Hydrology and Geology Assessment of the Pismo Creek Watershed, San Luis Obispo County, California

Report prepared for:

Central Coast Salmon Enhancement

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

LIST OF APPENDICES

EXECUTIVE SUMMARY

Balance Hydrologics has conducted a watershed-wide investigation in order to characterize the hydrologic and geologic (including geomorphologic) processes in the Pismo Creek watershed and identify particular conditions and sites where anadromous fish and other aquatic species may be affected by these processes. Our work has consisted of:

- Reviewing existing information, such as published geological and soils mapping, historical and false-color infrared photographs, historical anecdotes, and prior gaging in the watershed;
- Developing a GIS-based watershed model to calculate anticipated peak flows in the channel at a number of locations;
- Comparing the model data to peak streamflows measured in 1991 and 1992;
- Creating a synthetic long-term daily streamflow record based on correlation to nearby long-term stream gages;
- Carrying out a field investigation to evaluate:
  - Low-flows at a number of locations throughout the watershed,
  - Changes in basic water quality parameters and specific conductance (a measure of salinity) throughout the watershed,
  - Locations of ground-water discharge and recharge, and
  - Channel geomorphology, stability, and locations of significant sediment sources.

For the purposes of our investigation, we divide the watershed into four distinct geomorphic settings. The upper watershed is a mountainous block separated from Edna Valley by the Huasna Fault Zone. Edna Valley is a wide alluvial system, separated from Price Canyon by the Edna Fault Zone. Price Canyon is narrow with significant exposures of petroleum- and water-bearing formations, while the coastal area is largely urbanized.

Our field observations imply that ground-water discharge (gaining reaches) tends to occur near the two fault zones, as well as at localized areas in Price Canyon, while streams tend to lose water as they cross Edna Valley. Specific conductance increases somewhat in the localized, gaining reaches within Price Canyon, also suggesting inflow of slightly saltier ground water from the Pismo and Monterey formations. Water-quality analyses imply that localized gaining

reaches in Price Canyon may be the source of elevated specific conductance and/or sulfates, presumably emanating from oil-bearing geologic formations and/or associated with oil production activities in these areas. Canada Verde joins Pismo Creek after flowing over the Paso Robles Formation and following the trace of the Edna Fault, and appears to be a significant source of late-summer baseflow to the Price Canyon portion of the channel. This information is substantiated by general minerals analyses, which suggest that, to an extent, distinct ground-water sources supply water to the different tributaries. The 100-year flows in the watershed were computed to be values on the order of 150 to 200 cfs per square mile, and September low-flows are estimated to have ranged from 0 to 7.6 cfs (0 to 0.20 cfs per square mile) since 1968.

Channel morphology in the Upper Watershed appears to be relatively stable, where channels appear to be appropriate to channel gradients and watershed size. In Edna Valley, however, channels appear to be actively incising, with only limited natural bedrock grade control. While channel incision and subsequent bank failure is introducing stored sediment to the system, landslides in the upper watershed likely represent the most significant source of in-channel sediment. Sediment contributions from landslides may be somewhat limited, however, by the large in-line impoundment on West Corral de Piedra. Channel restoration activities in Edna Valley, such as stabilizing gullies, excavation and lowering of floodplains, and/or re-establishing overbank flows in straightened channels are likely to slow the process of incision, and should be coupled with measures to reduce the rate at which stormwater enters the channels, such as routing water into infiltration basins or wetlands, rather than directly to the stream channels.

This study is essentially a reconnaissance-level watershed investigation to the extent that it further elucidates some of the key issues to be addressed in watershed planning documents. Further studies, such as the re-establishment of a long-term ground-water monitoring program are required to better understand the nature of ground-water and stream interaction in Edna Valley. Similarly, the degree to which petroleum-bearing formations affect water quality and potential salmonid populations in the Price Canyon reach are not well-documented. We therefore recommend establishing a long-term water quality monitoring program with strategically-placed sampling locations (i.e. upstream and downstream of oil-bearing formations and production areas). Stream gages located near the mouth of Pismo Creek and at the upstream end of Price Canyon would be invaluable to a water quality program in Price Canyon, and would provide insight as to the relative contribution of low flows from various areas of the watershed.

1. INTRODUCTION

Central Coast Salmon Enhancement is conducting the Pismo Creek / Edna Valley Watershed Management Plan, a multi-disciplinary assessment of current and historical channel and hydrologic conditions in the Pismo Creek watershed in San Luis Obispo County, California, funded by the California State Department of Fish and Game. Central Coast Salmon Enhancement has requested that Balance Hydrologics conduct a geologic and hydrologic reconnaissance of the watershed. Work was awarded on April 19, 2007 and authorization to proceed was extended at that time.

The goal of this study is to provide a general geologic and hydrologic characterization of the watershed, including identifying identify particular conditions and sites which are affected by hydrologic and geomorphic processes. Much of our attention has been placed on the conditions and processes which affect opportunities for restoration of anadromous fish habitat in the creek channel and its watershed. An important challenge in developing the work scope and our analytical approaches has been interpreting existing information and studies in the context of habitat restoration planning- not necessarily the original primary purpose of those studies -- so that restoration potential may be meaningfully evaluated. We also attempted to emphasize certain sub-basins or general areas of information where new information seemed most needed, or where potential restoration opportunities have already been identified.

1.1 Objectives and Critical Questions

The primary objective of this report is to describe historic and present-day watershed and reach-scale hydrologic and geomorphic conditions in the Pismo Creek watershed. A central goal in establishing this objective is to outline whether these conditions have been or currently are limiting steelhead trout (*Oncorhynchus mykiss*) populations in Pismo Creek. With input from watershed stakeholders, several 'assessment framing' critical questions were formulated by Balance and Central Coast Salmon Enhancement to guide the process of answering this question and meeting the primary objective of the hydrologic and geomorphic assessment. Critical questions were originally proposed by Balance Hydrologics, revised by Central Coast Salmon Enhancement, and then refined again during a stakeholders meeting that took place on May 8, 2007. These questions include the following:

- What presently appear to be primary physical or geochemical fish habitat constraints, and to what extent do each of the following affect habitat:
  - Water quality?
  - Baseflow?
  - Sediment deposition?
  - Turbidity?

- What baseflows might be expected in the watershed under natural conditions, without diversions?

- Where are the main potential sediment sources, and to what degree have land management practices exacerbated these sources? What approaches may be employed in slowing the rate of sediment delivery to the channel?

- What are the water-quality implications of ground-water discharge from the geologic units associated with bituminous sandstone beds in the lower watershed?

- Where are stream baseflow sources and sinks -- i.e. where is the stream losing/gaining? What aquifer(s) provide(s) the source of water ('recharge areas') in the gaining reaches?

- What are presently the effective, channel-forming flows?

- What were the physical characteristics of historical stream conditions (pattern, bed conditions and stability)? Do these characteristics differ from present day conditions?

As is often the case, numerous other questions arose during the investigation. When feasible, we have collected data or prepared analyses to begin addressing some of these additional questions in this study, as discussed below. In other cases, we make specific recommendations for additional future studies.

1.2 Work Conducted

The organization of this report follows the same general chronology by which we conducted our study. We began with a review of background information, based on Salmon Enhancement and others' interpretation that low flows – and the attendant habitat, migration, temperature, and water-quality conditions – are primary constraints to the long-term viability of salmonid runs. Our search for pertinent information included historical aerial photography, published geologic and soils mapping, and prior regional work, including data published by various resource management agencies[1] and earlier work by Balance staff to assemble prior streamflow and sediment measurements (c.f., Hecht, 2006). Background information is presented in Section 2 of this report.

As we collected and reviewed this information, we conducted a reconnaissance-level, field-based baseflow-hydrology and channel-morphology assessment with an emphasis on low flows. The analysis was based in part on changes observed during the seasonal decline in flows during the early part of the dry season. An initial watershed reconnaissance visit was conducted on May 9, 2007 and stream walks were conducted in reaches where access permission had been granted and coordinated on June 6-7, 2007, with a follow-up visit occurring on July 10, 2007. During the stream walks, we recorded streamflow, specific conductance, and channel geometry[2]. Based on our observations during these initial field visits, we selected several locations for additional water quality sampling and analysis (general minerals). On July 3, 2007, Central Coast Salmon Enhancement staff collected samples from these locations.

Hydrology data and discussions are presented in Section 3, which includes watershed-wide peak-flow modeling results and historical baseflow estimates. Channel conditions observed during the field study are discussed in Section 4.

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1 Related information also has important applications to storm-water and wet-period conditions as well.
2 Similar measurements had been made by Balance staff at about a dozen sites during wet-year conditions in April 2005.

2. WATERSHED SETTING

The Pismo Creek watershed is located near the southern end of the Santa Lucia Mountains in San Luis Obispo County (Figure 1), just south of the city of San Luis Obispo, part of California's Coast Ranges Geomorphic Province. Elevations range from 2,850 feet in the headwaters to sea level at the mouth. The watershed is approximately 37.8 square miles in area, and drains into the Pacific Ocean via Pismo Lagoon in the City of Pismo Beach. Most land in the watershed is privately owned and is used for agriculture (viticulture, orchards, produce, and beef cattle) and oil production, with increasing residential development in Edna Valley, the central portion of the watershed. The lowermost reaches of the creek flow through urbanized portions of the City.

The geologic history of this region has given rise to distinct geomorphic settings in the watershed. For the purposes of this study, we consider four zones, shown in Figure 1:

1. The mountainous Upper Watershed is covered by grasslands with narrow riparian vegetation along headwater channels and canyon bottoms. This area includes headwaters of most tributaries to Pismo Creek. Limited grazing occurs here, but this zone is apparently predominately wild, largely owing to the steep slopes and minimal access.

2. Edna Valley is a gently sloping valley occupying the central portion of the watershed with elevations ranging from about 280 to 320 feet. Tributaries to Pismo Creek cross the valley flowing from northeast to southwest, and form the main stem of Pismo Creek at the southwestern edge of the valley. Land use here is predominately for agriculture, with increasing residential development.

3. The main branch of Pismo Creek crosses the San Luis Range through Price Canyon. Within the Pismo Watershed, elevations in the San Luis Mountains range from approximately 100 to 800 feet. Plains Exploration and Production Company (PXP) is the largest landholder in this area, where significant oil-bearing and bituminous geologic formations exist.

4. The terraces, floodplain and Pismo Lagoon at the Coast largely support residential housing and urban and tourist amenities associated with the town of Pismo Beach. Pismo Lagoon[3] is bordered by several municipal parks on the west bank, and private recreational vehicle park on the east bank.

[3] Habitat conditions and management needs for Pismo Lagoon, which supports tidewater gobies, a federally listed species, will be assessed as part of separate subsequent studies. As with Pismo Creek, low flows and sedimentation are thought to be significant issues.

2.1 Past Projects and Related Studies

Geology is a critical underpinning for habitat planning in the Pismo watershed. The watershed and immediate vicinity have been mapped geologically by Hall (1973), Dibblee (2004, 2006a,b), and Nitchman (1988). Their work has been applied to ground-water conditions by Iwanaga (1979) and Van Vlack (1991) and others. Soils have also been mapped (USDA, 1984). Neither geologists nor soil scientists have approached questions of erodibility, or channel stability, in the Pismo watershed as they have in other nearby watersheds (Knott, 1973; Glysson, 1977; Knudsen and others, 1992; Hecht and Malmon, 2002; Swanson, 2004). Gaging of Pismo Creek occurred in water years 1990 through 1992, sponsored by the City of Pismo Beach, and is detailed in contemporary memos and a previous Balance report for CCSE (Hecht, 2006). No prior watershed-wide analysis of baseflows – seemingly the key limiting factor – has been conducted. Important water-quality data collected by the Department of Fish and Game and other agencies is summarized in Hecht (2006), including the presence in Pismo Creek of naturally-occurring phenols, considered toxic to most fish, including salmonids. Spina (2004) provided an overview of instream habitat characteristics within the Pismo Creek watershed, and Jennifer Nelson (Department of Fish and Game) has completed a draft habitat typing report for conditions as they prevailed in 2005. Also in 2005, Balance conducted a one-day visit to portions of the watershed and collected a limited number of salinity measurements and stream discharge estimates, as summarized in Hecht (2006). A chronology of major floods is presented in Brown (2002) for Arroyo Grande Creek, but the effects of these floods on both riparian vegetation and bed conditions in Pismo Creek (which in turn affect baseflows) is presently lacking; the nature and recurrence of these events are critical factors in habitat assessment and watershed planning throughout central coastal streams, as discussed below.

2.2 Hydrography

The watershed has three major tributary basins in the upper watershed: West Corral de Piedra, East Corral de Piedra, and Cañada Verde[4]. A fourth significant tributary, Cuevitas Creek, enters Pismo Creek from the west in lower Price Canyon. The locations of these tributary basins are shown in Figure 1. Significant smaller tributary streams are present in each of these subwatersheds. Representative channel gradients for smaller upper watershed tributaries are

[4] Cañada Verde may also be referred to as the 'East Branch of Pismo Creek' in county or state planning documents, as indicated by signposts at the Route 227 bridge. For this study, we are using nomenclature per USGS topographic mapping.

approximately 6 to 8 percent[5]; for the lower reaches of East and West Corral de Piedra it is approximately 0.5 to 3 percent, and for the lower mainstem it is approximately 0.75 percent.

The region experiences a Mediterranean-type climate with cool, wet winters and hot, dry summers. The wet season typically extends from November through March with local long-term, mean annual precipitation ranging from 16 inches near the coast to approximately 33 inches in the headwaters (City of San Luis Obispo and County of San Luis Obispo, 2003). Winter temperatures typically range from 40 to 70°F while summer temperatures typically range from 60 to 90°F. Summertime fog can be an important hydrologic component for sustaining vegetation near the coast during summer months, which are otherwise usually dry.

2.3 Watershed Geology

The Pismo Creek watershed consists of three distinct geologic blocks separated by the Edna and Huasna fault zones (Figures 2 and 3). This section of the report describes the three blocks and the fault zones, with factors affecting (a) ground-water-bearing properties and yields, and (b) geomorphology and sediment production. The most detailed geologic mapping has been carried out by Hall (1973), with some limited additional work in the watershed by Nitchmann (1988) and Dibblee (2004, 2006a, 2006b). Geologic mapping is generally consistent between these authors. For the purposes of this investigation, we have used digital geologic data provided by the County of San Luis Obispo with descriptions of geology from both Hall (1973) and Dibblee (2004, 2006a, 2006b).

The upper watershed is underlain by Franciscan metasediments and ultrabasic rocks (mainly serpentines), and upper Cretaceous and early Tertiary sedimentary units. The Edna Valley comprises the middle third of the watershed, with a critical veneer of water-bearing sedimentary rocks typically 100 feet in thickness – ranging up to 300 feet -- overlying Franciscan and consolidated-sedimentary rocks (Van Vlack, 1991). The Coastal San Luis Range is composed of mainly mid- to late-Miocene (late-Tertiary) consolidated sedimentary rocks of the Monterey and Pismo formations, plus coeval volcanic units of the Obispo formation, forming most of the ridge along the coast.

[5] A channel gradient of 10 percent equals a rise of 528 feet over a longitudinal distance of roughly 5,280 feet (1 mile).

2.3.1 Upper watershed geology

North and east of the West Huasna Fault Zone, uplifted Tertiary marine sedimentary rocks are exposed in the watershed's highest elevations at the crest of the Santa Lucia Range. The Miocene Monterey formation caps the headwaters of the East and West Corral de Piedra subwatersheds, with some exposure of older underlying units, including the Point Sal, Obsipo (Hall, 1973), Toro (Dibblee, 2006) and other unnamed marine sedimentary units within the fault zone. Underlying Franciscan-assemblage basement rocks (and associated serpentine) are found immediately southwest of the fault zone in the hills which flank the northeast side of Edna Valley. As occurs elsewhere in Franciscan mélange, these metasediments and other basement rocks have no apparent stratigraphy or continuity, although small pockets of chert, greywacke, and greenstone have been mapped. These significant serpentine outcrops, metamorphosed masses of deep oceanic igneous materials, are likely associated with ancient fault movement in precursors to the West Huasna fault zone. Serpentines have been mapped in each of the three major tributaries to Pismo Creek, as shown on Figure 2.

Rapid uplift, deep valleys and seismic activity in relatively weak rocks mean that landsliding and other forms of mass wasting are an intrinsic process by which sediment and wood enter the streams of the Pismo watershed. Landslides and other processes of rapid downslope movement are frequent, extensive, and often large. As shown in Figure 2, they are especially prevalent in the steep upper watershed.

2.3.2 Edna Valley geology

Material eroded from the upper watershed areas has been deposited as alluvium (unconsolidated floodplain and channel deposits) in the basin between the Edna and West Huasna fault zones to form the Edna Valley. Prior to initiation of the Edna fault and uplift of the San Luis Range (probably during the early Pleistocene), streams generally flowed southwest and south, directly toward the coast, depositing the Paso Robles formation-- rounded pebbles and sandstone derived from the Monterey and Franciscan sediments of the Santa Lucia Range. Cleath (1978) divides the Paso Robles formation into two members, a lower marine and an upper non-marine member. Hall (1973) notes that water wells developed in the Paso Robles formation reflect a generally lower-transmissivity (lower permeability) aquifer than wells developed in the alluvium.

Following deposition of the Paso Robles formation, Quaternary alluvium was and continues to be deposited on the valley floor, typically atop the Paso Robles. Alluvium is generally the parent material of the richer valley-bottom soils supporting riparian vegetation, and is the substrate from which the bed and banks of the channels are formed. Locally, alluvium serves as an important aquifer for watershed residents.

2.3.3 Geology of the coastal mountains

The Pismo and Monterey formations are part of the broad Pismo Syncline, which spans the San Luis Range in the area of Price Canyon. Both formations are exposed throughout the range, and are noted as oil- and petroleum-bearing. In particular, the Edna member of the Pismo formation is cited by Hall (1973) as consisting of both non-bituminous and bituminous sandstone beds, and is the likely source of the prominent tar-filled beds and dikes, as well as saltier connate waters which drain to the creek and its tributaries. Several seeps and springs are also evident in heavily -fractured portions of the Pismo formation, such as along Price Canyon Road, just south of the town of Edna.

The Squire Member of the Pismo formation is also present along the Edna fault zone, especially in portions of the Canada Verde watershed.

2.4 Soils

The soils mantling these formations generally reflect the underlying geologic units from which they have developed. As with the geology, the distribution of soils is relatively heterogeneous, and many of the soils consist of silt and clay loams. These are prone to limited infiltration and ground-water recharge rates, as well as rapid and extensive erosion from land uses practices, which also compact or further diminish the permeability of the soils, or which concentrate flows beyond those typical of natural drainage (such as channel re-alignment for agriculture, urbanization, or confined animal grazing).

Figure 4 is a map showing the distribution of soils according to standard hydrologic groups, and indicates that the most permeable soils (Group A) are found in floodplains along the main stem of Canada Verde Creek and Tiber Canyon, as well as in a portion of the Cuevitas watershed. Group B soils are largely concentrated in the lower watershed and the San Luis Range, developed from the Pismo and Monterey formations, while Group C and D soils (silty and clayey loams with low infiltration rates and high runoff potential) are largely derived from and mapped as overlying Cretaceous basement rocks in the upper watershed. Soils developed in Edna Valley alluvium derived from the silt- and clay-rich rocks in the upper watershed are also mapped largely as Group D soils.

2.5 Hydrology

Rainfall in the watershed ranges from 16 inches at the coast to approximately 32 inches in the upper watershed (City of San Luis Obispo and County of San Luis Obispo, 2003). Mean annual rainfall at the San Luis Obispo Edna Valley station is approximately 22.45 inches, according to the long-term record of rainfall collected just west of the watershed at California Polytechnical Institute. Figure 5 is the City of San Luis Obispo rainfall record from 1904 to 2007. It shows an increase in the number of extreme events during the latter half of the last century. The maximum annual rainfall occurred in 1969, the same year the flood of record was recorded on nearby streams. Work for this study was conducted during spring 2007, during one of the driest two-year period on record.

The USGS and San Luis Obispo County have maintained a streamflow gaging station on Arroyo Grande near Arroyo Grande since 1939, and collected sediment transport data in the Arroyo Grande watershed during water years 1968 to 1972. Water-quality data were collected in the watershed during water year 1977 (c.f., Maisner, 2002). We have calculated a relationship between streamflow in Lopez Creek, a tributary to Arroyo Grande, to that on Pismo Creek, which was measured and recorded by Balance Hydrologics during water years 1990 to 1992. This relationship was used to produce a synthetic Pismo Creek streamflow record for 1939 through the present, as described in Section 3.1.4, below.

2.6 Hydrogeology

Cleath (1978) described the ground water geology of the San Luis Obispo area and concluded that economically significant ground-water resources in the Pismo watershed are limited to alluvium and the underlying Paso Robles formation in Edna Valley. Subsequent work by the California Department of Water Resources (Maisner and Tompkins, 2002) has also highlighted the Squire Member of the Pismo formation as an important ground-water resource. Within the Pismo watershed, this unit is primarily found in the middle portion of the Canada Verde watershed, as well as near the mouth of Price Canyon, in the hills just east of Price House.

Long-term ground-water monitoring data collected in Edna Valley is presented in Figure 6 for the period 1957 through 1993. The long-term record shows several extreme years when ground-water levels fell to significantly low elevations. These low water-table conditions are associated with drought years, or years with significantly below-average rainfall (Figure 5). It might be noted that, in each and every case, water levels recovered rapidly during the first wet year following a significant ground-water level decline, suggesting that the recharge functions of the watershed were operating effectively during the monitoring period. Long-term water-level measurements are no longer being made by the California Department of Water Resources.

3. HYDROLOGIC ASSESSMENT

The primary objectives of the hydrology assessment are to:

1. Describe the presence or absence of baseflow in various reaches during an extremely dry year,
2. Describe stream-aquifer interactions in terms of 'losing' and 'gaining' reaches.
3. Estimate the recurrence of peak flows at various locations in the watershed, and
4. Estimate the recurrence of channel-adjusting flows,
5. Identify general ground-water recharge areas that should be managed to maintain baseflow in the main stem of Pismo Creek,

These issues relate to ground-water recharge and flow, and associated ramifications on water quality and sensitive-habitat support, so Balance Hydrologics staff conducted a watershed-wide baseflow survey during spring and summer 2007, after one of the driest winters on record.

3.1 Methods

3.1.1 Baseflow surveys

Following our review of existing publications and data, we visited several locations throughout the watershed, as shown on Figure 7 and recorded streamflow and specific conductance. Specific conductance is a widely used measure of the ability of water to conduct electricity, and indicates the concentration of total dissolved solids (or 'salinity') in the water. As water passes over and through the ground, salts are dissolved, increasing the conductance. Higher specific conductance therefore typically indicates longer residence times in the ground, transmittal through soils or geologic units which may have higher natural concentrations of salts, or evaporation and concentration of dissolved ions; it can also derive from human or cultural sources that may be saltier than the stream. Lower specific conductance generally reflects runoff or recharge from direct rainfall, or limited residence time in the ground. As a result, we have used specific conductance as a tool for inferring water origin and movement.

At each location we measured streamflow according to:

- **Bucket-and-stopwatch method**, in which the time necessary to fill a known volume is recorded,

- **Float test method**, where the cross-sectional flow area is measured with a tape measure and multiplied by stream velocity, as measured by recording the time necessary for a float (twig or leaf) to travel a measured distance; the surface velocity is conventionally multiplied by 0.8 to estimate the mean velocity in the cross section, as surface velocities tend to be somewhat higher than average,

- **Dye method**, where the cross-section flow area is measured with a tape measure and multiplied by stream velocity, as measured by recording the time necessary for a cloud of standard water-tracing rhodamine WT dye to travel a measured distance, or

- **Visual estimate**, using a rapid assessment of channel cross-sectional area and water velocity. Visual estimates were made only after carrying out several measurements using the methods above, on each day. Low-flow visual estimates are considered to give reproducible order-of-magnitude approximations of flow, appropriate for comparisons between tributaries, but are of lower reliability than the other methods, all other factors being equal.

During 2007, flows were generally too low to measure with bucket-wheel current meters. Specific conductance was measured using a YSI Model 30 hand-held meter, calibrated with KOH standards, prepared by a commercial laboratory, of 500 and 1500 micromhos/cm.

3.1.2 General minerals sampling and analysis

On July 3, 2007, Central Coast Salmon Enhancement staff collected water quality samples at four locations, as shown in Figure 7 (sample station ID in parentheses):

- West Corral de Piedra Creek at Edna Road (WCER)

- Canada Verde at Corbett Canyon Road (CVCC)

- Pismo Creek at Ormonde Road (PCOR)

- Pismo Creek at Price House (PCPH)

Prior to entering the stream, all bottles and/or bags were be labeled with the sample identifier, date and time of collection. Samplers inspected the stream channel 50 to 100 yards upstream from the proposed sampling location for unusual conditions which might affect the concentration of nitrogen (e.g., fresh waste or animal carcass) or sediment (e.g., logjam) in the stream water, and recorded any anomalous conditions, including water color, odor or clarity and whether the stream was rising, falling or steady.

The stream was then entered at a location slightly downstream from the intended sampling section, to minimize bottom sediment entrained by walking. Grab samples were collected in the water column at a depth of approximately six tenths depth below the water surface. The sample bottle was rinsed three times with sample water prior to collection.

Measurements of pH were made using a LaMotte model 3-5886 Low Cost water monitoring kit. Discharge and specific conductance measurements were not made at the time of sampling.

All samples were carried back to the field vehicle, placed in an ice chest, and delivered to the analytical laboratory within 24 hours of sampling. The samples were analyzed by Creek Environmental Laboratories for general minerals as a means of assessing and relating (or 'major-ion fingerprinting') the likely sources of water.

3.1.3 Peak flow modeling

Peak flow estimates were carried out by:

1. Using the U.S. Army Corps of Engineers Hydrologic Modeling System (HEC-HMS) version 3.1.0 in conjunction with the Geospatial Hydrologic Modeling Extension (HEC-GeoHMS) version 1.1 for use with ArcView Geographic Information System (ArcGIS), and

2. Analyzing the 40-year record of peak flows in Lopez Creek near Arroyo Grande, as gaged by the U.S. Geological Survey (USGS) to identify the return periods for years during which peak flows were gaged on Pismo Creek by Balance Hydrologics.

HEC-HMS is an industry standard package for modeling rainfall, hydrologic losses, overland hydrograph routing, and runoff storage in detention basins or reservoirs. HEC-GeoHMS was developed as a geospatial hydrology tool kit for engineers and hydrologists. The program allows users to visualize spatial information, delineate subbasins and streams, construction inputs to hydrologic models, and assist with report preparation. It operates as an extension for ArcGIS that analyzes digital terrain information and transforms the drainage paths and watershed boundaries into a hydrology data structure that represents the watershed response to precipitation. The hydrologic results from HEC-GeoHMS are then imported to HEC-HMS, where meteorological data are added and the rainfall-runoff relation is simulated.

3.1.3.1 Meteorological model

The meteorological model was developed using the precipitation gage records from Lopez Dam (SLO #178.1) operated by the San Luis Obispo County Flood Control and Water Conservation District. The model encompasses the full period of record, from 1969 to present. A log-Pearson probability distribution was applied to the annual peak data and a frequency hyetograph was developed for the 1% exceedance (100-year, 24-hour) storm and an approximately 50% exceedance (or 2-year, 24-hour storm) based on 1992 rain data. The primary advantage in using actual 1992 rainfall data is that streamflow on Pismo Creek was gaged during water years 1990 through 1992 (Hecht, 2006), providing useful data for model calibration.

The rainfall distribution data was then entered in the HEC-HMS model and used to generate the flows in the Pismo Creek watershed model. The meteorologic model data are presented in Table 1.

3.1.3.2 Watershed model setup

The watershed model for Pismo Creek was developed in HEC-GeoHMS using the digital elevation model (DEM) for San Luis Obispo County developed in November 2001 by the County of San Luis Obispo and UC Santa Barbara Donald Bren School of Environmental Science and Management (http://lib.calpoly.edu:8080/gis/).

From this DEM, the Pismo Creek watershed and subbasins within the watershed were delineated using the GeoHMS extension in ArcGIS (Figure 8). The GeoHMS extension was then run to calculate the channel and watershed properties needed to calculate the time of concentration for the subbasins, including: flow direction, flow accumulation, river lengths and slopes, basin centroids, longest flow paths and centroidal flow paths.

Taking the above inputs, the HEC-GeoHMS extension exported the required data for adjustment by the user. Channel dimensions and Manning's roughness factors were estimated from field visits (c.f., Arcement and Schneider, 1989; Barnes, 1967) and prior gaging in the watershed and factored into the spreadsheet. Then using the Natural Resources Conservation Service (NRCS) TR-55 methodology, the time of concentration and lag time were estimated (Table 2).

After time of concentration and lag time were calculated, the GIS version of the model was exported to HEC-HMS. By using the GeoHMS extension, the subbasin, junction and river reach data are automatically populated in HEC-HMS, saving the user from entering the basin model information manually. In addition, this allows the HMS model to be georeferenced and aerial photos or background maps to be brought into the model.

At this time, the model represents the entire Pismo Creek watershed to the best of our abilities -- with one exception. There is a significant privately-owned reservoir active in the upper reaches of the West Corral de Piedra watershed that could not be modeled. Not enough information is available at this time to describe the dimensions and operation of the reservoir, so for the purposes of this model, a watershed was delineated at its approximate location, until such time as this information is available.

3.1.4 Baseflow modeling

Expected baseflows in Pismo Creek were modeled by correlating measured flows on Pismo Creek to those on Upper Lopez Creek. Pismo Creek was gaged by Balance Hydrologics during water years 1990, 1991, and 1992 for the City of Pismo Beach at a discontinued station located adjacent to the City's corporation yard, about 100 yards downstream from the lower railroad bridge. (Hecht, 2006). Streamflow was gaged using standard open-channel flow methods typical of hydrologic analysis prepared for water-rights applications. The approach used involves frequent measurements of water level in the stream, from which instantaneous streamflow is computed using rating curves established empirically by streamflow measurements at varying water levels (or 'stages').

On November 21 and 22, 1989, Balance Hydrologics personnel and City of Pismo Beach staff installed a standard 'Type C' outside staff plate, to which two stilling wells containing pre-calibrated Druck® pressure transducers were attached. The pressure transducers were connected to a Campbell Scientific CR10 datalogger, programmed to record in 15-minute intervals, housed within the corporation yard maintenance shed. City specialists, and occasionally Balance Hydrologics personnel, made daily observations of water level at the Type C staff plate. These observations aided Balance staff in post-calibrating the transducers and to establish when changes in bed conditions required a shift or a change in the empirical streamflow rating curves (see Bodhaine and Taft, 1961; Edwards and Glysson, 1992).

Each year, Balance Hydrologics staff made a number of streamflow measurements to empirically quantify the relationship between stage and instantaneous streamflow over the range of water levels which occurred during the year. Five measurements were made on the few days sustaining flow during the very dry conditions encountered during water year 1990, when total flow for the seasons was measured to be 79.8 acre feet. More frequent measurements were made during the storms of the subsequent two years. Measurements were made with Price-type bucket-wheel current meters, with both wading-rod and cable-suspension methods, using standard techniques and computations.

Mean daily streamflow values were calculated for the period of record by averaging the ninety-six 15-minute streamflow values for a given day. These data were plotted against mean daily streamflow on Lopez Creek on the same day to develop a correlation equation between the two creeks, as shown in Figure 9. Appendix A contains daily flow data and hydrographs for the Pismo Creek gaging period of record that were used in this correlation.

3.2 Findings and Discussion: Stream-Aquifer Interactions

3.2.1 Salinity Variations with Flow during early 1990s stream gaging

We measured specific conductance – an index of salinity -- many times throughout water year 1992. Data collected concurrent with streamflow measurements or stage observations are described in Hecht (2006). The data show that specific conductance increased exponentially as streamflow diminished. This exponential pattern is quite unusual in coastal streams, and suggests that the relationship is best interpreted as a combination of the typical regional pattern with a low-volume source or sources of water of elevated salinity. Work preceding our streamflow and specific conductance measurements pointed toward the conclusion that elevated salinities are found scattered in the southern third of the watershed, in waters emanating from tributaries and from springs reported to also discharge detectable levels of natural gasses and other atypical constituents, an inference consistent with the limited measurements of specific conductance made in April 2006, although flows were too large to point strongly to any particular aquifer, spring, or area as a source.

Specific conductance may serve as an indicator to help assess where unusual constituents may be entering the stream system, should future sampling establish our inferred linkage.

3.2.2 Summer 2007 Field surveys

Table 3 and Figure 10 summarize field baseflow data collected in the watershed during the study period. As expected, streamflows decreased through the summer at nearly all locations. Maximum streamflows were observed in the upper watershed on East Corral de Piedra Creek and in the lower watershed along Pismo Creek at Ormonde Road and at the Price House property, while several channels (East and West Corral de Piedra Creeks) were observed to be dry in May. These data suggest that streamflow readily infiltrates into the sands and gravels of the Edna Valley alluvium where streams enter the valley.

Streamflow returns to the channels at the south end of the valley where the Edna fault zone truncates alluvium and the Paso Robles formation (Figure 10). Ground-water up-welling along the fault is observable in East Corral de Piedra Creek in the town of Edna where noticeable increases in streamflow are evident over a short reach, in streambanks on the Main Stem of Pismo Creek downstream of the confluence of East and West Corral de Piedra Creeks, and just upstream of the confluence with Canada Verde Creek.

Similarly, streamflow in Canada Verde Creek was found to persist later into the summer, especially downstream of the Edna fault and the Squire member of the Pismo formation. Higher streamflow in this area may be attributed to upwelling of deeper ground-water in the Edna fault zone, or perhaps discharge from bedrock to a channel with limited alluvium and infiltration potential. The rolling hills of Canada Verde's tributaries are largely incised into the Paso Robles formation, with limited volumes of recent alluvium. Soils are mapped in this area largely as belonging to hydrologic soil group A and B (Figure 4), indicating that these areas may be especially suitable for ground-water recharge during storms, and also slow release of ground-water to streams during baseflow periods. Enhanced color-infrared photography (Figure 11) of the watershed indicates that the Canada Verde floodplain below the Edna fault consists of extensive wet meadows, perhaps related to seeps and springs emanating from either the Paso Robles or deeper formations. As a result, the riparian corridor in this area is fairly well-intact, with the exception of certain heavily-grazed areas.

At the confluence of East and West Corral de Piedra, the flow contribution from West Corral de Piedra was found to be greater than flows in East Corral de Piedra. A flow of 65 gallons per minute (gpm) was measured in West Corral compared to 14 gpm in East Corral.

Stream temperatures ranged from 13°C to 25.5°C with minimum temperatures occurring near the location where most ground-water inflow occurs at the confluence of East and West Corral de Piedra Creeks. Maximum temperatures were observed in areas of slow moving water at a variety of locations. Specific conductance ranged from 618 μmhos/cm to 2486 μmhos/cm, normalized to the standard 25°C. Minimum specific conductance was observed in the upper watershed in waters emanating from Cretaceous basement rocks, while maximum conductance was observed in the lower reaches of Pismo Creek just upstream and downstream of Highway 101. Figure 10 may suggest a slight increase in specific conductance associated with waters near the Edna fault zone, an influx of slightly fresher water as the stream passes through the Pismo formation, and a slight rise in conductance toward the mouth of the creek. While this rise may reflect in part brackish summer conditions in Pismo Lagoon, it likely is associated with inflows from bedrock seeps just upstream of the corporation yard. In fact, Hecht (2006) showed that measurements of specific conductance at Balance's corporation yard gage – well above the possible influence of the lagoon -- rose to the range of 2000 to 3000 μmhos/cm during the extended hard drought of 1990 and early 1991. We believe the rise in dry-year specific conductance is an indication of persistent bedrock inflows.

Table 4 presents the results of general minerals sampling and Figure 12 is a trilinear ('Piper') plot of the general mineral data. The Piper plot is a useful interpretative tool in illustrating differences and similarities among waters. Total dissolved solids and specific conductance were found to be lower in Canada Verde at Corbett Canyon Road. Pismo Creek at the Price House was found to be slightly higher in relative sulfate concentrations, perhaps due to upstream contact with bituminous sandstones and the related shales, either through natural seepage or indirectly as inflow from oil-production areas. Data reported by Entrix (2006) did not indicate an increase in sulfur concentrations upstream of Cuevitas Creek, and relationships shown in Figure 10 and discussed above imply the salinity increases are associated with areas upstream and downstream of the Entrix sampling stations. Therefore, if further investigations are to take place to evaluate a potential source of elevated sulfates, we recommend directing the investigation in the downstream portion of Price Canyon or in areas immediately downstream of Edna.

West Corral de Piedra also reflects a slightly different chemistry, with a higher relative magnesium concentration, perhaps reflecting upwelling of deeper water associated with the Edna fault zone and/or a greater influence of ground water emanating from the magnesium-rich, ultrabasic serpentinite which make up more of its watershed than those of the other tributaries. The general chemistry of lower Pismo Creek at low flow reflects a mixture of these waters, and other sources as well, and may change from year to year, depending upon rainfall and the recency of recharge.

3.3 Findings and Discussion: Surface Hydrology

3.3.1 Peak flows

The HEC-HMS watershed model for Pismo Creek was run with the 100-year and the 2-year storm meteorological data, calculating flows for these events at various locations within the watershed, as presented in Table 5 and shown in Figure 8. Modeled streamflows agree fairly well with the moderate peak flows measured during water year 1992 near the mouth of Pismo Creek (Hecht, 2006), suggesting that the model is fairly predictive at intermediate flows. We have described the 1992 peak as a 1.6-year event, based on the long-term record in Lopez Creek. Assuming that this event was of the same relative magnitude in Pismo Creek, the 1.6-year event may be described as 3,550 cfs in Pismo Creek, roughly 95 cfs per square mile. The unit runoff from the 1.6-year event in Lopez Creek was approximately 15 cfs per square mile in Lopez Creek, corresponding to approximately 935 cfs in the Pismo Watershed.[6]

Existing estimates of the 100-year discharge on Pismo Creek are fairly wide-ranging as well, as there is not a sufficiently long period of record to calculate the 100-year flow. Figure 13 is an annual peak series plot for Lopez Creek, and indicates the 100-year flow in that watershed to be on the order of 3,650 cfs (175 cfs per square mile). This corresponds to a 100-year flow of roughly 6,530 cfs in the Pismo Watershed. These two estimates are both well below the Federal Emergency Management Administration's 100-year flow estimate of 14,700 cfs (393 cfs per square mile), but in line with San Luis Obispo County's (Smith and Banerdt, 2004) estimate of 2387 cfs (156 cfs per square mile) at the Southern Pacific Railroad crossing. Entrix (2006) has estimated the 100-yr discharge on Pismo Creek at 55,937 cfs, based on extrapolation of estimates of the 100-year flow in Toro Creek near Morro Bay. It should be noted that 100-year flow in Toro Creek is based on a limited (7-year) data set. These estimates are all independent of a

[6] Runoff in the Santa Ynez watershed (USGS gaging station 11123500) during the February 1992 storm was approximately 70 cfs per square mile.

private impoundment on West Corral de Piedra near the mouth of the canyon; little is known about the operation and size of that reservoir.

The peak discharge on Lopez Creek for the period of record was 2,830 cfs on January 25, 1969, equal to a unit runoff of 135 cfs/sq. mi. Application of this peak unit runoff to Pismo Creek yields an estimate of about 5,000 cfs at the mouth for the 1969 storm. In fact, flows were large in the Pismo watershed; we have seen 1972[7] aerial photographs showing nearly all of the riparian vegetation in lowermost Price Canyon as having been episodically re-set (stripped away), a critical process in streams of similar size throughout the Central Coast region (c.f., Singer and Swanson, 1983; Capelli and Keller, 1988; Hecht, 1993) but one not documented on Pismo Creek.

3.3.2 Baseflow

We have applied the correlation equations shown in Figure 9 to the long-term record from Lopez Creek, a largely undisturbed watershed, to estimate an appropriate range of low flows in Pismo Creek, as presented in Table 6. Table 7 suggests that these low flows are not necessarily related to the total rainfall in a given year, so future evaluations of whether low flows in Pismo Creek are affected by changing land use in the watershed is perhaps best accomplished by continued comparison to the Lopez Creek gage. It should also be noted that the correlation presented in Figure 9 reflects watershed land use conditions in the early 1990s, after the West Corral de Piedra impoundment was in place, so using the correlation as a basis of comparison is valuable in terms of assessing the deviation from early 1990's conditions, but not necessarily deviation from pre-European contact conditions.

As shown in Table 6, the correlated baseflow record in Pismo Creek indicates a range of historical low flows, from 0 cfs in August and September of dry years (such as 2007) to as high as 7.5 cfs in extremely wet years. The median September low flow (to be expected in half of the years) was calculated to be 0.11 cfs. Correlations of low flows are simply estimates, warranting calibration, and may differ considerably along a sandy stream such as Pismo Creek.

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[7] The 1972 date is significant in assigning this re-set to the January and February 1969 storms, as a very localized major storm affected the San Luis Obispo area on January 18, 1973. The latter event is the storm of record for San Luis Obispo Creek and several adjacent tributaries (such as Los Osos Creek), but did not generate noteworthy peaks on many other regional streams (U.S. Army Corps of Engineers, 1973). We do not yet know the magnitude or effects of the 1973 event in the Pismo watershed, a topic worthy of future inquiry by the watershed group, perhaps through seeking eyewitness accounts of 1969 and 1973 floods.

It is important to note that significant geomorphic and beaver activity and the impounding of water throughout the City Corporation Yard Reach has made it difficult to re-occupy the Balance Hydrologics gage that was established near Highway 1 in the early 1990s. Late summer baseflow measurements made near the Price House Property in 2007, an extremely dry year, were in fact higher than those measured at the City Corporation Yard in 1991 and 1992 (Appendix A). This is perhaps an indication that the City Corporation Yard reach may have been a losing reach prior to the development of the beaver dam.[8] Summer low flows can also be affected by even moderate levels of ground-water pumping adjoining the stream. These estimates of typical low flows may therefore not be applicable to areas immediately upstream of the former gaging site (e.g., the Price House Property).

3.4 Conclusions of the Hydrologic Assessment

General

Information presently available for Pismo Creek and its tributaries is noticeably less than for most other watersheds of similar size in San Luis Obispo and northern Santa Barbara Counties. This study and related efforts through CCSE are an initial attempt to provide basic information readily available in most other areas of the region, such as watershed geology, streamflow, general water quality, and sources of baseflow. Efforts to collect additional primary observations and historical information in these arenas will be particularly valuable, and can support meaningful future watershed planning. At a minimum, we recommend:

1. Establishing a comprehensive ground-water monitoring program in Edna Valley, in which wells are monitored bi-annually in the early spring and later summer.
2. Establishing a water-quality monitoring program in Price Canyon, including standard field parameters, general minerals, and constituents (such as phenols) related to the naturally-occurring hydrocarbons in the watershed which are thought deleterious to key aquatic species.
3. Stream and sediment gaging and continuous water-quality monitoring (specific conductance, pH, and temperature) should be an integral component of a water quality monitoring program in Price Canyon, and would further document the persistence of low flows and sediment transport dynamics in the watershed. If feasible, additional gages on West Corral de Piedra and Canada Verde would provide further insight as to the relative baseflow contribution provided by each of these tributaries.

[8] City staff report that tidal influences do not extend more than 100 feet upstream of Highway 101.

Results of water-quality sampling for general minerals indicates that waters emanate from varying geologic sources within the watershed, and that distinct signatures are probably characteristic of a number of geologic units. As additional general mineral ('major ion') analyses are performed, the fingerprints of the individual geologic sources will become better known in the Pismo Creek watershed, as they are known in the Santa Ynez and other Santa Barbara County watersheds, and to a lesser extent in the Arroyo Grande watershed (c.f., Maisner and Thompson, 2002), In the Pismo Creek watershed, specific conductance-to-discharge relationships and major ion ratios can be important means of (a) understanding recharge processes, (b) evaluating the effectiveness of runoff control, and (c) evaluating sources of baseflow.

High-flow hydrology

Peak flows (100-year recurrence) can be expected to be on the order of 150 to 200 cfs per square mile and intermediate (1.6-year recurrence) flows can be expected to be on the order of 15 to 90 cfs per square mile, based on the modeling conducted, and calibrated to measured flows in nearby similar watersheds.

Soil types vary substantially throughout the Pismo Creek watershed. Considerable infiltration occurs, especially on soils with hydrologic classes A and B (see Figure 4). Land uses which diminish infiltration or which speed water from recharge area through furrows, gutters or ditches can add substantially to future flooding and diminish the recharge needed to sustain baseflows, especially on class A and B soils.

DWR monitored long-term ground-water fluctuations in a single well from 1958 through 1993, showing rapid recovery of the aquifers following sharp drawdowns during sequences of dry years (see Figure 6). Maintaining or enhancing the recharge functions in Edna Valley will be important for many stormwater- and watershed-management purposes. Rapid recovery from drought-year low levels may also serve as a useful metric to track watershed health. No long-term ground-water monitoring presently occurs in the watershed.

Maintenance of low flows essential for aquatic biota

Streams lose water to the ground in alluvial reaches (especially the youngest alluvium), and gain water as they flow through the Edna fault zone, the 'downstream end' of the larger valley-floor alluvial units upstream of Price Canyon. Recharge efforts in the central portion of the valley are likely to increase rates of ground-water discharge to Pismo Creek at the Edna Fault Zone.

September low flows are estimated to have ranged from 0 to 7.5 cfs since 1968. This is equal to approximately 0 to 0.20 cfs per square mile.

Previous-winter rainfall alone is not a reliable predictor of low flows in the watershed. The number of years since a 'recharge event' (a wetter-than-normal year) may be a major factor in predicting baseflow rates.

Canada Verde appears to have relatively persistent baseflow and a higher quality of wetlands. This is perhaps an indication that the Paso Robles formation – which outcrops widely in this watershed -- is able to recharge and release more water than younger Quaternary alluvium. Maintenance or enhancement of ground-water recharge throughout the watershed, but particularly in the Canada Verde watershed, should be encouraged to maintain baseflows downstream in Pismo Creek.

4. GEOMORPHIC ASSESSMENT

4.1 Objectives of the Geomorphic Assessment

The scope of the geomorphic assessment was guided by critical questions developed during the early stages of the project. The questions were developed with the findings of previous regional investigations in mind as well as those issues most pertinent to the stability of the riparian corridor and salmonid species currently inhabiting the watershed. Primary objectives of the geomorphic assessment are:

1. Identifying present-day stream conditions, especially as they relate to historical stream conditions. In particular, has there been significant vertical or lateral channel adjustment in the watershed during the last 100 years?
2. Identifying the types of potential sediment sources, and
3. Identifying the degree to which land management practices may have exacerbated these sources.

4.2 Methods

Geomorphic assessment methodologies consisted of 1) reviewing previous regional investigations, 2) obtaining and georeferencing historical aerial photographs and comparing changes in channel alignments, and 3) measuring channel dimensions during baseflow stream walks.

4.2.1 Aerial photography and watershed history

We obtained and reviewed the following aerial photographs and historical maps:

- Map entitled, "Area of San Luis Obispo", dated 1850;
- Parcel Map for San Luis Obispo County, dated 1890;
- Map of San Luis Obispo, Ventura, and Santa Barbara Counties, dated 1906
- Black and white aerial photography series obtained from the Fairchild Aerial Photograph collection at Whittier College, dated 1947;
- Black and white aerial photography series obtained from the U.S. Geological Survey dated April 29, 1970;
- False-color infrared aerial photography obtained from the U.S. Geological Survey National Aerial Photography Program (NAPP) dated June 13, 1989

Historical images were georeferenced to the UTM NAD83 coordinate system and compared to recent aerial photography from 1994, 2001, 2002, 2003, and 2005 to evaluate changes in stream course, riparian areas, and land use that may have taken place.

The goal of our analysis is to estimate change in areas supporting riparian vegetation over time using spatially-registered aerial photos from the years 2005, 1970, and 1947. Changes in riparian areas and land use were evaluated by comparing the 1947 photography to 2005 photography. Differences in channel locations and the degree to which channel incision has taken place was evaluated qualitatively through the use of stereo-paired aerial photographs. The 1970 and 1947 photos were scanned at high resolution and registered using the Geoprocessing tool in ArcGIS 9.2. The main stems of Pismo Creek, Cuevitas Creek, East and West Corral, and Canada Verde, were then digitized by tracing the riparian zone with as much accuracy as the resolution of the photo would allow. At times, estimates on the width of the riparian zone were made due to heavy vegetation extending down the hillsides towards the creek, or at tributary confluences. In both cases, an effort was made to keep a constant width as seen on nearby portions of the creek.

As part of this work, we attempted to also quantify how much development has occurred in Edna Valley and along Canada Verde Creek since 1970. Since the channels are significantly incised with limited floodplain connection throughout Edna Valley, we approximated the total extent of floodplain area according to mapped Quaternary deposits (Qal) and the Paso Robles formation (Qpr). Using these indicators, we digitized parcels that are clearly developed on both the 2005 and 1970 aerial photos. Areas outside the delineated floodplain were not evaluated for general land-use changes.

4.2.2 Channel geometry measurements

During our baseflow hydrology reconnaissance, representative channel geometry measurements were recorded at various locations in the watershed, as shown in Figure 14. Channel width was measured from top of bank to top of bank where feasible, as well as at the inferred geomorphic bankfull elevation. Pismo Creek is incised in many locations, so geomorphic bankfull width and depth were assessed only where evident. Evidence was primarily the development of an inset floodplain or depositional areas, and / or regular vertical spacing relationships between the base of alders and the streambed.

4.2.3 Review of existing data and prior regional work

Balance collected suspended and bedload sediment discharge data on Pismo Creek during water years 1991 and 1992 (Hecht, 2006). We have compared these data to data collected on a number of coastal California streams, including sediment discharge data collected by the U.S. Geological Survey in the upper Arroyo Grande and Santa Rita Creek basins during water years 1968 through 1973 (USGS, 1976). Measurements of suspended- and bedload-sediment discharge were made during 1991 and 1992 storms and are described thoroughly in Hecht (2006).

4.3 Findings and Discussion

The current character of the Pismo Creek Watershed reflects a dynamic system that responds to regular influences of climate changes, tectonics, watershed land use changes, plus localized disturbances. Aerial-photograph interpretation coupled with reconnaissance-level observations in the upper watershed lead us to believe that channel conditions are relatively undisturbed by humans and subject to periodic landslides or episodic events in the upper watershed. Streams tend to be incised in Edna Valley and portions of Price Canyon, with limited to well-developed riparian corridors in Edna Valley, and typically well-developed riparian corridors in Price Canyon and near the coast.

4.3.1 Watershed History

The Chumash people were among the first to inhabit this region, and likely used the Pismo Creek Watershed for hunting, fishing, and foraging. The first Europeans settled the area in the early and mid-1800s and began a long tradition of ranching and intensive agriculture that continues today (Brown, 2002). As is the case with many of California's coastal streams, this period of settlement appears to have coincided with widespread channel incision and straightening, as compaction of soils by cattle increased runoff rates and the volume of water delivered to channels, while re-alignment or straightening of streams by farmers lead to lower channel roughnesses, higher velocities, and increased erosion, a process increasingly referred to as 'hydromodification'. Relatively recent residential and suburban development in the watershed typically contributes to hydromodification, especially if impervious surfaces such as roofs, driveways, and roads are constructed such that they route runoff directly into local channels, without reducing the accelerated flow peaks.

Channel incision is evident through field observations and aerial photograph interpretation. For example, Figure 15 contains side-by-side aerial photography of Pismo Creek near the head of Price Canyon. The presence of a road crossing in this area, as visible in stereo-paired photographs, implies that the creek was not substantially incised in 1947, while recent field investigations reveal the stream to be significantly incised in this reach by as much as 25 feet.

Anecdotal evidence suggests that both East and West Corral de Piedra regularly overtop their banks, and a portion of West Corral de Piedra flows are diverted out of the Pismo Watershed and into the San Luis Obispo Creek where the stream enters Edna Valley (Anonymous landowner, personal comm., 2007). Prior to the arrival of European grasslands and livestock approximately 200 years ago, this floodplain process likely persisted throughout Edna Valley, with East and West Corral de Piedra and Canada Verde Creeks flowing across the Edna Valley at about the elevation of the valley flat, frequently overtopping their banks, and changing course. In Edna Valley today, however, the streams have largely been re-aligned and straightened for agricultural purposes. Access roads and low-density residential development have been introduced into Edna Valley as well, resulting in a higher portion of rainfall now entering the channel network more quickly, leading to higher peak flows, higher flow velocities, and increased erosion potential. These factors have led to widespread channel incision throughout the valley.

Throughout Edna Valley, channels are typically incised and appear to be hydrologically disconnected from the surrounding valley flat, and in many cases are straight with a limited riparian vegetated buffer. Figure 16 shows channel conditions on East Corral de Piedra near where it exits the mountainous upper watershed. Historical aerial photos show the presence of an alternate channel that does not exist today, suggesting that historically, the stream frequently overtopped its banks and occupied alternate channels. The channel has become disconnected from the floodplain in relatively recent times, perhaps with the development of intensive viticulture in this reach, or simply because a local farmer chose to fill in the alternate channel. In either case, today's channel is incised significantly and floodplain processes do not appear to be present.

The 1947 aerial photos only cover the mid-watershed from Edna Valley southeast extending along Canada Verde Creek. The lack of contrast of this set of photos created some difficulties when identifying the riparian zone. The areas identified are considered less accurate than those digitized from 1970 or 2005 photos. In order to obtain a total historic riparian area, we used the

1970 photos to fill in the remaining portion of the watershed. These photos were much easier to interpret due to their high contrast. Compared to a current set of photos from 2005, it appears that riparian areas have increased since 1947/1970 by approximately 40 acres in Edna Valley. This is likely due to diminished riparian areas associated with the 1969 flood. The 1970 aerial photographs may show a diminished riparian cover due to loss of riparian woodland during the January and February 1969 floods.

4.3.2 Sediment Discharge rates

Suspended- and bedload sediment transport were measured during various storms in water years 1991 and 1992, either by Balance staff or by Tina Grietens and her colleagues at the City of Pismo Beach. Although the number of data points collected during that monitoring period are not sufficient to merit a sediment yield computation, some inferences from the data set can be drawn, and are discussed in detail in Hecht (2006). A comparison of the empirically-derived 'sediment rating curve,' the relationship between sediment transport and stream discharge, on Pismo Creek (Hecht, 2006) to other coastal California streams (Knudsen and others, 1992) revealed that suspended sediment transport in Pismo Creek is an order of magnitude or more lower than Arroyo Grande above Phoenix Creek (at a site now flooded by Lopez Lake), an incising stream. It also shows substantially greater transport at a given flow in Pismo Creek than in streams such as Coyote Creek (near Gilroy) and the Ventura River at River Oaks.

Bedload sediment is transported by the stream by bouncing, rolling, or saltating along the bed. Bedload is supported by the bed, and moves at a rate much slower than the water during storms. The proportion of bedload is important and telling because it provides: (a) a basis for comparing channels of different geomorphic and salmonid-habitat types, (b) information about the sediment-production processes operative in the watershed, (c) indications of salmonid constraints, and (d) hints about how effective efforts might be at reducing sediment delivery to the streams. A comparison of suspended and bedload sediment during the early 1990s suggests that bedload may be about 10 percent of the suspended sediment within the range of flows sampled (Hecht, 2006). This is probably indicative of the contributions from the upper portion of the watershed, upstream of the mountain front north of Orcutt Road. In fact, the streambed of East Corral de Piedra Creek is visibly much coarser than the somewhat larger West Corral de Piedra Creek, likely associated with deposition of all coarse sediment from the uppermost watershed within impoundments on the latter. In contrast, Knott (1975) reported a relatively high percentage of bedload measured in Lopez Creek near Arroyo Grande.

It is likely that the proportion of coarse sediment we observed during 1991 and 1992 is reasonably typical of long-term conditions. Considerations which might have resulted in above-normal coarse-sediment percentages are that channels in coastal California tend to transport a larger proportion of bank material immediately following droughts, likely due to release from banks stabilized by root systems weakened by protracted drought (Hecht, 1993; Schumm, 2004). Bank material tends to be coarser than typical sediment loads in most channels. Also, the storms during water years 1991 and 1992 were notably more intense than usual, another factor which tends to draw coarser material from bed and bank storage. No major wildfires, however, were reported preceding the 1990-2 sediment monitoring; wildfires in the upper watershed of East Corral de Piedra Creek may be expected to coarsen the bed and the sediment in transport for several years (or more) following a major burn,

The low proportion of bedload – and the high proportion of much finer materials – suggests that much of the sediment load of Pismo Creek might be controlled within fields or vineyards and on the slopes. While this implication is based only on the watershed-wide sediment-transport dynamics, it should be noted that use of conventional erosion-control practices is a simpler and more-implementable set of tasks than controlling in-channel erosion and incision. Hence, reducing sediment yield in the Pismo watershed is likely to be achievable, all other influences permitting. Similarly, it will be particularly important to prevent de-stabilization of channels by ongoing or future land-use activities, such that there is time and effort available to implement the known, sound measures likely to effectively reduce sediment loads.

4.3.3 Channel geometry

Channel geometry measurements are presented in Table 8. Based on these measurements and aerial photograph interpretations, we find that channel types can be grouped according to four general geomorphic zones in which they lie, as described in Chapter 1 and shown in Figure 1. The upper watershed consists primarily of canyons, with steep gradients and very limited floodplain areas. We had only limited access to the steepest headwater channels, and observed typical moderate-slope riffle-pool morphologies near the mouths of canyons. Channels appear to be relatively stable at the mouths of the upper watershed canyons, apparently due to limited development in these areas, as well as relatively shallow depths to bedrock. Vertically-stable meandering channels are present in some areas. In many cases shallow depths to bedrock appear to be offering channel and grade stability, as was observed on West Corral de Piedra.

As the streams cross Edna Valley, they are largely confined to managed or incising channels, with very limited inset-floodplain development. Channels have incised to bedrock in some locations, oftentimes at depths of 25 to 30 feet below the former floodplain. Incision has occurred in Price Canyon as well. Large logjams, wood structures, and bedrock outcrops have led to the development of inset floodplains in some cases, although active meanders are limited. In most cases, the stream is confined to entrenched meanders and is only beginning to establish vertically-stable meander processes.

Several hundred feet downstream of the Price House, Pismo Creek flows beneath the Southern Pacific Railroad and enters a City-owned property. Water is very deep as the stream enters a long pool that extends nearly the length of the property. This is apparently due to a mature beaver dam that has become reinforced with live willow roots just upstream of Highway 1. The downstream side of the dam appears to coincide with the upstream extent of the lagoon, as indicated by increased salinities and the absence of stream flow.

4.4 Potential Restoration Approaches

Restoration of hydrologic processes is a primary goal in reducing flood velocities, erosion, and sediment delivery to channels in the Pismo Creek Watershed. Wetland creation approaches which slow the delivery of water from the upper watershed and create hydrologic connections to a wider floodplain in the lower watershed are anticipated to achieve a reduction in flood peaks and sediment transport rates, as follows:

- Stabilizing incising gullies. Through riparian plantings and installation of natural grade control structures, such as constructed log jams and live cribwalls, we anticipate a reduced incision rate and natural widening will take place. It should be noted that several gullies have incised to such great depths that stabilization by these methods may not be feasible.

- Excavation and lowering of floodplains. Along incised channels, we anticipate that this will result in reduced flood velocities, as well temporary water and sediment storage. Additional depressions in the floodplains can provide additional storage.

- Re-establishing overbank flows from re-aligned channels. Overflows from tributary channels into created valley-floor and lower alluvial-fan wetlands will reduce flows in the channel and the potential for erosion in the straightened channels.

4.5 Geomorphic Assessment Conclusions

Channels appear to be actively incising in Edna Valley, as indicated on aerial photographs, relationships between channel area and watershed area, and undercut tree root systems.

Channel incision is limited in several reaches by bedrock grade controls, especially where the channels enter and leave Edna Valley.

More information is needed regarding sediment generation and transport mechanisms and locations, including on-the-ground access to more of the watershed and

Within the upper Pismo watershed, it is not within the realm of economic or sustainable feasibility to consider stabilizing the larger landslides entering the two main branches and their major tributaries because:

- The number of major landslides is very large.
- Each major landslide is difficult and costly to repair, and often is not presently accessible.
- Landslides -- and the related sediment and wood delivery – recur frequently, with related requirements for frequent repair.
- Large volumes of sediment enter the stream system during days and weeks following a downslope event -- before repairs can be planned or funded -- with additional volumes entering before repairs can be completed.
- Large, active landslides in this watershed often develop on the steeper portions of older, larger slides; hence, repairs may fail, or they may induce failure in other portions of the older loosened materials.

It might also be noted that a program to attempt to stabilize landslides, even if affordable, might eventually result simply in more extensive slope failures that prove more damaging to the stream corridors below, much as a program of wildfire suppression can result in larger and more widespread burns.

5. LIMITATIONS

As stated in the introduction to the report, the objectives of this study are to provide Central Coast Salmon Enhancement with a characterization of the hydrologic and geomorphic processes that support anadromous fish habitat in the Pismo Creek watershed. This is a reconnaissance report, intended to bracket likely future conditions, to identify certain hydrologic or geomorphic factors which must be better known, and to help guide initial planning. This report should not be used to assess, site or design individual facilities and wells without further site-specific investigations. Similarly, it is not intended to serve as basis for flood management or detailed floodplain planning, both of which are conducted by well-defined and separate procedures, and which frequently require multiple lines of evidence. Use of these results for purposes other than those identified above can lead to significant environmental, public-safety or property losses. Balance Hydrologics should be contacted for consultation prior to considering use of this analysis for any purposes other than the reconnaissance, watershed-scale analysis specified above in this paragraph.

The application of geomorphic history to inferring future channel and corridor change has a long and respected record in the earth sciences. As with all historical or archival analysis, the better the record is known and understood, the more relevant and predictive the analysis can be. We do encourage those who have knowledge of other events or processes which may have affected the site or channel system to let us know at the first available opportunity.

Our findings suggest that waters found in different soils and areas generally have different salinity and/or major-ion signatures. The scope, however, is limited to reconnaissance sampling to assess and demonstrate whether this approach is useful in the Pismo watershed. Findings are generalized where appropriate. No implications should be drawn (a) quantitatively linking water quality with past or present water quality, and (b) that salinity- or major-ion-characterization are a complete picture of water quality conditions in this stream. Further work beyond the reconnaissance level will be necessary to refine this work or to distinguish water-quality specific reaches and their limits.

It should be noted that the hydrologic study and associated field measurements were conducted during a three-month period of a single water year and therefore, reflect a snapshot of conditions dependent on the local weather patterns present during May through July 2007, an extremely dry period. Conditions on the site are likely very different during relatively wet years.

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TABLES

Table 1. Meteorological data used in HEC-HMS modeling for Pismo Creek, San Luis Obispo County, California

Parameter	1992 Rainfall	100-year Rainfall
probability	approx 50% (2-yr)[1]	1%
output type	Annual Duration	Annual Duration
intensity duration	5 minutes	5 minutes
storm duration	24 hours	24 hours
Rainfall intensities (inches)		
5 minutes	0.19	0.21
15 minutes	0.33	0.37
1 hour	0.71	0.77
2 hours	1.03	1.13
3 hours	1.26	1.38
6 hours	1.76	1.93
12 hours	2.19	2.4
24 hours	2.73	3.02

Notes:
1) Maximum rainfall intensities from 1992 were used because peak discharge on Lopez Creek that year appears to have been an approximately 1.3-year flood event.
2) Rainfall intensity and duration for the 100-yr strom were derived according to methods outlined in the City and County of San Luis Obispo Waterway Management Plan (2003).
3) Mean Annual Precipitation in the Lopez Watershed is similar to that in the upper Pismo Watershed. data have not been scaled.

Table 2. Model parameters for peak flow calculations, Pismo Creek Watershed, County of San Luis Obispo, California

Watershed Name	Upper W Corral	Upper E Corral	Lower W Corral	Lower E Corral	Pismo Ck U/S Canada Verde	Canada Verde	Pismo Ck U/S Ormonde Rd	Pismo Ck U/S PxP Trib	PxP Tributary	Pismo Ck U/S Hwy 1
Subbasin Characteristics										
Drainage Area (mi^2)	4.5	4.1	4.3	1.8	0.6	9.7	1.6	1.5	7.0	2.3
Curve Number	83	83	81	79	82	81	81	74	79	78
Initial Abstraction (in)	0.41	0.41	0.47	0.53	0.44	0.47	0.47	0.70	0.53	0.56
Percent Impervious	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sheet Flow Characteristics										
Manning's Roughness Coefficient	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Flow Length (ft)	300	300	300	300	300	300	300	300	300	300
Two-Year 24-hour Rainfall (in)	3.8	4.0	3.3	3.1	2.9	2.9	2.8	2.7	2.9	2.5
Land Slope ($^{ft}/_{ft}$)	0.296	0.362	0.205	0.423	0.226	0.108	0.124	0.163	0.118	0.101
Sheet Flow Time of Travel (hr)	**0.18**	**0.17**	**0.23**	**0.18**	**0.23**	**0.32**	**0.31**	**0.28**	**0.31**	**0.35**
Shallow Concentrated Flow Characteristics										
Surface Description (1 - unpaved, 2 - paved)	1	1	1	1	1	1	1	1	1	1
Flow Length (ft)	9,005	15,184	12,554	11,846	4,273	16,912	8,492	6,097	12,880	10,172
Watercourse Slope ($^{ft}/_{ft}$)	0.2	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Average Velocity ($^{ft}/_{s}$)	7.286	5.670	4.526	3.391	4.790	4.024	3.967	3.819	3.635	3.686
Shallow Concentrated Flow Time of Travel (hr)	**0.34**	**0.74**	**0.77**	**0.97**	**0.25**	**1.17**	**0.59**	**0.44**	**0.98**	**0.77**
Channel Flow Characterisitics										
Cross-sectional Flow Area (ft^2)	72	72	200	225	16.5	100	280	280	200	280
Wetted Perimeter (ft)	26	26	50	45	14	30	51	51	41	51
Hydraulic Radius (ft)	2.8	2.8	4.0	5.0	1.2	3.3	5.5	5.5	4.9	5.5
Channel Slope ($^{ft}/_{ft}$)	0.040	0.031	0.009	0.014	0.020	0.006	0.007	0.005	0.009	0.004
Manning's Roughness Coefficient	0.058	0.058	0.048	0.045	0.055	0.032	0.055	0.06	0.05	0.07
Average Velocity ($^{ft}/_{s}$)	10.2	9.0	7.4	11.3	4.3	8.1	7.0	5.4	8.0	4.4
Flow Length (ft)	7,079	8,134	16,991	10,133	3,446	16,410	2,433	4,799	10,757	9,118
Channel Flow Time of Travel (hr)	**0.19**	**0.25**	**0.64**	**0.25**	**0.22**	**0.56**	**0.10**	**0.25**	**0.37**	**0.58**
Basin Time of Concentration (hr)	**0.72**	**1.16**	**1.63**	**1.40**	**0.71**	**2.05**	**1.00**	**0.97**	**1.67**	**1.70**
Basin Lag Time (hr)	**0.43**	**0.70**	**0.98**	**0.84**	**0.42**	**1.23**	**0.60**	**0.58**	**1.00**	**1.02**

Table 3. Summary of baseflow specific conductance measurements in the Pismo Creek Watershed, Summer 2007.

Map ID[1]	Waypoint	Location	Date	Distance upstream from mouth (meters)	Distance upstream from mouth (feet)	Streamflow (gpm)	Estimated/ Measured[2] (E/M)	Temperature (deg C)	Conductance (umhos@field temp)	Specific Conductance (umhos@25)	Watershed Area (square mi)
1		Pismo Lagoon at RV Park	5/9/07	388	1273	0	M	20.1	2532	2792	
2		Irrigation water in field adjacent to E Corral at Edna Rd	5/9/07	500	1640			30.1	1007	917	
3		Pismo Cr u/s of Hwy 1 Beaver Dam	5/9/07	773	2535	0	M	14.8	1262	1553	37.96
4		Pismo Cr at Price House RR bridge	5/9/07	1215	3985			14.2	1180	1485	
5		Pismo Creek at Price House	5/9/07	1400	4592	230	E	14.4	1158	1450	37.77
6		Canada Verde at Edna Road	5/9/07	2344	7688	20	E	14.7	1157	1440	
7		Pismo Cr at Ormonde Road	5/9/07	6114	20054	335	E	17.5	1175	1370	27.49
8		West Corral de Piedra at Edna	5/9/07	9443	30973	60	E	16.7	1126	1339	
9		Right bank spring at Upper W Corral	5/9/07	17903	58722			17.4	294	344	
10		Upper W Corral de Piedra	5/9/07	17941	58846	20	E	17.7	617	718	0.69
11	168	Cuevitas Creek at Price Cyn Road	6/6/07	4050	13284	20	E	14.8	902	1122	6.94
12	166	Pismo Cr just u/s of Ormonde Road	6/6/07	6278	20592	129	M	19.9	1207	1338	27.43
13	165	Pismo Cr at Bituminous SS outcrop	6/6/07	7662	25131	122	M	21.8	1138	1213	16.06
14	161	Left bank seep between Fish Ladder and Canada Verde	6/6/07	8099	26565			16	1037	1250	15.94
15	162	Pismo Cr btwn Fish Ladder and Canada Verde	6/6/07	8099	26565			16.4	1002	1198	15.94
16	157	Pismo Cr d/s of Fish Ladder	6/6/07	8680	28470	65	M	14.6	1161	1451	15.55
17	153	Pismo Cr at Fish Ladder	6/6/07	8725	28618		E	14.1	1144	1447	15.55
18	175	Pismo Lagoon at Little Town Park	6/7/07	388	1273			21	1927	2088	44.35
19	177	Pismo Creek at HWY 101	6/7/07	773	2535			15.3	1326	1626	
20	176	Pismo Creek at Price House (at u/s property line)	6/7/07	2046	6711	192	M	16.6	1182	1410	37.38
21	195	Canada Verde at Edna Road	6/7/07	2344	7688	1	E	14.7	1145	1395	
22	189	Canada Verde Tributary at Corbett Cyn Rd	6/7/07	4237	13897	1	E	17.6	708	826	0.44
23	190	Canada Verde Main Stem at Judith Ln and Corbett Cyn Rd	6/7/07	4457	14619	40	E	19.9	1039	1149	4.39
24	186	Spring-fed tributary to E Corral de Piedra	6/7/07	4677	15341			25.5	624	618	0.04
25	185	E Corral de Piedra at Moretti Cyn Road crossing	6/7/07	11955	39213	393	E	20.5	937	1026	4.23
26	169	Pismo Creek below E/W Corral Confluence	6/7/07	8844	29008			13	1090	1416	15.47
27	170	E Corral de Piedra, 60' u/s confluence	6/7/07	8873	29103	14	M	13.4	1140	1464	0.65
28	171	W Corral de piedra, 80' u/s confluence	6/7/07	8873	29103	65	M	13.1	1091	1412	15.47
29	188	W Corral de Piedra at Edna	6/7/07	9443	30973	21	M	16.3	1152	1382	
30	180	W Corral de Piedra at Dixon Bridge	6/7/07	15364	50394	1	E	20.9	634	687	4.77
31	36	Pismo Lagoon just d/s of Hwy 1	7/11/07	388	1273	0		21.1	2253	2486	44.35
32	38	Pismo Cr d/s of Beaver Dam	7/11/07	737	2417	0		17.6	1959	2276	38.06
33	37	Pismo Creek u/s of Beaver Dam	7/11/07	773	2535	0		15.8	1564	1898	37.96
34	40	upstream extent of Beaver Dam impoundment	7/11/07	903	2962			16.3	1567	1882	37.90
35	39	Pismo Cr near water treatment plant	7/11/07	1032	3385	0		15.6	1529	1870	37.92
36	41	Pismo Cr at Price House (at d/s prop line)	7/11/07	1718	5635	88	M	17.2	1280	1512	37.49
37		W Corral at Edna	7/11/07	9443	30973	11.2	M	19.5	1156	1301	

Notes:

1) See Figure 7 for observation locations
2) Streamflow was either visually estimated (E) or measured using a bucket and stopwatch method, float test, or dye tracer method.

Table 4. Summary of field measurements and water quality analyses in the Pismo Creek Watershed, San Luis Obispo County, California

PARAMETER	UNITS	METHOD	REPORTING LIMIT	Pismo Creek at Price House	Pismo Creek at Ormonde Road	West Corral de Piedra Creek at Edna Road	Canada Verde Creek at Corbett Canyon Road
Lab I.D.				07-C8368	07-C8369	07-C8370	07-C8371
Latitude, NAD83	degrees			N35.147018	N35.177447	N35.201410	N35.186431
Longitude, NAD83	degrees			W120.631619	W120.620211	W120.61169	W120.578943
Elevation, NGVD29	feet			33	122	227	233
Lab used				Creek Environmental Labs	Creek Environmental Labs	Creek Environmental Labs	Creek Environmental Labs
Sample collected by				nicole smith, emma chow	nicole smith, emma chow	nicole smith, emma chow	nicole smith, emma chow
Sample filtering				no	no	no	no
Date	MM/DD/YY			July 3, 2007	July 3, 2007	July 3, 2007	July 3, 2007
Time	HH:MM			1:00 PM	1:40 PM	2:30 PM	3:30 PM
Flow	gpm			--	--	--	--
pH	umhos/cm			8	8	8	8
Temperature	degF			64	68	64	69
Temperature	deg C			17.9	20	17.9	20.6
Alkalinity (total)	mg/L CaCO3			500	440	580	310
Hardness (total)	mg/L CaCO3	EPA 200.7	1	610	550	750	340
pH	pH Units	SM4500-H B	0.1	7.7	8	7.8	8.1
Specific conductance (@ 25 C°)	umhos/cm	SM2510	1	1700	1200	1200	1400
Total dissolved solids (TDS)	mg/L	SM 2540 C	10	1100	780	800	500
Bicarbonate (as CaCO3)	mg/L	SM 23208	2	500	440	580	310
Calcium (Ca)	mg/L	EPA 200.7	0.03	110	100	120	68
Carbobate (as CaCO3)	mg/L	SM 23208	2	Not Detected	Not Detected	Not Detected	Not Detected
Chloride (Cl)	mg/L	EPA 300.0	10	160	110	42	61
Iron (Fe)	mg/L	EPA 200.7	0.02	0.13	0.19	Not Detected	0.35
Magnesium (Mg)	mg/L	EPA 200.7	0.03	85	74	110	41
Manganese (Mn)	mg/L	EPA 200.7	0.02	0.26	0.17	0.03	Not Detected
Potassiuim (K)	mg/L	EPA 200.7	0.1	3	2.5	0.6	3.8
Sodium (Na)	mg/L	EPA 200.7	0.05	120	82	50	48
Sulfate (SO4)	mg/L	EPA 300.0	0.5	250	100	160	33
Hydroxide Alkalinity as CaCO3	mg/L	SM 23208	2	Not Detected	Not Detected	Not Detected	Not Detected
Nitrate as N	mg/L	EPA 300.0	0.1	0.1	Not Detected	2.5	0.8
Nitrate as N03	mg/L	EPA 300.0	0.4	0.4	Not Detected	11	3.5
Copper		EPA 200.7	0.05	Not Detected	Not Detected	Not Detected	Not Detected
Zinc		EPA 200.7	0.05	0.05	Not Detected	Not Detected	Not Detected

Sampling carried out by Central Coast Salmon Enhancement, Inc.

Table 5. Summary of reconnaissance HEC-HMS results for the Pismo Creek Watershed, San Luis Obispo County, California

			2-year Storm		100-year Storm	
HEC-HMS Description	**Type**	**Drainage Area** (mi^2)	**Peak Flow** (cfs)	**Volume** (ac-ft)	**Peak Flow** (cfs)	**Volume** (ac-ft)
Upper W Corral de Piedra	subbasin	4.5	781	234	953	349
W Corral de Piedra Reservoir	**junction**	**4.5**	**781**	**234**	**953**	**349**
Lower W Corral de Piedra	subbasin	4.3	437	199	538	303
W Corral de Piedra at Mouth	**junction**	**8.8**	**1,209**	**433**	**1,476**	**652**
Upper E Corral de Piedra	subbasin	4.1	561	212	687	315
E Corral de Piedra at base of foothills	**junction**	**4.1**	**561**	**212**	**687**	**315**
Lower E Corral de Piedra	subbasin	1.8	172	73	213	114
E Corral de Piedra at Mouth	**junction**	**5.9**	**724**	**285**	**889**	**429**
E and W Corral de Piedra	**junction**	**14.7**	**1,900**	**718**	**2,324**	**1,081**
Pismo Ck at Fish Ladder	subbasin	0.6	103	30	126	46
Canada Verde	subbasin	9.7	857	441	1,053	673
Pismo Ck and Canada Verde	**junction**	**25.0**	**2,795**	**1,190**	**3,418**	**1,800**
Pismo Ck U/S Ormonde Rd	subbasin	1.6	212	75	261	114
Pismo Ck at Ormonde Rd	**junction**	**26.6**	**2,909**	**1,265**	**3,565**	**1,914**
Pismo Ck U/S PxP	subbasin	1.5	114	45	143	74
Pismo Ck U/S PxP Tributary	**junction**	**28.2**	**2,972**	**1,309**	**3,647**	**1,988**
PxP Tributary	subbasin	7.0	605	285	748	444
Pismo Ck and PxP Tribuatary	**junction**	**35.2**	**3,441**	**1,594**	**4,242**	**2,433**
Pismo Ck U/S Hwy 1	subbasin	2.3	183	87	228	137
Pismo Creek at Highway 1	**junction**	**37.4**	**3,550**	**1,682**	**4,381**	**2,570**

Table 6. Calculated mean monthly summer flows on Pismo Creek at Highway 1.

Year	June		July		August		September		October	
	(cfs)	(gpm)	(cfs)	(gpm)	(cfs)	(gpm)	(cfs)	(gpm)	(cfs)	(gpm)
1968	0.17	77	0.06	29	0.05	24	0.03	14	1.71	768
1969	12.34	5538	8.92	4002	5.24	2351	4.31	1936	0.07	30
1970	0.23	104	0.10	43	0.20	88	0.11	50	3.43	1538
1971	0.36	163	0.06	28	0.02	9	0.02	9	0.88	395
1972	0.03	13	0.02	9	0.01	4	0.02	8	0.08	38
1973	2.97	1331	1.05	471	0.65	291	0.12	55	0.06	28
1974	3.04	1366	1.14	511	0.70	312	0.24	106	0.15	66
1975	0.87	388	0.08	35	0.06	27	0.06	28	0.62	279
1976	0.04	17	0.01	6	0.05	21	0.30	133	0.28	126
1977	0.03	14	0.01	4	0.00	1	0.01	5	0.10	47
1978	4.21	1887	2.10	941	1.86	836	0.63	285	0.02	7
1979	0.21	94	0.06	25	0.03	15	0.02	8	0.12	56
1980	4.20	1885	2.69	1209	0.87	391	0.63	284	0.11	48
1981	0.09	42	0.06	26	0.04	19	0.04	19	2.17	973
1982	3.32	1492	0.93	419	0.09	41	0.08	38	0.10	46
1983	25.59	11486	13.65	6128	8.18	3672	6.33	2840	0.23	101
1984	2.79	1251	1.22	546	0.22	97	0.14	61	7.33	3288
1985	0.30	133	0.10	43	0.23	102	0.46	206	1.52	683
1986	3.52	1581	2.07	928	0.94	422	1.05	473	0.13	60
1987	0.40	180	0.22	100	0.13	59	0.08	37	1.44	645
1988	0.08	35	0.05	24	0.06	25	0.06	28	0.42	191
1989	0.06	29	0.03	14	0.03	14	0.04	20	0.07	32
1990	0.03	15	0.02	8	0.02	7	0.01	6	0.06	28
1991	0.05	23	0.02	11	0.02	7	0.01	6	0.02	8
1992	0.05	22	0.03	11	0.02	7	0.02	7	0.03	11
1993	2.54	1141	0.40	181	0.23	102	0.10	45	0.10	44
1994	0.06	28	0.04	16	0.03	14	0.03	12	0.10	44
1995	8.47	3803	5.41	2429	3.83	1720	3.38	1517	0.17	75
1996	3.08	1384	1.52	682	1.25	561	0.56	251	2.12	953
1997	5.67	2544	4.59	2061	3.91	1753	2.32	1042	0.53	237
1998	26.58	11927	15.18	6813	8.63	3874	7.62	3418	2.70	1210
1999	2.52	1130	1.00	447	0.37	164	0.27	122	5.61	2516
2000	2.00	900	0.78	348	0.14	63	0.35	155	0.29	131
2001	0.88	395	0.23	104	0.08	38	0.10	46	2.09	940
2002	0.08	37	0.04	20	0.03	15	0.04	16	0.12	54
2003	0.12	52	0.04	17	0.03	12	0.02	9	0.04	17
2004	1.00	450	0.45	200	0.10	46	0.22	98	0.04	16
2005	4.53	2031	3.23	1448	1.90	853	1.67	751	2.40	1079
2006	3.84	1724	1.99	892	0.72	323	0.46	205	1.91	859
2007	0.06	27	0.05	22		0		0	0.49	219
average	3.16	1,419	1.74	781	1.05	460	0.82	359	1.00	447
min	0.03	13	0.01	4	0.00	0	0.01	0	0.02	7
max	26.58	11,927	15.18	6,813	8.63	3,874	7.62	3,418	7.33	3,288
median	0.87	392	0.23	102	0.13	53	0.11	48	0.20	88
std dev	5.92	2,657	3.45	1,550	2.10	934	1.73	767	1.58	708

Notes:
Correlated according to the relationship between measured mean daily discharge on Lopez Creek and that on Pismo Creek during water years 1991 and 1992 (see Figure 9).

Table 7. Annual rainfall at San Luis Obispo and estimated total annual runoff in the Pismo Watershed

year		annual precipitation		
	(ac-ft)	(inches)	(ac-ft)	runoff coeff.
1968	1644	16.75	33857	0.05
1969	109253	54.62	110405	0.99
1970	4108	16.30	32948	0.12
1971	3179	20.65	41741	0.08
1972	782	12.27	24802	0.03
1973	34135	40.04	80934	0.42
1974	15643	30.92	62500	0.25
1975	4270	24.17	48856	0.09
1976	329	15.68	31695	0.01
1977	110	11.53	23306	0.00
1978	47998	48.72	98479	0.49
1979	4588	19.75	39921	0.11
1980	37236	33.35	67411	0.55
1981	12162	19.28	38971	0.31
1982	21124	28.50	57608	0.37
1983	73800	38.54	77902	0.95
1984	6811	18.80	38001	0.18
1985	2822	14.85	30017	0.09
1986	21281	30.48	61610	0.35
1987	2084	13.45	27187	0.08
1988	1486	18.98	38365	0.04
1989	1014	17.11	34585	0.03
1990	95	11.56	23367	0.00
1991	3202	18.07	36525	0.09
1992	4992	22.51	45500	0.11
1993	13746	30.46	61570	0.22
1994	1570	19.34	39093	0.04
1995	34248	41.95	84795	0.40
1996	10368	24.06	48633	0.21
1997	37411	31.42	63510	0.59
1998	66607	43.83	88595	0.75
1999	4417	16.12	32584	0.14
2000	10573	24.86	50250	0.21
2001	11321	24.51	49543	0.23
2002	1108	15.99	32321	0.03
2003	2949	22.92	46329	0.06
2004	3922	16.02	32382	0.12
2005	26867	40.09	81035	0.33
2006	14876	16.45	33251	0.45
2007	660	6.62	13381	0.05
average	16,370	24.29	49,094	0.24
min	95	6.62	13,381	0.00
max	109,253	54.62	110,405	0.99
median	4,790	20.20	40,831	0.13
std dev	23,487	11.17	22,583	0.25

Notes:
Total annual runoff in Pismo Creek is calculated according to the relationship between mean daily discharge on Lopez Creek compared to that Pismo Creek during water years 1991 and 1992 (see Figure 9).

Table 8. Summary of channel geometry measurements in the Pismo Creek Watershed, Summer 2007.

Map ID	Waypoint	Location	Date	Distance upstream from mouth		Channel top width	Channel top height	Bankfull Depth	Bankfull Width	Approximate bankfull Area	Watershed Area
				(meters)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(square mi)
2		Pismo Cr u/s of Hwy 1 Beaver Dam	5/9/07	773	2535			6.5	40	260	37.96
3		Pismo Cr at Price House RR bridge	5/9/07	1215	3985			8	35	280	
4		Pismo Creek at Price House	5/9/07	1400	4592						37.77
5		Pismo Cr at Ormonde Road	5/9/07	6114	20054			10			27.49
6	166	Pismo Cr just u/s of Ormonde Road	6/6/07	6278	20592			8.5	38	323	27.43
7	163	Pismo Creek d/s of Fish Ladder at Power lines	6/6/07			75	35				
8	154	Pismo Cr d/s of Fish Ladder	6/6/07			44	10	2	11	22	15.55
9	176	Pismo Creek at Price House (at u/s property line)	6/7/07	2046	6711	49	12	4	17	68	37.38
10		Canada Verde Trib at Orcutt Rd	6/7/07			20	14				
11	192	Canada Verde Tributary at Orcutt Rd SE of Tiffany Rd	6/7/07			3	4				
12	187	E Corral de Piedra at Orcutt Rd	6/7/07			15	15				
13	185	E Corral de Piedra at Moretti Cyn Road crossing	6/7/07	5578	18296			2.75	10	28	4.23
14	170	E Corral de Piedra, 60' u/s confluence	6/7/07	8873	29103	28	20				0.65
15	40	upstream extent of Beaver Dam impoundment	7/11/07	903	2962			11.1	19.25	214	37.90
16		West Corral de Piedra at Ziel Property				40	5.25	18	2.3	41	4.80

FIGURES

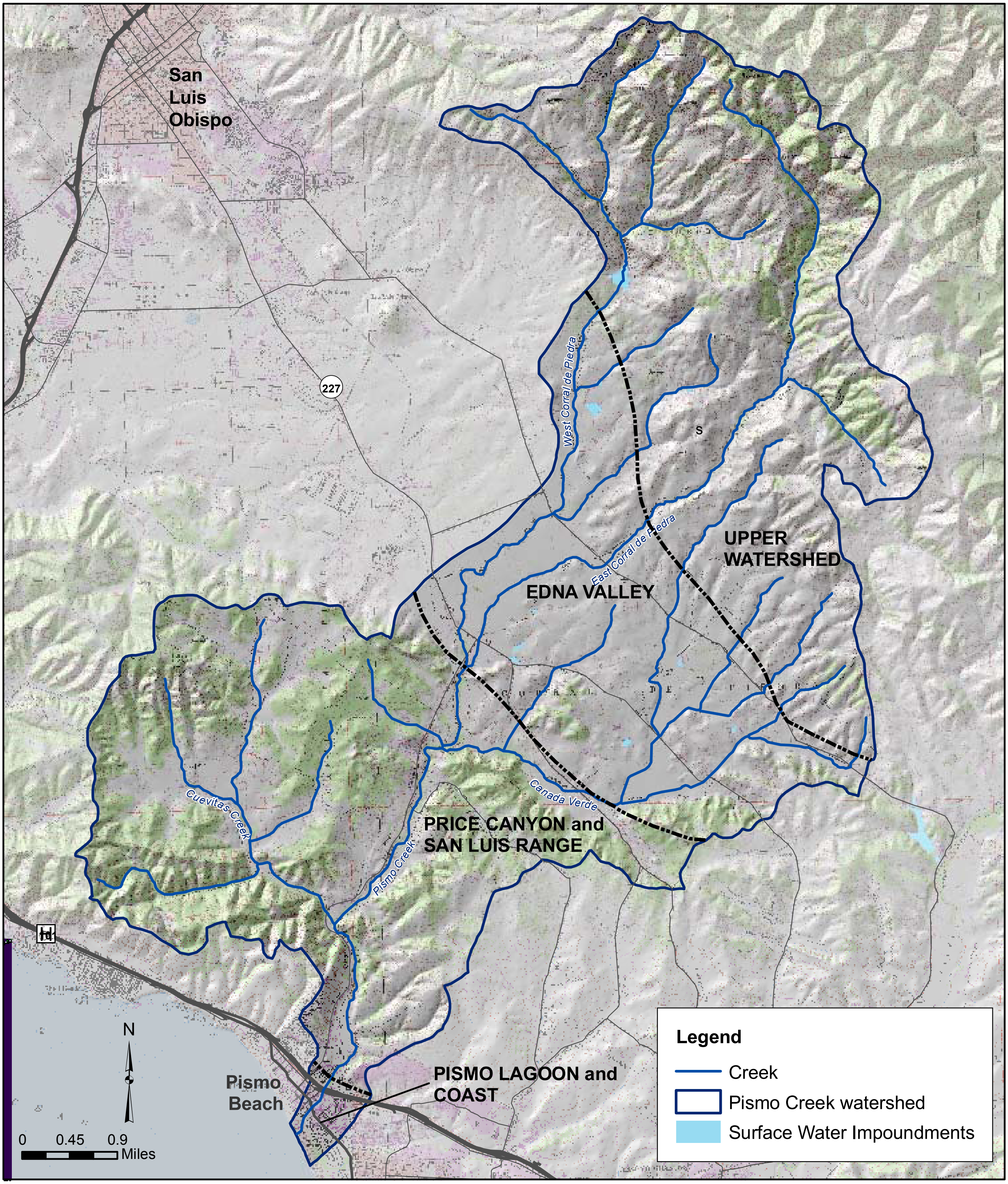

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Figure 1. Watershed map showing geomorphic zones, Pismo Creek Watershed, San Luis Obispo County, California

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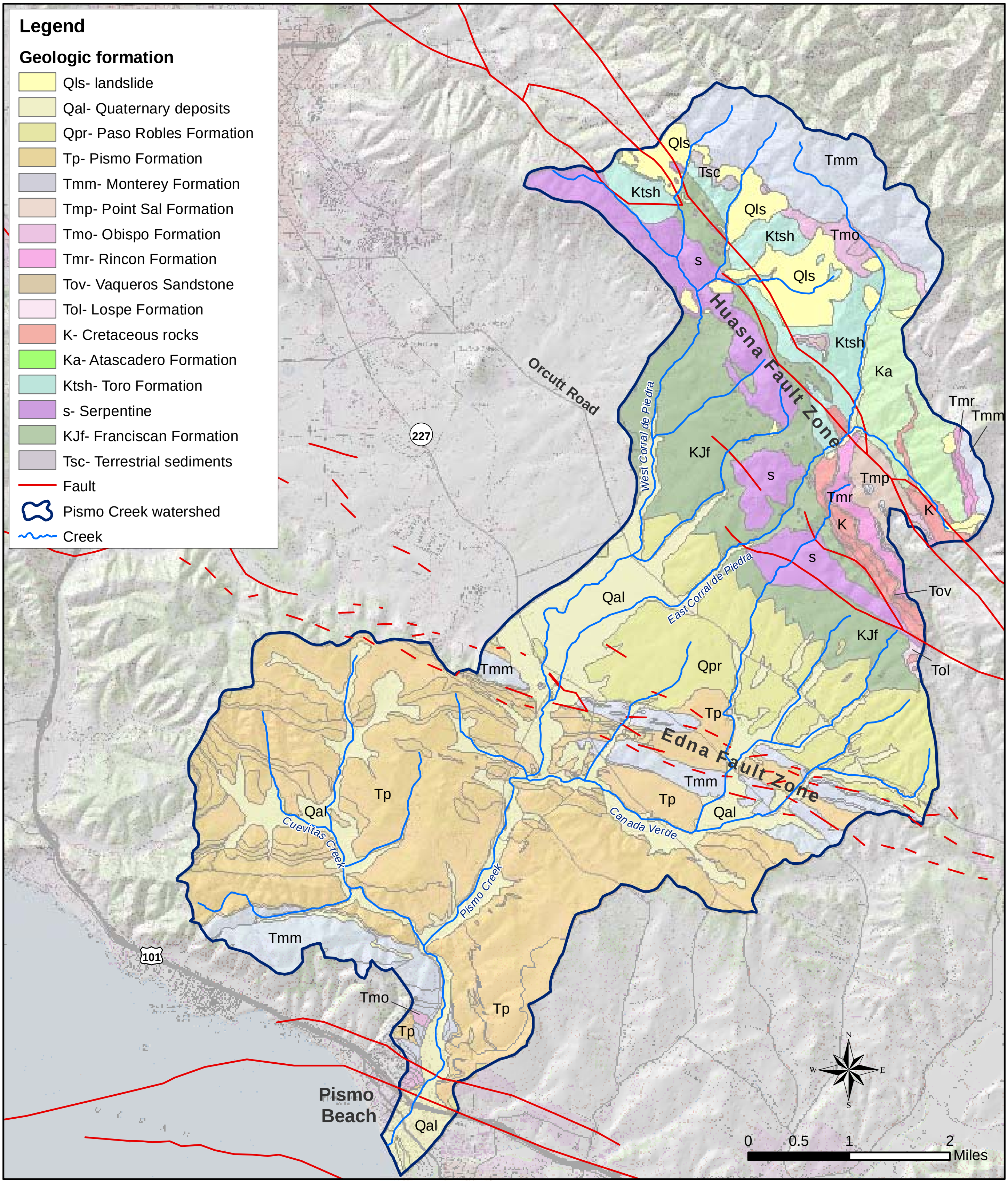

Figure 2. Geologic map of the Pismo Creek Watershed, San Luis Obispo County, California

Source: San Luis Obispo Department of Planning and Building, as adapted from Hall, 1973

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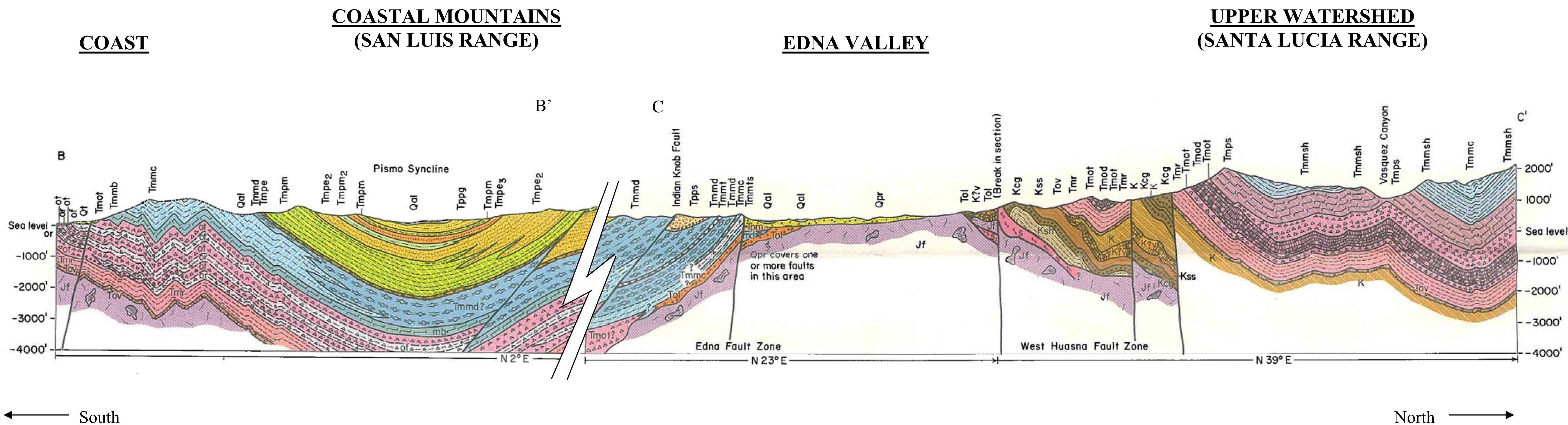

Qal. Alluvial deposits. Qal -consolidated pebbles, sand, silt, and clay. Locally includes older alluvial deposits and beach sand.

Qt. Terrace deposits. Unconsolidated sand, silt, clay, pebbles. Deposits on marine and stream terraces.

Qpr. "Paso Robles Formation" Sandstone, siltstone, claystone, Monterey clasts; Qprt – "Paso Robles?" angular clasts of tuff.

Tpp. Pismo Formation; Tpps. Squire Member. Tpps, massive white medium – to coarse-grained sandstone; Tppsc, chert pebble conglomerate; Tppsb, bituminous sandstone.

Tppg. Gragg Member massive white sandstone; Tppgb, locally bituminous sandstone; Tppg1 bedded white sandstone; Tppg2, massive or bedded white siltstone; Tppgc, chert, pebble conglomerate.

Tmpm. Miguelito Member. Tmpm, brown clay and silt, becoming more diatomaceous and with cherty or opaline shale beds in west; Tmpm2, diatomaceous siltstone, siltstone, or sandy siltstone.

Tmmc. Monterey Formation; Tmmb, siltstone or chert and blocky weathering dolomitic claystone or silt; Tmmts, tuffaceous silt; Tmmc, opaline or cherrty shale, some dolomite; Tmmd, diatomite, some blue tuff, locally interbedded with opaline shale and sandstone (Tmms, sandstone loc dolomitic or tuffaceous); Tmmsh siliceous siltstone and claystone with *Pecten discus*; Tmmt, white or blue vitric tuff, locally includes some tuff ss; Tmmsl, claystone and siltstone.

Tmps. Point Sal Formation. Tmps, light brown or tan siltstone, commonly foraminiferal or diatomaceous, some brown chert and dolomitic siltstone. In part equivalent to Tmmb, Tmpssh, mudstone or claystone interbedded with beds (6"-3') of dolomitic siltstone.

Tmo. Obispo Formation. Tmop, perlitic breccia; Tmot, fine-to coarse-grained white tuff or crystalline tuff, Tmor, res., silicified or zeolitized tuff; Tmof, tuffaceous bedded claystone and silt, fine-gr bedded tuff; Tmod, diabase and some tuffaceous siltstone or tuff.

Tov. Vaqueros Sandstone. Tov, coarse-grained gray calcareous arkosic arenite.

Tol. Lospe Formation ? Tol, conglomerate with porphyritic hornblende monzonite and Franciscan clasts, tuff, red and green sand, or clay and locally calcareous pods or beds.

K. Cretaceous rocks. K, undifferentiated sand; conglomerate and silt; Kss, biotite rich arkose or arkosic wacke; Kcg, cobble conglomerate; Ksh, dark brown mudstone; K?v, brown vesicular basalt, olivine (?) basalt or diabase.

S. Serpentinite and ultrabasic rocks.

Jf. Franciscan rocks. JF, undifferentiated, mostly greywacke and microgray wacke; gw, greywacke; sc, schist; cg, conglomerate; mv metavolcaninc rocks; ch, green; wh, and red chert, cly, claystone; v, basalt, pillow basalt; No stratigraphic order implied.

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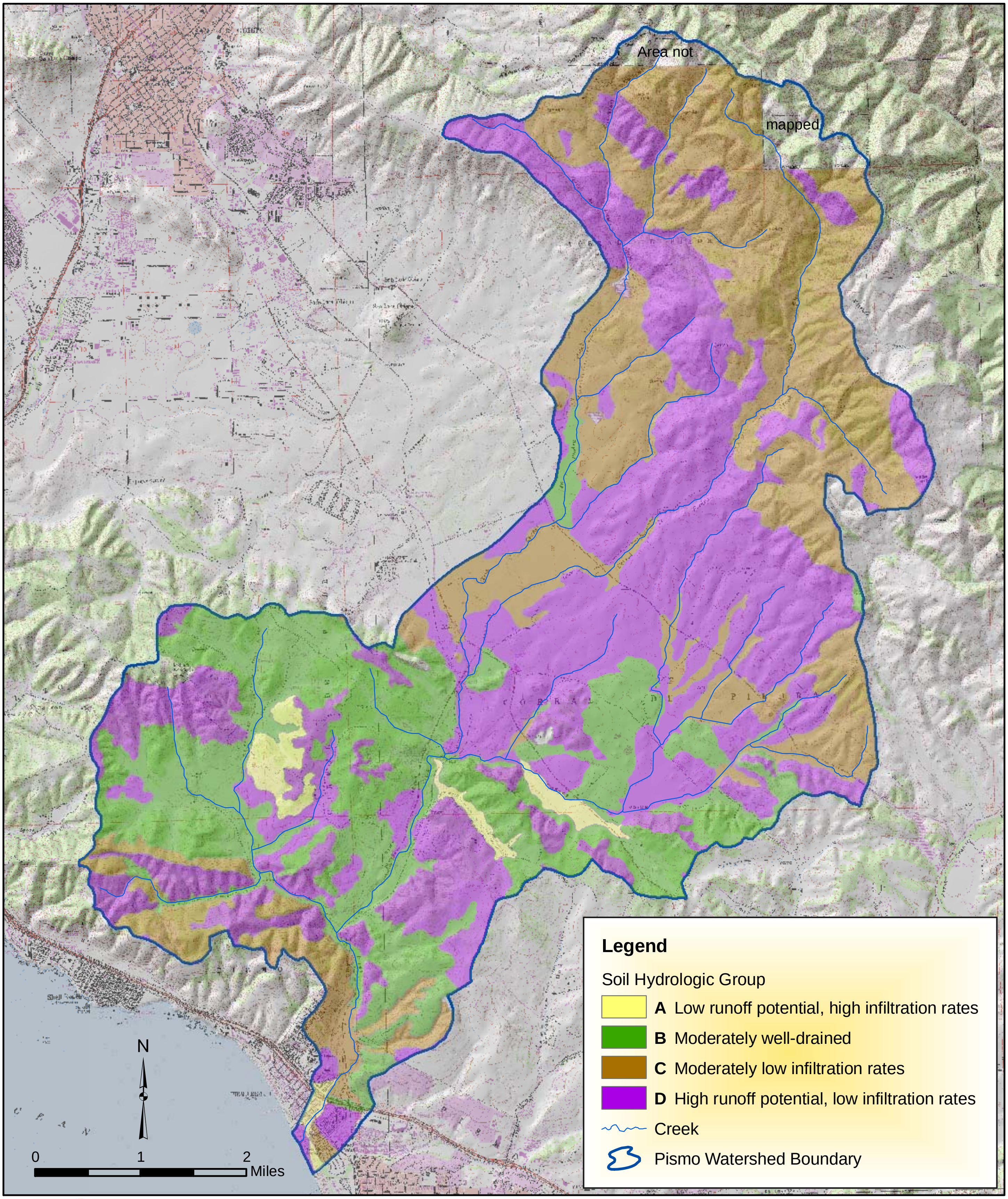
Figure 3. Geologic Cross-Section in the vicinity of the Pismo Creek Watershed.

Source: Hall (1973), Cross-sections B-B' and C-C'



Balance Hydrologics, Inc.

Figure 4. Soil Hydrologic Groups, Pismo Creek Watershed, San Luis Obispo County, California

Source data: U.S.Department of Agriculture, Natural Resources Conservation Service, 2001, Soil Survey Geographic database for San Luis Obispo County, California, Coastal Part.

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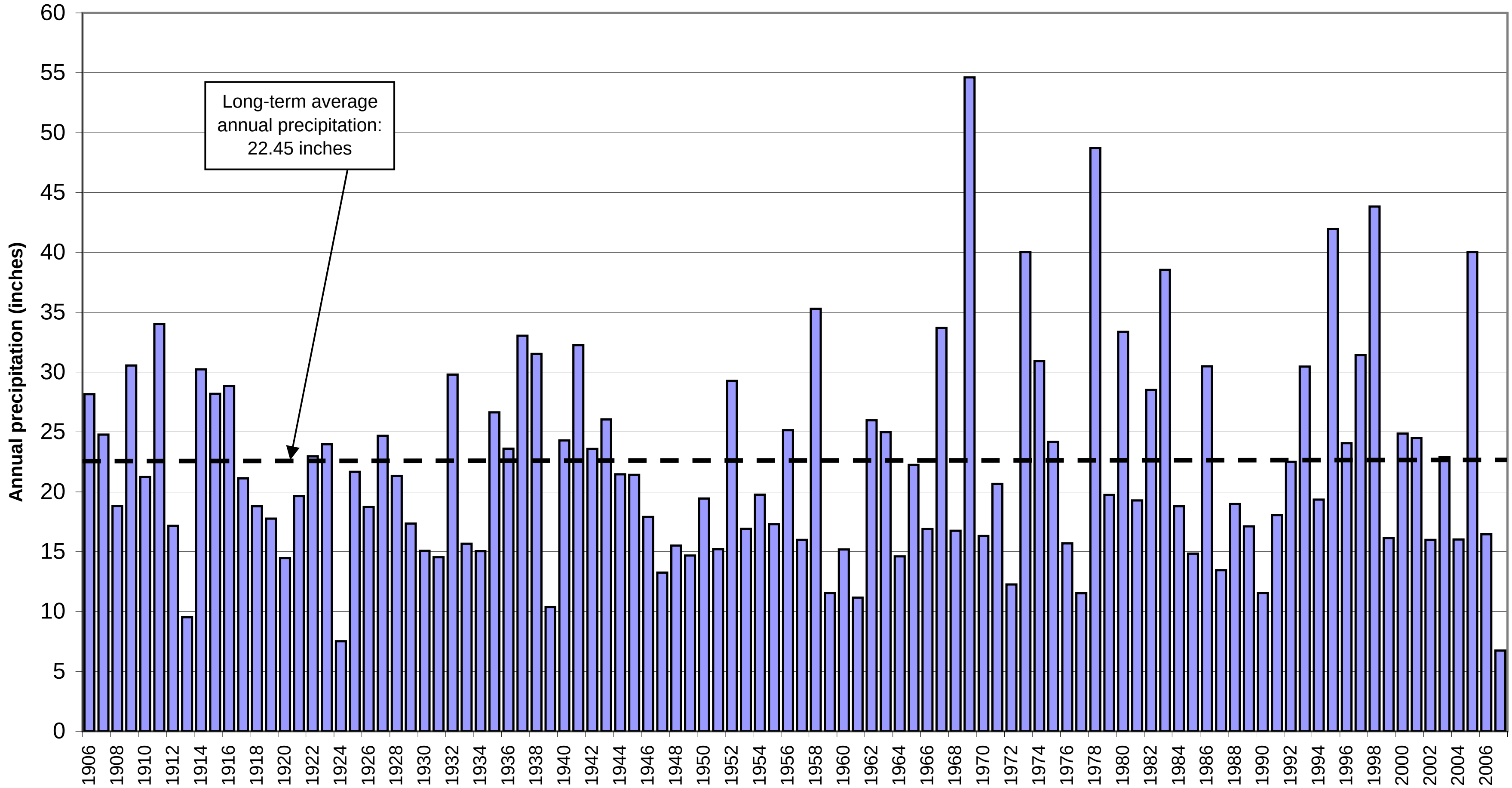

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Figure 5. Annual precipitation by water year, 1906-2007, San Luis Obispo, California.
Sources: California Date Exchange Center, Station SLO 1906-1981, 1984-2007
Western Regional Climate Center, Station SLO-Polytec, 1982-1983

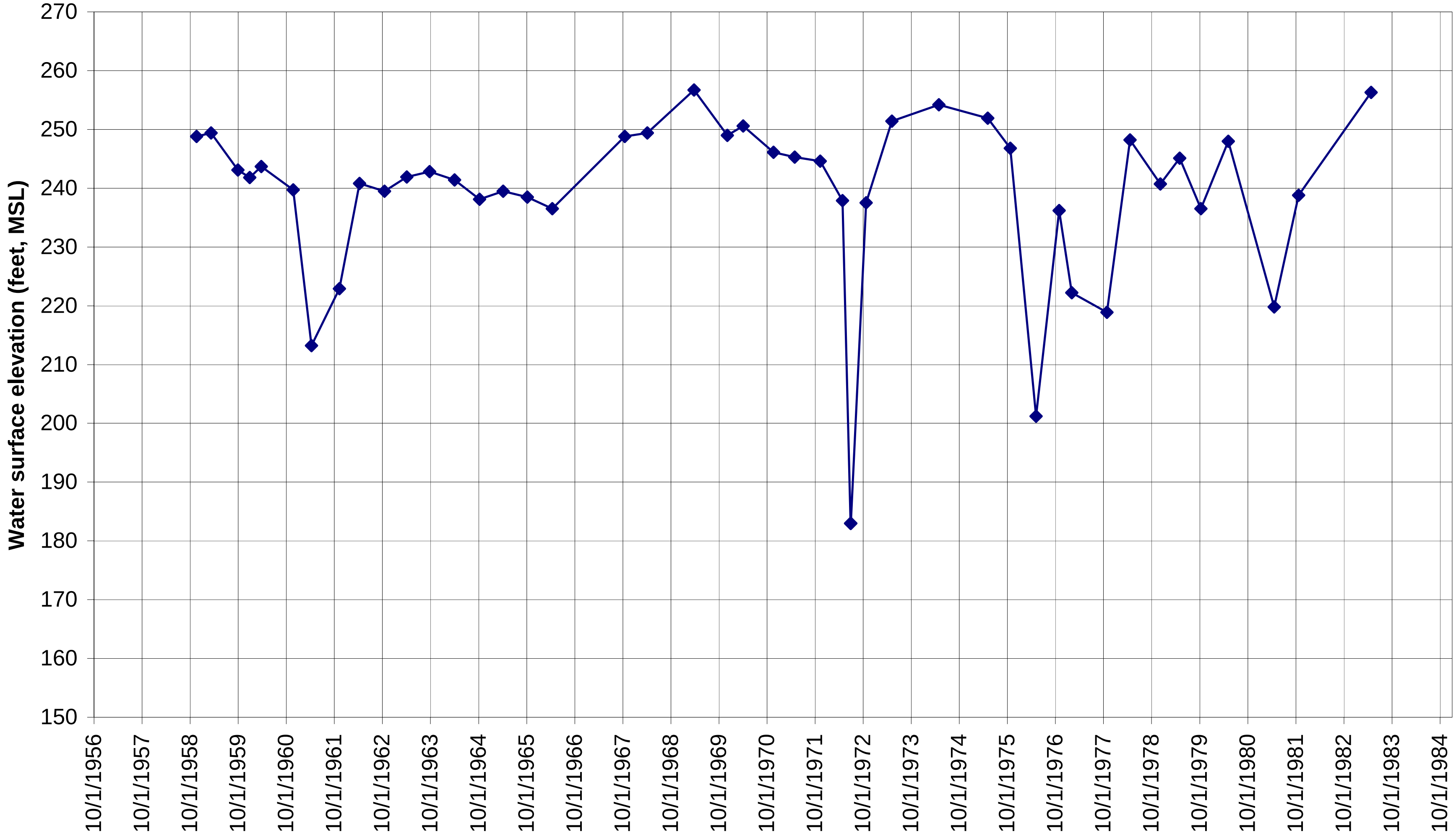

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Figure 6. Ground water elevatations in Edna Valley, San Luis Obispo County, California
Data provided by the California Department of Water Resources for well number 31S13E19H001M located near Biddle Ranch Road at Edna Road.

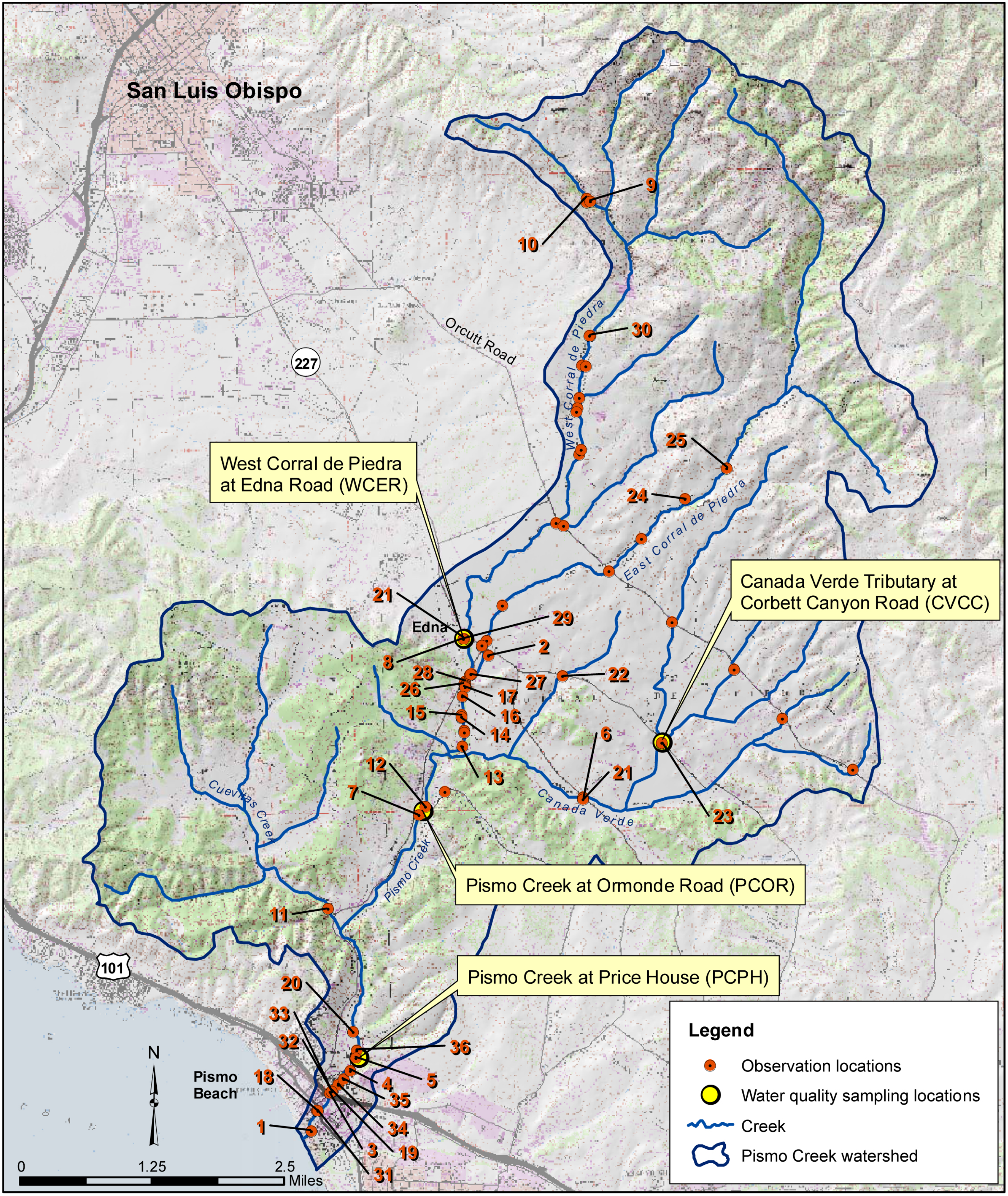

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Figure 7. Locations of streamflow and specific conductance measurements in the Pismo Creek Watershed, San Luis Obispo County, California

Unnumbered locations were dry at the time of field work.

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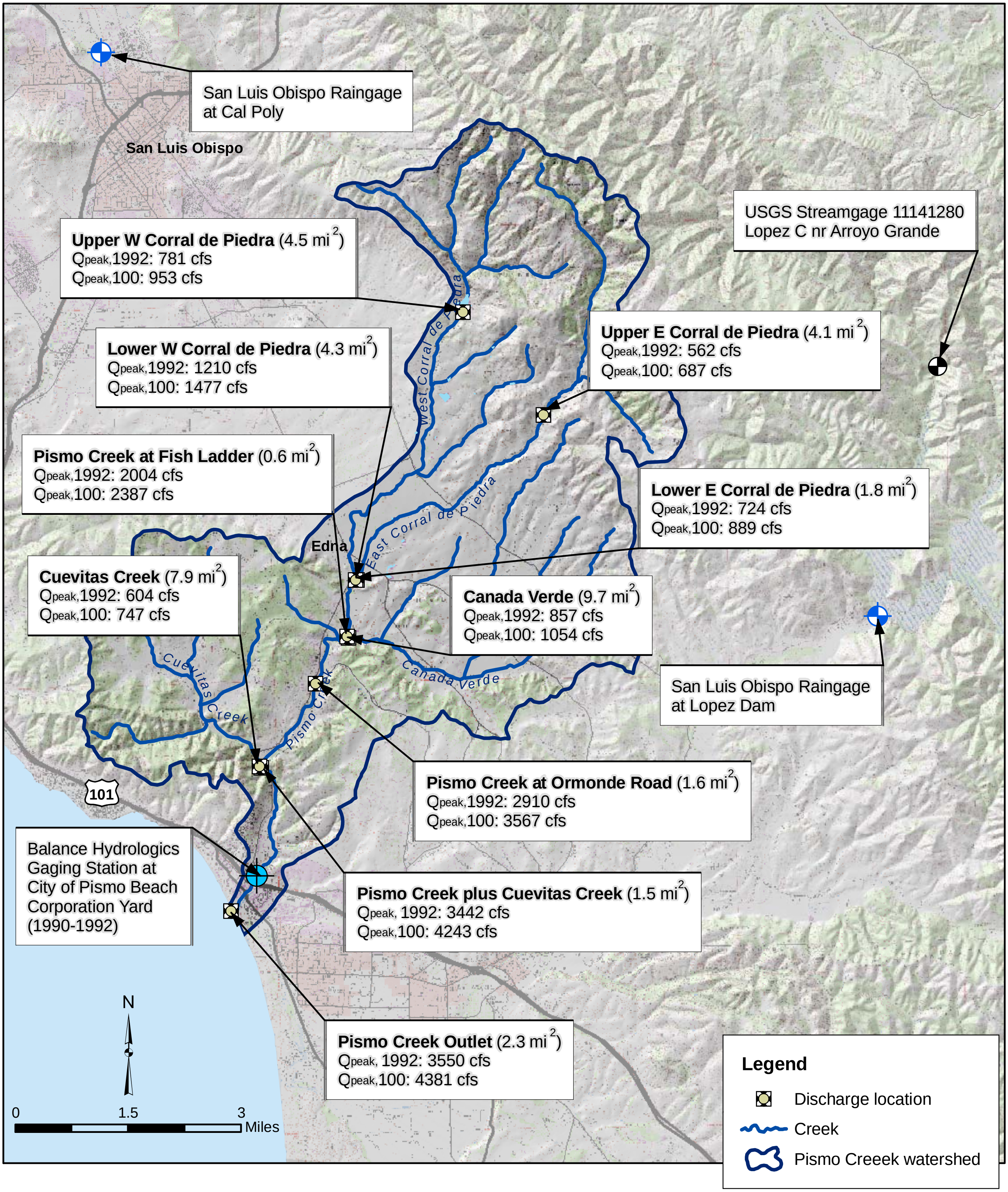

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Figure 8. Subwatershed locations and HEC-HMS peak flow estimates for the Pismo Creek watershed, San Luis Obispo County, California

Qpeak, 1992: Estimated peak discharge associated with rainfall observed during the February 15, 1992 storm, an approximately 1.6-year flood event as measured on Lopez Ck.
Qpeak, 100: Estimated peak discharge associated with the 100-yr, 24-hr rainfall event.

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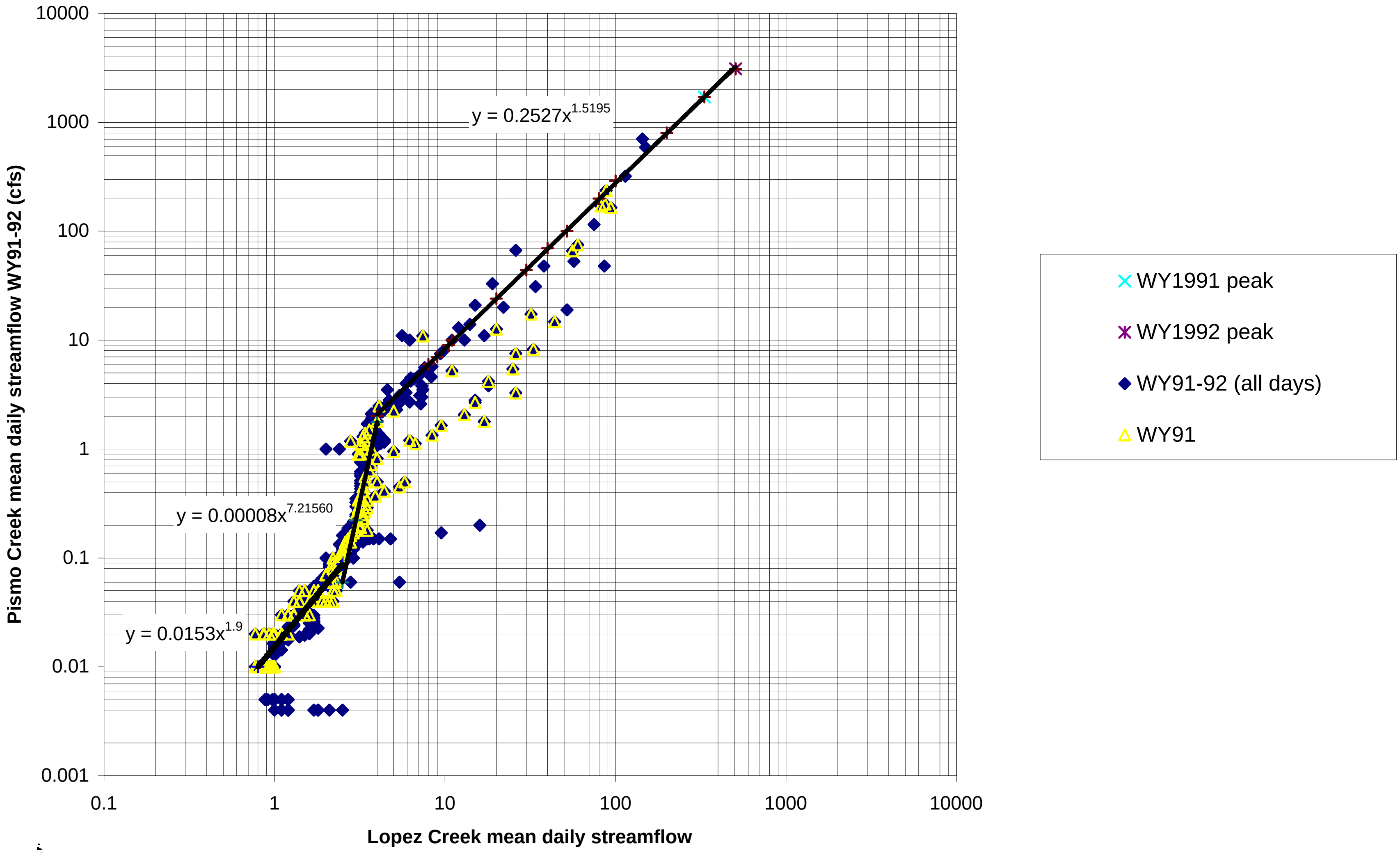

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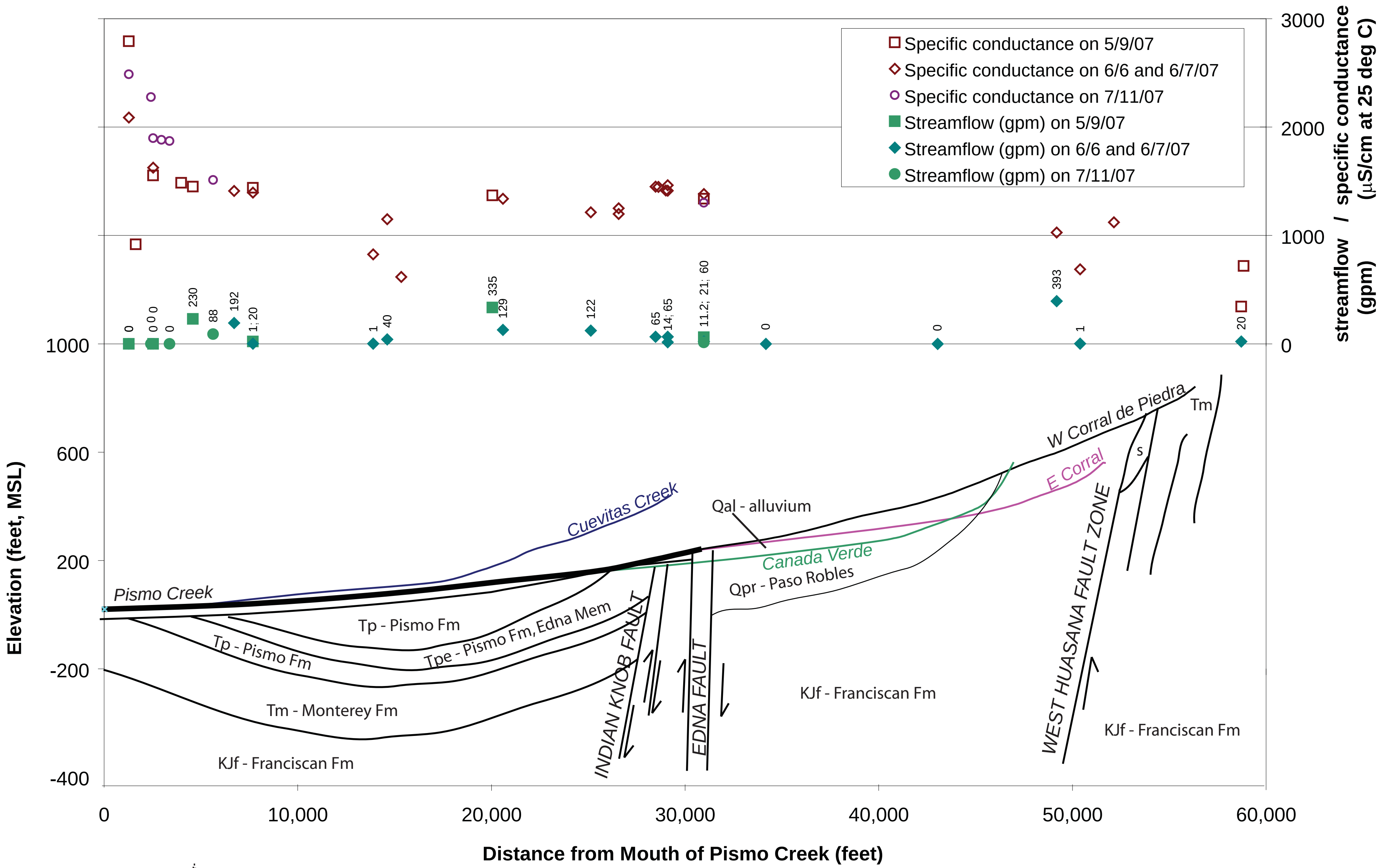
Figure 9. **Mean daily streamflow correlation: Pismo Creek to Upper Lopez Creek**
Data are for the period of record on Pismo Creek, as gaged by Balance Hydrologics during water years 1991 and 1992. Lopez Creek data provided by the US Geological Survey for station 11141280: (LOPEZ C NR ARROYO GRANDE CA)

207133 Pismo_Q.XLS,Fig9 Lopez-Pismo daily corr



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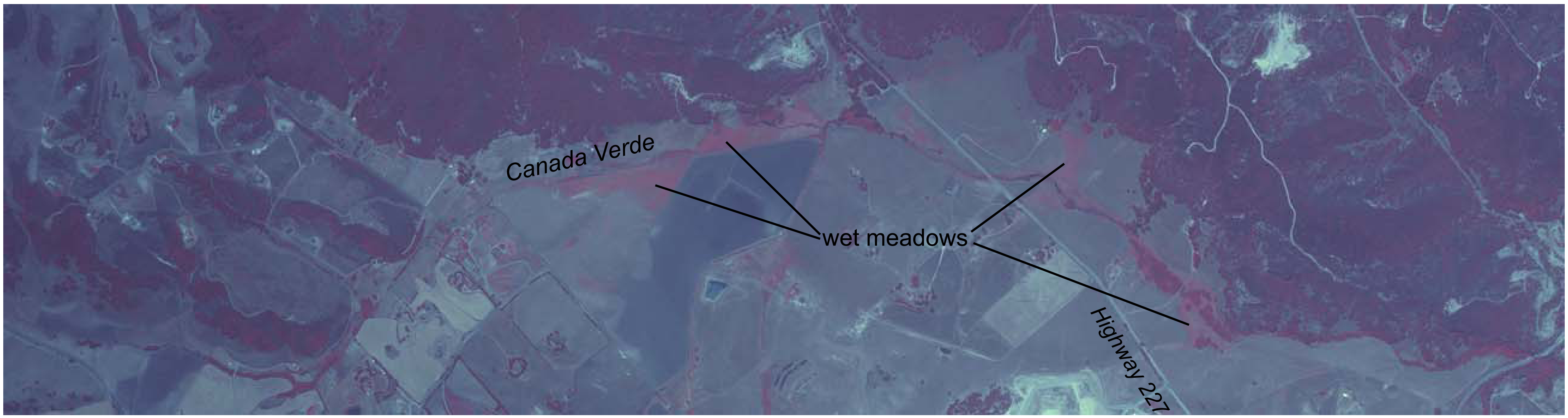
Rev. 1/21/08

Figure 10. **Schematic cross section and stream longitudinal profile showing showing locations of specific conductance and stream discharge measurements as related to the local underlying geology, Pismo Creek Watershed, San Luis Obispo County, California**

207133 Pismo watershed\207133 geology\207133 long x-sect.dwg



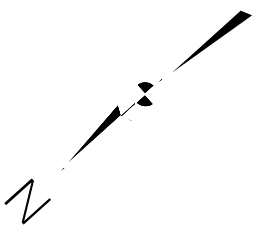


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Figure 11. Enhanced Color Infrared Photograph of Canada Verde Creek, June, 1989
Pismo Creek Watershed, San Luis Obsipo County, California,

Darker red colors represent increased plant vigor.

Shallow ground water along the floodplain appears to be emanating from both adjacent hillsides (Tertiary sedimentary geologic formations), as well as the valley floor itself (Quaternary Paso Robles Formation and alluvium) to create extensive wet meadows.

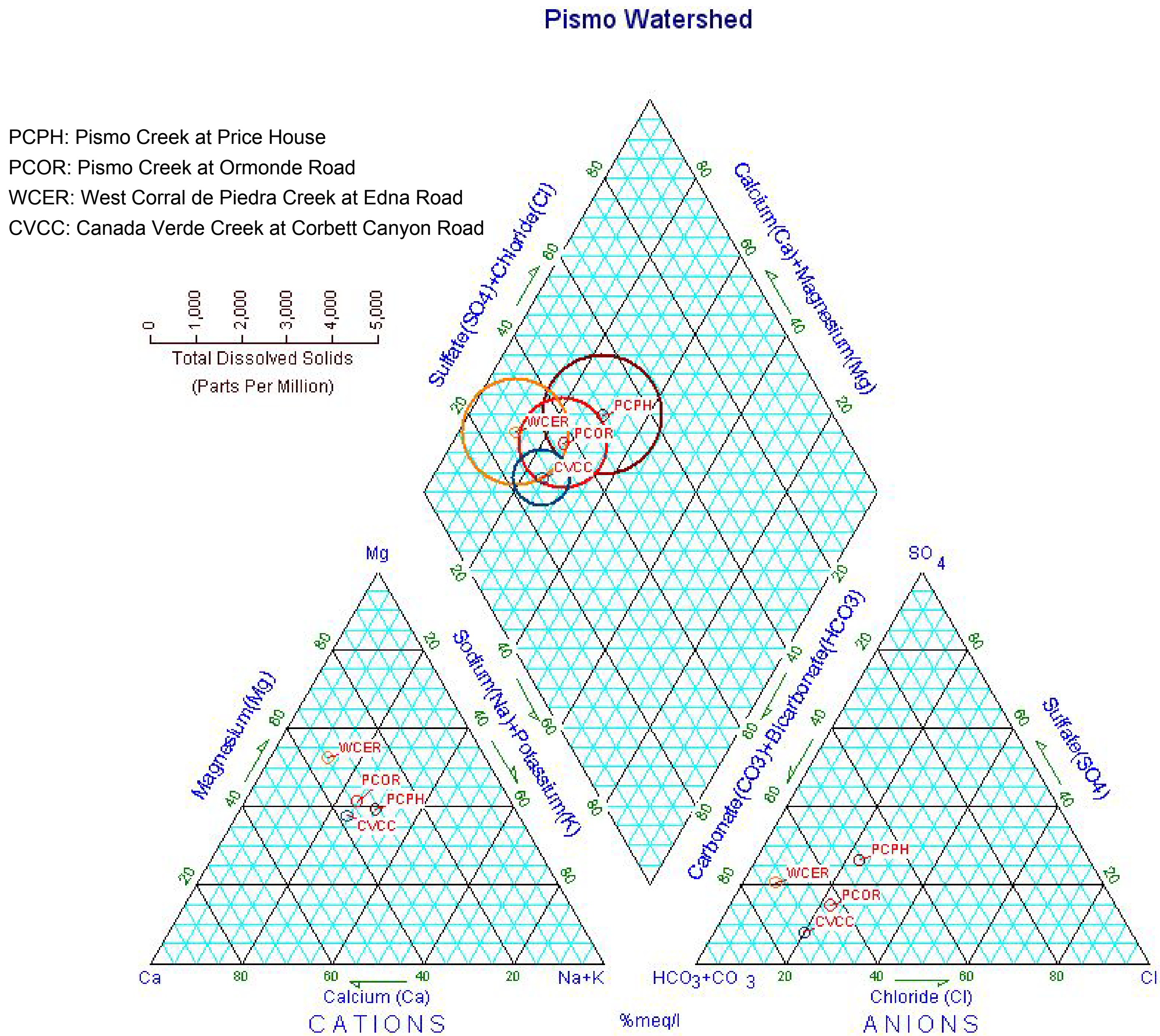

Figure 12. **Piper Plot of baseflow waters in the Pismo Creek Watershed, San Luis Obsipo County, California**

The Piper plot is a useful interpretative tool in illustrating differences and similarities among waters. Total dissolved solids and specific conductance were found to be lower in Canada Verde at Corbett Canyon Road. Pismo Creek at the Price House was found to be slightly higher in relative sulfate concentrations, perhaps due to upstream contact with bituminous sandstones and the related shales, either through natural seepage or indirectly as inflow from oil-production areas.

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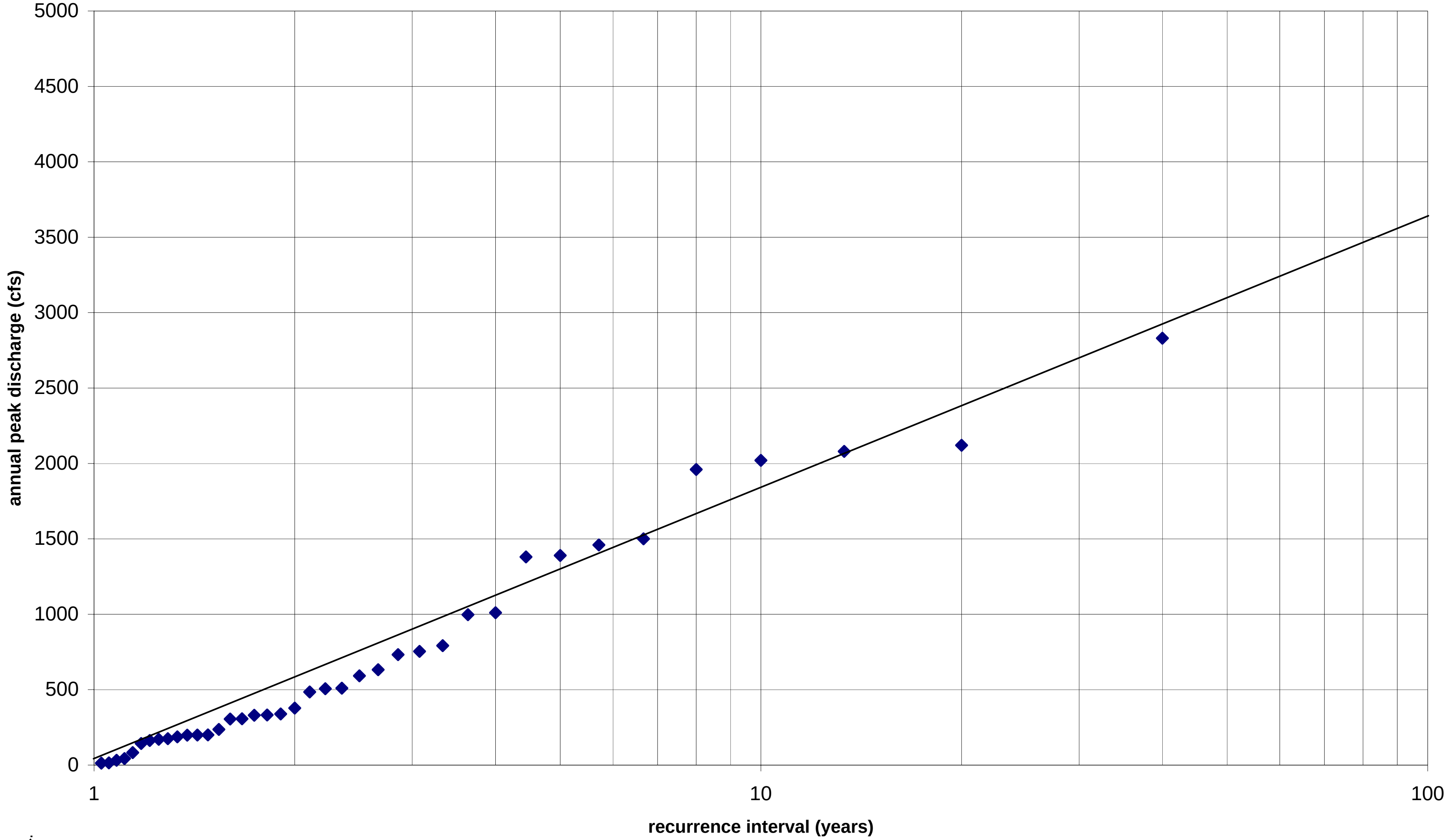

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Figure 13. **Annual peak series for Lopez Creek near Arroyo Grande, California**
Data provided by the US Geological Survey for station 11141280.
The 100-year discharge is extrapolated from the series and estimated at 3700 cfs, corresponding to a unit runoff of 177 cfs per square mile.

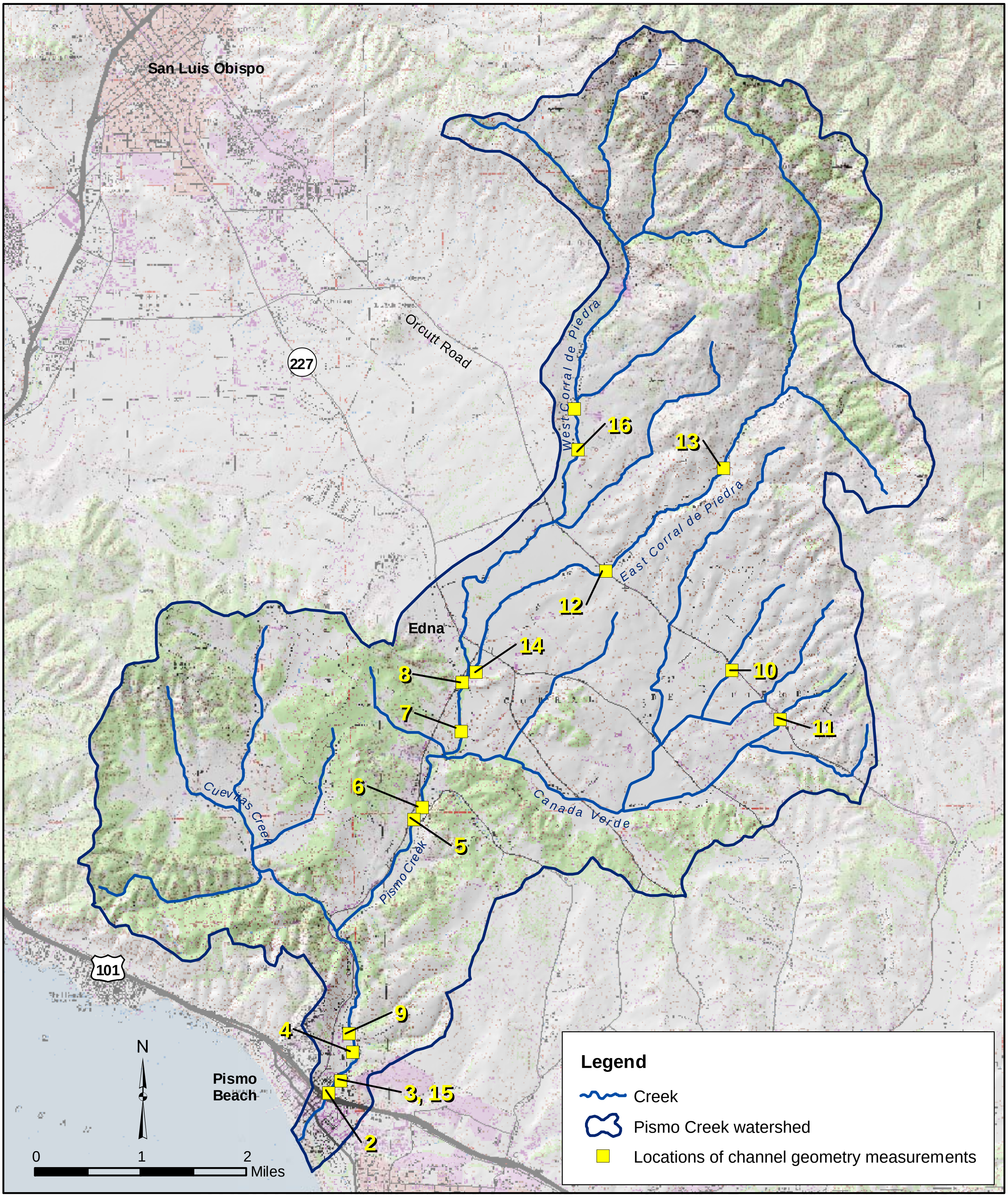

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Figure 14. Locations of channel geometry measurements, Pismo Creek Watershed, San Luis Obispo County, California

Channel geometry data provided in Table 8.

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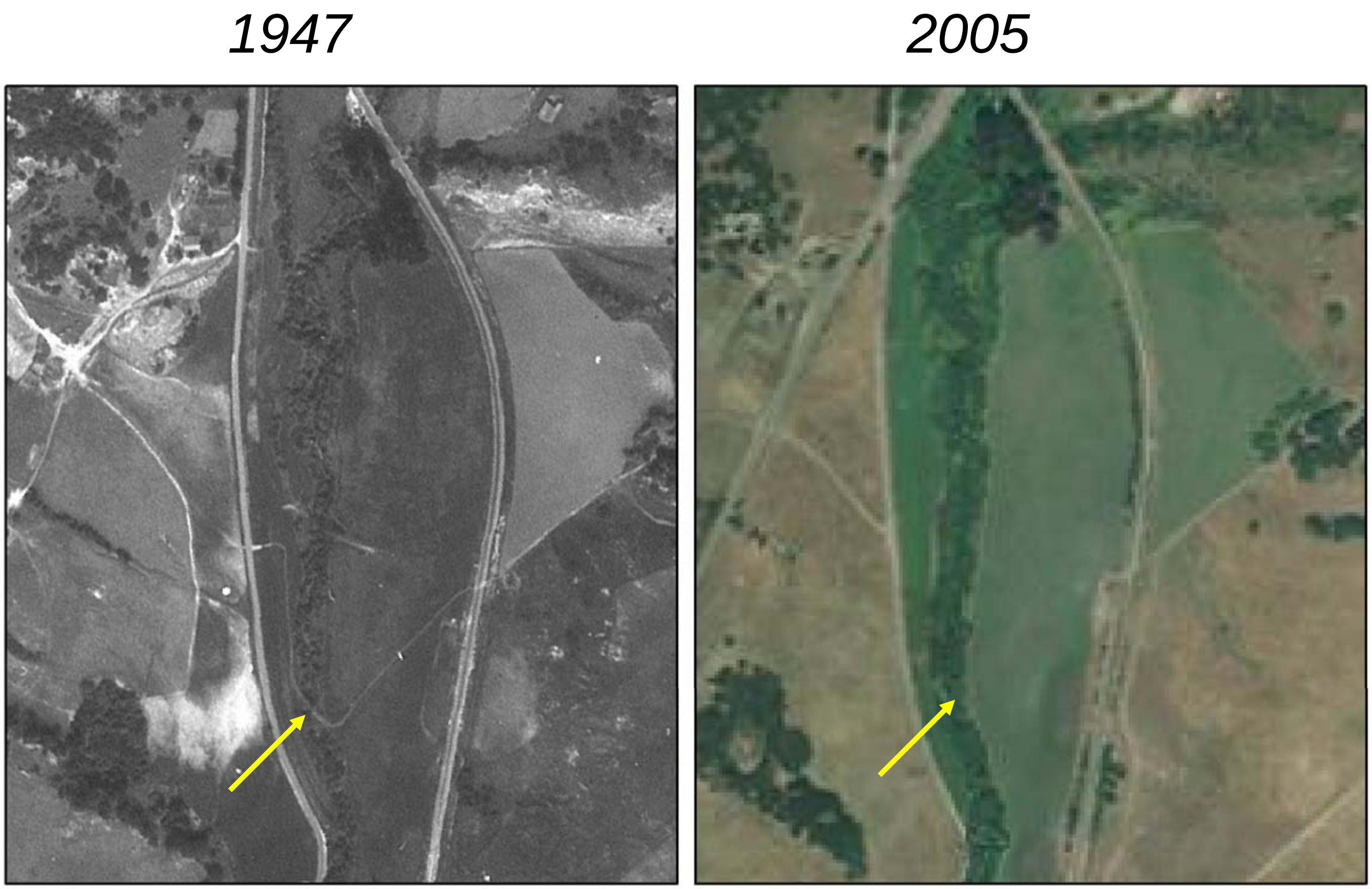

Figure 15. **Pismo Creek above Price Canyon in 1947 and 2005, Pismo Creek Watershed, San Luis Obispo County, California**
Stereo-viewing and the presence of a road crossing indicate that the channel was not substantially incised in 1947, while recent field investigations imply it to be significantly (20 feet or more) incised under present-day conditions.

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1947 2005

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Figure 16. **East Corral de Piedra Creek in 1947 and 2005, Pismo Creek Watershed, San Luis Obsipo County, California,**
The absence of alternate channels in more recent times suggests that the stream has become incised, with less-frequent inundation of the floodplain. Field observations reveal that the channel is currently incised approximately 15 feet below the floodplain. Note also the apparent decrease in vegetation, perhaps associated with the development of intensive viticulture on this parcel.

APPENDICES

APPENDIX A

Mean daily discharge on Pismo Creek during water years 1991 and 1992

Annual Daily Discharge Record

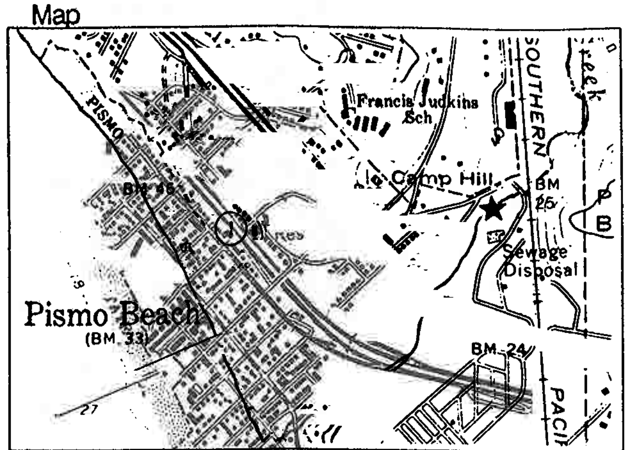
Water Year: 1991
Stream: Pismo Creek
Station: Corporation Yard Gage

Station Location

Lat 35 08'34" Long 120 38'0".

About 0.1 mile downstream of S.P.R.R. bridge and directly behind City Corporation Yard, approximately 60 yards northwest of main shed.

Map



Pismo Beach, California Quadrangle, 1:24000

Watershed Descriptors

Approximately 25 square-mile watershed with mixed land uses, including wildlands in the headwaters, grazing and agriculture in Edna Valley, and oil production and residential development in and adjacent to Price Canyon. Substantial water storage and some diversions to stock ponds exist upstream of gage.

Extreme Flows

Date	Time	Gage Ht. (ft)	Discharge (cfs)	Notes
8/04/91	1831	2.59	64	bar was breached
3/19/91	0006	8.23	1710	R. I. = 3 to 10 yrs
3/20/91	0356	6.43	820	
3/26/91	1526	7.59	1350	R. I. = 2 to 5 yrs
3/26/91	2356	4.58	310	

Note: Recurrence interval based upon analysis of annual floods.

Gaging Record

Gage established Nov. 23, 1989, and operated continuously through present. Instrumentation disconnected during summer months when stream is normally dry. Gaging sponsored by the City of Pismo Beach.

Mean Daily Disharge: October 1, 1990 through September 30, 1991

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
1	0.00	0.00	0.00	0.00	0.00	1.20	2.69	0.20	0.06	0.05	0.02	0.01
2	0.00	0.00	0.00	0.00	0.00	0.50	2.07	0.19	0.05	0.05	0.02	0.01
3	0.00	0.00	0.00	0.00	0.00	0.18	1.65	0.18	0.05	0.04	0.02	0.01
4	0.00	0.00	0.00	0.00	0.00	17.36	1.34	0.17	0.05	0.04	0.02	0.01
5	0.00	0.00	0.00	0.00	0.00	5.22	1.12	0.16	0.05	0.04	0.02	0.01
6	0.00	0.00	0.00	0.00	0.00	2.23	0.95	0.15	0.05	0.04	0.02	0.01
7	0.00	0.00	0.00	0.00	0.00	1.8	0.82	0.14	0.05	0.04	0.02	0.01
8	0.00	0.00	0.00	0.00	0.00	1.5	0.72	0.14	0.05	0.04	0.02	0.01
9	0.00	0.00	0.00	0.00	0.00	1.4	0.63	0.13	0.04	0.04	0.02	0.01
10	0.00	0.00	0.00	0.00	0.00	1.3	0.56	0.12	0.04	0.04	0.02	0.01
11	0.00	0.00	0.00	0.00	0.00	1.2	0.50	0.12	0.04	0.04	0.02	0.01
12	0.00	0.00	0.00	0.00	0.00	1.1	0.45	0.11	0.04	0.04	0.02	0.01
13	0.00	0.00	0.00	0.00	0.00	1.0	0.41	0.11	0.04	0.03	0.02	0.01
14	0.00	0.00	0.00	0.00	0.00	1.0	0.37	0.10	0.04	0.03	0.02	0.01
15	0.00	0.00	0.00	0.00	0.00	0.9	0.34	0.10	0.04	0.03	0.02	0.01
16	0.00	0.00	0.00	0.00	0.00	0.9	0.31	0.10	0.04	0.03	0.02	0.01
17	0.00	0.00	0.00	0.00	0.00	10.92	0.29	0.09	0.04	0.03	0.02	0.01
18	0.00	0.00	0.00	0.00	0.00	170.41	0.27	0.09	0.04	0.03	0.02	0.01
19	0.00	0.00	0.00	0.00	0.00	237.40	0.25	0.09	0.03	0.03	0.02	0.01
20	0.00	0.00	0.00	0.00	0.00	165.62	0.50	0.08	0.03	0.03	0.02	0.01
21	0.00	0.00	0.00	0.00	0.00	7.55	0.45	0.08	0.03	0.03	0.02	0.01
22	0.00	0.00	0.00	0.00	0.00	3.27	0.41	0.08	0.03	0.03	0.02	0.01
23	0.00	0.00	0.00	0.00	0.00	1.79	0.37	0.07	0.03	0.03	0.02	0.01
24	0.00	0.00	0.00	0.00	0.00	12.62	0.34	0.07	0.03	0.03	0.02	0.01
25	0.00	0.00	0.00	0.00	0.00	74.96	0.31	0.07	0.03	0.03	0.02	0.01
26	0.00	0.00	0.00	0.00	0.00	177.46	0.29	0.07	0.03	0.03	0.02	0.01
27	0.00	0.00	0.00	0.00	1.18	66.21	0.27	0.06	0.03	0.03	0.02	0.01
28	0.00	0.00	0.00	0.00	2.49	14.73	0.25	0.06	0.05	0.03	0.02	0.01
29	0.00	0.00	0.00	0.00		8.24	0.23	0.06	0.05	0.02	0.02	0.01
30	0.00	0.00	0.00	0.00		5.44	0.22	0.06	0.05	0.02	0.01	0.01
31	0.00		0.00	0.00		4.19		0.06		0.02	0.01	
MEAN	0.00	0.00	0.00	0.00	0.13	32.25	0.65	0.11	0.04	0.03	0.02	0.01
MAX	0.00	0.00	0.00	0.00	2.49	237.40	2.69	0.20	0.06	0.05	0.02	0.01
MIN	0.00	0.00	0.00	0.00	0.00	0.18	0.22	0.06	0.03	0.02	0.01	0.01
TOTAL (cfs days)	0.00	0.00	0.00	0.00	3.67	999.60	19.38	3.31	1.23	1.04	0.60	0.30
ac-ft	0.00	0.00	0.00	0.00	7.3	1982.2	38.4	6.6	2.4	2.1	1.2	0.6

Water Year 1991 Totals

Mean: 4.16 cfs
Max: 237.40 cfs
Min.: No flow
cfs-days: 1025
Acre-ft.: 2033

Monitor's Comments

1. Station is located in a straight channel reach, and is isolated from tidal action by elevation and by a weir at the head of Pismo Creek estuary, just upstream of Highway 101.
2. Flows between March 8 and March 16, 1991 are estimated from regression analysis of falling limb flows and rainfall data.
3. Stage - discharge relationship for flows greater than 72 cfs was extended by standard slope - area measurements for the four crests cited above.

Annual Hydrologic Record

Water Year:	**1992**
Stream:	**Pismo Creek**
Station:	**Corporation Yard Gage**

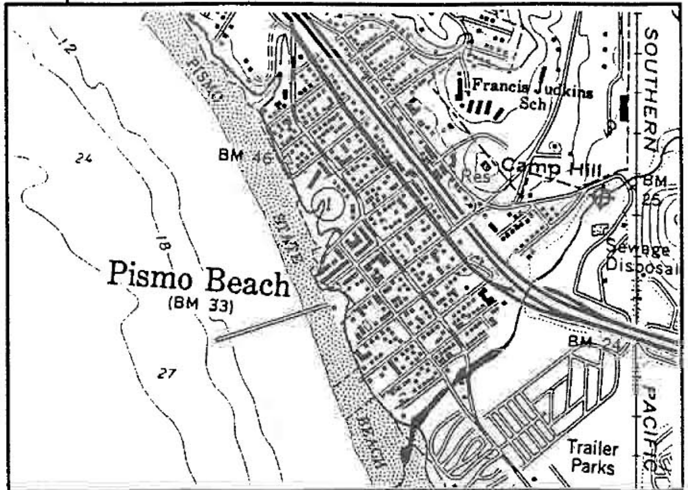
Station Location

Lat 35 08' 34" Long 120 38' 00"
About one-tenth of a mile downstream of the Southern Pacific Railroad Bridge and behind the City of Pismo Beach Corporation Yard.

Watershed Descriptors

Drainage area upstream of the gage is approximately 25 square miles. Wildlands,agriculture, livestock production, oil and gas production, and residential development occur within the watershed.

Map



Pismo Beach, California Quadrangle 1:24,000

Peak Flows

Date &Time	Gage Ht (ft)	Discharge (cfs)
12/29/91 19:15	2.14	25
1/5/92 14:45	3.98	212
2/12/92 8:00	11.07	3100
2/15/92 5:45	11.42	3300

Gaging Record

Gage established November 23, 1989 & operated continuously through present. Gaging is in cooperation with the city of Pismo Beach.

Mean Daily Flow (cubic feet per second)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
1	.01	0	0	.06	.12	4.2	2.1	.81	.09	.03	0	0
2	.01	0	0	.06	.11	4.5	2.0	.78	.09	.03	0	0
3	.01	0	0	1.0	.11	4.3	2.0	.76	.09	.03	0	0
4	.01	0	0	.10	.11	4.0	1.9	.73	.09	.03	0	0
5	.01	0	0	67	.11	10	1.8	.70	.08	.03	0	0
6	.01	0	0	2.8	.11	14	1.7	.68	.08	.02	0	0
7	.01	0	0	.20	.10	10	1.6	.65	.08	.02	0	0
8	.01	0	0	.17	.10	8.0	1.5	.62	.07	.02	0	0
9	.01	0	0	.15	.10	4.6	1.4	.59	.07	.02	0	0
10	.01	0	0	.15	48	3.5	1.4	.57	.07	.02	0	0
11	.01	0	0	.15	19	3.1	1.3	.54	.07	.02	0	0
12	.01	0	0	.15	705	3.0	1.3	.51	.06	.02	0	0
13	.01	0	0	.15	320	2.6	1.3	.49	.06	.02	0	0
14	.01	0	0	.15	48	2.7	1.3	.46	.06	.02	0	0
15	.01	0	0	.14	590	3.1	1.2	.43	.06	.02	0	0
16	0	0	0	.14	115	2.8	1.2	.40	.05	.02	0	0
17	0	0	0	.14	53	2.6	1.2	.38	.05	.02	0	0
18	0	0	0	.14	31	2.5	1.2	.35	.05	.02	0	0
19	0	0	0	.13	20	2.3	1.1	.32	.05	.02	0	0
20	0	0	0	.13	33	2.8	1.1	.30	.05	.02	0	0
21	0	0	0	.13	21	3.3	1.1	.27	.05	.02	0	0
22	0	0	0	.13	13	5.6	1.0	.24	.04	.02	0	0
23	0	0	0	.12	10	11	1.0	.21	.04	.02	0	0
24	0	0	0	.12	7.5	3.5	.99	.19	.04	.01	0	0
25	0	0	0	.12	5.7	2.8	.97	.16	.04	.01	0	0
26	0	0	0	.12	5.2	2.5	.94	.13	.04	.01	0	0
27	0	0	1.0	.11	4.9	2.4	.91	.11	.04	.01	0	0
28	0	0	3.8	.11	4.6	2.3	.89	.10	.03	.01	0	0
29	0	0	11	.11	4.4	2.2	.86	.10	.03	.01	0	0
30	0	0	3.8	.11		2.2	.83	.10	.03	.01	0	0
31	0	0	.06	.10		2.1		.10		.01	0	
MEAN	0	0	.65	2.4	71	4.4	1.3	0.4	.06	.02	0	0
MAX	.01	0	11	67	705	14	2.1	0.8	.09	.03	0	0
MIN	0	0	0	.06	.10	2.2	0.8	.10	.03	.01	0	0
cfs days	.14	0	20	74	2059	132	39	13	2	0.6	0	0
ac-ft	.28	0	39	148	4084	263	78	25	4	1	0	0

Monitor's Comments

1. Station is located in a straight channel reach isolated from tidal action by elevation and by a weir at the head of Pismo Creek estuary.
2. Stage-discharge relationship for flows greater than 72 cfs extended by slope-area surveys.

Water Year 1992 Totals:	
Mean:	6.4
Max:	705
Min:	0
cfs days:	2340
ac-ft:	4640

Balance Hydrologics, Inc. 1760 Solano Avenue Suite 209 Berkeley, CA 94707 (510) 527-0727 fax: (510) 527-8531

APPENDIX B

Selected water quality analyses in the Pismo Creek Watershed from previous years

ANALYTICAL CHEMISTS
and
BACTERIOLOGISTS
Approved by State of California

Tel: 408 724-5422
FAX: 408 724-3188

SOIL CONTROL LAB

42 HANGAR WAY
WATSONVILLE
CALIFORNIA
95076
USA

A Division of Control Laboratories Inc.

In any reference, please quote Certified Analysis Number appearing hereon.

94216-17-4205

Balance Hydrologics Inc.
1760 Solano Avenue - Suite 209
Berkeley CA 94707

19 MAR 92

Attn: Barry Hecht

CERTIFIED ANALYTICAL REPORT

MATERIAL: Water samples received 04 March 1992
IDENTIFICATION: Storm Run-Off
REPORT: Quantitative chemical analysis is as follows expressed as milligrams per liter (parts per million):

Sample Identification	Total Suspended Solids
PT 1	340
PT 2	48[illegible]0
PT 3	1250
PT 4	870
PT 5	1070
SC 1	18
LLG 1	59
LLG 2	320
SJV 1	950
SJV 2	21
LPT 7	76
PISMO 1	9400
PISMO 2	175
PISMO 3	1050
PISMO 4	380
PISMO 5	2800
PISMO 6	2000

The undersigned certifies that the above is a true and accurate report of the findings of this Laboratory.

Analyst

ANALYTICAL CHEMISTS
and
BACTERIOLOGISTS
Approved by State of California

Tel: 408 724-5422
FAX: 408 724-3188

SOIL CONTROL LAB

42 HANGAR WAY
WATSONVILLE
CALIFORNIA
95076
USA

A Division of Control Laboratories Inc.

In any reference, please quote Certified Analysis Number appearing hereon.

95963-3-4205

Balance Hydrologics Inc.
1760 Solano Avenue - Suite 209
Berkeley CA 94707

10 JUL 92

Attn: Barry Hecht

CERTIFIED ANALYTICAL REPORT

MATERIAL: Water samples received 07 July 1992
IDENTIFICATION: Pismo Creek & Sisquoc River
REPORT: Quantitative chemical analysis is as follows expressed as milligrams per liter (parts per million):

Sample Identification	Total Suspended Solids *
~~920304 Sisquoc St. 3.94~~	~~18~~
920305 19:00 Pismo St. 1.07	650
920305 Pismo St. 0.96	380

* By Standard Method 209D; whole sample was used for each analysis

The undersigned certifies that the above is a true and accurate report of the findings of this Laboratory.

Analyst

COPY

Central Coast Analytical Services

CENTRAL COAST
ANALYTICAL SERVICES
Air, Water & Hazardous Waste Analysis
141 Suburban Road, Suite C-4
San Luis Obispo, California 93401
(805) 543-2553

LAB NUMBER : B-0572
COLLECTED : 3/04/85
RECEIVED : 3/05/85
REPORTED : 5/20/85
P.O. NUMBER : Verbal

Submitted By:

City of Pismo Beach
1000 Bello Ave.
Pismo Beach, CA 93449

SAMPLE DESCRIPTION:
Surface Water from Pismo Creek
Sampled by:
Tim Cleath

REPORT

CONSTITUENT	REPORTED AS		LEVEL FOUND
ALUMINUM	Al	-	---
ARSENIC	As	-	<0.01
BARIUM	Ba	-	0.2
BERYLLIUM	Be	-	---
CADMIUM	Cd	-	<0.005
CHROMIUM, TOTAL	Cr	-	<0.005
CHROMIUM, HEXAVALENT	Cr(VI)	-	---
COBALT	Co	-	---
COPPER	Cu	-	---
LEAD	Pb	-	<0.006
MERCURY	Hg	-	<0.0002
MOLYBDENUM	Mo	-	---
NICKEL	Ni	-	---
SELENIUM	Se	-	<0.005
SILVER	Ag	-	<0.01
THALLIUM	Tl	-	---
VANADIUM	V	-	
ZINC	Zn	-	---
		-	
		-	

(<)-means less than and this is the detection limit as applied to this analysis.

Encl: Invoice # 8771
MH/dm

Respectfully submitted,
CENTRAL COAST ANALYTICAL SERVICES

By Mary Havlicek

Mary Havlicek, Ph.D., President

CERTIFIED WATER LABORATORY BY THE DEPARTMENT OF PUBLIC HEALTH FOR COMPLETE CHEMICAL AND BACTERIOLOGY

ACIDIC/PHENOLIC EXTRACTABLE PRIORITY POLLUTANTS

EPA METHOD 625

CENTRAL COAST ANALYTICAL SERVICES, INC.

141-C Suburban Road, San Luis Obispo, CA 93401

SAMPLE B 0572

Submitted March 5, 1985

Submitted by Mr. Tim Cleath for Pismo Beach

Compound Analyzed	Detection Limit micrograms/liter	Concentratio micrograms/li
Phenol	0.3	0.3
2-Chlorophenol	0.3	not found
2-Nitrophenol	0.5	not found
2,4-Dimethylphenol	0.5	not found
2,4-Dichlorophenol	0.5	not found
4-Chloro-3-methylphenol	1.0	1.4
Trichlorophenol	1.0	1.1
2,4-Dinitrophenol	5.0	not found
4-Nitrophenol	5.0	not found
2-Methyl-4,6-dinitrophenol	5.0	not found
Pentachlorophenol	1.0	not found

The Priority Pollutant compounds listed above as "not found" would have been reported if present at or above the listed detection limits.

BASE/NEUTRAL EXTRACTABLE PRIORITY POLLUTANTS

CENTRAL COAST ANALYTICAL SERVICES

Submitted March 5, 1985

SAMPLE B 0572

Submitted by Mr. Tim Cleath for Pismo Beach

Surface Water from Pismo Creek

Compound Analyzed	Detection Limit micrograms/liter	Concentration micrograms/liter
1,3-Dichlorobenzene	0.5	not found
1,4-Dichlorobenzene	0.5	not found
Hexachloroethane	1.	not found
Bis(2-chloroethyl)ether	0.5	not found
1,2-Dichlorobenzene	0.5	not found
Bis(2-chloroisopropyl)ether	2.	not found
N-Nitrosodi-n-propylamine	2.	not found
Nitrobenzene	0.5	not found
Hexachlorobutadiene	1.	not found
1,2,4-Trichlorobenzene	0.5	not found
Isophorone	1.	not found
Naphthalene	0.5	not found
Bis(2-chloroethoxy)methane	2.	not found
Hexachlorocyclopentadiene	1.	not found
2-Chloronaphthalene	0.5	not found
Acenaphthalene	1.	not found
Acenaphthene	0.5	not found
Dimethyl phthalate	0.5	not found
2,6-Dinitrotoluene	2.	not found
Fluorene	0.5	not found
4-Chlorophenyl phenyl ether	1.	not found
2,4-Dinitrotoluene	3.	not found
Diethyl phthalate	1.	not found
N-Nitrosodiphenylamine	1.	not found
Hexachlorobenzene	0.5	not found

SAMPLE B 0572

Surface Water from Pismo Creek

Continued

Compound Analyzed	Detection Limit micrograms/liter	Concentration micrograms/liter
4-Bromophenyl phenyl ether	0.5	not found
Phenanthrene	1.	not found
Anthracene	1.	not found
Dibutyl phthalate	1.	not found
Fluoranthene	1.	not found
Pyrene	1.	not found
Benzidine	40.	not found
Butyl benzyl phthalate	1.	not found
Bis(2-ethylhexyl) phthalate	1.	not found
Chrysene	2.	not found
Benzo(a)anthracene	5.	not found
3,3'-Dichlorobenzidine	20.	not found
Di-n-octyl phthalate	2.	not found
Benzo(b)fluoranthene	5.	not found
Benzo(k)fluoranthene	5.	not found
Benzo(a)pyrene	7.	not found
Indeno(1,2,3-c,d)pyrene	10.	not found
Dibenzo(a,h)anthracene	10.	not found
Benzo(ghi)perylene	10.	not found
N-Nitrosodimethyl amine	2.	not found

The Priority Pollutant compounds listed above as "not found" would have been reported if present at or above the listed detection limits.

Respectfully submitted,
CENTRAL COAST ANALYTICAL SERVICES, INC.

Stephen C Havlicek

Stephen C. Havlicek, Ph.D.
Vice President

BROWN AND CALDWELL
ANALYTICAL LABORATORIES

LOG NO: P85-03-402

Received: 28 MAR 85
Reported: 15 APR 85

Stephen Havlicek
Central Coast Analytical Services
141 Suburban Road,, Suite 4-C
San Luis Obispo, CA. 93401

Purchase Order: 5363

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, GROUND WATER SAMPLES	DATE SAMPLED
03-402-1	B-0572 PISMO CREEK WATER	

PARAMETER	03-402-1
Pri. Poll. Pesticides/PCBs	
Date Extracted	04/02/85
Date Analyzed	04/03/85
Aldrin, ug/L	<1
Chlordane, ug/L	<1
Dieldrin, ug/L	<1
Endosulfan I, ug/L	<1
Endosulfan II, ug/L	<1
Endosulfan sulfate, ug/L	<1
Endrin, ug/L	<1
Endrin aldehyde, ug/L	<1
Heptachlor epoxide, ug/L	<1
Heptachlor, ug/L	<1
Aroclor 1016, ug/L	<1
Aroclor 1221, ug/L	<1
Aroclor 1232, ug/L	<1
Aroclor 1242, ug/L	<1
Aroclor 1248, ug/L	<1
Aroclor 1254, ug/L	<1
Aroclor 1260, ug/L	<1
Aroclor 1262, ug/L	<1

1255 POWELL STREET EMERYVILLE, CA 94608 (415) 428-2300 • 373 SOUTH FAIR OAKS AVENUE PASADENA, CA 91105 (818) 795-7553 (213) 681-4655

LOG NO: P85-03-402

Received: 28 MAR 85
Reported: 15 APR 85

Stephen Havlicek
Central Coast Analytical Services
141 Suburban Road,, Suite 4-C
San Luis Obispo, CA. 93401

Purchase Order: 5363

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, GROUND WATER SAMPLES	DATE SAMPLED
03-402-1	B-0572 PISMO CREEK WATER	

PARAMETER	03-402-1
Toxaphene, ug/L	<1
BHC, alpha isomer, ug/L	<1
BHC, beta isomer, ug/L	<1
BHC, delta isomer, ug/L	<1
BHC, gamma isomer (Lindane), ug/L	<1
p,p'-DDD, ug/L	<1
p,p'-DDE, ug/L	<1
p,p'-DDT, ug/L	<1
EPA Method 614 Pesticides:	
Date Extracted	04/02/85
Demeton, ug/L	<1
Diazinon, ug/L	<1
Disulfoton, ug/L	<1
Ethion, ug/L	<1
Guthion, ug/L	<1
Malathion, ug/L	<1
Ethyl Parathion, ug/L	<1
Methyl Parathion, ug/L	<1
2,4-D, ug/L	<5
2,4,5-TP Silvex, ug/L	<1

Edward Wilson

Edward Wilson, Laboratory Director

BROWN AND CALDWELL

1255 POWELL STREET EMERYVILLE, CA 94608 (415) 428-2300 • 373 SOUTH FAIR OAKS AVENUE PASADENA, CA 91105 (818) 795-7553 (213) 681-4655

[S]ANITATION A[N]D OPERATION [C]ONSULTANTS IN[C]

31133 W.VIA COLINAS-ST-101
WESTLAKE VILLAGE,CA. 91362
(213)889-4256

CITY OF PISMO BEACH
SAMPLE TYPE-PISMO CREEK WATER
DATE SAMPLED-2/1/85
DATE REPORTED-3/12/85
LOG NO.-801-1-8950

LAB ANALYSIS

CONSTITUENT	QUANTITY		MAXIMUM LIMIT
OIL&GREASE-	3.5	MG/L	-
IRON-	0.11	MG/L	-
MAGNESIUM-	74	MG/L	-
SULFIDE-	7.13	MG/L	-
T.O.C.	7.6	MG/L	-

RECEIVED
MAR 18 1985
CITY OF PISMO BEACH
PUBLIC SERVICES

I DECLARE UNDER PENALTY OF PERJURY, THAT THE FOREGOING IS TRUE AND ACCURATE.

J Lovelace
LAB DIVISION

INVOICE NO. 3234
INV. DATED 3/15/85

A TOTAL OPERATION SERVICES CORPORATION

APPENDIX C

Water quality laboratory analytical results from 2007 general minerals sampling

CREEK ENVIRONMENTAL LABORATORIES, INC.
A Minority-owned Business Enterprise
141 SUBURBAN ROAD, SUITE C-5 • SAN LUIS OBISPO, CA 93401 • (805) 545-9838 • FAX (805) 545-0107

Steph Wald
Central Coast Salmon Enhancement
592 South 13th St.
Grover Beach, CA

Log Number: 07-C8368
Order: 03522
Received: 07/03/07
Printed: 07/16/07

REPORT OF ANALYTICAL RESULTS

Sample Description	Sampled By	Sampled Date @ Time	Matrix
Pismo Ck at Price House	Nicole Smith & Emma Chow	07/03/07@13:00	Aqueous

Analyte	Result	DLR	Dilution Factor	Units	Method	Date Analyzed	Date Prepared	Batch
Carbonate Alkalinity as CaCO3	Not Detected	2	1	mg/L	SM 2320B	07/14/07		6427
Bicarbonate Alkalinity as CaCO3	500	2	1	mg/L	SM 2320B	07/14/07		6427
Hydroxide Alkalinity as CaCO3	Not Detected	2	1	mg/L	SM 2320B	07/14/07		6427
Total Alkalinity as CaCO3	500	2	1	mg/L	SM 2320B	07/14/07		6427
Chloride	160	10	10	mg/L	EPA 300.0	07/11/07		6305
Electrical Conductance	1,700	1	1	umhos/cm	SM 2510	07/03/07		6154
Nitrate as N	0.1	0.1	1	mg/L	EPA 300.0	07/03/07		6113
Nitrate as NO3	0.4	0.4	1	mg/L	EPA 300.0			
pH	7.7	0.1	1	pH units	SM 4500-H B	07/03/07		6154
Sulfate	250	0.5	1	mg/L	EPA 300.0	07/03/07		6113
Total Dissolved Solids	1,100	10	1	mg/L	SM 2540 C	07/10/07		6371
Calcium	110	0.03	1	mg/L	EPA 200.7	07/11/07		6307
Hardness	610	1	NA	mg/L CaCO3	EPA 200.7			
Copper	Not Detected	0.05	1	mg/L	EPA 200.7	07/11/07		6307
Iron	0.13	0.02	1	mg/L	EPA 200.7	07/11/07		6307
Potassium	3.0	0.1	1	mg/L	EPA 200.7	07/11/07		6307
Magnesium	85	0.03	1	mg/L	EPA 200.7	07/11/07		6307
Manganese	0.26	0.02	1	mg/L	EPA 200.7	07/11/07		6307
Sodium	120	0.05	1	mg/L	EPA 200.7	07/11/07		6307
Zinc	0.05	0.05	1	mg/L	EPA 200.7	07/11/07		6307

DLR = Detection Limit for Reporting. Results of "Not Detected" are below DLR.

CREEK ENVIRONMENTAL LABORATORIES

Lab Director, Michael Ng

CREEK ENVIRONMENTAL LABORATORIES, INC.
A Minority-owned Business Enterprise
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Steph Wald
Central Coast Salmon Enhancement
592 South 13th St.
Grover Beach, CA

Log Number: 07-C8369
Order: 03522
Received: 07/03/07
Printed: 07/16/07

REPORT OF ANALYTICAL RESULTS

Sample Description	Sampled By	Sampled Date & Time	Matrix
Pismo CK at Ormande Rd.	Nicole Smith & Emma Chow	07/03/07@13:40	Aqueous

Analyte	Result	DLR	Dilution Factor	Units	Method	Date Analyzed	Date Prepared	Batch
Carbonate Alkalinity as CaCO3	Not Detected	2	1	mg/L	SM 2320B	07/14/07		6427
Bicarbonate Alkalinity as CaCO3	440	2	1	mg/L	SM 2320B	07/14/07		6427
Hydroxide Alkalinity as CaCO3	Not Detected	2	1	mg/L	SM 2320B	07/14/07		6427
Total Alkalinity as CaCO3	440	2	1	mg/L	SM 2320B	07/14/07		6427
Chloride	110	10	10	mg/L	EPA 300.0	07/11/07		6305
Electrical Conductance	1,200	1	1	umhos/cm	SM 2510	07/06/07		6324
Nitrate as N	Not Detected	0.1	1	mg/L	EPA 300.0	07/03/07		6113
Nitrate as NO3	Not Detected	0.4	1	mg/L	EPA 300.0			
pH	8.0	0.1	1	pH units	SM 4500-H B	07/03/07		6325
Sulfate	100	0.5	1	mg/L	EPA 300.0	07/03/07		6113
Total Dissolved Solids	780	10	1	mg/L	SM 2540 C	07/10/07		6371
Calcium	100	0.03	1	mg/L	EPA 200.7	07/11/07		6307
Hardness	550	1	NA	mg/L CaCO3	EPA 200.7			
Copper	Not Detected	0.05	1	mg/L	EPA 200.7	07/11/07		6307
Iron	0.19	0.02	1	mg/L	EPA 200.7	07/11/07		6307
Potassium	2.5	0.1	1	mg/L	EPA 200.7	07/11/07		6307
Magnesium	74	0.03	1	mg/L	EPA 200.7	07/11/07		6307
Manganese	0.17	0.02	1	mg/L	EPA 200.7	07/11/07		6307
Sodium	82	0.05	1	mg/L	EPA 200.7	07/11/07		6307
Zinc	Not Detected	0.05	1	mg/L	EPA 200.7	07/11/07		6307

DLR = Detection Limit for Reporting. Results of "Not Detected" are below DLR.

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Steph Wald
Central Coast Salmon Enhancement
592 South 13th St.
Grover Beach, CA

Log Number: 07-C8370
Order: 03522
Received: 07/03/07
Printed: 07/16/07

REPORT OF ANALYTICAL RESULTS

Sample Description	Sampled By	Sampled Date @ Time	Matrix
W. Corral at Edna	Nicole Smith & Emma Chow	07/03/07@14:30	Aqueous

Analyte	Result	DLR	Dilution Factor	Units	Method	Date Analyzed	Date Prepared	Batch
Carbonate Alkalinity as CaCO3	Not Detected	2	1	mg/L	SM 2320B	07/14/07		6427
Bicarbonate Alkalinity as CaCO3	580	2	1	mg/L	SM 2320B	07/14/07		6427
Hydroxide Alkalinity as CaCO3	Not Detected	2	1	mg/L	SM 2320B	07/14/07		6427
Total Alkalinity as CaCO3	580	2	1	mg/L	SM 2320B	07/14/07		6427
Chloride	42	1	1	mg/L	EPA 300.0	07/03/07		6113
Electrical Conductance	1,400	1	1	umhos/cm	SM 2510	07/03/07		6154
Nitrate as N	2.5	0.1	1	mg/L	EPA 300.0	07/03/07		6113
Nitrate as NO3	11	0.4	1	mg/L	EPA 300.0			
pH	7.8	0.1	1	pH units	SM 4500-H B	07/03/07		6154
Sulfate	160	0.5	1	mg/L	EPA 300.0	07/03/07		6113
Total Dissolved Solids	800	10	1	mg/L	SM 2540 C	07/10/07		6371
Calcium	120	0.03	1	mg/L	EPA 200.7	07/11/07		6307
Hardness	750	1	NA	mg/L CaCO3	EPA 200.7			
Copper	Not Detected	0.05	1	mg/L	EPA 200.7	07/11/07		6307
Iron	Not Detected	0.02	1	mg/L	EPA 200.7	07/11/07		6307
Potassium	0.6	0.1	1	mg/L	EPA 200.7	07/11/07		6307
Magnesium	110	0.03	1	mg/L	EPA 200.7	07/11/07		6307
Manganese	0.03	0.02	1	mg/L	EPA 200.7	07/11/07		6307
Sodium	50	0.05	1	mg/L	EPA 200.7	07/11/07		6307
Zinc	Not Detected	0.05	1	mg/L	EPA 200.7	07/11/07		6307

DLR = Detection Limit for Reporting. Results of "Not Detected" are below DLR.

CREEK ENVIRONMENTAL LABORATORIES

Lab Director, Michael Ng

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Steph Wald
Central Coast Salmon Enhancement
592 South 13th St.
Grover Beach, CA

Log Number: 07-C8371
Order: 03522
Received: 07/03/07
Printed: 07/16/07

REPORT OF ANALYTICAL RESULTS

Sample Description	Sampled By	Sampled Date @ Time	Matrix
E. Corral at Corbett Cyn.	Nicole Smith & Emma Chow	07/03/07@15:30	Aqueous

Analyte	Result	DLR	Dilution Factor	Units	Method	Date Analyzed	Date Prepared	Batch
Carbonate Alkalinity as CaCO3	Not Detected	2	1	mg/L	SM 2320B	07/14/07		6427
Bicarbonate Alkalinity as CaCO3	310	2	1	mg/L	SM 2320B	07/14/07		6427
Hydroxide Alkalinity as CaCO3	Not Detected	2	1	mg/L	SM 2320B	07/14/07		6427
Total Alkalinity as CaCO3	310	2	1	mg/L	SM 2320B	07/14/07		6427
Chloride	61	1	1	mg/L	EPA 300.0	07/03/07		6113
Electrical Conductance	790	1	1	umhos/cm	SM 2510	07/03/07		6154
Nitrate as N	0.8	0.1	1	mg/L	EPA 300.0	07/03/07		6113
Nitrate as NO3	3.5	0.4	1	mg/L	EPA 300.0			
pH	8.1	0.1	1	pH units	SM 4500-H B	07/03/07		6154
Sulfate	33	0.5	1	mg/L	EPA 300.0	07/03/07		6113
Total Dissolved Solids	500	10	1	mg/L	SM 2540 C	07/10/07		6371
Calcium	68	0.03	1	mg/L	EPA 200.7	07/11/07		6307
Hardness	340	1	NA	mg/L CaCO3	EPA 200.7			
Copper	Not Detected	0.05	1	mg/L	EPA 200.7	07/11/07		6307
Iron	0.35	0.02	1	mg/L	EPA 200.7	07/11/07		6307
Potassium	3.8	0.1	1	mg/L	EPA 200.7	07/11/07		6307
Magnesium	41	0.03	1	mg/L	EPA 200.7	07/11/07		6307
Manganese	Not Detected	0.02	1	mg/L	EPA 200.7	07/11/07		6307
Sodium	48	0.05	1	mg/L	EPA 200.7	07/11/07		6307
Zinc	Not Detected	0.05	1	mg/L	EPA 200.7	07/11/07		6307

DLR = Detection Limit for Reporting. Results of "Not Detected" are below DLR.

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Lab Director, Michael Ng

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