMAP in one of its objectives, Balance was asked to:

1. Identify which contaminants or sets of contaminants are present in San Francisquito Creek, Los Trancos Creek and Bear Creek, and to prioritize analyses for more detailed study in future years;
2. assess if a relationship exists between the presence, absence or concentration of contaminants and streamflow; and
3. evaluate the amount of suspended sediment and bedload being transported by the three streams and compare them to results from other locations in the watershed also monitored during water year 2005 for other projects.

2.1 Local Influences on Water Quality

Restoration of habitat for steelhead -- a federally-listed threatened species greatly valued by the watershed community at large -- in the San Francisquito Creek drainage has been the focus of substantial efforts over the past ten years. Technical professionals and knowledgeable residents with experience in these streams suspect that water quality may be a significant constraint to the size and robustness of the steelhead population in San Francisquito Creek and its tributaries. Steelhead are anadromous[2] salmonids which spawn and rear throughout the free-flowing headwaters of the San Francisquito Creek watershed. Water-quality impairment may likely affect other sensitive local species or possibly other beneficial uses as well.

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[2] Migrates to the ocean as a juvenile and returns to fresh water to spawn.

The principal sources of potential concern include:

- horses and perhaps other livestock, particularly those boarded on land adjacent to the stream channels of San Francisquito Creek and its tributaries and/or using the stream or riparian buffer areas;
- septic systems, or other on-site wastewater-treatment units;
- urban runoff, including road and highway surface runoff, which may contribute nutrients and other constituents, such as heavy metals;
- pulses of water which have been repeatedly observed and documented in the streams at low flow, that may originate from human-managed sources, perhaps from flushing of swimming pools and other chlorinated ponds; and
- common garden, orchard and lawn or turf chemicals (i.e., fertilizers, pesticides).

Urban runoff and animal wastes from horses and other domesticated species, when washed into the creeks of the watershed, may be acutely toxic to steelhead and other fish or aquatic species. Chronic toxicity and/or indirect effects of these loadings may also counteract sustained regional efforts to improve and restore populations of steelhead. Each of the other sources listed above can also have chronic or acute toxicity.

The quantity of baseflow is also an important factor in maintaining habitat quality. Too little water in the creeks during the spring and summer can impede out-migration of year-old fish and affect summer survival of newly hatched "young-of-the-year". Insufficient baseflow also magnifies the effects of introduced pollutants by reducing the amount of dilution available to decrease pollutant concentrations, and at very low flows can lead to impaired conditions such as local increases in temperature or decreases in dissolved oxygen.

2.2 Related Water Quality Studies in the Watershed

We know of only one recent sub-watershed-scale investigation of water quality. As part of a grant from the Packard Foundation, the San Francisquito Watershed Council asked Balance to conduct a three-year water quality study in the Bear Creek portion of the larger watershed during water years 2000 through 2002. Balance has reported the results of the first two years of monitoring (Owens and others, 2001; 2002) and a draft report summarizing data from all three years of monitoring is currently undergoing final review. Both published and unpublished data from the Bear Creek study are used in this report as a basis for comparison. The Bear Creek watershed encompasses the northwestern headwaters of San Francisquito Creek, as shown in Figure 1. Thus, water-quality problems in the Bear Creek watershed can directly affect nearly all other spawning and rearing areas in the San Francisquito Creek watershed. Conversely, measures which control causes of toxicity to fish in the Bear Creek system will benefit nearly the entire local steelhead population, as well as other species in the San Francisquito Creek watershed. Knowledge of natural and anthropogenic factors affecting water quality in Bear Creek can help in planning and assessing water quality elsewhere in the watershed.

3. STATION LOCATIONS

3.1 Bear Creek Sub-watershed Station

The Bear Creek at Sand Hill Road station (designated as BCSH) is located on the northern border of the Jasper Ridge Biological Preserve (Figure 1), approximately 2.5 miles upstream of the San Francisquito Creek at Piers Lane station. Balance has periodically monitored streamflow and water-quality constituents at this site, which receives flows from almost one-half of the San Francisquito Creek watershed above Piers Lane, since the spring of 1997. Prior to the current study, the most complete sets of data were compiled during water years 2000 to 2002, when this station was one of eight stations in the watershed regularly monitored on behalf of the San Francisquito Watershed Council (see Section 2.2 above). Balance continued to operate the gaging station during water year 2003 but only minimal water quality measurements were made that year.

Through the combined efforts of Stanford Management Co., Stanford Linear Accelerator Center, and the Jasper Ridge Biological Preserve, this location became the fourth station in the LTMAP monitoring network. In fall 2003 (WY2004), Kinnetic Laboratories, Inc. (Santa Cruz) installed new monitoring equipment on the left bank of Bear Creek, about 200 feet downstream from Sand Hill Road and only a short distance from the previous gaging location. As described in more detail in Section 4.1, this installation was severely damaged by the storm that began on Dec. 31, 2005. Temporary probes were installed one week later and permanent replacement of the instream components occurred in May 2006, with the assistance of Kinnetic Laboratories, Inc. The station is equipped with a tipping-bucket rain gauge, a streamside staff plate, a datalogger and automated sampler pumping unit housed within an enclosure, and several water-quality probes. Water level, water temperature, specific conductance (an index of salinity), dissolved oxygen, and pH are continuously monitored. Water levels are measured using pressure transducers. Manual measurements of water levels at a staff plate, streamflow and water quality parameters are made at regular intervals to calibrate the electronic record. The station is connected to a land-line telephone so that real-time data can be monitored over the Internet. The automated sampler is designed to collect aliquots over a specified period into a composite sample bottle kept chilled in an ice bath. Following sampled events, sub-samples of the mixed composite sample are poured into prepared sample bottles for laboratory analysis of individual constituents.

3.2 Piers Lane Stations

The other two LTMAP stations discussed in this report[3] are located on Los Trancos Creek and San Francisquito Creek, just upstream from their confluence, where Piers Lane crosses both creeks (Figure 1). The stations are within 100 yards of each other and only a short distance downstream (north) of Interstate 280. The stations were installed in fall 2001 by staff of Kinnetic Laboratories, Inc. and Larry Walker Associates (Davis) under contract to the City of Palo Alto. The station on San Francisquito Creek is equipped with a tipping-bucket rain gauge. From installation through fall 2005, water levels at both stations were measured by an ultrasonic sonar transponder mounted on the bridge above the creek at each site. Following failure of the transponder at the San Francisquito Creek station in November 2005, Balance installed a set of temporary probes and worked with City of Palo Alto Regional Water Quality Control Plant and Stanford staff to develop a repair plan that would also address maintenance problems at both Piers Lane stations, as detailed in previous monitoring reports. To improve reliability, a datalogger and pressure transducers were installed at the San Francisquito Creek station in February 2006, and the specific conductance probe was replaced with a different brand. Both stations remain powered by batteries, but solar panels were installed at each site to reduce or eliminate intermittent problems with battery failure that have resulted in occasional loss of monitoring data. The cable to the rain gauge was sheathed in conduit and buried to reduce chances of rodent damage. Sampling tubes at both stations were replaced and a second conduit was installed between the enclosures and the streams to carry the probe cables and reduce constriction in the original conduits. Otherwise, each station is equipped with the same instrumentation described above for the Bear Creek station and is monitored using the same protocols. Cell phone telemetry was attempted in the past but found to drain the batteries too quickly to make the data available in real-time.[4]

Balance initiated operation of the newly-installed Piers Lane stations, designated as San Francisquito Creek at Piers Lane (SFPL) and Los Trancos Creek at Piers Lane (LTPL), at the start of water year 2002. For a number of reasons detailed in the first-year (WY2002) monitoring report (Owens and others, 2003), only a limited number of samples were collected during the first year of operation. Monitoring during water years 2003 to 2006 more closely followed the envisioned sampling sequence.

[3] The fourth LTMAP station, on San Francisquito Creek at Newell Road, a short distance upstream of Highway 101, has been operated by staff of the City of Palo Alto Regional Water Quality Control Plant since it was installed in fall 2001. Monitoring at this site is coordinated with activities at the upstream stations but results are interpreted by City staff and reported under separate cover.

[4] Connection to AC power or a land-line telephone would decrease obstacles to real-time data availability but is reportedly not feasible at this time.

3.3 Other Stations in the Watershed

As part of a series of cooperating projects, Balance also monitored a number of locations in the San Francisquito Creek watershed upstream of Piers Lane during water year 2006 (Figure 1). The main focus was on monitoring streamflow and sediment discharge. Data from some of these other stations are used in this report for comparison to the data collected at the Piers Lane stations. Comparison of flow records among stations helps to verify the gaging data and describe and document differences in hydrologic responses to rainfall. These differences are proving larger than expected, such as very low baseflows on West Union Creek, or flashy storm peaks on Dry Creek, and may prove in and of themselves to be of significance to stream management, including steelhead restoration. Selected stations are described below.

3.3.1 Los Trancos Creek at Arastradero Road

Balance operates another station on Los Trancos Creek (LTAA) about 1.8 miles upstream of Piers Lane on behalf of Stanford University Utilities Division. This upstream station has been in operation since November 1994. Suspended-sediment and bedload discharge are also collected at this site.

3.3.2 Searsville sub-watershed stations

Balance operated gages at Searsville Dam and upstream from Searsville Lake on Corte Madera Creek at Westridge Drive during water year 2006. Data collection from the Searsville sub-watershed stations focuses on sediment transport. Searsville and Corte Madera Creek flow data were considered in this report where such comparisons were useful.

3.3.3 U.S. Geological Survey station on San Francisquito Creek

USGS stream gage #1164500 (San Francisquito Creek at Stanford University) is located approximately 0.5 miles downstream from Piers Lane. This station was originally established in 1931 and has maintained a continuous record of flow since 1954. USGS staff regularly collected suspended-sediment (but not bedload sediment) data at this station from the mid-1960s to early 1970s (Brown and Jackson, 1973).

4. HYDROLOGIC SUMMARY, WATER YEAR 2006

Observations and measurements from our water year 2006 site visits are documented in Table 1 (Bear Creek), Table 2 (Los Trancos Creek) and Table 3 (San Francisquito Creek). Annual hydrologic summaries for each of the three creeks are presented in Forms 1 to 3. Table 4 is a hydrologic summary for all three creeks over the period of record, which for Bear Creek, includes gaging results from the earlier three-year water quality study (water years 2000 to 2002).

Daily flow hydrographs for the three creeks are plotted together in Figure 2 and for individual creeks in Figures 3 to 5. Figure 6 shows the unit flow hydrograph for each creek. "Unit flow", calculated by dividing the mean daily flow by the watershed area, allows comparison of the response to rainfall among different watersheds. In general, the magnitude of streamflow is governed by the size of the watershed, so that a larger watershed produces higher flows. However, differences among streams in wet- and dry-season baseflows also reflect variations in the geology, topography and management of diversions within their watersheds.

4.1 Narrative Summary

In general, water year 2006 was a wet year in terms of total rainfall (Figure 7) and total flow, and peak flows for the year were fairly large (Figure 2). The water year began with low baseflows in early October, then light rains fell during October and November. This year, as in previous years, many of the early rainfall events were small and similarly-sized making it difficult to define a distinct "first-flush"[5] in water year 2006. Occasional heavy rains occurred from mid-December 2005 through early January of 2006. The major storm of the season and the highest peak flows of the year at all three stations occurred on December 31, 2005 (described further below and in Section 4.3). The high flows damaged the equipment at Bear Creek when the concrete structure to which the pressure transducers and probes were anchored was lifted up and washed a short distance downstream, while the creek was still rising (and probably several hours before the flow peak occurred). This damage to the gaging station resulted in a week-long gap in the Bear Creek record, until Balance staff were able to install a set of temporary probes, which remained in place until a full repair could be performed in May 2006.

[5] "First-flush" refers to a storm event that is strong enough to produce runoff and which occurs after a period of weeks or months of dry weather. The term is typically applied to the first major storm event of the wet-season but it may also be used to describe any significant storm occurring after a prolonged dry period. Since first-flush storms mobilize accumulated sediment, litter, nutrients and other pollutants, the resultant runoff often contains higher concentrations of these constituents than are observed in runoff from subsequent storms. Note that the first flush from impermeable surfaces, such as roads and roofs, often occurs earlier in the season than the first flush from open space lands, which must first become saturated.

Because the peak water levels from the December 2005 storm were well above the flow measurements that we have performed, the peak flow estimates for all three stations were based on cross-section and longitudinal surveys of high-water marks. On Bear Creek (Figure 3), the estimated peak flow rate was about 3,800 cubic feet per second (cfs) on December 31, 2005. On San Francisquito Creek (Figure 4), the highest calculated peak flow rate was 4,290 cfs on December 31, 2005 at 8:15 to 8:30. On Los Trancos Creek (Figure 5), the highest calculated peak flow rate was about 640 cfs on December 31, 2005 at 8:15.

The remainder of January and February 2006 were relatively dry. Rains began again at the close of February and continued through mid-April 2006, keeping flow persistently well above average; large storms occurred on March 25 and April 4. Recessional flows during the spring were higher than usual until June and July, which were quite warm and dry.

4.2 Precipitation

Water year 2006 rainfall recorded at the Piers Lane tipping-bucket rain gauge totaled at least 26 inches (the rain gauge did not function for a short portion of the year), or *at least* 141 percent of the long-term mean annual precipitation of 18.5 inches (Rantz, 1971). Actual rainfall at Piers Lane was even higher but the rain gauge was inoperable from mid-January to mid-February 2006, probably due to clogging from bird droppings. Higher in the watershed, the tipping-bucket rain gauge at the Bear Creek at Sand Hill Road station recorded approximately 36.7 inches of rain in water year 2006, approximately 141 percent of the long-term mean annual precipitation of about 26 inches for the station location.

We obtained the rainfall records for two index precipitation stations in the region, Mount Hamilton and the San Francisco Airport, from the California Data Exchange Center (CDEC). Water year 2006 precipitation at Mount Hamilton was also above-normal at 138 percent of the long-term average values, while rainfall at the San Francisco Airport was 173 percent of the long-term average. The rainfall totals agree with our flow totals, which indicate that water year 2006 was somewhat wetter than water year 2005, and significantly wetter than average.

4.3 Peak Flows

4.3.1 Return Period of Peak Flows

Even though we do not have a sufficient period of record to calculate the return period of water year 2006 peak flows at the stations that we monitor for this project, we can characterize the peak flows at the USGS gaging station on San Francisquito Creek (USGS number 11164500). The estimated peak flow for this station for water year 2006 as reported by the USGS was approximately 5,000 cfs (still provisional), which corresponds to a 19-year return period (5.2 percent chance of being exceeded in any year), based on the annual-peak series. This is significantly higher than the median peak flow of 1,560 cfs, which is equivalent to the 2-year return period (50 percent chance of being exceeded in any year).

Based on our observations and limited-duration gaging records at stations within the watershed, we believe that the peaks flows had a higher return period in the Bear Creek section of the watershed than in the Searsville Lake or Los Trancos Creek sections, consistent with a regional pattern of much higher recurrences in the North Bay than South Bay.

4.3.2 Timing of flow peaks at various stations

Note that the individual peaks at upstream stations would sum to a value significantly larger than the flow at the USGS gage, *if* all of them had occurred at the same time. Typically, upstream stations peak first (e.g., Bear Creek), as flow moves downstream. However, the peaks actually occurred at different times and therefore some were out of phase. The best of example of this was Searsville Lake, where the peak flow occurred about an hour after the peak flow at San Francisquito Creek at Piers Lane. Because Searsville Lake has large marsh and open water areas, runoff entering the lake must first fill all those storage areas in the marsh and delta before lake levels rise and the outflow reaches its peak. The net effect is a delay through Searsville Lake, which reduces the height of the flood peak downstream.

The flow peaks at the two Piers Lane stations did occur at about the same time.

4.4 Unexplained Flow Surges

In fall 2005, we noted regular flow spikes in Bear Creek on weekend days, mainly during November, with flow increasing by about 0.08 cfs (35 gallons per minute). See Appendix D. Specific conductance decreased by about 100 to 150 microsiemens (µs) during the spikes, consistent with additions of water to the creek that were less saline than the background level of approximately 800 to 900 µs. The temperature record was not affected by these spikes (Figure 13). The spikes may have increased dissolved oxygen levels slightly due to increased turbulence as the higher flows passed over riffles.

During April 28 through 30, 2006 we noticed a sharp decrease in flow for the Los Trancos Creek at Piers Lane station (Figures 5 and 6); the dip in flow was accompanied by a sharp increase in water temperature (Figure 12). Neither this dip in flow nor sharp rise in water temperature was recorded at Balance's upstream Los Trancos Creek station.

During July 18 through 20, we recorded several sharp increases in flow for the Los Trancos Creek at Piers Lane station (Figures 5 and 6). The water temperature did not appear to be greatly affected, but was rising quickly due to the weather conditions. This spike was not recorded at Balance's upstream Los Trancos Creek station.

During August 3 through 5, we recorded increased flow at Bear Creek at Sand Hill Road; this flow increase was accompanied by increased water temperature and decreased specific conductance. This leads us to believe that some amount of warmer, fresher water was discharged to Bear Creek.

In addition to the flow surges mentioned above, we continued to note significant abrupt changes in flow (mainly *dips* in flow) at the Bear Creek station that could be due to diversions such as the Bear Gulch intake facility. These changes are consistent with operation of upstream diversions by California Water Service Company;[6] other (unregulated) diversions are also likely to have occurred.

We have previously noted spikes of either high temperature, high salinity or both at all three of the monitoring stations.

4.5 Creating a Record of Streamflow

We develop a record of streamflow in two steps. First, a record of water levels is compiled from the recorded electronic data and calibrated with field observations. Flow rates are then computed from the water levels using empirical equations developed specifically for each site from field measurements.

4.5.1 Developing a record of water levels

The monitoring equipment at the Bear Creek at Sand Hill Road station and the San Francisquito Creek at Piers Lane station includes two pressure transducers, which measure water levels in the creek at 15-minute intervals, and a Campbell Scientific CR10X datalogger to record the water-level data. The Los Trancos Creek at Piers Lane station is equipped with an ultrasonic sonar transponder connected to an American Sigma 950 flow meter and datalogger. Field measurements and observations at each station are used to calibrate the electronic record. Observations during site

[6] Personal communication from Darin Duncan, California Water Service Co. to Marty Laporte, Stanford University FACOPS, May 26, 2006.

visits include: water level (or gage height) at the staff plate, high water marks, the presence of twig and leaf dams which may temporarily raise or lower water levels, signs of sedimentation or scour, and the specific conductance and temperature of the water (Tables 1 to 3).

During this year, as is typically done, we applied multiple stage shifts to the electronic water-level record to account for intermittent sedimentation, leaf dams and algae growth that affect the water-level elevation at the monitoring locations. We found that observed high-water marks corresponded well (usually within 0.2 to 0.3 feet) with the recorded water-level peaks, providing additional confidence in the stage record.

For short sections of record when the equipment was not working properly (sonar transponder at SFPL and destroyed probes at BCSH) we correlated a flow record from nearby creeks. For San Francisquito Creek, we used Bear Creek and USGS gaging data. For Bear Creek we correlated data from Corte Madera Creek, and calibrated that data using the surveyed high-water marks and flow measurements performed during the period of missing data.

4.5.2 Computing flows

Based on our periodic site visits, staff plate readings, and flow measurements (Tables 1 to 3), we create an empirical stage-to-discharge relationship ("stage-discharge rating curve") for each gage. This rating curve is then applied to the electronic record of water levels measured by the pressure transducers (at BCSH and SFPL) and the sonar transponder (at LTPL).

At low flows, the sonar transponder values have a large amount of variation, up to about 0.3 feet per day. We consider most of this variation to be "noise" in the instrument reading that does not reflect actual changes in water levels, although a lower-amplitude (0.02-foot) diurnal pattern of water-level change is typically observed during low-flow periods. The flow record becomes particularly "noisy" at the 15-minute level of detail, which is why we present the data in daily form. Mean daily stream flow values appear to be fairly accurate because daily averaging removes most of the noise.

As with all other gaging of natural streams, some uncertainty remains (especially at high and low flows) in spite of efforts to be as precise as possible. We do not have manual measurements at the peak flow levels. Peak-flow estimates for this study are based on extension of the stage-discharge curve from our highest measured flow to the peak water level recorded by the automated monitoring equipment. As stated previously, due to exceptionally high water levels, peak flow estimates for the December 31, 2005 storm were based on standard indirect peak flow measurements made by cross-sectional and longitudinal surveys of high-water marks.

5. WATER QUALITY SAMPLING APPROACH

Larry Walker Associates developed the water quality monitoring plan for the two LTMAP stations at Piers Lane while under contract to the City of Palo Alto (LWA, 2001). Their Draft Surface Water Quality Monitoring Plan 2001/02, available from the City of Palo Alto, provides a complete description of the methods and protocols used in this study. Because the Bear Creek at Sand Hill Road stream gage is also part of the LTMAP study, the same protocols were used there as at the Piers Lane stations and results are comparable. Interested readers are referred to the water quality monitoring plan for additional detail.

5.1 Timing of Sampling Visits

The hydrologic conditions during which a sample is taken are an important factor influencing the analyzed or observed values. For example, sampling baseflow in late August can be expected to provide very different results from sampling a first-flush event in October, or a mid-winter storm. The LTMAP monitoring program is designed to measure field parameters on each sampling visit and collect samples for ammonia, nitrate, phosphate, mercury, total and dissolved metals, and organophosphate pesticides four to five times annually. Sediment sampling occurs from fall through spring, when flows are sufficiently elevated to transport sediment, but not in summer.

5.2 Field Measurements and Laboratory Analyses

The focus of the study is on characterizing water quality in the two streams during both baseflow and storm periods, particularly with regard to those constituents potentially affecting fisheries and aquatic habitat conditions. Thus, the sampling plan includes a broad range of chemical constituents, and both total and dissolved constituent analyses:

<u>Field Measurements</u>

- streamflow (cubic feet per second, or cfs)
- specific conductance (microsiemens, or µs @ 25°C)
- water temperature (°C)
- dissolved oxygen (mg/L)
- pH
- qualitative remarks, for example, odors, color, clarity, (if noticeable), and anomalies

Laboratory Analyses

- metals (aluminum, copper, lead, mercury, nickel, selenium, silver and zinc)
- organophosphate pesticides (diazinon and chlorpyrifos)
- nitrate-nitrogen and ammonia-nitrogen
- total phosphorus
- total hardness (needed to interpret metal toxicity)
- total suspended solids
- bedload sediment

5.3 Exceptions and Deviations from Proposed Methods

Deviations almost inevitably occur in hydrologic studies, usually at very high or low flows, such as the responses necessary when a tree falls or other changes in the channel at the sampling location are encountered.

During the third year of monitoring at the Bear Creek at Sand Hill Road station, we were unable to complete the following items as they were initially outlined in the project proposal:

- All three sets of composite water-quality samples were collected as time-paced samples, rather than flow-paced samples [7]. We also did not collect a fourth set of wet-season samples because the rainfall pattern during March and April 2006 was not conducive to sampling a spring storm. In addition, the dry-season samples collected in August 2006 were grab samples, rather than longer-duration composite samples, and this sample analysis was for a more limited set of constituents. Due to budget constraints, no water quality samples will be collected at this station during water year 2007.
- The staff plate, pressure transducers and all three water quality probes were destroyed by the storm which began on Dec. 31, 2005. As a result, there are data gaps in the flow record from this date until a temporary gage was installed one week later, and on June 1, 2006 when the permanent gage and probes were installed and being calibrated (Figure 3). The flow record for these intervals was synthesized from Balance's records on Corte Madera and San Francisquito Creeks.
- The first year monitoring report identified the need to clean the three water quality probes more often to minimize fouling by algae and sediment and regular maintenance subsequently improved probe performance. The specific conductance, pH, and dissolved oxygen probes destroyed by the December 2005 storm were not replaced until permanent repairs occurred in May 2006, so the only available data on these parameters

[7] While the *Monitoring Plan* specified flow–paced composite sampling to facilitate calculation of event-based concentrations, we have found that time-paced sampling is more practical for several reasons (see discussion in Section 7 of our WY2004 report).

during the five-month interval are from hand-held meters. While all three replacement probes have worked well to date, their performance during water year 2007 is uncertain given the envisioned reduced frequency of site visits.

During the fifth year of monitoring Los Trancos Creek and San Francisquito Creek at Piers Lane, we were unable to complete the following items as they were initially outlined in the project proposal:

- All three sets of composite water-quality samples were collected as time-paced samples, rather than flow-paced samples. We also did not collect a fourth set of wet-season samples because the rainfall pattern during March and April 2006 was not conducive to sampling a spring storm. Due to the unanticipated cost of station repairs (see Section 3.2), the dry-season samples collected in August 2006 were grab samples, rather than longer-duration composite samples, and this sample analysis was for a more limited set of constituents. We plan to continue using time-paced sampling during water year 2007.

- Despite more frequent checking on the data and condition of the tipping-bucket rain gauge at the San Francisquito Creek station, the rain gauge was inoperable from mid-January to mid-February 2006, probably due to clogging from bird droppings. The effect is a slight under-reporting of rainfall, as described above, and does not materially affect interpretations.

- Prior reports noted that the pH, dissolved oxygen and specific conductance probes at both stations worked intermittently or not at all due to the need for frequent cleaning, and that probe calibration was impeded due to constriction of the cables in the conduit leading from the enclosures to the stream. The latter problem was mostly alleviated by the February 2006 repairs, largely funded by the City of Palo Alto Regional Water Quality Control Plant. The sampling tubes in the existing conduits were replaced and the probe cables were transferred to a second conduit reducing constrictions. The pH and dissolved oxygen probes at both Piers Lane stations continue to perform poorly, so the only available data on these parameters are from hand-held meters. The specific conductance probe at the Los Trancos Creek station remains erratic but the new specific conductance (and temperature) probe installed at the San Francisquito Creek station performed well from November 2005 through July 2006 (Figure 10), when water levels dropped below the probe sensor, and after October 2006 when the sensor was lowered further.

Recommendations for improving the monitoring program during water year 2007 and subsequent years are presented briefly in Chapter 7 below.

6. RESULTS AND DISCUSSION OF WATER QUALITY SAMPLING

This chapter includes a discussion of findings by individual constituent or constituent group. Results of manual measurements of specific conductance, temperature, pH, and dissolved oxygen are included in Tables 1 to 3. The specific dates when composite and/or grab water quality samples were collected, the laboratory reporting limits[8], and the analytical results are presented in Table 5 (Bear Creek) and Table 6 (San Francisquito Creek and Los Trancos Creek). Results of suspended-sediment sampling during and between storms, used to estimate annual suspended-sediment yields, are presented in Table 8 (Bear Creek) and Table 9 (San Francisquito Creek and Los Trancos Creek). All laboratory reports are collected in Appendix A (Piers Lane stations) and Appendix B (Bear Creek). Detailed hydrographs showing the timing of sample collection at each station for various constituents during each of the water-quality sampling visits are graphically presented in Appendix C.

During the fifth year of operating the two Piers Lane stations, and the third year of operating the Bear Creek at Sand Hill Road station, we collected time-paced composite water-quality samples on three occasions at all three stations: wet-season samples were collected on: November 28 to 29, 2005; December 1 to 2, 2005; and December 28 to 29, 2005. We had intended to sample a fourth storm in spring 20006 to assess the effects of warming conditions and landscape fertilizer and pesticide applications on water quality. However, this monitoring objective was not realized in water year 2006 because the rainfall pattern during March and April did not provide a sufficient dry period to allow constituent accumulation prior to sampling. This year's dry-season baseflow sample was collected as a grab sample on August 9, 2006 and submitted to the laboratory for a more limited (focused) set of analyses.

6.1 Water Quality Objectives

The San Francisco Bay office (Region 2) of the Regional Board regulates water quality in the Bay area in accordance with the Water Quality Control Plan or 'Basin Plan' (RWQCB, 1995). The Basin Plan includes both numeric and narrative water quality objectives against which the LTMAP monitoring results in Tables 5 and 6 are evaluated. The water quality objectives for trace metals in the 1995 Basin Plan, for the South Bay below the Dumbarton Bridge and tributary streams which discharge into this portion of the Bay, were previously written as total recoverable concentrations, rather than the more bioavailable dissolved concentrations of the metals, because they were established in 1986 preceding the U.S. EPA directive on aquatic life criteria for metals. Furthermore, the U.S. EPA

[8] Laboratory reporting limits varied due to the methods used and the amount of sample dilution required.

ambient water quality criteria for many metals have been updated since 1986 to incorporate more recent toxicity data and/or revisions to how the criteria were calculated.

To address these inconsistencies, the U.S. EPA criteria promulgated by the California Toxics Rule (CTR) included changes to the water quality objectives for arsenic, cadmium, chromium, copper (fresh water only), lead, nickel, silver and zinc. The updated water quality objectives were adopted by the Regional Board in 2004, approved by the U.S. EPA (Region 9) on January 5, 2005[9], and are now included in the Basin Plan. Beginning with the water year 2005 report, Tables 5 and 6 were modified to incorporate the new water quality objectives for dissolved trace metal constituents into the Basin Plan objectives rather than showing them on separate lines. We note that the existing Basin Plan objective for mercury was retained pending development of new water quality objectives for this constituent, which will likely be based on fish-tissue concentrations.

6.1.1 Composite sampling effects on interpretation of acute-toxicity levels

When assessing the sample concentrations reported in this study, it is important to keep in mind that the composite samples are typically collected over periods of 12 to 36 hours, while the acute toxicity objective is a 1-hour average and the chronic toxicity objective is a 4-day or 96-hour average.

Particularly as regards the *acute* toxicity objective, concentrations in composite samples are likely to be significantly *lower* than the highest, short-term concentrations experienced by stream biota during the sampling period. One reason is simply that a high concentration in one aliquot is diluted by other aliquots of lower concentration, especially when the composite sampling interval includes a substantial period of baseflow prior to or following the storm (see Appendix C: sampling hydrographs). Additionally, exploratory sampling on Dry Creek during the previous Bear Creek study (Owens and others, 2001) indicated that concentrations of many constituents (including copper) increase as flows rise and decrease as flows decline, such that concentrations of dissolved metals could vary by at least a factor of two over the course of a storm event. Finally, the effect of metals toxicity would be magnified by changes in hardness, which typically decreases with increased stream flow. As a result, when metals concentrations are highest, the hardness values would be lowest (and much lower than reported from the composite sample), increasing the effective toxicity at a given metals concentration.

[9] The Basin Plan amendment was previously approved by the State Water Resources Control Board on July 22, 2004, and by the California Office of Administrative Law on October 4, 2004.

Thus, a composite sample concentration equal to one-half the acute toxicity objective (1-hour period), such as occasionally occurred with dissolved copper in water year 2005 (see Owens and others, 2006), *may* indicate that the peak concentration actually exceeded that limit. For these constituents, synoptic grab sampling (multiple grab samples over the course of a single storm) and/or grab samples collected at the peak of multiple storms over a season, would be useful to better define the relationship between composite sample concentrations and acute water quality objectives.

6.2 Specific Conductance

Specific conductance values during water year 2006 were within the range of previous sampling results and are generally within the expected range for the San Francisquito watershed. Occasional spikes and dips in specific conductance (along with changes in flow) are indicators of water additions of unknown origin (see section 4.4 and Appendix D).

Specific conductance, a widely used index for salinity or total dissolved solids (TDS), was measured in the field and recorded at field temperatures, then later converted to an equivalent value at 25°C according to the accepted relationship between specific conductance and temperature. The expected range of specific conductance in the San Francisquito Creek watershed is from about 100 to 2000 µs (all values are normalized to 25°C). The lowest levels occur during storms, when flows are diluted with rain and fresh runoff. The highest levels are typically observed in early fall, when flows are lowest, prior to the onset of seasonal rains.

During water year 2006, specific conductance ranged from about 100 to 1,000 µs (values from Figure 9) in Bear Creek (Table 1; Figure 9) and from about 200 to 1,400 µs (values from Figure 10) in San Francisquito Creek (Table 3; Figure 10). Based solely on manual measurements, observed specific conductance ranged from about 180 to 1,600 µs in Los Trancos Creek (Table 2). As was observed in previous water years, specific conductance was again typically lowest in Bear Creek and highest in Los Trancos Creek. Specific conductance levels in all three streams were at the lower end of the range in spring and summer of 2006, as would be expected during a relatively-high rainfall year.

6.3 Nitrogen

As noted above, nitrogen has been identified as one of the potential pollutants affecting steelhead fisheries habitat in the San Francisquito Creek watershed, with possible sources including horse stables, fertilizers, yard waste, and failing residential septic systems. The most readily accessible forms of nitrogen in stream systems are typically nitrate (NO3-) and ammonia (NH3), although relatively large amounts of nitrogen can be stored in both living and dead biomass (i.e., leaf litter). Ammonia is the form produced during decomposition of organic matter and is also common in fertilizers. When mixed with water, the majority of ammonia quickly reacts to form the relatively harmless ammonium ion (NH4+) which, due to its positive charge, is rapidly taken up by plants or microbially converted to nitrate. However, a small amount remains as un-ionized ammonia, which can be toxic to fish and aquatic invertebrates. The concentration of un-ionized ammonia increases with increased pH and water temperature above certain thresholds. Nitrate, in contrast, persists much longer in the environment and is more mobile in soil.

6.3.1 Ammonia-nitrogen

Ammonia-nitrogen was not detected on any of the four sampling dates during water year 2006.

In previous years, total ammonia concentrations have occasionally exceeded the detection limit of 0.2 mg/L, with 13 of 15 detections occurring during wet season sampling. While the Regional Board has not established a specific acute toxicity objective for ammonia, the calculated un-ionized ammonia fraction of the total ammonia concentration has typically remained below 10 percent of the 0.025 mg/L threshold for chronic (annual median) exposure to un-ionized ammonia cited in the Basin Plan (RWQCB, 1995), and the highest level attained was about 50 percent of the threshold.

6.3.2 Nitrate-nitrogen

Nitrate-nitrogen concentrations were within the range of previous sampling results during water year 2006 and also within the expected range for streams draining developed areas of the Santa Cruz Mountains.[10]

Nitrification is the process whereby ammonia-nitrogen (NH3) is microbially converted to nitrite (NO2-), and then nitrate (NO3-). The intermediate step occurs rapidly, so nitrite-nitrogen concentrations are usually very low or undetectable. Samples collected for nitrate analysis are preserved on ice and must be analyzed within 48 hours. However, timely delivery and processing of nitrate samples collected late in the work week and over weekends is problematic because laboratories are closed on weekends. To address this constraint, most of the water year 2006 samples were collected in acidified bottles, extending the hold time to 28 days, and submitted to the laboratory for “nitrite plus nitrate” analysis. The two analyses are listed separately in Tables 5 and 6

[10] For comparison, the Pajaro River Watershed Water Quality Management Plan (Applied Science and Engineering, 1999) reported that nitrate-nitrogen concentrations of 0.05 to 2.0 mg/L would be expected in “uncompromised” streams draining *undeveloped* (open-space) portions of the Santa Cruz Mountains.

but, for practical purposes, we assume that virtually all of the nitrogen under the "nitrite plus nitrate" column is nitrate-nitrogen.

Nitrate-nitrogen concentrations were detected in all three creeks on all dates sampled in water year 2006 and similar to values observed in previous years. Nitrate (or nitrate plus nitrite) concentrations (as nitrogen) ranged from 0.08 to 1.4 mg/L in Bear Creek (Table 5), from 1.7 to 5.6 mg/L in Los Trancos Creek, and from 0.87 to 2.5 mg/L in San Francisquito Creek. As observed in water year 2005, nitrate-nitrogen concentrations were higher in Los Trancos Creek than in the other two creeks on every sampling date. Wet-season nitrate-nitrogen concentrations are generally expected to be highest during first-flush events early in the season, when sufficient runoff is present to flush accumulated nitrate into the stream but flows are below the threshold where nitrate concentrations become highly diluted by fresh runoff.

In past years, nitrate concentrations in Los Trancos Creek and San Francisquito Creek have tended to be highest during the first-flush and dry-season sampling events and much lower during larger mid-winter and spring storms. In contrast, based on a more limited data set, nitrate concentrations in Bear Creek have generally been highest during winter storms. The same general patterns were observed this year. We note that the nitrate concentration of dry-season baseflow samples from Los Trancos Creek and San Francisquito Creek were elevated and similar to values observed in water year 2005. The dry-season sample from Bear Creek had a nitrate concentration of 0.08 mg/L, slightly less than the values measured in water year 2005 (0.2 mg/L), water year 2004 (0.10 mg/L), or the 0.14 to 0.63 mg/L observed in the 3-year study encompassing water years 2000 through 2002 (Balance Hydrologics, unpublished data).

6.4 Organophosphate Pesticides

Diazinon and chlorpyrifos were not detected in any sample during water year 2006.

San Francisquito Creek is listed by the State Water Quality Control Board as being impaired by the common organophosphate pesticide, diazinon. As of December 31, 2004, the U.S. EPA banned sales of diazinon-containing outdoor, non-agricultural products in the United States in order to eliminate all residential uses of the insecticide. In the Bay Area, the Regional Board recently proposed a total maximum daily load (TMDL) that addresses diazinon (Johnson, 2004) in an effort to reduce pesticide-related toxicity in urban creeks. The TMDL process calls for development of numeric targets that translate the current Basin Plan's narrative toxicity objective.[11] The Regional Board has proposed diazinon concentration targets of 0.05 µg/L (four-day average) and 0.08 µg/L (one-hour average), not to be exceeded more than once every three years.[12] These objectives were originally identified by the California Department of Fish and Game and are consistent with the federal antidegradation policy promulgated in the Code of Federal Regulations (Title 40, §131.12).

Concentrations of diazinon, and another common organophosphate pesticide, chlorpyrifos, were below the detection limit in all three streams on all dates sampled in water year 2006 (Tables 5 and 6). Neither pesticide was detected in samples from Los Trancos Creek and San Francisquito Creek in water years 2002 to 2005 [13] or from Bear Creek during water years 2004 and 2005. For comparison, during the Bear Creek water-quality study, diazinon was detected only once in three years, at 15.3 ug/L in October 2000, and chlorpyrifos was never detected in any sample.

6.5 Metals

Composite water quality samples collected from the three streams during the water year 2006 wet-season were analyzed for total and dissolved concentrations of eight metals commonly associated in part with urban and suburban development in the San Francisquito Creek watershed: aluminum, copper, lead, mercury, nickel, selenium, silver, and zinc. In contrast to previous years, the water year 2006 dry-season samples were collected as grab samples and submitted for analysis of a more limited suite of constituents. Total metals concentrations were *not* analyzed but concentrations of all *dissolved* metals except aluminum were measured.

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[11] Waters should remain free of toxics at concentrations lethal to or adversely impacting aquatic organisms (RWQCB, 1995).

[12] The proposed numerical standard is intended to apply only to the Clean Water Act Section 303(d) listing process methodology and does not revise water quality objectives. As described in the Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) list (California State Water Resources Control Board, 2004), the process by which a water segment is placed on or removed from the 303(d) list involves consideration of single or multiple lines of evidence and statistical evaluation of numeric water quality data. For example, a water segment can be listed if there are two or more exceedances in a set of up to 24 samples (for toxicants), or five or more exceedances in a set of up to 30 samples (for conventional pollutants). To be *delisted*, a water segment must have less than or equal to two exceedances in a set of 28 to 36 samples (for toxicants), or four or less exceedances in a set of 26 to 30 samples (for conventional pollutants).

[13] Samples collected for the Bear Creek water-quality study, and for the LTMAP study during water year 2002 and most of water year 2003, were analyzed for organophosphate pesticide content using a methodology with a detection limit of 0.5 ug/L. The LTMAP study began using a more sensitive methodology, with a detection limit of 0.05 ug/L, starting with the June 26, 2003 sampling.

6.5.1 Metals not detected

As in past years, almost all metals were detected in either the dissolved or solid form in all three streams on every sampling date (Tables 5 and 6). The sole exception in water year 2006 was silver, which was not detected in any of the three streams on any sampling date this year. In water year 2005, silver was similarly not detected in Los Trancos Creek or San Francisquito Creek on any occasion but was observed in three samples from Bear Creek. During water year 2005 dry-season sampling, aluminum, lead and silver were not detected in either total or dissolved form in any stream. This year (water year 2006), dissolved lead was also below the detection limit in dry-season samples collected on August 9, 2006.

6.5.2 Dissolved vs. Total Metals

"Speciation" is the term that describes partitioning of the total load of a specific metal between the dissolved and particulate forms. Metals in the dissolved form are considered more readily available to aquatic organisms and therefore potentially more deleterious (see below). The fraction of the metal present in the dissolved form depends upon on the pH of the water, the chemical properties of the metal, and the nature of the suspended solids that are present (Sansalone and Buchberger, 1997a, 1997b):

- At typical San Francisquito watershed baseflow pH levels of 7.5 to 8.5 (Tables 1 to 3), metals are generally more likely to adsorb onto particles, while lower pH levels during storm events favor the dissolved form (Paulson and Amy, 1993).
- Copper and lead are more likely to form complexes with sediments in the system and thus have a greater particulate fraction, whereas the majority of the total zinc is often in the dissolved phase (Characklis and Wiesner, 1997; Flores-Rodriguez and others, 1994).
- Higher suspended sediment or turbidity concentrations will increase the particulate metal fraction due to the greater number of sites available for adsorption. It is important to note that many metals have been shown to be associated with the smallest of the suspended particles (Dempsey and others, 1993; Sansalone and Buchberger, 1997a).

6.5.3 Hardness-dependant toxicity

As noted above, metals have been found to be less toxic to aquatic organisms when ambient hardness levels are higher. As a result, the U.S. EPA recently developed specific criteria for the dissolved form of selected trace metals. These criteria are hardness-dependent, since calcium and magnesium (the primary components of hardness[14]) act to buffer metal toxicity. The criteria were adopted in California through the California Toxics Rule (CTR) and have been incorporated into Basin Plan documents by the nine Regional Boards.

[14] The convention is to express total hardness in terms of an equivalent concentration of calcium carbonate ($CaCO_3$).

In general, hardness is lowest in Bear Creek, and slightly higher in Los Trancos Creek than in San Francisquito Creek (Tables 5 and 6). Hardness generally decreased as streamflow increased, reflecting reduced contributions of ground water relative to surface runoff during storms. Thus, hardness levels in water year 2006 were lowest during the mid-winter (Dec. 28 to 29, 2005) storm samplings, ranging from 118 to 229 mg/L as CaCO3. Hardness levels were higher during the dry-season samplings, ranging from 272 to 774 mg/L as CaCO3. Hardness in Los Trancos Creek and San Francisquito Creek was higher in water year 2006 than in water year 2004 but similar values for the other three years. Hardness in Bear Creek was similar in water year 2006 to values observed during water years 2005 and 2004.

The CTR states that "For purposes of calculating freshwater aquatic life criteria for metals . . . [f]or waters with a hardness of over 400 mg/l as calcium carbonate, a hardness of 400 mg/l as calcium carbonate shall be used . . ." Thus, the range of regulatory values shown in Tables 5 and 6 for the five hardness-dependent trace metals sampled as part of the LTMAP program are calculated for the range of 100 to 400 mg/L as CaCO3. These water quality objectives are presented separately in Table 7 for hardnesses of 100 to 400 mg/L. At the hardness levels typically observed in the three creeks during the dry season (>250 mg/L as CaCO3), the potential toxicity of trace metal ions is low.

6.5.4 Aluminum

Aluminum concentrations were within the range of previous sampling results during water year 2006. The Regional Board has not established acute or toxicity objectives for this constituent but concentrations of aluminum in both forms were similar to published values for aluminum concentrations in surface waters in natural streams of the United States (Hem, 1985), which include contributions from urban sources.

In all three creeks, *total aluminum* concentrations were highest in composite samples collected during the storm event from Dec. 1 to 2, 2005 (Tables 5 and 6). This is not unexpected since aluminum is a major naturally-occurring component of the silts and clays that largely comprise suspended sediment[15], and suspended sediment concentrations were as high on these dates as during the Dec. 28 to 29, 2005 storm (Table 9). Total aluminum was not analyzed in the water year 2006 dry-season samples.

[15] The acid digestion performed for total metal analysis also typically releases a much larger amount of the mineral than is naturally present in the stream.

Dissolved aluminum concentrations were low or non-detectable during the wet season, similar to values observed in previous years. The water year 2006 dry-season samples were not analyzed for aluminum content, however, in previous years dissolved aluminum concentrations in dry-season samples from all three streams have typically ranged from very low (10 µg/L) to non-detectable. Aluminum concentrations were not analyzed in the earlier Bear Creek study.

6.5.5 Copper

Dissolved copper concentrations were high in water year 2006 wet-season composite samples. This finding suggests that dissolved copper concentrations may have exceeded aquatic acute toxicity levels established by the Regional Board at some point during the storm event. Focused sampling in water year 2007 to investigate this possibility is proposed below.

Sources of copper in the San Francisquito Creek watershed include dust from vehicle brake pads, automotive fluids, wash waters, architectural building materials, and geologic sources. During the water year 2006 wet season, *total copper* concentrations in the three streams ranged from 4.3 to 47 µg/L (Tables 5 and 6), similar to values measured in previous years. The highest concentration in each stream occurred on the same date, the Dec. 1 to 2, 2005 storm event. Total copper concentrations in all three streams were lowest in samples from the initial sampling event of the water year 2006 season, the storm which occurred on Nov. 28 to 29, 2005. Total copper concentrations were not analyzed in dry-season samples.

Concentrations of *dissolved copper* in wet-season samples from the three streams ranged from 4.0 to 9.4 ug/L during water year 2006 (Tables 5 and 6). Concentrations were similar to those previously measured at all three stations for the LTMAP program, and at the Sand Hill Road station during the earlier Bear Creek study (1.8 µg/L to 9.9 µg/L). In all three streams, the highest values were measured in samples collected during the Dec. 1 to 2, 2005 storm event. The dissolved copper concentration in the sample collected from San Francisquito Creek during this event was elevated (9.4 ug/L) but at a hardness level of 239 mg/L as $CaCO_3$ (Table 6), did not exceed the chronic toxicity objective for dissolved copper (Table 7: hardness level of 200 mg/L as $CaCO_3$) established by the Regional Board. Both dissolved copper concentrations and hardnesses were lower in all three streams during the larger event sampled on Dec. 28 to 29, 2005. Dry-season samples from all three streams had much lower dissolved copper concentrations and values were similar to those observed in previous years.

More than most streams draining to San Francisco Bay, geologic sources of copper may be contributing to the levels observed in the San Francisquito channels. Copper tends to be present at higher-than-usual concentrations in basic volcanic rocks (such as the Mindego or Franciscan volcanics which occur in the Los Trancos and San Francisquito sub-watersheds) or in sediments derived from them (such as the Purisima, and to a lesser extent, the Butano and Santa Clara formations found in all three sub-watersheds). Isolated exceedances have been reported in wells and streams drawing from most of these formations in other watersheds[16].

We note that while wet-season dissolved copper concentrations were below the acute and chronic toxicity objectives in all of the water year 2006 composite samples, peak dissolved copper concentrations in the streams may have exceeded the acute toxicity threshold during some portion of the sampling interval for the reasons discussed above in Section 6.1.1.

6.5.6 Lead

Lead concentrations were within the range of previous sampling results during water year 2006 and when detected, dissolved lead concentrations were well below the aquatic acute and chronic toxicity thresholds established by the Regional Board.

Total lead concentrations in water year 2006 samples ranged from nondetectable to 21 μg/L (Tables 5 and 6). Concentrations in samples from Los Trancos Creek and San Francisquito Creek were similar to those observed in wet-season samples during previous years. The highest concentrations observed this year were in samples collected from the three streams during the Dec. 1 to 2, 2005 event. The 21 μg/L total lead concentration in the sample from Bear Creek exceeded levels previously observed in this stream but was lower than the 30 μg/L sampled from Los Trancos Creek in water year 2003 during a much larger storm on Dec. 13 to 15, 2002. Total lead concentrations were not analyzed in dry-season samples in water year 2006 but in previous years levels have generally been nondetectable in dry-season samples from all three streams.

Dissolved lead was detected one time each in San Francisquito Creek and Bear Creek during the water year 2006 wet season, and twice in Los Trancos Creek, less than in water year 2005 and similar to previous years. Where detected, concentrations of dissolved lead in wet-season samples ranged from 0.4 to 0.6 μg/L this year (Tables 5 and 6). The only detections in San Francisquito Creek and Bear Creek occurred during the Dec. 1 to 2, 2006 event, while in Los Trancos Creek, the dissolved

[16] For more detail on geologic sources of trace metals in the San Francisquito watershed, see Appendix C of the WY2003 LTMAP monitoring report (Owens and others, 2004).

lead concentration for the sample from that storm was identical to the concentration in the sample from the previous event (0.4 µg/L). For comparison, in the earlier Bear Creek study, wet season concentrations of dissolved lead ranged from 2.6 to 8.4 µg/L in grab samples from stations in the Dry Creek watershed, which receives runoff from Highway 280. As observed in water year 2005, dissolved lead was nondetectable in water year 2006 dry-season samples from all three streams. All detections were well below the acute and chronic toxicity objectives for dissolved lead established by the Regional Board.

The predominant source of lead in the watershed is probably residues from leaded gasoline, bound to organic matter or soil near roads and highways, and transported in urban runoff. Lead concentrations were nondetectable in samples from stations in other watersheds monitored during the same study. Lead is rarely reported from streams or wells in the region where human influences are minimal, and does not seem to have a significant or discernible geologic source, although likely present in trace quantities.

6.5.7 Mercury

All mercury data are from grab samples. As was also observed in water year 2005, total mercury concentrations in water year 2006 samples regularly approached or exceeded the Regional Board chronic (4-day average) standard of 0.025 µg/L. Total and dissolved mercury concentrations in samples collected through the LTMAP program have never approached the aquatic acute (1-hour average) standard of 2.4 µg/L.

Mercury is of increasing concern locally, as studies document remobilization of mercury from natural ore bodies near New Almaden plus adjoining areas and from sediments deposited in San Francisco Bay during the hydraulic gold-mining era, followed by bioconcentration in fish and waterfowl once inorganic mercury is biomethylated by microbes. Methylmercury, an organic compound produced by microbial transformation of elemental mercury under anoxic conditions, generally increases (bioaccumulates or biomagnifies) with each step up the food chain. Because methylmercury is a potent neurotoxin that impairs the nervous system, the state of California has issued fish consumption advisories for mercury in about 20 water bodies and the san Francisco Bay-Delta region. In addition, on August 9, 2006, the Water Board adopted a Basin Plan amendment including a revised TMDL for mercury in San Francisco Bay, two new water quality objectives (based on fish tissue concentrations), and an implementation plan to achieve the TMDL. Approval by the State Water Resources Control Board is pending.

Total mercury concentrations in water year 2006 samples ranged from 0.0036 to 0.28 µg/L in Bear Creek (Table 5), from 0.0037 to 0.04 µg/L in San Francisquito Creek, and from 0.0028 to 0.07 µg/L in Los Trancos Creek (Table 6). Wet-season concentrations in the latter two streams were similar to values observed in previous seasons; the highest value from Bear Creek (0.28µg/L) surpassed the maximum value of 0.11 µg/L from previous samplings. Total mercury concentrations in all three streams exceeded the Regional Board chronic (4-day average) standard of 0.025 µg/L in samples collected during the storm events of Dec. 1 to 2 and Dec. 28 to 29, 2005. Total mercury concentrations during the earlier Nov. 28 to 29, 2005 event were much lower in samples collected from Bear Creek and San Francisquito Creek but not Los Trancos Creek, where concentrations were slightly below the chronic toxicity standard. Total mercury concentrations were not analyzed in dry-season samples in water year 2006 but in previous years concentrations in dry-season samples have been well below all toxicity standards.

Dissolved mercury concentrations in samples from the three streams ranged from 0.0015 to 0.0070 µg/L during water year 2006, similar to values measured in previous years, and well below the regulatory standard. The highest concentrations in all three streams were found in samples collected during the December 28 to 29, 2005 storm event. Dissolved mercury concentrations were not analyzed in dry-season samples in water year 2006. However, the lowest wet-season dissolved mercury concentrations, in samples from the Nov. 28 to 29, 2005 event, were similar to levels in dry-season samples collected from these streams in water years 2003 to 2005.

6.5.8 Nickel

Nickel concentrations were within the range of previous sampling results during water year 2006 and dissolved nickel concentrations were well below the aquatic acute and chronic toxicity thresholds established by the Regional Board.

Total nickel concentrations in wet-season samples from Los Trancos Creek and San Francisquito Creek ranged from 4.7 to 15 µg/L in water year 2006 (Table 6), similar to values measured in previous years. As observed for lead, total nickel concentrations in these two streams and in Bear Creek (Table 5) were highest during the Dec. 1 to 2, 2005 storm, and lower in samples collected earlier in the season during a smaller event. Total nickel concentrations were not analyzed in dry-season samples in water year 2006 but concentrations of this constituent have been low in dry-season samples from all three streams in previous years.

Dissolved nickel concentrations ranged from 3.1 to 5 μg/L in Los Trancos Creek during water year 2006, from 4.4 to 6 μg/L in San Francisquito Creek, and from 2.4 to 4.2 μg/L in Bear Creek. During the wet season, concentrations in Bear Creek and Los Trancos Creek were highest in samples collected during the Dec. 1 to 2, 2005 storm, while concentrations in San Francisquito Creek were highest during the Nov. 28 to 29, 2005 event. Dissolved nickel concentrations in the water year 2006 dry-season samples from San Francisquito Creek and Los Trancos Creek equaled or exceeded those measured in water year 2005, but concentrations in dry-season samples from Bear Creek were lower than in water year 2005. All values were far below acute and chronic toxicity objectives for dissolved nickel established by the Regional Board.

6.5.9 Selenium

Selenium concentrations were within the range of previous sampling results during water year 2006 and total and dissolved selenium concentrations were well below the aquatic acute and chronic toxicity thresholds established by the U.S EPA.

For all three water year 2006 wet-season sampling events, *total selenium* concentrations were 0.2 μg/L in Los Trancos Creek and 0.3 μg/L in San Francisquito Creek (Table 5). Concentrations in Bear Creek ranged from 0.1 to 0.5 μg/L (Table 6), with the highest concentration measured during the Dec. 1 to 2, 2005 storm. Values were similar to and often lower than concentrations observed in previous years. Total selenium concentrations were not analyzed in dry-season samples in water year 2006 but in previous years, levels have generally been in the lower half of the range. All concentrations were far below the U.S. EPA (National Toxic Rule) aquatic acute toxicity objective of 20 μg/L and the chronic toxicity objective of 5 μg/L.

Dissolved selenium concentrations in the three streams ranged from nondetectable to 0.4 μg/L in water year 2006, following no particular trend but similar to values measured in previous years. All values were far below acute and chronic toxicity objectives for dissolved selenium established by the U.S. EPA. Selenium concentrations were not analyzed in the Bear Creek study but these concentrations are within the background range expected for this element, which is present in trace concentrations within rocks throughout the watershed.

6.5.10 Silver

Silver, in either the total or dissolved form, was not reported above the 0.2 μg/L detection limit in any sample during water year 2006.

In previous years, silver was detected on three occasions in Bear Creek in water year 2005, once in Los Trancos Creek in WY2004, and once each in Los Trancos Creek and San Francisquito Creek in WY2003. The Regional Board has not established acute or chronic toxicity standards for silver. However, the Regional Board has established an aquatic instantaneous maximum value for dissolved silver.

6.5.11 Zinc

Zinc concentrations were within the range of previous sampling results during water year 2006 and dissolved zinc concentrations were well below the aquatic acute and chronic toxicity thresholds established by the Regional Board

Zinc tends to be substantially more abundant and more soluble than other trace metals. In general, as with other metals, one would expect higher *total zinc* concentrations at high flows, when streams are transporting elevated loads of suspended sediment, and this is the pattern which has been observed on Los Trancos Creek and San Francisquito Creek in previous years. In water year 2006, total zinc concentrations in wet-season samples varied from 30 to 71 μg/L on San Francisquito Creek, from 7 to 54 μg/L on Los Trancos Creek, and from 10 to 110 μg/L on Bear Creek (Tables 5 and 6), with values generally similar to concentrations observed during past years. This year, the highest concentrations observed in Bear Creek and San Francisquito Creek occurred in samples from the Dec. 1 to 2, 2005 storm, while the highest concentrations in Los Trancos Creek were in samples collected on Dec. 28 to 29, 2005. Dry-season samples were not analyzed for total zinc concentrations in water year 2006 but in previous years, concentrations in most samples have generally been less than 10 μg/L.

In water year 2006, wet-season *dissolved zinc* concentrations in the three streams ranged from 10 to 47 μg/L (Tables 5 and 6), similar to levels measured in previous years. In each stream, the lowest concentration was measured in samples from the Nov. 28 to 29, 2005 event, with higher levels in either the Dec. 1 to 2 or Dec. 28 to 29, 2005 storms depending on the particular stream. Dissolved zinc concentrations did not show a trend of higher concentrations with increasing streamflows, as was observed during water years 2003 and 2004. Dissolved zinc concentrations in dry-season samples from all three streams were below the detection limit, lower than in water year 2005 and typical of dry-season values observed in most previous years. Dissolved zinc concentrations in all samples were well below the acute and chronic toxicity objectives for dissolved zinc established by the Regional Board. Both local geologic formations[17] and anthropogenic sources, such as road runoff and galvanized architectural materials (e.g., roofs, fencing, gutters), likely contribute to observed dissolved zinc levels.

6.6 Water Temperature

Water temperatures during water year 2006 were within the range of previous measurements for most of the year, but higher than usual mid-summer temperatures may have stressed fish.

6.6.1 Water temperature affects fish

Water temperature strongly affects steelhead habitat. Although steelhead can withstand high water temperatures of 29˚C for a short period of time, and 25˚C for longer periods, they have progressively-increasing difficulty extracting dissolved oxygen from water at temperatures above 21˚C (Lang and others, 1998) and require a larger food source to sustain their elevated metabolism (Smith, pers. comm.). Therefore, water temperatures of 21˚C and below are considered to provide adequate summer habitat, and values chronically above 25˚C are likely not viable for the local steelhead population.

6.6.2 Temperature monitoring probes

Each of the three stations includes one or two in-stream probes that continuously record water temperatures. Manual temperature measurements during water year 2006 site visits followed the same seasonal pattern and values recorded by the in-stream probes (Figures 11 to 13). The December 31, 2005 storm destroyed the temperature probe at the Bear Creek station, so only manual measurements were made during the five-month interval until the probe was replaced on May 31, 2006. Water temperatures were within the acceptable range for steelhead habitat during *most,* but not *all* of the water year 2006 season.

[17] Elsewhere in the Santa Cruz Mountains, zinc and cadmium are reported in elevated concentrations in both waters and sediment emanating from portions of the Monterey formation and the lower Purisima formation (c.f., Ricker and others, 2001; also, see Majmundar, 1980). Both units outcrop in portions of the San Francisquito and Los Trancos sub-watersheds (Balance Hydrologics, 1996). Both formations are also known geologic sources of phosphate.

6.6.3 Temperature differences between creeks

As observed in the four previous years (WY2002 to WY2005), water temperatures in San Francisquito Creek (Figure 11) appeared to be slightly warmer than in Los Trancos Creek during the dry season (Figure 12). Dry-season temperatures in Bear Creek (Figure 13) were similar to Los Trancos Creek and cooler than in San Francisquito Creek.

6.6.4 Artificial temperature spikes

We noted an artificial high-temperature spike on Los Trancos Creek April 28 through 30, 2006, which corresponded with a sharp decrease in flow (Figures 5 and 12). Although ambient temperatures seem to have been rising during that period, other creeks did not show as much of a temperature increase. If this flow dip was due to an upstream diversion, it shows that diversions affect water temperature in addition to decreasing flow. We noted another high-temperature flow spike on Bear Creek during August 3 through 5 (see Section 4.4 and Figures 6 and 13).

6.6.5 Temperature effects of July heat wave

Water temperatures rose in late July, in response to a heat wave, and the duration of high temperatures was longer than any period since LTMAP measurements began in fall 2001. For the first time, maximum daily water temperatures in both San Francisquito Creek and Bear Creek exceeded 25˚C and mean daily water temperatures in all three streams exceeded the 21˚C threshold for periods of 24 hours per day for 5 consecutive days, and an average of 15 hours per day, during the 18-day period from July 13 through July 30, 2006 (SFPL).

6.7 pH

pH values during water year 2006 were within the range of previous measurements. This parameter is not considered to be a problem.

As stated above in Section 5.3, the pH probes at the two Piers Lane stations were essentially non-functional in water year 2006, so this parameter was measured regularly using hand-held meters. A continuous record of pH at the Bear Creek station is available from probe replacement on May 31, 2006 through the close of the monitoring period, supplemented by manual measurements. pH varied from 7.6 to 8.4 in Bear Creek (Table 1, Figure 14), from 7.3 to 8.7 in Los Trancos Creek (Table 2, Figure 14), and from 7.3 to 8.5 in San Francisquito Creek (Table 3, Figure 14). pH values were similar to measurements from previous years and, once again, pH was typically slightly higher in Los Trancos Creek than in the other two streams on both dry- and wet-season sampling dates.

We note that fisheries biologists familiar with the northern Santa Cruz Mountains and San Francisco Peninsula streams have found that pH is very rarely a limiting factor in regards to steelhead habitat, so long as there is flow moving from pool to pool.

6.8 Dissolved Oxygen

Dissolved oxygen concentrations were occasionally low during late summer and fall, which may be limiting for biota.

As stated above in Section 5.3, the dissolved oxygen probes at the Los Trancos Creek and San Francisquito Creek stations were essentially non-functional in water year 2006. At the Bear Creek station, the dissolved oxygen probe performed well until it was destroyed by the December 31, 2005 storm, and the replacement probe installed on May 31, 2006 has also performed well. Dissolved oxygen concentrations in Bear Creek (Table 1, Figure 15) varied between 54 and 100 percent of saturation. Based solely on manual measurements, water year 2006 dissolved oxygen concentrations varied between 67 and 100 percent of saturation in Los Trancos Creek (Table 2, Figure 16) and between 17 and 100 percent of saturation in San Francisquito Creek (Table 3, Figure 17). As reported in previous years, dissolved oxygen concentrations were typically highest in Los Trancos Creek, and higher in Bear Creek than in San Francisquito Creek. Concentrations decreased in all three streams during summer months, when water temperatures were high, streamflow was low, and there is little turbulence. Concentrations in Bear Creek and to an even greater extent in San Francisquito Creek, dropped even lower during the early fall months of 2005, when dead leaves blown into the creek had begun to rot but were not yet flushed downstream by high flows from winter storms.

As noted in our WY2003 report (Owens and others, 2004), manual measurements of dissolved oxygen can vary considerably depending upon where in the creek the probe is placed, with values ranging from about 15 to 60 percent saturation at locations as little as one foot apart. This situation is particularly common in the fall, when the streams are full of dead leaves. Based on our monitoring data to date, we expect dissolved oxygen concentrations in all three creeks to range from 10 to 14 mg/L (90 to 100 percent saturation) during the winter and especially at high flows, when turbulence and cold ambient water temperatures promote oxygen saturation. Dissolved oxygen concentrations become more limiting for fish as streamflows decrease and temperatures rise in spring and summer, with the lowest concentrations occurring in the fall, at the start of the next water year but before rains raise water levels and flush leaves from the creeks.

6.9 Sediment

Sediment concentrations were within the range of previous sampling results during water year 2006.

San Francisquito Creek is listed by the State Water Resources Control Board as impaired due to sediment loading. All creeks carry some sediment; problems can arise when creeks carry too much sediment. Biologically, too much fine sediment can reduce oxygen circulation to buried eggs, abrade fish gills, fill hiding and resting niches and impede post-storm feeding. Too much coarse sediment affects bed conditions in a number of ways that can constrain steelhead habitat, including filling pools and undercut banks, creating 'soft' beds that are prone to scour, and forming mid-channel bars that divert flows into the banks, inducing bank erosion. Excess sediment can also settle out at low-gradient locations, reducing pool depths and decreasing the flood capacity of the channel.

Monitoring sediment concentrations and rates of sediment transport is important as a way of evaluating the amount of sediment being carried by the creek, to assess the mobility of spawning gravels and document changes that may signal improving or worsening conditions. Previous Balance reports have documented rates of sediment transported in various watersheds upstream from Piers Lane (Balance Hydrologics, 1996; Owens and others, 2001; Owens and Hecht, 2002), as well as the role of Searsville Lake in trapping sediment and the contributions from different geologic formations. In this watershed, we have observed a number of sources, both natural (e.g., bank failure, landslides) and human-caused or human-exacerbated (e.g., failure of culvert outfalls, construction erosion control measures, bank protection). Detailing these sources, however, is beyond the scope of this report.

Following convention, we distinguish two types of sediment in transport, each of which is measured during storms using specific types of samplers and sampling methods. Suspended sediment is supported by the turbulence of the water and is transported at a velocity approaching the mean velocity of flow. In the San Francisquito Creek watershed, as elsewhere in the Santa Cruz Mountains, suspended sediment consists primarily of fine sands, silts, and clays. Bedload sediment is supported by the bed of the stream; it rolls and saltates along the bed, commonly within the lowermost 3 inches of the water column. Movement can be either continuous or intermittent, but is generally much slower than the mean velocity of the stream. At the Piers Lane sites and in the Bear Creek watershed, bedload consists primarily of coarse sands and gravels, but will also include cobbles at extreme high flows. Total sediment discharge is the sum of bedload-sediment and suspended-sediment discharges.

6.9.1 Suspended sediment

Suspended-sediment samples were collected from all three stations throughout the water year at various dates and levels of flow (Table 4) using standard methods and equipment adopted by the Federal Interagency Sedimentation Program (FISP: see Hecht, 1983). All grab samples were analyzed by Soil Control Laboratories of Watsonville, California, a state-certified laboratory. Composite samples were analyzed at the Regional Water Quality Control Plant in Palo Alto and these results are also shown in Tables 5 and 6 under the heading "Total Suspended Solids". No suspended-sediment samples were collected when stream waters were visibly clear. From past experience, we have found that samples collected when the streams are clear produce no useful information because they test below the analytical reporting limit of 5.0 mg/L.

By multiplying the reported suspended-sediment concentrations by the streamflow at the time the sample was taken, concentrations (mg/L) were converted into an instantaneous suspended-sediment "load" (tons/day), as shown in Tables 8 and 9. We then plotted sediment load as a function of streamflow to create suspended-sediment rating curves describing the general trend of the data points for each creek (Figures 18 and 19). We also applied the suspended-sediment rating curves to the records of streamflow (at 15-minute intervals) to calculate a total annual suspended-sediment load for each creek (Forms 4 to 6). Interpretation of suspended-sediment rates and total loads is discussed in Section 6.9.3 below.

6.9.2 Bedload sediment

The *Draft Surface Water Quality Monitoring Plan 2001/02* (LWA, 2001) does not include consideration or protocols for measurements of bedload-sediment transport. At all three LTMAP gaging stations discussed in this report, the threshold for significant bedload transport occurs at flow depths and velocities that border on being too deep to sample safely by wading. However, through the close of water year 2006, we have occasionally been successful in measuring bedload transport at the Bear Creek station and at the Los Trancos Creek station at Piers Lane. A greater emphasis on collecting bedload sediment transport data may develop as the LTMAP matures, as bed conditions tend to be an important constraint to anadromous fish populations in the Santa Cruz Mountains, and bedload monitoring is one effective way of characterizing them (Hecht and Enkeboll, 1980; Roques and Angelo, 2004; Hecht and Owens, 2006). On January 2, 2006, we attempted to sample San Francisquito Creek at Piers Lane for bedload using a winch-suspended sampler from the bridge. We did collect bedload samples, but due to the high velocities, turbulence, and bouldery creek bottom, the samples collected were not sufficiently large or graded to be what we thought were valid representations of bedload discharge.

Although we have only a limited number of bedload-sediment measurements on Bear Creek and Los Trancos Creek at Piers Lane, as compared to the number of suspended-sediment samples, we have constructed bedload rating curves for each station (Figures 18 and 19). Bedload samples are converted to a discharge rate (in units of tons per day) and then plotted as a function of flow. As expected, sediment discharge increases as flow increases. We also applied the bedload rating curve to the record of streamflow (at 15-minute intervals) to calculate annual bedload totals for Bear Creek (Form 4 and Table 4) and Los Trancos Creek (Form 5 and Table 4). Interpretation of bedload-sediment rates and total loads for these two stations is discussed in Section 6.9.3 below.

6.9.3 Sediment discussion

Suspended-sediment rating curves for both San Francisquito and Los Trancos Creeks were slightly higher than last year (water year 2005). In Bear Creek, the suspended-sediment rating curve was the same as last year. The higher sediment rating curves may reflect increased sediment production and availability due to high peak flows and abundant rainfall.

Comparison of the suspended-sediment rating curves for the Los Trancos Creek and San Francisquito Creek at Piers Lane stations (Figure 18) with the rating curve for Bear Creek station (Figure 19) shows that Los Trancos Creek generally carries higher suspended-sediment loads at a given flow than San Francisquito Creek or Bear Creek. Higher rates of transport in tributary streams at a given flow is a typical condition and nearly universal throughout the Bay Area (c.f., Hecht, 1983), since tributary watersheds tend to be steeper and more subject to erosion due to higher flow velocities. In addition, suspended-sediment concentrations in San Francisquito Creek are diluted by outflows from Searsville Lake, which traps a large proportion of the sediment load from tributary streams higher in the watershed. We compared the sediment rating curve for Bear Creek to rating curves of other creeks that we monitor in the watershed, and found that sediment-discharge rates (as a function of flow) for Bear Creek are lower than rates for Corte Madera or Los Trancos Creeks.

It is important to note that storm flow in San Francisquito Creek is typically twice as high as flow in Bear Creek[18], and usually three to five times greater than flow in Los Trancos Creek (Figure 2), so San Francisquito Creek still transports more sediment load. This is evident in the annual sediment summaries (Forms 4 to 6), which show that the calculated total suspended-sediment load in San

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[18] The relationship between flow at the Bear Creek at Sand Hill Road station and flow at San Francisquito Creek at Piers Lane varies seasonally with the amount of outflow from Searsville Lake. Typically, differences in flow between the two sites are smaller at the start of the wet season, when the water level in the lake is below the spillway. Later in the wet season, differences are greater once the lake begins to spill freely.

Francisquito Creek was about 34,000 tons in water year 2006, compared to about 12,000 tons in Bear Creek and 4,800 tons in Los Trancos Creek.

Sediment discharge rates at each of the stations show a strong dependence on flow at the time of the measurement; when flow is higher, the creeks carry more sediment. Therefore, sediment totals for each stream also vary from year to year depending on the amount of rainfall and the size of the largest flood peak (Table 4). This concept of "episodicity" is useful for interpreting the sediment measurements within the context of the inter-annual variability in climate conditions. Rather than trying to calculate an average sediment discharge per year, we acknowledge that there will be large year-to-year variability in sediment discharge.

6.9.4 Assessed bias of automated suspended-sediment sampling (excerpted from the WY2004 monitoring report)

[**Note to Readers:** the subsection below from the WY2004 report is included herein because the test and the results, even though preliminary and likely to be repeated, may inform readers who seek to interpret the suspended sediment data presented in this report.]

The standard method for sampling suspended sediment is to use an isokinetic sampler to collect a depth- and width-integrated sample (Porterfield, 1972; Edwards and Glysson, 1999). Depth integration is important because the concentration of suspended sediment increases from the stream surface downwards to the bed. We typically use a DH-48 hand-held sampler to collect equal-transit-rate[19] sub-samples at multiple verticals across the width of the creek. We wanted to assess the degree of bias associated with using an automated sampler to collect suspended sediment samples, because the automated sampler does not have an isokinetic intake, instead, it draws the sample from a fixed point, and creates a composite sample from which a sub-sample is decanted and analyzed. However, by subsampling from the stream at regular intervals (time-paced sampling) or from pre-set volumes of flow (flow-paced sampling), the automated sampler can theoretically produce a more accurate representation of suspended sediment transport during the entire course of a particular storm event than is possible from one or two manually-collected grab samples.

[19] Equal-transit-rate (ETR) means that the sampler is lowered and raised at a constant rate at a particular vertical point on a transect across the width of the creek, then moved to the next point where the process is repeated.

The initial tests[20] reported below were conducted in the early afternoon of February 18, 2004. Streamflow in Bear Creek, which had peaked at about 499 cfs at about 5 AM that morning, had decreased to approximately 185 cfs in early afternoon and was falling slowly while we collected the set of samples for this test. The four types of samples used in this analysis are:

- "composite" - We pumped about 8 liters of creek water into a bucket using the ISCO or Sigma sampler; the sample was then swirled and mixed and a sub-sample was decanted into a bottle.
- "direct pump" – We used the ISCO or Sigma sampler to pump water directly from the creek into a bottle.
- "at intake" – We plunged a DH-48 hand-held sampler from the surface to the approximate location of the sampler intake near the streambed and held it there for about 15 seconds, then quickly raised it out of the water and poured the sample into a bottle.
- "depth-integrated" – We used the DH-48 to collect depth-integrated sub-samples at three verticals across about half the width of the creek; the sample was then poured from the DH-48 into a bottle.

The samples were collected in the order listed above, and all within a time span of ten minutes. The sample bottles used were identical 500-milliliter polyethylene bottles. All samples were sent to the same analytical laboratory (Soil Control Lab) and analyzed using identical methods. The results, detailed in Table 9 of the WY2004 report and discussed below, are consistent with our understanding of the limitations of different methods for sampling suspended sediment. For each type of sample, we present the suspended sediment concentration reported by the laboratory and the resulting suspended-sediment load for a 24-hour period:

- "composite" = 276 mg/l = 135 tons/day – This is the lowest value and probably reflects settling-out of the heaviest particles during the interval (a few seconds) between completion of mixing and decanting the sub-sample from the composite vessel into the sample bottle.
- "direct pump" = 350 mg/l = 171 tons/day – This is the highest value and probably reflects the high sediment concentrations near the bottom of the water column, where the intake is located. The shape of the intake port and the resulting intake velocities could also be influencing the results.

[20] We still intend to conduct at least two more tests of a similar nature when conditions are appropriate before drawing any firm conclusions.

- "at intake" = 331 mg/l = 161 tons/day – This value is relatively high but slightly lower than the value from the "direct pump" test, perhaps due to an influx of water as the DH-48 sampler was being lowered and raised through the water column above the intake location.

- "depth-integrated" = 308 mg/l = 150 tons/day – Because this sample was manually collected using standard methods, it is the standard for comparison of the other types of samples collected.

Based on the results of this initial test, the sub-sample from the composite bottle under-represented suspended-sediment concentrations in the creek by about 9 percent, as compared to the depth-integrated sample, even though the sample collected through the automated sampler over-represented suspended-sediment concentrations by about 14 percent. While it appears that the two effects partially offset each other in this first test, additional test results will give us more confidence in our interpretation. Furthermore, we expect the results of the sampling techniques to differ depending on the flow level at which the test is conducted, since the relative fractions of the different sediment size classes mobilized will differ with stream flow.

7. FUTURE MONITORING AND RECOMMENDATIONS

The following recommendations are offered for consideration by the LTMAP working group based on our experience and observations since inception of monitoring:

1. We plan to sample water quality at the two Piers Lane sites on five occasions in water year 2007. Our focus will continue to be on monitoring first-flush storms in late fall and early winter, larger less-frequent mid-winter storms, a spring storm, and one non-storm (baseflow) sampling in late summer. Due to budget constraints, no water quality sampling other than occasionally collecting sediment grab samples will occur at the Bear Creek at Sand Hill Road station next year. However, the gaging program at this site will be maintained at a minimal (baseline) level that will still provide valuable data on streamflows.

2. The repairs made to the Piers Lane stations in water year 2006 should improve their performance in subsequent years. Replacement of the mal-functioning sonar transponder at the San Francisquito Creek site with a datalogger and pressure transducers, and installation of a more reliable specific conductance probe, will improve data quality and increase the efficiency of processing gaging and water quality data. Planning for a similar upgrade to the Los Trancos Creek station when funds become available, prior to failure of the remaining transponder, would be both prudent and cost-effective

3. We recommend that additional grab samples be collected in water year 2007 and analyzed for dissolved copper and hardness concentrations to better define the relationship between composite sample concentrations of dissolved copper and the acute water quality objective. Our approach will be to collect grab samples for these analyses at the same time the other grab samples (ammonia, mercury) are collected, typically at or near the peak of the hydrograph, during multiple storms (perhaps, four to five) over the course of a season.

8. LIMITATIONS

Analyses and information included in this report are intended for use at the watershed scale and for the planning and long-term monitoring purposes described above. Analyses of channels and other water bodies, rocks, earth properties, topography and/or environmental processes are generalized to be useful at the scale of a watershed, both spatially and temporally. Information and interpretations presented in this report should not be applied to specific projects or sites without the expressed written permission of the authors, nor should they be used beyond the particular area to which we have applied them. Balance Hydrologics, Inc. should be consulted prior to applying the contents of this report to evaluating water supply or any out-of-stream uses not specifically cited in this report.

Readers who have additional pertinent information, who observed changed conditions, or who may note material errors should contact us with their findings at the earliest possible date, so that timely changes may be made.

9. ACKNOWLEDGEMENTS

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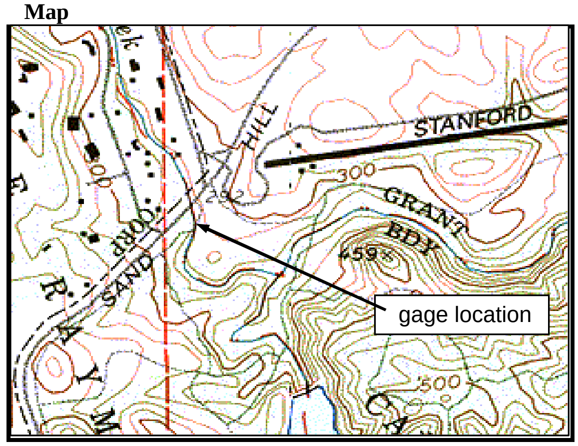
FORMS

Water Year:	**2006**	
Stream:	Bear Creek	
Station:	at Sand Hill Road	**BCSH**
County:	San Mateo County, CA	

Form 1. Annual Hydrologic Record

Map



Station Location / Watershed Descriptors

Latitude: 37 24' 40", Longitude: 122 14' 28" Jasper Ridge Biological Preserve, Stanford, CA. Gage is installed on left bank, about 200 feet downstream from Sand Hill Rd. Staff-plate pool is eroded into hard sandstone; underflow is thought to be minimal. Land use includes forested open space, and suburban uses in valleys. Drainage area above gage is 11.7 sq. miles.

Mean Annual Flow (MAF)

MAF for WY 2006 is 18.33 cfs. MAF for 2005 was 11.21 cfs. MAF for WY 2004 was 5.87 cfs. WY 2002 was 5.12 cfs. WY 2001 was 3.71 cfs. WY 2000 was 10.65 cfs.

Peak Flows

Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)	Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)
12/22/05	16:30	4.86	380	3/6/06	4:30	5.44	401
12/26/05	3:30	5.35	487	3/14/06	3:45	4.58	254
12/31/05	**7:00**	**10.70**	**3,800**	3/25/06	5:45	6.80	862
1/2/06	14:00	6.55	942	3/31/06	17:00	4.19	250
2/27/06	21:00	4.42	257	4/4/06	11:45	4.27	264
3/3/06	6:15	4.48	267	4/16/06	10:45	5.58	540

The peak for the period of record (Oct. 1999 to Sept. 2007) was 3,800 cfs on Dec. 31, 2005

Period of Record

Staff plate installed 5/12/97. New datalogger and probes installed Nov. 2003. Flow, sediment transport, water quality, and specific conductance measured periodically. Gaging sponsored by Jasper Ridge Biological Preserve.

WY 2006 Daily Mean Flow (cubic feet per second)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
1	0.01	0.06	15.84	*69*	9.64	28.00	62.30	6.82	*2*	0.84	0.40	0.24
2	0.02	0.09	1.70	*300*	14.77	46.88	69.43	5.67	2.22	0.82	0.40	0.20
3	0.04	0.04	0.54	*88*	13.18	118.94	101.84	4.55	2.20	0.78	0.46	0.19
4	0.04	0.07	0.39	*43*	11.46	46.60	120.28	4.37	2.06	0.76	0.65	0.22
5	0.04	0.06	0.37	*28*	9.24	55.84	81.98	3.33	1.82	0.74	0.51	0.24
6	0.08	0.09	0.38	17.69	7.61	213.19	53.12	1.70	1.67	0.71	0.43	0.29
7	0.07	0.12	0.38	18.16	6.56	89.54	47.78	2.66	1.56	0.68	0.44	0.20
8	0.09	0.25	0.45	13.35	5.83	59.17	38.10	5.46	1.45	0.64	0.39	0.31
9	0.07	0.18	0.43	11.08	5.30	49.92	27.93	5.18	1.47	0.62	0.39	0.45
10	0.09	0.16	0.42	9.16	4.72	51.91	22.05	4.04	1.43	0.60	0.36	0.45
11	0.05	0.16	0.48	11.78	4.38	57.17	42.75	3.46	1.44	0.58	0.34	0.40
12	0.08	0.16	0.49	10.90	4.21	43.44	80.52	3.10	1.43	0.59	0.37	0.39
13	0.06	0.21	0.55	10.19	4.09	39.31	54.67	2.74	1.42	0.59	0.38	0.24
14	0.08	0.19	0.55	40.58	3.89	137.25	37.00	2.42	1.37	0.57	0.39	0.19
15	0.09	0.18	0.59	22.54	3.86	78.85	29.63	2.33	1.34	0.55	0.36	0.23
16	0.08	0.15	0.64	10.90	3.69	63.87	125.40	2.22	1.27	0.54	0.34	0.28
17	0.10	0.12	0.90	10.17	4.40	79.98	78.22	2.12	1.27	0.51	0.32	0.30
18	0.07	0.17	96.25	23.09	3.84	64.23	45.56	2.00	1.19	0.47	0.30	0.30
19	0.03	0.15	23.93	12.58	3.61	48.68	32.79	2.72	1.17	0.48	0.31	0.30
20	0.04	0.19	3.87	10.93	3.61	80.56	24.11	3.77	1.07	0.46	0.30	0.30
21	0.03	0.12	14.41	9.65	3.46	96.15	27.61	4.17	1.00	0.49	0.32	0.28
22	0.05	0.10	150.12	8.44	3.36	61.00	28.91	2.49	0.97	0.46	0.29	0.28
23	0.12	0.14	34.97	7.38	3.21	49.45	23.44	2.13	0.95	0.42	0.27	0.27
24	0.10	0.14	5.93	6.58	3.13	46.95	17.36	1.88	0.97	0.38	0.27	0.26
25	0.07	1.44	18.90	5.82	3.03	345.98	13.36	1.92	0.96	0.39	0.25	0.31
26	0.11	2.04	151.89	4.97	3.24	83.96	11.82	1.75	0.96	0.39	0.26	0.30
27	0.08	1.56	14.72	4.93	58.24	53.93	10.70	1.51	0.93	0.41	0.29	0.33
28	0.06	1.73	85.31	5.17	99.42	69.12	9.41	1.58	0.92	0.40	0.24	0.35
29	0.10	3.74	21.40	15.74		83.63	8.53	1.53	0.89	0.40	0.28	0.37
30	0.09	1.59	37.98	13.25		50.66	7.70	1.54	0.84	0.45	0.46	0.39
31	0.04		*849*	12.59		78.75		1.79		0.46	0.42	
MEAN	0.07	0.51	49.48	27.60	10.89	79.77	44.48	3.00	1.34	0.55	0.36	0.30
MAX. DAY	0.12	3.74	849.00	300.00	99.42	345.98	125.40	6.82	2.22	0.84	0.65	0.45
MIN. DAY	0.01	0.04	0.37	4.93	3.03	28.00	7.70	1.51	0.84	0.38	0.24	0.19
cfs days	2.1	15.4	1533.8	855.6	305.0	2472.9	1334.3	93.0	40.2	17.2	11.2	8.9
ac-ft	4.1	30.5	3042.3	1697.1	604.9	4905.0	2646.6	184.4	79.8	34.1	22.2	17.6

Monitor's Comments

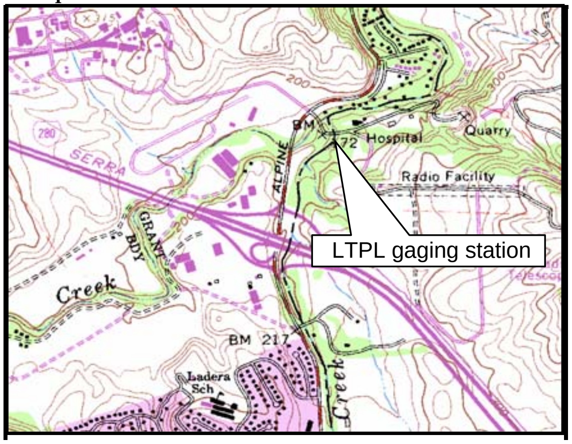
1. We collected a continuous stage record for the water year except for the period from 12/31 to 1/7 before the pressure transducers destroyed by high flows were replaced and on 6/1/06 when the datalogger program was replaced. Flows for these intervals were based on data from Balance Hydrologics' gages on Corte Madera and San Francisquito Creeks and from the peak flow estimate for 12/31 (see comment 5)
2. Diversions upstream of the gaging location affect flow in the creek. Also, a small amount of water intermittently flows into the creek from a ditch on the northwest side of Sand Hill Road (upstream of the gaging station).
3. Multiple stage shifts were applied to the rating equation. Stage shifts adjust for local scour and fill in addition to water-level changes due to algal growth or dams caused by accumulation of fallen leaves.
4. Daily values with more than 2 to 3 significant figures result from electronic calculations. No additional precision is implied.
5. The peak flow estimate for 12/31 is based on surveyed elevations of high water marks and channel cross sections.

Water Year 2006 Totals:		
Mean annual flow	**18.33**	(cfs)
Max. daily flow	**849**	(cfs)
Min. daily flow	**0.01**	(cfs)
Annual total	**6,690**	(cfs-days)
Annual total	**13,269**	(ac-ft)

Water Year:	**2006**	
Stream:	Los Trancos Creek	
Station:	Piers Lane	**LTPL**
County:	San Mateo County, CA	

Form 2. Annual Hydrologic Record

Map



Station Location / Watershed Descriptors

Latitude: 37° 24' 48" N, Longitude: 122° 11' 29" W, in San Mateo County, CA. The gaging station is located under Piers Lane bridge at Los Trancos Creek. Land use includes open space, sports fields, small commercial areas, and low-density residential. There is a water diversion about 1.8 miles upstream. Los Trancos Creek watershed area above gaging station = 7.8 square miles .

Mean Annual Flow

Mean annual flow (MAF) for WY 2006 was 7.09
MAF for WY2005 was 3.56; for WY2004 was 2.70 cfs; and for WY2003 was 2.63 cfs.

Peak Flows

Date	Time[2] (24-hr)	Gage Ht. (feet)	Discharge (cfs)	Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)
12/18/05	19:30	2.88	80	3/14/06	3:15	3.40	110
12/26/05	3:30	4.11	160	3/25/06	5:30	5.60	300
12/31/05	**8:15**	**7.80**	**640**	3/31/06	17:45	3.39	115
1/2/06	14:15	5.58	300	4/2/06	21:45	3.12	100
2/27/06	20:15	3.48	120	4/4/06	11:30	3.84	145
3/6/06	5:15	3.74	135	4/16/06	11:45	3.21	100

The peak for the period of record (October 2002 to May 2006 was 640 cfs on 12/16/02.

Period of Record

Equipment installed October 2001. Periodic site visits to measure flow, make observations, and collect water quaility samples have been made since Feburary 2002. Gaging sponsored by Stanford University Utilities Division.

WY 2006 Daily Mean Flow (cubic feet per second)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
1	0.15	0.19	4.05	52.46	2.75	14.49	29.55	8.80	1.61	0.33	0.18	0.16
2	0.13	0.20	0.73	128.65	3.66	21.30	34.67	7.00	1.56	0.30	0.17	0.14
3	0.14	0.22	0.53	23.73	4.17	44.96	60.93	6.28	1.67	0.30	0.17	0.14
4	0.16	0.24	0.45	8.28	4.12	17.36	70.27	5.75	1.55	0.29	0.17	0.14
5	0.15	0.21	0.40	6.75	3.80	19.06	43.72	5.35	1.47	0.29	0.17	0.14
6	0.13	0.22	0.40	6.25	3.58	64.93	27.88	5.20	1.40	0.26	0.18	0.14
7	0.14	0.26	0.49	6.60	2.55	30.90	29.15	5.03	1.22	0.24	0.20	0.14
8	0.17	0.53	0.58	5.18	1.49	17.83	25.42	4.74	1.00	0.23	0.20	0.15
9	0.14	0.23	0.40	4.66	1.39	15.16	20.62	4.64	0.96	0.23	0.18	0.17
10	0.14	0.19	0.40	3.19	1.26	14.79	19.08	4.48	0.93	0.21	0.15	0.17
11	0.13	0.19	0.43	1.68	1.29	15.32	37.60	4.35	0.95	0.18	0.16	0.20
12	0.14	0.18	0.50	1.67	1.24	12.09	45.68	4.35	0.93	0.21	0.16	0.19
13	0.14	0.19	0.48	1.56	1.18	10.43	28.72	4.41	0.85	0.21	0.18	0.18
14	0.15	0.20	0.40	11.53	1.17	40.44	21.32	3.75	0.81	0.17	0.18	0.19
15	0.18	0.20	0.44	5.46	1.11	17.00	18.67	3.43	0.77	0.21	0.19	0.24
16	0.13	0.19	0.42	4.37	1.03	20.72	39.25	3.26	0.68	0.19	0.16	0.27
17	0.13	0.17	0.92	6.20	2.31	37.65	27.56	3.22	0.66	0.18	0.16	0.26
18	0.15	0.17	34.45	9.53	3.43	18.28	18.86	3.12	0.78	0.17	0.16	0.23
19	0.15	0.17	7.77	6.07	4.26	13.97	16.09	3.50	0.81	0.34	0.15	0.24
20	0.15	0.17	1.29	5.29	4.56	35.17	14.24	3.66	0.73	0.70	0.17	0.24
21	0.16	0.18	3.43	5.55	4.09	27.29	13.49	4.61	0.65	0.21	0.18	0.24
22	0.16	0.18	19.17	5.00	3.65	16.66	12.56	3.65	0.54	0.18	0.18	0.22
23	0.17	0.16	6.58	4.66	3.10	13.85	10.85	3.04	0.39	0.15	0.18	0.21
24	0.18	0.19	1.19	4.83	3.42	12.70	10.33	2.68	0.43	0.15	0.16	0.21
25	0.16	0.36	3.82	4.99	3.37	115.86	9.76	2.56	0.41	0.15	0.15	0.22
26	0.18	0.22	29.88	4.61	2.49	32.66	8.94	2.24	0.42	0.15	0.15	0.21
27	0.17	0.21	5.76	3.70	33.73	25.22	6.54	2.03	0.36	0.16	0.16	0.24
28	0.18	0.49	9.86	2.85	42.75	29.76	3.17	1.85	0.33	0.17	0.18	0.25
29	0.19	0.78	2.57	4.05		44.85	4.75	1.80	0.32	0.17	0.20	0.26
30	0.18	0.29	3.11	3.74		27.20	7.18	1.70	0.29	0.18	0.18	0.28
31	0.17		190.11	3.23		42.26		1.71		0.17	0.15	
MEAN	0.16	0.25	10.68	11.17	5.25	28.07	23.89	3.94	0.85	0.23	0.17	0.20
MAX. DAY	0.19	0.78	190.11	128.65	42.75	115.86	70.27	8.80	1.67	0.70	0.20	0.28
MIN. DAY	0.13	0.16	0.40	1.56	1.03	10.43	3.17	1.70	0.29	0.15	0.15	0.14
cfs days	4.8	7.4	331.0	346.3	147.0	870.1	716.8	122.2	25.5	7.1	5.3	6.1
ac-ft	9.6	14.7	656.5	686.9	291.5	1725.9	1421.9	242.3	50.5	14.1	10.5	12.1

Monitor's Comments

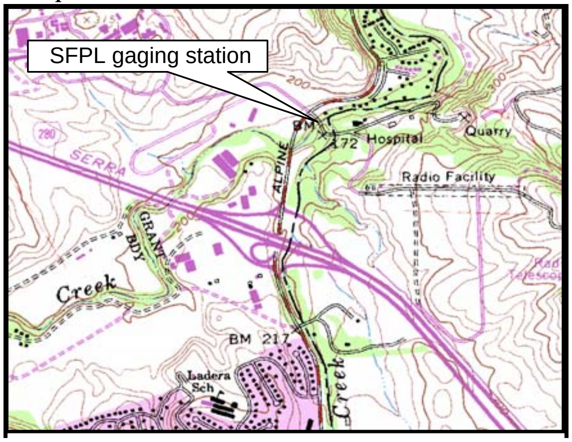
1. We collected a continuous record for the entire water year to date.
2. Multiple stage shifts were applied to the rating equation; stage shifts adjust for local scour or fill and leaf debris build-up
3. The upper portion of the rating curve is based on several high-flow estimates.
4. Daily values with more than 2 to 3 significant figures result from electronic calculations; no additional precision is implied.
5. Stanford operates a surface water diversion and fish ladder, about 1.8 miles upstream of this station, which may divert water out of Los Trancos Creek from December 1 to April 30.

Water Year 2006 Totals to date:		
Mean annual flow	**7.09**	(cfs)
Max. daily flow	**190**	(cfs)
Min. daily flow	**0.13**	(cfs)
Annual total	**2,590**	(cfs-days)
Annual total	**5,137**	(ac-ft)

Water Year:	**2006**	
Stream:	San Francisquito Creek	
Station:	Piers Lane	**SFPL**
County:	San Mateo County, CA	

Form 3. Annual Hydrologic Record

Map



Station Location / Watershed Descriptors

Latitude: 37° 24' 48" N, Longitude: 122° 11' 29" W in San Mateo County, CA. The gaging station is located directly under Piers Lane bridge at San Francisquito Creek, immediately upstream of its confluence with Los Trancos Creek. Land use includes open space, low-density residential, and some commercial uses. The watershed area above gaging station = 29.9 square miles.

Mean Annual Flow

Mean annual flow (MAF) for WY 2006 was 40.09
MAF for WY 2005 was 24.35; for WY2004 was 11.02 cfs; and for WY2003 was 15.40 cfs

Peak Flows

Date	Time[2] (24-hr)	Gage Ht. (feet)	Discharge (cfs)	Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)
12/18/05	22:15	6.27	380	2/27/06	23:00	6.60	480
12/22/05	19:00	7.26	819	3/3/06	8:30	6.58	466
12/26/05	4:15	7.56	980	3/25/06	7:45	9.58	2,040
12/31/05	**8:15**	**12.98**	**4,300**	4/16/06	12:15	6.82	570
1/2/06	15:15	9.07	1,900				

The peak for the period of record (October 2002 to May 2006) was 4,300 cfs on 12/31/05

Period of Record

Equipment installed October 2001. Periodic site visits to measure flow, make observations, and collect water quaility samples have been made since Feburary 2002. Gaging sponsored by Stanford University Utilities Division.

WY 2006 Daily Mean Flow (cubic feet per second)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
1	0.23	*0.3*	22.18	239.30	29.06	86.29	139.35	28.14	6.64	1.58	0.55	0.56
2	0.24	*0.3*	7.70	764.11	38.57	105.11	119.61	28.60	7.10	1.50	0.51	0.52
3	0.23	*0.3*	1.74	237.52	36.29	250.29	229.32	26.97	5.81	1.40	0.38	0.38
4	0.21	*0.3*	1.23	93.96	32.69	103.58	269.32	26.11	5.29	1.55	0.48	0.37
5	0.22	0.36	1.04	51.94	28.00	79.12	175.15	22.08	4.85	1.54	0.90	0.41
6	0.23	0.37	0.98	40.23	23.59	422.76	117.69	18.95	5.38	1.07	0.52	0.44
7	0.24	*0.4*	0.99	38.93	21.03	166.97	106.85	18.14	4.29	1.23	0.54	0.49
8	0.24	*1.4*	1.02	30.32	19.37	101.60	103.40	23.57	3.20	1.21	0.54	0.48
9	0.22	*1.0*	1.02	25.08	17.34	77.75	76.38	22.06	4.01	0.83	0.40	0.65
10	0.21	*0.7*	0.99	21.99	15.08	77.90	66.32	19.04	4.23	0.91	0.46	0.84
11	0.23	0.74	0.95	24.39	13.95	89.08	97.46	17.30	3.32	1.04	0.33	0.76
12	0.24	0.72	0.99	22.77	13.09	62.44	185.45	16.46	3.92	0.78	0.37	0.73
13	0.24	0.68	0.93	21.18	12.56	52.33	136.58	12.69	4.61	1.05	0.44	0.66
14	0.25	0.74	0.93	77.81	10.93	212.92	94.38	11.07	4.42	1.20	0.34	0.63
15	*0.3*	0.70	0.94	65.88	9.71	111.23	79.00	13.51	3.45	0.79	0.40	0.46
16	*0.3*	0.67	0.95	34.55	8.09	85.25	200.66	12.02	4.65	0.88	0.47	0.37
17	0.25	0.72	2.02	28.11	11.34	145.48	144.48	9.75	3.30	0.79	0.49	0.37
18	0.29	0.65	228.73	69.06	10.57	87.98	92.86	7.48	3.06	0.77	0.47	0.39
19	0.28	0.69	123.93	42.31	8.51	61.45	73.72	8.63	3.08	0.71	0.33	0.46
20	0.28	0.67	23.38	32.27	7.50	111.87	59.22	14.36	2.14	0.66	0.39	0.49
21	0.28	0.72	27.57	29.21	8.11	145.11	55.89	14.59	2.61	0.68	0.44	0.49
22	0.29	0.66	361.66	26.26	7.90	84.41	52.31	14.13	2.38	0.67	0.40	0.47
23	0.30	0.62	135.88	22.56	7.83	64.11	46.78	9.49	2.29	0.66	0.42	0.49
24	0.36	0.65	32.61	20.65	7.51	56.27	39.72	8.61	2.26	0.63	0.42	0.48
25	0.33	1.14	40.31	18.67	7.06	816.92	34.64	8.27	2.20	0.50	0.47	0.32
26	*0.4*	1.44	375.50	16.44	7.44	172.97	32.05	8.02	1.90	0.49	0.42	0.35
27	*0.3*	0.96	67.16	15.37	105.65	114.19	29.64	7.65	2.30	0.54	0.45	0.41
28	*0.3*	1.60	174.73	15.10	276.38	130.27	27.06	6.80	2.06	0.51	0.48	0.47
29	*0.3*	3.34	84.08	47.09		173.90	25.27	6.79	1.14	0.50	0.43	0.52
30	*0.4*	1.31	61.24	37.69		114.91	24.97	6.83	1.49	0.34	0.39	0.61
31	*0.4*		1704.17	39.55		148.74		6.67		0.41	0.53	
MEAN	0.28	0.83	112.50	72.59	28.40	145.59	97.85	14.67	3.58	0.88	0.46	0.50
MAX. DAY	0.39	3.34	1704.17	764.11	276.38	816.92	269.32	28.60	7.10	1.58	0.90	0.84
MIN. DAY	0.21	0.30	0.93	15.10	7.06	52.33	24.97	6.67	1.14	0.34	0.33	0.32
cfs days	9	25	3488	2250	795	4513	2936	455	107	27	14	15
ac-ft	17	49	6918	4464	1577	8952	5823	902	213	54	28	30

Monitor's Comments

1. We collected a continuous record for the entire water year thus far, except for 16 days in October and November when the sonar transponder was damaged by rain (italics and reduced decimal places).
2. Multiple stage shifts were applied to the rating equation; stage shifts adjust for local scour or fill.
3. Daily values with more than 2 to 3 significant figures result from electronic calculations; no additional precision is implied.
4. Flow is regulated by multiple diversions and an upstream lake (Searsville Lake).

Water Year 2006 Totals to date:		
Mean annual flow	**40.09**	(cfs)
Max. daily flow	**1704**	(cfs)
Min. daily flow	**0.39**	(cfs)
Annual total	**14,634**	(cfs-days)
Annual total	**29,027**	(ac-ft)

Form 4. Annual sediment-discharge record, Bear Creek at Sand Hill Road, water year 2006

Water Year: **2006**
Stream: Bear Creek
Station: at Sand Hill Road **BCSH**
County: San Mateo County, CA

Total annual sediment discharge (suspended- plus bedload-sediment discharge)
WY 2006: 12,160 ***tons***

WY 2006 Daily Suspended-Sediment Discharge *(tons)*

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	
1	0.0	0.0	4.2	*26*	0.5	4.2	50.5	0.2	*0*	0.0	0.0	0.0	
2	0.0	0.0	0.0	*747*	1.1	13.8	20.5	0.2	0.0	0.0	0.0	0.0	
3	0.0	0.0	0.0	*42*	0.9	90.6	37.3	0.1	0.0	0.0	0.0	0.0	
4	0.0	0.0	0.0	*9*	0.7	11.0	55.0	0.1	0.0	0.0	0.0	0.0	
5	0.0	0.0	0.0	*4*	0.4	31.8	84.6	0.1	0.0	0.0	0.0	0.0	
6	0.0	0.0	0.0	1.6	0.3	266.1	34.4	0.0	0.0	0.0	0.0	0.0	
7	0.0	0.0	0.0	1.7	0.2	41.0	14.3	0.0	0.0	0.0	0.0	0.0	
8	0.0	0.0	0.0	0.9	0.2	17.6	12.1	0.2	0.0	0.0	0.0	0.0	
9	0.0	0.0	0.0	0.6	0.1	12.5	7.5	0.1	0.0	0.0	0.0	0.0	
10	0.0	0.0	0.0	0.4	0.1	13.9	3.9	0.1	0.0	0.0	0.0	0.0	
11	0.0	0.0	0.0	0.7	0.1	17.1	2.5	0.1	0.0	0.0	0.0	0.0	
12	0.0	0.0	0.0	0.6	0.1	9.5	13.9	0.0	0.0	0.0	0.0	0.0	
13	0.0	0.0	0.0	0.5	0.1	7.7	38.6	0.0	0.0	0.0	0.0	0.0	
14	0.0	0.0	0.0	9.8	0.1	105.7	15.7	0.0	0.0	0.0	0.0	0.0	
15	0.0	0.0	0.0	2.7	0.1	31.4	6.9	0.0	0.0	0.0	0.0	0.0	
16	0.0	0.0	0.0	0.6	0.1	20.4	4.4	0.0	0.0	0.0	0.0	0.0	
17	0.0	0.0	0.0	0.9	0.1	0.1	140.6	0.0	0.0	0.0	0.0	0.0	
18	0.0	0.0	51.0	3.0	0.1	32.1	32.1	0.0	0.0	0.0	0.0	0.0	
19	0.0	0.0	4.4	0.8	0.1	20.8	10.6	0.0	0.0	0.0	0.0	0.0	
20	0.0	0.0	0.1	0.6	0.1	12.0	5.6	0.1	0.0	0.0	0.0	0.0	
21	0.0	0.0	2.0	0.5	0.1	39.2	2.9	0.1	0.0	0.0	0.0	0.0	
22	0.0	0.0	152.8	0.4	0.1	48.1	3.8	0.0	0.0	0.0	0.0	0.0	
23	0.0	0.0	9.7	0.3	0.1	18.7	4.2	0.0	0.0	0.0	0.0	0.0	
24	0.0	0.0	0.2	0.2	0.0	12.3	2.8	0.0	0.0	0.0	0.0	0.0	
25	0.0	0.0	4.3	0.2	0.0	11.3	1.5	0.0	0.0	0.0	0.0	0.0	
26	0.0	0.0	213.5	0.1	0.1	865.5	0.9	0.0	0.0	0.0	0.0	0.0	
27	0.0	0.0	1.3	0.1	49.7	37.1	0.7	0.0	0.0	0.0	0.0	0.0	
28	0.0	0.0	53.5	0.1	57.2	14.7	0.6	0.0	0.0	0.0	0.0	0.0	
29	0.0	0.1	3.3	1.3		27.3	0.4	0.0	0.0	0.0	0.0	0.0	
30	0.0	0.0	55.7	1.0		36.6	0.4	0.0	0.0	0.0	0.0	0.0	**Qss**
31	0.0		*7670*	0.8		13.2		0.0		0.0	0.0		**Annual**
TOTAL	0	0	8226	858	112	1883	609	2	0	0	0	0	**11,693**
Max.day	0	0	7670	747	57	865	141	0	0	0	0	0	**7,670**

WY 2006 Daily Bedload-Sediment Discharge *(tons)*

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	
1	0.0	0.0	0.2	*1*	0.0	0.2	2.0	0.0	*0*	0.0	0.0	0.0	
2	0.0	0.0	0.0	*30*	0.0	0.6	0.8	0.0	0.0	0.0	0.0	0.0	
3	0.0	0.0	0.0	*2*	0.0	3.6	1.5	0.0	0.0	0.0	0.0	0.0	
4	0.0	0.0	0.0	*0*	0.0	0.4	2.2	0.0	0.0	0.0	0.0	0.0	
5	0.0	0.0	0.0	*0*	0.0	1.3	3.4	0.0	0.0	0.0	0.0	0.0	
6	0.0	0.0	0.0	0.1	0.0	10.6	1.4	0.0	0.0	0.0	0.0	0.0	
7	0.0	0.0	0.0	0.1	0.0	1.6	0.6	0.0	0.0	0.0	0.0	0.0	
8	0.0	0.0	0.0	0.0	0.0	0.7	0.5	0.0	0.0	0.0	0.0	0.0	
9	0.0	0.0	0.0	0.0	0.0	0.5	0.3	0.0	0.0	0.0	0.0	0.0	
10	0.0	0.0	0.0	0.0	0.0	0.6	0.2	0.0	0.0	0.0	0.0	0.0	
11	0.0	0.0	0.0	0.0	0.0	0.7	0.1	0.0	0.0	0.0	0.0	0.0	
12	0.0	0.0	0.0	0.0	0.0	0.4	0.6	0.0	0.0	0.0	0.0	0.0	
13	0.0	0.0	0.0	0.0	0.0	0.3	1.5	0.0	0.0	0.0	0.0	0.0	
14	0.0	0.0	0.0	0.4	0.0	4.2	0.6	0.0	0.0	0.0	0.0	0.0	
15	0.0	0.0	0.0	0.1	0.0	1.3	0.3	0.0	0.0	0.0	0.0	0.0	
16	0.0	0.0	0.0	0.0	0.0	0.8	0.2	0.0	0.0	0.0	0.0	0.0	
17	0.0	0.0	0.0	0.0	0.0	0.0	5.6	0.0	0.0	0.0	0.0	0.0	
18	0.0	0.0	2.0	0.1	0.0	1.3	1.3	0.0	0.0	0.0	0.0	0.0	
19	0.0	0.0	0.2	0.0	0.0	0.8	0.4	0.0	0.0	0.0	0.0	0.0	
20	0.0	0.0	0.0	0.0	0.0	0.5	0.2	0.0	0.0	0.0	0.0	0.0	
21	0.0	0.0	0.1	0.0	0.0	1.6	0.1	0.0	0.0	0.0	0.0	0.0	
22	0.0	0.0	6.1	0.0	0.0	1.9	0.2	0.0	0.0	0.0	0.0	0.0	
23	0.0	0.0	0.4	0.0	0.0	0.7	0.2	0.0	0.0	0.0	0.0	0.0	
24	0.0	0.0	0.0	0.0	0.0	0.5	0.1	0.0	0.0	0.0	0.0	0.0	
25	0.0	0.0	0.2	0.0	0.0	0.5	0.1	0.0	0.0	0.0	0.0	0.0	
26	0.0	0.0	8.5	0.0	0.0	34.6	0.0	0.0	0.0	0.0	0.0	0.0	
27	0.0	0.0	0.1	0.0	2.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	
28	0.0	0.0	2.1	0.0	2.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	
29	0.0	0.0	0.1	0.1		1.1	0.0	0.0	0.0	0.0	0.0	0.0	
30	0.0	0.0	2.2	0.0		1.5	0.0	0.0	0.0	0.0	0.0	0.0	**Qbed**
31	0.0		*307*	0.0		0.5		0.0		0.0	0.0		**Annual**
TOTAL	0	0	329	34	4	75	24	0	0	0	0	0	**468**
Max.day	0	0	307	30	2	35	6	0	0	0	0	0	**307**

Daily values are based on calculations of sediment discharge at 15-minute intervals.
Multiple sediment-discharge rating curves were used for different periods of the year and ranges of flow.
Data is missing from 12/31/05 to 1/6/06 when the pressure transducers destroyed by the high flows were replaced and on 6/1/05 when the datalogger program was replaced.
The sediment-discharge record from 12/31 to 1/6 is based on a correlated flow record using data from the Balance Hydrologics' gages on Corte Madera and San Franciscquito Creeks and peak-flow estimates from surveyed high water marks and channel cross sections.

Balance Hydrologics, Inc. 841 Folger Ave., Berkeley, CA 94710 (510) 704-1000; fax: (510) 704-1001

Form 5. Annual sediment-discharge record, Los Trancos Creek at Piers Lane, water year 2006

Water Year: **2006**
Stream: Los Trancos
Station: at Piers Lane **LTPL**
County: San Mateo County, CA

Total annual sediment discharge
(suspended- plus bedload-sediment discharge)
WY 2006: 4,761 *tons*

WY 2006 Daily Suspended-Sediment Discharge *(tons)*

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	
1	0.0	0.0	1.0	70.3	0.2	5.4	22.6	2.0	0.1	0.0	0.0	0.0	
2	0.0	0.0	0.0	574.6	0.4	13.6	46.9	1.3	0.1	0.0	0.0	0.0	
3	0.0	0.0	0.0	19.4	0.4	64.7	97.0	1.0	0.1	0.0	0.0	0.0	
4	0.0	0.0	0.0	1.7	0.4	7.7	146.4	0.8	0.1	0.0	0.0	0.0	
5	0.0	0.0	0.0	1.1	0.4	16.3	49.4	0.7	0.1	0.0	0.0	0.0	
6	0.0	0.0	0.0	1.0	0.3	129.7	19.6	0.7	0.1	0.0	0.0	0.0	
7	0.0	0.0	0.0	1.1	0.2	25.0	23.2	0.6	0.0	0.0	0.0	0.0	
8	0.0	0.0	0.0	0.7	0.1	8.0	16.5	0.6	0.0	0.0	0.0	0.0	
9	0.0	0.0	0.0	0.5	0.0	5.8	10.6	0.5	0.0	0.0	0.0	0.0	
10	0.0	0.0	0.0	0.3	0.0	5.5	9.2	0.5	0.0	0.0	0.0	0.0	
11	0.0	0.0	0.0	0.1	0.0	6.2	48.0	0.5	0.0	0.0	0.0	0.0	
12	0.0	0.0	0.0	0.1	0.0	3.7	59.0	0.5	0.0	0.0	0.0	0.0	
13	0.0	0.0	0.0	0.1	0.0	2.7	21.2	0.5	0.0	0.0	0.0	0.0	
14	0.0	0.0	0.0	4.8	0.0	55.8	11.4	0.4	0.0	0.0	0.0	0.0	
15	0.0	0.0	0.0	0.8	0.0	7.3	8.7	0.3	0.0	0.0	0.0	0.0	
16	0.0	0.0	0.0	0.5	0.0	20.9	52.2	0.3	0.0	0.0	0.0	0.0	
17	0.0	0.0	0.1	1.1	0.2	38.7	19.8	0.3	0.0	0.0	0.0	0.0	
18	0.0	0.0	38.9	2.4	0.3	8.5	8.9	0.2	0.0	0.0	0.0	0.0	
19	0.0	0.0	2.7	0.9	0.5	4.9	6.5	0.3	0.0	0.0	0.0	0.0	
20	0.0	0.0	0.0	0.7	0.5	43.4	5.1	0.3	0.0	0.0	0.0	0.0	
21	0.0	0.0	0.5	0.8	0.4	19.7	4.6	0.6	0.0	0.0	0.0	0.0	
22	0.0	0.0	19.2	0.6	0.3	7.0	4.0	0.3	0.0	0.0	0.0	0.0	
23	0.0	0.0	1.5	0.5	0.2	4.8	2.9	0.2	0.0	0.0	0.0	0.0	
24	0.0	0.0	0.0	0.6	0.3	4.1	2.7	0.2	0.0	0.0	0.0	0.0	
25	0.0	0.0	0.9	0.6	0.3	478.1	2.4	0.2	0.0	0.0	0.0	0.0	
26	0.0	0.0	58.4	0.5	0.2	27.5	2.0	0.1	0.0	0.0	0.0	0.0	
27	0.0	0.0	0.8	0.4	57.3	16.0	1.3	0.1	0.0	0.0	0.0	0.0	
28	0.0	0.0	4.2	0.2	51.9	23.5	0.3	0.1	0.0	0.0	0.0	0.0	
29	0.0	0.0	0.2	0.4		55.8	0.6	0.1	0.0	0.0	0.0	0.0	
30	0.0	0.0	0.6	0.4		18.7	1.4	0.1	0.0	0.0	0.0	0.0	**Qss**
31	0.0		1482.1	0.3		65.8		0.1		0.0	0.0		**Annual**
TOTAL	0.0	0.1	1611.1	687.6	115.1	1195.0	704.4	14.3	0.7	0.1	0.0	0.0	**4,328**
Max.day	0.0	0.0	1482.1	574.6	57.3	478.1	146.4	2.0	0.1	0.0	0.0	0.0	**1,482**

Daily Bedload-Sediment Discharge *(tons)*

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	
1	0.0	0.0	0.1	7.0	0.0	1.4	4.7	0.1	0.0	0.0	0.0	0.0	
2	0.0	0.0	0.0	57.5	0.0	6.5	9.7	0.1	0.0	0.0	0.0	0.0	
3	0.0	0.0	0.0	1.9	0.0	0.8	14.6	0.1	0.0	0.0	0.0	0.0	
4	0.0	0.0	0.0	0.2	0.0	1.6	4.9	0.1	0.0	0.0	0.0	0.0	
5	0.0	0.0	0.0	0.1	0.0	13.0	2.0	0.1	0.0	0.0	0.0	0.0	
6	0.0	0.0	0.0	0.1	0.0	2.5	2.3	0.1	0.0	0.0	0.0	0.0	
7	0.0	0.0	0.0	0.1	0.0	0.8	1.6	0.1	0.0	0.0	0.0	0.0	
8	0.0	0.0	0.0	0.1	0.0	0.6	1.1	0.1	0.0	0.0	0.0	0.0	
9	0.0	0.0	0.0	0.1	0.0	0.6	0.9	0.1	0.0	0.0	0.0	0.0	
10	0.0	0.0	0.0	0.0	0.0	0.6	4.8	0.0	0.0	0.0	0.0	0.0	
11	0.0	0.0	0.0	0.0	0.0	0.4	5.9	0.0	0.0	0.0	0.0	0.0	
12	0.0	0.0	0.0	0.0	0.0	0.3	2.1	0.0	0.0	0.0	0.0	0.0	
13	0.0	0.0	0.0	0.0	0.0	5.6	1.1	0.0	0.0	0.0	0.0	0.0	
14	0.0	0.0	0.0	0.5	0.0	0.7	0.9	0.0	0.0	0.0	0.0	0.0	
15	0.0	0.0	0.0	0.1	0.0	2.1	5.2	0.0	0.0	0.0	0.0	0.0	
16	0.0	0.0	0.0	0.1	0.0	3.9	2.0	0.0	0.0	0.0	0.0	0.0	
17	0.0	0.0	0.0	0.1	0.0	0.9	0.9	0.0	0.0	0.0	0.0	0.0	
18	0.0	0.0	3.9	0.2	0.0	0.5	0.7	0.0	0.0	0.0	0.0	0.0	
19	0.0	0.0	0.3	0.1	0.0	4.3	0.5	0.0	0.0	0.0	0.0	0.0	
20	0.0	0.0	0.0	0.1	0.1	2.0	0.5	0.1	0.0	0.0	0.0	0.0	
21	0.0	0.0	0.0	0.1	0.0	0.7	0.4	0.0	0.0	0.0	0.0	0.0	
22	0.0	0.0	1.9	0.1	0.0	0.5	0.3	0.0	0.0	0.0	0.0	0.0	
23	0.0	0.0	0.1	0.1	0.0	0.4	0.3	0.0	0.0	0.0	0.0	0.0	
24	0.0	0.0	0.0	0.1	0.0	47.8	0.2	0.0	0.0	0.0	0.0	0.0	
25	0.0	0.0	0.1	0.1	0.0	2.8	0.2	0.0	0.0	0.0	0.0	0.0	
26	0.0	0.0	5.8	0.1	0.0	1.6	0.1	0.0	0.0	0.0	0.0	0.0	
27	0.0	0.0	0.1	0.0	5.7	2.4	0.0	0.0	0.0	0.0	0.0	0.0	
28	0.0	0.0	0.4	0.0	5.2	5.6	0.1	0.0	0.0	0.0	0.0	0.0	
29	0.0	0.0	0.0	0.0	0.5	1.9	0.1	0.0	0.0	0.0	0.0	0.0	
30	0.0	0.0	0.1	0.0		6.6	0.2	0.0	0.0	0.0	0.0	0.0	**Qbed**
31	0.0		148.2	0.0		2.3		0.0		0.0	0.0		**Annual**
TOTAL	0.0	0.0	161.1	68.8	12.0	121.2	68.4	1.2	0.1	0.0	0.0	0.0	**433**
Max.day	0.0	0.0	148.2	57.5	5.7	47.8	14.6	0.1	0.0	0.0	0.0	0.0	**148**

Daily values are based on calculations of sediment discharge at 15-minute intervals.
Daily values with more than 2 significant figures result from electronic calculations. No additional precision is implied.

Balance Hydrologics, Inc. 841 Folger Ave., Berkeley, CA 94710 (510) 704-1000; fax: (510) 704-1001

Form 6. Annual sediment-discharge record, San Francisquito Creek at Piers Lane, water year 2006

Water Year: **2006**
Stream: San Francisquito Creek
Station: at Piers Lane **SFPL**
County: San Mateo County, CA

WY 2006 Daily Suspended-Sediment Discharge *(tons)*

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	Qss Annual
1	0.0	*0*	5.5	249.8	3.4	32.3	82.0	3.2	0.2	0.0	0.0	0.0	
2	0.0	*0*	0.4	3973.5	6.0	48.5	73.6	3.3	0.2	0.0	0.0	0.0	
3	0.0	*0*	0.0	308.6	5.3	313.4	218.7	2.9	0.1	0.0	0.0	0.0	
4	0.0	*0*	0.0	37.1	4.3	44.2	346.0	2.8	0.1	0.0	0.0	0.0	
5	0.0	0.0	0.0	10.9	3.1	30.9	125.3	2.0	0.1	0.0	0.0	0.0	
6	0.0	0.0	0.0	6.5	2.2	818.7	55.6	1.5	0.1	0.0	0.0	0.0	
7	0.0	*0*	0.0	6.1	1.8	113.3	46.6	1.3	0.1	0.0	0.0	0.0	
8	0.0	*0*	0.0	3.7	1.5	41.9	43.6	2.2	0.0	0.0	0.0	0.0	
9	0.0	*0*	0.0	2.5	1.2	24.3	23.4	2.0	0.1	0.0	0.0	0.0	
10	0.0	*0*	0.0	1.9	0.9	24.5	17.6	1.5	0.1	0.0	0.0	0.0	
11	0.0	0.0	0.0	2.4	0.8	32.9	49.0	1.2	0.0	0.0	0.0	0.0	
12	0.0	0.0	0.0	2.1	0.7	15.6	147.9	1.1	0.1	0.0	0.0	0.0	
13	0.0	0.0	0.0	1.8	0.6	11.0	77.0	0.6	0.1	0.0	0.0	0.0	
14	0.0	0.0	0.0	32.4	0.5	207.6	35.8	0.5	0.1	0.0	0.0	0.0	
15	*0*	0.0	0.0	19.0	0.4	50.6	25.0	0.7	0.0	0.0	0.0	0.0	
16	*0*	0.0	0.0	4.8	0.3	31.2	233.4	0.6	0.1	0.0	0.0	0.0	
17	0.0	0.0	0.1	3.3	0.6	85.9	86.0	0.4	0.0	0.0	0.0	0.0	
18	0.0	0.0	254.4	19.5	0.5	31.4	34.7	0.2	0.0	0.0	0.0	0.0	
19	0.0	0.0	90.4	7.2	0.3	15.3	21.9	0.3	0.0	0.0	0.0	0.0	
20	0.0	0.0	2.3	4.2	0.2	67.0	14.0	0.8	0.0	0.0	0.0	0.0	
21	0.0	0.0	4.8	3.4	0.3	88.1	12.5	0.9	0.0	0.0	0.0	0.0	
22	0.0	0.0	734.1	2.8	0.3	28.8	10.9	0.8	0.0	0.0	0.0	0.0	
23	0.0	0.0	107.5	2.0	0.2	16.5	8.8	0.4	0.0	0.0	0.0	0.0	
24	0.0	0.0	4.4	1.7	0.2	12.8	6.3	0.3	0.0	0.0	0.0	0.0	
25	0.0	0.0	10.8	1.4	0.2	4083.3	4.8	0.3	0.0	0.0	0.0	0.0	
26	*0*	0.0	829.0	1.1	0.2	124.6	4.1	0.3	0.0	0.0	0.0	0.0	
27	*0*	0.0	19.7	0.9	135.5	52.3	3.5	0.2	0.0	0.0	0.0	0.0	
28	*0*	0.0	162.7	0.9	327.9	71.0	2.9	0.2	0.0	0.0	0.0	0.0	
29	*0*	0.1	32.1	9.4		125.4	2.6	0.2	0.0	0.0	0.0	0.0	
30	*0*	0.0	24.3	6.1		53.7	2.5	0.2	0.0	0.0	0.0	0.0	
31	*0*		18030.9	6.4		122.7		0.2		0.0	0.0		
TOTAL	0.0	0	20314	4734	499	6820	1816	33	1.9	0.1	0.0	0.0	**34,217**
Max.day	0.0	0.1	18031	3973	328	4083	346	3	0.2	0.0	0.0	0.0	**18,031**

Daily Bedload-Sediment Discharge *(tons)*

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	Qbed Annual
1													
2													
3													
4													
5	Daily Bedload Discharge was not calculated because of the lack of bedload measurements												
6													
7													
8													
9													
10	Daily Bedload Discharge was not calculated because of the lack of bedload measurements												
11													
12													
13													
14													
15	Daily Bedload Discharge was not calculated because of the lack of bedload measurements												
16													
17													
18													
19													
20	Daily Bedload Discharge was not calculated because of the lack of bedload measurements												
21													
22													
23													
24													
25	Daily Bedload Discharge was not calculated because of the lack of bedload measurements												
26													
27													
28													
29													
30													
31	Daily Bedload Discharge was not calculated because of the lack of bedload measurement												
TOTAL	...	...	...	...	...	...	...	...	...	...	...	...	**...**
Max.day	...	...	...	...	...	...	...	...	...	...	...	...	**...**

Daily values are based on calculations of sediment discharge at 15-minute intervals.
Daily values with more than 2 significant figures result from electronic calculations. No additional precision is implied.
We collected a continuous record for the entire water year to date except for 16 days in October and November when the sonar transponder was damaged by rain.

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TABLES

Table 1. Station Observer Log: Bear Creek at Sand Hill Road, water year 2006

Site Conditions				Streamflow				Water Quality Observations							High-Water Marks		Remarks
Date/Time (mm/dd/yr)	Observer	Stage (feet)	Hydrograph R/F/S/B)	Measured Discharge (cfs)	Estimated Discharge (cfs)	Instrument Used (AA/PY)	Estimated Accuracy (e/g/f/p)	Water Temperature (oC)	Field Specific Conductance (µmhos/cm)	Adjusted Specific Conductance (at 25 oC)	pH (pH)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% sat.)	Additional sampling? (Qbed, etc.)	Estimated stage at staff plate (feet)	Inferred dates? (mm/dd/yr)	
9/21/05 10:20	jg, zr	1.10	B	…	…	…	…	14.9	555	699	7.8	7.8	77%	…	…	…	installed new staff plate on stilling well near gate- downstream but In same pool as old staff plate, no change in gage height reading, moved ph/do/sc stilling well a few inches to make room for staff plate, removed old PVC by tree, left old staff plate in place
10/17/05 16:00	jg, zr	1.10	B	0.06	…	flume	p	14.4	575	734	7.9	…	…	…	…	…	cleaned DO probe, gate still closed, flow taken with 8" Cutthroat flume, measurement seemed good, but discharge reading is low
11/6/05 19:05	zr,nn, bjm	1.12	B	…	0.1	visual	p	12.4	552	743	7.8	6.1	56%	…	…	…	programmed sampler
11/17/05 11:45	zr,jg	1.10	B	…	…	…	…	10.6	520	735	7.9	7.1	63%	…	…	…	leaf dam just below gate and many leaves in pool, silt on top of DO probe, turned probe so it's now resting horizontally, dumped pump sample and turned off sampler, construction in progress across Sand Hill at horse park
11/28/05 17:10	zr, jg	1.05	B	…	…	…	…	8.6	315	470	7.7	8.0	60%	…	…	…	programmed sampler
11/29/05 20:25	zr, jg	1.12	F, B	…	2.08	…	p	10.6	464	641	7.9	6.6	57%	WQ composite, grabs, Qss	…	…	collected sample, sample volume ~ 15 liters, reset sampler for next storm
12/1/05 17:30	jo	2.38	F	…	45.0	visual	p	14.3	…	…	7.8	…	…	WQ grabs, Qss	2.9	12/1	raining and dark, water turbid, many leaves floating
12/2/05 11:25	zr, nn	1.22	F	…	…	…	…	11.2	394	534	7.6	9.5	87%	)ss, WQ composite	3.1	12/1	composite sampling complete, sample volume ~ 5 liters
12/21/05 17:00	zr, cn	1.99	R	32	…	AA	g	13.5	368	471	8.1	10.6	100%	)ss, WQ composite	3.8?	12/18	water is turbid, cleaned probes
12/22/05 12:30	jo	2.30	F, R	…	54.0	visual	p	13.6	229	299	…	…	…	Qss, Qbed	2.8	12/22	water turbid but not opaque, rain increasing, mostly leaves moving as bedload
12/27/05 11:45	zr, he	1.62	F	…	10	visual	p	12	309	420	…	10.5	98%	…	4.8 to 5	12/26	cloudy, on and off light rain, cleaned debris from stilling well
12/28/05 10:05	jo	3.55	R	…	142	floats	p	13.5	195	255	…	…	…	Qss, WQ grabs	4.8	12/26	water light brown and fully turbid
12/29/05 8:35	zr, he	2.00	F	…	28	visual	p	10.8	233	320	7.9	9.9	88%	WQ composite	…	…	collect and partition composite sample, sample volume ~ 12 liters, no grab
1/2/06 8:00	jg, ds	3.85	R	…	…	…	…	12	169	223	…	10.4	96%	Qbed, Qss	10.0 to 13.3	12/31	new staff plate, stilling well, probes, and concrete destroyed in storm, high flows, difficult to wade, bed is very sandy at road crossing, high water mark almost to gage box, old staff plate intact
1/2/06 14:00	jg, ds	6.55	R	942	…	floats	p	…	…	…	…	…	…	…	…	…	peak flow calculation taken from float test and high water mark survey
1/6/06 17:00	zr,sb	2.06	F	…	16	visual	p	12.1	306	406	7.9	10.3	97%	..	…	…	installed new staff plate, stilling well, pressure transducers
1/11/06 9:47	jg, bkh	1.93	B	12.3	…	PY	g	11	354	483	…	10.6	97%	..	…	…	deposition of sand, gravels, and cobbles across concrete weir, tree is snagged across weir
1/17/06 9:19	jo	1.89	B	…	…	…	…	…	…	…	…	…	…	…	…	…	met with PC, AL, KK to plan gage repairs
1/31/06 16:00	jo, he	2.01	B	…	…	…	…	…	…	…	…	…	…	…	…	…	surveyed cross section and high water mark from 12/31 storm
2/16/06 12:15	zr, bkh	1.72	B	3.7	…	PY	g,f	8.1	359	533	8.4	11.7	100%	…	…	…	left bank fence gate has been removed and concrete blocks have been removed from channel, new algae growth on bed
2/27/06 15:10	jo	1.96	R	…	11	visual	p	…	…	…	…	…	…	…	…	…	only moderate turbidity, about 1 foot visibility
3/17/06 9:45	zr, tb	2.98	F	66	…	AA	g,f	10.1	249	346	8.3	10.4	93%	Qss			no bedload transport, rain ending upon arrival
3/28/06 13:45	zr, jo	2.99	R	…	…	…	…	10.6	277	391	…	…	…	Qss, Qbed	17.5	3/25	moderate rain just lightened, air cooling, water turbid, grey-brown, occasional floating sticks and leaves
4/6/06 8:44	jo	2.72	F	…	…	…	…	…	…	…	…	…	…	Qss	…	…	water too high to fully install new gage, temporary installation of sampler intake tubing
4/27/06 17:00	jo	1.86	B	10.0	…	AA	…	17	410	489	…	…	…	…	…	…	water clear, concrete sill exposed fully across creek, but riffle at crossing has formed, elevating pool level, oak leaves floating in creek, bed brown with algae
5/2/06 12:30	zr, jg	1.78	B	…	4.9	visual	p	13.3	414	534	7.8	10.6	100%	…	…	…	water is low and clear
5/25/06 15:30	zr	1.60	B	1.9	…	PY	f	16.3	504	606	8.1	9.7	99%	…	…	…	new gate across creek, water is clear, and has dropped considerably since last visit
5/31/06 16:45	jo	1.59	B	…	…	…	…	…	…	…	…	…	…	…	…	…	sunny, hot, equipment installation with Jeremy from Kinetics, added new PT's, DO, pH, SC, T
6/8/06 12:30	cn, bjm	1.55	B	1.9	…	PY	g	14.7	486	605	7.6	8.3	77%	…	6.7	March-April	water clear, lots (>50) of small fish in creek
7/17/06 14:15	zr, js	1.44	B	0.5	…	PY	g	20	539	595	8.2	6.6	74%	…	…	…	more than 100 1-2" fish near gate and more a few small fish in pools, water is clear, many water striders
8/9/06 11:15	zr, jo	1.43	B	0.5	…	PY	g	17.9	449	519	7.7	8.2	86%	WQ grabs	…	…	water clear, low, many fish in pool with gage, WQ grab samples taken 40' upstream of staff plate
10/5/06 15:30	jg	1.445	B	0.4	…	PY	f	…	…	613	7.6	…	…	WQ grabs	…	…	water clear, with grayish turbid area near left bank at stilling well

Notes:

Obs Key: jo is Jonathan Owens, jg is John Gartner, bkh is Brian Hastings, bjm is Bonnie Mallory, sb is Scott Brown, nn is Nathan Neufeld, zr is Zan Rubin, cn is Christian Nilsen, he is Hilary Ewing, tb is Travis Baggett, ds is Dave Shaw

Stage: Water level observed at outside staff plate

Hydrograph: Describes stream stage as rising (R), falling (F), steady (S), baseflow (B), or diversion underway (D)

Instrument: If measured, typically made using a standard (AA) or pygmy (PY) bucket-wheel ("Price-type") current meter. If estimated, from rating curve(R), visual (V), or float test

Estimated measurement accuracy: Excellent (E) = +/- 2%; Good (G) = +/- 5%; Fair (F) = +/- 8%; Poor (P) estimated percent accuracy given

High-water mark (HWM): Measured or estimated at location of the staff plate

Specific conductance: Measured in micromhos/cm in field; then adjusted to 25degC by equation (1.8813774452 - [0.050433063928 * field temp] + [0.00058561144042 * field temp^2]) * Field specific conductance

Additional Sampling: Qbed = Bedload, Qss = Suspended sediment, WQ = water quality; DO = Dissolved oxygen msmt., pH = pH msmt., NH3 = ammonia (grab) sample, Hg = mercury (grab) sample

Table 2. Station observer log: Los Trancos Creek at Piers Lane, water year 2006

Site Conditions				*Streamflow*				*Water Quality Observations*							*High-Water Marks*		*Remarks*
Date/Time *(mm/dd/yr)*	Observer(s)	Stage (staff plate) *(feet)*	Hydrograph *(R/F/S/B/P)*	Measured Discharge *(cfs)*	Estimated Discharge *(cfs)*	Instrument Used *(AA/PY)*	Estimated Accuracy *(e/g/f/p)*	Water Temperature *(°C)*	Specific Conductance at field temp. *(µmhos/cm)*	Specific Conductance at 25C *(uS@25°C)*	pH *(pH)*	Dissolved Oxygen *(mg/L)*	Dissolved Oxygen *(% sat.)*	Additional sampling? *(Qbed, etc.)*	Estimated stage at staff plate *(feet)*	Inferred dates? *(mm/dd/yr)*	
9/14/05 10:55	jg, zr	0.85	B	…	0.18	visual	p	13.0	1160	1537	7.3	8.5	89%	…	…	…	changed battery, some leaves dammed in controlling riffle, download
10/17/05 12:10	jg, zr	0.82	B	0.11	…	PY	g	13.9	1222	1581	8.1	…	…	…	…	…	water clear, some leaves at controlling riffle
11/2/05 15:03	jo	0.84	B	…	0.15	visual	p	13.2	1206	1558	8.21	9.4	89%	…	…	…	thick brown algae on bed, water clear, some leaves on controlling riffle
11/6/05 20:48	bjm, nn, zr	0.85	B	…	0.10	visual	p	13.5	1225	1601	8.21	9.3	89%	…	…	…	programmed sampler to begin 11/7/05 05:00
11/10/05 15:00	jg, zr	0.84	B	0.20	…	PY	f	13.6	1122	1463	8.2	9.0	86%	…	0.99	11/9/05	algae on bed, no bedload transport yet this year, ground moist, download
11/17/05 16:10	jg, zr	0.82	B	…	0.12	visual	p	12.9	1213	1611	…	8.8	84%	…	…	…	sunny and dry weather, slight smell of dead animal
11/28/05 18:10	jg, zr	0.84	B	…	0.2	visual	p	10.1	1059	1516	8.2	7.6	67%	…	…	…	programmed sampler to begin 11/28/05 19:00, began raining at ~ 7:00
11/29/05 16:00	jg, zr	0.94	B	…	0.5	visual	p	12.6	474	635	8.0	9.0	85%	WQ grabs, composite	1.16	11/29/05	collected WQ samples, total composite volume 11.5 liters, grab samples taken at 16:35, programmed sampler to start at 12/1/05 05:00
12/1/05 18:15	jo	1.77	F	…	9	visual	p	14.7	…	…	8.0	…	…	WQ grabs, Qss	2.07	12/1/05	dark and raining; foam on surface; water turbid; reconnected hose to sampler
12/2/05 13:10	zr, nn	0.96	B	…	0.5	visual	p	11.5	903	1216	8.1	9.8	91%	WQ composite	1.60	12/1/06	collected WQ composite sample, total volume ~ 3 liters, water clear, sand and gravel on bed cleaned of algae
12/21/05 11:05	zr, cn	1.12	F	1.52	…	PY	p	13.4	803	1030	8.2	9.7	93%	…	3.5	12/19/05	water clear, cleared debris from staff plate, download
12/22/05 16:40	jo	2.85	R	79	…	float	p	15.3	257	320	…	…	…	2 Qss	…	…	water opaque and reddish brown, bedload was felt to be moving, but too deep and fast to sample
12/27/05 13:30	zr, he	1.36	R	…	5	visual	p	13	652	864	…	10.4	99%	…	4.17	recent	water clear, set up sampler to begin at 14:00
12/28/05 13:10	jo	1.63	F	…	4.5	visual	p	14	379	489	…	…	…	WQ grabs, Qss, Qbed	3.6	12/26/05	water turbid but not opaque, light reddish brown
12/29/05 10:20	zr, he	1.12	R	…	3	visual	p	11.3	793	1099	…	11.0	100%	WQ composite	…	…	retrieved WQ composite, total volume ~12 liters
1/2/06 16:00	jg, ds	4.75	P, R	204	…	float	p	11.6	138	190	…	10.8	100%	Qss	…	…	water fast and high, too deep to wade, very turbid
1/11/06 17:20	jg, bkh	1.11	B	1.6	…	PY	f	12.6	883	1182	…	9.7	92%	…	…	…	getting dark during flow measurement, download
1/25/06 16:42	jg, jo	1.29	B	…	…	…	…	…	…	…	…	…	…	…	…	…	surveyed high water channel profile
2/14/06 8:39	jo	1.05	B	…	1.12	visual	p	9.9	745	1072	8.2	10.8	96%	…	…	…	installed new conduit and solar panel, water clear, download
2/16/06 14:00	bkh, jo	1.02	B	1.22	…	pygmy	g	9.2	709	1040	8.5	9.4	82%	…	…	…	water clear, dry period last 10 to 12 days
2/24/06 8:27	jg, jo	1.24	B	…	1.7	visual	p	8.1	603	911	8.4	11.4	97%	…	…	…	tour new equipment with M. Laporte and B. Eggleston, water clear, no leaves in riffle
3/22/06 14:15	zr, cn	1.79	F	16.4	…	AA	e	11.6	464	623	8.4	11.1	100%	…	…	…	water slightly turbid, download data
4/4/06 16:40	jg, zr	3.86	F	79.2	…	AA	f	11.8	267	365	8.0	10.5	97%	Qss, 2 Qbed	…	…	staff plate knocked off, water turbid
4/22/06 10:30	zr	1.66	B	…	9	visual	p	12.0	491	668	8.3	10.1	94%	…	…	…	water slightly turbid, download data
5/2/06 17:00	jg, zr	1.41	B	6.5	…	AA	g	17.2	621	737	8.3	9.1	95%	…	…	…	rocks have moved at controlling riffle since last fall
5/25/06 16:30	zr	1.03	B	2.4	…	PY	g	15.2	650	813	8.4	9.2	91%	…	…	…	water clear, sand on bed has no algae, download data
7/17/06 9:45	zr, js	0.82	B	0.5	…	PY	f	17.3	1066	1262	8.7	7.0	72%	…	…	…	water clear, many eucalyptus leaves on bed, less algae than San Francisquito Creek
8/9/06 12:20	jo, zr	0.76	B	0.2	…	PY	g, f	18.4	1232	1419	7.9	8.3	89%	WQ grabs	…	…	water clear, many 1-inch to 3-inch fish in creek
10/5/06 9:30	jg	1.00	B, F	1.0	…	PY	g	…	…	956	8.1	…	…	…	1.2	10/5/06	water brown, white foam, first precipitation of new water year in early am

Observer Key: jo= Jonathan Owens; bjm= Bonnie Mallory; jg = John Gartner, zr = Zan Rubin, cn = Christian Nilsen, js = John Stamm, he = Hillary Ewing, nn = Nathan Neufeld; ds = Dave Shaw; bkh = Brian Hastings

Stage: Water level observed at outside staff plate

Hydrograph: Describes stream stage as rising (R), falling (F), steady (S), baseflow (B), uncertain (U), or peak (P).

Instrument: If measured, typically made using a standard (AA) or pygmy (PY) bucket-wheel ("Price-type") current meter. If estimated, from rating curve (R) or visual (vis. est.).

Estimated measurement accuracy: Excellent (E) = +/- 2%; Good (G) = +/- 5%; Fair (F) = +/- 8%; Poor (P) = +/- > 8%

High-water mark (HWM): Measured or estimated at location of the staff plate

Additional Sampling: Qbed = Bedload, Qss = Suspended sediment, WQ = water quality; DO = Dissolved oxygen msmt., pH = pH msmt., NH3 = ammonia (grab) sample, Hg = mercury (grab) sample

Table 3. Station observer log: San Francisquito Creek at Piers Lane, water year 2006

Site Conditions				*Streamflow*				*Water Quality Observations*							*High-Water Marks*		*Remarks*
Date/Time	Observer(s)	Stage (staff plate)	Hydrograph	Measured Discharge	Estimated Discharge	Instrument Used	Estimated Accuracy	Water Temperature	Specific Conductance at field temp.	Specific Conductance at 25C	pH	Dissolved Oxygen	Dissolved Oxygen	Additional sampling?	Estimated stage at staff plate	Inferred dates?	
(mm/dd/yr)		*(feet)*	*(R/F/S/B)*	*(cfs)*	*(cfs)*	*(AA/PY)*	*(e/g/f/p)*	*(°C)*	*(μmhos/cm)*	*(uS@25°C)*	*(pH)*	*(mg/L)*	*(% sat.)*	*(Qbed, etc.)*	*(feet)*	*(mm/dd/yr)*	
9/14/05 11:23	jg. zr	3.33	B	…	0.4	visual	p	14.5	1046	1297	7.7	7.4	75%	…	…	…	found a discarded tarp and cabinet beneath bridge
10/17/05 9:26	jg, zr	3.33	B	0.3	…	PY	g	12.5	1052	1412	7.8	…	…	…	…	…	water clear
11/2/05 15:29	jo	3.35	B	…	…	…	…	12.8	925	1232	7.7	7.9	73%	…	…	…	water clear, brown algae on rocks
11/6/05 20:10	bjm, zr	3.36	B	…	0.1	PY	p	12.8	988	1316	7.4	8.8	84%	…	…	…	set up sampler, water clear
11/10/05 10:55	jg, zr	3.40	B	0.7	…	PY	f	12.4	822	1106	7.8	5.4	51%	…	3.41	11/9/05	rained yesterday, installed temporary probes and datalogger
11/17/05 16:25	jg, zr	3.37	B	…	0.3	visual	p	11.8	774	1059	8.1	2.6	24%	…	…	…	download, recent installation functioning well
11/28/05 17:45	jg, zr	3.40	B	…	…	…	…	9.4	745	1087	7.7	2.0	17%	…	…	…	set up sampler
11/29/05 16:40	jg, zr	3.62	B	…	1.5	visual	p	10.6	610	862	7.9	5.8	52%	WQ grabs, composite	4.00	11/28/05	collected and partitioned composite samples, sample volume ~ 5 liters rained earlier today, download, set up sampler for Dec 1 event
12/1/05 18:30	jo	5.08	P, F	…	100	visual	p	13.6	…	…	7.7	…	…	WQ grabs, Qss	…	…	raining and dark, many leaves and twigs in flow, turbid
12/2/05 12:45	zr, nn	3.72	B	…	…	…	…	11.9	449	598	7.5	8.0	73%	Qss, WQ composite	4.95	12/1/05	water still turbid, collected and partitioned composite sample, many hawks
12/21/05 12:00	zr, cn	4.08	F	15.6		visual	p	12.4	487	656	8.1	7.7	67%	…	6.33	12/19/06	water light brown and turbid, download data
12/22/05 16:26	jo	6.80	R	…	…	…	p	14.3	309	396	…	…	…	2 Tss	…	…	many pieces of floating wood in creek; too deep to wade for bedload sampling
12/27/05 12:52	zr, he	4.68	F	…	55	visual	p	12.3	347	468	…	10.3	97%	..	…	…	set up sampler
12/28/05 13:10	jo	6.02	R, P	…	…	…	…	13.5	242	316	…	…	…	WQ grabs, Tss	7.5	12/26/05	water brown and turbid, smells like dirt
12/29/05 9:45	he, zr	5.00	F	…	95	visual	p	11.4	307	424	8.1	9.8	90%	WQ composite	…	…	retrieved composite sample, total volume ~ 12 liters
1/2/06 17:30	jg, ds	7.94	P	1730	…	AA	p	11.7	159	213	…	10.1	93%	Tss	…	…	very high flows. bridge board measurement, getting dark
1/11/06 16:51	bkh, jg	4.29	B	24.7	…	AA	g	11.7	446	612	…	9.1	85%	Tss	…	…	surveyed flood high water marks
1/25/06 17:33	jg, jo	4.15	…	…	…	…	…	…	…	…	…	…	…	…	…	…	additional surveying just before dark
1/31/06 10:25	jo, he	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	additional surveying for high flow indirect measurement
2/14/06 8:48	jo	3.99	B	…	…	…	…	9.7	528	764	8.1	10.2.	90%	…	…	…	installed new datalogger and probes, water turbid and cloudy, rock on bed covered with fine sediment, download
2/15/06 17:43	jo	3.98	B	…	…	…	…	10.2	484	691	…	…	…	…	…	…	completed installation of new datalogger, probes, solar panel
2/16/06 14:50	bkh, zr	4.92	B	10.3	…	PY	e	8.8	492	730	8.5	10.6	95%	…	…	…	water clear, matted vegetation rebounding in flooded areas, leafing out, download
2/24/06 10:10	jg, jo	3.92	B	…	2.5	visual	p	7.7	543	830	7.6	10.5	89%	…	…	…	site tour with M. Laporte and B. Eggleston, removed temporary datalogger and probes, download
3/22/06 16:04	zr, cn	5.09	F	79.6	…	AA	g	10.2	357	510	8.2	10.3	100%	Tss	8.0, 12.0	1/2/06	cloudy, high flows, water turbid, download
4/4/06 17:00	jg, zr	6.40	F	…	…	…	…	11.7	278	381	8.0	10.7	99%	Tss			water turbid, surging at staff plate
4/6/06 10:35	jo	5.42	F	…	…	…	…	…	…	…	…	…	…	…	…	…	quick visit to install grounding strip
4/22/06 11:20	zr	5.70	B	…	…	…	…	12.7	431	576	8.3	9.6	81%	…	…	…	water green and slightly turbid, download data
5/2/06 17:45	jg, zr	4.25	B	11.8	…	AA	g	17.7	598	695	7.3	8.2	89%	…	…	…	grass growing on WY 2006 sand deposits, tree leaves are full
5/20/06 19:30	jo	4.00	B	…	…	…	…	…	…	…	…	…	…	…	…	…	aborted attempt to set up sampler, blown fuse
5/25/06 17:00	zr	3.92	B	8.9	…	PY	g	17.9	682	795	8.1	7.1	75%	…	…	…	water is clear, lots of algae on bed, download data, replaced fuse
7/17/06 0:00	zr, js	3.49	B	1.2	…	PY	f	19.0	846	960	8.4	6.6	72%	…	…	…	water clear, algae on bed, several 1-2" fish
8/9/06 13:15	jo, zr	3.38	B	0.49	…	PY	f	19.6	1015	1135	7.7	7.7	85%	WQ grabs	…	…	water clear, algae on rocks, crayfish in pool and riffle
10/5/06 11:00	jg	3.46	B	0.87	…	PY	f	…	…	759	8.1	…	…		5.55	10/5/06	water brown, white foam, first precipitation of new water year in early am

Observer Key: jo= Jonathan Owens; bjm= Bonnie Mallory; jg = John Gartner, zr = Zan Rubin, cn = Christian Nilsen, js = John Stamm, he = Hillary Ewing, nn = Nathan Neufeld; ds = Dave Shaw; bkh = Brian Hastings

Stage: Water level observed at outside staff plate

Hydrograph: Describes stream stage as rising (R), falling (F), steady (S), baseflow (B), or uncertain (U).

Instrument: If measured, typically made using a standard (AA) or pygmy (PY) bucket-wheel ("Price-type") current meter. If estimated, from rating curve (R) or visual (vis. est.).

Estimated measurement accuracy: Excellent (E) = +/- 2%; Good (G) = +/- 5%; Fair (F) = +/- 8%; Poor (P) = +/- > 8%

High-water mark (HWM): Measured or estimated at location of the staff plate

Additional Sampling: Qbed = Bedload, Qss = Suspended sediment, WQ = water quality; DO = Dissolved oxygen msmt., pH = pH msmt., NH3 = ammonia (grab) sample, Hg = mercury (grab) sample

Table 4. Hydrologic summary for the period of record, Bear Creek at Sand Hill Road, Los Trancos and San Francisquito Creeks at Piers Lane

	Annual Flow [4]				Sediment Discharge [4]				Peak Flow		
Water Year [1]	Mean Annual Flow	Maximum Daily Mean Flow	Minimum Daily Mean Flow	Total Flow Volume	Suspended Sediment	% suspended	Bedload Sediment	% bedload	Peak Flow	Peak Stage [5]	Date Time
	(cfs)	*(cfs)*	*(cfs)*	*(ac-ft)*	*(tons)*		*(tons)*		*(cfs)*	*(ft)*	*(24-hr)*
Bear Creek at Sand Hill Road [2, 6]											
2000	10.65	684	0.01	7,728	24,426	93%	1,778	7%	2,050	8.81	2/13/00 20:45
2001	3.71	113	0.01	2,689	681	87%	98	13%	353	4.26	1/25/01 16:45
2002	5.12	189	0.01	3,704	1,681	91%	171	9%	733	5.78	12/2/01 7:45
2003	6.86	434	0.01	4,965	11,258	94%	762	6%	2,231	9.29	12/16/02 5:45
2004	5.87	282	0.01	4,260	5,624	91%	555	9%	1,186	7.28	1/1/04 12:15
2005	10.77	257	0.01	8,113	2,460	96%	98	4%	487	5.35	12/30/04 21:30
2006	18.33	849	0.01	13,269	11,693	96%	468	4%	3,800	10.70	12/31/05 7:00
Los Trancos Creek at Piers Lane [3]											
2003	2.67	123	0.01	1,934	2,494	…	…	…	649	7.58	12/16/02 6:30
2004	2.70	136	0.02	1,461	2,991	…	…	…	582	5.47	2/25/04 11:00
2005	3.56	67	0.02	2,575	1,424	94%	85	6%	357	4.33	2/18/05 6:00
2006	7.09	190	0.13	5,137	4,328	91%	433	9%	640	7.80	12/31/05 8:15
San Francisquito Creek at Piers Lane [3]											
2003	15.40	782	0.09	11,146	10,097	…	…	…	2,706	12.46	12/16/02 6:30
2004	11.02	453	0.12	8,002	6,910	…	…	…	1,474	9.67	1/1/04 13:15
2005	24.35	509	0.05	17,627	9,463	…	…	…	749	7.77	2/15/05 21:00
2006	40.09	1,704	0.39	29,027	34,217	…	…	…	4,300	12.98	12/31/05 8:15

Notes:

General: Values displaying more than 2 or 3 significant figures are the result of electronic calculations; no additional precision is implied.

1) Hydrologic monitoring is conducted by "water years", rather than calendar years, to encompass whole rainfall seasons. Water year 2006 (WY2006) extends from October 1, 2005 through September 30, 2006 and corresponds to the water year used by most federal agencies.

2) The period of record for the Bear Creek at Sand Hill Road station is October 12, 1999 to Sept. 30, 2006.

3) The period of record for the Piers Lane stations is October 2002 to Sept. 30, 2006; the partial record from the initial season (WY2002) of monitoring is not shown.

4) Daily flow values were computed from instantaneous flow calculated at 15-minute intervals. Sediment discharge values were totalled from calculations at 15-minute intervals. Maximum daily flow is the highest mean daily flow of the year.

5) Stage is the staff plate reading; the staff plate is set at an arbitrary datum and does not represent the absolute depth of water in the creek.

6) In water year 2006, Bear Creek peak flow (12/31/2005) was estimated from surveyed high-water marks. Because the gaging equipment was destroyed in the high flows, daily mean flow on that day was calculated from the 15-minute flow record synthesized by correlation with other creeks..

Table 5. Summary of water quality for Bear Creek at Sand Hill Road, water year 2006.

Field observations [1]							*Nutrients* [2]				*Pesticides*		*Others* [3]	
Date and Time	Observer	Gage Height	Hydrograph	Discharge	Water Temperature	Specific conductance	**Ammonia-N**	**Nitrate-N**	**Nitrate-N + Nitrite-N**	**Phosphate-P**	**Chlorpyrifos**	**Diazinon**	**Total Suspended Solids**	**Hardness**
		(feet)	*(R,F,B,U)*	*(cfs)*	*(°C)*	*(µmhos/cm @ 25°C)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(ug/L)*	*(ug/L)*	*(mg/L)*	*(mg/L)*
Analytical detection limits [5]						**11/28-29/2005**	0.2	0.1	0.1	0.02	0.05	0.05	0.5	1.0
						12/1-2/2005	0.2	...	0.1	0.02	...	...	0.5	1.0
						12/28-29/2005	0.2	0.1	0.1	0.02	0.05	0.05	0.5	1.0
						8/9/2006	0.2	0.1	...	0.02	...	...	...	1.0
Bear Creek at Sand Hill Road														
11/28-29/2005	JG, ZR	**comp.**	**comp.**	**3.9**				0.27	0.34 (0.33)	0.86 (0.89)	ND (ND)	ND (ND)	20 (20)	199
11/29/2005 20:25	JG, ZR	1.12	F	2.1	10.6	641	ND (ND)							
12/1-2/2005	JG, ZR	**comp.**	**comp.**	**16.3**				...	1.4	2.73	...	...	390	165
12/1/2005 17:26	JO	2.38	F	51	14.3	...	ND (ND)							
12/27-28/2005	ZR, HE	**comp.**	**comp.**	**56.2**				0.95	0.94	1.65 (0.83)	ND	ND	50	118
12/28/2005 9:48	JO	3.42	R	175	13.5	251	ND (ND)							
8/9/2006 11:00	JO, ZR	1.42	B	0.5	17.9	519	ND (ND)	0.08	...	0.15	...	...	...	272
All 8/9/2006 samples were grab samples														
Minimum over period of record							0.20	0.08	0.10	0.15	ND	ND	1.8	94
Maximum over period of record							0.44	0.95	1.40	2.73	ND	ND	420	272
SF Bay RWQCB (1995)--Aquatic acute toxicity: 1-hour average							---[6]	---[7]	---[7]	---[7]	---[8]	---[8]	---[9]	None
SF Bay RWQCB (1995)--Aquatic chronic toxicity: 4-day average							---[6]	---[7]	---[7]	---[7]	---[8]	---[8]	---[9]	None

11/28-29/2005 composite programmed sampler to start 11/28/05 at 18:00 and collect 48, 375-ml samples at 30-minute intervals; sample collection ended 11/29/05 at 17:30

12/1-2/2005 composite programmed sampler to start 12/1/05 at 4:00 and collect 48, 375-ml samples at 30-minute intervals; sample collection ended 12/2/05 at 3:30.

12/27-28/2005 composite programmed sampler to start 12/27/05 at 13:00 and collect 54, 325-ml samples at 30 minute intervals; sample collection ended 12/28/05 at 15:30

Table 5. Summary of water quality for Bear Creek at Sand Hill Road, water year 2006 (continued).

Field observations [1]		*Trace Metals* [4]															
Date and Time	Discharge	**Aluminum (total)**	**Aluminum (dissolved)**	**Copper (total)**	**Copper (dissolved)**	**Lead (total)**	**Lead (dissolved)**	**Mercury (total)**	**Mercury (dissolved)**	**Nickel (total)**	**Nickel (dissolved)**	**Selenium (total)**	**Selenium (dissolved)**	**Silver (total)**	**Silver (dissolved)**	**Zinc (total)**	**Zinc (dissolved)**
	(cfs)	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*
Analytical detection limits: [5]	**11/28-29/2005**	100	100	0.6	0.6	0.4	0.4	0.0005	0.0005	0.6	0.6	0.1	0.1	0.2	0.2	5.0	5.0
	12/1-2/2005	1000	10	0.6	0.6	0.4	0.4	0.0010	0.0005	0.6	0.6	0.1	0.1	0.2	0.2	5.0	5.0
	12/28-29/2005	200	10	0.6	0.6	0.4	0.4	0.0005	0.0005	0.6	0.6	0.1	0.1	0.2	0.2	5.0	5.0
	8/9/2006	...	...	...	0.6	...	0.4	...	...	...	0.6	...	0.1	...	0.2	...	5.0
Bear Creek at Sand Hill Road																	
11/28-29/2005	**3.9**	960 (890)	80 (ND)	5.1 (5.5)	4.9	1.4 (1.5)	ND			4.6 (5.0)	2.4	0.1 (0.1)	ND	ND (ND)	ND	10 (11)	13
11/29/2005 20:25	2.1							0.0036 (0.0038)	0.0023 (0.007)								
12/1-2/2005	**16.3**	11,000	30	40.0	8.0	21.0	0.5			28	4.2	0.5	ND	ND	ND	110	36
12/1/2005 17:26	51							0.11	0.0029								
12/28-29/2005	**56.2**	1,800	57	14.8	4.7	3.1	ND			9.0	3.3	0.2	0.2	ND	ND	31	26
12/28/2005 9:50	175							0.28	0.0044								
8/9/2006 11:00	0.5	...	...	...	1.4	...	ND	...	...	...	2.7	...	0.2	...	ND	...	ND
All 8/9/2006 samples were grab samples																	
Minimum over period of record		ND	ND	1.20	1.2	ND	ND	0.0017	0.0010	3.2	2.4	ND	ND	ND	ND	8	6
Maximum over period of record		11,000	190	60	10.6	21.0	0.9	0.28	0.0076	28	7.0	0.6	0.3	1.3	0.3	110	41
SF Bay RWQCB (1995)--Aquatic acute toxicity: 1-hour average [10]		None		None	13.4 - 49.6	None	64.6 - 288	2.4	2.4	None	468 - 1,186	20	20	None	3.4 - 37.4	None	117 - 379
SF Bay RWQCB (1995)-- Aquatic chronic toxicity: 4-day average [10]		None		None	9.0 - 29.3	None	2.5 - 10.9	0.025	0.025	None	52 - 132	5	5	(instantaneous maximum; no acute or chronic toxicity		None	118 - 382

Table 5. Summary of water quality for Bear Creek at Sand Hill Road, water year 2006 (continued).

Notes: **ND = not detected** **ns = not sampled,**

1) Observer Key: jo is Jonathan Owens; zr is Zan Rubin; he is Hillary Ewing, jg is John Gartner
   Hydrograph: R=Rising; P=Peak; F=Falling; B=Baseflow; U=Uncertain **Bold** flow values indicate average flow during the period of composite sampling
   All specific conductance and temperature measurements were made in the field.
   Values reported in parentheses are replicate subsamples.
2) Ammonia and phosphate samples were preserved upon collection with sulfuric acid (H_2SO_4) to pH<2. Nitrate samples were iced but not preserved if analysis could occur within 48 hours; otherwise, nitrate samples were also preserved with sulfuric acid.
3) All total suspended sediment (TSS) analyses of *composite* samples were performed by the RWQCP lab (City of Palo Alto) with a detection limit of 0.5 mg/L. Results of TSS *grab* samples, analyzed by Soil Control Lab (Watsonville, CA) with a detection limit of 5.0 mg/L, are presented elsewhere in this report.
4) Total recoverable metals samples were preserved (unfiltered) upon collection with nitric acid (HNO_3). Dissolved metals samples were filtered in the laboratory, then preserved with nitric acid.
5) Reporting Limits vary with analytical method, laboratory, quality control measures, and sample concentration, due to the dilution needed to bring the sample into analytical range.
   Thus, the reporting limit may vary slightly among samples collected at different sites on the same day.
   Aluminum, nitrate, organophosphate pesticide (diazinon, chlorpyrifos) and mercury analyses performed by Caltest (Napa).
   Laboratory analyses for all other metals, ammonia, phosphate, hardness and suspended sediment (composite samples only) performed by the City of Palo Alto RWQCP.
6) Un-ionized ammonia concentrations chronically in excess of 0.025 mg/L (annual median value) can be toxic (RWQCB, 1995).
   The fraction of total ammonia that is in the toxic, un-ionized form increases with increases in pH and temperature. Mean daily temperatures in Bear Creek varied from about 6.3 to 23.4°C, and pH measurements ranged from 7.6 to 8.4 during the water year 2006 monitoring period.
7) Biostimulatory constituents should not be present in amounts that stimulate excessive aquatic growth (RWQCB, 1995).
8) Waters should remain free of toxics at concentrations lethal to or adversely impacting aquatic organisms (RWQCB, 1995).
9) Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses (RWQCB, 1995).
10) The California Toxics Rule, adopted statewide by the Regional Boards in 2004, then approved by the U.S. EPA and incorporated into the Basin Plans establishes aquatic acute and chronic toxicity objectives for dissolved concentrations of hardness-dependent trace metals. The range shown is for hardness of 100 to 400 mg/L as $CaCO_3$, because the CTR states that "For purposes of calculating freshwater aquatic life criteria for metals . . . [f]or waters with a hardness of over 400 mg/l as calcium carbonate, a hardness of 400 mg/l as calcium carbonate shall be used . . .'

   The objectives are calculated based on the following equations:

Dissolved Copper, 1-hour average = $(e\{0.9422 [\ln(\text{hardness})] - 1.700\}) \times (0.960)$
Dissolved Copper, 4-day average = $(e\{0.8545 [\ln(\text{hardness})] - 1.702\}) \times (0.960)$

Dissolved Lead, 1-hour average = $(e\{1.273[\ln(\text{hardness})] - 1.460\}) \times (1.46203 - \{[\ln(\text{hardness})] \times [0.145712]\})$
Dissolved Lead, 4-day average = $(e\{1.273[\ln(\text{hardness})] - 4.705\}) \times (1.46203 - \{[\ln(\text{hardness})] \times [0.145712]\})$

Dissolved Nickel, 1-hour average = $(e\{0.8460 [\ln(\text{hardness})] + 2.255\}) \times (0.998)$
Dissolved Nickel, 4-day average = $(e\{0.8460 [\ln(\text{hardness})] + 0.0584\}) \times (0.997)$

Dissolved Silver, instantaneous maximum = $(e\{1.72 [\ln(\text{hardness})] - 6.52\}) \times (0.85)$

Dissolved Zinc, 1-hour average = $(e\{0.8473 [\ln(\text{hardness})] + 0.884\}) \times (0.978)$
Dissolved Zinc, 4-day average = $(e\{0.8473 [\ln(\text{hardness})] + 0.884\}) \times (0.986)$

for dissolved concentrations of metals, based on hardness. The objectives are calculated based on the following equations:

Dissolved Copper, 1-hour average = $(e\{0.9422 [\ln(\text{hardness})] - 1.700\}) \times (0.960)$
Dissolved Copper, 4-day average = $(e\{0.8545 [\ln(\text{hardness})] - 1.702\}) \times (0.960)$

Dissolved Lead, 1-hour average = $(e\{1.273[\ln(\text{hardness})] - 1.460\}) \times (1.46203 - \{[\ln(\text{hardness})] \times [0.145712]\})$
Dissolved Lead, 4-day average = $(e\{1.273[\ln(\text{hardness})] - 4.705\}) \times (1.46203 - \{[\ln(\text{hardness})] \times [0.145712]\})$

Dissolved Nickel, 1-hour average = $(e\{0.8460 [\ln(\text{hardness})] + 2.255\}) \times (0.998)$
Dissolved Nickel, 4-day average = $(e\{0.8460 [\ln(\text{hardness})] + 0.0584\}) \times (0.997)$

Dissolved Silver, instantaneous maximum = $(e\{1.72 [\ln(\text{hardness})] - 6.52\}) \times (0.85)$

Dissolved Zinc, 1-hour average = $(e\{0.8473 [\ln(\text{hardness})] + 0.884\}) \times (0.978)$
Dissolved Zinc, 4-day average = $(e\{0.8473 [\ln(\text{hardness})] + 0.884\}) \times (0.986)$

11/28-29/2005 composite	programmed sampler to start 11/28/05 at 18:00 and collect 48, 375-ml samples at 30-minute intervals; sample collection ended on 11/29/05 at 17:30
12/1-2/2005 composite	programmed sampler to start 12/1/05 at 4:00 and collect 48, 375-ml samples at 30-minute intervals; sample collection was stopped on 12/2/05 at 12:30.
12/27-28/2005 composite	programmed sampler to start 12/27/05 at 13:00 and collect 54, 325-ml samples at 30 minute intervals; sample collection ended on 12/28/05 at 15:30
8/9/2006 grab	collected a grab sample on 8/9/2006 at 11:00

Table 6. Summary of water quality at San Francisquito and Los Trancos Creeks at Piers Lane, water year 2006.

Field observations [1]							*Nutrients* [2]				*Pesticides*		*Others* [3]	
Date and Time	Observer	Gage Height	Hydrograph	Discharge	Water Temperature	Specific conductance	**Ammonia-N**	**Nitrate-N**	**Nitrate + Nitrite-N**	**Phosphate-P**	**Chlorpyrifos**	**Diazinon**	**Total Suspended Solids**	**Hardness**
		(feet)	*(R,P,F, B,U)*	*(cfs)*	*(°C)*	*(µmhos/cm @ 25°C)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(ug/L)*	*(ug/L)*	*(mg/L)*	*(mg/L)*
Analytical detection limits: [5]						**11/28-29/2005**	0.2	0.1	0.1	0.02	0.05	0.05	…	1.0
						12/1-2/2005	0.2	…	0.1	0.02	0.05	0.05	0.5	1.0
						12/28-29/2005	0.2	0.1	0.1	0.02	0.05	0.05	0.5	1.0
						8/9/2006	0.2	0.2	…	0.02	...	...	...	1.0
San Francisquito Creek at Piers Lane														
11/28-29/2005	JG, ZR	**comp.**		**3.9**				1.4	1.3	0.58	ND	ND	…	361
11/29/2005 17:00	JG, ZR	3.62	F	3.0	10.6	862	ND							
12/1-2/2005	JG, ZR	**comp.**		**26.1**				…	0.87	1.35	ND	ND	150	239
12/1/2005 18:30	JO	5.08	P, F	93	13.6	…	ND							
12/28-29/2005	ZR, HE	**comp.**		**101**				0.95	0.94	0.95	ND	ND	82 (78)	152 (137)
12/28/2005 13:17	JO	6.03	F	320	13.5	310	ND							
8/9/2006 13:10	JO, ZR	3.38	B	0.5	19.6	1131	ND (ND)	2.5	…	0.12	...	...	...	502
All 8/9/2006 samples were grab samples														
Minimum over period of record							ND	0.38	0.38	0.12	ND	ND	2.2	101
Maximum over period of record							1.2	5.5	3.3	3.98	ND	ND	377	643
Los Trancos Creek at Piers Lane														
11/28-29/2005	JG, ZR	**comp.**		**1.0**				2.6 (2.6)	2.7	0.98	ND	ND	8	429
11/29/2005 16:35	JG, ZR	0.94	F	0.5	12.6	635	ND							
12/1-2/2005	JG, ZR	**comp.**		**4.3**				…	3.1	Sample bottle broke in transit to lab.				299
12/1/2005 18:15	JO	1.77	F	11.0	14.7	…	ND		Total P and TSS not analyzed due to limited sample volume.					
12/28-29/2005	ZR, HE	**comp.**		**9.7**				1.8	1.7	0.92	ND	ND	23	279
12/28/2005 12:45	JO	1.63	F	9.8	14.0	480	ND							
8/9/2006 12:00	JO, ZR	0.76	B	0.2	18.4	1410	ND (ND)	5.6	…	0.25	...	...	...	774
All 8/9/2006 samples were grab samples														
Minimum over period of record							ND	0.43	0.91	0.15	ND	ND	1.5	184
Maximum over period of record							0.79	5.7	5.2	7.05	ND	ND	527	830
SF Bay RWQCB (1995)--Aquatic acute toxicity: 1-hour average							---[6]	---[7]	---[7]	---[7]	---[8]	---[8]	---[9]	None
SF Bay RWQCB (1995)--Aquatic chronic toxicity: 4-day average							---[6]	---[7]	---[7]	---[7]	---[8]	---[8]	---[9]	None

Table 6. Summary of water quality at San Francisquito and Los Trancos Creeks at Piers Lane in Water Year 2006 (continued).

Field observations [1]		*Trace Metals* [4]															
Date and Time	Discharge	**Aluminum (total)**	**Aluminum (dissolved)**	**Copper (total)**	**Copper (dissolved)**	**Lead (total)**	**Lead (dissolved)**	**Mercury (total)**	**Mercury (dissolved)**	**Nickel (total)**	**Nickel (dissolved)**	**Selenium (total)**	**Selenium (dissolved)**	**Silver (total)**	**Silver (dissolved)**	**Zinc (total)**	**Zinc (dissolved)**
	(cfs)	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*
Analytical detection limits: [5]	**11/28-29/2005**	100	100	0.6	0.6	0.4	0.4	0.0005	0.0005	0.6	0.6	0.1	0.1	0.2	0.2	5.0	5.0
	12/1-2/2005	500	10	0.6	0.6	0.4	0.4	0.0005	0.0005	0.6	0.6	0.1	0.1	0.2	0.2	5.0	5.0
	12/28-29/2005	200, 500	10	0.6	0.6	0.4	0.4	0.0005	0.0005	0.6	0.6	0.1	0.1	0.2	0.2	5.0	5.0
	8/9/2006	...	...	...	0.6	...	0.4	...	...	...	0.6	...	0.1	...	0.2	...	5.0
San Francisquito Creek at Piers Lane																	
11/28-29/2005	**3.9**	670	70	8.7	4.0	1.7	ND			7.0	6.0	0.3	0.2	ND	ND	31	23
11/29/2005 17:00	3.0							0.0037	0.0015								
12/1-2/2005	**26.1**	4,300	15	47.0	9.4	9.0	0.6			15.0	5.0	0.3	0.2	ND	ND	71	31
12/1/2005 18:30	93							0.0400	0.0021								
12/28-29/2005	**101**	3,400	30	23 (20)	5.3 (5.1)	3.9 (3.9)	ND (ND)			14 (14)	4.4 (4.6)	0.3 (0.3)	0.2 (0.2)	ND (ND)	ND (ND)	32 (30)	30 (47)
12/28/2005 13:20	320							0.026	0.0046								
8/9/2006 13:10	0.5	...	...	...	1.6	...	ND	...	...	...	6.0	...	0.4	...	ND	...	ND
All 8/9/2006 samples were grab samples																	
Minimum over period of record		ND	ND	1.5	1.3	ND	ND	0.0009	ND	3.7	3.0	0.2	0.1	ND	ND	ND	ND
Maximum over period of record		12,000	190	74.0	17.0	17.0	1.10	0.13	0.042	38.0	9.0	1.3	0.4	ND	0.3	110	47
Los Trancos Creek at Piers Lane																	
11/28-29/2005	**1.00**	150	60	4.3	6.3 (6.2)	ND	0.4 (ND)			4.7	3.2 (3.1)	0.2	0.4 (0.2)	ND	ND (ND)	7	10 (6)
11/29/2005 16:35	0.5							0.0028	0.0015								
12/1-2/2005	**4.30**	2,600	14	14.0	8.4	5.0	0.4			10.0	4.5	0.2	0.2	ND	ND	31	31
12/1/2005 18:15	11.0							0.0710	0.0039								
12/28-29/2005	**9.7**	1,100	12	13.8	4.0	2.0	ND			8.0	4.3	0.2	0.1	ND	ND	54	11
12/28/2005 12:45	9.8							0.0260	0.0051								
8/9/2006 12:00	0.2	...	...	...	1.6	...	ND	...	...	...	5.0	...	0.1	...	ND	...	ND
All 8/9/2006 samples were grab samples																	
Minimum over period of record		ND	ND	ND	1.4	ND	ND	0.0010	ND	3.0	2.9	ND	ND	ND	ND	ND	ND
Maximum over period of record		33,000	110	82.0	10.9	30.0	1.2	0.27	0.0080	117	12.0	2.1	0.4	0.3	ND	180	50
SF Bay RWQCB (1995)--Aquatic acute toxicity: 1-hour average [10]		None		None	13.4 - 49.6	None	64.6 - 288	2.4	2.4	None	468 - 1,186	20	20	None	3.4 - 37.4	None	117 - 379
SF Bay RWQCB (1995)-- Aquatic chronic toxicity: 4-day average [10]		None		None	9.0 - 29.3	None	2.5 - 10.9	0.025	0.025	None	52 - 132	5	5	(instantaneous maximum; no acute or chronic toxicity level		None	118 - 382

Table 6. Summary of water quality at San Francisquito and Los Trancos Creeks at Piers Lane, water year 2006 (continued).

Notes: **ND = not detected** **ns = not sampled,** **na = not analyzed**

1) Observer Key: jo is Jonathan Owens; zr is Zan Rubin; he is Hillary Ewing, jg is John Gartner
Hydrograph: R=Rising; P=Peak; F=Falling; B=Baseflow; U=Uncertain **Bold** flow values indicate average flow during the period of composite sampling
All specific conductance and temperature measurements were made in the field.
Values reported in parentheses are replicate subsamples.

2) Ammonia and phosphate samples were preserved upon collection with sulfuric acid (H_2SO_4) to pH<2. Nitrate samples were iced but not preserved if analysis could occur within 48 hours; otherwise, nitrate samples were also preserved with sulfuric acid.

3) All total suspended sediment (TSS) analyses of *composite* samples were performed by the RWQCP lab (City of Palo Alto) with a detection limit of 0.5 mg/L.
Results of TSS *grab* samples, analyzed by Soil Control Lab (Watsonville, CA) with a detection limit of 5.0 mg/L, are presented elsewhere in this report.

4) Total recoverable metals samples were preserved (unfiltered) upon collection with nitric acid (HNO_3). Dissolved metals samples were filtered in the laboratory, then preserved with nitric acid.

5) Reporting Limits vary with analytical method, laboratory, quality control measures, and sample concentration, due to the dilution needed to bring the sample into analytical range.
Thus, the reporting limit may vary slightly among samples collected at different sites on the same day.
Aluminum, nitrate, organophosphate pesticide (diazinon, chlorpyrifos) and mercury analyses performed by Caltest (Napa).
Laboratory analyses for all other metals, ammonia, phosphate, hardness and suspended sediment (composite samples only) performed by the City of Palo Alto RWQCP.

6) Un-ionized ammonia concentrations chronically in excess of 0.025 mg/L (annual median value) can be toxic (RWQCB, 1995).
The fraction of total ammonia that is in the toxic, un-ionized form increases with increases in pH and temperature. Mean daily temperatures varied from about 6.5 to 24.1°C in San Francisquito Creel and from about 7.5 to 22.6°C in Los Trancos Creek during the water year 2006 monitoring period. pH measurements ranged from 7.3 to 8.5 in San Francisquito Creek and from 7.3 to 8.7 in Los Trancos Creek during water year 2006.
The proportion of total ammonia in the un-ionized form increases as a function of pH and temperature.

7) Biostimulatory constituents should not be present in amounts that stimulate excessive aquatic growth (RWQCB, 1995).

8) Waters should remain free of toxics at concentrations lethal to or adversely impacting aquatic organisms (RWQCB, 1995).

9) Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses (RWQCB, 1995).

10) The California Toxics Rule, adopted statewide by the Regional Boards in 2004, then approved by the U.S. EPA and incorporated into the Basin Plans establishes aquatic acute and chronic toxici objectives for dissolved concentrations of hardness-dependent trace metals. The range shown is for hardness of 100 to 400 mg/L as $CaCO_3$, because the CTR states that "For purposes o calculating freshwater aquatic life criteria for metals . . . [f]or waters with a hardness of over 400 mg/l as calcium carbonate, a hardness of 400 mg/l as calcium carbonate shall be used . .
The objectives are calculated based on the following equations

Dissolved Copper, 1-hour average = (e{0.9422 [ln(hardness)] - 1.700}) x (0.960)
Dissolved Copper, 4-day average = (e{0.8545 [ln(hardness)] - 1.702}) x (0.960)

Dissolved Lead, 1-hour average = (e{1.273[ln(hardness)] - 1.460}) x (1.46203 - {[ln(hardness)] x [0.145712]})
Dissolved Lead, 4-day average = (e{1.273[ln(hardness)] - 4.705}) x (1.46203 - {[ln(hardness)] x [0.145712]})

Dissolved Nickel, 1-hour average = (e{0.8460 [ln(hardness)] + 2.255 }) x (0.998)
Dissolved Nickel, 4-day average = (e{0.8460 [ln(hardness)] + 0.0584}) x (0.997)

Dissolved Silver, instantaneous maximum = (e{1.72 [ln(hardness)] - 6.52}) x (0.85)

Dissolved Zinc, 1-hour average = (e{0.8473 [ln(hardness)] + 0.884 }) x (0.978)
Dissolved Zinc, 4-day average = (e{0.8473 [ln(hardness)] + 0.884}) x (0.986)

San Francisquito Creek at Piers Lane

11/28-29/2005 composite	programmed sampler to start on 11/28/05 at 19:15 and collect 48, 375-ml samples at 30-minute intervals; sample collection was stopped 11/29/05 at 17:00
12/1-2/2005 composite	programmed sampler to start 12/1/05 at 5:00 and collect 48, 350-ml samples at 30-minute intervals; sample collection ended 12/2/05 at 4:30.
12/27-28/2005 composite	programmed sampler to start 12/27/05 at 14:00 and collect 54, 325-ml samples at 30 minute intervals; sample collection ended 12/28/05 at 16:30
8/9/2006 grab	collected a grab sample on 8/9/2006 at 13:30

Los Trancos Creek at Piers Lane

11/28-29/2005 composite	programmed sampler to start on 11/28/05 at 19:30 and collect 48, 350-ml samples at 30-minute intervals; sample collection was stopped 11/29/05 at 16:00
12/1-2/2005 composite	programmed sampler to start 12/1/05 at 5:00 and collect 48, 375-ml samples at 30-minute intervals; sample collection ended 12/2/05 at 4:30.
12/27-28/2005 composite	programmed sampler to start 12/27/05 at 14:00 and collect 54, 300-ml samples at 30 minute intervals; sample collection ended 12/28/05 at 16:30
8/9/2006 grab	collected a grab sample on 8/9/2006 at 12:30

Table 6. Summary of water quality at San Francisquito and Los Trancos Creeks at Piers Lane, water year 2006.

Field observations [1]							*Nutrients* [2]				*Pesticides*		*Others* [3]	
Date and Time	Observer	Gage Height	Hydrograph	Discharge	Water Temperature	Specific conductance	**Ammonia-N**	**Nitrate-N**	**Nitrate + Nitrite-N**	**Phosphate-P**	**Chlorpyrifos**	**Diazinon**	**Total Suspended Solids**	**Hardness**
		(feet)	*(R,P,F, B,U)*	*(cfs)*	*(°C)*	*(µmhos/cm @ 25°C)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(ug/L)*	*(ug/L)*	*(mg/L)*	*(mg/L)*
Analytical detection limits: [5]						**11/28-29/2005**	0.2	0.1	0.1	0.02	0.05	0.05	…	1.0
						12/1-2/2005	0.2	…	0.1	0.02	0.05	0.05	0.5	1.0
						12/28-29/2005	0.2	0.1	0.1	0.02	0.05	0.05	0.5	1.0
						8/9/2006	0.2	0.2	…	0.02	...	...	...	1.0
San Francisquito Creek at Piers Lane														
11/28-29/2005	JG, ZR	**comp.**		**3.9**				1.4	1.3	0.58	ND	ND	…	361
11/29/2005 17:00	JG, ZR	3.62	F	3.0	10.6	862	ND							
12/1-2/2005	JG, ZR	**comp.**		**26.1**				…	0.87	1.35	ND	ND	150	239
12/1/2005 18:30	JO	5.08	P, F	93	13.6	…	ND							
12/28-29/2005	ZR, HE	**comp.**		**101**				0.95	0.94	0.95	ND	ND	82 (78)	152 (137)
12/28/2005 13:17	JO	6.03	F	320	13.5	310	ND							
8/9/2006 13:10	JO, ZR	3.38	B	0.5	19.6	1131	ND (ND)	2.5	…	0.12	...	...	...	502
All 8/9/2006 samples were grab samples														
Minimum over period of record							ND	0.38	0.38	0.12	ND	ND	2.2	101
Maximum over period of record							1.2	5.5	3.3	3.98	ND	ND	377	643
Los Trancos Creek at Piers Lane														
11/28-29/2005	JG, ZR	**comp.**		**1.0**				2.6 (2.6)	2.7	0.98	ND	ND	8	429
11/29/2005 16:35	JG, ZR	0.94	F	0.5	12.6	635	ND							
12/1-2/2005	JG, ZR	**comp.**		**4.3**				…	3.1	Sample bottle broke in transit to lab.				299
12/1/2005 18:15	JO	1.77	F	11.0	14.7	…	ND		Total P and TSS not analyzed due to limited sample volume.					
12/28-29/2005	ZR, HE	**comp.**		**9.7**				1.8	1.7	0.92	ND	ND	23	279
12/28/2005 12:45	JO	1.63	F	9.8	14.0	480	ND							
8/9/2006 12:00	JO, ZR	0.76	B	0.2	18.4	1410	ND (ND)	5.6	…	0.25	...	...	...	774
All 8/9/2006 samples were grab samples														
Minimum over period of record							ND	0.43	0.91	0.15	ND	ND	1.5	184
Maximum over period of record							0.79	5.7	5.2	7.05	ND	ND	527	830
SF Bay RWQCB (1995)--Aquatic acute toxicity: 1-hour average							---[6]	---[7]	---[7]	---[7]	---[8]	---[8]	---[9]	None
SF Bay RWQCB (1995)--Aquatic chronic toxicity: 4-day average							---[6]	---[7]	---[7]	---[7]	---[8]	---[8]	---[9]	None

Table 6. Summary of water quality at San Francisquito and Los Trancos Creeks at Piers Lane in Water Year 2006 (continued).

Field observations [1]		*Trace Metals* [4]																	
Date and Time	Discharge	**Aluminum (total)**	**Aluminum (dissolved)**	**Copper (total)**	**Copper (dissolved)**	**Lead (total)**	**Lead (dissolved)**	**Mercury (total)**	**Mercury (dissolved)**	**Nickel (total)**	**Nickel (dissolved)**	**Selenium (total)**	**Selenium (dissolved)**	**Silver (total)**	**Silver (dissolved)**	**Zinc (total)**	**Zinc (dissolved)**
	(cfs)	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*	*(ug/L)*
Analytical detection limits: [5]	**11/28-29/2005**	100	100	0.6	0.6	0.4	0.4	0.0005	0.0005	0.6	0.6	0.1	0.1	0.2	0.2	5.0	5.0
	12/1-2/2005	500	10	0.6	0.6	0.4	0.4	0.0005	0.0005	0.6	0.6	0.1	0.1	0.2	0.2	5.0	5.0
	12/28-29/2005	200, 500	10	0.6	0.6	0.4	0.4	0.0005	0.0005	0.6	0.6	0.1	0.1	0.2	0.2	5.0	5.0
	8/9/2006	...	...	...	0.6	...	0.4	...	...	...	0.6	...	0.1	...	0.2	...	5.0
San Francisquito Creek at Piers Lane																	
11/28-29/2005	**3.9**	670	70	8.7	4.0	1.7	ND			7.0	6.0	0.3	0.2	ND	ND	31	23
11/29/2005 17:00	3.0							0.0037	0.0015								
12/1-2/2005	**26.1**	4,300	15	47.0	9.4	9.0	0.6			15.0	5.0	0.3	0.2	ND	ND	71	31
12/1/2005 18:30	93							0.0400	0.0021								
12/28-29/2005	**101**	3,400	30	23 (20)	5.3 (5.1)	3.9 (3.9)	ND (ND)			14 (14)	4.4 (4.6)	0.3 (0.3)	0.2 (0.2)	ND (ND)	ND (ND)	32 (30)	30 (47)
12/28/2005 13:20	320							0.026	0.0046								
8/9/2006 13:10	0.5	...	...	...	1.6	...	ND	...	...	...	6.0	...	0.4	...	ND	...	ND
All 8/9/2006 samples were grab samples																	
Minimum over period of record		ND	ND	1.5	1.3	ND	ND	0.0009	ND	3.7	3.0	0.2	0.1	ND	ND	ND	ND
Maximum over period of record		12,000	190	74.0	17.0	17.0	1.10	0.13	0.042	38.0	9.0	1.3	0.4	ND	0.3	110	47
Los Trancos Creek at Piers Lane																	
11/28-29/2005	**1.00**	150	60	4.3	6.3 (6.2)	ND	0.4 (ND)			4.7	3.2 (3.1)	0.2	0.4 (0.2)	ND	ND (ND)	7	10 (6)
11/29/2005 16:35	0.5							0.0028	0.0015								
12/1-2/2005	**4.30**	2,600	14	14.0	8.4	5.0	0.4			10.0	4.5	0.2	0.2	ND	ND	31	31
12/1/2005 18:15	11.0							0.0710	0.0039								
12/28-29/2005	**9.7**	1,100	12	13.8	4.0	2.0	ND			8.0	4.3	0.2	0.1	ND	ND	54	11
12/28/2005 12:45	9.8							0.0260	0.0051								
8/9/2006 12:00	0.2	...	...	...	1.6	...	ND	...	...	...	5.0	...	0.1	...	ND	...	ND
All 8/9/2006 samples were grab samples																	
Minimum over period of record		ND	ND	ND	1.4	ND	ND	0.0010	ND	3.0	2.9	ND	ND	ND	ND	ND	ND
Maximum over period of record		33,000	110	82.0	10.9	30.0	1.2	0.27	0.0080	117	12.0	2.1	0.4	0.3	ND	180	50
SF Bay RWQCB (1995)--Aquatic acute toxicity: 1-hour average [10]		None		None	13.4 - 49.6	None	64.6 - 288	2.4	2.4	None	468 - 1,186	20	20	None	3.4 - 37.4	None	117 - 379
SF Bay RWQCB (1995)-- Aquatic chronic toxicity: 4-day average [10]		None		None	9.0 - 29.3	None	2.5 - 10.9	0.025	0.025	None	52 - 132	5	5	(instantaneous maximum; no acute or chronic toxicity level		None	118 - 382

Table 6. Summary of water quality at San Francisquito and Los Trancos Creeks at Piers Lane, water year 2006 (continued).

Notes: **ND = not detected** **ns = not sampled,** **na = not analyzed**

1) Observer Key: jo is Jonathan Owens; zr is Zan Rubin; he is Hillary Ewing, jg is John Gartner
Hydrograph: R=Rising; P=Peak; F=Falling; B=Baseflow; U=Uncertain **Bold** flow values indicate average flow during the period of composite sampling
All specific conductance and temperature measurements were made in the field.
Values reported in parentheses are replicate subsamples.

2) Ammonia and phosphate samples were preserved upon collection with sulfuric acid (H_2SO_4) to pH<2. Nitrate samples were iced but not preserved if analysis could occur within 48 hours; otherwise, nitrate samples were also preserved with sulfuric acid.

3) All total suspended sediment (TSS) analyses of *composite* samples were performed by the RWQCP lab (City of Palo Alto) with a detection limit of 0.5 mg/L.
Results of TSS *grab* samples, analyzed by Soil Control Lab (Watsonville, CA) with a detection limit of 5.0 mg/L, are presented elsewhere in this report.

4) Total recoverable metals samples were preserved (unfiltered) upon collection with nitric acid (HNO_3). Dissolved metals samples were filtered in the laboratory, then preserved with nitric acid.

5) Reporting Limits vary with analytical method, laboratory, quality control measures, and sample concentration, due to the dilution needed to bring the sample into analytical range.
Thus, the reporting limit may vary slightly among samples collected at different sites on the same day.
Aluminum, nitrate, organophosphate pesticide (diazinon, chlorpyrifos) and mercury analyses performed by Caltest (Napa).
Laboratory analyses for all other metals, ammonia, phosphate, hardness and suspended sediment (composite samples only) performed by the City of Palo Alto RWQCP.

6) Un-ionized ammonia concentrations chronically in excess of 0.025 mg/L (annual median value) can be toxic (RWQCB, 1995).
The fraction of total ammonia that is in the toxic, un-ionized form increases with increases in pH and temperature. Mean daily temperatures varied from about 6.5 to 24.1°C in San Francisquito Creel and from about 7.5 to 22.6°C in Los Trancos Creek during the water year 2006 monitoring period. pH measurements ranged from 7.3 to 8.5 in San Francisquito Creek and from 7.3 to 8.7 in Los Trancos Creek during water year 2006.
The proportion of total ammonia in the un-ionized form increases as a function of pH and temperature.

7) Biostimulatory constituents should not be present in amounts that stimulate excessive aquatic growth (RWQCB, 1995).

8) Waters should remain free of toxics at concentrations lethal to or adversely impacting aquatic organisms (RWQCB, 1995).

9) Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses (RWQCB, 1995).

10) The California Toxics Rule, adopted statewide by the Regional Boards in 2004, then approved by the U.S. EPA and incorporated into the Basin Plans establishes aquatic acute and chronic toxici objectives for dissolved concentrations of hardness-dependent trace metals. The range shown is for hardness of 100 to 400 mg/L as $CaCO_3$, because the CTR states that "For purposes o calculating freshwater aquatic life criteria for metals . . . [f]or waters with a hardness of over 400 mg/l as calcium carbonate, a hardness of 400 mg/l as calcium carbonate shall be used . .
The objectives are calculated based on the following equations

Dissolved Copper, 1-hour average = (e{0.9422 [ln(hardness)] - 1.700}) x (0.960)
Dissolved Copper, 4-day average = (e{0.8545 [ln(hardness)] - 1.702}) x (0.960)

Dissolved Lead, 1-hour average = (e{1.273[ln(hardness)] - 1.460}) x (1.46203 - {[ln(hardness)] x [0.145712]})
Dissolved Lead, 4-day average = (e{1.273[ln(hardness)] - 4.705}) x (1.46203 - {[ln(hardness)] x [0.145712]})

Dissolved Nickel, 1-hour average = (e{0.8460 [ln(hardness)] + 2.255 }) x (0.998)
Dissolved Nickel, 4-day average = (e{0.8460 [ln(hardness)] + 0.0584}) x (0.997)

Dissolved Silver, instantaneous maximum = (e{1.72 [ln(hardness)] - 6.52}) x (0.85)

Dissolved Zinc, 1-hour average = (e{0.8473 [ln(hardness)] + 0.884 }) x (0.978)
Dissolved Zinc, 4-day average = (e{0.8473 [ln(hardness)] + 0.884}) x (0.986)

San Francisquito Creek at Piers Lane

11/28-29/2005 composite	programmed sampler to start on 11/28/05 at 19:15 and collect 48, 375-ml samples at 30-minute intervals; sample collection was stopped 11/29/05 at 17:00
12/1-2/2005 composite	programmed sampler to start 12/1/05 at 5:00 and collect 48, 350-ml samples at 30-minute intervals; sample collection ended 12/2/05 at 4:30.
12/27-28/2005 composite	programmed sampler to start 12/27/05 at 14:00 and collect 54, 325-ml samples at 30 minute intervals; sample collection ended 12/28/05 at 16:30
8/9/2006 grab	collected a grab sample on 8/9/2006 at 13:30

Los Trancos Creek at Piers Lane

11/28-29/2005 composite	programmed sampler to start on 11/28/05 at 19:30 and collect 48, 350-ml samples at 30-minute intervals; sample collection was stopped 11/29/05 at 16:00
12/1-2/2005 composite	programmed sampler to start 12/1/05 at 5:00 and collect 48, 375-ml samples at 30-minute intervals; sample collection ended 12/2/05 at 4:30.
12/27-28/2005 composite	programmed sampler to start 12/27/05 at 14:00 and collect 54, 300-ml samples at 30 minute intervals; sample collection ended 12/28/05 at 16:30
8/9/2006 grab	collected a grab sample on 8/9/2006 at 12:30

Table 7. Water quality objectives for dissolved trace metals concentrations at hardness levels typically observed in the San Francisquito Creek watershed.

Trace Metal	Water Quality Objectives [1]	Ambient Total Hardness Levels [2]			
		100	200	300	400
		(mg/L as $CaCO_3$)			
Copper	CMC (1-hour average)	13.4	25.8	37.8	49.6
Copper	CCC (4-day average)	9.0	16.2	22.9	29.3
Lead	CMC (1-hour average)	64.6	136.1	208.6	280.8
Lead	CCC (4-day average)	2.5	5.3	8.1	10.9
Nickel	CMC (1-hour average)	468	842	1186	1513
Nickel	CCC (4-day average)	52	94	132	168
Silver	Instantaneous Maximum	3.4	11.4	22.8	37.4
Zinc	CMC (1-hour average)	117	211	297	379
Zinc	CCC (4-day average)	118	213	300	382

Notes:

1. The California Toxics Rule (CTR), which includes water quality objectives for hardness-dependent trace metals, was adopted by the Regional Water Quality Control Board, Region 2 (San Francisco Bay), then approved by the State Water Resources Control Board on July 22, 2004 and by the California Office of Administrative Law on October 4, 2004. The criteria maximum concentration (CMC) is equivalent to the prior aquatic "acute" toxicity objective, while the criteria continuous concentration (CCC) is equivalent to the prior aquatic "chronic" toxicity objective.

2. Since calcium and magnesium are the primary components of hardness, the convention is to express total hardness in terms of an equivalent concentration of calcium carbonate ($CaCO_3$). The range shown is for hardness of 100 to 400 mg/L as CaCO3. The CTR states that "For purposes of calculating freshwater aquatic life criteria for metals . . . [f]or waters with a hardness of over 400 mg/l as calcium carbonate,

Table 8. Measurements and calculations of sediment transport, Bear Creek at Sand Hill Road, water year 2006

	Field Observations [1]					*Bedload Sampling Details*						*Sediment Transport*				
Sample Date:Time	**Observer(s)**	**Stage**	**Stream Condition**	**Streamflow Discharge**	**Streamflow Value Source**	**Active Bed Width**	**Sampler Width**	**No. of Verts.**	**Time/Vert.**	**Total Time**	**Sample Dry Weight**	**Bedload Discharge**	**Bedload Discharge**	**Suspended Sediment Concentration**	**Suspended Sediment Discharge**	**Turbidity**
		(ft)	*R,F,B,U*	*(cfs)*	*M,R,E*	*(ft)*	*(ft)*		*(sec)*	*(sec)*	*(gm)*	*(lb/sec)*	*(tons/day)*	*(mg/l)*	*(tons/day)*	*(ntu)*
Bear Creek at Sand Hill Road																
11/28-29/2005 comp.	zr, jg	comp.	R,F	**3.89**	R	...	...	...	...	...	...	...	...	**20**	**0.21**	...
11/29/05 20:25	zr, jg	1.115	F	2.05	R	...	...	...	...	...	...	...	...	1.2	0.01	1.2
12/1-2/2005 comp.	zr, nn	comp.	R,F	**16.3**	R	...	...	...	...	...	...	...	...	**390**	**17**	...
12/1/05 17:30	jo	2.38	F	58.3	R	...	...	...	...	...	...	...	...	500	79	410
12/2/05 12:10	zr, nn	1.2	F	1.24	R	...	...	...	...	...	...	...	...	52	0.17	61
12/21/05 17:10	zr, cn	1.98	R	32.3	M	...	...	...	...	...	...	...	...	38	3.3	67
12/22/05 12:10	jo	2.32	F	53.2	R	...	...	...	...	...	...	...	...	7.3	1.0	24
12/22/05 12:20	jo	2.31	F	53.2	R	15.0	0.25	7	60	420	14.2	0.004	0.19	...	...	...
12/28-29/2005 comp.	zr, he	comp.	R	**56.2**	R	...	...	...	...	...	...	...	...	**50**	**7.6**	...
12/28/05 9:50	jo	3.35	R	155	R	too deep and fast to safely collect bedload samples							...	250	104	178
12/28/05 10:15	jo	3.60	R	184	R	too deep and fast to safely collect bedload samples							...	319	158	211
1/2/06 8:18	jg, ds	4.13	R	222	R	...	...	...	...	...	...	...	...	674	404	220
1/2/06 8:25	jg, ds	4.30	R	246	R	17.0	0.25	1	15	15	1831.4	18.307	768	...	...	...
1/2/06 8:48	jg, ds	4.45	R	262	M	...	...	...	...	...	...	...	...	644	455	290
1/11/06 9:25	jg, bkh	1.93	B	12.3	M	...	...	...	...	...	...	...	...	13.5	0.45	8
2/27/06 15:05	jo	1.96	R	9.44	R	...	...	...	...	...	...	...	...	16.5	0.42	36
3/17/06 10:00	zr, tb	2.96	F	65.6	M	...	...	...	...	...	...	...	...	35.8	6.3	64
3/28/06 13:35	jo, zr	2.99	U	73.1	R	5	0.25	4	60	240	548	0.101	4.2	90.9	18	85
4/6/06 10:15	jo	2.72	F	52.3	R	...	...	...	...	...	...	...	...	20.9	2.95	27

Notes and explanations

1) Observer Key: jo = Jonathan Owens; bkh = Brian Hastings; jg = John Gartner; zr = Zan Rubin; nn = Nathan Neufeld; cn = Christian Nilsen; ds = Dave Shaw; tb = Travis Baggett; he = Hillary Ewing
   Stream Condition: R = rising, F = falling, B = baseflow, U = uncertain
   Streamflow discharge is the measured or estimated instantaneous flow at the time that sediment was sampled. The value is usually taken from the datalogger record and typically differs from the mean flow for the day. **Bold** flow values indicate average flow during the period of composite sampling.
   Streamflow Value Source: M = measured; R = rating curve; E = estimated; Streamflow for composite samples is mean flow for the sampling period.
2) Active Bed Width is estimated by the field observer as the width through which significant amounts of bedload are being transported.
   Sampler Width and Type: 0.25 = 3-inch Helley Smith; 0.50 = 6-inch Helley Smith
3) Values for sediment discharge showing more than two to three digits are the result of calculations; increased precision is not implied.
   Bedload Discharge (lbs/sec) = [active bed width (ft) * sample dry weight (gm) * 0.002205 (lbs)]/ [sampler width (ft) * sampling time (sec)]
   Bedload Discharge (tons/day) = [active bed width (ft) * sample dry weight (gm) * 86,400 (sec)]/ [sampler width (ft) * sampling time (sec) * 907,200 (gm)]
   The detection limit for suspended sediment is 5 mg/L ; values shown as <5 indicate that the sample was below the detection limit.
   If the creek is visibly clear, then suspended sediment samples are not collected because concentrations would likely be below the detection limit.

Table 9. Measurements and calculation of sediment transport, San Francisquito and Los Trancos Creeks at Piers Lane, water year 2006

Field observations					Bedload Sampling Details						Bedload Discharge		Suspended sediment		
Date and Time	Observer	Stage	Stream Condition	Discharge	Active Bed Width	Sampler Width	No. of Verts.	Time/Vert.	Total Time	Sample Dry Weight	Bedload-Sediment Discharge Rate	Bedload-Sediment Discharge Rate	Total Suspended Solids	Suspended Sediment discharge	Turbidity
		(feet)	*(R, F, B)*	*(cfs)*	*(ft)*	*(ft)*		*(sec)*	*(sec)*	*(gm)*	*(lb/sec)*	*(tons/day)*	*(mg/L)*	*(tons/day)*	*(NTU)*
San Francisquito Creek at Piers Lane															
11/29/2005 16:40	jg, zr	3.63	B	3	…	…	…	…	…	…	…	…	18	0.1	15
12/1/2005 18:30	jo	5.12	F	92	…	…	…	…	…	…	…	…	260	65	170
12/22/2005 16:50	jo	6.97	R	590	…	…	…	…	…	…	…	…	880	1401	360
12/22/2005 17:00	jo	7.02	R	670	…	…	…	…	…	…	…	…	990	1789	380
12/28/2005 13:05	jo	6.06	F	280	…	…	…	…	…	…	…	…	198	149	188
1/2/2006 19:00	jg, ds	7.48	P, F	1050	56.2	0.25	10	…	525.2	631.6	0.596	25.02	1455	4121	1500
1/11/2006 16:30	bkh, jg	4.32	B	25	…	…	…	…	…	…	…	…	20	1.4	13
3/22/2006 15:43	zr, cn	5.09	F	80	…	…	…	…	…	…	…	…	23	5.0	24
4/4/2006 17:00	jg, zr	6.33	F	360	…	…	…	…	…	…	…	…	244	237	220

Notes and explanations

1) Observer Key: jo = Jonathan Owens; bkh = Brian Hastings; jg = John Gartner; zr = Zan Rubin; cn = Christian Nilsen; ds = Dave Shaw
Stream Condition: R = rising, F = falling, B = baseflow, U = uncertain
Streamflow discharge is the measured or estimated instantaneous flow at the time that sediment was sampled. The value is usually taken from the datalogger record and typically differs from the mean flow for the day. **Bold** flow values indicate average flow during the period of composite sampling.
Streamflow Value Source: M = measured; R = rating curve; E = estimated; Streamflow for composite samples is mean flow for the sampling period.
2) Active Bed Width is estimated by the field observer as the width through which significant amounts of bedload are being transported.
Sampler Width and Type: 0.25 = 3-inch Helley Smith; 0.50 = 6-inch Helley Smith
3) Values for sediment discharge showing more than two to three digits are the result of calculations; increased precision is not implied.
Bedload Discharge (lbs/sec) = [active bed width (ft) * sample dry weight (gm) * 0.002205 (lbs)]/ [sampler width (ft) * sampling time (sec)]
Bedload Discharge (tons/day) = [active bed width (ft) * sample dry weight (gm) * 86,400 (sec)]/ [sampler width (ft) * sampling time (sec) * 907,200 (gm)]
The detection limit for suspended sediment is 5 mg/L ; values shown as <5 indicate that the sample was below the detection limit. .
If the creek is visibly clear, then suspended sediment samples are not collected because concentrations would likely be below the detection limit.

Table 9. Measurements and calculation of sediment transport,
San Francisquito and Los Trancos Creeks at Piers Lane, water year 2006 (cont.)

	Field observations				*Bedload Sampling Details*						*Bedload Discharge*		*Suspended sediment*		
Date and Time	Observer	Stage	Stream Condition	Discharge	Active Bed Width	Sampler Width	No. of Verts.	Time/Vert.	Total Time	Sample Dry Weight	Bedload-Sediment Discharge Rate	Bedload-Sediment Discharge Rate	Total Suspended Solids	Suspended Sediment discharge	Turbidity
		(feet)	*(R, F, B)*	*(cfs)*	*(ft)*	*(ft)*		*(sec)*	*(sec)*	*(gm)*	*(lb/sec)*	*(tons/day)*	*(mg/L)*	*(tons/day)*	*(NTU)*
Los Trancos Creek at Piers Lane															
11/29/2005 16:05	jg, zr	0.96	B	0.5	…	…	…	…	…	…	…	…	4.6	0.01	6
12/1/2005 18:15	jo	1.68	F	11.3	…	…	…	…	…	…	…	…	220	6.71	200
12/22/2005 16:40	jo	2.7	F	68	…	…	…	…	…	…	…	…	1300	238	500
12/22/2005 17:03	jo	2.65	F	66.0	…	…	…	…	…	…	…	…	930	166	520
12/28/2005 12:45	jo	1.63	F	11.5	6	0.25	3	70	210	31.8	0.008	0.34	112	3.5	93
1/2/2006 16:00	jg, ds	7.94	P	231	…	…	…	…	…	…	…	…	3570	2225	1800
3/22/2006 14:45	zr, cn	1.77	F	16.3	…	…	…	…	…	…	…	…	29	1.3	25
4/4/2006 15:58	jg, zr	3.04	P, F	93.0	…	…	…	…	…	…	…	…	515	129.2	400
4/4/2006 16:12	jg, zr	2.89	F	85.0	7.3	0.25	3	45	135	1346	0.642	26.95	…	…	…
4/4/2006 16:30	jg, zr	2.87	F	83.0	6.5	0.25	3	45	135	1503	0.638	26.79	…	…	…
4/4/2006 17:00	jg, zr	2.78	F	79.0	…	…	…	…	…	…	…	…	403	85.9	380

Notes and explanations

1) Observer Key: jo = Jonathan Owens; bkh = Brian Hastings; jg = John Gartner; zr = Zan Rubin; cn = Christian Nilsen; ds = Dave Shaw
   Stream Condition: R = rising, F = falling, B = baseflow, U = uncertain
   Streamflow discharge is the measured or estimated instantaneous flow at the time that sediment was sampled. The value is usually taken from the datalogger record and typically differs from the mean flow for the day. **Bold** flow values indicate average flow during the period of composite sampling.
   Streamflow Value Source: M = measured; R = rating curve; E = estimated; Streamflow for composite samples is mean flow for the sampling period.
2) Active Bed Width is estimated by the field observer as the width through which significant amounts of bedload are being transported.
   Sampler Width and Type: 0.25 = 3-inch Helley Smith; 0.50 = 6-inch Helley Smith
3) Values for sediment discharge showing more than two to three digits are the result of calculations; increased precision is not implied.
   Bedload Discharge (lbs/sec) = [active bed width (ft) * sample dry weight (gm) * 0.002205 (lbs)]/ [sampler width (ft) * sampling time (sec)]
   Bedload Discharge (tons/day) = [active bed width (ft) * sample dry weight (gm) * 86,400 (sec)]/ [sampler width (ft) * sampling time (sec) * 907,200 (gm)]
   The detection limit for suspended sediment is 5 mg/L ; values shown as <5 indicate that the sample was below the detection limit.
   If the creek is visibly clear, then suspended sediment samples are not collected because concentrations would likely be below the detection limit.

FIGURES

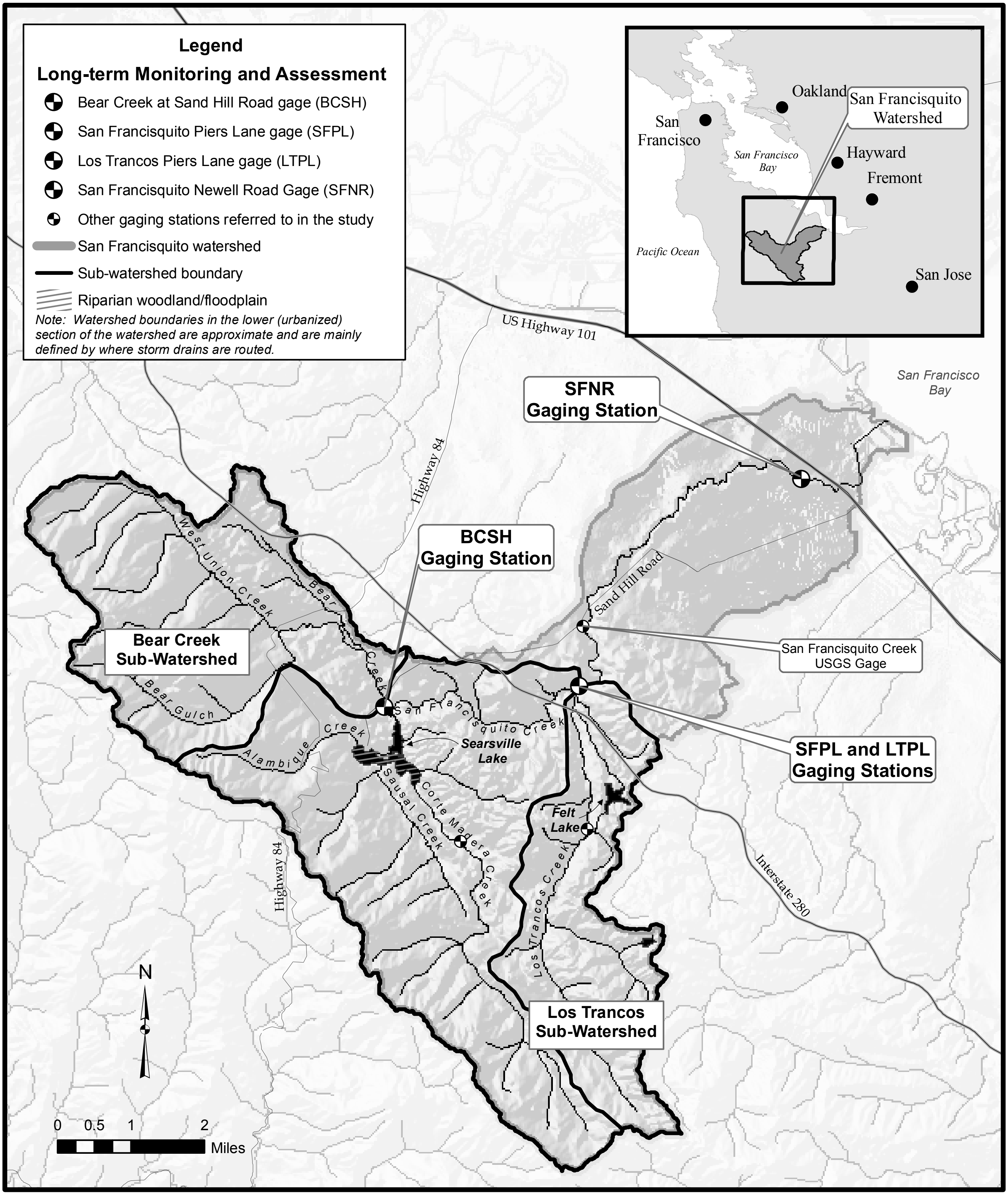

Figure 1. Stream monitoring location in the San Francisquito watershed
The Piers Lane stations are located just above the confluence of San Francisquito and Los Trancos Creeks. The Bear Creek station is located downstream of Sand Hill Road.

Balance Hydrologics, Inc.

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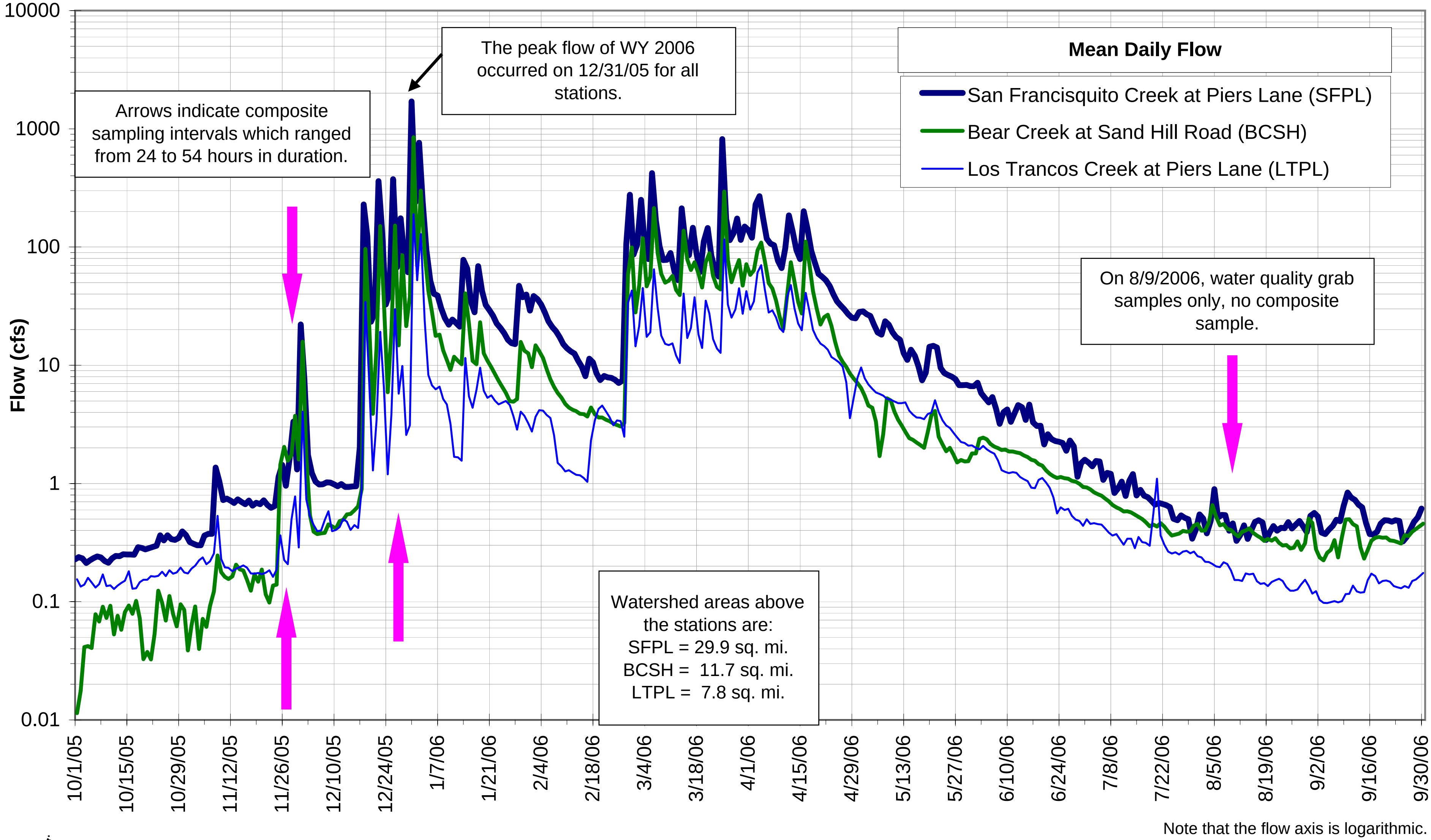

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Figure 2. Daily flow hydrographs for San Francisquito, Los Trancos and Bear Creeks, water year 2006. Flow in San Francisquito Creek is generally greater than flow in Bear Creek or Los Trancos Creek, as one would expect from its larger drainage area. The sampling dates were chosen to measure water quality during the first flush, winter storms, and summer baseflow. A springtime sampling was envisioned but the rainfall pattern was not conducive.

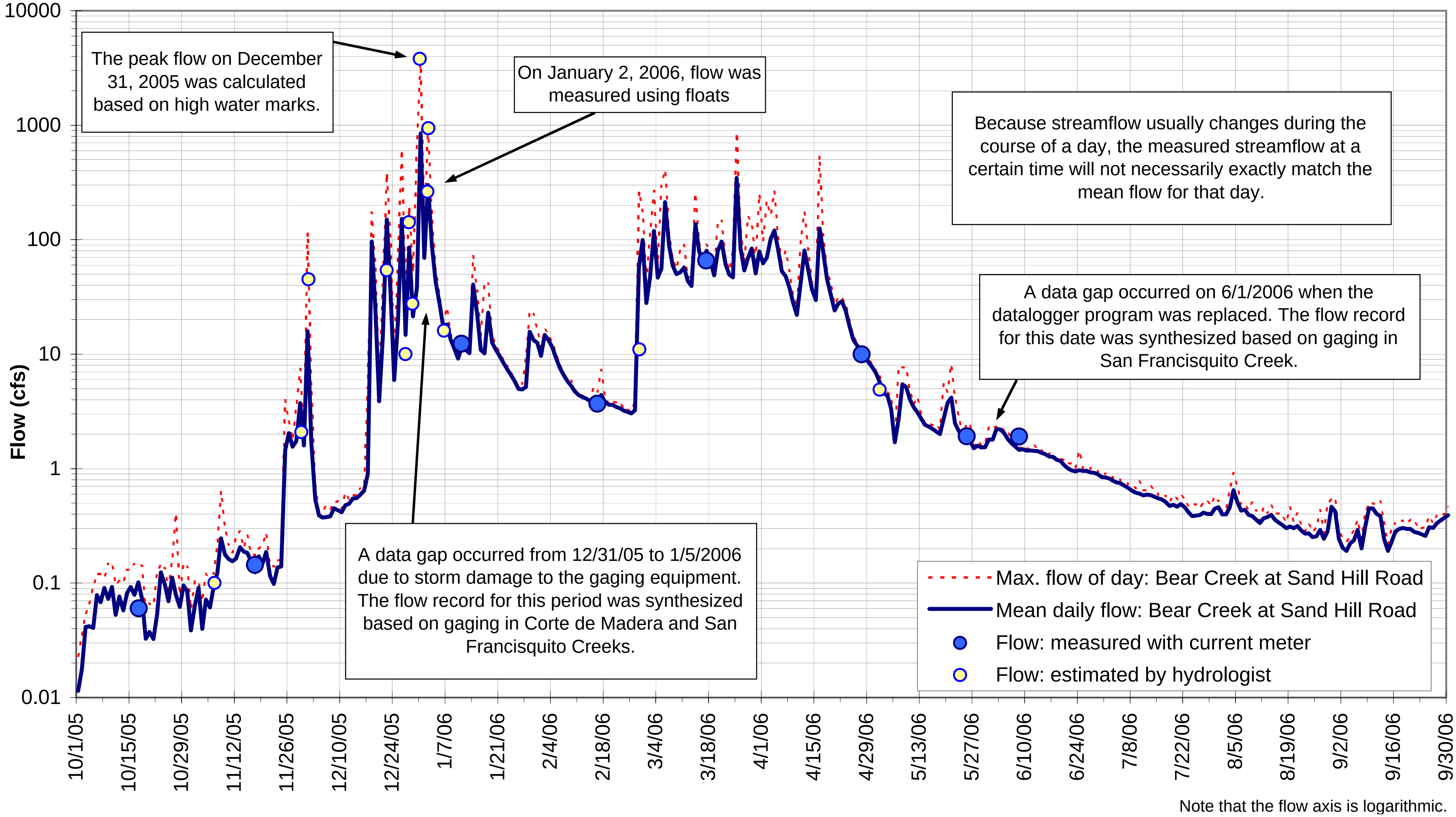

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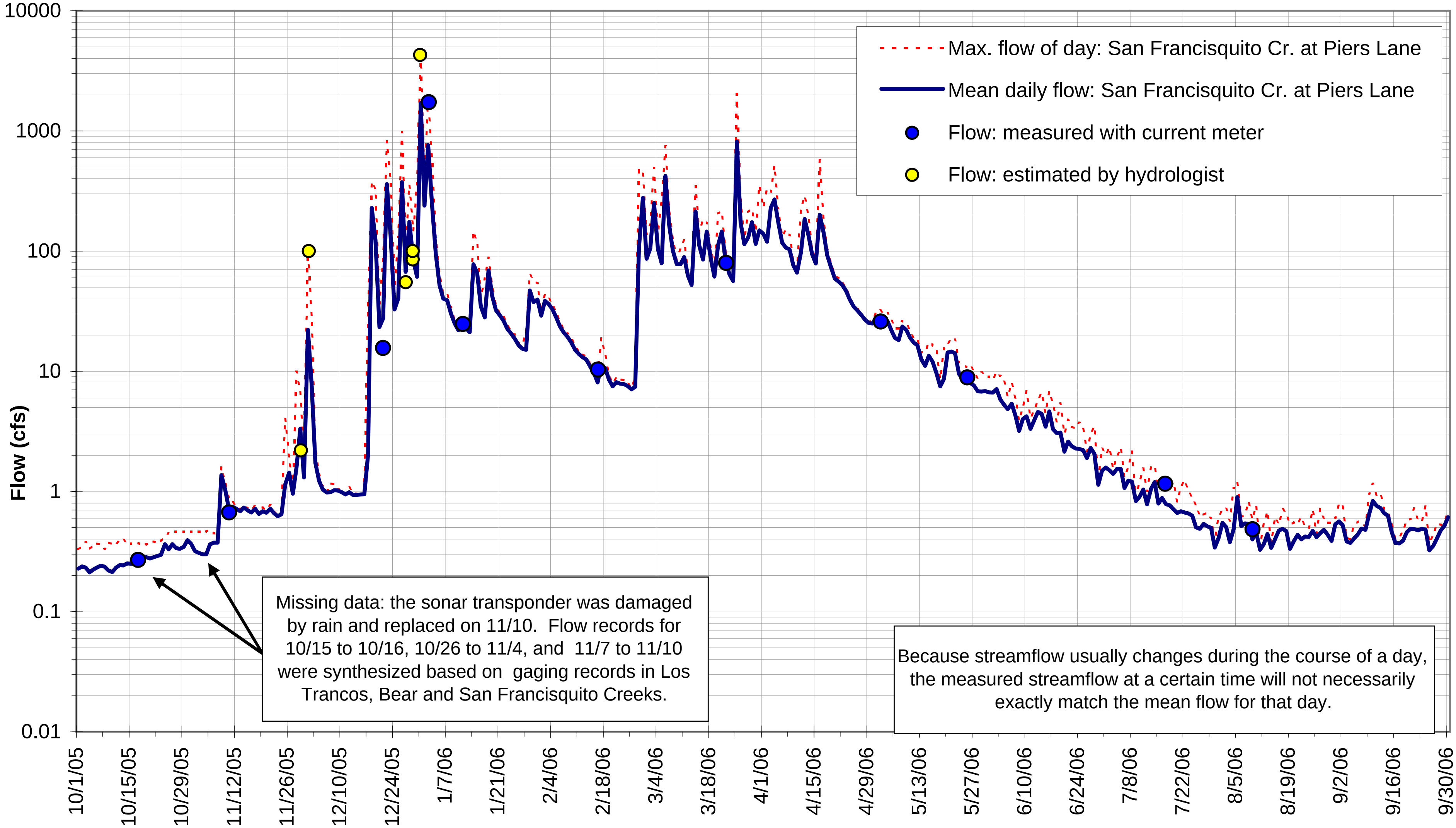
Figure 3. Daily flow hydrograph for Bear Creek at Sand Hill Road, water year 2006. Some flow regulation occurs upstream of this station. The peak flow was approximately 3,800 cfs on December 31, 2005 at about 7:00 AM. A flow of 0.01 cfs approaches our detection limit; flow below that level can be considered almost zero.



Note that the flow axis is logarithmic.

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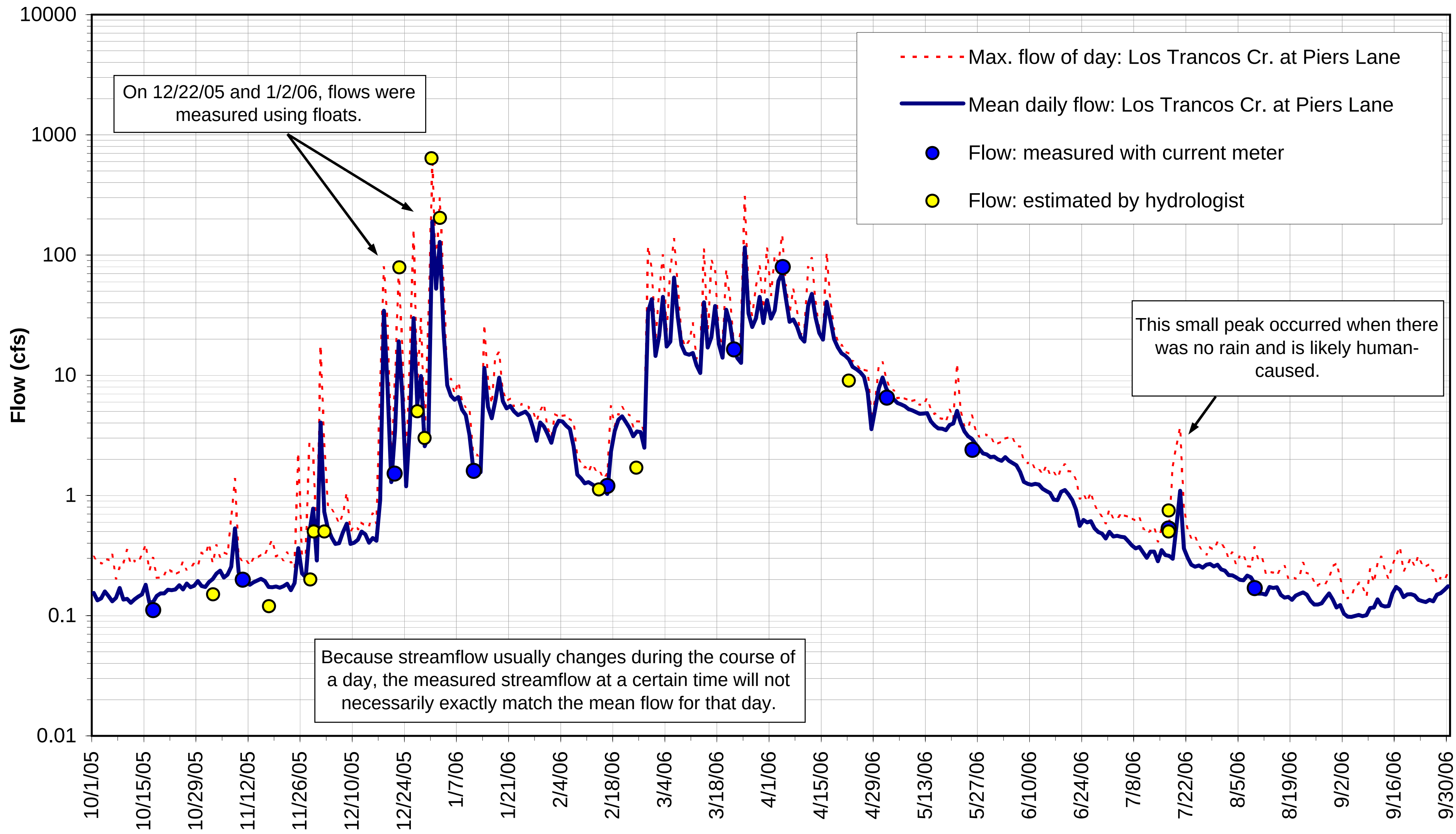
Figure 4. Daily flow hydrograph for San Francisquito Creek at Piers Lane, water year 2006. The peak flow was approximately 4,300 cfs on December 31, 2005 at 8:15 am.



Note that the flow axis is logarithmic.

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Figure 5. Daily flow hydrograph for Los Trancos Creek at Piers Lane, water year 2006. The peak flow was approximately 640 cfs on December 31, 2005 at 8:15 AM.

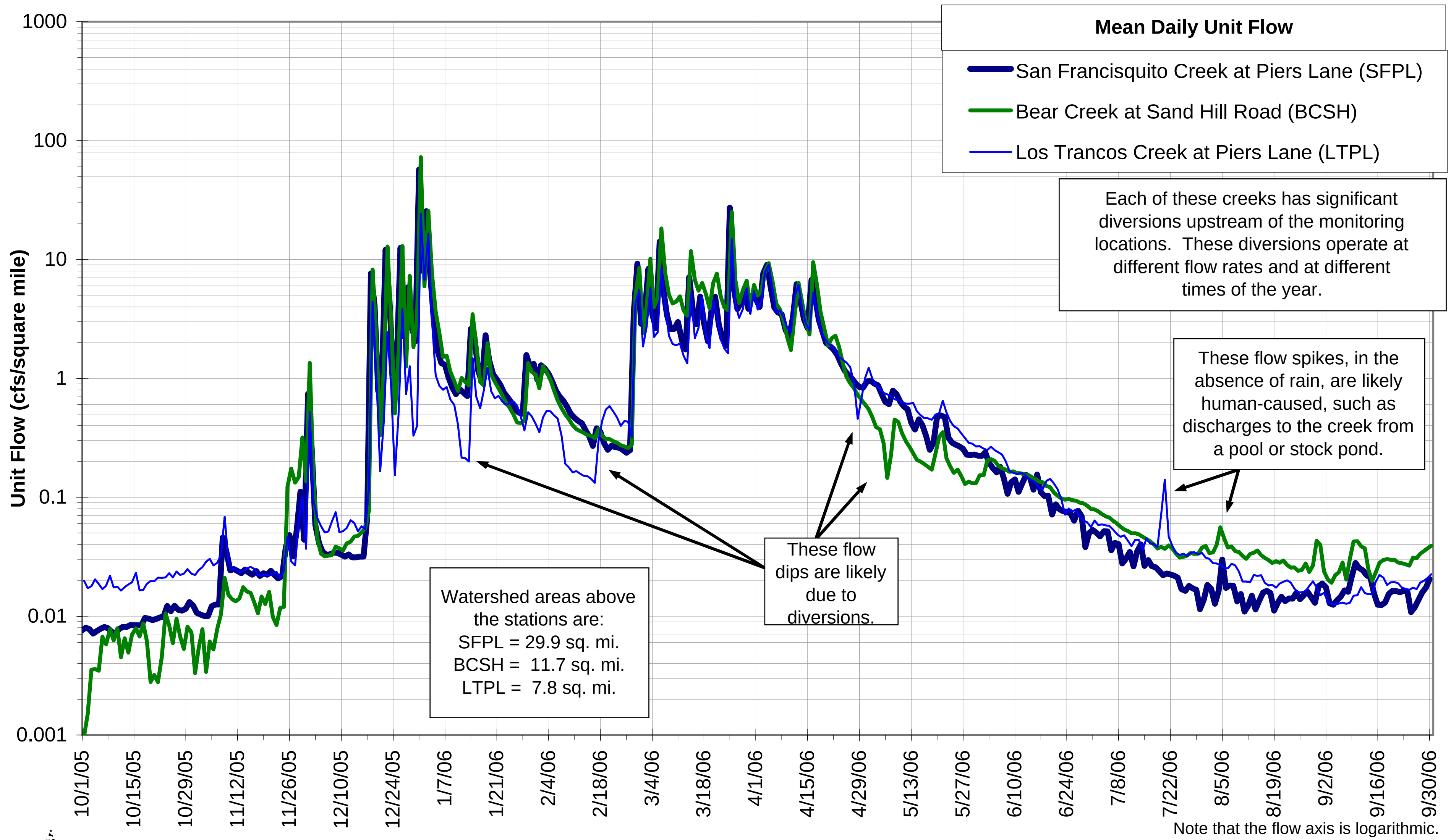

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Figure 6. Unit flow hydrographs for San Francisquito, Los Trancos and Bear Creeks, water year 2006. Unit flow is calculated by normalizing flow by watershed area. On a unit-flow basis, wet-season baseflow is lowest in Los Trancos Creek. In most cases, this lower flow is probably due to diversions but can also be influenced by geology, topography and weather patterns.

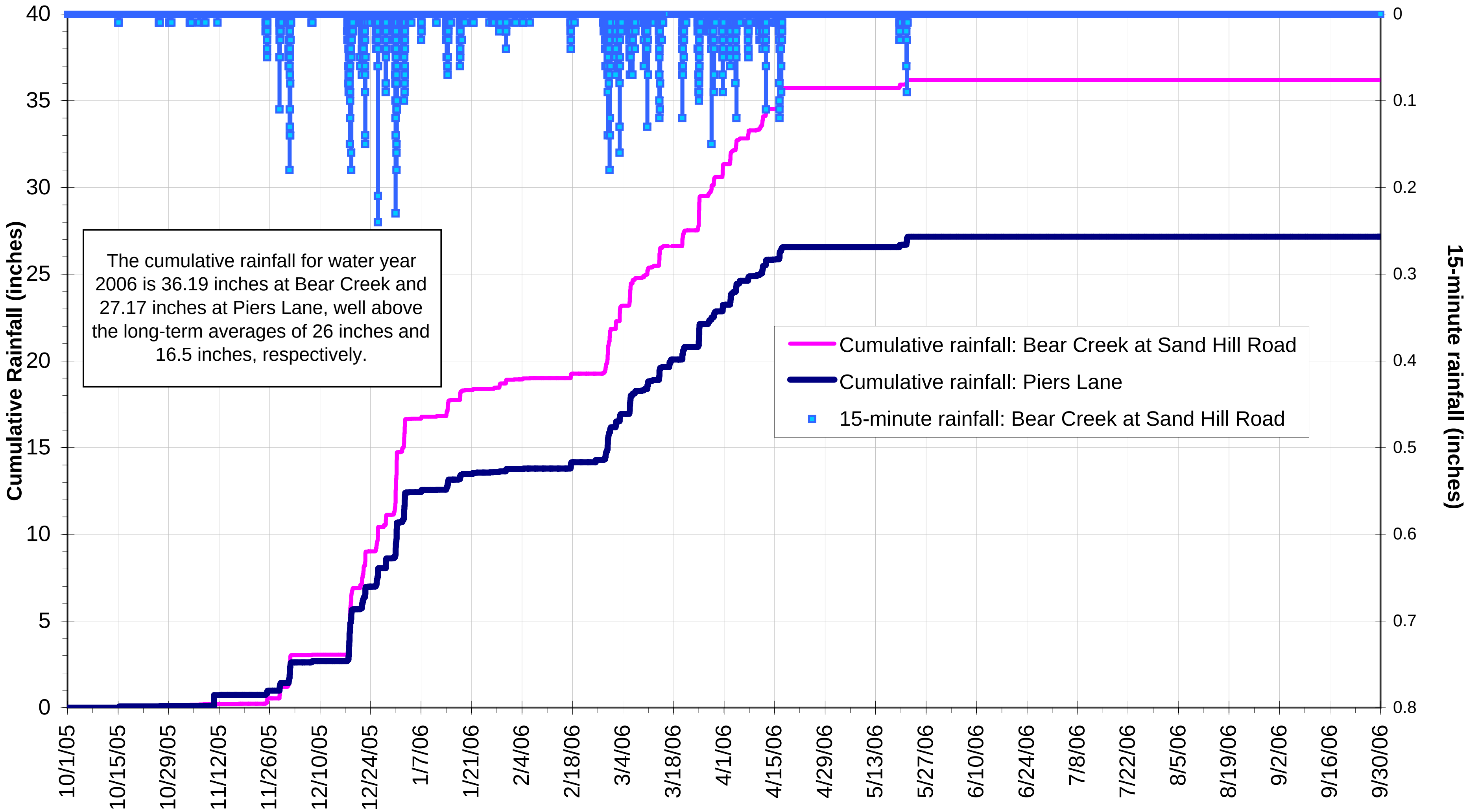

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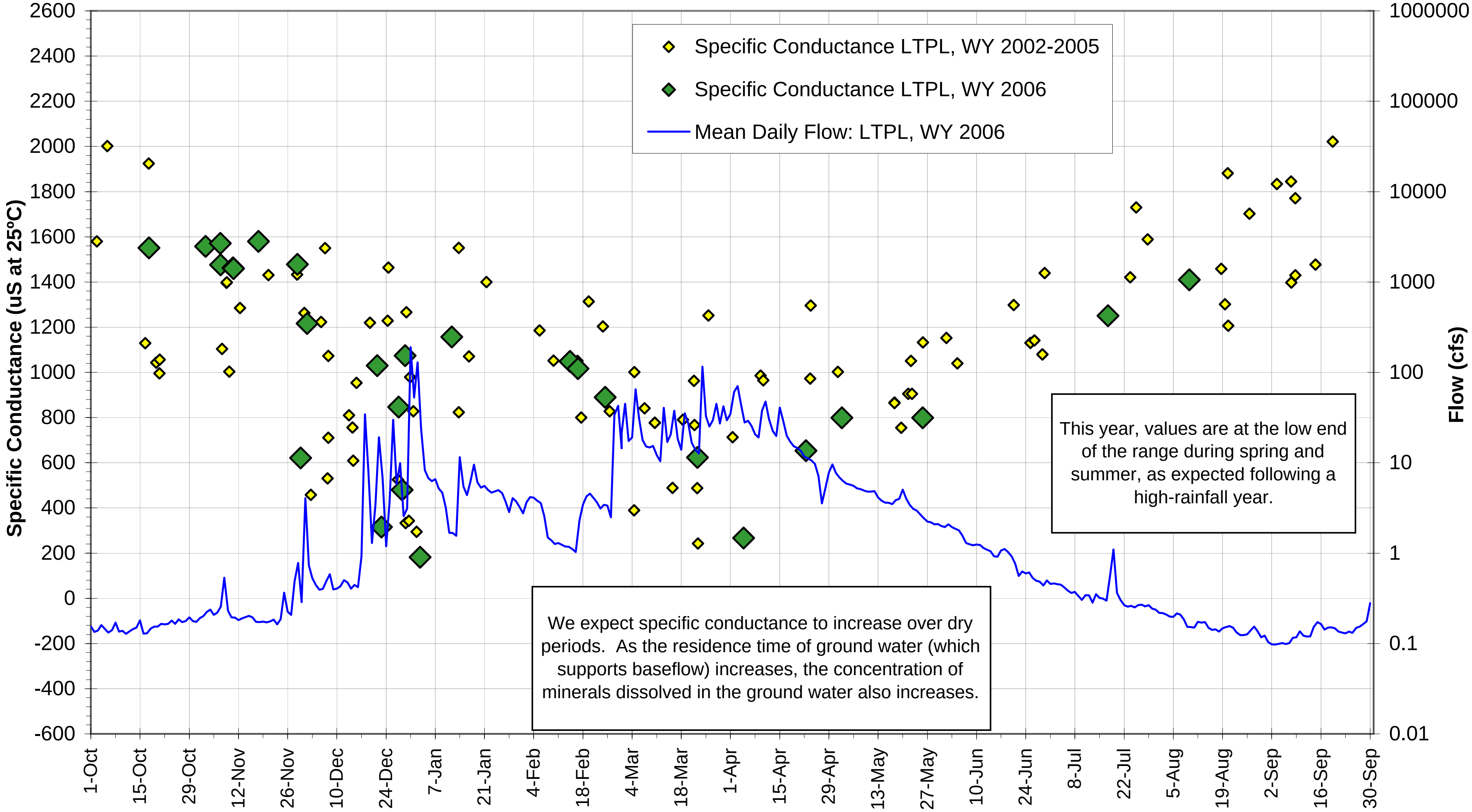
Figure 7. Cumulative 15-minute precipitation record at Bear Creek at Sand Hill Road, and San Francisquito Creek at Piers Lane, water year 2006. Total rainfall this water year is about 40 percent above average. The different totals between the two stations illustrate the rainfall gradient within the watershed (linked to distance from the hills).



Note: 1) the flow axis is logarithmic, and 2) the date axis does not include the year because multiple years of data are shown.

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Figure 8. Specific conductance measurements, Los Trancos Creek at Piers Lane, water years 2002 to 2006. Specific conductance measurements during water year 2006 are higher in Los Trancos Creek than in San Francisquito Creek or Bear Creek. This difference between creeks may be due to geologic influences or human causes. The flow record is plotted for reference.

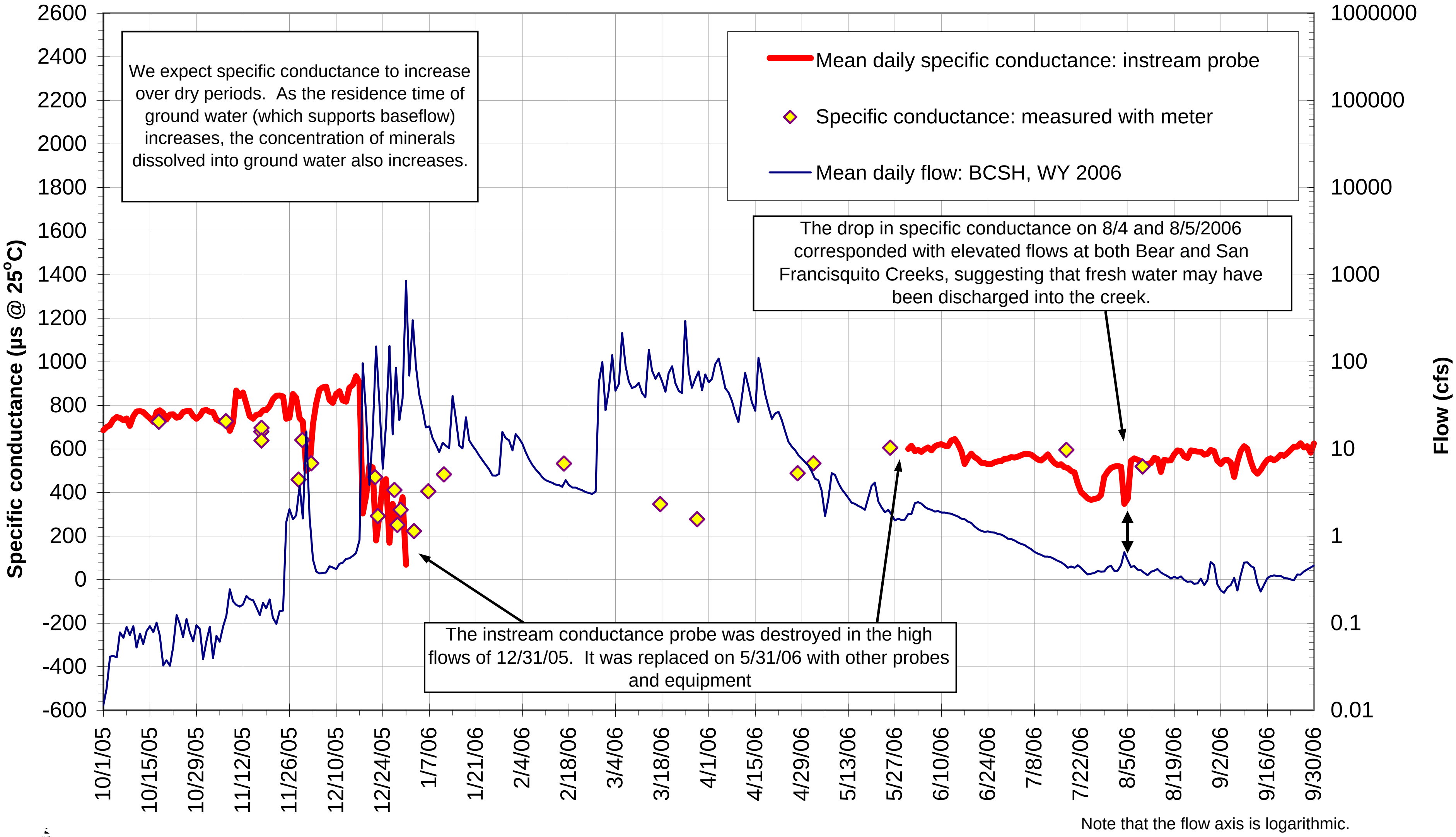

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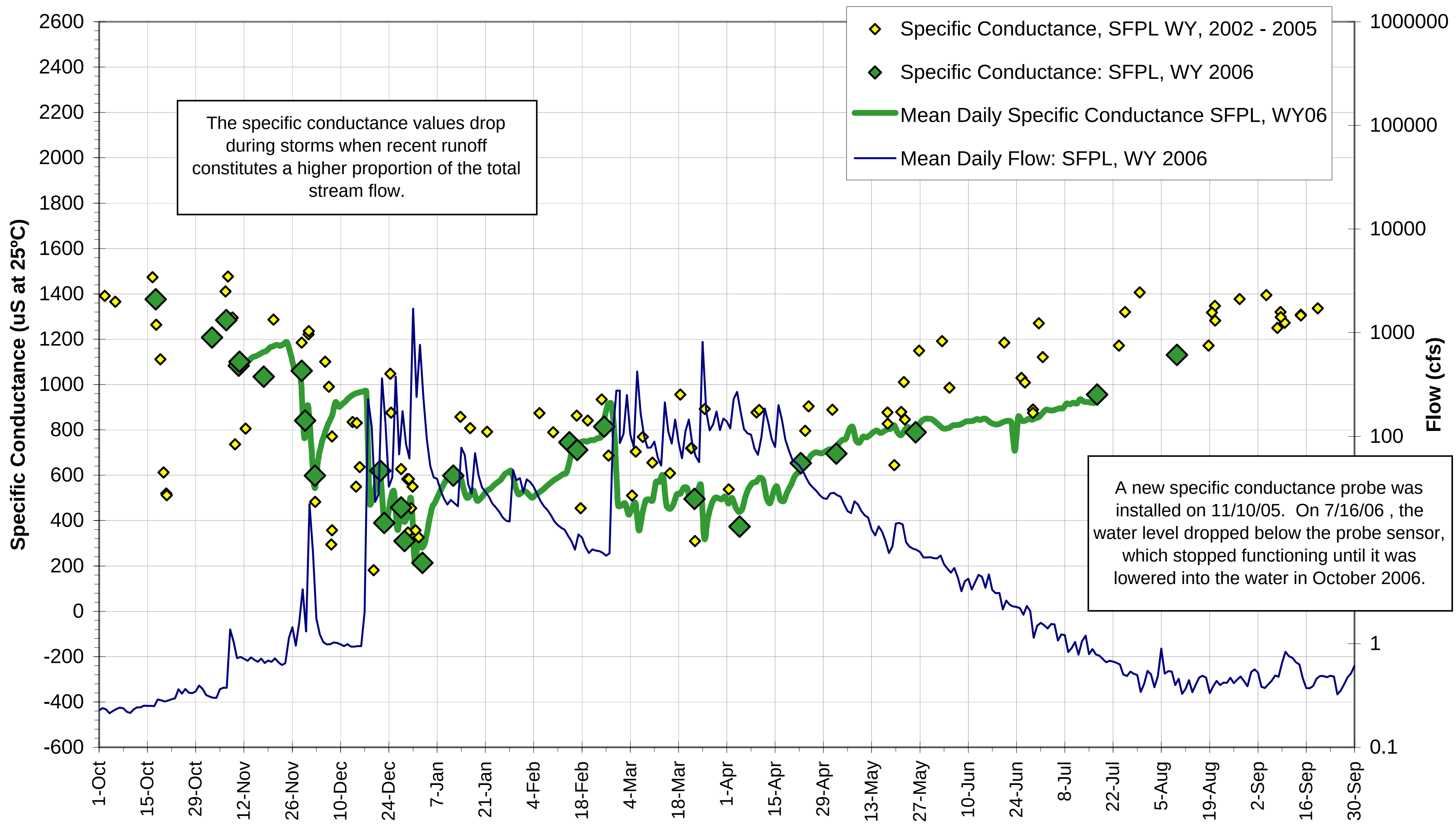
Figure 9. Specific conductance measurements, Bear Creek at Sand Hill Road, water year 2006. Specific conductance measurements in Bear Creek during water year 2006 are lower than in Los Trancos Creek or San Francisquito Creek. This difference between creeks may be due to geologic influences or human causes. The flow record is plotted for reference.



Note: 1) the flow axis is logarithmic, and 2) the date axis does not include the year because multiple years of data are shown.

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Figure 10. Specific conductance measurements, San Francisquito Creek at Piers Lane, water years 2002 to 2006. Specific conductance measurements are generally similar for all years, with lower values during storms. This year, values are at the low end of the range during spring and summer, as expected following a relatively high rainfall year. The flow record is plotted for reference.

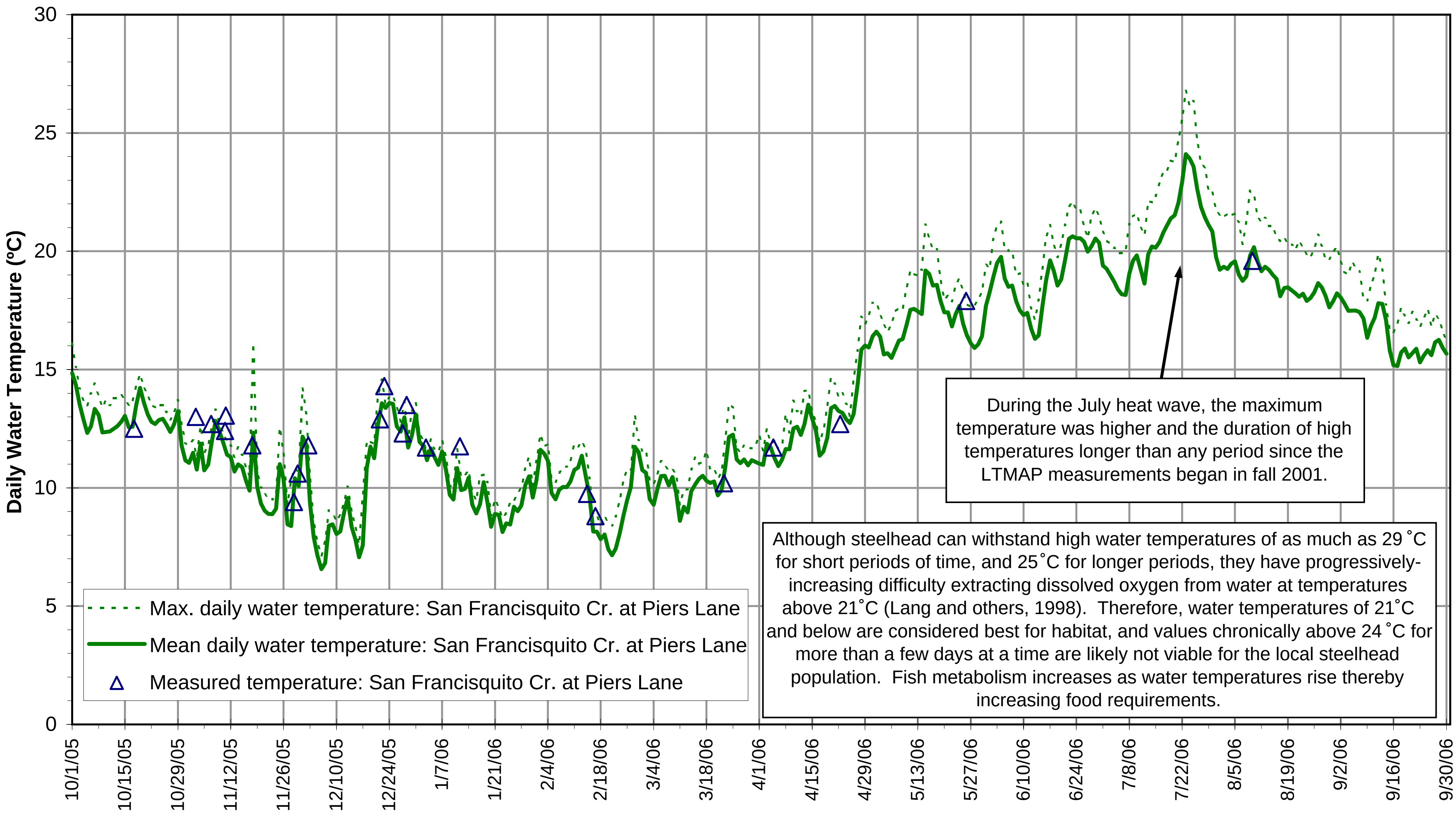

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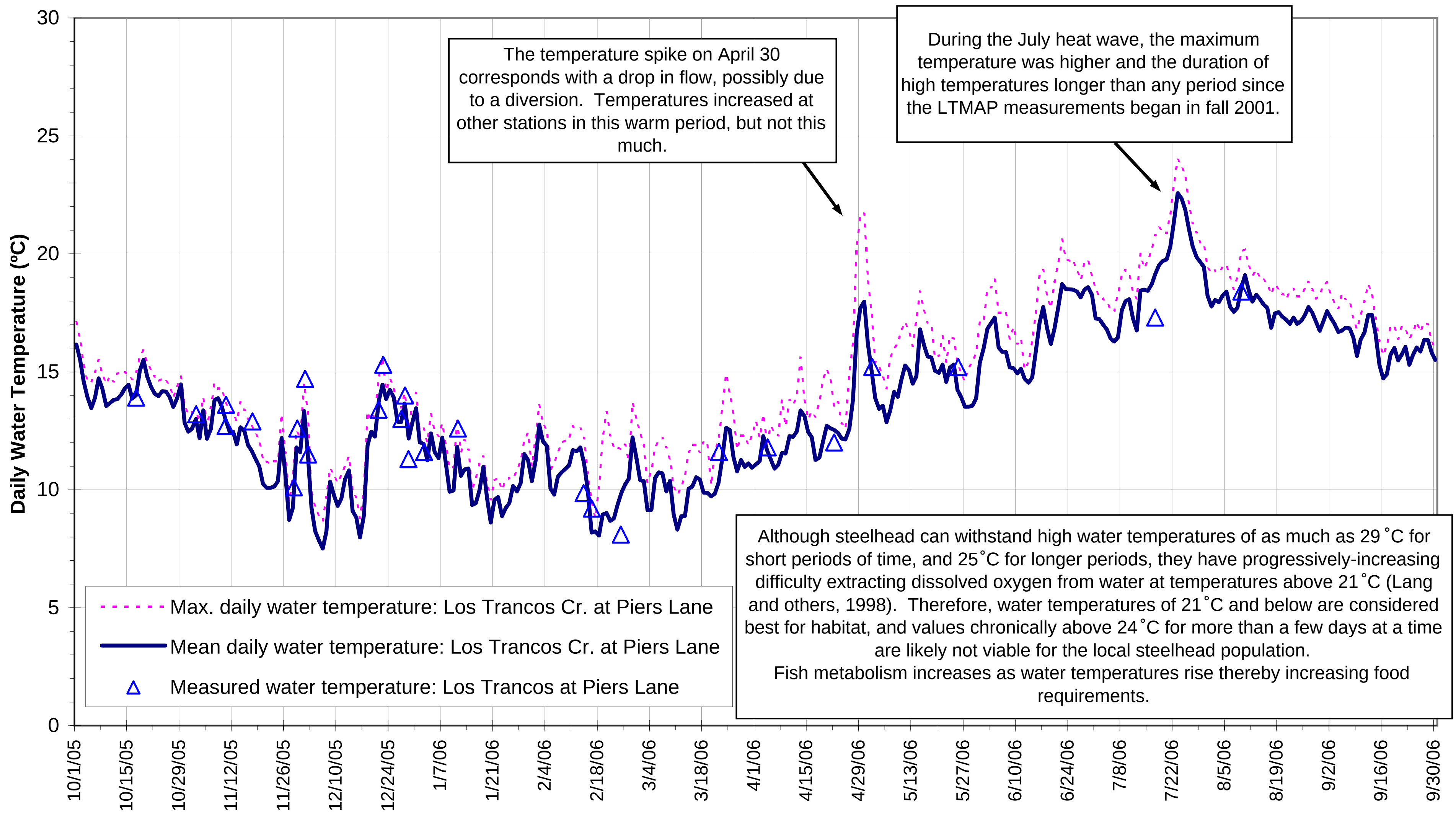
Figure 11. Daily water temperature record for San Francisquito Creek at Piers Lane, water year 2006. Temperature patterns are similar at the San Francisquito Creek, Los Trancos Creek and Bear Creek stations. Water temperatures seem to be slightly cooler in San Francisquito Creek than in Los Trancos Creek during the winter and warmer during the summer.



Balance Hydrologics, Inc.

Figure 12. Daily water temperature record for Los Trancos Creek at Piers Lane, water year 2006. Temperature patterns are similar at the San Francisquito Creek, Los Trancos Creek and Bear Creek stations. Water temperature seems to be slightly warmer in Los Trancos Creek than in San Francisquito Creek during the winter and cooler during the summer.

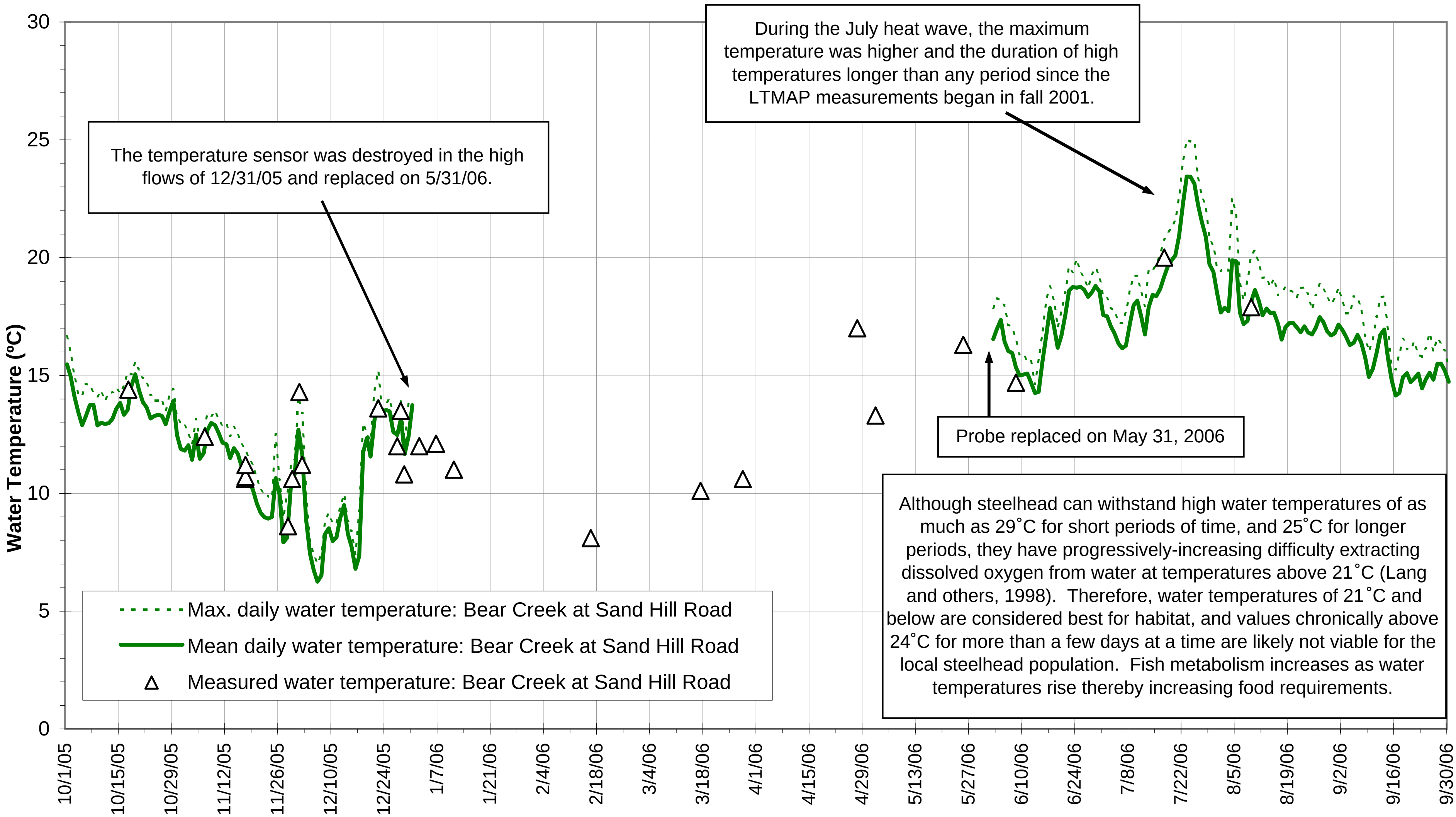


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Figure 13. Daily water temperature record for Bear Creek at Sand Hill Road, water year 2006. We believe the temperature patterns during the data gap from December 31, 2005 to May 31, 2006 at this station were similar to the patterns downstream. Temperature patterns at this station were similar to the downstream station, San Francisquito Creek at Piers Lane, prior to December 31, 2005 and in previous water years.

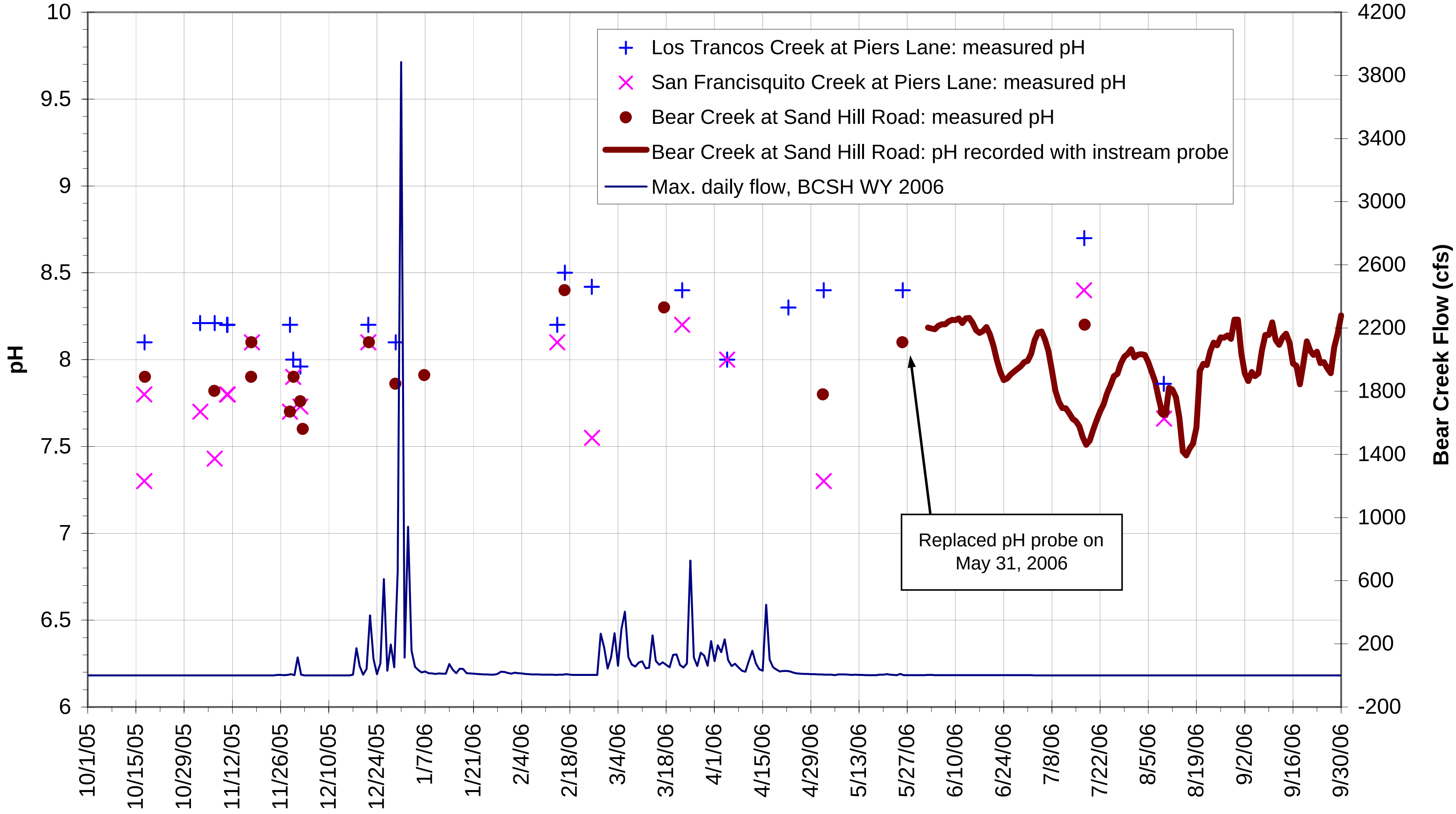

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Figure 14. pH measurements in San Francisquito Creek, Los Trancos Creek and Bear Creek, water year 2006. Field measurements were made with hand-held pH meters. A new pH probe was installed on May 31, 2006 at Bear Creek and seems to have worked well for the remainder of the year. The instream pH probes did not work at the Piers Lane stations. The flow record is plotted for reference.

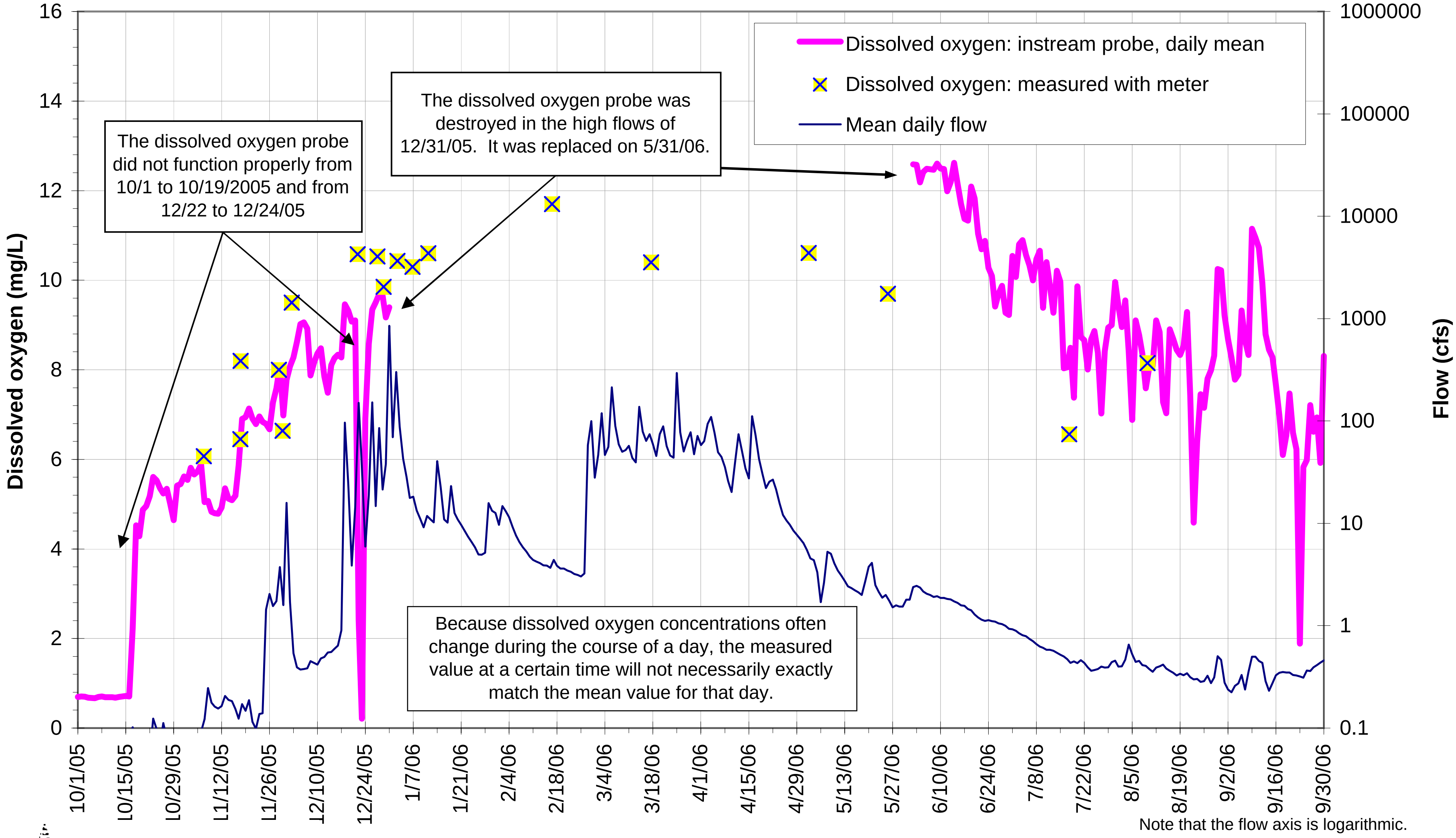

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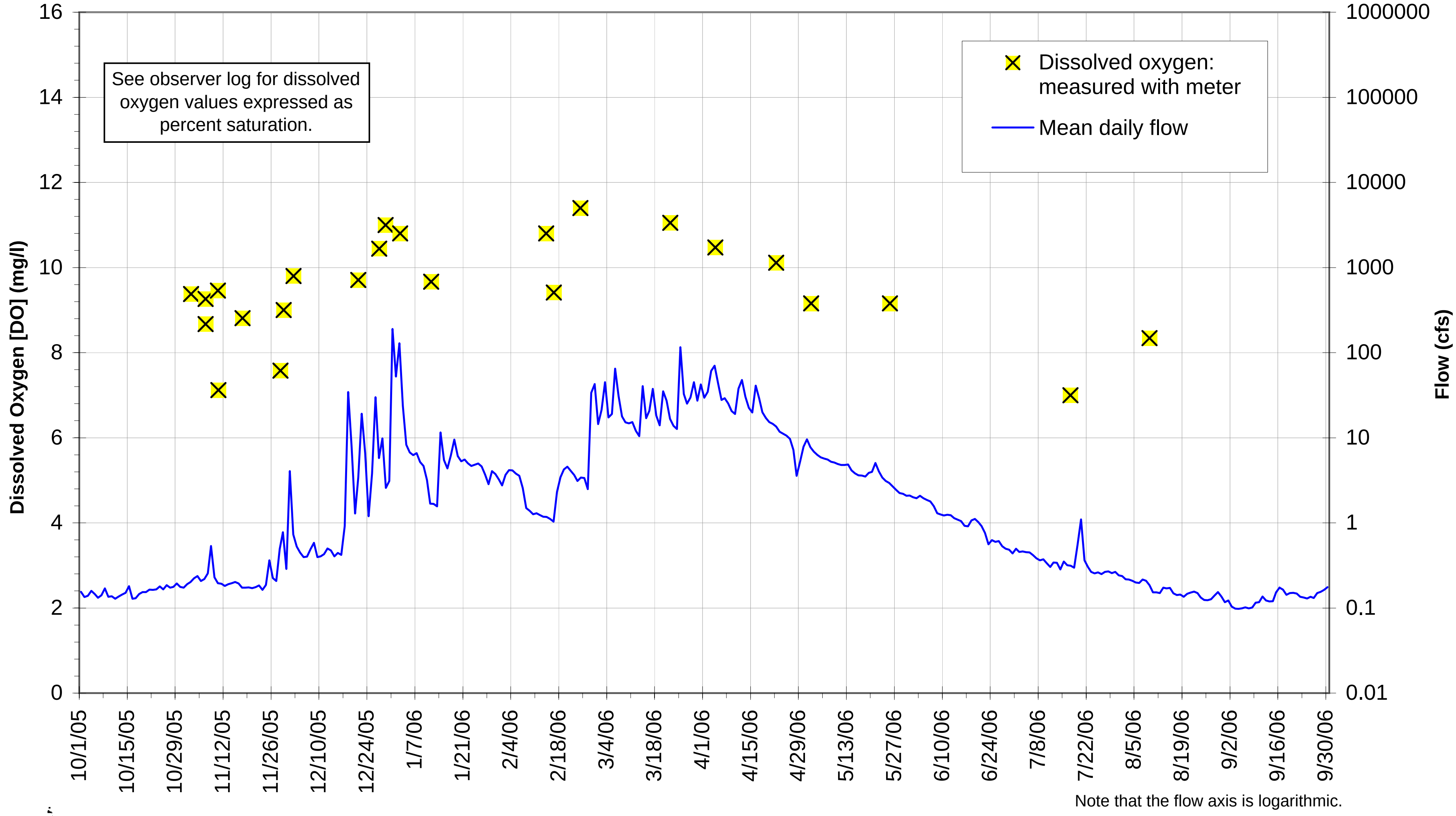
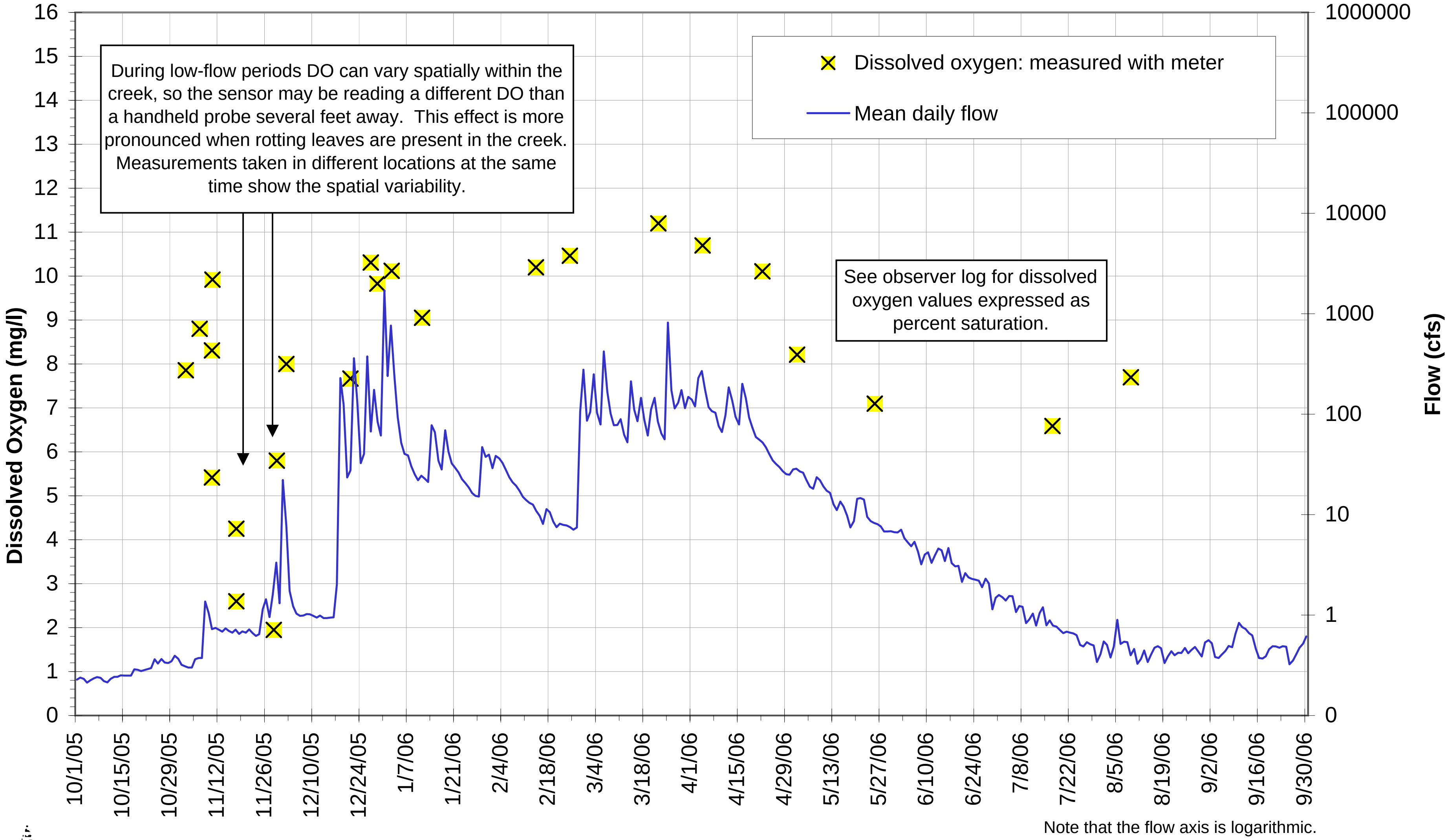
Figure 15. Dissolved oxygen concentrations at Bear Creek at Sand Hill Road, water year 2006. The instream probe functioned well until it was destroyed on December 31, 2005. Dissolved oxygen concentrations are lower during late summer and fall low flows when water temperatures are higher, stream turbulence is lower, and decomposing leaves create localized oxygen demand. The flow record is plotted for reference. See observer log for dissolved oxygen values expressed as percent saturation.



Balance Hydrologics, Inc.

Figure 16. Dissolved oxygen concentrations in Los Trancos Creek at Piers Lane, water year 2006. Dissolved oxygen levels in Los Trancos Creek are almost always close to 100% saturation. The dissolved oxygen probe did not function well. Field measurements by Balance staff indicate that dissolved oxygen concentrations are lower during late summer and fall low flows when water temperatures are higher, stream turbulence is lower, and decomposing leaves create localized oxygen demand. The flow record is plotted for reference.



Balance Hydrologics, Inc.

Figure 17. Dissolved oxygen concentrations in San Francisquito Creek at Piers Lane, water year 2006. The dissolved oxygen probe did not function well. Field measurements by Balance staff indicate that dissolved oxygen concentrations are lower during late summer and fall low flows when water temperatures are higher, stream turbulence is lower, and decomposing leaves create localized oxygen demand.

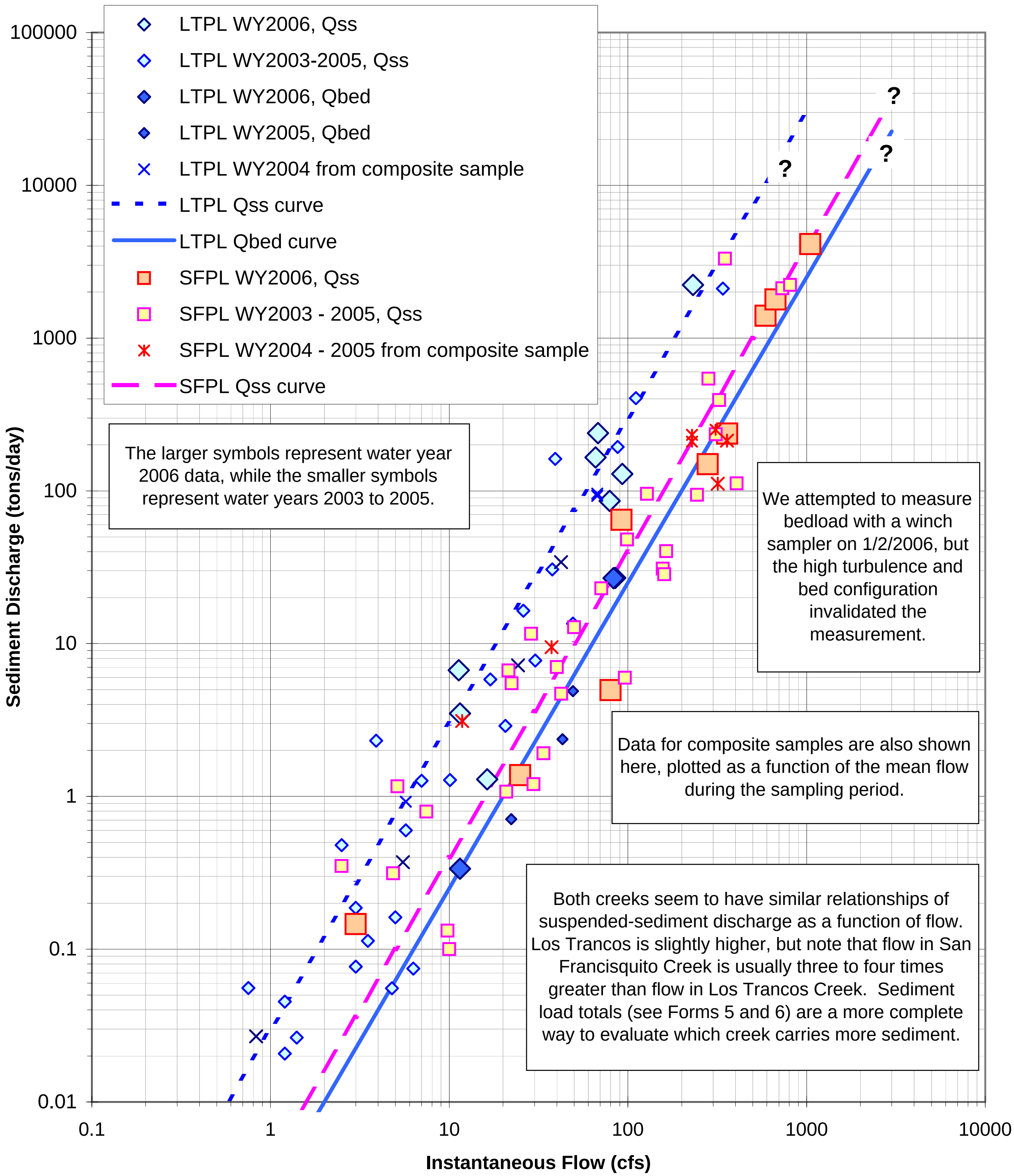


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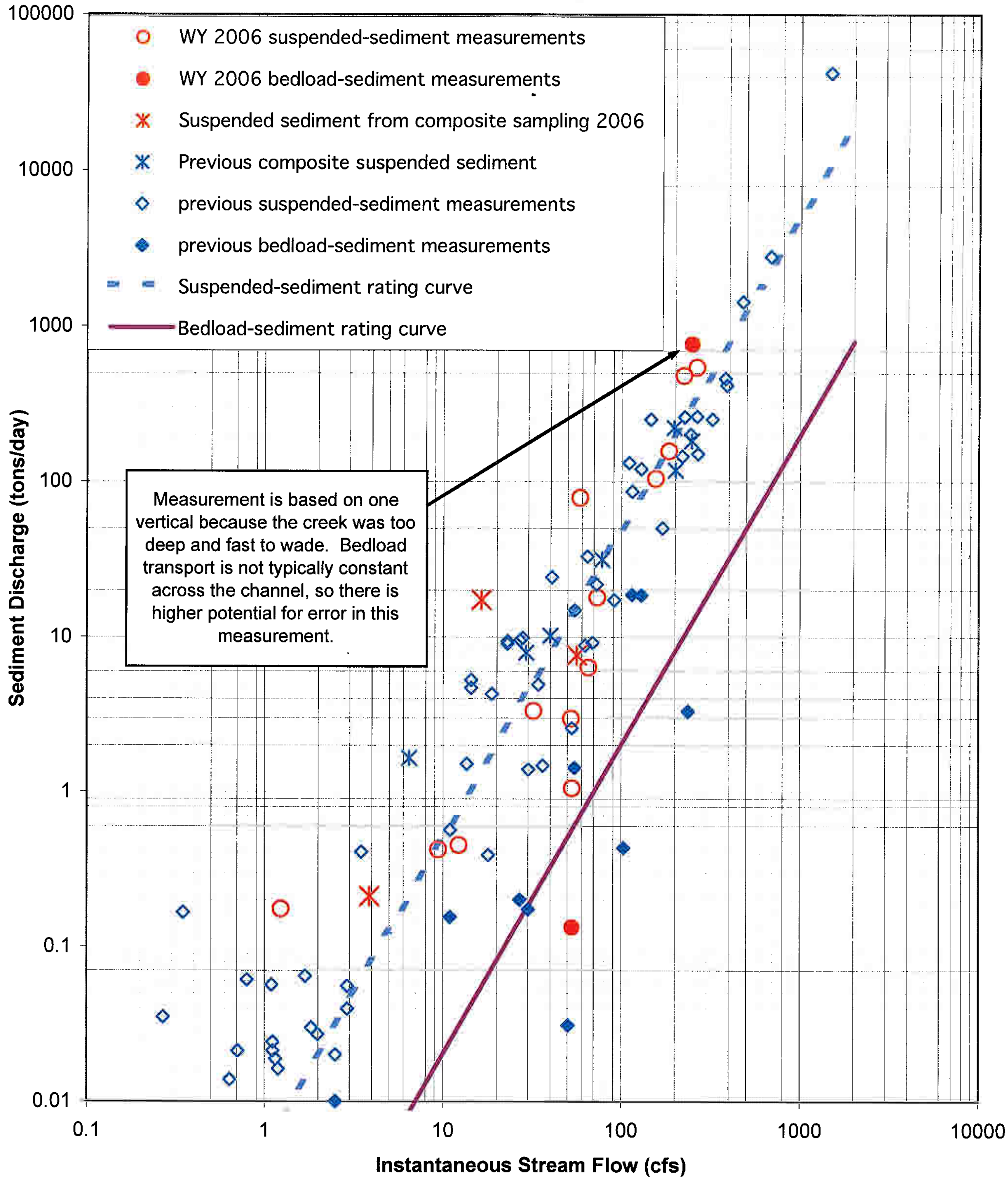
Figure 18. Sediment measurements and rating curves for the Piers Lane stations. The samples collected on January 2, 2006 on San Francisquito Creek are the highest-flow sediment samples collected at this site.



Balance Hydrologics, Inc.

Figure 19. Sediment measurements and rating curves for Bear Creek at Sand Hill Road, water years 1998-2006. Sediment as a function of flow seems similar in water year 2006 as in previous years.

APPENDIX A

Laboratory Results and Chain of Custody Forms
(Piers Lane Stations)

Not Included in Electronic Version of Report

APPENDIX B

Laboratory Results and Chain of Custody Forms (Bear Creek)

Not Included in Electronic Version of Report

APPENDIX C

Detailed Hydrographs of Wet-season Periods during which Composite Samples were Collected

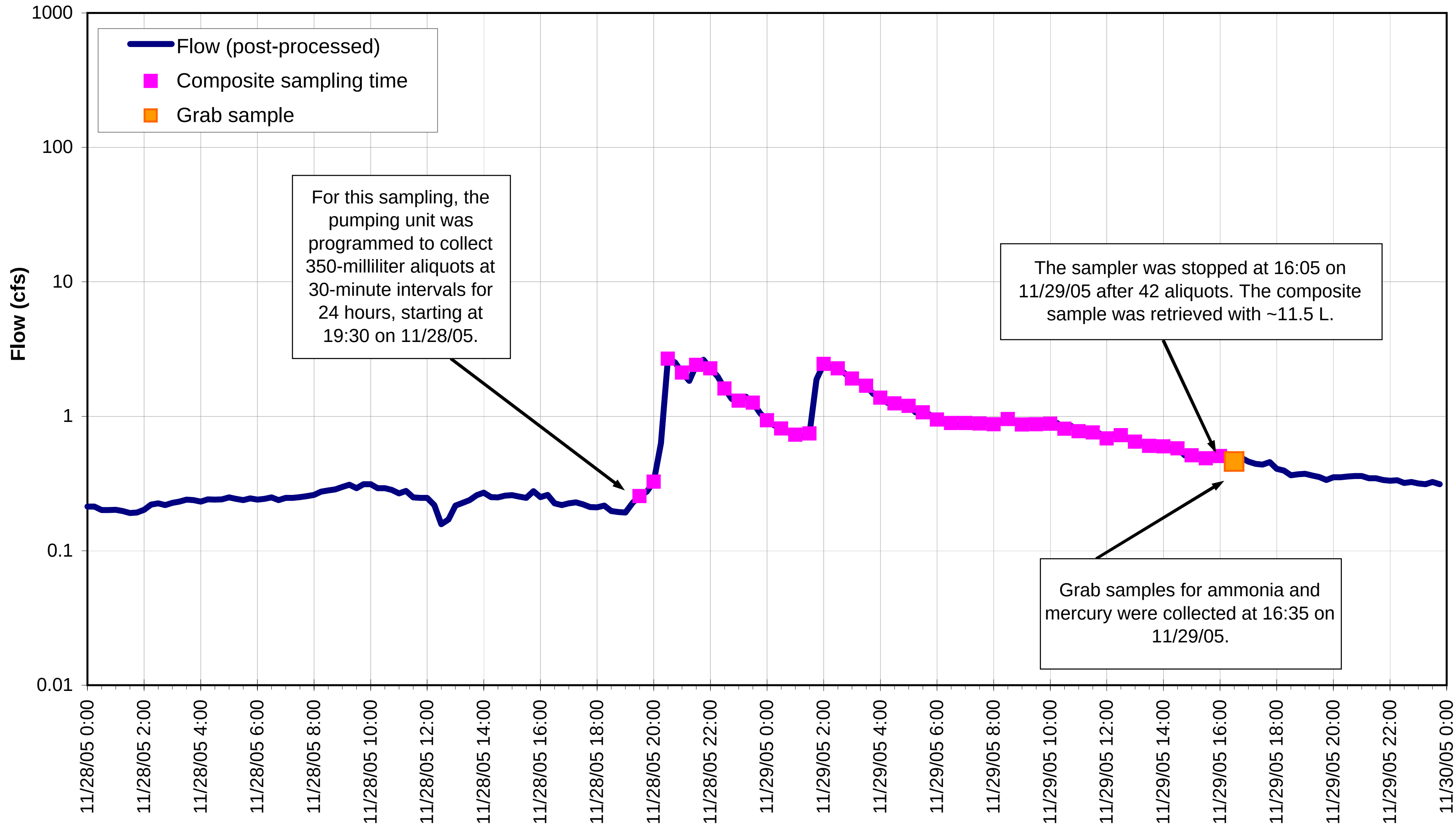


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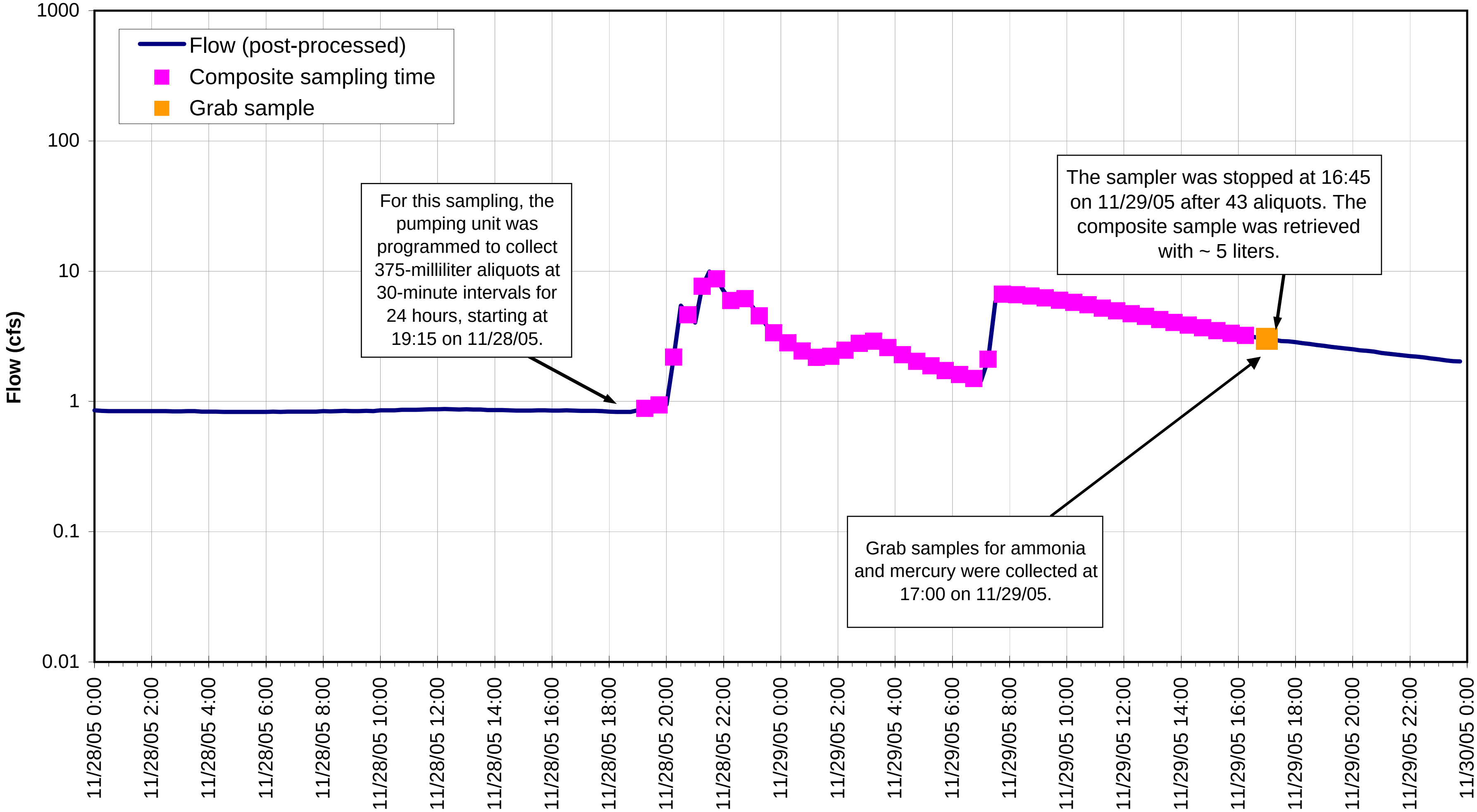
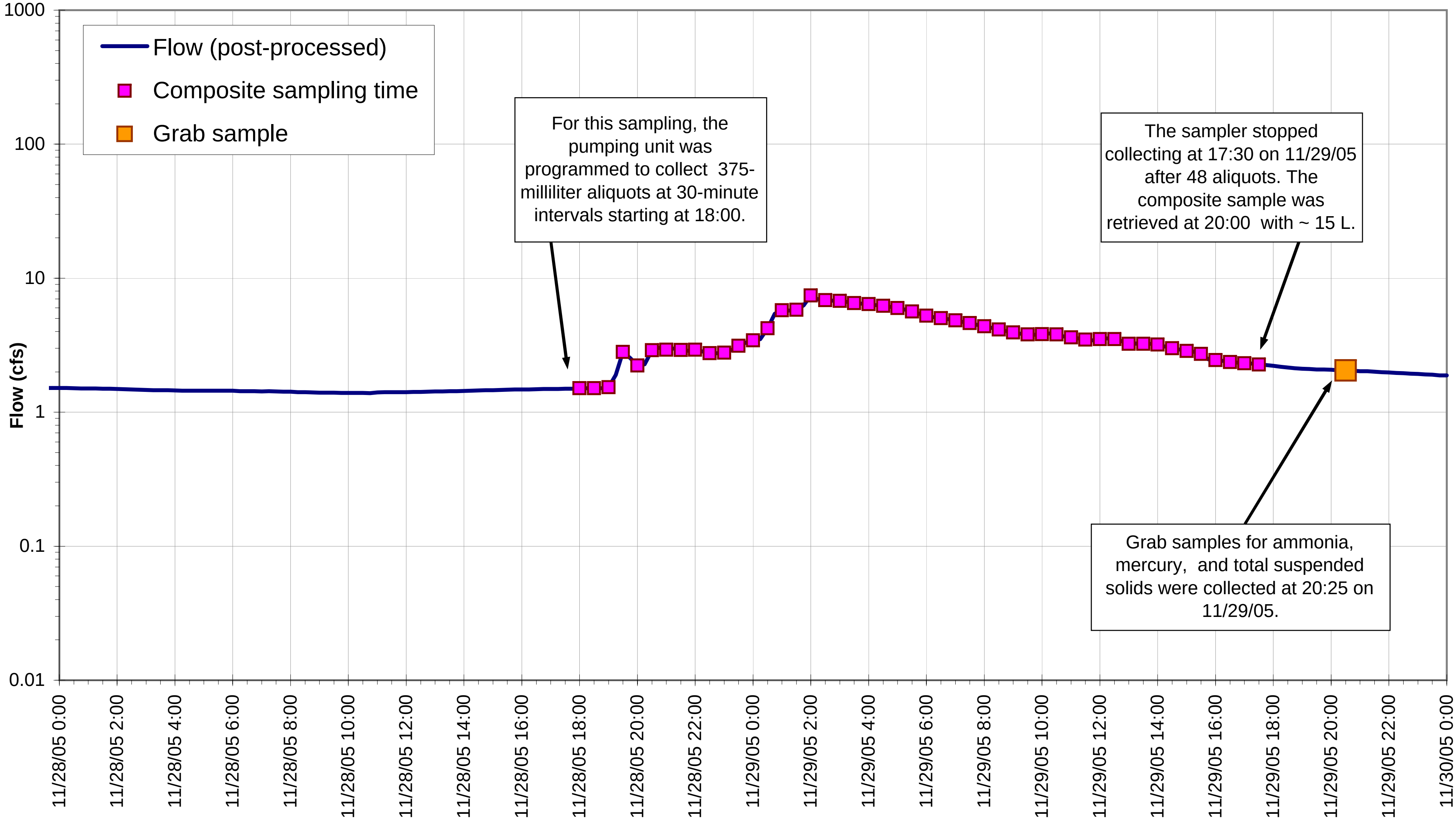
Figure C1. Water-quality sampling detailed hydrograph, November 28 to 29, 2005, Los Trancos Creek at Piers Lane. This sampling was intended to capture runoff from the first-flush event. The sampling was time-paced and grab samples were collected after the flow peak.



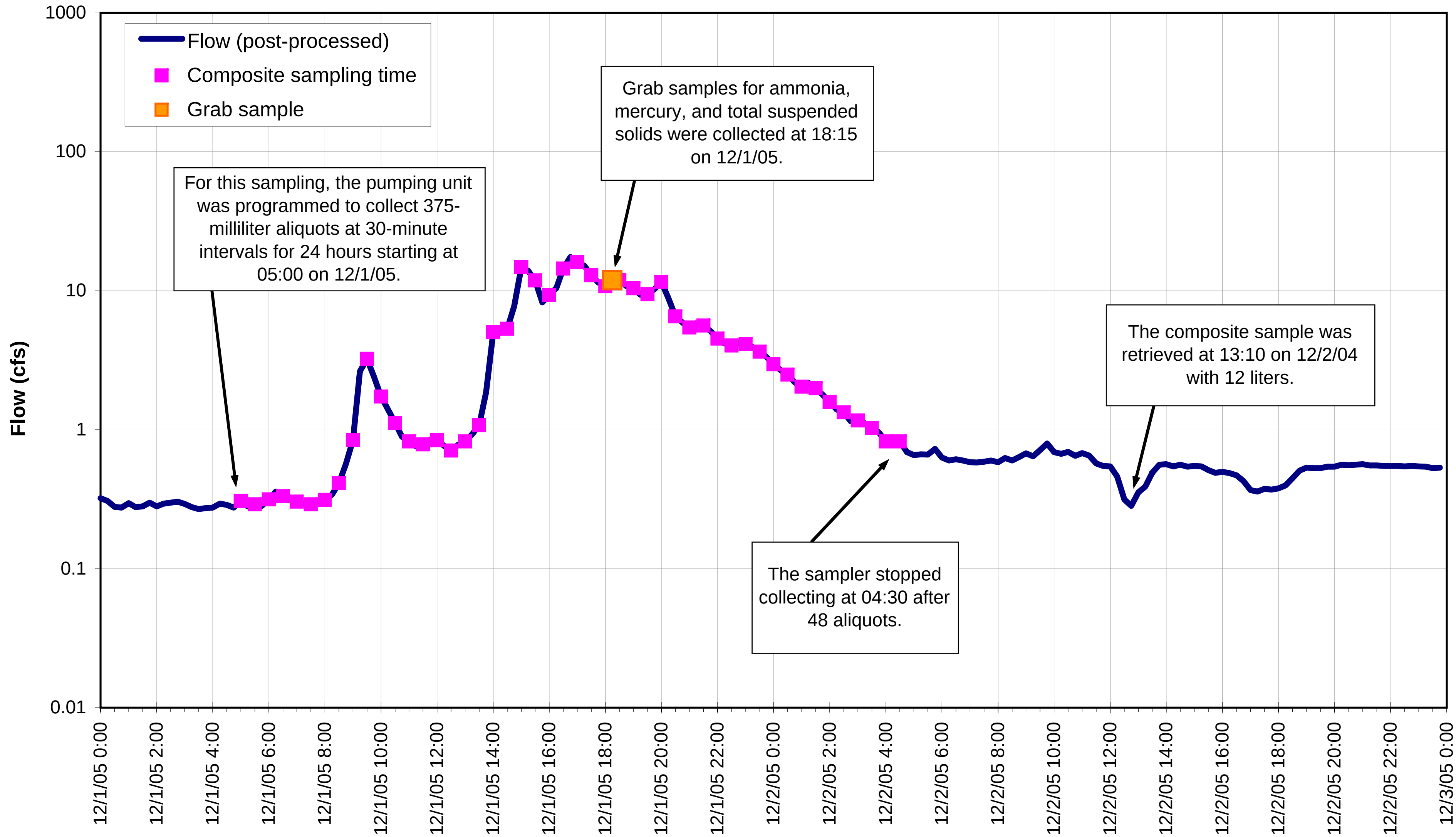
Balance Hydrologics, Inc.

Figure C2. Water-quality sampling detailed hydrograph, November 28 to 29, 2005, San Francisquito Creek at Piers Lane. This sampling was intended to capture runoff from the first-flush event. The sampling was time-paced and grab samples were collected after the flow peak.



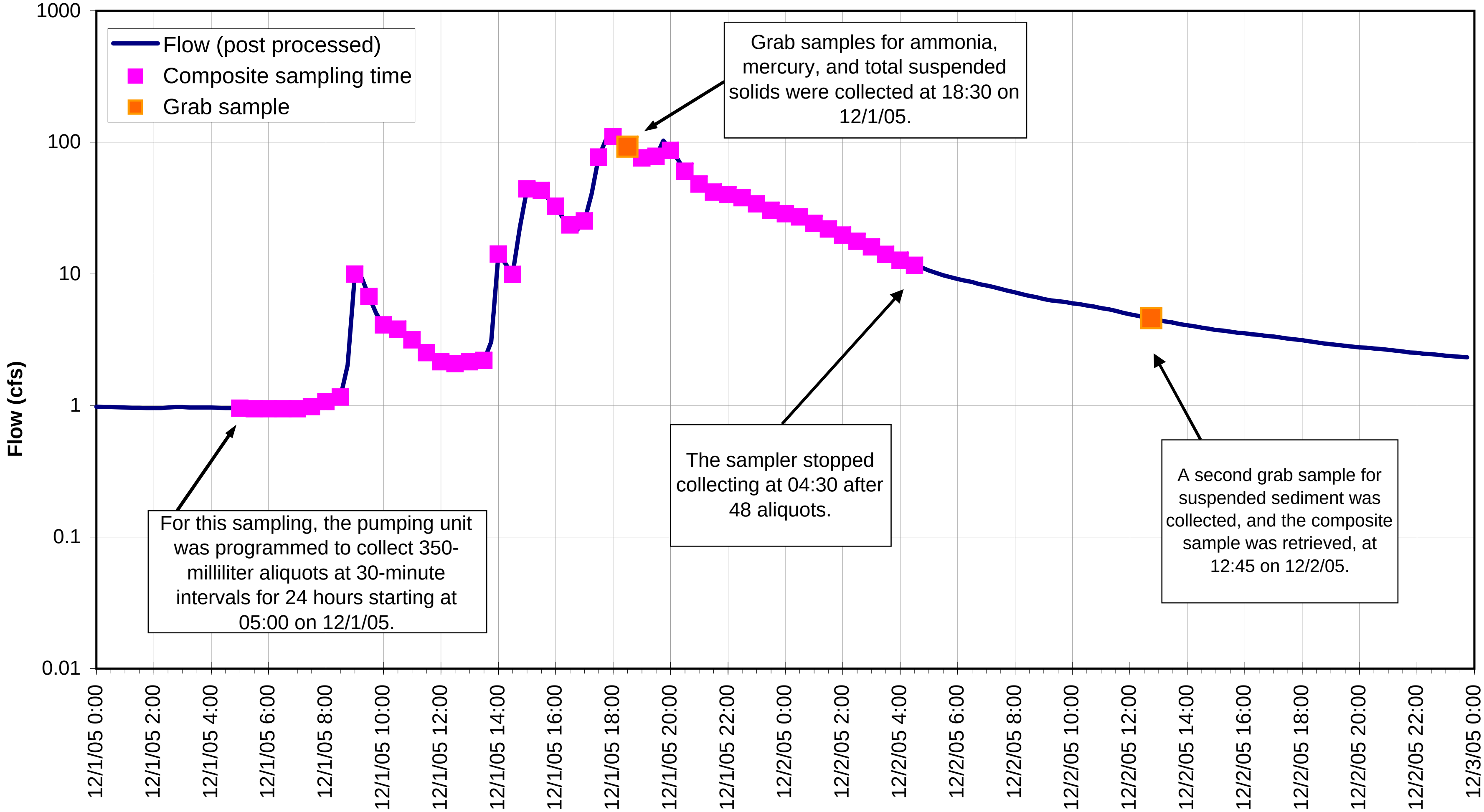
Balance Hydrologics, Inc.

Figure C3. Water-quality sampling detailed hydrograph, November 28 to 29, 2005. Bear Creek at Sand Hill Road. This sampling was intended to capture runoff from the first-flush event. The sampling was time-paced and grab samples were collected after the flow peak.



Balance Hydrologics, Inc.

Figure C4. Water-quality sampling detailed hydrograph, December 1 to 2, 2005, Los Trancos Creek at Piers Lane. This sampling was intended to capture runoff from a slightly higher first flush than the November 29 storm. The sampling was time-paced and grab samples were collected just after the flow peak.



Balance Hydrologics, Inc.

Figure C5. Water-quality sampling detailed hydrograph, December 1 to 2, 2005, San Francisquito Creek at Piers Lane. This sampling was intended to capture runoff from a moderate winter storm. The sampling was time-paced and grab samples were collected just after the flow peak.

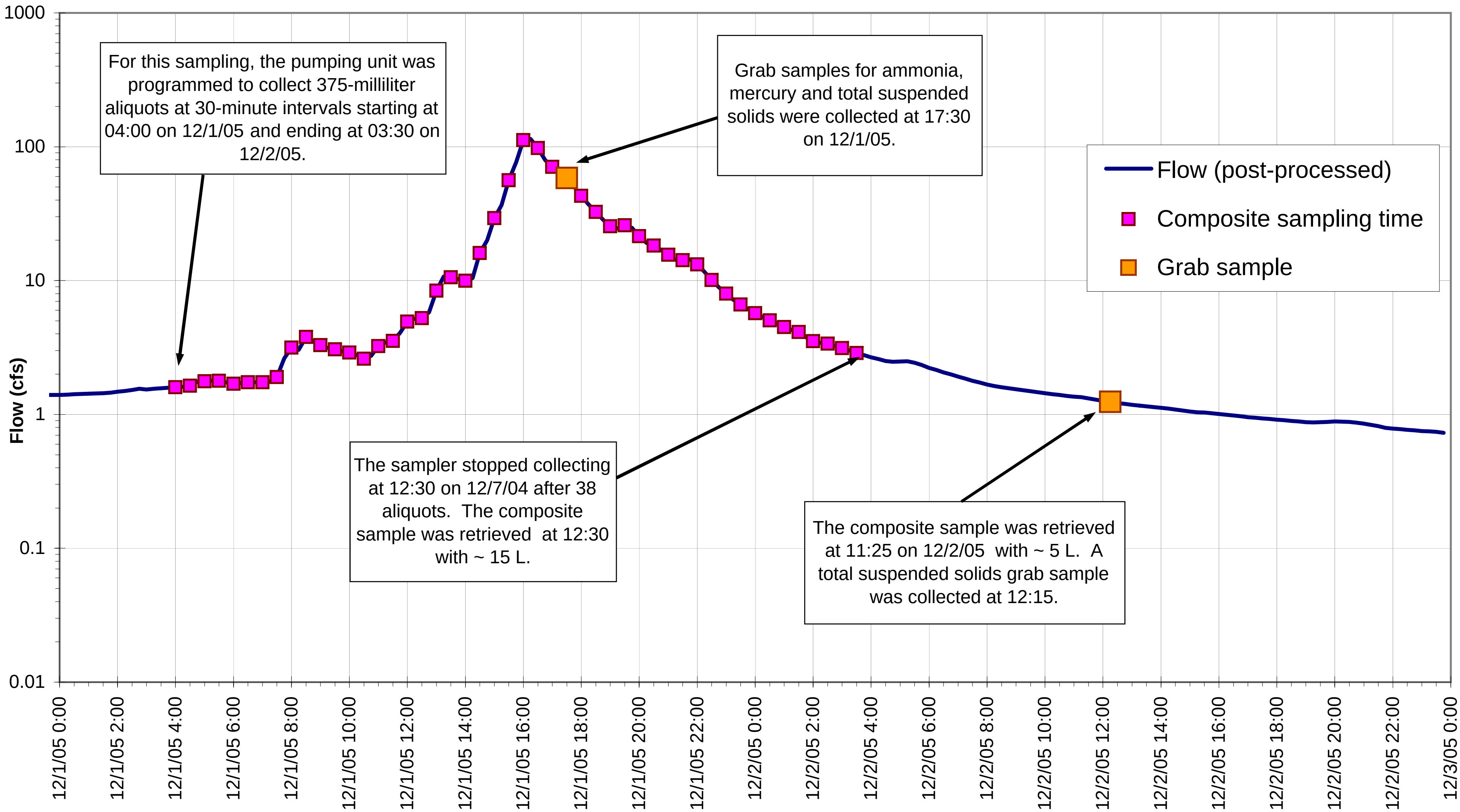


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Figure C6. Water-quality sampling detailed hydrograph, December 1 to 2, 2005, Bear Creek at Sand Hill Road. This sampling was intended to capture runoff from a moderate winter storm. The sampling was time-paced and grab samples were collected shortly after the flow peak.

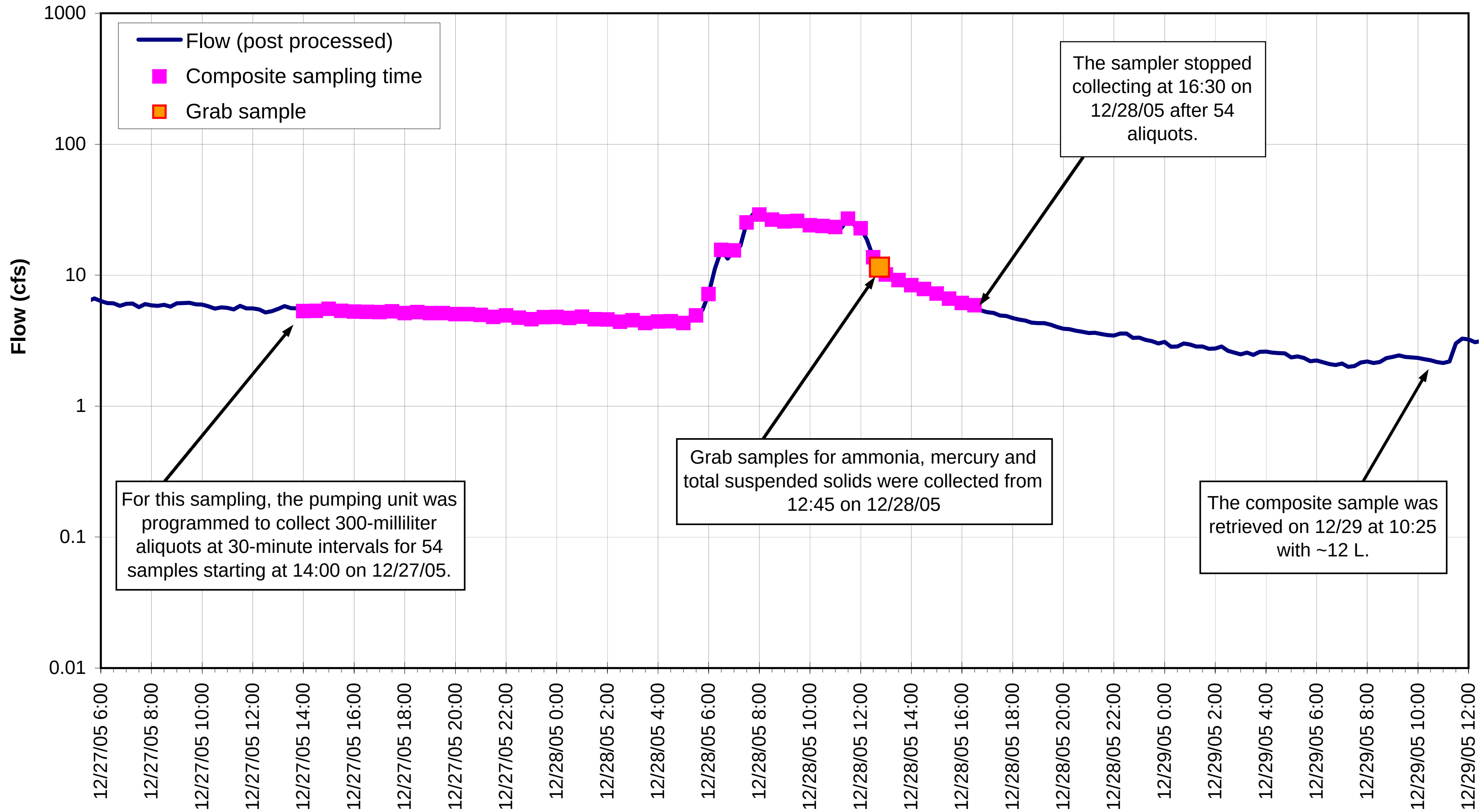

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Figure C7. Water-quality sampling detailed hydrograph, December 27 to 28, 2005, Los Trancos Creek at Piers Lane. This sampling captured runoff from a winter storm with moderately high flows. The sampling was time-paced and grab samples were collected during the flow peak.

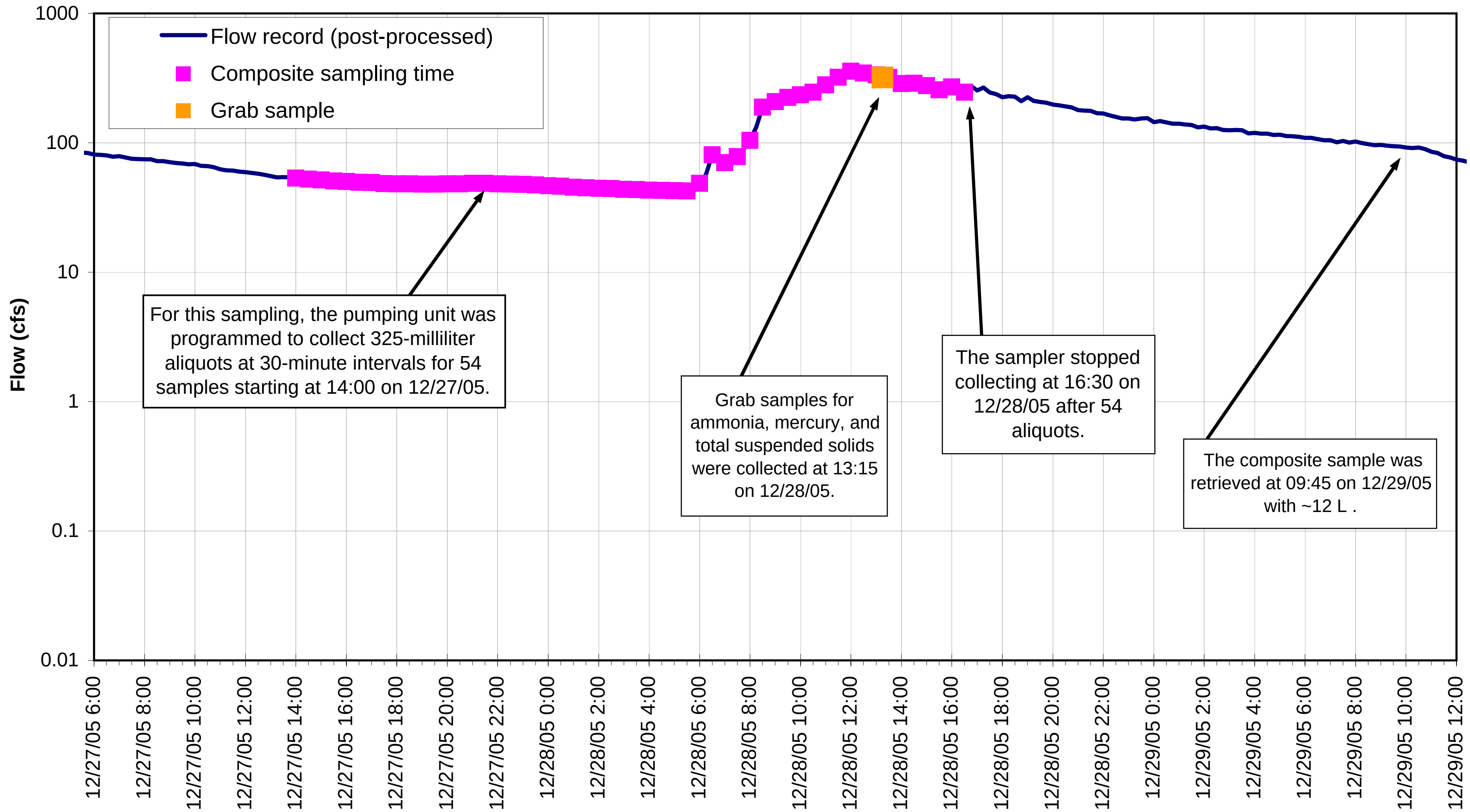

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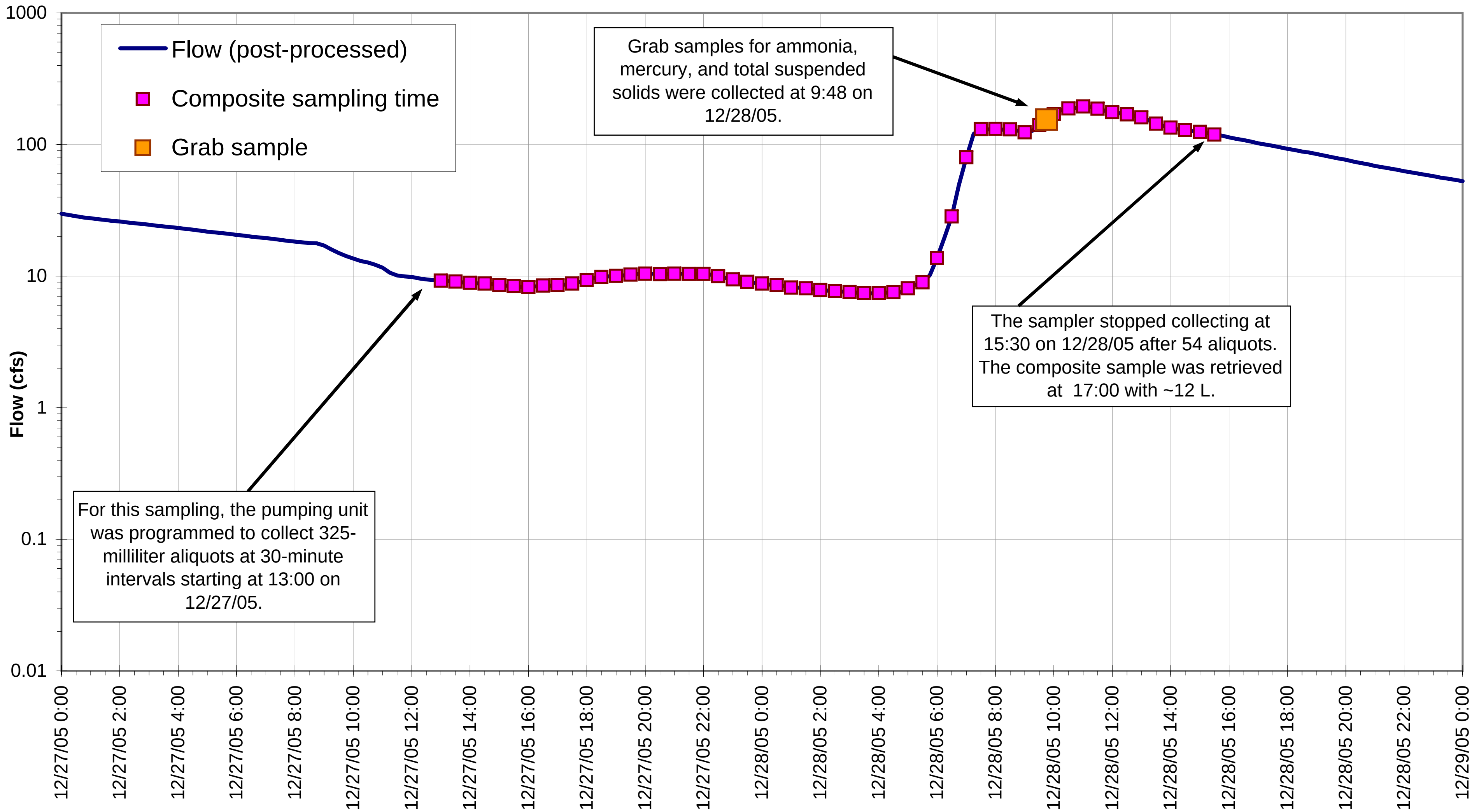
Figure C8. Water-quality sampling detailed hydrograph, December 27 to 28, 2005, San Francisquito Creek at Piers Lane. This sampling captured runoff from a large winter storm event, with flows among the highest of the water year. The sampling was time-paced and grab samples were collected at the flow peak.



Balance Hydrologics, Inc.

Figure C9. Water-quality sampling detailed hydrograph, December 27 to 28, 2005, Bear Creek at Sand Hill Road. This sampling was intended to capture runoff from a moderate winter storm. The sampling was time-paced and grab samples were collected at the flow peak.

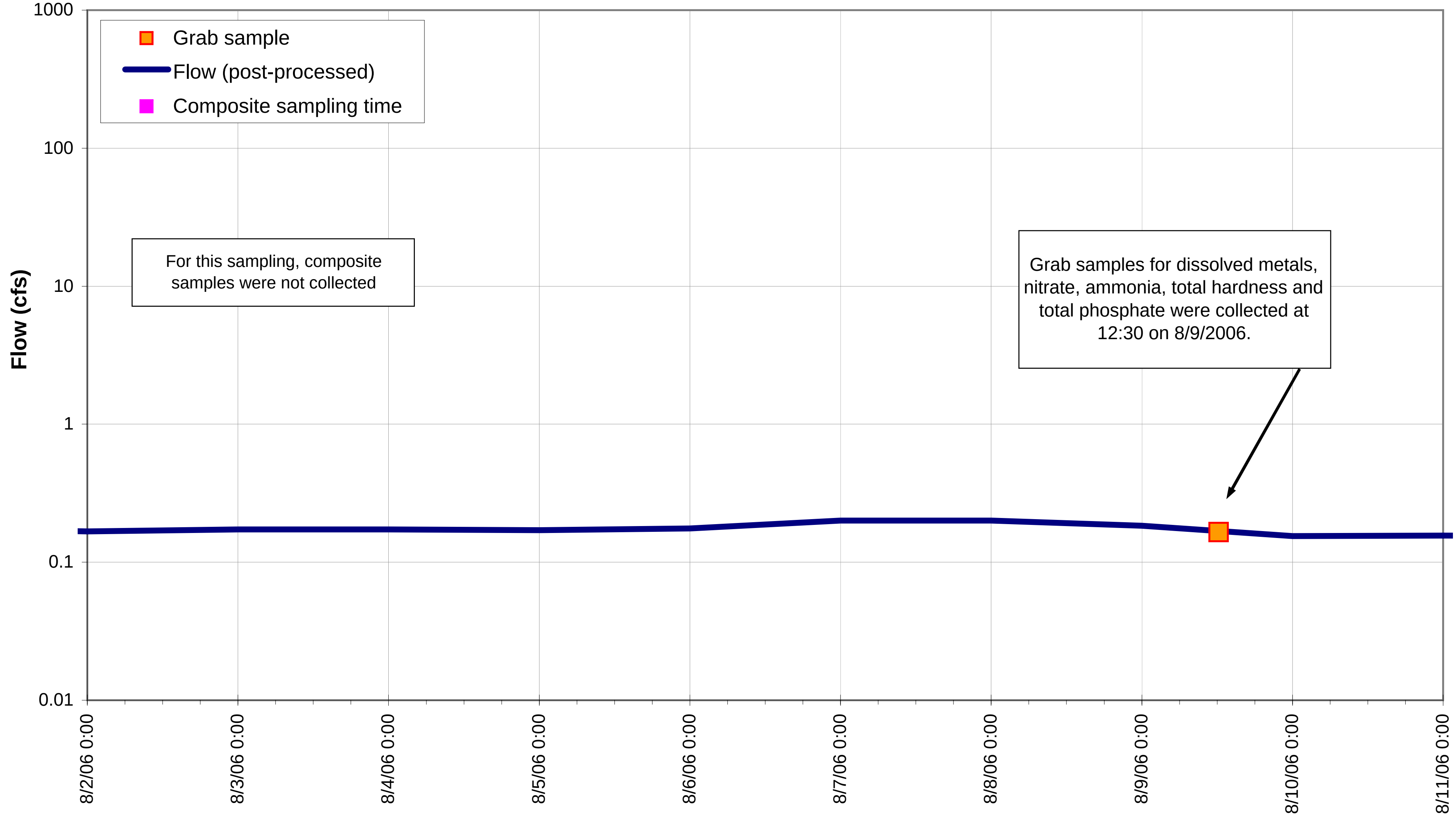


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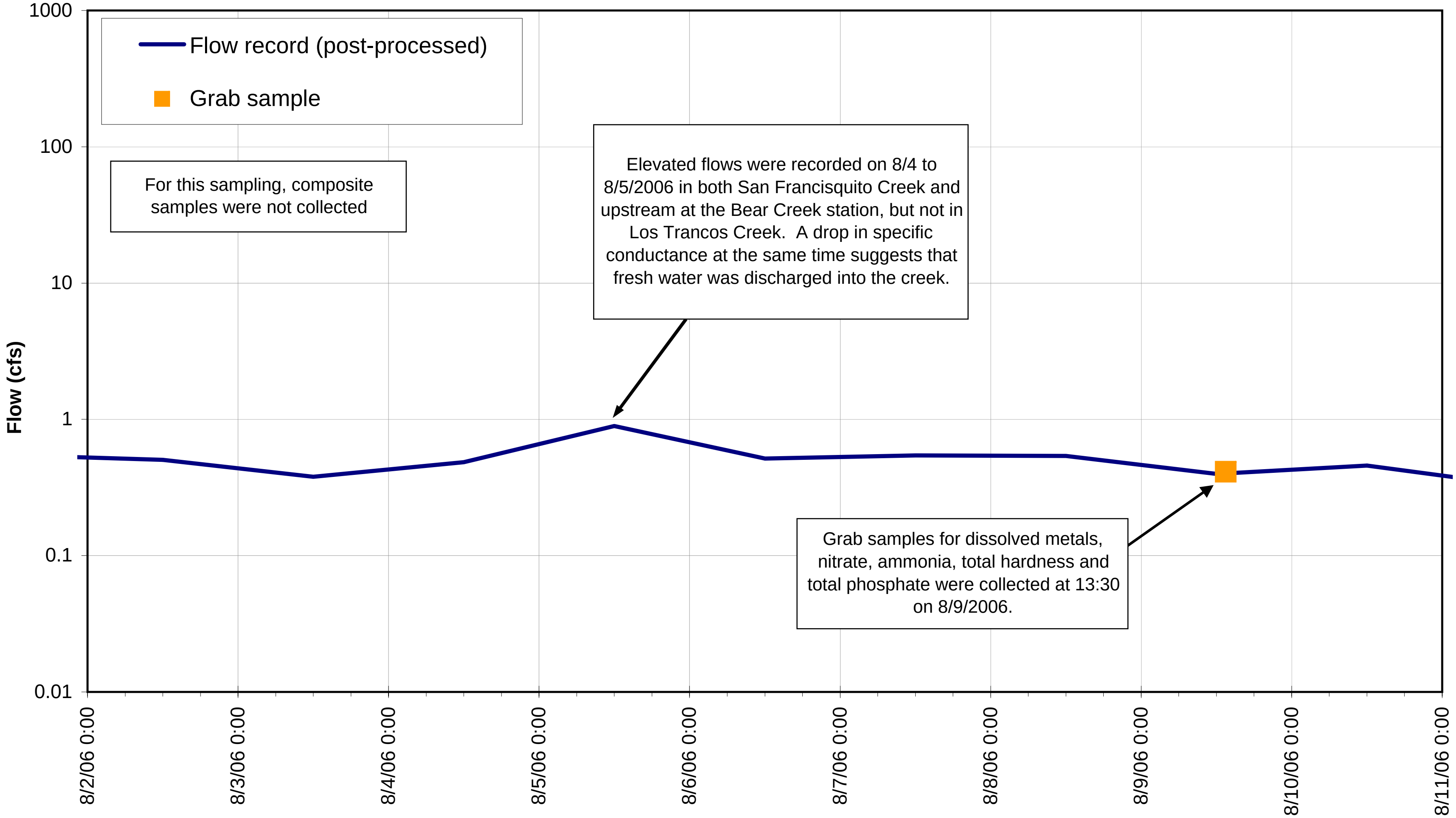
Figure C10. Water-quality sampling detailed hydrograph, August 9, 2006, Los Trancos Creek at Piers Lane. This sampling captured summer baseflow conditions. Grab samples were collected on August 9, 2006. The automated pump sampler was not used.



Balance Hydrologics, Inc.

Figure C11. Water-quality sampling detailed hydrograph, August 9, 2006, San Francisquito Creek at Piers Lane. This sampling captured summer baseflow conditions. Grab samples were collected on August 9, 2006. The automated pump sampler was not used.

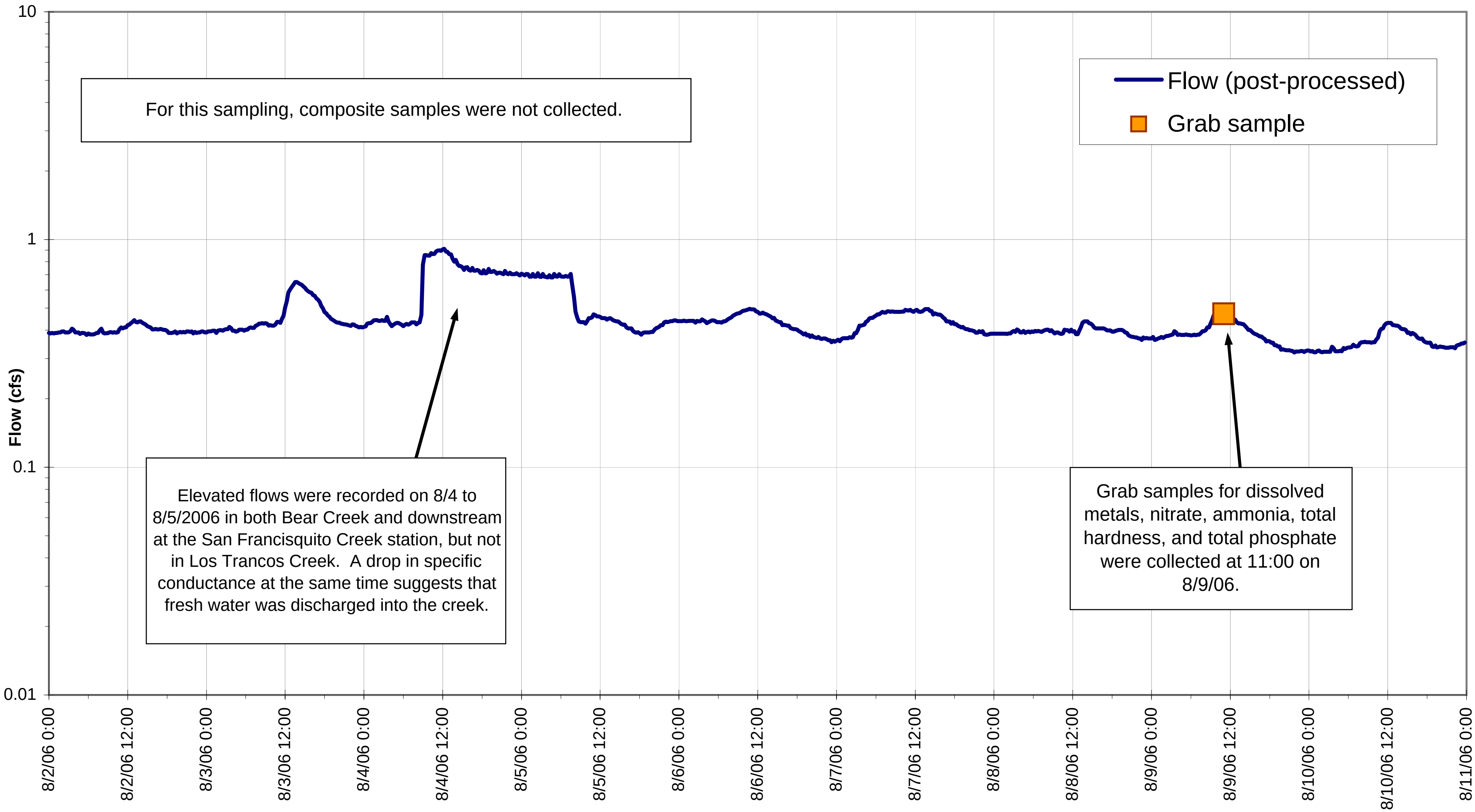


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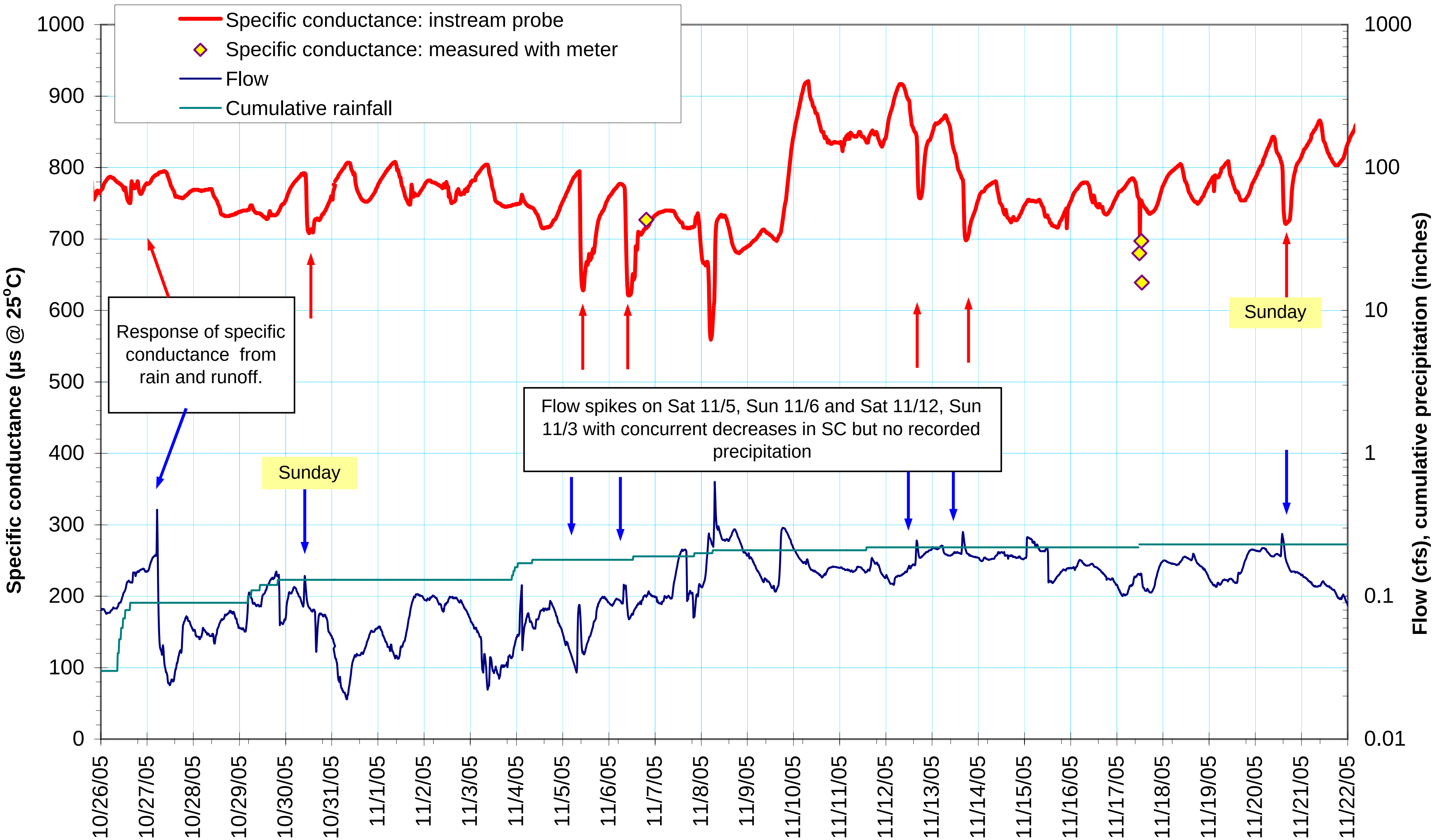
Figure C12. Water-quality sampling detailed hydrograph, August 9, 2006 Bear Creek at Sand Hill Road. This sampling was intended to capture summer baseflow conditions. Grab samples were collected on August 9, 2006. The automated pump sampler was not used.

APPENDIX D

Figure D1

Specific Conductance Anomalies at Bear Creek at Sand Hill Road



Balance Hydrologics, Inc.

Figure D1. Specific conductance anomalies at Bear Creek at Sand Hill Road. Dips in specific conductance suggest that the unexpected increases in flow are from water that is considerably less saline than the background creek water. The increase in flow is relatively small for such a large decrease in specific conductance, so the salinity difference must be large. The anomalies have occurred on two Saturdays and four Sundays in a row.