



SWAMP Assessment Report for the Central Coast Region	1997-99
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**Central Coast Ambient Monitoring Program Hydrologic Unit Report  
for the 1997-99 Pajaro River Watershed Rotation Area**

January 2003



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# 1. EXECUTIVE SUMMARY

The Pajaro River watershed encompasses over 1,300 square miles in parts of four counties of central coastal California. The major direct tributaries to the Pajaro River include San Benito River, Tequisquita Slough, Pacheco Creek, Llagas Creek, Uvas Creek, and Corralitos Creek (See [Map 3.1](#) for a map of the Pajaro River watershed). The Pajaro River flows to Monterey Bay.

The Pajaro River watershed encompasses parts of four counties: San Benito County (about 65% of the watershed area), Santa Clara County (about 20% of the watershed), Santa Cruz County (about 10% of the watershed) and Monterey County (less than 5% of the watershed). There are five incorporated cities within the watershed: Watsonville, Gilroy, Morgan Hill, Hollister, and San Juan Bautista. The Pajaro River watershed contains a wide variety of land uses, including row crop agriculture, livestock grazing, forestry, industrial, and rural/urban residential. The watershed also contains significant amounts of natural vegetative cover, which provides habitat to numerous native bird and wildlife species.

Pajaro River watershed flow patterns are characteristic of a Mediterranean climate, with higher flows during the wetter, cooler winter months and low flows during the warmer, drier summer months. Principal water sources for the Pajaro River and its tributaries are surface runoff, springs, subsurface flow into the channels, and reclaimed wastewater entering the watershed through percolation from water discharged by South County Regional Wastewater Authority (SCRWA). The first three water sources are subject to large flow variations due to climatic influences, while the discharge from the SCWRA tends to influence flow year-round.

## WATER QUALITY MONITORING ACTIVITIES

The Pajaro River watershed was sampled by Central Coast Regional Water Quality Control Board (RWQCB) staff, and by the California Department of Fish and Game (CDFG) through various subcontracts from December 1997 through January 1999. The Pajaro River watershed was sampled to assess the relative contribution of conventional pollutants (nutrients, dissolved solids, etc.), toxins, metals, and other pollutants from major tributary streams to document ambient water quality. The water quality monitoring design followed the “watershed characterization” approach adopted by the RWQCB Central Coast Ambient Monitoring Program Strategy (CCAMP) (Regional Water Quality Control Board Central Coast Region 1998). Water quality monitoring stations for the Pajaro River Watershed Characterization were selected using the CCAMP tributary-based approach. Representative stations were located along the main stem of the Pajaro River and at the lower end of each major tributary. Additional stations were placed on Llagas Creek to support Total Maximum Daily Load (TMDL) development.

On a monthly basis, the RWQCB collected water samples at numerous sites (see [Table 3.1](#)) in the Pajaro River watershed. The water samples were analyzed for nutrients (nitrogen and phosphorus), pH, temperature, dissolved oxygen, total dissolved solids, conductivity, turbidity, total suspended solids, total volatile solids, chlorophyll *a*, total coliform, and fecal coliform. During the water quality monitoring events, RWQCB staff documented field observations to assess eutrophic and/or aesthetic impairment conditions. Included in the field observations were percent terrestrial plant cover, algal cover, presence of odor or scum, and other habitat observations.

Chemical testing to determine the concentrations of synthetic organic chemicals and metals in sediment, in the water column, and in the tissue of aquatic organisms was conducted once at a number of sites in the watershed. Twelve tissue sites, five sediment sites, and ten water chemistry sites were evaluated. At several sites clams (*Corbicula fluminea*), roach (*Hesperoleucus symmetricus*) and crayfish (*Procambarus clarkii*) were also deployed to examine the relationships in chemical uptake in different species.

In addition to water, sediment, and tissue quality evaluation, nine sites in the Pajaro River and tributaries were assessed for benthic invertebrate community structure using the California Rapid Bioassessment Protocol (Harrington, 1996). This protocol includes an assessment of habitat quality.

## **WATER QUALITY PROBLEMS IDENTIFIED**

CCAMP monitoring activities have documented levels of pH, nutrients (nitrate and ammonia), dissolved oxygen, and total dissolved solids in the Pajaro River watershed that do not meet Central Coast Water Quality Control Plan (Basin Plan) water quality standards and/or objectives (Regional Water Quality Control Board, Central Coast 1994). Other conventional water quality parameters of concern include temperature, algae (attached and suspended), sediment, and bacteria. At a number of sites, metals (mercury, chromium, copper, lead, cadmium, nickel, and zinc) were detected at concentrations that exceeded several water quality standards. Synthetic organic chemicals were also detected at some sites at concentrations that exceeded several water quality standards. Specific exceedences of water quality standards in the Pajaro River watershed include:

Exceedences of Basin Plan pH municipal and domestic supply standard (mean values greater than objective of 8.3 pH units) were observed at two sites in the Pajaro River watershed (Tres Pinos Creek (305TRE) and Pajaro River at Frazier Lake Road (305FRA)).

Water samples from three stations along the southern portion of Llagas Creek exceeded the State nitrate drinking water standard of 10 mg/L (NO<sub>3</sub> as N).

The Basin Plan objective of 0.025 mg/L NH<sub>3</sub> as N was exceeded once at the Tequisquita Slough (305TES) site, where it reached 0.072 mg/L NH<sub>3</sub> as N.



Fifty-one (51) exceedences of Basin Plan dissolved oxygen standard for the COLD beneficial use (measurements less than the objective of 7.0 mg/L) were observed at twelve sites in the Pajaro River watershed.

Three exceedences of Basin Plan dissolved oxygen standard for the WARM beneficial use (minimum values less than objective of 5.0 mg/L for WARM) were observed at the Tequisquita Slough (305TES) site in the Pajaro River watershed.

Annual average Total Dissolved Solids (TDS) levels, at all Llagas Creek sites, exceeded the Basin Plan site-specific water quality objective of 200 mg/L (annual average).

In the single set of water column samples taken for a suite of trace elements at each site, concentrations of several metals indicated a problem at San Benito River at Y Road (305SAN) and Pajaro River at Betabel Road (305PAJ). Both sites exceeded Basin Plan standards for Aquatic Life (both Cold and Warm Water Habitat) for copper and lead. The Betabel Road (305PAJ) site also exceeded the Aquatic Life standards for cadmium, nickel, and zinc. The Y Road site exceeded Aquatic Life standards for chromium. Water samples from Clear Creek at Halfway Hill also exceeded the chromium standard. The San Benito River below Hernandez Reservoir exceeded standards for chromium and copper. From seven water column samples of mercury, the Y Road site stands out, with average values exceeding the California Toxics Rule water quality objective and over 50% of individual samples exceeding this standard. The Clear Creek Road site also exceeded the CTR objective on average, and other sites in the watershed had elevated levels of mercury at times.

## **POTENTIAL WATER QUALITY PROBLEMS**

Potential exceedence of Basin Plan Narrative Biostimulatory Objective related to nuisance growth of algae was observed at various locations in the watershed. Nutrient enrichment of streams may lead to eutrophication. CCAMP 1998 data from the Pajaro watershed imply that impacts to water quality occur when average nitrate concentrations reach or exceed 2.25 mg/L (NO<sub>3</sub> as N), well below the drinking water standard. At or above these concentrations, CCAMP data indicate dissolved oxygen levels (concentration and percent saturation) are reduced below the Basin Plan numeric objectives.

Orthophosphate may also be contributing to the exceedence of the Basin Plan Narrative Biostimulatory Objective. Algae (measured as Chlorophyll *a*) most readily use the orthophosphate form of phosphorus. CCAMP data shows the recommended objective of 0.12 mg/L orthophosphate as P, was exceeded on average at two sites in the Pajaro River watershed.

All but two sites in the Pajaro River watershed had samples that did not meet the implied Basin Plan oxygen saturation objective of 85 percent at some point during 1998. Many of the sites had multiple samples that did not meet the implied Basin Plan oxygen saturation objective. The Tequisquita Slough (305TES) site, Llagas Creek sites Luchessa Avenue (305LUC) and Bloomfield Avenue (305LLA), and the Pajaro River

sites at Betabel Road (305PAJ), Frazier Lake Road (305FRA), and Thurwachter Bridge (305THU) did not meet the oxygen saturation objective more than 50 percent of the time.

At San Benito River at the Y Road (305SAN) site, individual TDS values were above the Basin Plan site-specific water quality objective of 1400 mg/L in September and October 1998. However, the annual mean for San Benito River at Y Road (305SAN) was 992 mg/L.

Lower Pajaro River sites of Chittenden Gap (305CHI) and Murphy's Crossing (305MUR) reached or were over the Basin Plan site-specific water quality objective of 1000 mg/L for TDS in August, September, and October 1998. However, annual means for each site were 849 mg/L and 791 mg/L respectively.

Legacy organochlorine pesticides and several currently applied organophosphate pesticides can be found in most tributaries of the Pajaro River system. DDT compounds were widespread, with levels in all clam tissue samples exceeding the Maximum Tissue Residual Levels (MTRL).

## **RECOMMENDATIONS**

It is recognized that a variety of actions at the state and local level will need to be taken to address impacts and threatened impacts to water quality and associated beneficial uses. In some cases it is clear that water quality has been impacted and implementation of management practices is required. In other cases there is a need to reevaluate current state standards to determine if impacts truly exist or if the current standards are not representative of historic watershed conditions. To address these issues, the following Regional Board actions are recommended:

### **1. Basin Planning** (review and revise as needed)

- ❖ Evaluate existing Basin Plan regional and site specific objectives to determine appropriateness:
  - pH
  - Temperature
  - Total dissolved solids
  - Nitrogen (total, organic, nitrate, nitrite, ammonia) as N
  - Conductivity
  - Metals
  - Synthetic organic chemicals
- ❖ Evaluate the need for new regional objectives or water body specific objectives:
  - Turbidity
  - Numeric nutrient objective for protection of aquatic life
  - Total suspended solids
  - Total volatile solids
  - Total volatile dissolved solids

- Phosphorus (total, organic, phosphate, polyphosphate, orthophosphate) as P
- Chlorophyll *a*
- ❖ Riparian protection policy – Develop a policy to support region-wide riparian corridor protection.
- ❖ New/revised beneficial use designations e.g.
  - Aquifer/Ground water recharge – Revise to show connectivity between surface and ground water quality
  - Biocriteria to support in-stream protection

**2. Nonpoint Source Management** - Develop and implement watershed wide management measures for the protection and enhancement of beneficial uses. Specific management measures should be implemented to:

- ❖ Manage nutrient sources. Priority areas to consider include Lower Llagas Creek, the main stem of Pajaro River, Salsipuedes Creek, Tequisquita Slough, and Pacheco Creek.
- ❖ Manage sediment sources. Priority areas to consider include the San Benito River watershed.
- ❖ Manage dissolved oxygen and temperature levels. Priority areas to consider include in the main stem Pajaro River, Llagas Creek, and Tequisquita Slough watersheds.
- ❖ Manage for riparian corridor protection. Priority areas to consider include the Llagas Creek, upper Pajaro River, Salsipuedes Creek, Tres Pinos Creek, and San Benito River watersheds.
- ❖ Manage metal sources. Priority areas to consider include the Pajaro River watershed (particularly the vicinity of the Betabel Road (305PAJ), Clear Creek and San Benito River.
- ❖ Manage synthetic organic chemical sources. Priority areas to consider include the Pajaro River, Salsipuedes Creek, lower San Benito River, and Pacheco Creek.
- ❖ Manage salt sources. Several winter surface water diversions are proposed for groundwater recharge, including one at Chittenden Gap. Elevated levels of dissolved solids in surface waters should be taken into account during the planning process.

**3. Nonpoint Source Monitoring** – Add monitoring requirements for nonpoint source projects that include the following parameters:

- ❖ Nutrients
- ❖ Turbidity
- ❖ Temperature
- ❖ Dissolved oxygen (concentration and percent saturation)
- ❖ Metals (mercury and manganese)
- ❖ Synthetic organic chemicals
- ❖ Riparian corridor health
- ❖ Erosion and sedimentation
- ❖ Total dissolved solids

4. **Orders** – Revise National Pollutant Discharge Elimination System permits, Waste Discharge Requirements, Water Quality Certifications, etc. to:
  - ❖ Manage nutrient sources/discharge
  - ❖ Manage sediment sources/discharge
  - ❖ Manage for riparian corridor protection
  - ❖ Manage for dissolved oxygen and temperature levels
  - ❖ Manage metal sources/discharge
  - ❖ Manage synthetic organic chemicals sources
  - ❖ Manage total solids (dissolved, suspended, volatile dissolved, and volatile suspended)
  
5. **Order Monitoring** – Revise monitoring programs for National Pollutant Discharge Elimination System permits, Waste Discharge Requirements, Water Quality Certifications, etc. to:
  - ❖ Include:
    - pH
    - Temperature (24 hour duration)
    - Dissolved oxygen (concentration and percent saturation) (24 hour duration)
    - Total dissolved solids
    - Total suspended solids
    - Total volatile suspended solids
    - Total volatile dissolved solids
    - Nitrogen (total, organic, nitrate, nitrite, ammonia) as N
    - Conductivity
    - Turbidity
    - Phosphorus (total, organic, phosphate, polyphosphate, orthophosphate) as P
    - Chlorophyll *a*
    - Metals (mercury in the entire Pajaro River Watershed and manganese in the Llagas watershed)
    - Synthetic organic chemicals
    - General minerals
    - Longitudinal elevation profile (for gravel mining operations)
    - Biocriteria
  
6. **Data Analysis** - Develop an index relating the various surface water quality parameters (Nutrients, Chlorophyll *a*, Dissolved Oxygen, Temperature, etc.) that is capable of ranking sites with respect to nutrient risk or impact, and that accommodates the multiple forms in which nutrients are present. Examine Pajaro River watershed data in the context of the larger regional framework.
  
7. **Ambient Monitoring**
  - i. Measure flow as a regular component of conventional water quality monitoring.

- ii. Conduct 24-hour monitoring of dissolved oxygen (concentration and percent saturation), pH and temperature periodically during low flow periods.

## 2. INTRODUCTION

The Pajaro River watershed was sampled from December 1997 through January 1999 to assess the relative contribution of conventional pollutants (nutrients, dissolved solids, etc.), toxins, metals, and other pollutants from major tributary streams to document ambient water quality. Basic study design followed the "watershed characterization" approach adopted by the Central Coast Water Quality Control Board's Central Coast Ambient Monitoring Program (CCAMP, 1998).

On a monthly basis beginning in December, 1997, the Regional Water Quality Control Board (RWQCB) sampled the watershed for a number of basic water quality parameters to provide information on nutrients, coliform, turbidity, suspended solids, temperature and oxygen conditions, and to document whether eutrophication or aesthetic impairment was observed. This portion of the program was funded through Regional Board contracts with private laboratories. One of the major goals of this sampling was to provide information towards development of Total Maximum Daily Load (TMDL) assessments of nutrients in the Llagas and Pajaro River watersheds.

Sites were assessed for benthic invertebrate community structure, using California Rapid Bioassessment Protocols. This component of the program was conducted by the California Department of Fish and Game (CDFG) Aquatic Bioassessment Laboratory in Rancho Cordova, and was funded by the Association of Bay Area Governments (AMBAG) from Clean Water Act 205(j) grant funds.

The same AMBAG watershed planning grant funded analysis of sediment chemistry at several sites in the watershed. The Granite Canyon Marine Pollution Laboratory conducted sediment toxicity analysis of these samples, with funds provided by the State Water Resources Control Board. The RWQCB funded a one-time sampling of water chemistry (organochlorine and organophosphate pesticides, metals), and of mercury in sediment and water at sites in the upper San Benito watershed. The Department of Fish and Game State Mussel Watch laboratory collected additional mercury data in water at sites in the watershed during the fall of 1998 at their own expense, and continued this effort into 1999.

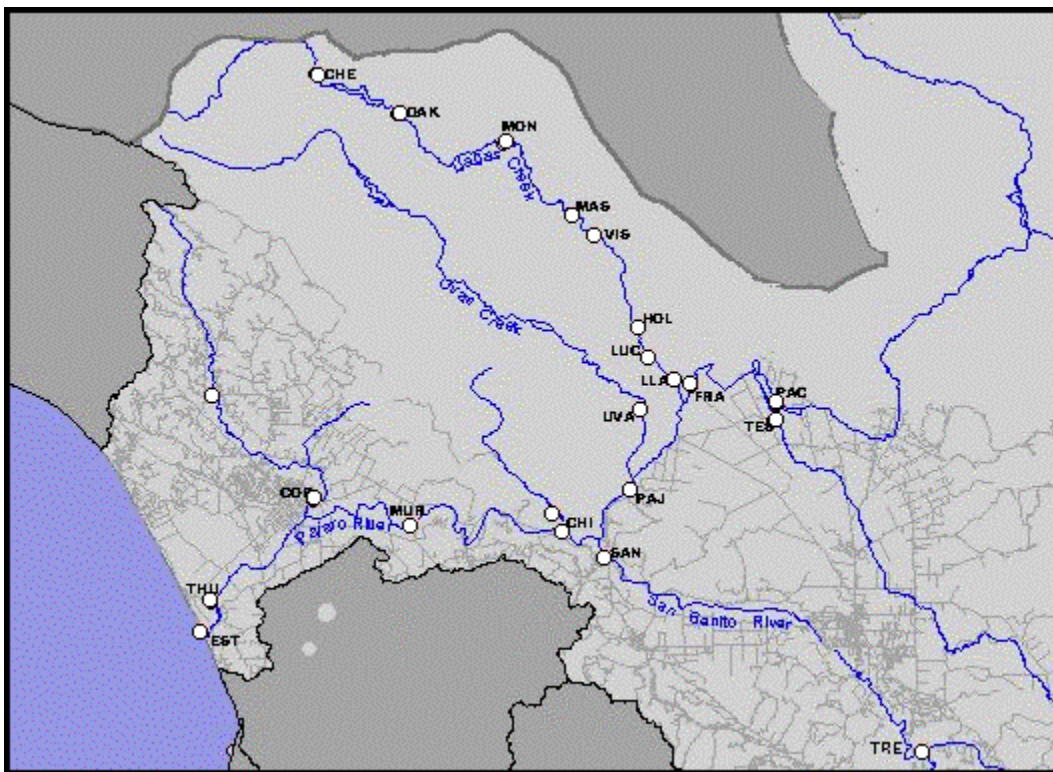
Freshwater clams (*Corbicula fluminea*) were placed at sites in the watershed, including the downstream reach of a number of major tributaries, above their junctions with the Pajaro River. This component of the project, conducted by the California Department of Fish and Game (CDFG), utilized funds provided through the State Mussel Watch Program and the Regional Water Quality Control Board. Clams were analyzed for bioaccumulation of metals and synthetic organic chemicals. At several of these sites, California roach and crayfish were also deployed and analyzed for metals and synthetic organics. This effort was funded through the California State Mussel Watch endowment, in order to evaluate the differing bioaccumulation potential of the various species.

### 3. MONITORING METHODS

#### SITE SELECTION

Sites for the Pajaro River watershed characterization were selected using the CCAMP tributary-based approach (CCAMP 1998). Sites were placed at safe access locations along the main stem of the Pajaro River and at the lower end of each major tributary entering the Pajaro River. Additional sites were placed on Llagas Creek to support TMDL development. Due to funding constraints, sediment, tissue, and benthic invertebrate sampling was conducted at a subset of the characterization sites. Mercury sampling was conducted at both characterization sites and in the upper San Benito watershed in an area of known problems. Site locations for conventional water quality are shown on ([Map 3.1](#)). Types of sampling conducted at various sites and sample count at each site are shown in ([Table 3.1](#)).

**[Map 3.1](#) - Sampling site locations for conventional water quality sampling Pajaro River Watershed Characterization, 1998.**



**Table 3.1** - Types and frequency of sampling conducted at various sites in the Pajaro River Watershed Characterization, 1998.



Hydrologic Subarea	H2OBody	Site Tag	Site Description	Latitude	Longitude	Conventional Water Quality	CDFG Mercury in Water	Sediment Chemistry - metals	Sediment Chemistry - organics	Sediment Toxicity	Organics and Metals in H2O	Clam Tissue Chemistry	Crayfish Tissue Chemistry	Roach Tissue Chemistry	Rapid Bioassessment
30510	Pajaro River	305PJE	Pajaro River Estuary	36.8507	-121.809				1	1					1
30530	Uvas Creek	305UVA	Uvas Creek @ Bloomfield Avenue	36.9651	-121.531	1/mo	1/mo				1				1
30510	Corralitos Creek	305COR2	Upper Corralitos Creek	36.9677	-121.798										2
30530	Llagas Creek	305LLA	Llagas Creek @ Bloomfield Avenue	36.9763	-121.511	2/mo	1/mo	1	1	1	1	1	1	1	2
30540	Pacheco Creek	305PAC	Pacheco Creek	36.9442	-121.384	1/mo	1/mo				1	1			2
30520	Pajaro River	305PAJ	Pajaro River @ Betabel Road	36.9168	-121.548	2/mo	1/mo		1	1	1	1	1		2
30520	Pajaro River	305PES	Pescadero Creek	36.9015	-121.584								1		2
30510	Salsipuedes Creek	305COR	Salsipuedes Creek - Down stream of Corralitos Creek	36.9128	-121.744	1/mo	1/mo		1	1	1	1	1		2
30550	San Benito River	305SAN	San Benito @ Y Road	36.8875	-121.558	1/mo	1/mo	1	1	1	1	1			2
30550	Clear Creek	305CCC	Clear Creek @ Clear Creek Road	36.3567	-120.779		1/mo								
30550	Clear Creek	305GOA	Clear Creek @ Goat Mountain	36.3689	-120.749			1	1		1				
30550	Clear Creek	305HAH	Clear Creek @ Halfway Hill	36.3737	-120.734			1			1				
30550	Hernandez Reservoir	305LAZ	Lazy 10 Marina					1	1		1				
30550	Laguna Creek	305LAG	Laguna Creek	36.377	-120.835			1	1		1				
30530	Llagas Creek	305CHE	Llagas Creek @ Chesbro Reservoir	37.1263	-121.731	1/mo	1/mo								
30530	Llagas Creek	305HOL	Llagas Creek @ Holsclaw Road	37.004	-121.535	1/mo	1/mo								
30530	Llagas Creek	305LUC	Llagas Creek @ Lucchessa Avenue	36.9907	-121.531	1/mo	1/mo								
30530	Llagas Creek	305MON	Llagas Creek @ Monterey Road	37.0957	-121.616	1/mo	1/mo								
30530	Llagas Creek	305OAK	Llagas Creek @ Oak Glen Avenue	37.1149	-121.687	1/mo	1/mo								
30530	Llagas Creek	305WIS	Llagas Creek @ Buena Vista Avenue	37.0489	-121.558	1/mo	1/mo								
30510	Pajaro River	305CHI	Pajaro River @ Chittenden Gap	36.9003	-121.596	2/mo	1/mo					1	1	1	
30530	Pajaro River	305FRA	Pajaro River (Miller Canal) @ Framer Lake Road	36.9714	-121.5	1/mo	1/mo								
30510	Pajaro River	305MUR	Pajaro River @ Murphy's Crossing	36.9053	-121.675	1/mo	1/mo								
30510	Pajaro River	305THU	Pajaro River @ Thurwachter Bridge	36.8798	-121.792	2/mo	1/mo	1	1	1	1	1	1		
30530	San Benito River	305BRI	San Benito River, Bridge d/s Willow Creek	36.6022	-121.191			1			1				
30550	San Benito River	305HRL	San Benito River below Hernandez Reservoir	36.3786	-120.897		1/mo	2			1	1			
30550	San Benito River	305HRU	San Benito River above Hernandez Reservoir	36.3585	-120.786		1/mo	1			1	1			
30550	San Benito River	305SBA	San Benito River above unknown tributary	36.4459	-120.974		1/mo	1			1				
30550	San Benito River	305SUR	Survey Marker/San Benito River	36.3087	-120.708			1	1		1				
30550	San Benito River	305UIT	Unknown Tributary to San Benito River	36.4471	-120.976			1	1		1				
30530	Teguisquita Slough	305TES	Teguisquita Slough	36.9429	-121.443	1/mo	1/mo				1	1			
30550	Tres Pinos Creek	305TRE	Tres Pinos Creek	36.7881	-121.358	1/mo	1/mo	1			1				
30550	Willow Creek	305WIL	Willow Creek	36.5939	-121.194			1			1				

The sites sampled during the Pajaro River watershed characterization are grouped into the following reaches for the purposes of this report:

### **Pajaro River**

Lower – Pajaro River Estuary (305PJE) and Thurwachter Bridge (305THU)

Middle - Murphy's Crossing (305MUR), Pescadero Creek (305PES) and Chittenden Gap (305CHI)

Upper - Betabel Road (305PAJ) and Frazier Lake Road (305FRA)\*\*.

\*\*The Frazier Lake Road site is actually sampled at Miller Canal where it crosses Frazier Lake Road. Though it is not actually the original Pajaro River channel, it receives the majority of the flow from the San Felipe Lake area and rejoins the original main stem downstream of Llagas Creek. It is referred to in this document as an Upper Pajaro River site.

### **San Benito River**

Lower - Y Road (305SAN), Tres Pinos Creek (305TRE)

Upper – Bridge d/s of Willow Creek (305BRI), Willow Creek (305WIL), San Benito River above unnamed tributary (305SBA), Unnamed tributary to San Benito River (305UIT), San Benito River below Hernandez Reservoir (305HRL), Lazy 10 Marina (305LAZ), Laguna Creek (305LAG), San Benito River above Hernandez Reservoir (305HRU), Clear Creek at Clear Creek Road (305CCC), Clear Creek at Goat Mountain (305GOA), Clear Creek at Halfway Hill (305HAH), and Survey Marker/San Benito River (305SUR)

### **Tequisquita Slough**

Tequisquita Slough (305TES)

### **Pacheco Creek**

Pacheco Creek (305PAC)

### **Llagas Creek**

Lower - Bloomfield Avenue (305LLA), Lucchessa Avenue (305LUC), and Holsclaw Road (305HOL)

Upper - Buena Vista Avenue (305VIS), Masten Avenue (305MAS), Monterey Road (305MON), Oak Glen Avenue (305OAK), and Chesbro Reservoir (305CHE)

### **Uvas Creek**

Uvas Creek at Bloomfield Avenue (305UVA)

### **Corralitos Creek**

Lower - Salsipuedes Creek (305COR)

Upper - Upper Corralitos Creek (305COR2)

## MONTHLY WATER QUALITY SAMPLING

Monthly sampling for basic water quality parameters was conducted in the Pajaro River watershed at ten sites. Four of these sites were sampled biweekly in conjunction with TMDL development for the Pajaro River and Llagas Creek. Several other sites on Llagas Creek were sampled monthly to support TMDL development. Conventional water quality monitoring activities at various sites are described in ([Table 3.1](#)).

Basic water quality parameters including water temperature (°C), dissolved oxygen (mg/L), pH, conductivity (uS), and turbidity (NTUs) were collected using a multi-function meter (803PS Solomat) provided by the Watershed Institute at California State University Monterey Bay. The meter was calibrated within 2 days of each sampling period according to protocols established by the Watershed Institute. Chlorophyll *a* analysis was performed at Moss Landing Marine Laboratory facilities. Methodologies for this analysis are described in more detail below.

In addition to regular water quality sampling, pre-dawn dissolved oxygen (mg/L) measurements were taken at each site in the Pajaro River watershed three times over the course of the summer to assess changes in oxygen concentration due to biological respiration. All sites analyzed for dissolved oxygen were sampled from 0400 to 0630 am (prior to full sunlight) using the multi-function meter (803PS Solomat) or a LaMotte Dissolved Oxygen Test Kit (EPA approved). The three sampling events were conducted at approximately monthly intervals from July through September.

Samples collected for analysis through the RWQCB contract laboratory included nitrate (as N), nitrite (as N), ammonia (as N), total phosphate (as P), orthophosphate (as P), total and fecal coliform, total suspended solids, total dissolved solids, and volatile suspended solids. At least 10% of all samples were taken in duplicate for quality assurance purposes. Sample bottles (appropriately prepared) were provided by the contract laboratory. Laboratory quality assurance measures followed those established in the contract laboratory's EPA approved quality assurance document. EPA method number, practical quantification limit (PQL), bottle types, preservative, and holding times for water quality contract laboratory analysis are shown in ([Table 3.2](#)).

**Table 3.2** - EPA method number, practical quantification limit (PQL), units of measurement, bottle types and size, preservative, and holding time for water quality contract laboratory analysis.

Parameter	EPA Method	PQL	Units	Bottle Type	Preservative	Holding Time
Nitrate (NO <sub>3</sub> )	300.0	0.1	mg/l	8 oz. Plastic	H <sub>2</sub> SO <sub>4</sub>	48 hours
Nitrite (N)	353.2	0.05	mg/l	"	"	"
Ammonia (NH <sub>3</sub> )	350.1	0.02	mg/l	"	"	"
Total Phosphate	365.4	0.1	mg/l	"	"	"
Ortho-phosphate	365.1	0.02	mg/l	8 oz. plastic	none	48 hours
Total Suspended Solids	160.2	0.5	mg/l	1 liter plastic	none	7 days
Total Dissolved Solids	160.1	10.0	mg/l	"	"	"
Volatile Solids	160.4	10.0	mg/l	"	"	"
Total and Fecal Coliform	15 tube multiple fermentation	2 – 160,000	MPN/100 ml	100 ml plastic	Sodium thiosulfate	24 hours

Qualitative assessments were made at each station for several parameters. Percent coverage scores were categorized as 0%, 1 - 25%, 26 - 50%, 51 - 75%, and 75 - 100%. Assessments included:

- Algae coverage (%)
- In-channel terrestrial plant coverage (%)
- Presence of odor, foam, scum, floating mats or slippery substrate
- Corridor shading (%)
- Land use in vicinity

## CHLOROPHYLL A METHODOLOGY

Fluorescence analysis of chlorophyll *a* was done at all conventional water quality sites. Dark amber 100 milliliter (ml) bottles were supplied by the RWQCB contract laboratory. At least 10% of all samples were taken in duplicate for quality assurance purposes. Collected water samples were stored in the dark at 4°C and processed at Moss Landing Marine Laboratories within 12 hours of collection according to the protocols of

Welschmeyer (1994). Five to 20 mls of sample water (with amount dependent on Chlorophyll *a* concentrations from previous Chlorophyll *a* analysis) were filtered onto a 25  $\mu$ m glass microfiber filter, rinsed with 5 ml distilled water, and placed in 5 ml of 90% acetone solution in a glass fluorometer tube. Samples were stored at least overnight at -4°C. The glass filter was then flattened with a spatula on the bottom of the glass tube and centrifuged at low speed for 3-5 minutes. Chlorophyll *a* fluorescence was measured with a Turner Designs 10 AU fluorometer.

## **BENTHIC MACROINVERTEBRATE SAMPLING**

Benthic macroinvertebrates were sampled at sites in the Pajaro River watershed ([Table 3.1](#)) during April and August 1998 using California Stream Bioassessment Protocols (CSBPs) and quality assurance guidance for non-point source assessments (Harrington, 1996). The CSBP's were used with one modification: due to a paucity of good riffle habitat at some sites, a stream reach or "site" was defined using three rather than five consecutive riffles.

The length of each riffle was determined. A random number table was used to establish a point randomly along the length of the riffle, at which point a transect was established perpendicular to stream flow. Starting with the transect at the lowermost riffle, the benthos within a two square foot area was dislodged upstream of a one ft. wide, 0.5 mm mesh D-frame kick-net. Sampling of the benthos was performed by "kicking" the upper layers of substrate to dislodge invertebrates in the substrate. Stream flow moved organisms downstream into the kick-net. The duration of sampling ranged from 60-120 seconds, depending on the amount of boulder and cobble-sized substrates that required rubbing by hand; more and larger substrate requires more time to process. Three locations representing the habitats along the transect were sampled and combined into a composite sample (representing a 6 ft square foot area). This composite sample was transferred into a 500 ml wide-mouth plastic jar containing approximately 200 ml of 95% ethanol. This technique was repeated for each of the three riffles comprising each stream reach, or "site".

At the laboratory, each sample was rinsed through a No. 35 standard testing sieve (0.5 mm brass mesh) and transferred into a tray marked with 20 pre-numbered 25 square centimeter grids. All detritus was removed from one randomly selected grid at a time and placed in a petri dish for inspection under a stereomicroscope. All invertebrates from the selected grid were separated from the surrounding detritus and transferred to vials containing 70% ethanol and 2% glycerol. This process was continued until 300 organisms were removed from each sample. The material left from the processed grids was transferred into a jar with 70% ethanol and labeled as "remnant" material. Any remaining unprocessed sample from the tray was transferred back to the original sample container and archived in 70% ethanol. Macroinvertebrates were then identified to a standard taxonomic level, typically genus level for insects and order or class for non-insects.

Physical habitat quality was assessed for sampling reaches using the U.S. Environmental Protection Agency (EPA) Rapid Bioassessment Protocols (RBPs) (Plafkin et al. 1989) ([Table 3.3](#)). Habitat quality assessments were recorded at each sampled riffle and for each sampling reach during macroinvertebrate sampling events.

**Table 3.3** - U.S. EPA Rapid Bioassessment Protocol habitat parameters and scoring used to assess physical habitat quality for reaches within the Pajaro River watershed, Pajaro River Watershed Characterization, 1998.

	<b>OPTIMAL</b>	<b>SUBOPTIMAL</b>	<b>MARGINAL</b>	<b>POOR</b>
<b>1. Epifaunal Substrate/Available Cover</b>	Greater than 70% (50% for low gradient streams) of substrate favorable for epifaunal colonization and fish cover; most favorable is a mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% (30-50% for low gradient streams) mix of stable habitat, well-suited for full colonization potential, adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale)	20-40% (10-30% for low gradient streams) mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% (10% for low gradient streams) stable habitat; lack of habitat is obvious, substrate unstable or lacking.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
<b>2. Embeddedness</b>	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
<b>3. Velocity/Depth Regimes (deep &lt; 0.5 m, slow &lt; 0.3 m/s)</b>	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow).	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low)	Dominated by 1 velocity/depth regime (usually slow-deep).
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
<b>4. Sediment Deposition</b>	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
<b>Parameters to be evaluated within the sampling reach</b>				
<b>5. Channel Flow Status</b>	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel, or <25% of channel substrate is exposed	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
<b>6. Channel Alteration</b>	Channelization or dredging absent or minimal, stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging (greater than past 20 yrs) may be present, but recent channelization is not present	Channelization may be extensive, embankments or shoring structures present on both banks, and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement, over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
<b>7. Frequency of Riffles (or bends)</b>	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream = 7:1 (generally 5 to 7); variety of habitat is key	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend, bottom contours provide some habitat, distance between riffles divided by the width of the stream is between 15 to 25	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.



## TISSUE BIOACCUMULATION SAMPLING

Fresh water clams (*Corbicula fluminea*) were placed at 12 sites in the Pajaro River watershed ([Table 3.1](#)). In general, stations were at the lower end of each major tributary, upstream of its confluence with the Pajaro. Two stations were on the Pajaro itself; at Thurwachter Bridge in the lower watershed and at the Chittenden Gap stream flow gauge. Two stations were also located above and below Hernandez Reservoir.

Clams were transplanted from the Russian River and held at Aptos Creek until deployment. They were placed in mesh bags at each station and secured to a rebar stake pounded into the substrate. Clams remained in the creeks for a minimum of four weeks before retrieval. Clams were initially deployed from February 17 to March 12, 1998. The high flows of winter of 1998 resulted in loss of all but two of the samples (at Thurwachter Bridge and Uvas Creek). Clams were redeployed from August 6 through September 4 except at the two upper San Benito sites, where clams were deployed from September 22 to October 21.

Forty-five clams were composited and analyzed from each site. They were analyzed for a suite of trace elements, synthetic organic compounds, and polynuclear aromatic hydrocarbons, according to the protocols and quality assurance guidance established by the State Mussel Watch Program ([Table 3.4](#)). California roach and crayfish were deployed at five of the clam sites during the August through September sampling period to compare chemical uptake rates to clams.

**Table 3.4 - Trace metals, Synthetic Organic Compounds, and Polynuclear Aromatic Hydrocarbons Analyzed by the State Mussel Watch Program.**

<u>Trace Elements</u>	
Aluminum	Nickel
Arsenic	Lead
Cadmium	Selenium
Chromium	Silver
Copper	Titanium
Mercury	Zinc
Manganese	
<u>Synthetic Organic Compounds</u>	
aldrin	ethion
cis-chlordane	HCH, alpha
trans-chlordane	HCH, beta
chlordene, alpha	HCH, gamma
chlordene, gamma	HCH, delta
chlorpyrifos	heptachlor
dacthal	heptachlor epoxide
DDD, o, p'	HCB
DDD, p, p'	methoxychlor
DDE, o, p'	cis-nonachlor
DE-E, p, p'	trans-nonachlor
DDMU, p, p'	oxadiazon
DDT, o, p'	oxychlordan
DDT, p, p'	parathion, ethyl
diazinon	parathion, methyl
dichlorobenzophenone-p, p'	PCB 1248
dicofol (Kerithane)	PCB 1254
dieldrin	PCB 1260
endosulfan I	tetradifon (Tedon)
endosulfan II	toxaphene
endrin	
<u>Polynuclear Aromatic Hydrocarbons (PAHs)</u>	
naphthalene	fluoranthene
1-methylnaphthalene	pyrene
2-methylnaphthalene	benz[a]anthracene
biphenyl	chrysene
2,6-dimethylnaphthalene	benzo[b]fluoranthene
acenaphthylene	benzo[k]fluoranthene
2,3,5-trimethylnaphthalene	benzo[e]pyrene
fluorene	benzo[a]pyrene
phenanthrene	perylene
anthracene	indeno[1,2,3-cd]pyrene
1-methylphenanthrene	diabenz[a,h]anthracene
benz[ghi]perylene	

## **SEDIMENT TOXICITY AND CHEMISTRY SAMPLING**

Sites in the Pajaro River watershed were selected for sediment chemistry analysis ([Table 3.1](#)). Sediment samples were collected in May 1998, with methodology following that of the California State Mussel Watch Program (CDFG, 1990). Analysis of trace metals was conducted at the CDFG facility at Moss Landing Marine Laboratories. Protocols followed those of the State Mussel Watch Program. Synthetic organic pesticides, polyaromatic hydrocarbons, and polychlorinated biphenyls were analyzed through a contract with the State Mussel Watch Program. Samples were also analyzed for Total Organic Carbon (TOC) and grain size ([Table 3.5](#)).

**Table 3.5 - Constituents evaluated for sediment chemistry analysis by California Department of Fish and Game, Water Pollution Control Laboratory.**

Analyte	EPAMethod	Units	Analyte	EPAMethod	Units
% Clay	Plumb	%	Benzo(k)fluoranthene	8270B	ug/Kg
% Sand	Plumb	%	beta-BHC	8080A	ug/Kg
% Silt	Plumb	%	Chrysene	2270B	ug/Kg
% Solids	1603	%	delta-BHC	8080A	ug/Kg
Azinphos-methyl	2140	ug/Kg	Dibenzo(a,h)anthracene	8270B	ug/Kg
Bolstar	8140	ug/Kg	Dieldrin	8080A	ug/Kg
Cadmium	6020	mg/kg	Endosulfan-I	8080A	ug/Kg
Chlorpyrifos	8140	ug/Kg	Endosulfan-II	8080A	ug/Kg
Chromium	6020	mg/kg	Endosulfan-Sulfate	8080A	ug/Kg
Copper	6020	mg/kg	Endrin	8080A	ug/Kg
Coumaphos	8140	ug/Kg	Endrin Aldehyde	8080A	ug/Kg
Demeton-O	2140	ug/Kg	Endrin Ketone	8080A	ug/Kg
Demeton-S	8140	ug/Kg	Flouanthene	2270B	ug/Kg
Diazinon	8140	ug/Kg	Flourene	8270B	ug/Kg
Dichlorvos	8140	ug/Kg	gamma-BHC	8080A	ug/Kg
Disulfoton	8140	ug/Kg	gamma-Chlordane	8080A	ug/Kg
Ethoprop	8140	ug/Kg	Heptachlor	8080A	ug/Kg
Fensulfothion	8140	ug/Kg	Heptachlor-Epoxyde	8080A	ug/Kg
Fenthion	2140	ug/Kg	Indeno(1,2,3-cd)pyrene	8270B	ug/Kg
Lead	6020	mg/kg	Methoxychlor	8080A	ug/Kg
Mercury	7471	mg/kg	Naphthalene	8270B	ug/Kg
Merphos	2140	ug/Kg	PCBs	8080A	ug/Kg
Mevinphos	8140	ug/Kg	Phenanthrene	2270B	ug/Kg
Naled	8140	ug/Kg	Pyrene	8270B	ug/Kg
Nickel	6020	mg/kg	Toxaphene	8080A	ug/Kg
Parathion-methyl	8140	ug/Kg	4,4'-DDD	608	ug/L
Particle Size Wt(<0.002mm)	Plumb	gm	4,4'-DDE	608	ug/L
Particle Size Wt(>0.0156mm)	Plumb	gm	4,4'-DDT	608	ug/L
Particle Size Wt(>0.002mm)	Plumb	gm	Aldrin	608	ug/L
Particle Size Wt(=0.0039mm)	Plumb	gm	alpha-BHC	602	ug/L
Particle Size Wt(=0.0078mm)	Plumb	gm	alpha-Chlordane	608	ug/L
Particle Size Wt(=0.0313mm)	Plumb	gm	Azinphos-methyl	614	ug/L
Particle Size Wt(=0.0625mm)	Plumb	gm	beta-BHC	602	ug/L
Particle Size Wt(=0.125mm)	Plumb	gm	Cadmium	200.8	ug/L
Particle Size Wt(=0.25mm)	Plumb	gm	Chromium	200.8	ug/L
Particle Size Wt(=0.5mm)	Plumb	gm	Copper	200.8	ug/L
Particle Size Wt(=16mm)	Plumb	gm	delta-BHC	602	ug/L
Particle Size Wt(>1mm)	Plumb	gm	Demeton-O	614	ug/L
Particle Size Wt(>2mm)	Plumb	gm	Diazinon	614	ug/L
Particle Size Wt(=32mm)	Plumb	gm	Dieldrin	602	ug/L
Particle Size Wt(>4mm)	Plumb	gm	Disulfoton	614	ug/L
Particle Size Wt(>8mm)	Plumb	gm	Endosulfan-I	608	ug/L
Phorate	8140	ug/Kg	Endosulfan-II	608	ug/L
Ronnel	8140	ug/Kg	Endosulfan-Sulfate	608	ug/L
Stuphos	8140	ug/Kg	Endrin	608	ug/L
Tokuthion	2140	ug/Kg	Endrin Aldehyde	608	ug/L
Trichloronate	8140	ug/Kg	Endrin Ketone	602	ug/L
Weight Coarse	Plumb	gm	Ethion	614	ug/L
Weight Fine	Plumb	gm	gamma-BHC	608	ug/L

Sites in the Pajaro River watershed were also sampled for sediment toxicity testing by the University of California, Davis staff at Granite Canyon Marine Laboratories (GCML). Sediment was collected in January 1998 and was tested with the amphipod *Hyalella*. Collection methods and quality assurance protocols followed those utilized by GCML for the Bay Protection and Toxic Cleanup Program.

## **MERCURY SAMPLING**

Sediment and water samples were collected at sites throughout the watershed on June 30, 1998 and analyzed for the presence of mercury. Samples were sent both to the Regional Water Quality Control Board's contract laboratory (water and sediment) and to the CDFG Mussel Watch laboratory (water only). Detection limits for mercury in water at the two labs differed significantly. The detection limit was 0.02 parts per billion at the contract lab, and 0.038 parts per trillion at the CDFG lab. Most of the sites were located in the upper watershed of the San Benito River, and are described in ([Table 3.1](#)).

CDFG at Moss Landing Marine Laboratories continued to conduct mercury analysis at 22 sites throughout the Pajaro River watershed into 1999. Samples were collected and analyzed according to the protocols of the CDFG State Mussel Watch Program.

## 4. MONITORING RESULTS

### A. CONVENTIONAL WATER QUALITY

#### CCAMP ATTENTION AND ACTION LEVELS

The Central Coast Basin Plan contains a number of numeric objectives for various water pollutants. However, for many analytes, objectives either have not been set, or are in narrative form. In order to screen data quickly for potential problems, it is useful to have numeric guidelines. For this reason, CCAMP has adopted Attention and Action levels. Attention levels are levels at which a problem may be occurring. These have generally been derived from the literature, objectives from other states, or guideline values from U.S. EPA or other agencies. An action level is a level at which an established water quality objective has been exceeded. Water quality objectives can be found in the Central Coast Region Water Quality Control Plan (<http://www.swrcb.ca.gov/rwqcb3/>).

#### PH

The pH level is a measure of hydrogen activity in the water column. The pH level is an important consideration in several chemical processes observed in surface waters. For example, relatively small changes in pH can greatly alter the rate of nitrification and denitrification (Metcalf and Eddy, 1979). The pH level also has a significant effect on the toxicity of ammonia and other chemicals (U.S. EPA, 1993, 1999), as well as the availability of metals (U.S. EPA, 1991). The pH levels in surface water may experience diurnal variation as a by-product of the photosynthetic process (Hynes, 1970). During the day aquatic plants (e.g. algae) use carbon dioxide resulting in elevated pH levels. During the night algae produce carbon dioxide resulting in lower pH levels (Metcalf and Eddy, 1979).

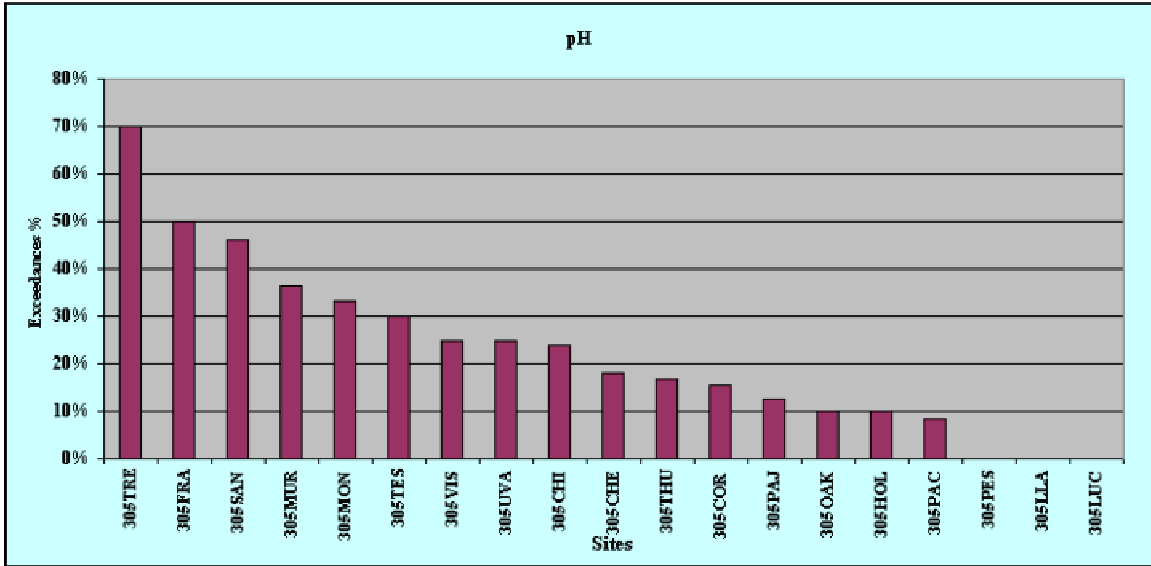
The Basin Plan pH water quality objectives for surface waters with the Municipal and Domestic Supply (MUN) and Agriculture Supply (AGR) beneficial uses are a minimum pH of 6.5 and a maximum pH of 8.3. The Basin Plan pH water quality objectives for surface waters with the Cold Freshwater Habitat (COLD) and Warm Freshwater Habitat (WARM) beneficial uses are a minimum pH of 7.0 and a maximum pH of 8.5.

Samples from sites on the main stem of the Pajaro River (Thurwachter Bridge (305THU), Murphy's Crossing (305MUR), Chittenden Gap (305CHI), Betabel Road (305PAJ), and Frazier Lake Road (305FRA)) had pH levels ranging between 6.98 and 9.02. All sites had maximum pH levels that exceeded the Basin Plan pH surface water objective of 8.3 (Figure 4.1). However, with the exception of the Frazier Lake Road (305FRA) site, the mean pH level for each site on the main stem of the Pajaro River was below the instantaneous maximum surface water objective of 8.3 (Figure 4.2). The mean pH level for the Frazier Lake Road (305FRA) site was 8.39. All sites on the main stem of the Pajaro River, with the exception of the Frazier Lake Road (305FRA) site, had minimum

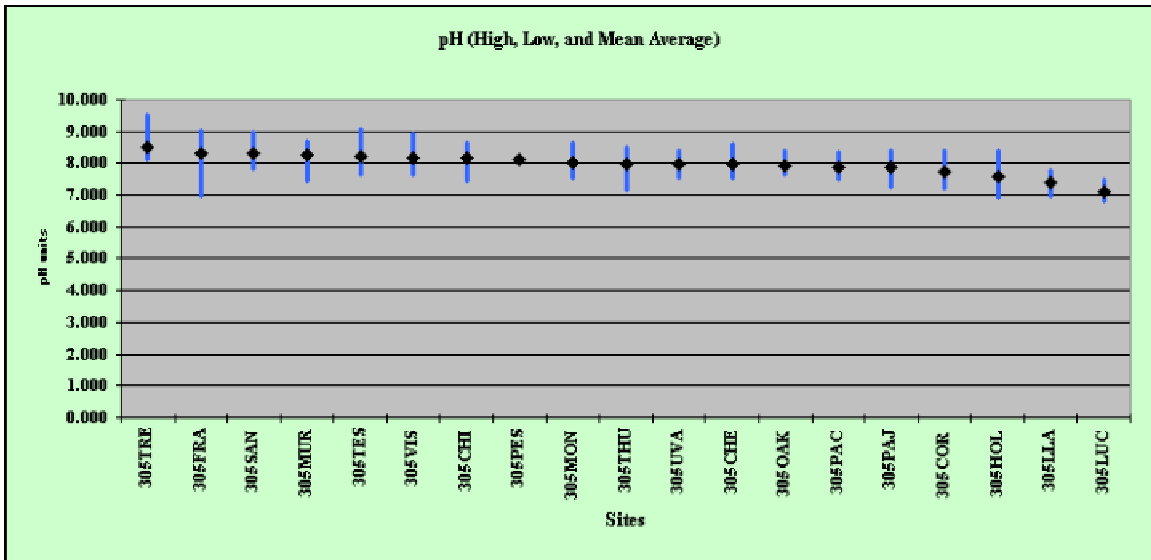


pH levels that were above the Basin Plan pH surface water instantaneous minimum objective of 7.0.

**Figure 4.1 - Percent of samples exceeding Basin Plan objective for pH (pH values greater than 8.3) Pajaro Watershed Characterization, 1998.**



**Figure 4.2 - Mean and Range of pH at sites sampled during the Pajaro River Watershed Characterization, 1998.**



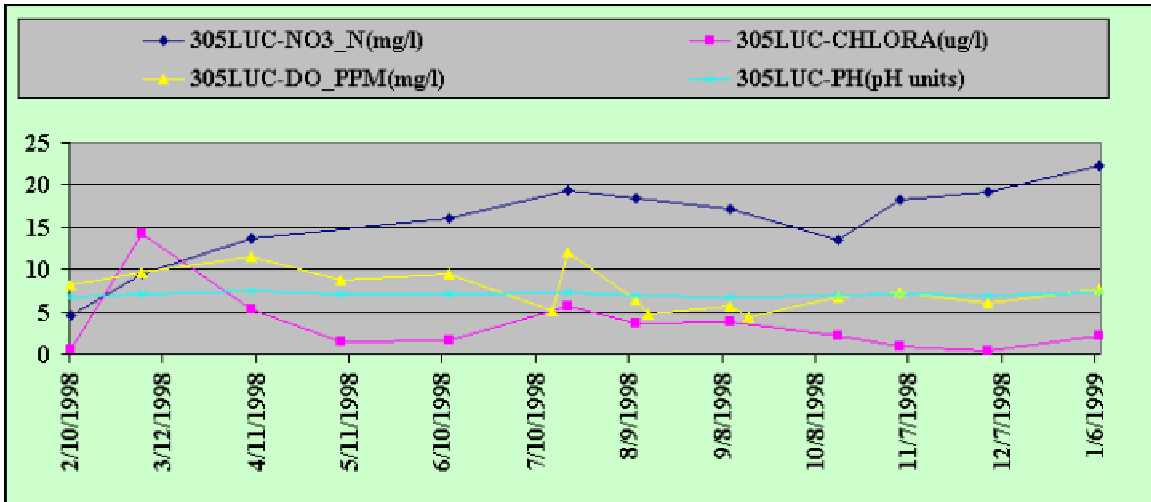
On the lower San Benito River pH data was collected at Y Road (305SAN) and Tres Pinos Creek (305TRE). Similar to the main stem of the Pajaro River, both sites had maximum pH levels that exceeded the Basin Plan pH instantaneous maximum surface

water objective of 8.3. The Y Road (305SAN) site mean pH level was below the instantaneous maximum surface water objective of 8.3, however, the Tres Pinos Creek (305TRE) site mean pH level was 8.49, exceeding the instantaneous maximum surface water objective of 8.3.

Tequisquita Slough (305TES) site pH values ranged between 7.61 and 9.06, with a mean pH level of 8.21. The Tequisquita Slough site had maximum pH levels that exceeded the Basin Plan pH instantaneous maximum surface water objective of 8.3. However, the mean pH level for the site was below the instantaneous maximum surface water objective of 8.3.

In lower Llagas Creek, minimum pH levels in samples from several sites (Holsclaw Road (305HOL), Lucchessa Avenue (305LUC), and Bloomfield Avenue (305LLA)) were lower than 7.0 pH units. Similar to the Frazier Lake Road (305FRA) site, these sites all showed signs of excessive nutrient enrichment and/or algal growth. The four sites with minimum pH values lower than 7.0 (Frazier Lake Road (305FRA), Bloomfield Avenue (305LLA), Holsclaw Road (305HOL), and Lucchessa Avenue (305LUC)) (Figure 4.3) also showed signs of oxygen depletion in predawn sampling.

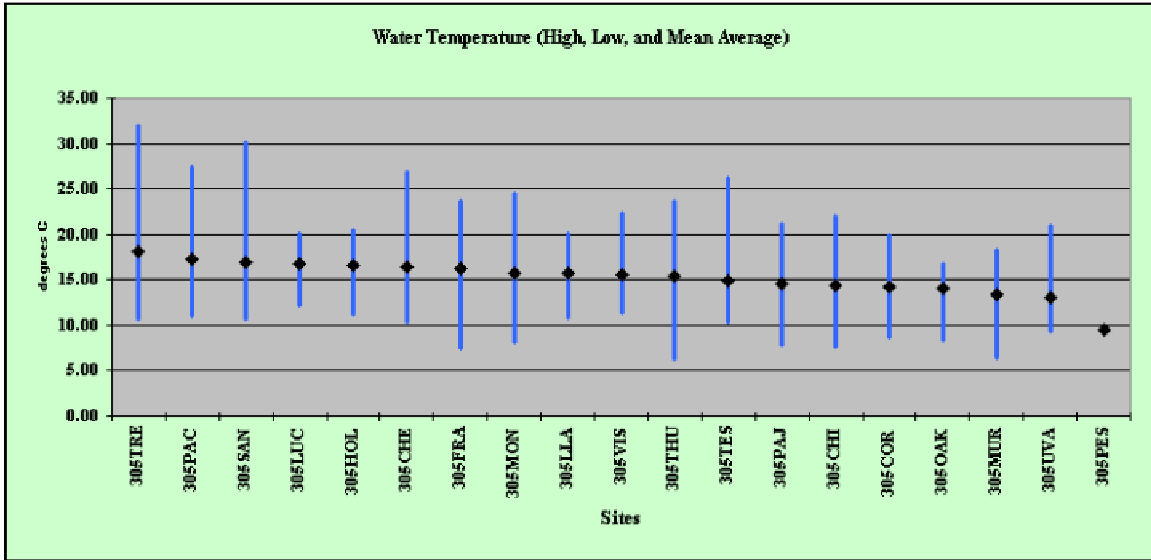
**Figure 4.3 - Time series of pH, dissolved oxygen, nitrate, and chlorophyll *a* values from Llagas Creek at Lucchessa Avenue (305LUC), Pajaro River Watershed Characterization, 1998.**



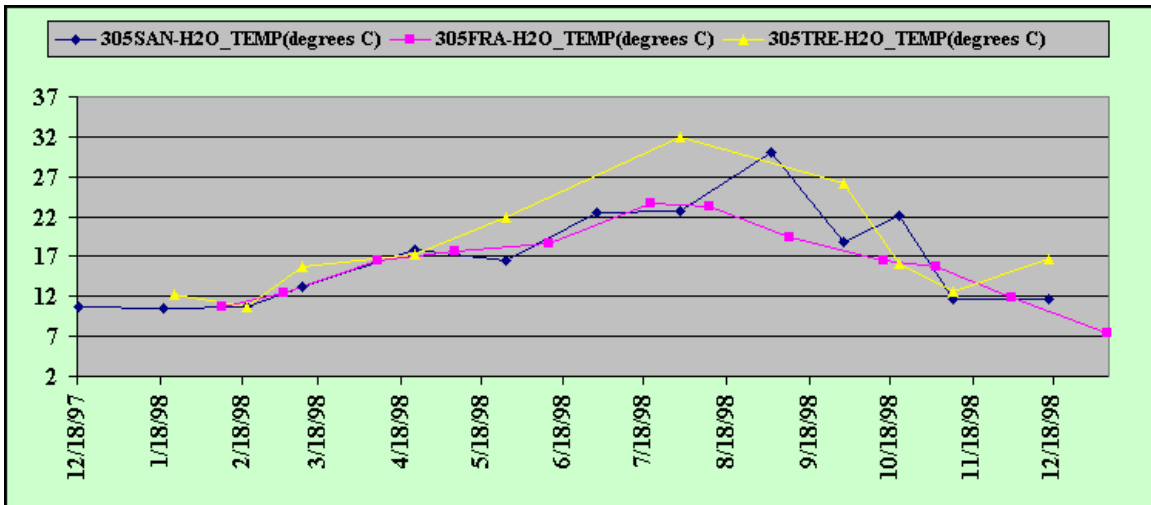
## WATER TEMP

High surface water temperature was identified as an impairment to fish habitat on several tributaries in the Pajaro River watershed (AMBAG, 1984). Water temperature data collected for this study showed a distinct seasonal trend, with most sites remaining within the optimum temperature range of 13°C to 21°C described for steelhead trout by Moyle (1976) (Figure 4.4). However, several sites stand out in exhibiting excessively high summer temperatures (Figure 4.5).

**Figure 4.4** - Mean and Range of water temperatures ( $^{\circ}\text{C}$ ) at sites visited during the Pajaro River Watershed Characterization, 1998.



**Figure 4.5** - Time series of temperature data ( $^{\circ}\text{C}$ ) from San Benito River at Y Road (305SAN), Pajaro River at Frazier Lake Road (305FRA), and Tres Pinos Creek (305TRE) Pajaro River Watershed Characterization, 1998.



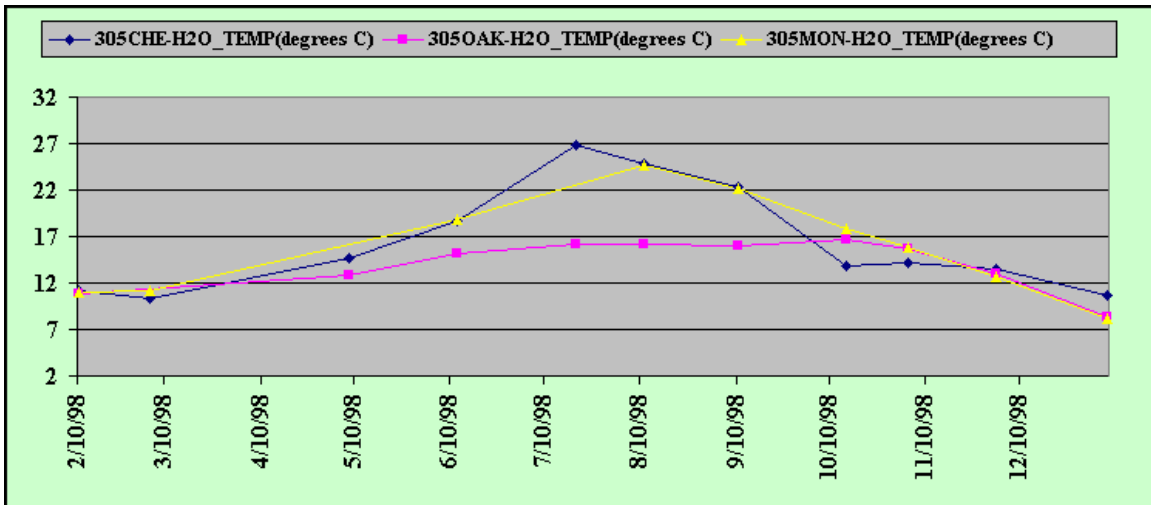
On the main stem of the Pajaro River, summer temperatures at the Frazier Lake Road (305FRA) site reached  $23.7^{\circ}\text{C}$ . On the lower San Benito River sites (Y Road (305SAN) and Tres Pinos Creek (305TRE)) temperatures reached  $30.1^{\circ}\text{C}$  and  $32.0^{\circ}\text{C}$  respectively. It is interesting to note that the Tres Pinos Creek (305TRE) site was very disturbed by construction activities and riparian vegetation at this site was minimal or non-existent.

Surface water temperatures at the Tequisquita Slough (305TES) and Pacheco Creek (305PAC) sites reached 26.2°C and 27.4°C respectively (temperatures above 24°C may create conditions of stress for trout). These summer surface water temperatures are at the upper limits of trout tolerance and lethal under conditions of low dissolved oxygen (Moyle et al.1976).

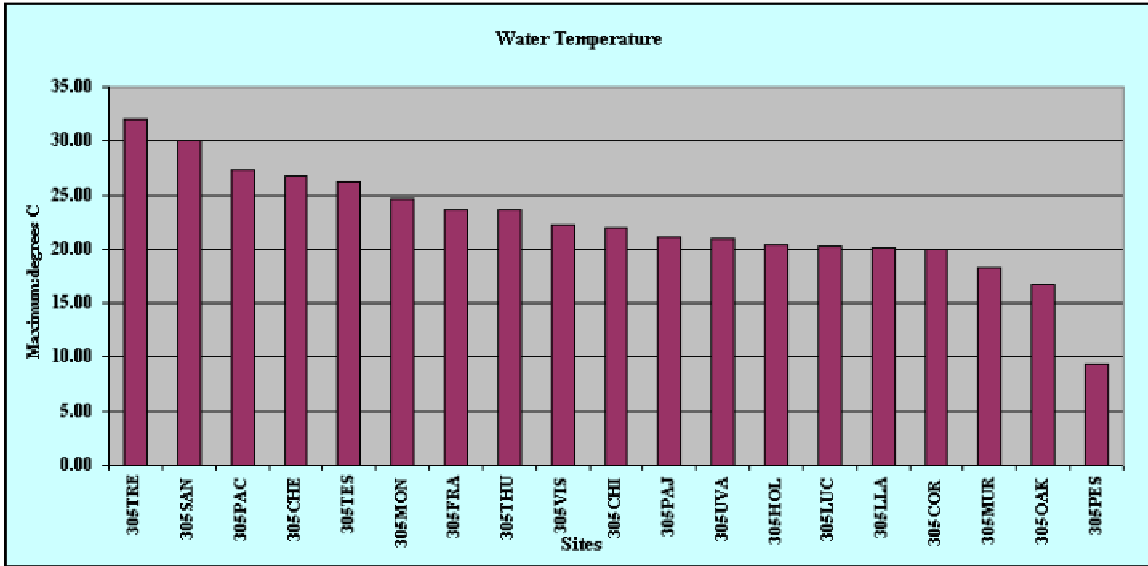
Several sites on Llagas Creek (Bloomfield Avenue (305LLA), Luchessa Avenue (305LUC), Holsclaw Road (305HOL), and Oak Glen Avenue (305OAK)) had temperature levels that remained within the optimum temperature range of 13°C to 21°C described for steelhead trout. However, Buena Vista Avenue (305VIS), Monterey Road (305MON), and Chesbro Reservoir (305CHE) sites had maximum temperatures that exceeded 21°C (22.3°C, 24.8°C, and 26.8°C respectively). Again, these summer surface water temperatures are at the upper limits of trout tolerance and lethal under conditions of low dissolved oxygen. On Llagas Creek, water temperatures exhibited the least variation downstream of the reservoir at Oak Glen Avenue (305OAK), possibly because of reservoir releases made from cooler bottom waters. Within several miles downstream, temperature returned to near those observed above the reservoir (Figure 4.6).

Uvas Creek at Bloomfield Avenue (305UVA) and Salsipuedes Creek (305COR) site had temperature levels that remained within the optimum temperature range of 13°C to 21°C described for steelhead trout. Maximum temperatures are shown in (Figure 4.7).

**Figure 4.6 - Time series of temperature data (°C) from three sites on Llagas Creek, above Chesbro Reservoir (305CHE), at Oak Glen Road (305OAK), and at Monterey Road (305MON) Pajaro River Watershed Characterization, 1998.**



**Figure 4.7 - Maximum temperatures measured at sites sampled during the Pajaro River Watershed Characterization, 1998.**



## DISSOLVED OXYGEN

Basin Plan standards for dissolved oxygen concentrations are 7.0 mg/L minimum for areas designated as cold water (COLD) or spawning habitat (SPWN) and 5.0 mg/L for other fresh water beneficial uses (includes WARM and waters without designated beneficial uses). The Basin Plan surface water quality objective for oxygen saturation is “the median value should not fall below 85% as a result of controllable water quality conditions”. All sites evaluated in this study are designated in the Basin Plan as having one or more of the beneficial uses discussed above.

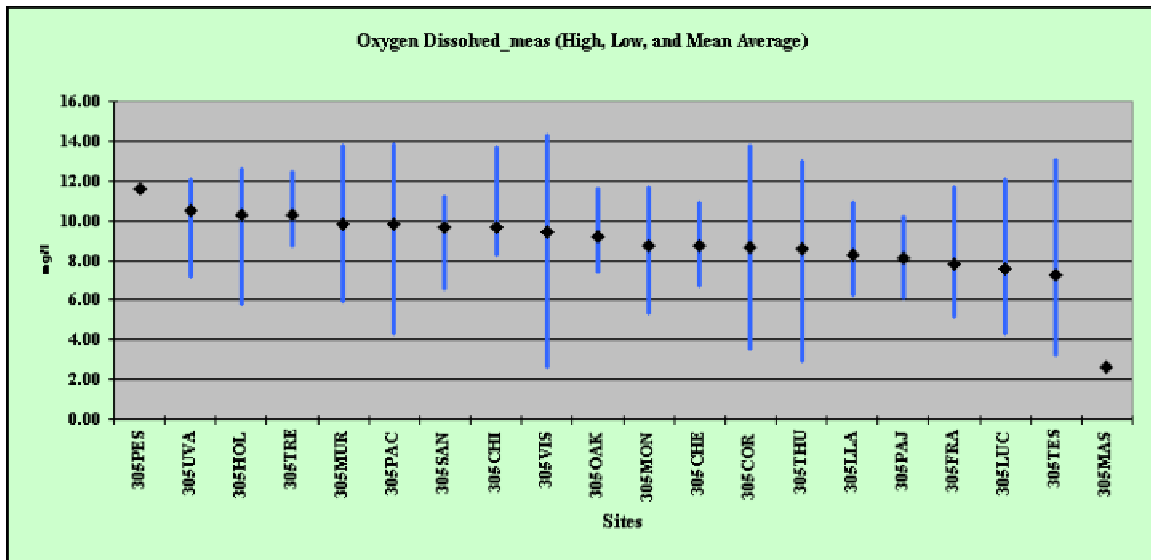
Wide diurnal ranges in dissolved oxygen levels are an indication of eutrophic conditions<sup>1</sup>. Aquatic plants produce oxygen during photosynthesis and consume oxygen during respiration. High mid-day values (on the Central Coast generally greater than 11.0 mg/L) and low pre-dawn values (on the Central Coast below 7.0 mg/L for COLD waters and below 5.0 mg/L for WARM waters) may be indicative of significant aquatic plant photosynthetic activity (U.S. EPA, 2000). Narrow, but depressed diurnal ranges (low dissolved oxygen concentration and/or percent saturation) may also be indicative of eutrophic conditions due to decaying plant material. Narrow dissolved oxygen ranges that remain near full saturation levels (approximately 9-10 mg/L and above 85% saturation) indicate the absence of eutrophic conditions.

With the exception of the Chittenden Gap site (305CHI), wide ranges in dissolved oxygen levels were measured on the main stem of the Pajaro River (Figure 4.8). On the

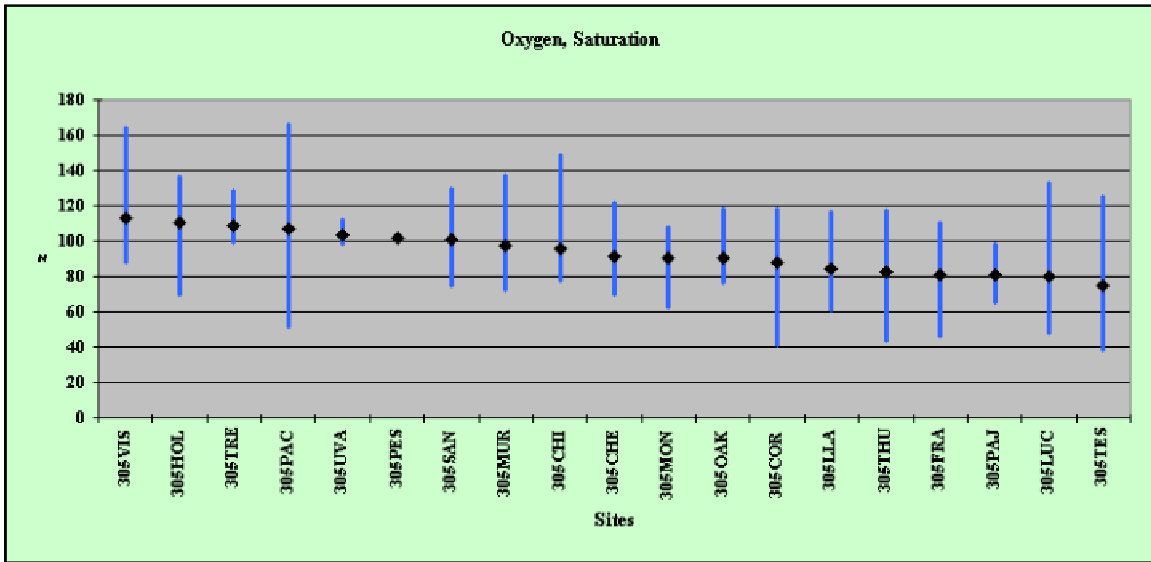
<sup>1</sup> Dissolved oxygen concentration and percent saturation are also affected by water temperature, salinity, and elevation.

lower Pajaro River at Thurwachter Bridge (305THU), an oxygen sag was measured in summer months (pre-dawn dissolved oxygen level of 2.95 mg/L). Three other sites (Frazier Lake Road (305FRA), Betabel Road (305PAJ), and Murphy's Crossing (305MUR)) on the main stem of the Pajaro River had dissolved oxygen levels measured below 7.0 mg/L during 1998. At all main stem sites of the Pajaro River, with the exception of the Betabel Road (305PAJ) site, super-saturated conditions were observed during the summer months. Samples from the Betabel Road (305PAJ) site did not meet the Basin Plan objective for dissolved oxygen percent saturation 75% of the time and did not meet the cold water dissolved oxygen concentration standard 26% of the time. The other four sites on the main stem of the Pajaro River had minimum values below the 85% saturation objective, with the lower Pajaro River site at Thurwachter Bridge (305THU) and the upper Pajaro River site Frazier Lake Road (305FRA) having minimum saturation values in the 50 percent range (Figure 4.9).

**Figure 4.8** - Mean and Range of dissolved oxygen (mg/L) concentrations at sites sampled during the Pajaro River Watershed Characterization, 1998.

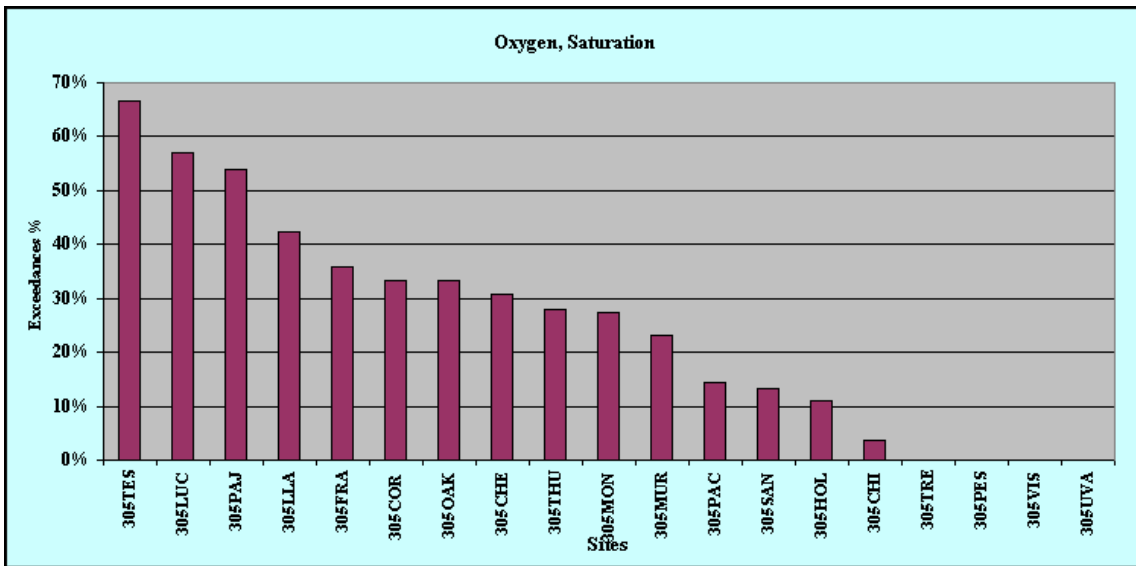


**Figure 4.9 - Median and Range of dissolved oxygen percent saturation at sites sampled during the Pajaro River Watershed Characterization, 1998.**



Wide ranges in dissolved oxygen levels were also measured at Tequisquita Slough (305TES) and Pacheco Creek (305PAC) sites during the summer months. These sites had dissolved oxygen levels measured below 5.0 mg/L, not meeting Basin Plan standards. Oxygen saturation level of 85 percent (Basin Standard) was also not met at Tequisquita Slough (305TES), where oxygen saturation levels fell below the 85% saturation during both summer and fall. The Tequisquita Slough (305TES) site had oxygen saturation levels over 125 percent (super-saturation) one time in March 1998. Oxygen saturation level was never below 85 percent at the Pacheco Creek (305PAC). However, the Pacheco Creek (305PAC) site had oxygen saturation levels over 125 percent (super-saturation) four times during the summer, with oxygen saturation levels of 167 percent in June 1998. The Tequisquita Slough (305TES) site did not meet the Basin Plan objective for warm water dissolved oxygen concentration standard 20% of the time (Figure 4.8) and did not meet the general objective for oxygen saturation 65% of the time (Figure 4.10).

**Figure 4.10** – Percent of samples exceeding Basin Plan objective for oxygen saturation during the Pajaro River Watershed Characterization, 1998.



Wide ranges in dissolved oxygen levels were also measured at the Salsipuedes Creek (305COR) site during late summer and early fall. This site was one of five locations in the Pajaro River watershed where dissolved oxygen levels were measured below 5.0 mg/L. At the Salsipuedes Creek (305COR) site oxygen saturation levels fell below the 85% saturation during both summer and fall. Violations of dissolved oxygen levels and oxygen saturation levels at sites in Salsipuedes Creek and the Pajaro River watershed may indicate that eutrophic conditions (excessive aquatic plant activity) exist at these sites. The presumption that eutrophic conditions exist at Salsipuedes Creek (305COR), Tequisquita Slough (305TES), and Thurwachter Bridge (305THU) appears to be supported by chlorophyll *a* data.

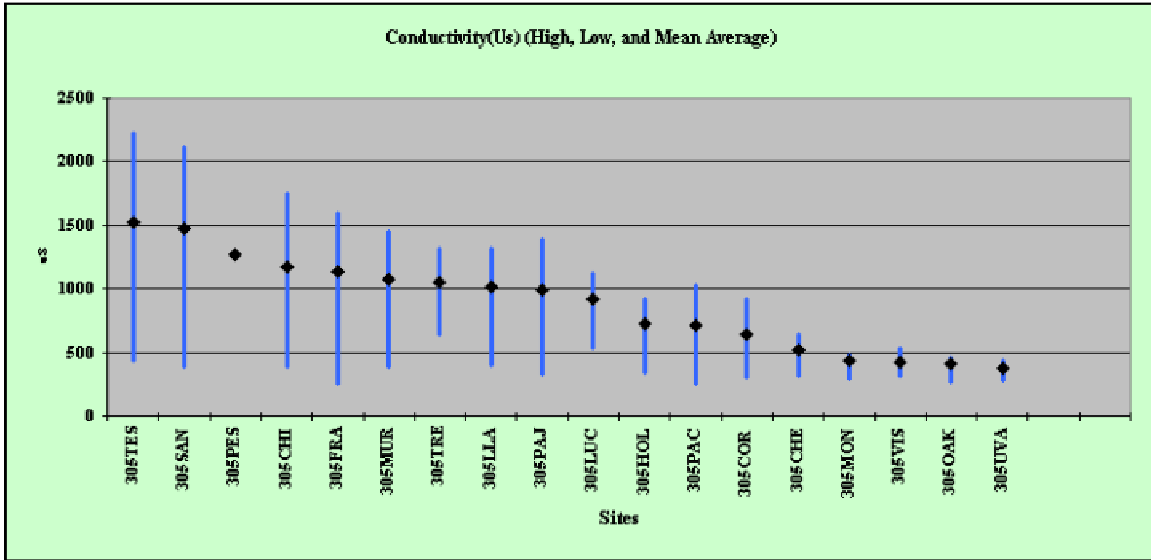
## CONDUCTIVITY

The Central Coast Basin Plan identifies conductivity levels over 750 uS/cm (0.75 mmho/cm) as indicative of "increasing problems" for agricultural water use. The Basin Plan cites 3000 uS/cm (3.0 mmho/cm) as indicative of "severe problems". The 750 uS/cm level has been adopted as the CCAMP attention level for conductivity.

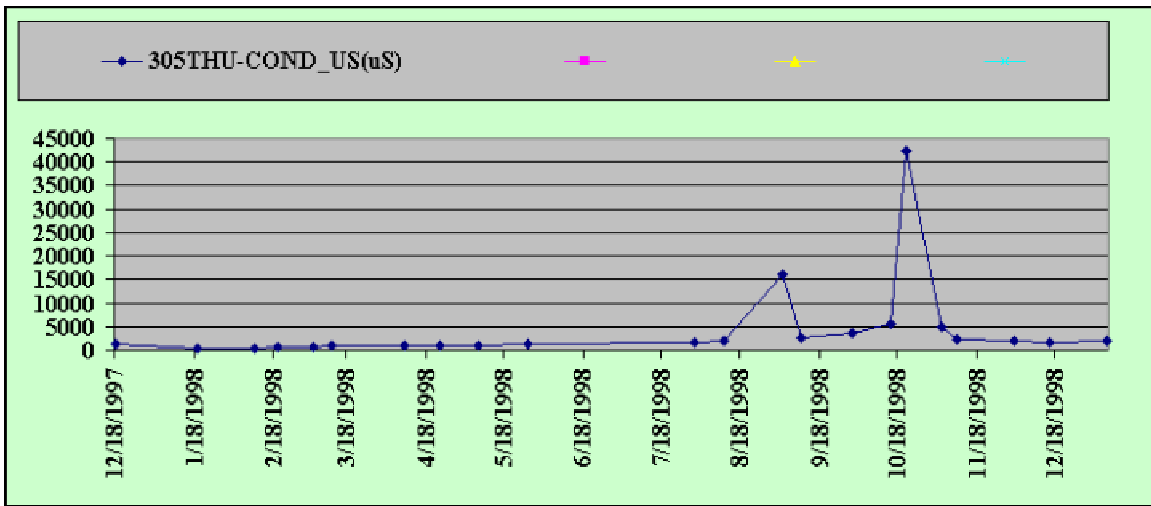
In general, highest conductivity levels were found on the main stem of the Pajaro River ([Figure 4.11](#)). On the lower Pajaro River, the Thurwachter Bridge (305THU) site had two exceedingly high conductivity values in August and October 1998, 16,040 uS/cm and 42,360 uS/cm respectively ([Figure 4.12](#)). These high conductivity values indicate periodic tidal influence at this site.



**Figure 4.11** - Mean and Range of conductivity (uS/cm) at sites sampled during the Pajaro River Watershed Characterization, 1998.



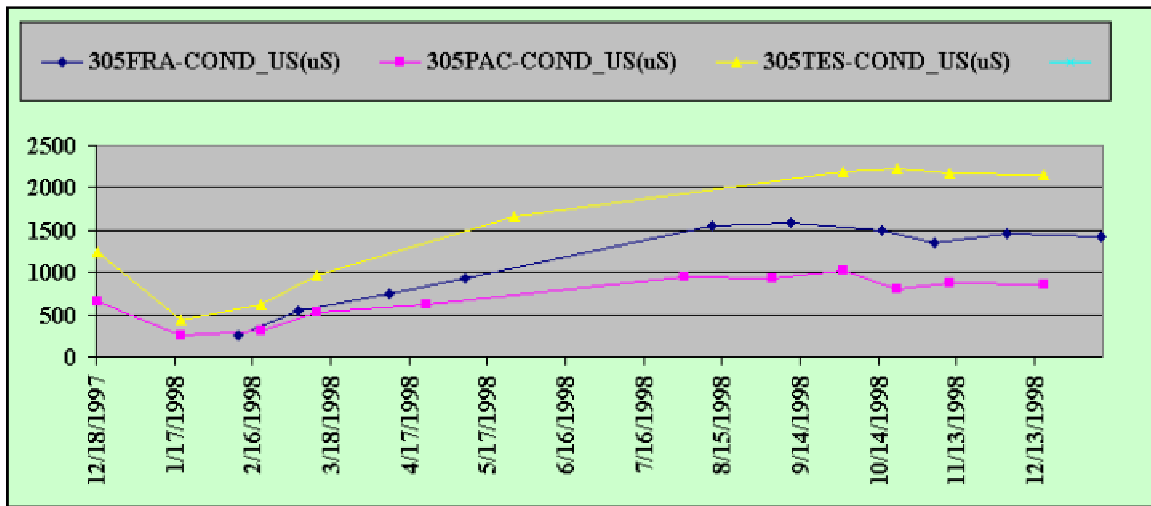
**Figure 4.12** - Conductivity levels (uS/cm) found at Thurwachter Bridge (305THU), Pajaro River Watershed Characterization, 1998.



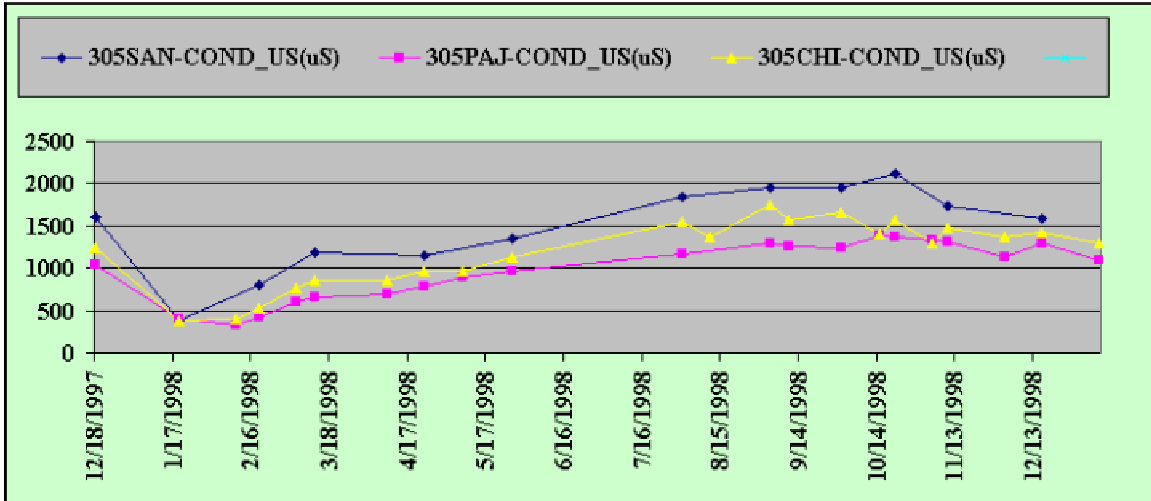
Maximum conductivity exceeded 3,000 uS/cm only at the Thurwachter Bridge (305THU) site. Levels as high as 2110 uS/cm were seen on the San Benito River at Y Road (305SAN) and Tequisquita Slough (305TES) reached 2225 uS/cm. Several sites tributary to the main stem of the Pajaro River (Tequisquita Slough (305TES), Tres Pinos Creek (305TRE), San Benito River at Y Road (305SAN), Bloomfield Avenue (305LLA), and Luchessa Avenue (305LUC)) had average conductivity values that exceeded attention levels (Figure 4.11).

Aside from Thurwachter Bridge (305THU), Tequisquita Slough (305TES) had the highest average conductivity level, at 1,554 uS/cm. As evidenced by the concentrations depicted in [Figure 4.13](#), Tequisquita Slough (305TES) mean conductivity level concentration of 1554 uS/cm, when compared to Pacheco Creek (305PAC) with a mean conductivity concentration of 721 uS/cm, appears to be a significant input of conductivity to the Pajaro River (305FRA). Similarly, as shown in [Figure 4.14](#), the influence of San Benito River at Y Road (305SAN) can be seen on the downstream Chittenden Gap (305CHI) site when compared to the upstream site at Betabel Road (305PAJ). Tributaries entering the Pajaro River from the northern watershed area generally had lower overall conductivity and TDS values.

**Figure 4.13** - Conductivity of Pajaro River samples at Frazier Road (305FRA) and upstream at Pacheco Creek (305PAC) and Tequisquita Slough (305TES), Pajaro River Watershed Characterization, 1998.



**Figure 4.14** - Conductivity of samples taken on the San Benito River at Y Road (305SAN), upstream on the Pajaro River at Betabel Road (305PAJ), and downstream at Chittenden Gap (305CHI), Pajaro River Watershed Characterization, 1998.



## TOTAL DISSOLVED SOLIDS

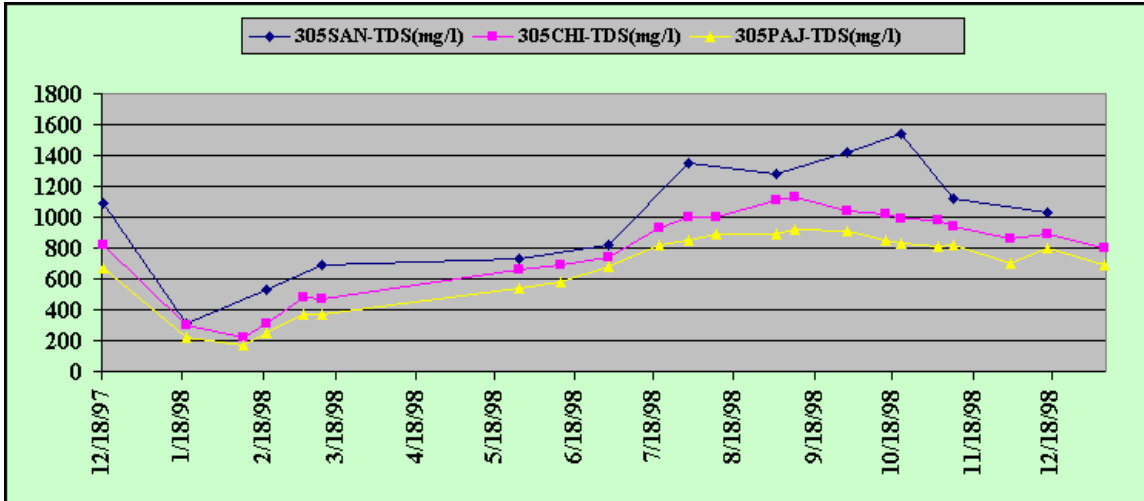
In the Pajaro River watershed, Total Dissolved Solids (TDS) objectives have been established for specific surface water bodies. The objectives, as annual means, for the Pajaro River at Chittenden Gap is established at 1000mg/L, at San Benito River at 1400 mg/L, and at Llagas Creek at 200 mg/L.

During the months of June through November 1998, the lower Pajaro River site at Thurwachter Bridge (305THU) had very high total dissolved solids (TDS) levels with an annual mean of 1807 mg/L. Peak TDS measurements were observed in August (9450 mg/L) and October (6500 mg/L) 1998. These high TDS values high coincide with conductivity values and again suggest tidal influence at this site.

During July through October 1998, individual TDS values at the middle Pajaro River sites of Murphy's Crossing (305MUR) and Chittenden Gap (205CHI), repeatedly exceeded the 1000mg/L surface water quality objective. However, annual means for each site were 849 mg/L and 791 mg/L respectively.

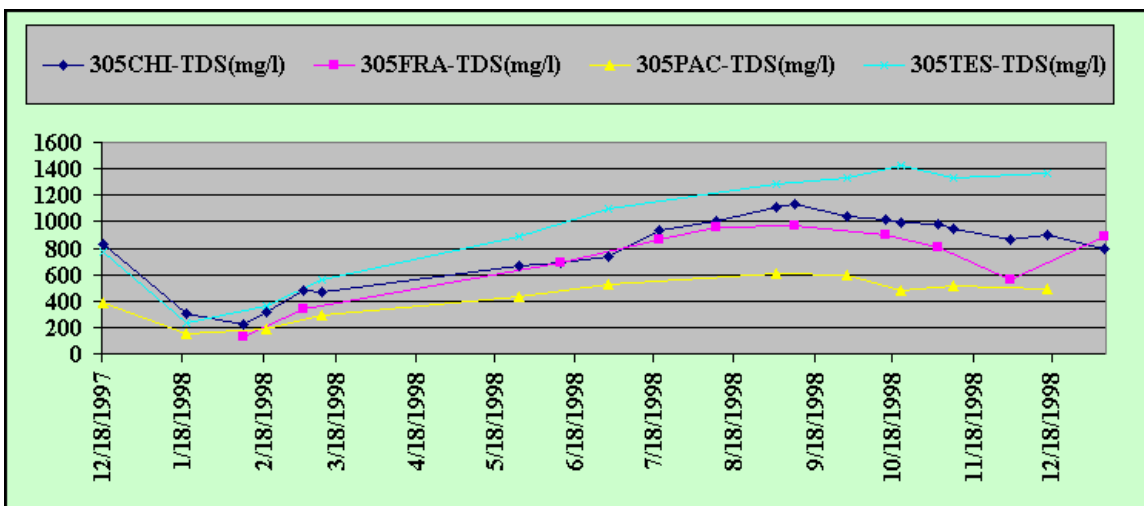
Individual values at the San Benito River at Y Road (305SAN) site were periodically above Basin Plan specific numeric objectives of 1400 mg/L (annual mean) for TDS. However, the annual mean for San Benito River at Y Road (305SAN) was 992 mg/L. Moving further downstream ([Figure 4.15](#)), the San Benito River appears to be a source of increasing dissolved solids in the Pajaro River between Betabel Road (305PAJ) and Chittenden Gap (305CHI).

**Figure 4.15** – Total dissolved solids concentrations at San Benito River (304SAN), upstream on the Pajaro River at Betabel Road (305PAJ), and downstream at Chittenden Gap (305CHI), Pajaro River Watershed Characterization, 1998.



Values at the Tequisquita Slough (305TES) site were also elevated (peak TDS of 1790 mg/L) relative to the Basin Plan specific numeric objective (annual mean) for TDS of 1000 mg/L on the mainstem of the Pajaro River at Chittenden Gap. As evidenced by the concentrations depicted in (Figure 4.16), Tequisquita Slough (305TES) annual mean TDS concentration of 976 mg/L, when compared to Pacheco Creek (305PAC) with an annual mean TDS concentration of 489 mg/L, seems to be a dominant input of elevated TDS to the Pajaro River.

**Figure 4.16** – Total dissolved solids concentrations at Tequisquita Slough (305TES), Pacheco Creek (305PAC), Frazier Lake Road (305FRA), and Chittenden Gap (305CHI), Pajaro River Watershed Characterization, 1998.



On lower Llagas Creek, at the Bloomfield Avenue (305LLA), Lucchessa Avenue (305LUC), and Holsclaw Road (305HOL) sites, TDS was frequently over twice the surface water objective of 200 mg/L (annual mean). At the Bloomfield Avenue (305LLA) and the Lucchessa Avenue (305LUC) sites, TDS always exceeded the surface water objective of 200 mg/L and annual average TDS values for each site were more than twice the surface water objective (623 mg/L and 574 mg/L respectively). For the Holsclaw Road (305HOL) site, some TDS values were below the surface water objective, however annual average TDS levels at the site was 472 mg/L, more than twice the surface water objective.

Conductivity and TDS levels in surface waters tended to peak in late summer and were at their lowest values during winter. Conductivity at all sites (except 305THU) is shown in [Figure 4.11](#) and 305THU is shown in [Figure 4.12](#). Total dissolved solids at all sites are shown in ([Figure 4.17](#)).

**Figure 4.17 - Mean and Range of total dissolved solids (mg/l) concentrations from samples collected during the Pajaro River Watershed Characterization, 1998.**

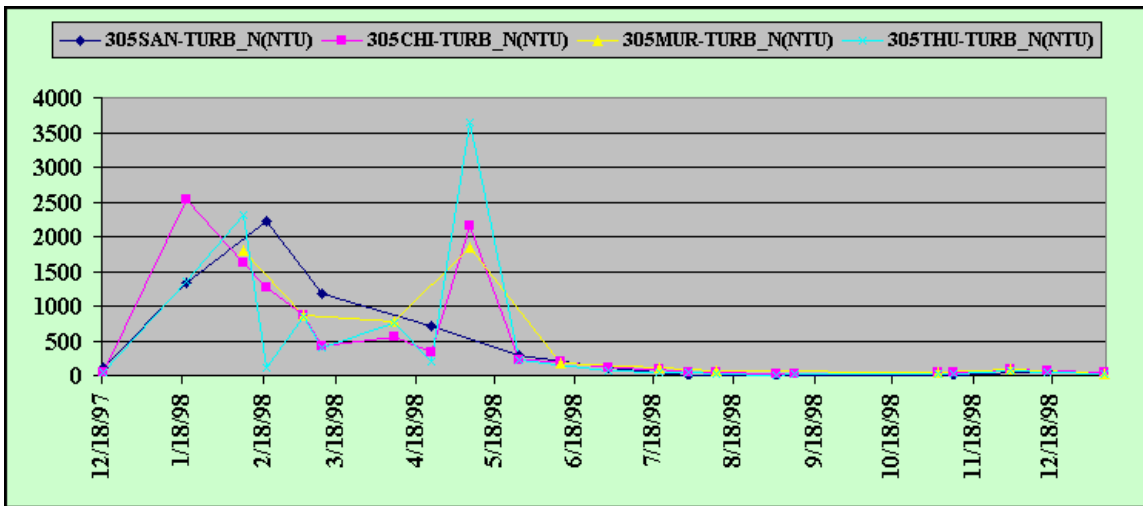


The patterns of conductivity and total dissolved solids in the surface waters of the Pajaro River watershed appear to be similar to patterns of concentrations present in the associated groundwater basins. Conductivity commonly exceeds levels known to cause increasing problems for agricultural use. Elevated dissolved solids in ground water of the Pajaro basin is a serious problem currently being addressed through the activities of the Pajaro Valley Water Management Agency (Hansen et al., 2000). Several winter surface water diversions are proposed for groundwater recharge, including one at Chittenden Gap. These elevated levels of dissolved solids in surface waters should be taken into account during the planning process.

## TURBIDITY AND TOTAL SUSPENDED SOLIDS

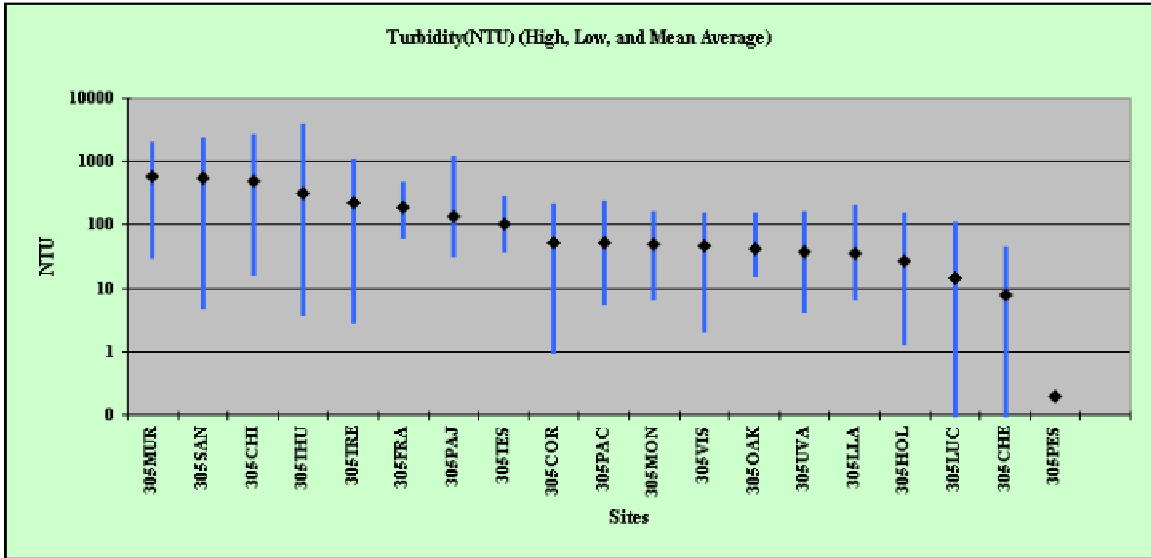
Turbidity was typically highest during winter months, reflecting runoff during rain events. On the lower Pajaro River Thurwachter Bridge (305THU) site, peak turbidity levels of 3650 nephelometric turbidity units (NTU) were found on May 8, 1998 after an unseasonable rain. Similarly, on the middle reach of the Pajaro River, peak turbidity levels of 1850 NTU were found on May 8, 1998 at the Murphy's Crossing (305MUR) site. Winter turbidity levels on the lower and middle Pajaro River (Thurwachter Bridge (305THU), Murphy's Crossing (305MUR), and Chittenden Gap (305CHI)) appear to be influenced by inflow from the San Benito River ([Figure 4.18](#)).

**Figure 4.18** – Turbidity levels at Y Road (305SAN), Chittenden Gap (305CHI), Murphy's Crossing (305MUR), and Thurwachter Bridge (305THU), Pajaro River Watershed Characterization, 1998.



Turbidity levels at the San Benito River Y Road (305SAN) site were elevated in the winter (average value = 1148 NTU, based on data collected January through May 1998) and remained elevated through April 1998. The turbidity levels at the San Benito River Y Road (305SAN) site behaved similarly to those sites on the lower and middle Pajaro River. This is supported by the data collected from January through May 1998, that shows mean turbidity levels at Y Road (305SAN), Chittenden Gap (305CHI), Murphy's Crossing (305MUR), and Thurwachter Bridge (305THU) averaging 1148 NTU, 1220 NTU, 1320 NTU, and 1095 NTU respectively ([Figure 4.19](#)). This is in sharp contrast to mean turbidity levels of 199 NTU during this same period, at the upper Pajaro River site (Betabel Road (305PAJ)), just up stream of the confluence between the Pajaro River and the San Benito River.

**Figure 4.19 - Mean and Range of turbidity levels observed at sites during the Pajaro River Watershed Characterization, 1998.**



Turbidity levels at sites on the upper Pajaro River (Betabel Road (305PAJ) and Frazier Lake Road (305FRA)), and Tequisquita Slough (305TES) behaved similarly over the course of the year. All three had peak turbidity levels in February 1998, followed by a decline through April 1998. All three sites then showed increased turbidity levels in May 1998 through October 1998. The increased levels during May 1998 through October 1998 were below the peak levels, but significantly higher than other sites in the Pajaro River watershed (60 to 250 NTU's versus 1 to 50 NTU's for other sites). Phytoplankton blooms, indicated by high chlorophyll *a* values at both the Betabel Road (305PAJ) and Frazier Lake Road (305FRA) sites, may be contributing to the elevated turbidity levels observed during summer months.

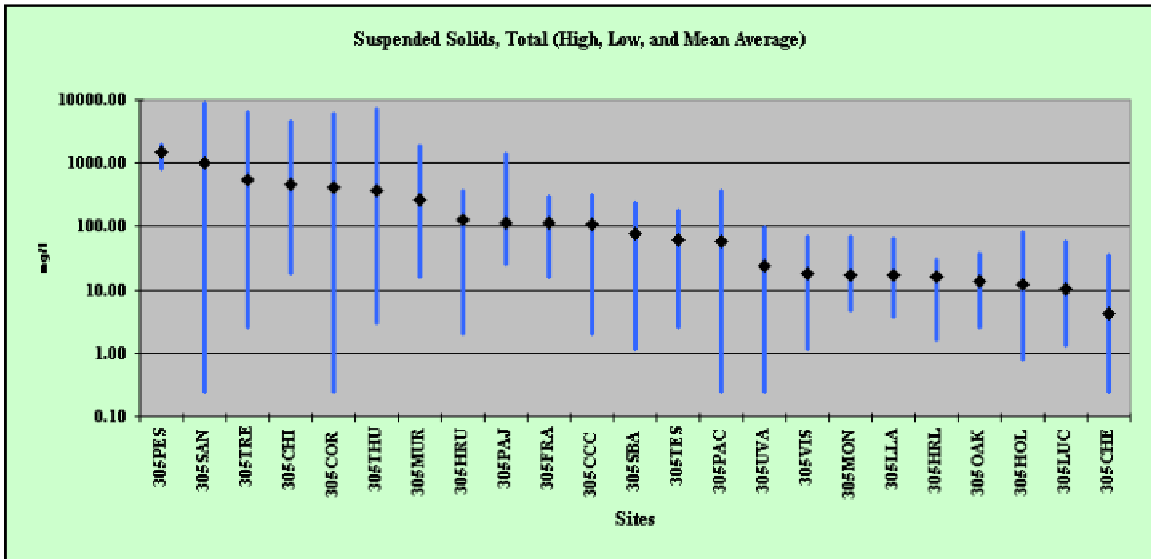
All other sites in the Pajaro River watershed turbidity levels were elevated in the winter and low in the summer. Typical mean turbidity values were below 50 NTU and with summer values usually below 15 NTUs.

On the lower Pajaro River Thurwachter Bridge (305THU) site, peak total suspended solids (TSS) levels of 6960 mg/L were found in January 1998. Similarly, at both sites of the middle reach of the Pajaro River, TSS levels peaked in January/February 1998. TSS levels in the lower/middle Pajaro River appear to show a clear pattern of seasonal variation with winter TSS levels above 1000 mg/L and summer TSS levels below 100 mg/L. Winter TSS levels on the lower and middle Pajaro River (Thurwachter Bridge (305THU), Murphy's Crossing (305MUR), and Chittenden Gap (305CHI)) appear to be influenced by inflow from the San Benito River.

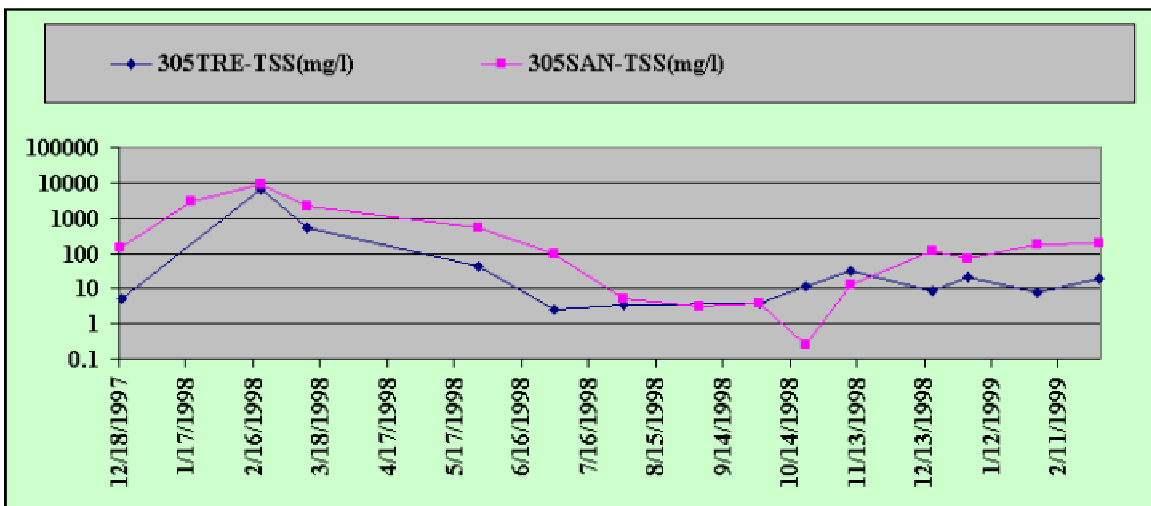
The lower San Benito River, Y Road (305SAN) and Tres Pinos Creek (305TRE) sites, had two of the highest average concentrations of TSS, 1238 mg/L and 654 mg/L

respectively (Figure 4.20). Peak TSS levels on lower San Benito River were recorded during January, February, and March 1998. The Y Road (305SAN) site had the highest TSS observed, at 8870 mg/L (Figure 4.21). TSS levels in the lower San Benito River appear to show a clear pattern of seasonal variation with winter TSS levels above 1000 mg/L and summer TSS levels below 10 mg/L.

**Figure 4.20** - Mean and Range total suspended solids (TSS) levels at all Pajaro River Watershed sites, Pajaro River Watershed Characterization, 1998.



**Figure 4.21** - Total suspended solids (TSS) levels at lower San Benito River Y Road (305SAN) and Tres Pinos Creek (305TRE) sites, Pajaro River Watershed Characterization, 1998.





The Salsipuedes Creek (305COR) site, behaves similarly to the lower Pajaro River with peak winter TSS levels above 1000 mg/L and summer TSS levels below 10 mg/L.

Four other sites in the Pajaro River watershed (Frazier Lake Road (305FRA), Tequisquita Slough (305TES), Pacheco Creek (305PAC), and Bloomfield Avenue (305LLA)) had relatively constant TSS levels through out the year. TSS values typically ranged between 10 mg/L and 100 mg/L.

In addition to chronic erosion sources, there were several other factors that may have contributed to variable TSS levels in the Pajaro River watershed. The winter of 1997-98 was unusually wet, as a record setting "El Nino" condition was present offshore. This resulted in a number of catastrophic erosion events in the Pajaro River watershed. Culvert and levee failures were observed, and the river frequently flooded adjacent lands. A major settling basin adjacent to the San Benito River at Y Road (305SAN) had several catastrophic failures during the El Nino winter. Its levees collapsed into the river in some places, and a complete failure of the levee resulted in draining of the entire basin and its contents to the San Benito River.

The San Benito River watershed appears to have been a major contributor of sediment to the Pajaro River watershed in 1998. Possible sediment sources include structural failures (culvert, settling basin, levee, etc.), gravel mining, road maintenance, and flood control activities. The lower and middle reaches of the Pajaro River, particularly downstream of San Benito River, had elevated total suspended solids (TSS) and turbidity levels. Other than the Salsipuedes Creek (305COR) site, which had high TSS concentrations during January, TSS and turbidity contribution from other tributaries was relatively low.

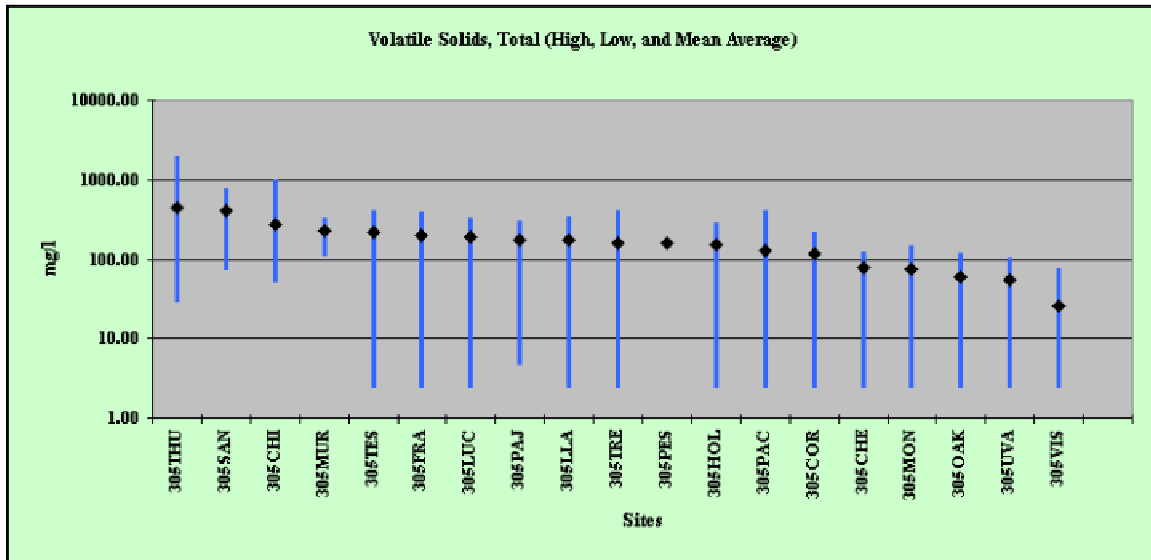
Suspended solids measurements are highly "event" dependent, meaning the variability in the data is highly dependent on storm flow, and variability can be extreme. Landslides and catastrophic erosion events can dramatically alter sample results. In addition, grab samples tend not to be highly representative of sediment concentrations collected through depth and width integrated techniques. Most appropriate sampling strategies for this type of parameter include event-based sampling using integrated sampling techniques. Though the conclusions drawn here point to the San Benito River as a major source of sediment to the Pajaro system, these findings are based on monthly grab samples only, and would require more detailed sampling methods if explicit sediment source allocations are deemed necessary.

## **VOLATILE SOLIDS**

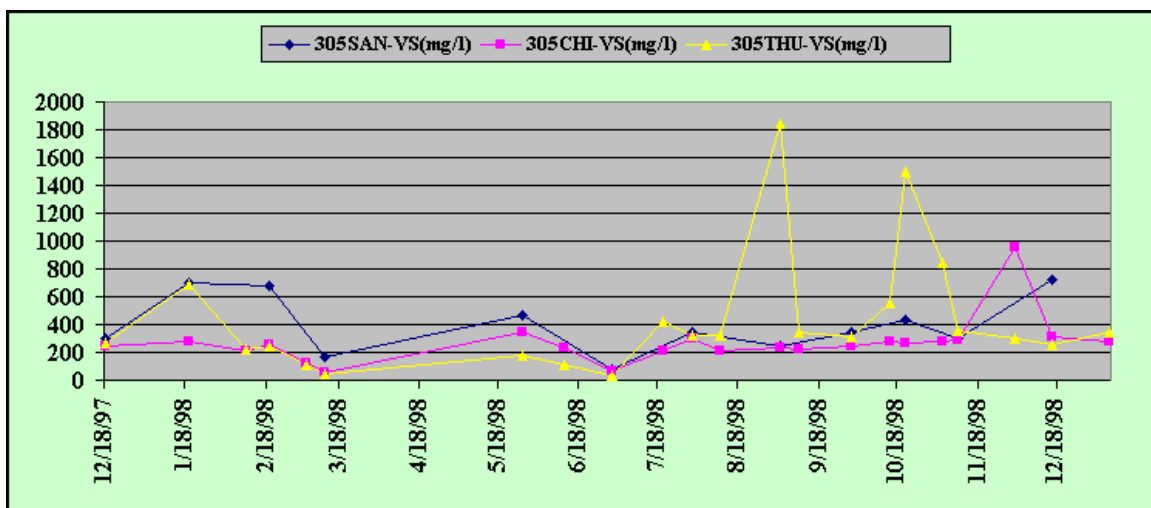
The concentration of Total Volatile Solids (TVS) is used as a measurement of organic material in the water column, and is a consideration in understanding nutrient cycling and organic material content. The San Benito River (Y Road (305SAN) and the Pajaro River (Chittenden Gap (305CHI) and Thurwachter Bridge (305THU)) had elevated concentrations through most of the year ([Figure 4.22](#)). Thurwachter Bridge (305THU) TVS peaks coincided with peaks in TDS and conductivity, suggesting high organic content in tidally influenced water. Chittenden Gap (305CHI) TVS values generally

tracked San Benito River values, suggesting the San Benito River is heavily influencing the main stem of the Pajaro River downstream of the confluence. Other sites were lower overall with increases in summer months (Figure 4.23).

**Figure 4.22** - Mean and Range of total volatile solids (TVS) levels (mg/l) at sites sampled during the Pajaro River Watershed Characterization, 1998.



**Figure 4.23** - Total volatile solids (TVS) levels (mg/l) at San Benito River Y Road (305SAN) and Chittenden Gap (305CHI) and Thurwachter Bridge (305THU), Pajaro River Watershed Characterization, 1998.

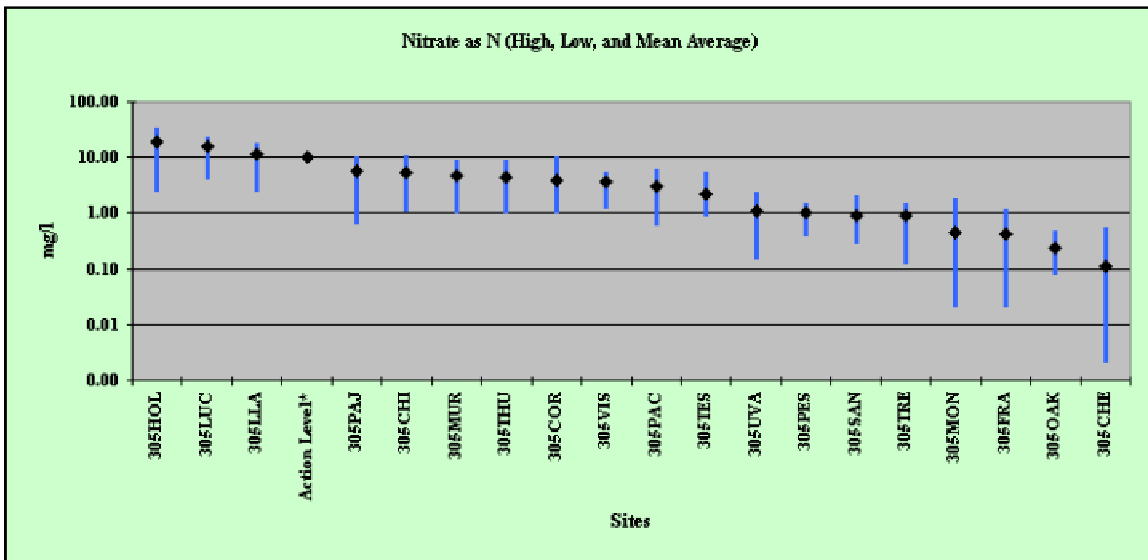


## NITRATE

The Central Coast Basin Plan drinking water standard for nitrate nitrogen is 10 mg/L NO<sub>3</sub> as N (45 mg/L NO<sub>3</sub> as NO<sub>3</sub>). CCAMP has adopted this Basin Plan standard as an action level for maximum concentrations of nitrate-N. The tentative CCAMP attention level is 2.25 mg/L NO<sub>3</sub> as N. This value is twice the suggested objective (1.2 mg-N/L inorganic nitrogen (ammonia, nitrite, and nitrate summed as N)) for the watershed developed by Williamson (1994).

Generally speaking, nitrate levels throughout the Pajaro River watershed are excessive when compared to the CCAMP attention level (2.25 mg/L NO<sub>3</sub> as N) except in the San Benito River and Uvas Creek watersheds. The Pajaro River and Llagas Creek are included on the 303(d) list as impaired by nutrients, and nitrate concentrations form the basis for this listing. Data on nitrate collected by this study support these listings. Average nitrate values at all sites are shown in (Figure 4.24).

**Figure 4.24 - Mean and Range nitrate (NO<sub>3</sub> as N) concentrations (mg/l) at sites sampled during the Pajaro River Watershed Characterization, 1998.**

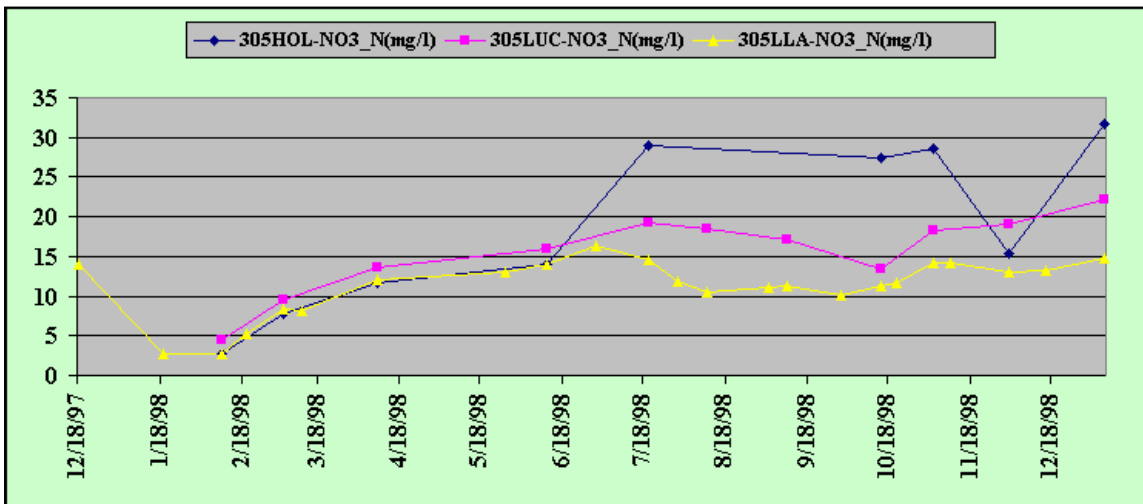


On the lower/middle Pajaro River sites (Thurwachter Bridge (305THU), Murphy's Crossing (305MUR), and Chittenden Gap (305CHI)) nitrate levels were below 3.5 mg/L NO<sub>3</sub> as N during the winter months (January through May) and then climbed sharply to 6 to 10 mg/L NO<sub>3</sub> as N (June through September). The nitrate levels measured at the upper Pajaro River site, Betabel Road (305PAJ), behaved very similarly to the sites on the lower/middle Pajaro River. All of the sites on the Pajaro River below the confluence with Llagas Creek, seemed to be heavily influenced by Llagas Creek nitrogen levels. The lower/middle Pajaro River sites, the upper Pajaro River site Betabel Road (305PAJ), and lower Llagas Creek sites (Bloomfield Avenue (305LLA), Luchessa Avenue (305LUC),

Holsclaw Road (305HOL)) showed elevated levels of nitrate (5 to 30 mg/L NO<sub>3</sub> as N) during June through October.

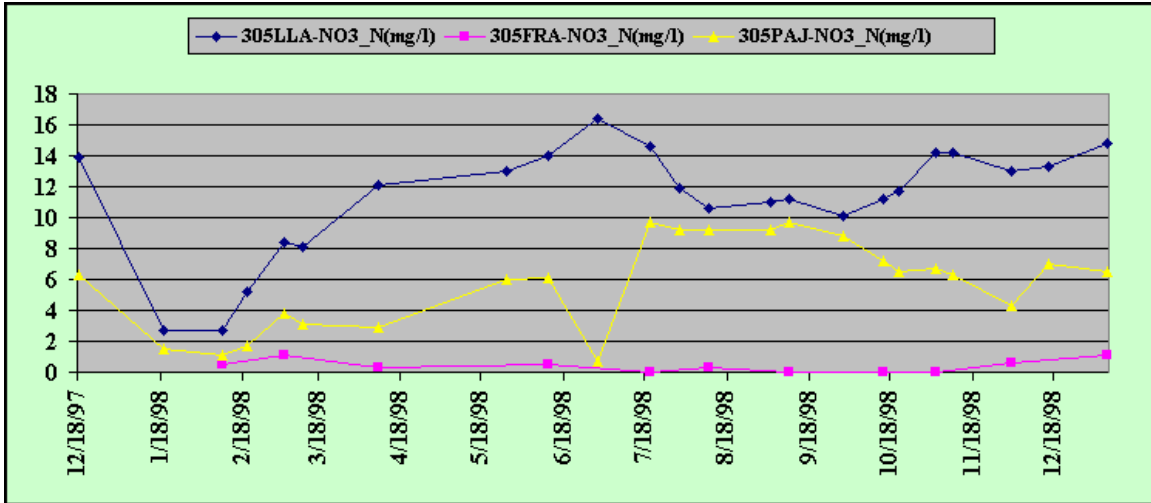
All sites on lower Llagas Creek (Bloomfield Avenue (305LLA), Lucchessa Avenue (305LUC), Holsclaw Road (305HOL)) were extremely elevated (10 to 31 mg/L NO<sub>3</sub> as N) during March through December 1998 (Figure 4.25). During 1998, nitrate nitrogen at all three sites exceeded the Basin Plan drinking water standard for nitrate nitrogen of 10 mg/L NO<sub>3</sub> as N except during January and February. The nitrate levels in the upper Llagas Creek sites (above Masten Avenue (305MAS).) were typically under 1.5 mg/L NO<sub>3</sub> as N.

**Figure 4.25** – Nitrate levels (NO<sub>3</sub> as N) on lower Llagas Creek Bloomfield Avenue (305LLA), Lucchessa Avenue (305LUC), and Holsclaw Road (305HOL), Pajaro River Watershed Characterization, 1998.

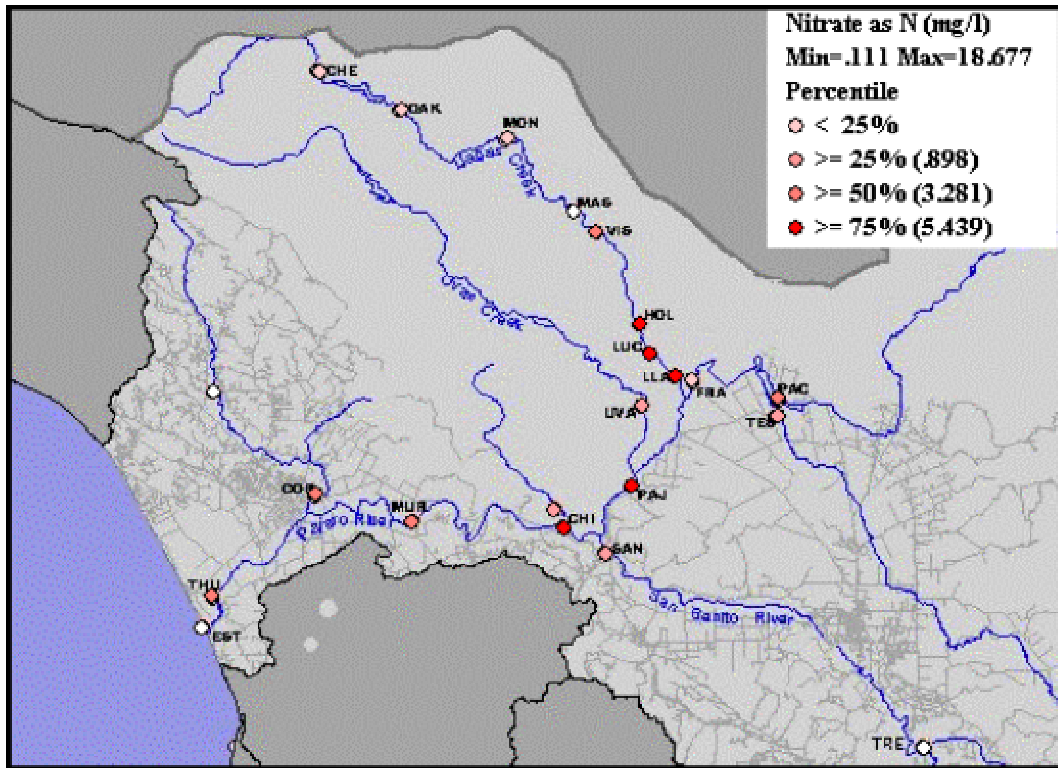


The data collected in 1998 clearly shows that lower Llagas Creek is a significant source of elevated nitrate nitrogen in the Pajaro River. Time series data for Llagas Creek and the Pajaro River from Betabel Road (305PAJ) downstream, clearly point to the influence of Llagas Creek on the main stem (Figure 4.26). Any efforts to reduce nitrates in the Pajaro River should target lower Llagas Creek (Map 4.1).

**Figure 4.26** - Nitrate levels (NO<sub>3</sub> as N) at Bloomfield Avenue (305LLA), Frazier Lake Road (305FRA), and Betabel Road (305PAJ), Pajaro River Watershed Characterization, 1998.



**Map 4.1** - Nitrate concentrations in water (ug/l) samples collected from the Pajaro River watershed, 1998 – 1999, expressed as quartiles, Pajaro River Watershed Characterization, 1998.



While not as high as lower Llagas Creek, Salsipuedes Creek (305COR) also showed elevated nitrate levels in summer months (June through October), reaching 9.7 mg/L NO<sub>3</sub> as N by the end of September.

Sites upstream of Llagas Creek at Pacheco Creek (305PAC) and Tequisquita Slough (305TES) were somewhat elevated with nitrate values ranging between 0.7 and 5.0 mg/L NO<sub>3</sub> as N. Sites on the lower San Benito River (Y Road (305SAN) and Tres Pinos Creek (305TRE)) and Uvas Creek (305UVA) never exceeded 2.0 mg/L NO<sub>3</sub> as N.

Upstream of Llagas Creek, the upper Pajaro River Frazier Lake Road (305FRA) site had very low nitrate levels. The nitrate levels at this site rarely exceeded 1.0 mg/L NO<sub>3</sub> as N and were typically below 0.6 mg/L NO<sub>3</sub> as N. The low nitrate levels at the Frazier Lake Road (305FRA) site were associated with very high chlorophyll a values. The data implies that upstream (Pacheco Creek (305PAC) and Tequisquita Slough (305TES)) inputs of nitrogen and phosphorus were sufficient to sustain aquatic plant growth at the Frazier Lake Road (305FRA) site and that a significant portion of the available nitrate nitrogen is utilized by the aquatic plant growth. [Table 4.1](#) depicts the water body response at various sites to nitrate concentrations exceeding 2.25 mg/L (NO<sub>3</sub> as N).

**Table 4.1 - Characteristics of Water Bodies with nitrate Concentrations Exceeding 2.25 mg/L (NO<sub>3</sub> as N), Pajaro River Watershed Characterization, 1998.**

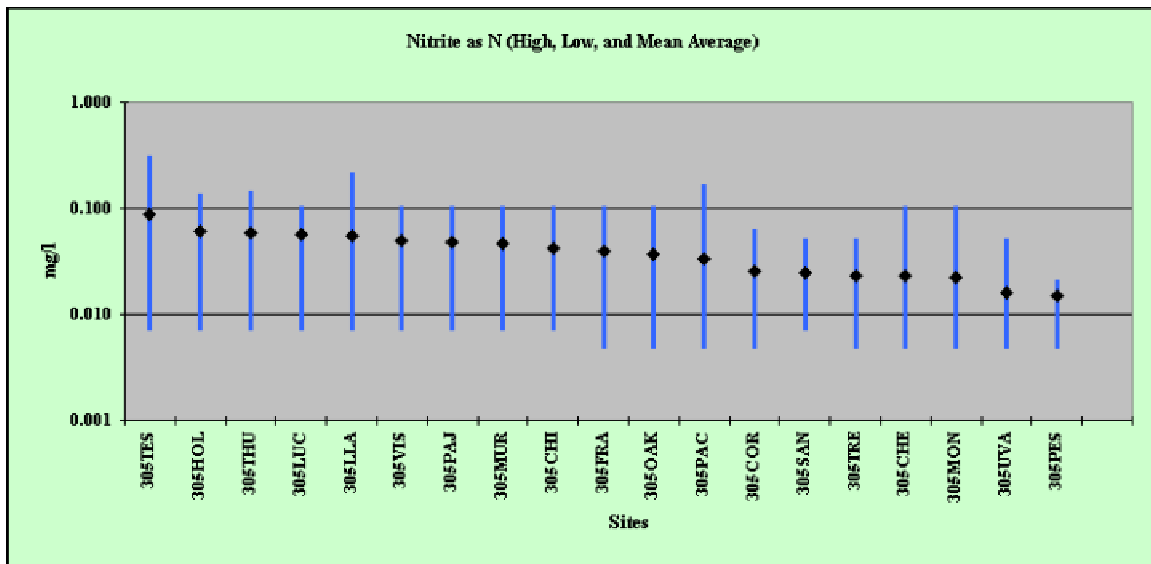
STATION ID AND LOCATION	AVERAGE NITRATE (AS N) CONCENTRATION	CHARACTERISTICS
035PAC Pacheco Creek	2.93 mg/L	<p>Maximum D.O. concentration=13.2 mg/L Minimum D.O. concentration = 4.33 mg/L</p> <p>Minimum D.O. concentration less than 7.0 mg/L for 3 samples out of 16 total samples or 19 % of samples.</p> <p>Oxygen saturation less than 85% for 2 samples out of 15 total samples or 13 % of samples.</p>
305COR Salaspuedes Creek	4.21 mg/L	<p>Maximum D.O. concentration=13.77 mg/L Minimum D.O. concentration = 3.59 mg/L</p> <p>Minimum D.O. concentration less than 7.0 mg/L for 4 samples out of 16 total samples or 25 % of samples.</p> <p>Oxygen saturation less than 85% for 6 samples out of 15 total samples or 40% of samples.</p>
305PAJ Pajaro River at Betabel Road	6.09 mg/L	<p>Maximum D.O. concentration=10.22 mg/L Minimum D.O. concentration = 6.09 mg/L Minimum D.O. concentration less than 7.0 mg/L for 7 samples out of 27 total samples or 26 % of samples.</p> <p>Oxygen saturation less than of 85% for 17 samples out of 24 total samples or 71 % of samples.</p>
305LUC Llagas Creek at Lucchessa Avenue	15.60 mg/L	<p>Maximum D.O. concentration=12.04 mg/L Minimum D.O. concentration = 4.35 mg/L</p> <p>Minimum D.O. concentration less than 7.0 mg/L for 7 samples out of 15 total samples or 47 % of samples.</p> <p>Oxygen saturation less than of 85% for 7 samples out of 12 total samples or 58 % of samples.</p>

Finally, it is important to view the change in nitrate concentration at each site as a function of flow. The reduction in nitrate concentrations during periods of higher flow may indicate a dilution effect. However, winter nitrate loads in the Pajaro River watershed may be similar or higher than loads during summer months.

## **NITRITE**

Nitrite is a relatively unstable nitrogen form and is easily oxidized to the nitrate form. Nitrite is typically present in small concentrations and seldom exceeds 0.1 mg/L NO<sub>2</sub> as N (Metcalf and Eddy, 1979). In the Pajaro River watershed, sites with higher nitrate levels generally had higher nitrite values. All sites in the Pajaro River watershed had mean nitrite values at or below 0.061 mg/L NO<sub>2</sub> as N, except Tequisquita Slough (305TES). Tequisquita Slough (305TES) stands out in the data set in that the mean nitrite value was 0.1 mg/L NO<sub>2</sub> as N and five nitrite measurements at the site exceeded 0.1 mg/L NO<sub>2</sub> as N. Tequisquita Slough (305TES) was also unique because the elevated nitrite levels occurred without correspondingly high nitrate levels. Average nitrite concentrations are shown in (Figure 4.27).

**Figure 4.27** - Mean and Range of nitrite (NO<sub>2</sub> as N) concentrations (mg/l) at sites sampled during the Pajaro River Watershed Characterization, 1998.



## AMMONIA

Some confusion exists with the terminology and calculations used to describe concentrations of ammonia. The term unionized (undissociated) ammonia refers to NH<sub>3</sub>, the gaseous and most toxic form of ammonia. Ionized ammonia refers to NH<sub>4</sub><sup>+</sup>, the ammonium-ion or dissociated ammonia. Total ammonia (NH<sub>3</sub> + NH<sub>4</sub><sup>+</sup>) refers to the combined concentrations of the unionized and ionized forms of ammonia (Morgan and Turner, 1977). Temperature and pH are the most important conditions that control the equilibrium between ammonia (NH<sub>3</sub>) and ammonium (NH<sub>4</sub><sup>+</sup>) in the water column.

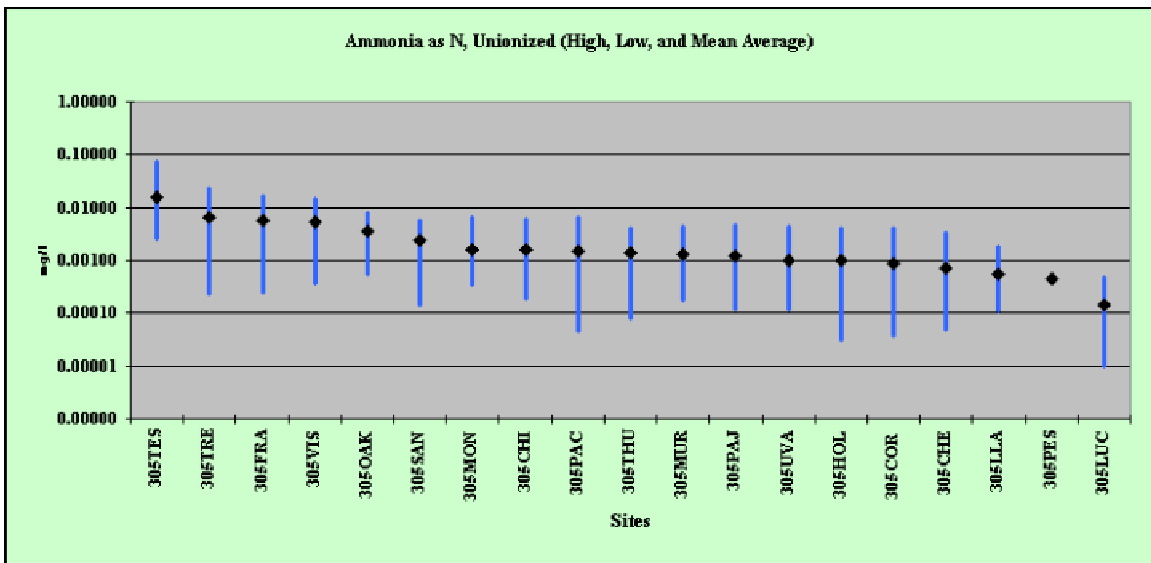
The U.S. EPA has published new standards for evaluation of ammonia toxicity and new methods of evaluating both chronic and acute criteria (U.S. EPA 1999). While the new methods indicate that slightly higher levels of ammonia may be tolerable under certain



conditions, information provided in the document regarding sensitivity of early life stage salmonids (such as steelhead trout), appears to support the existing Basin Plan objective of 0.025 mg/L NH<sub>3</sub> as N. In the Pajaro River watershed pH is typically high, with mean averages generally exceeding 7.9. High ammonia levels, along with generally high pH imply that ammonia may have a toxic effect on fish at various locations in the watershed.

Total ammonia reported as nitrogen (as N), was collected as part of conventional water quality sampling in the Pajaro watershed. Using temperature and pH data collected in the field, the total ammonia concentrations were used to calculate unionized ammonia (NH<sub>3</sub>) as N. The Basin Plan objective for unionized ammonia (NH<sub>3</sub>) was exceeded only once at the Tequisquita Slough (305TES) site, at 0.072 mg/L NH<sub>3</sub> as N in December 1998. The average unionized ammonia level at the Tequisquita Slough (305TES) site is 0.016 mg/L NH<sub>3</sub> as N (Figure 4.28).

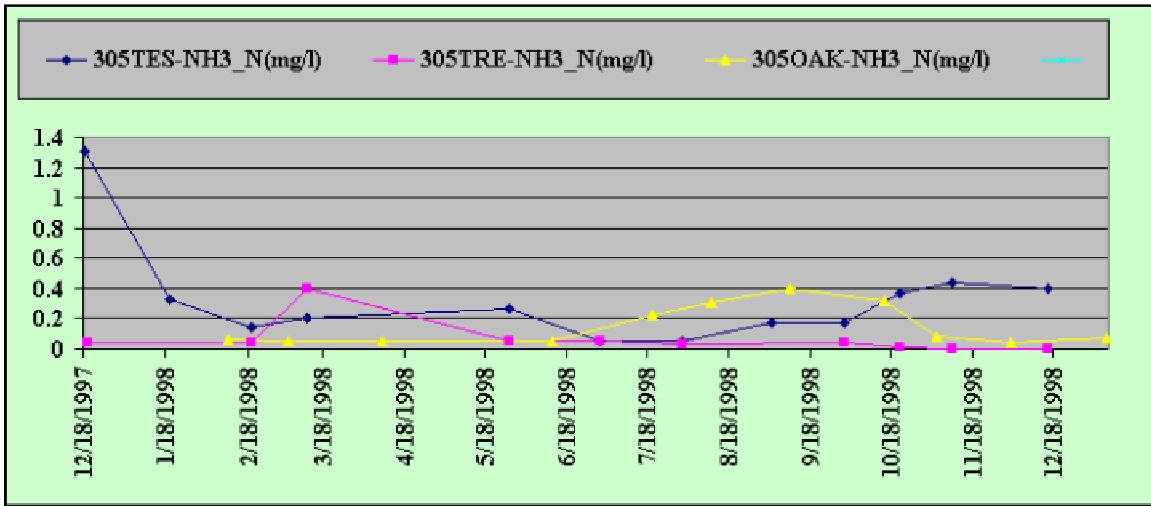
**Figure 4.28 - Mean and Range of unionized ammonia (as N) concentrations (mg/l) at sites sampled during the Pajaro River Watershed Characterization, 1998.**



Total ammonia levels were relatively high at several sites, though no Basin Plan standards are available. Total ammonia levels at the Tres Pinos Creek (305TRE) site on lower San Benito River watershed were elevated, but in spring months. These elevated total ammonia levels at the Tres Pinos Creek (305TRE) site also corresponded with elevated orthophosphate and unionized ammonia values. However, the unionized ammonia levels were below the Basin Plan objective. Time series for Total Ammonia (NH<sub>3</sub> as N) concentrations (mg/l) at Tequisquita Slough (305TES), Tres Pinos (305TRE), and Llagas Creek at Oak Glen Road (305OAK) sites are found in (Figure 4.29).

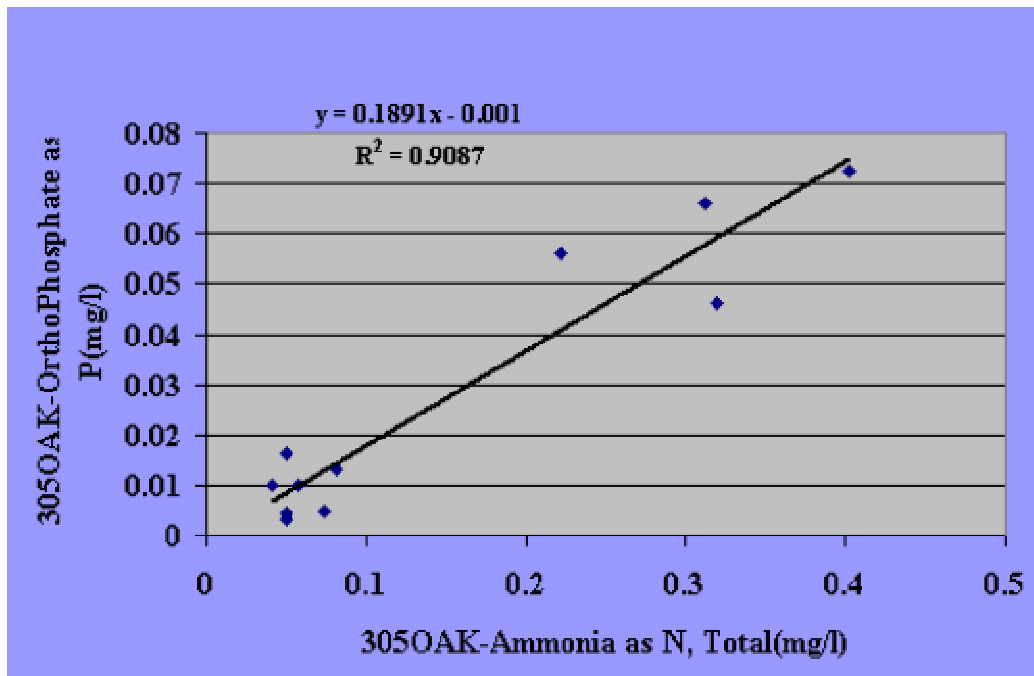
**Figure 4.29 - Time series for total ammonia (NH<sub>3</sub> as N) concentrations (mg/l) at Tequisquita Slough (305TES), Tres Pinos (305TRE), and Llagas**

**Creek at Oak Glen Road (305OAK) sampled during the Pajaro River Watershed Characterization, 1998.**



One potential source of total ammonia and orthophosphate, is ammonium orthophosphate fertilizer, one of the most commonly applied forms of phosphorus fertilizer. High ammonia levels co-occurring with high orthophosphate levels at some sites suggest influence from this type of fertilizer. Confined animal facilities also represent a potential source of total ammonia, orthophosphate, and coliform bacteria. The Tequisquita Slough (305TES) site has high levels of all of these pollutants. At the Oak Glen Road (305OAK) site below Chesbro Reservoir, elevated total ammonia levels in the summer were highly correlated with orthophosphate (Figure 4.30). The fact that correspondingly high levels of ammonia and orthophosphate are not found downstream of Oak Glen at Monterey Road indicates that instream nutrient uptake may be occurring in this reach of the creek.

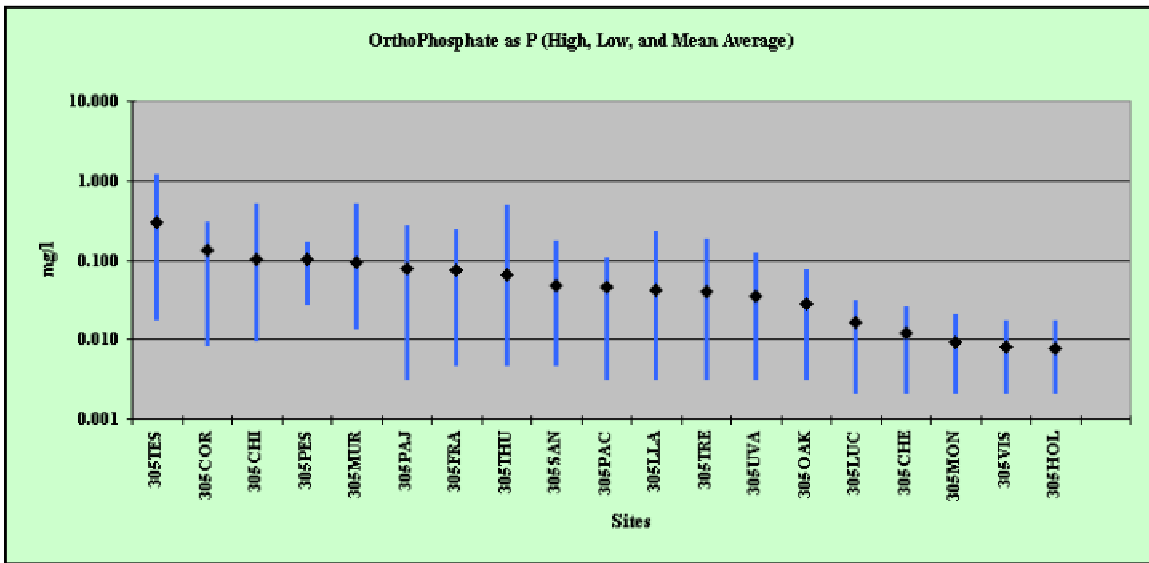
**Figure 4.30 - Regression of ammonia (mg/L) against orthophosphate (mg/L) concentrations at Llagas Creek on Oak Glen Avenue (305OAK), Pajaro River Watershed Characterization, 1998.**



## ORTHOPHOSPHATE

Orthophosphate is the dissolved, inorganic fraction of phosphorus that is biologically available for uptake. There is no Basin Plan objective for orthophosphate ( $\text{PO}_4$ ). Williamson (1994) suggest a Pajaro River watershed phosphorus (P) objective of 0.12 mg-P/L phosphate (this denotes 0.12 mg/L of phosphate ( $\text{PO}_4$ ) expressed as phosphorus). The CCAMP attention level has been set using the distribution of the Pajaro River watershed data set and values recommended by Williamson (1994). The CCAMP attention level is 0.12 mg/L orthophosphate as P. Mean orthophosphate (as P) levels for all sites are shown in [\(Figure 4.31\)](#).

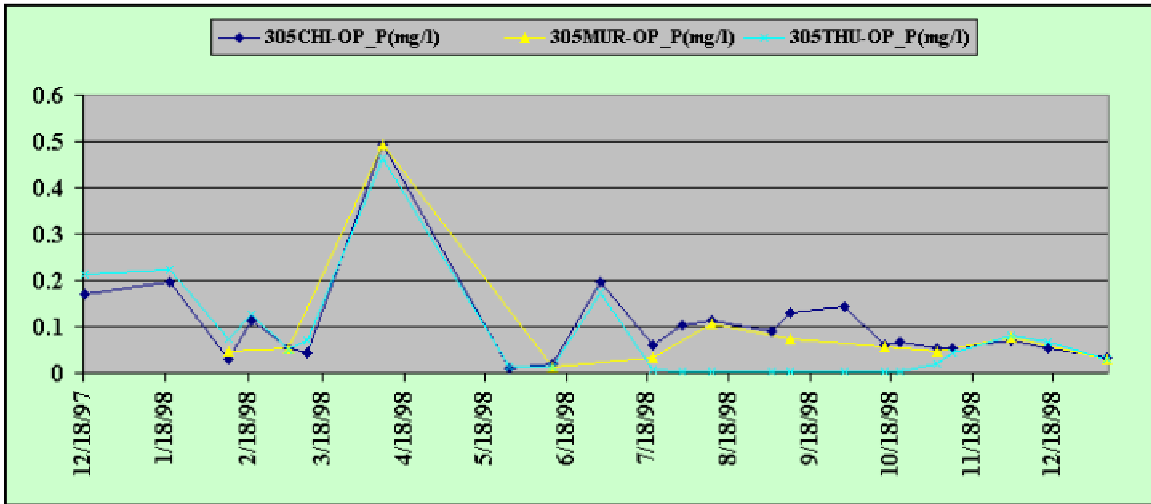
**[Figure 4.31](#) - Mean and Range of orthophosphate ( $\text{PO}_4$  as P) concentrations (mg/l) at sites sampled during the Pajaro River Watershed Characterization, 1998.**



The highest level of orthophosphate (1.12 mg/L as P) was measured at the Tequisquita Slough (305TES) site during December 1997. The average value at this site was 0.25 mg/L of orthophosphate as P, well above the CCAMP attention level. Orthophosphate maximum concentrations at this site closely follow those of total ammonia and nitrite.

The Salsipuedes Creek (305COR) site had an average value of 0.14 mg/L orthophosphate as P. All other sites on the Pajaro River had maximum orthophosphate values that exceeded the CCAMP attention level of 0.12 mg/L orthophosphate as P. The main stem Pajaro River sites, from Chittenden Gap (305CHI) and downstream, had a spike in orthophosphate values on April 9th ([Figure 4.32](#)).

**Figure 4.32** - Orthophosphate (as P) concentrations (mg/l) on lower Pajaro River sites, Pajaro River Watershed Characterization, 1998.

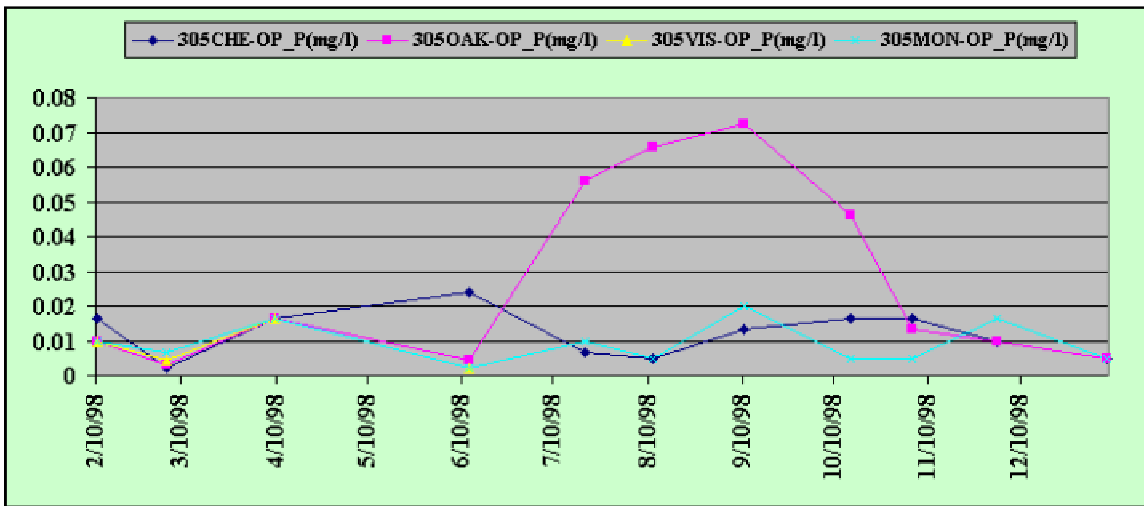


Except at the Bloomfield Avenue (305LLA) site, lower Llagas Creek had low levels of orthophosphate, with means typically under 0.02 mg/L of orthophosphate as P. Lower Llagas Creek sites that showed the highest nitrate levels conversely had low levels of orthophosphate, suggesting that phosphorus may be the limiting nutrient for plant growth in this system. At the Bloomfield Avenue (305LLA) site, several high orthophosphate spikes (up to 0.24 mg/L of orthophosphate as P) were documented.

Except at the Oak Glen Avenue (305OAK) site (mean value of 0.025 mg/L of orthophosphate as P), low levels of orthophosphate were measured on upper Llagas Creek, with means typically under 0.01 mg/L of orthophosphate as P. Although the levels were generally low, summer levels were typically two to three times greater than winter values (Figure 4.33).

**Figure 4.33** - Orthophosphate (as P) concentrations (mg/l) on upper Llagas Creek watershed, above Chesbro Reservoir (305CHE), at Oak Glen Road

**(305OAK), at Buena Vista Avenue (305VIS), and at Monterey Road (305MON), Pajaro River Watershed Characterization, 1998.**



The sites of San Benito River at Y Road (305SAN) and Tres Pinos Creek (305TRE) had maximum orthophosphate values that exceeded the CCAMP attention level of 0.12 mg/L orthophosphate as P, even though the mean values for both sites were 0.048 mg/L orthophosphate as P.

Ammonium orthophosphate fertilizer is one of the most commonly applied forms of phosphorus fertilizer. High ammonia levels co-occurring with high orthophosphate levels at some sites strongly suggest influence from this type of fertilizer. Confined animal facilities also represent a potential source of ammonia, orthophosphate, and fecal coliform.

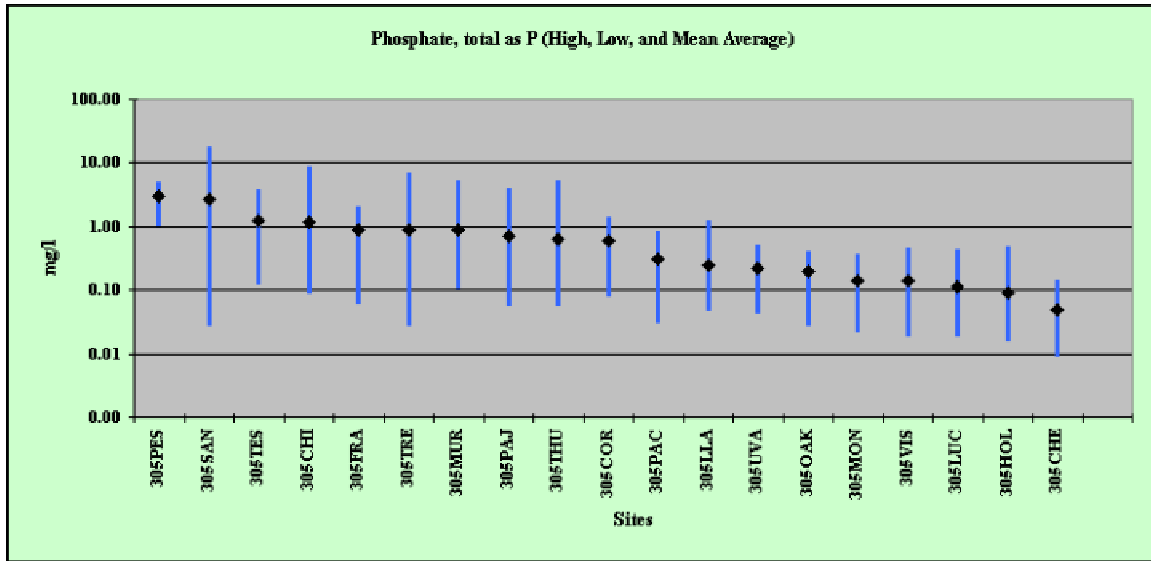
## TOTAL PHOSPHATE

Williamson (1994) recommended that the objective for phosphate be set relative to the nitrate objective, based on concentrations in algae of about 7 to 10 parts nitrogen to one part phosphorus. They recommended a phosphorus objective of 0.12 mg-P/L (this denotes 0.12 mg/L of phosphate expressed as phosphorus) for the Pajaro River system. EPA guidance states that total phosphorus should not exceed 0.1mg-P/L in flowing streams. The tentative CCAMP attention level is 0.12 mg /L total phosphate as P.

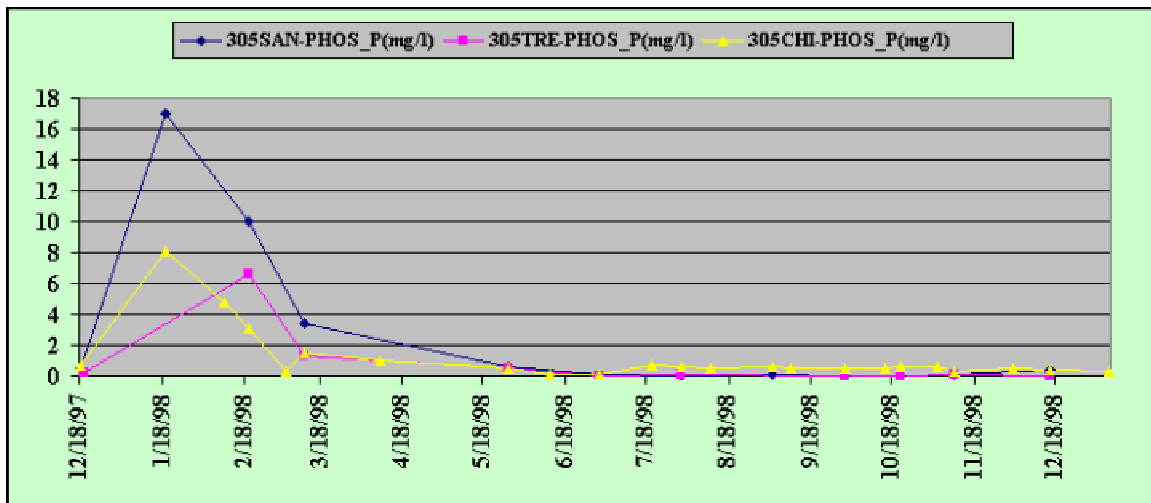
Overall, total phosphate levels in the Pajaro River system are elevated, with all sites having peak total phosphate levels that exceed the CCAMP attention level of 0.12 mg /L total phosphate as P. Highest mean total phosphate concentrations were found in the San Benito River and downstream (Figure 4.34). Total phosphate levels peaked during winter, with extremely high values on the San Benito River Y Road (305SAN), Tres Pinos Creek (305TRE), and on the Pajaro River at Chittenden Gap (305CHI), reaching 17.0 mg/L, 6.6 mg/L, and 8.1 mg/L, respectively (Figure 4.35). Tequisquita Slough (305TES) concentrations were somewhat elevated throughout the year (Figure 4.36). Peak total

phosphate levels in the winter were typically associated with high suspended solids levels.

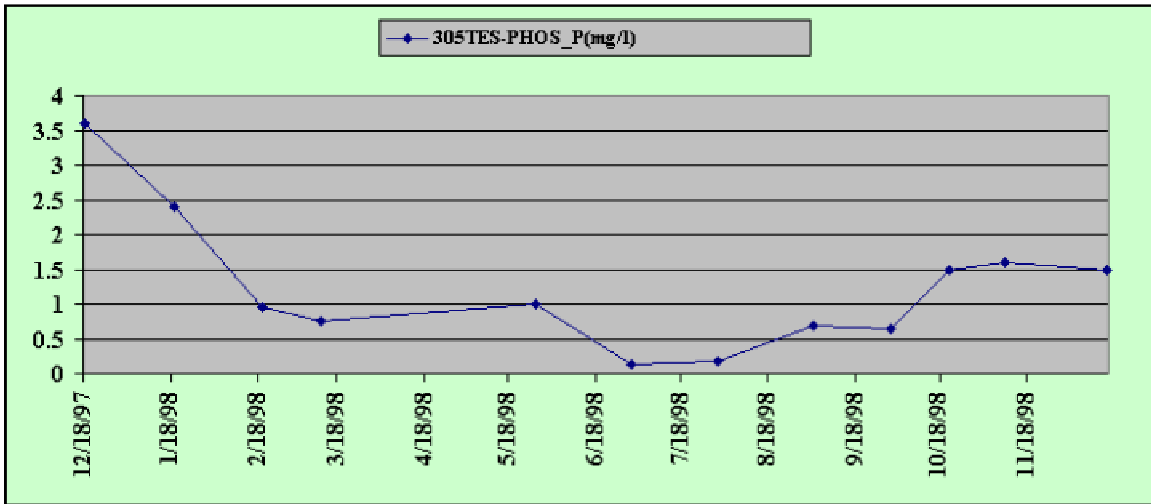
**Figure 4.34** - Mean and Range of total phosphate (PO<sub>4</sub> as P) concentrations (mg/l) at sites sampled during the Pajaro River Watershed Characterization, 1998.



**Figure 4.35** - Total phosphate (as P) concentrations (mg/l) for the San Benito River Y Road (305SAN), Tres Pinos Creek (305TRE), and the Pajaro River at Chittenden Gap (305CHI), Pajaro River Watershed Characterization, 1998.

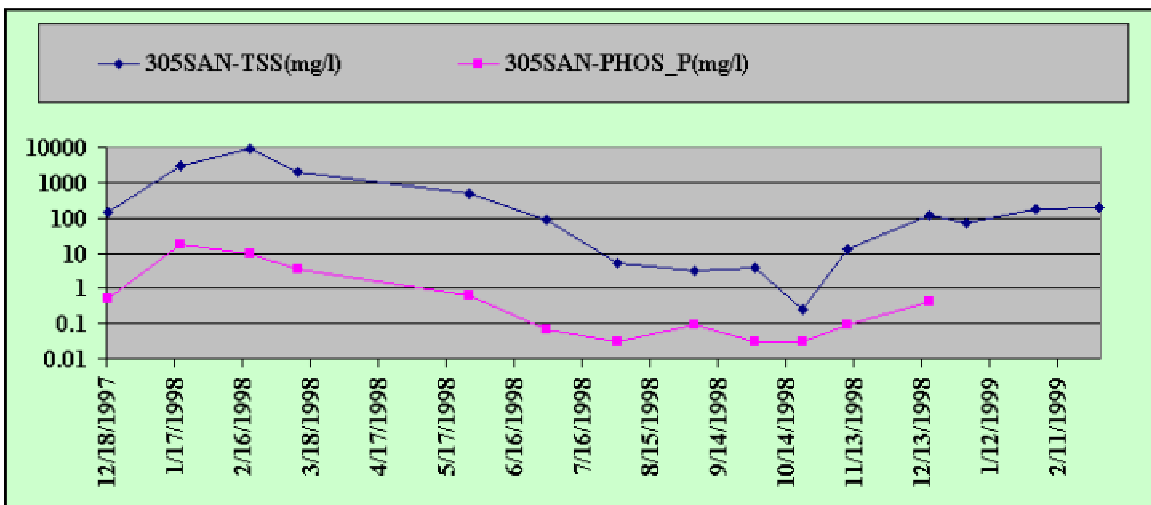


**Figure 4.36** - Total phosphate (as P) concentrations (mg/l) for Tequisquita Slough (305TES), Pajaro River Watershed Characterization, 1998.



Extremely high levels of total phosphate seen during the winter in the San Benito River and moving downstream are correlated with high total suspended solids values (Figure 4.37). A major settlement basin adjacent to the San Benito River near Y Road (305SAN) had several catastrophic failures during the El Nino winter. Its levees collapsed into the river in some places, and a complete failure of the levee resulted in draining of the entire basin and its contents to the San Benito River. This may explain at least some of the very high sediment, turbidity, and total phosphate levels seen immediately downstream of this site during February.

**Figure 4.37** - Total suspended solids concentrations (mg/l) and total phosphate concentrations (mg/l) at Y Road on the San Benito River (305SAN), Pajaro River Watershed Characterization, 1998.



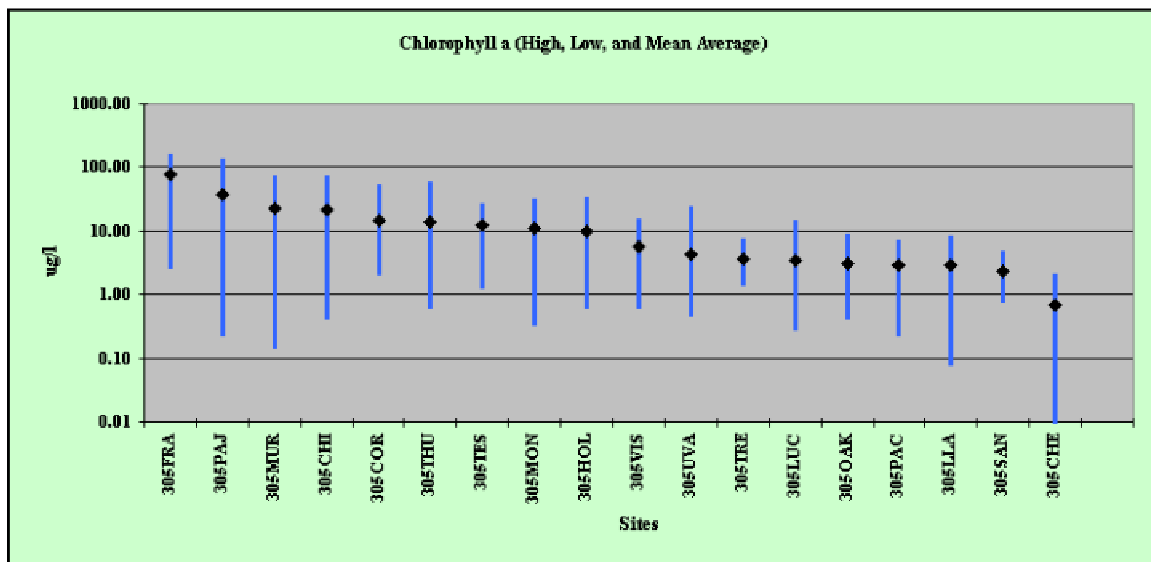


## CHLOROPHYLL *a*

Chlorophyll *a* is a pigment found in plants. It is a surrogate measure for phytoplankton abundance in the water column. The Central Coast Basin Plan does not currently have a numeric standard for chlorophyll *a*. The state of North Carolina has set a maximum chlorophyll *a* (measured as sestonic chlorophyll *a* per unit volume of water) standard of 40 ug/L for warm water (lakes, reservoir, and other waters subject to growths of macroscopic or microscopic vegetation not designated as trout waters) and 15 ug/L for cold water streams (lakes, reservoir, and other waters subject to growths of macroscopic or microscopic vegetation designated as trout waters) (North Carolina DENR, January 2002). CCAMP has adopted a tentative attention level of 15 ug/L for chlorophyll *a* for all waters with the COLD beneficial use.

Elevated levels of chlorophyll *a* were measured on the main stem of the Pajaro River, particularly on the upper reaches (Figure 4.38). All five sites on the main stem of the Pajaro River exhibited maximum chlorophyll *a* concentrations over 40 ug/L, more than twice the adopted CCAMP attention level. All sites on the main stem of the Pajaro River also exhibited mean chlorophyll *a* concentrations over 10 ug/L. An algal bloom, exceeding CCAMP attention levels by several-fold, was clearly evident on the main stem Pajaro River in midsummer.

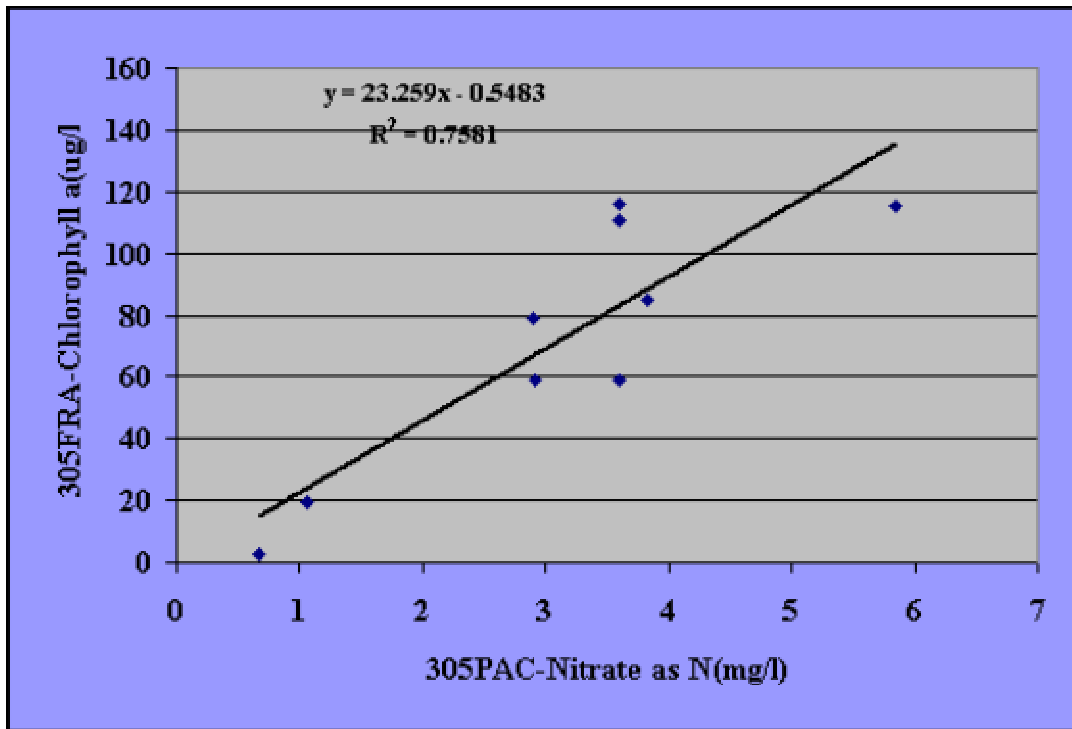
**Figure 4.38** - Mean and Range of chlorophyll *a* concentrations (ug/l) at sites sampled during the Pajaro River Watershed Characterization, 1998.



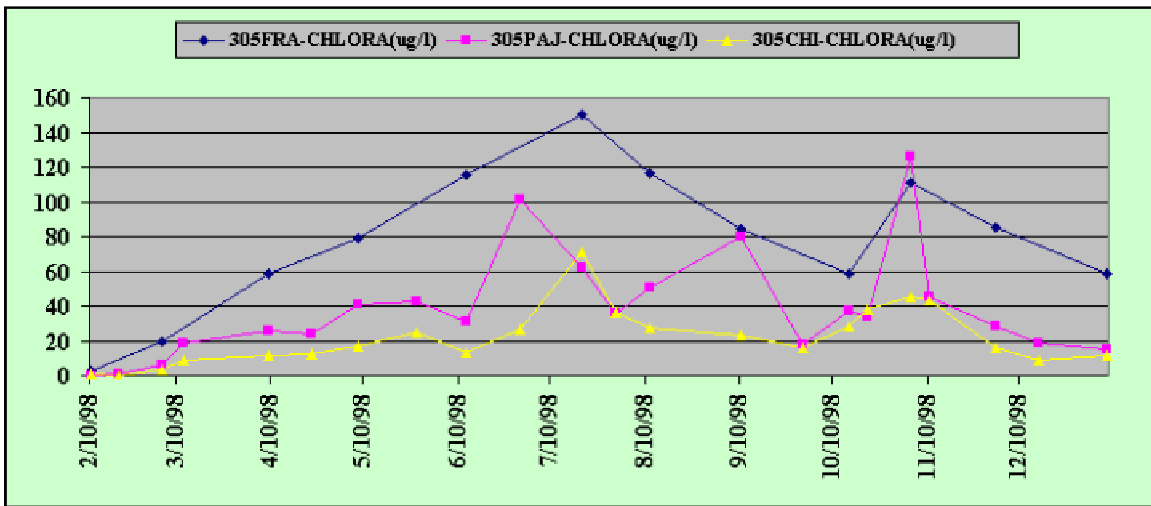
Of the six tributaries in the Pajaro River watershed, sites on Tequisquita Slough, Llagas Creek, Uvas Creek, and Salsipuedes Creek exhibited maximum chlorophyll *a* concentrations over 15 ug/L, the CCAMP attention level. Both Tequisquita Slough and Salsipuedes Creek also had mean values over 10 ug/L, nearing the CCAMP attention level.

A relatively high correlation is evident between the nitrate levels entering the river from Pacheco Creek (305PAC) and the chlorophyll *a* concentrations downstream at Frazier Lake Road (305FRA) (Figure 4.39). The Pajaro River at Frazier Lake Road (305FRA) had the highest and most sustained levels of chlorophyll *a* measured, reaching 150 ug/L in July 1998. Summer increases in both parameters are common, however, and a causal relationship cannot necessarily be inferred. Elevated summertime orthophosphate levels enter the Pajaro River from Tequisquita Slough (305TES). Abundant supply of nitrogen and phosphorus from upstream sources appears to be fueling the chlorophyll *a* bloom at Frazier Lake Road (305FRA). The Pajaro River at the Betabel Road (305PAJ) site, downstream from Frazier Lake Road, also had elevated levels, and other main stem sites followed suit (Figure 4.40).

**Figure 4.39** - Regression of nitrate (NO<sub>3</sub> as N) levels entering the river from Pacheco Creek (305PAC) and chlorophyll *a* (ug/L) concentrations downstream at Frazier Lake Road (305FRA), Pajaro River Watershed Characterization, 1998.



**Figure 4.40** - Chlorophyll *a* concentrations (ug/l) at Frazier Lake Road (305FRA), Betabel Road (305PAJ), and Chittenden Gap (305CHI), Pajaro River Watershed Characterization, 1998.

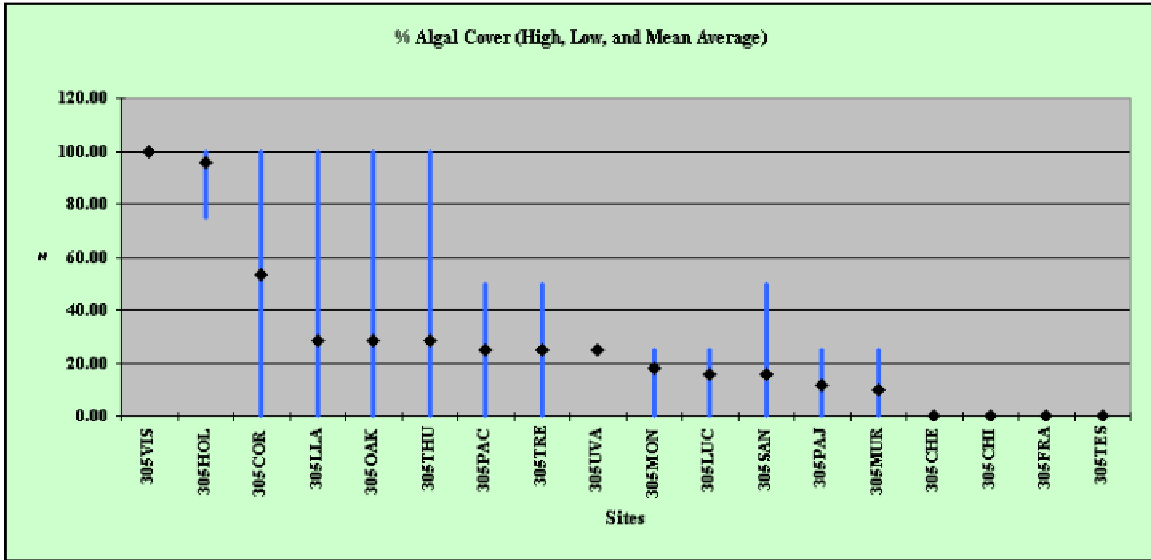


In spite of extremely high nitrate levels in the lower Llagas Creek watershed, chlorophyll *a* values were comparatively moderate. Most Llagas Creek sites had relatively low chlorophyll *a* levels, well under 10 ug/L, but the Holsclaw Road (305HOL) and Monterey Road (305MON) sites at times exceeded 30 ug/L. The extremely high summer concentrations seen on the main stem of the Pajaro River were never observed on Llagas Creek.

## PERCENT ALGAL COVER

Heavy filamentous algal cover was particularly prevalent at Holsclaw Road (305HOL) and Buena Vista Avenue (305VIS) on lower Llagas Creek. Further downstream at the Lucchessa Avenue (305LUC) and Bloomfield Avenue (305LLA), cover was less extensive. Salsipuedes Creek (305COR) developed a thick algal cover during the summer months. Several sites had virtually no algal cover, including the Pajaro River at Frazier Lake Road (305FRA) and Chittenden Gap (305CHI), and Tequisquita Slough (305TES) (Figure 4.41).

**Figure 4.41** - Mean and Range percent algal cover for sites sampled during the Pajaro River Watershed Characterization, 1998.



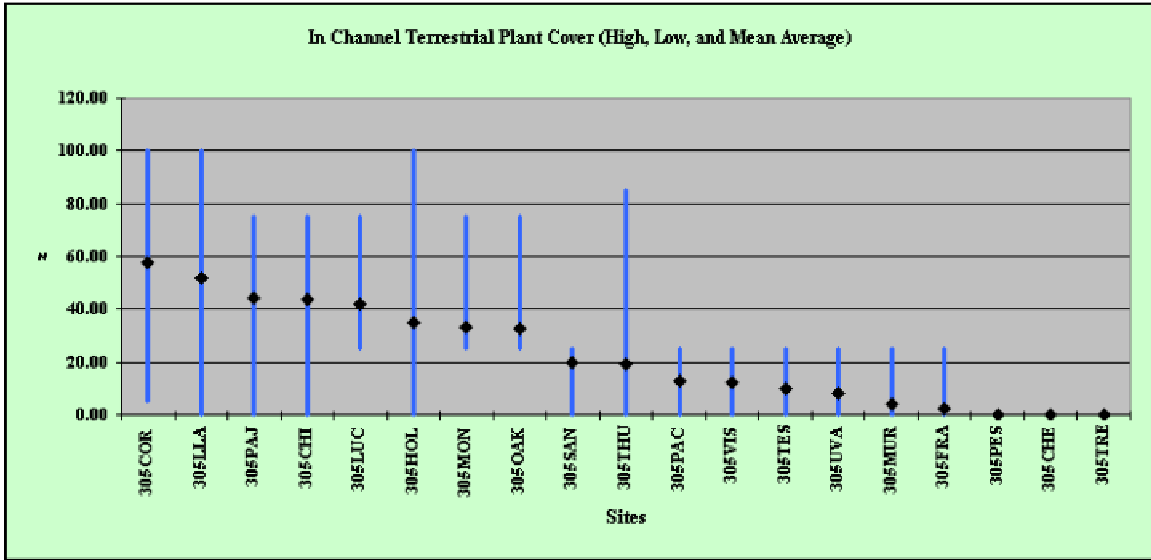
Williamson (1994) indicates that algal growth on Llagas Creek at some sites was limited by the availability of rocky substrate for attachment, and this is likely also the case at various sites in the Pajaro River watershed. The Pajaro River at Frazier Lake Road (305FRA) had extremely high levels of chlorophyll *a* but virtually no attached algae, suggesting nutrient uptake by planktonic algae rather than filamentous algae.

## PERCENT TERRESTRIAL PLANT COVER

Terrestrial plants were relatively abundant in the channel on the Pajaro River at the Chittenden Gap (305CHI) and Betabel Road (305PAJ) sites and at most sites on Llagas Creek downstream of Chesbro reservoir (Figure 4.42). Highest in-channel terrestrial plant cover was found at the Bloomfield Avenue (305LLA) site on lower Llagas Creek and the Salsipuedes Creek (305COR) site.

In channel terrestrial plant growth was most abundant in nutrient-rich, channelized systems typified by relatively fine-grained substrates, such as Salsipuedes and Llagas creeks. Though well-shaded corridors such as Uvas Creek and upper Llagas Creek had relatively low percent cover, as expected, lowest in-channel vegetation was associated with the highly disturbed, sandy bottom Tres Pinos system.

**Figure 4.42 - Mean and Range terrestrial plant in-channel cover for sites sampling during the Pajaro River Watershed Characterization, 1998.**

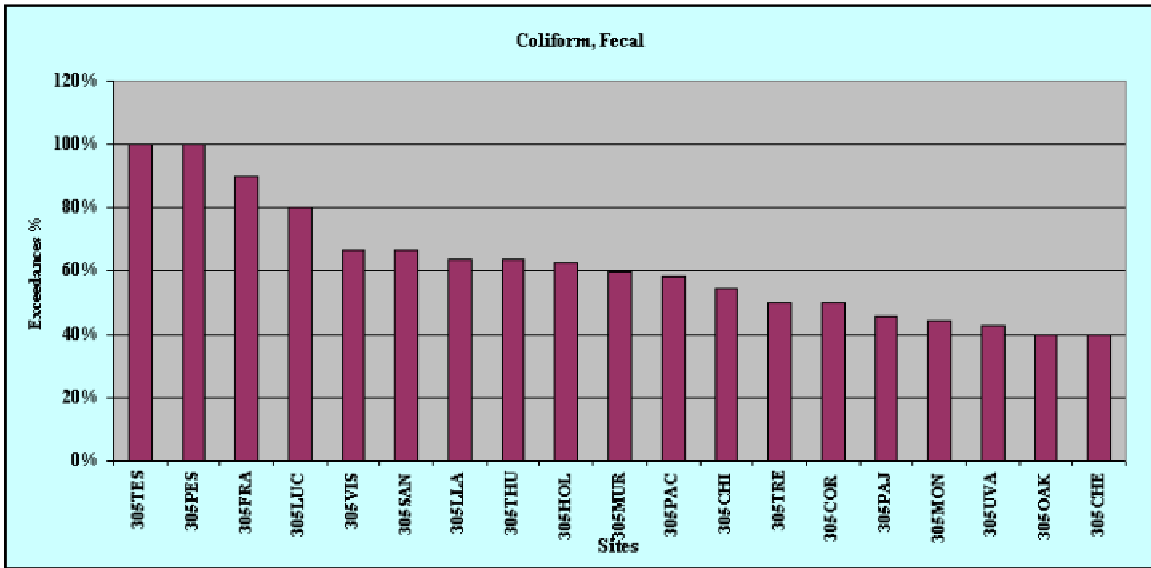


## TOTAL AND FECAL COLIFORM

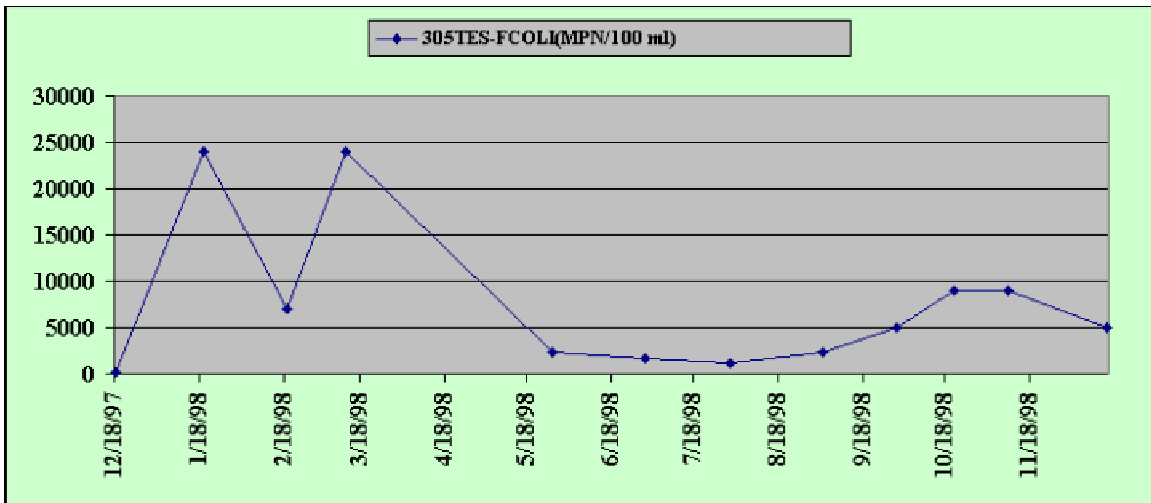
The Basin Plan body contact standard for fecal coliform states, “Fecal coliform concentration, based on a minimum of not less than five samples for any 30-day period, shall not exceed a log mean of 200 Most Probable Number (MPN)/100 ml, nor shall more than ten percent of total samples during any 30-day period exceed 400 MPN/100 ml.” The CCAMP sampling strategy used does not measure bacteria with the intent of determining regulatory compliance. However, using an attention level of 200 MPN/100 ml for fecal coliform, it is apparent that numerous sites in the watershed warrant concern (Figure 4.43). Several sites had high values (greater than 5000 MPN/100ml) during winter runoff periods, including Pajaro River (Betabel Road (305PAJ), Murphy’s Crossing (305MUR), and Thurwachter Bridge (305THU)), lower Llagas Creek (Buena Vista Avenue (305VIS), Holsclaw Road (305HOL), and Bloomfield Avenue (305LLA)) Tequisquita Slough (305TES), and San Benito River at Y Road (305SAN). Tequisquita Slough (305TES) had particularly elevated levels, with all measured values exceeding 200 MPN/100 ml (Figure 4.44). Unlike most other sites, Tequisquita Slough (305TES) exhibited high values during summer months.

Fecal coliform levels in excess of 200 MPN/100ml were common in the Pajaro River watershed and imply that water body contact standards may be exceeded at times. Elevated levels at Tequisquita Slough correspond with elevated levels of orthophosphate and ammonia, and may suggest impacts from confined animal facilities.

**Figure 4.43** - Percent of samples exceeding CCAMP attention levels (200 MPN/100 ml) for fecal coliform during the Pajaro River Watershed Characterization, 1998.



**Figure 4.44** - Fecal coliform (MPN/100 ml) over time at Tequisquita Slough, during the Pajaro River Watershed Characterization, 1998.



## B. METALS CHEMICAL TESTING

Chemical testing to determine the concentrations of metals in sediment, in the water column, and in the tissue of aquatic organisms was conducted at a number of sites in the watershed. Because of limited funding site visits were generally limited to one time, with the exception of a special study on mercury conducted by the State Mussel Watch Laboratory.

CCAMP considers a variety of guideline values in making site assessments. Where available, Basin Plan or California Toxics Rule standards are used, but other guidelines, particularly for sediment and tissue, come from other sources including U.S. Environmental Protection Agency, U.S. Food and Drug Administration, National Academy of Sciences, United Nations Food and Agriculture Organization, State Mussel Watch Program, and others. These are discussed in more detail below. Basin Plan standards for Aquatic Life (both COLD and WARM water habitats) are dependent on water hardness. In this study, all samples were considered “hard” (CaCO<sub>3</sub> concentrations greater than 100 mg/l).

For the purposes of this evaluation, the term “exceedence” is meant to imply a measurement over the guideline value being applied for discussion purposes. It is not meant to infer a regulatory exceedence as defined by the California Toxics Rule. For example, in many instances only one sample is being collected at a given site. The CTR allows for one exceedence in a three-year period, without triggering a violation. Therefore, according to the CTR it is not possible to consider a single sample exceedence a regulatory violation. However, for the screening purposes of this study, a single exceedence of a standard or guideline value is considered worthy of mention.

Test results confirm at least one metals problem in the watershed; high concentrations of mercury were found in the San Benito River and its tributaries. Study results also indicate that elevated concentrations of metals may exist at several other sites in the watershed.

Tissue - Eleven tissue sites were sampled through the State Mussel Watch Program at several locations in the Pajaro watershed ([Table 3.1](#)). All sites were sampled once using transplanted freshwater clams (*Corbicula fluminea*). At two of the tissue sites roach (*Hesperoleucus symmetricus*) were deployed and at five sites crayfish (*Procambarus clarkii*) were deployed, to get a better understanding of the range of chemical uptake in different species (designated here with an “R” or “C”, respectively). Tissue samples were placed at the Pajaro River at Thurwachter Road (305THU)<sup>C</sup>, Chittenden Gap (305CHI)<sup>R,C</sup> and Betabel Road (305PAJ)<sup>C</sup>; Salsipuedes Creek (305COR)<sup>C</sup>, Llagas Creek (305LLA)<sup>R</sup><sup>C</sup>, Pescadero Creek (305PES), Pacheco Creek (305PAC), San Benito River (305SAN, 305HRL, 305HRU), and Tequisquita Slough (305TES). Samples were evaluated for aluminum, cadmium, chromium, copper, manganese, mercury, nickel, lead, silver and zinc.

It is of interest to note that of the ten bags of shellfish (clams) deployed at sites in August 1998, two samples were retrieved in very poor condition (Pajaro at Thurwachter (305THU) and Chittenden Gap (305CHI)), and one sample set was entirely dead (San Benito River at Y Road (305SAN)). The reasons for the poor condition of these samples is unknown. Additionally, samples retrieved from the Tres Pinos Creek (305TRE) site were dried up and samples retrieved from the Pacheco Creek (305PAC) site were buried.

Where available, Maximum Tissue Residual Levels as defined by the California Toxics Rule were used as tissue criteria. These levels are available only for cadmium, nickel, and mercury. In the absence of MTRL values, or guideline values from the National Academy of Sciences or the Food and Drug Administration, Median International Standards (MIS) were used for evaluation of concentrations of other metals in tissue. MIS criteria are available for all metals measured except aluminum and nickel. MIS were developed by taking the median value of available standards from various countries for a particular trace element. In some cases, the number of countries with standards for a chemical is very low, in particular for chromium, where only one value was available. . MIS are not currently considered acceptable criteria for 303(d) listing rationale, but in some cases are the only guideline values available.

Sediment - Sediment chemistry sampling was focused primarily on the San Benito River and its tributaries, primarily because of historical mercury issues in that watershed identified through Toxic Substances Monitoring Program sampling. Sampling was conducted on two separate sampling days, with five sites sampled in March 31, 1998 and thirteen sites sampled on June 30, 1998. This latter sampling event included a number of new sites in the San Benito watershed, with particular focus on Clear Creek, and was conducted for metals only. Sample count and timing was dependent on funding sources and availability. Sites are listed in ([Table 3.1](#)). Samples were evaluated for cadmium, chromium, copper, mercury, nickel, lead, and zinc.

NOAA Effects Range Median and Effects Range Low were used as guideline values to evaluate the data (Long and Morgan, 1990). These values were developed using existing datasets which include information on both toxic effects and chemical concentrations. The ERM is the median (or 50<sup>th</sup> percentile) concentration of all toxic samples, and has been used in other state programs (such as the Bay Protection and Toxic Cleanup Program) as an indication of “probable effects”. The ERL is calculated in the same fashion as the ERM, but represents the 10<sup>th</sup> percentile of the samples showing toxicity. More recent evaluations (Long, et al., 1998) indicate that a toxicity of approximately 38% is associated with the ERL level. NOAA values are not available for aluminum and manganese.

Water - Sampling for a suite of metals was conducted on two separate sampling days, with 10 conventional water quality sites sampled in March 31, 1998 and thirteen sites sampled on June 30, 1998 coincident with, but upstream of sediment sampling. This latter sampling event included a number of new sites in the San Benito watershed, with particular focus on Clear Creek, and was conducted for metals only. Sample count and timing was dependent on funding sources and availability. In addition, mercury was



sampled on May 1, 1998, and then monthly over a period of seven months from September 1998 to March, 1999 by the State Mussel Watch Laboratory, as part of a special study.

Criteria used for evaluation of water quality data included Basin Plan water quality objective for cold water fish habitat. Manganese does not have numeric criteria for this beneficial use. The only Basin Plan standard available for manganese is for irrigation supply. The California Toxics Rule criterion was applied for mercury because it is more protective than other Basin Plan standards.

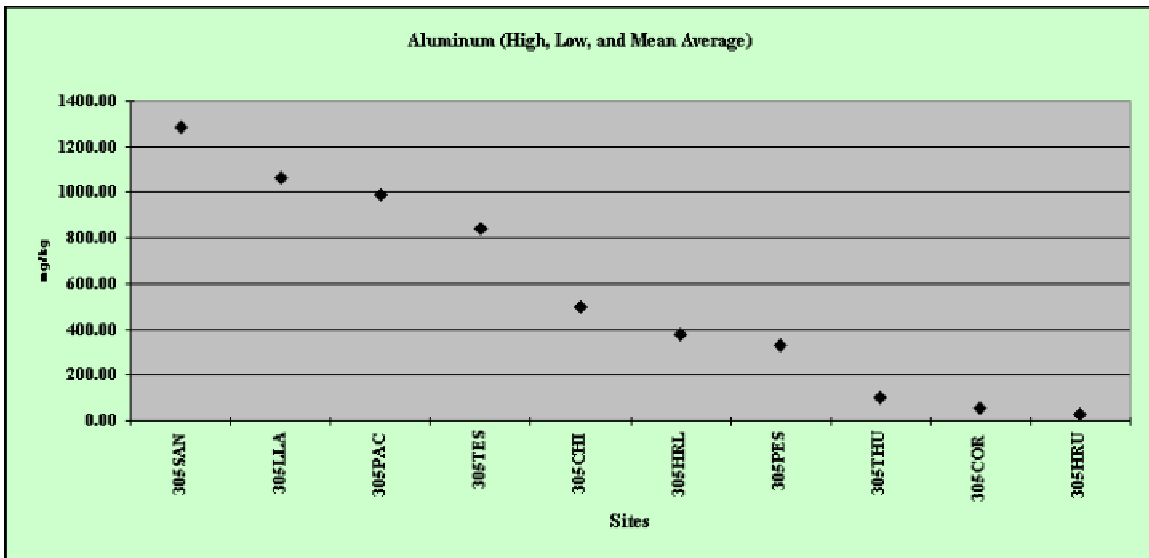
## ALUMINUM

Water – No data was collected for aluminum in water.

Sediment – No data was collected for aluminum in sediment.

Tissue – No standards are available for aluminum in tissue. However, by comparing data to the State Mussel Watch Elevated Data Level 95 for transplanted clams, it seems that aluminum is present in fairly high concentrations throughout the watershed (Figure 4.45). The EDL95 is 446.0 mg/kg. Clam tissue collected from a number of sites exceeded this value, and ranged as high as 1288.0 mg/kg at Y Road on the San Benito River (305SAN). Aluminum is found in serpentinite, a component of the Franciscan mélange common in areas of the upper Pajaro and San Benito watersheds.

**Figure 4.45** - Mean and Range of Aluminum concentrations (mg/kg) in transplanted clam tissue at sites sampled during the Pajaro River Watershed Characterization, 1998.



## CADMIUM

Water - All water column samples collected for cadmium were “non-detects”, with the exception of the Pajaro River at Betabel Road site (305PAJ), which had a value of .0036 mg/l, well under the Basin Plan standard for cold water fish of 0.03 mg/l, but slightly in exceedence of the standard for fish spawning of 0.003 mg/l.

Sediment – All samples were below the ERM and ERL for cadmium. It should be noted however, that sediment was not collected at the Betabel Road site (305PAJ) where cadmium levels were slightly elevated in water.

Tissue – Three samples exceeded the Maximum Tissue Residual Level for cadmium in Inland Waters of 0.64 mg/kg. The highest value measured in clam tissue was at the San Benito River at Y Road (305SAN) (1.999 mg/kg). Other sites that had slightly elevated levels were on the San Benito River above Hernandez Reservoir (305HRU) and at Pescadero Creek (305PES). Tissue levels were not elevated at the Betabel Road site (305PAJ).

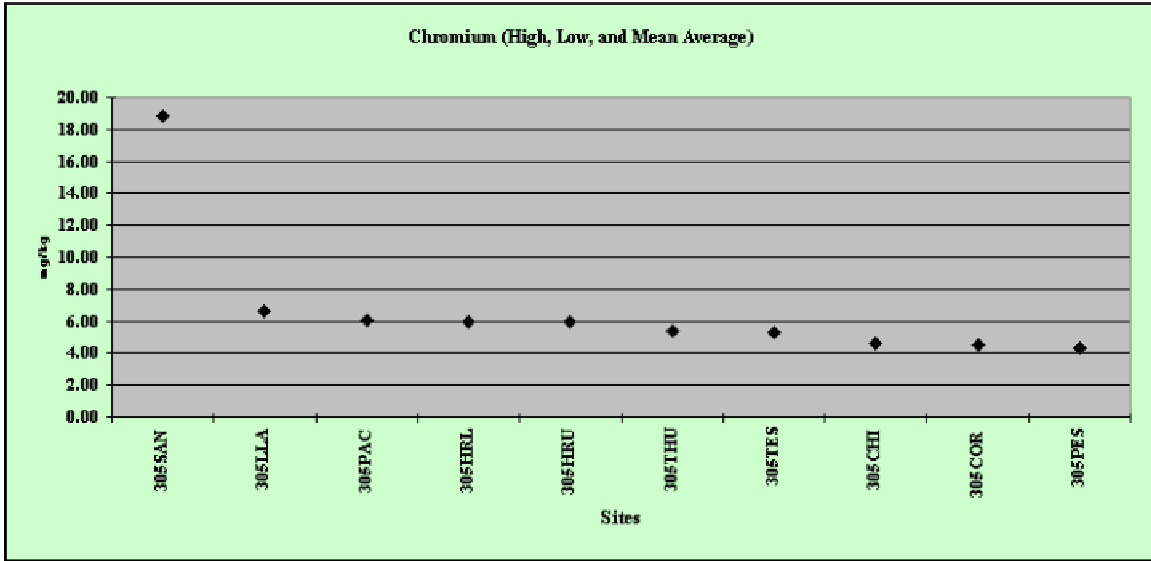
## CHROMIUM

Water – Two measurements exceeded Basin Plan COLD and WARM water fish standard of 0.05 mg/l for total chromium. The highest measurement was 0.079 mg/l, taken on Clear Creek at Halfway Hill (305HAH). The other was 0.062 mg/l, taken at Y Road on the San Benito River (305SAN) during the March sampling event. This was one of two measurements taken at this site; the other sample, taken in June, was a “non-detect”.

Sediment – None of the samples exceeded the NOAA ERL for chromium of 81.0 mg/kg. The sample collected just below Hernandez Reservoir (305HRL) came close, at 80.5 mg/kg.

Tissue – All samples exceeded the Median International Standard for chromium of 1.0 mg/kg. Highest levels were documented at the site on San Benito River at Y Road (305SAN), where chromium concentrations reached 18.82 mg/kg, almost 20 times the MIS ([Figure 4.46](#)). Health-based guideline values such as MTRLs are not available for this trace element. Chromium is found in serpentinite, a component of the Franciscan mélange common in areas of the upper Pajaro River and San Benito River watersheds.

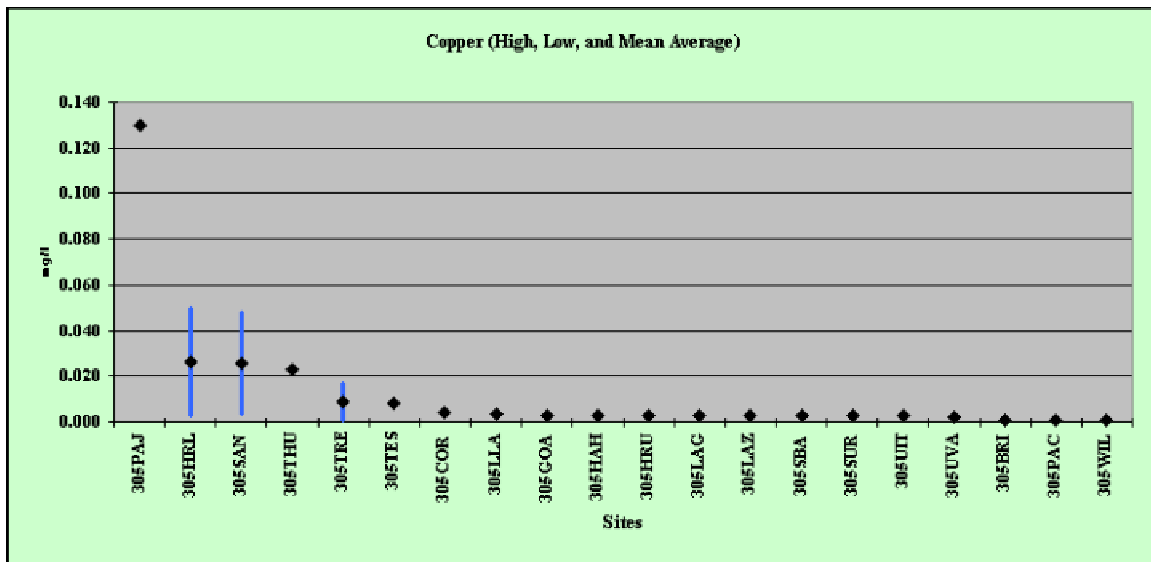
**Figure 4.46** - Mean and Range of Chromium concentrations (mg/kg) in transplanted clam tissue at sites sampled during the Pajaro River Watershed Characterization, 1998.



## COPPER

Water – Copper measurements from two sites exceeded the Basin Plan cold water fish standard for copper of 0.03 mg/l. The highest measurement was on the Pajaro River at Betabel Road (305PAJ), at 0.13 mg/l. The other exceedence was 0.048 mg/l, taken at Y Road on the San Benito River (305SAN) during the March sampling event. This was one of two measurements taken at this site; the other sample, taken in June, was well under the standard ([Figure 4.47](#)).

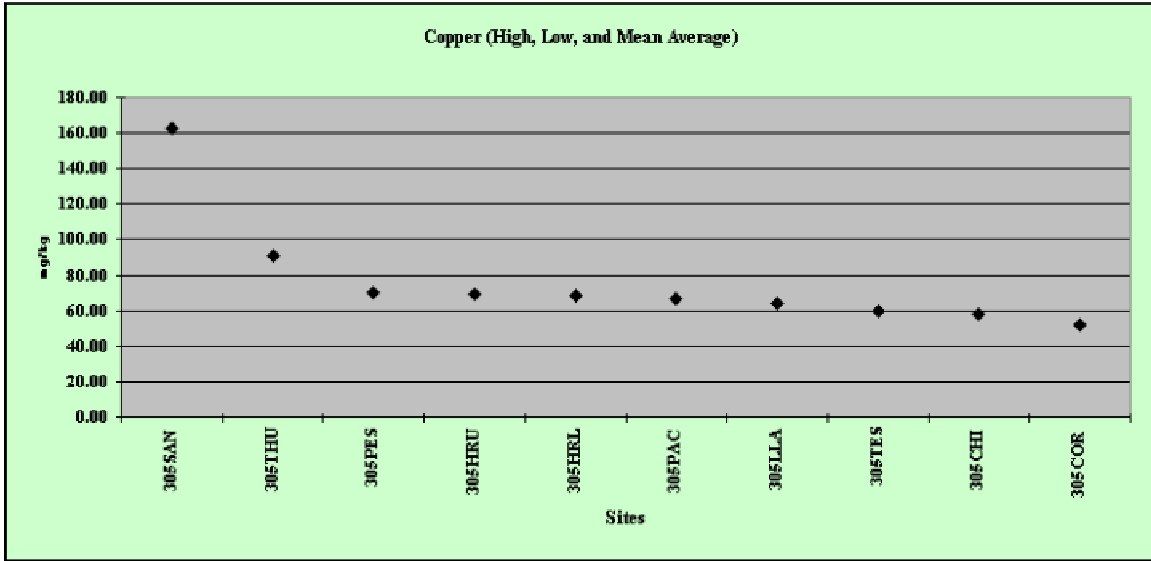
**Figure 4.47** - Mean and Range of Copper concentrations (mg/l) in water at sites sampled during the Pajaro River Watershed Characterization, 1998.



Sediment – None of the samples exceeded the NOAA ERL for copper of 34.0 mg/kg. The highest value measured was 27.0 mg/kg, at an upper San Benito River site (305SUR).

Tissue – All samples exceeded the Median International Standard for copper of 20.0 mg/kg. Highest levels were documented at the site on San Benito River at Y Road (305SAN) at 162.96 mg/kg ([Figure 4.48](#)).

**Figure 4.48 - Mean and Range of Copper concentrations (mg/kg) in transplanted clam tissue at sites sampled during the Pajaro River Watershed Characterization, 1998.**



## LEAD

Water – Levels of lead in water samples at two sites exceeded the Basin Plan standard for cold water fish of 0.03 mg/l. At the Betabel Road site (305PAJ) on the Pajaro River, lead measured 0.048 mg/l. The other exceedence was 0.040 mg/l, taken at Y Road on the San Benito River (305SAN) during the March sampling event. This was one of two measurements taken at this site; the other sample, taken in June, was a “non-detect”.

Sediment – None of the samples exceeded the NOAA ERL for lead of 46.70 mg/kg. The highest value measured was 13.15 mg/kg, at Tres Pinos Creek (305TRE).

Tissue – None of the samples exceeded the Median International Standard for lead of 2.0 mg/kg. The highest level measured was 0.71 mg/kg, at Pacheco Creek (305PAC).

## MANGANESE

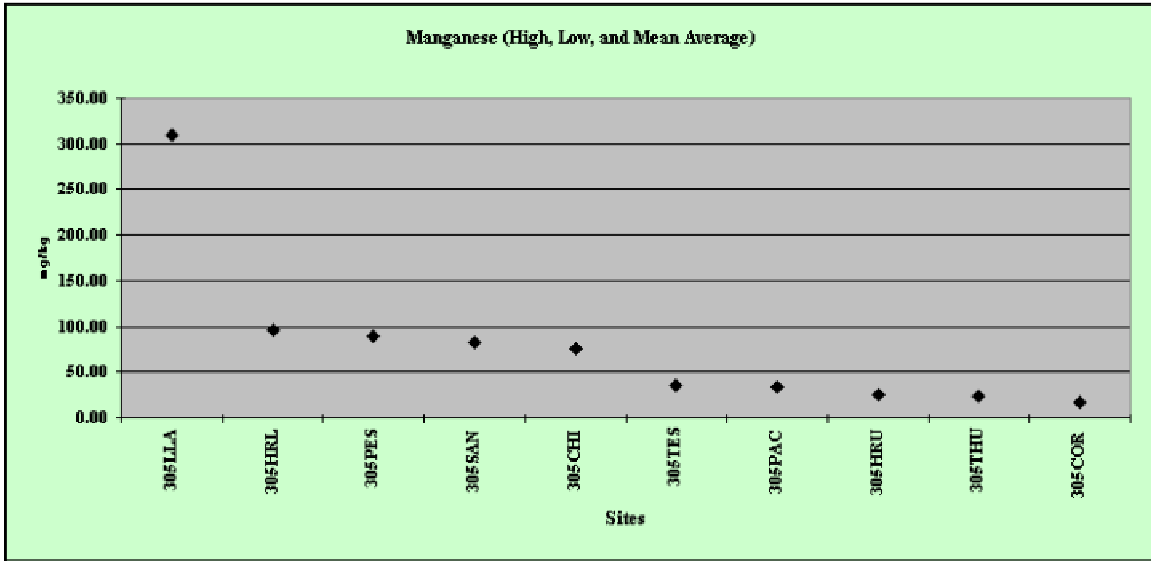
Water – No data is available for manganese in water.

Sediment – No data is available for manganese in sediment.

Tissue – No tissue standards or guideline values are available for manganese in tissue. In lieu of guideline values and to provide data context, tissue levels are compared to manganese levels in all freshwater clam data from the State Mussel Watch program. The Elevated Data Level is the 95<sup>th</sup> percentile for transplanted freshwater clams from the

State Mussel Watch database; this value is 6.24 mg/kg. Levels at all sites exceeded this value, and at the Llagas Creek site (305LLA) reached 298.0 mg/kg (Figure 4.49).

**Figure 4.49 - Mean and Range of Manganese concentrations (mg/kg) in transplanted clam tissue at sites sampled during the Pajaro River Watershed Characterization, 1998.**



## MERCURY

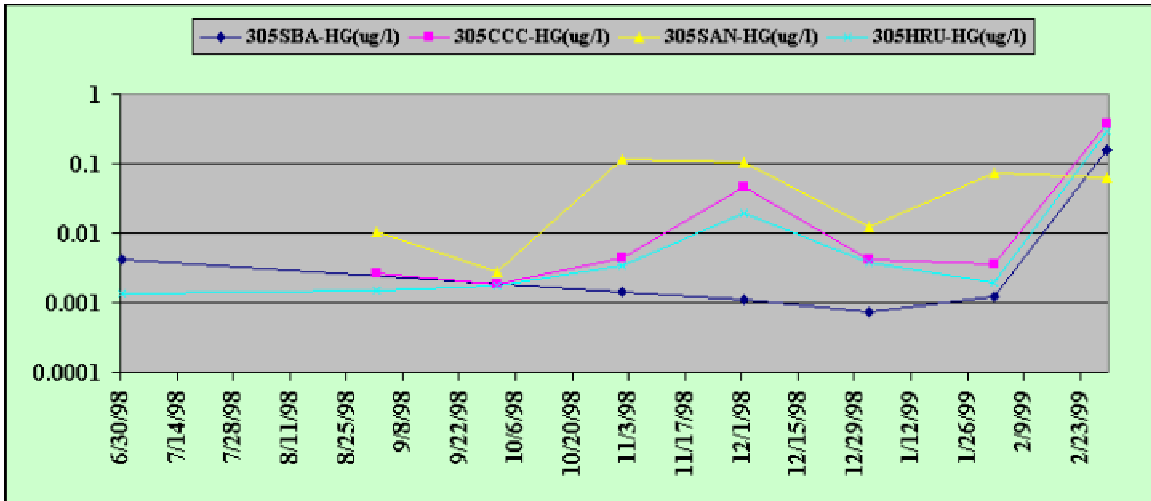
Water – Because of the special study conducted on mercury by the State Mussel Watch Program, considerably more data is available for mercury in water than for any other metal. One hundred and fifty three (153) mercury measurements were taken at 27 sites. Five of these sites were sampled only once on 6/30/98; the rest were sampled on eight separate occasions (or when water was available) over a period from May 1998 through March 1999.

The California Toxics Rule water quality objective was applied to mercury data, because at 0.051 ug/l it is considerably more protective than the Basin Plan standard for cold water fish of 0.2 ug/l. Two sites exceeded this value on average and many exceeded it as a maximum value (Figure 4.50). Highest average mercury levels were found on Clear Creek at Clear Creek Road (305CCC) and at San Benito River at Y Road (305SAN), at 0.064 and 0.055 ug/l, respectively (Map 4.2). The Y Road site (305SAN) had the most frequent rate of criteria exceedence, at 57.1% (four times out of seven samples). All of the other sites where values exceeded the standard did so just once. A number of these maximum values occurred in March 1999 (Figure 4.51). Total Suspended Solids values were also higher on this date as a result of a prior rain event.

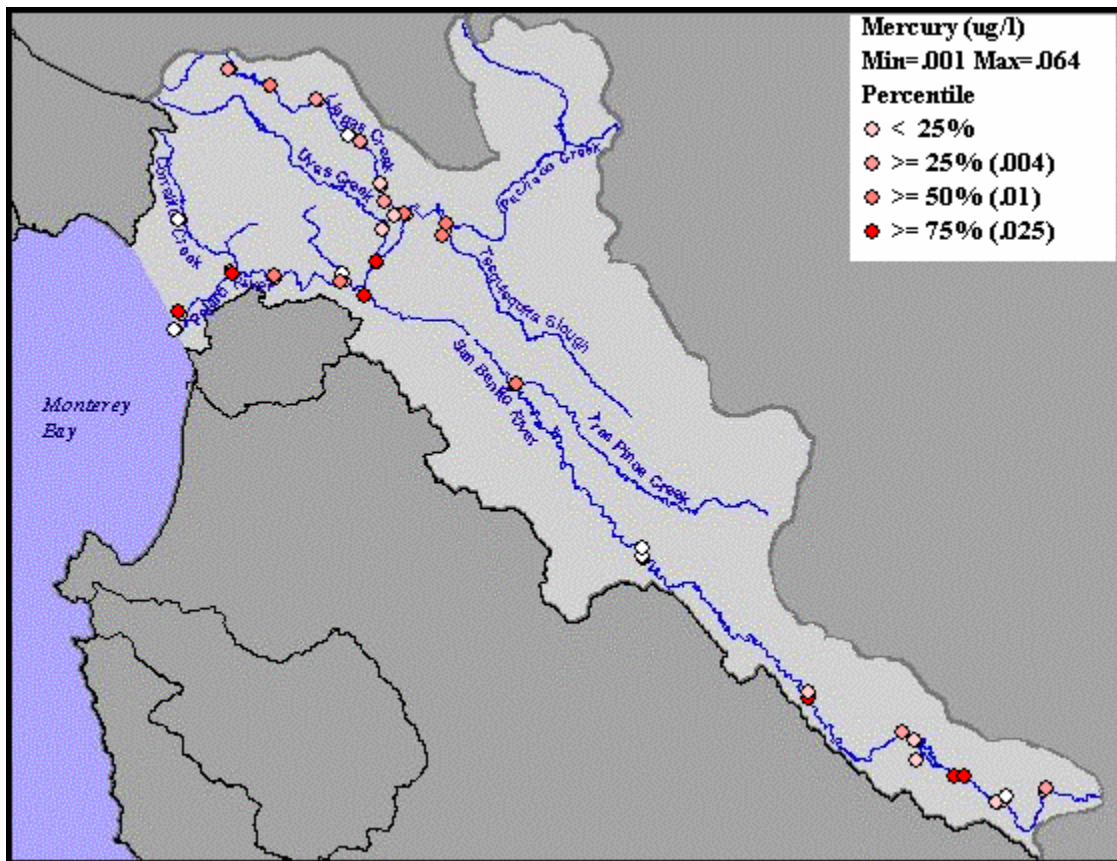
**Figure 4.50** - Mean and Range of Mercury concentrations (ug/l) in water at sites sampled during the Pajaro River Watershed Characterization, 1998.



**Figure 4.51** - Mercury concentrations over time at Clear Creek (Clear Creek Road) (305CCC), San Benito River at Y Road (305SAN), San Benito River above Hernandez Reservoir (305HRU), and San Benito River above unnamed tributary (305SBA), Pajaro River Watershed Characterization, 1998.



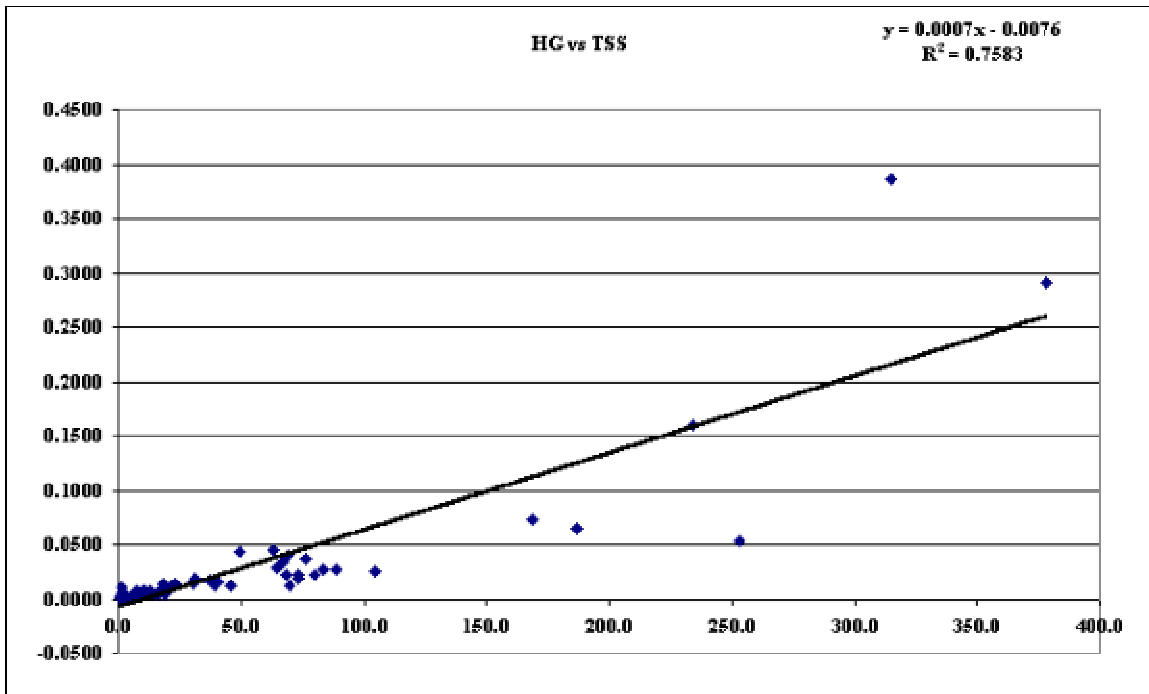
**Map 4.2** – Mercury concentrations in water (ug/l) samples collected from the Pajaro River watershed, expressed as quartiles, Pajaro River Watershed Characterization, 1998.



Elevated mercury levels were anticipated on the San Benito watershed because of known problems resulting from mining activities, particularly in the Clear Creek watershed. Other sites had occasional elevated levels of mercury as well, which were not anticipated. These included a sample collected from Salsipuedes Creek (305COR), which reached 0.217 ug/l in November 1998. Other sites where values peaked on this day included the Pajaro River at Betabel Road (305PAJ) and at Murphy’s Crossing (305MUR), and Llagas Creek at Oak Glen Road (305OAK). Levels at the Y Road site on San Benito River also peaked on this day. Unfortunately, Total Suspended Solids were not collected for this sampling event, so it is unclear if this is directly associated with a storm event ([Figure 4.52](#)).

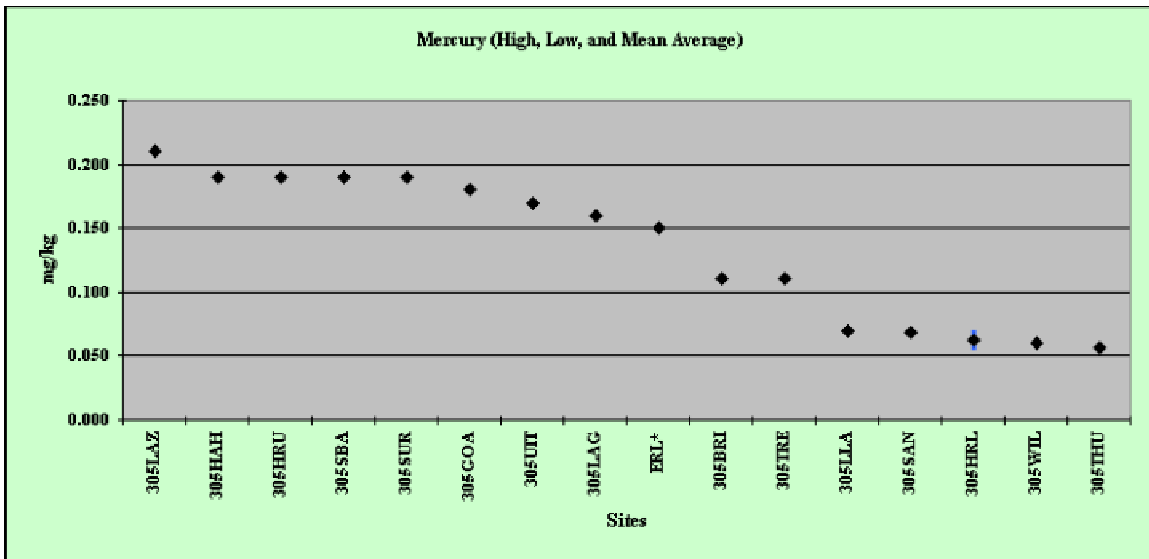


**Figure 4.52** - Regression of Mercury (ug/l) levels and total suspended solids (mg/l) levels in water in the Pajaro River Watershed Characterization, 1998.

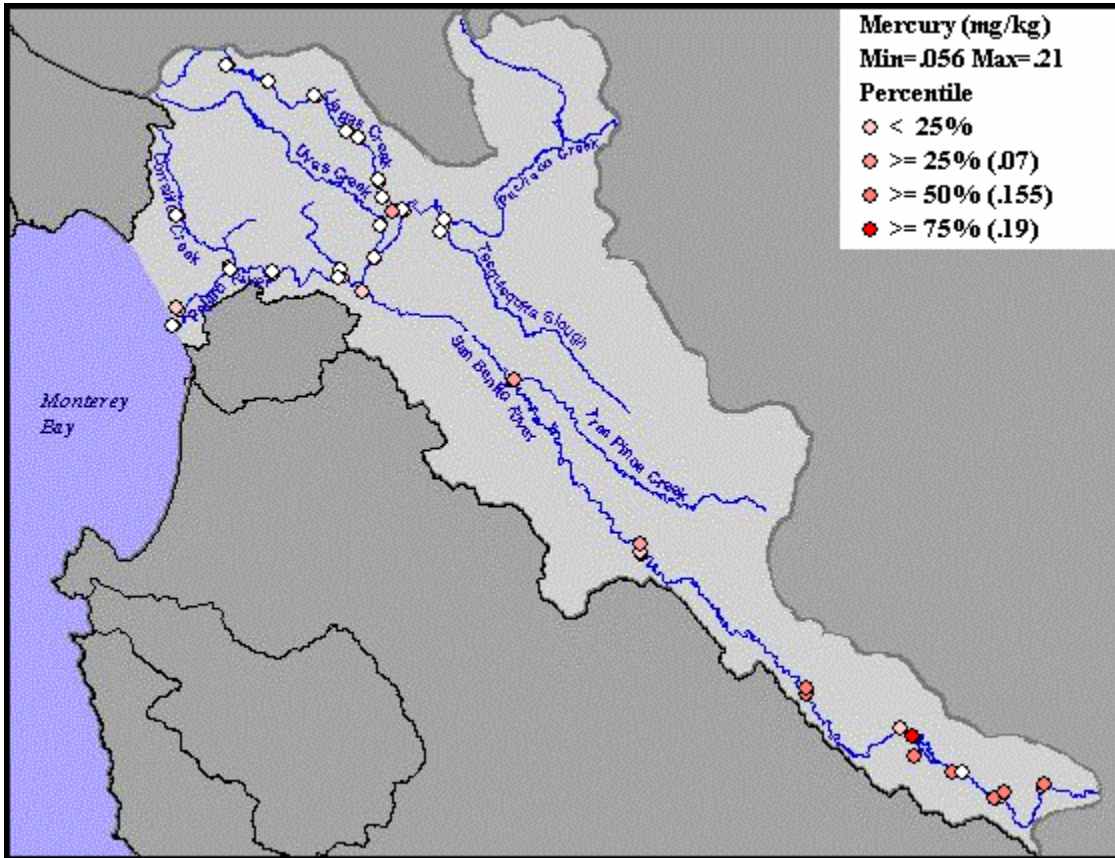


Sediment – Several of the sites in the upper San Benito and Clear Creek watersheds exceeded the NOAA ERL for mercury of 0.15 mg/kg, though none exceeded the ERM value of 0.71 mg/kg (Map 4.3). The highest level was found in sediments collected from the edge of Hernandez Reservoir (305LAZ) at 0.21 mg/kg (Figure 4.53).

**Figure 4.53** - Mean and Range of Mercury concentrations in sediment (mg/kg) collected from the Pajaro River Watershed Characterization, 1998.

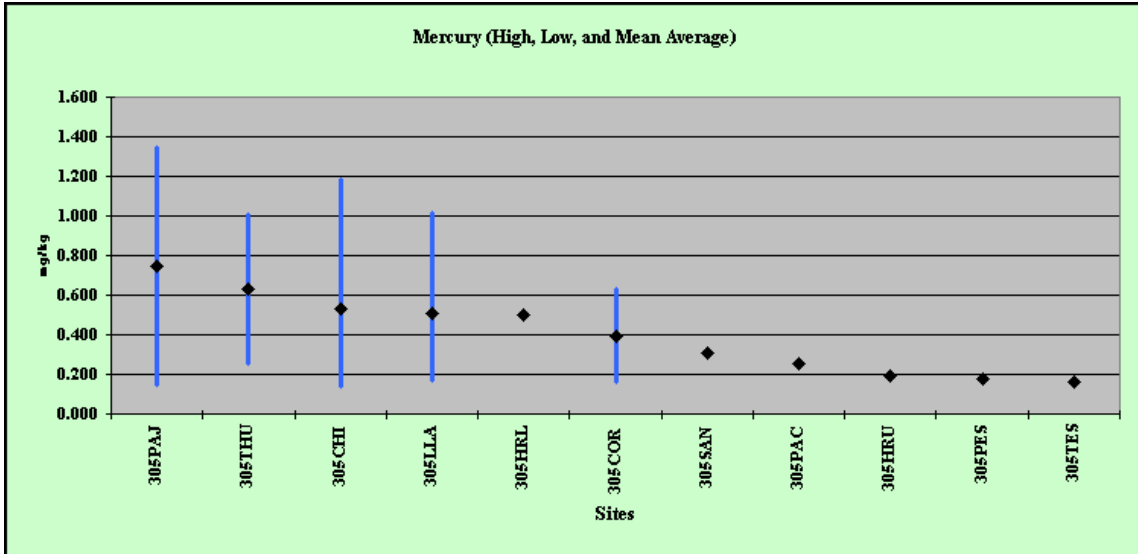


**Map 4.3 – Mean Mercury concentrations in sediment samples collected from sites in the Pajaro River Watershed Characterization, 1998.**



Tissue – Tissue collected from several sites in the Pajaro watershed exceeded the Maximum Tissue Residual Level identified in the California Toxics Rule, of 0.37 mg/kg. Highest mean values were from sites outside of the San Benito watershed, including the Pajaro River at Betabel Road (305PAJ), Thurwachter Bridge (305THU), and Chittenden Gap (305CHI), and Llagas Creek (305LLA). All of the above sites included measurements from crayfish as well as freshwater clams, and it appears from examining the data that crayfish are more efficient bioaccumulators of mercury than are clams. When evaluating these sites using clam data only, none of these sites exceeded the MTRL, and in fact the only site that did was just below Hernandez Reservoir (305HRL), where mercury values in clam tissue were 0.50 mg/kg. In (Figure 4.54), the range of values obtained from multiple tissue measurements at five sites can be seen, and it should be noted that all of the higher end range values are from crayfish. Four of these measurements from crayfish tissue exceeded 1.0 mg/kg, and all five measurements exceeded the MTRL.

**Figure 4.54** – Mean and Range of Mercury concentrations in tissue samples (mg/kg) collected from the Pajaro River Watershed Characterization, 1998.

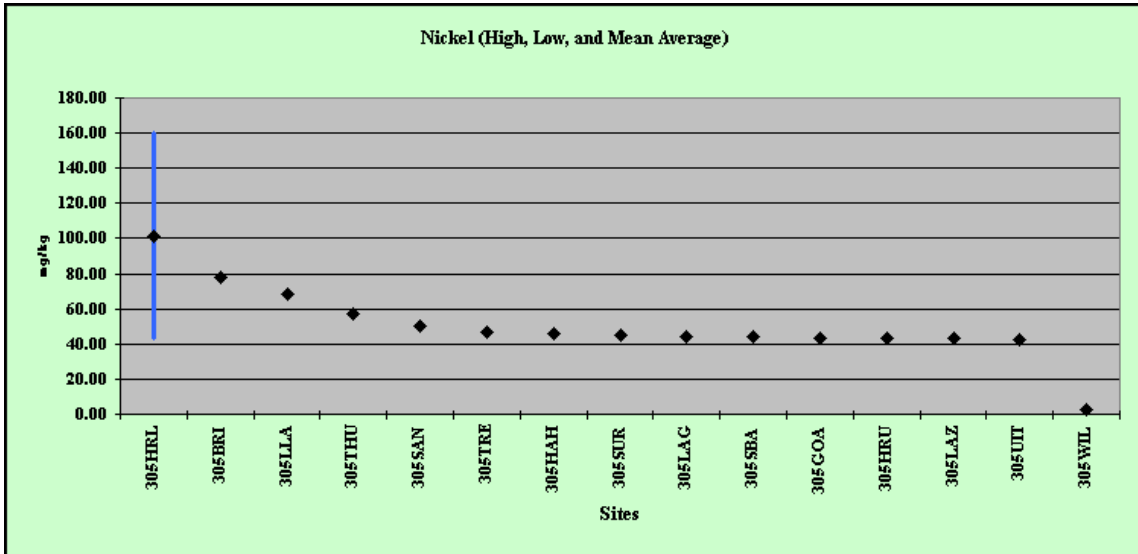


## NICKEL

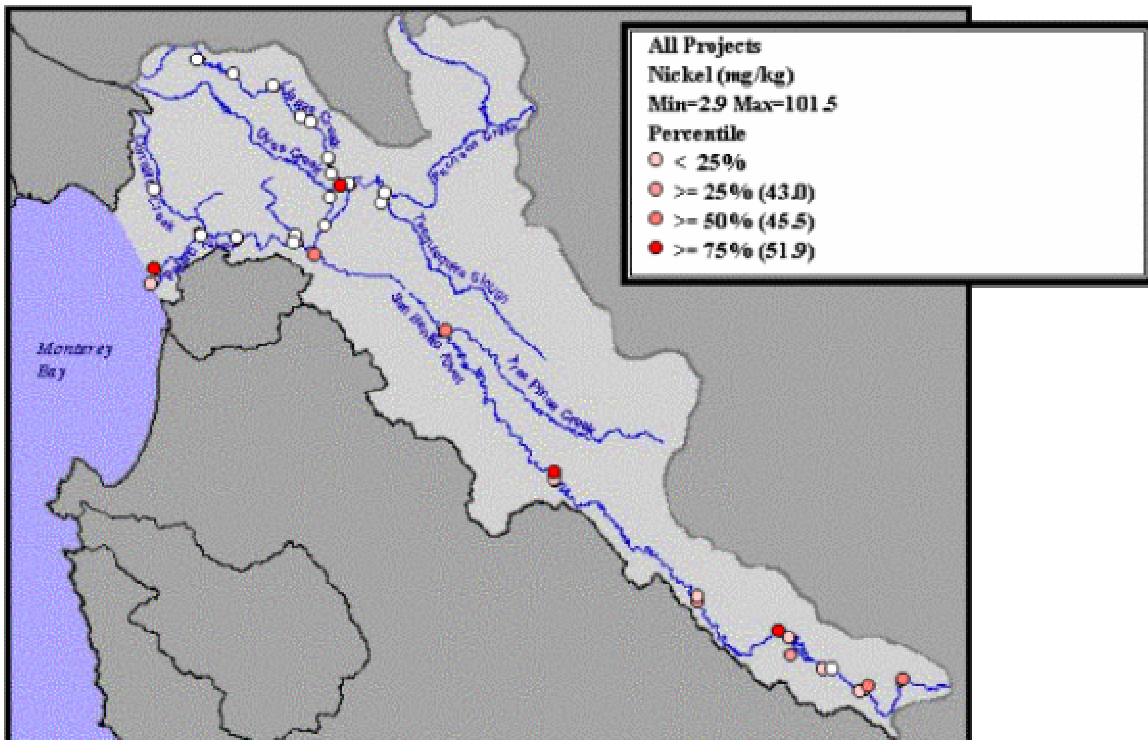
Water – Nickel standards in water are highly variable. The Basin Plan standards for cold and warm water habitat beneficial use are both set at 0.4 mg/l. The Basin Plan standard for agriculture beneficial use (irrigation) is 0.2 mg/l. For reference (though not applicable here), the Basin Plan standard for the protection of marine habitat is 0.002 mg/l. Only one site exceeded applicable Basin Plan criteria, and that was the Betabel Road site (305PAJ) on the Pajaro River, where nickel levels were 0.47 mg/l. The next highest concentration was at Y Road (305SAN) on the San Benito River, where nickel levels were 0.088 mg/l.

Sediment – Most sites exceeded the NOAA ERL for nickel of 20.9 mg/kg and four sites exceeded the ERM of 51.6 mg/kg (Figure 4.55 and Map 4.4). Highest levels were found below Hernandez Reservoir on the San Benito River (305HRL), which averaged 101.50 mg/kg and ranged as high as 160.0 mg/kg. Other sites with elevated measurements included the San Benito River downstream of Willow Creek (305 BRI), Llagas Creek (30LLA), and the lower Pajaro River at Thurwachter Bridge (305THU). Background levels of nickel are commonly high in areas with serpentinite soils such as are found in this area.

**Figure 4.55** – Mean and Range of Nickel concentrations (mg/kg) in sediment samples collected from the Pajaro River Watershed Characterization, 1998.



**Map 4.4** – Mean Nickel concentrations in sediment samples collected from sites in the Pajaro River Watershed Characterization, 1998.



Tissue – The MTRL for Nickel, according to the California Toxics Rule is 28.0 mg/kg. This value is high compared to the 95<sup>th</sup> percentile Elevated Data Level for transplanted clams in State Mussel Watch data, which is 1.4 mg/kg. The MTRL value is calculated from the CTR water quality objective of 4.6 mg/l, which is over ten-fold higher than the Basin Plan standard for cold water fish and which does not appear particularly protective when compared to other available standards. The highest nickel concentration measured in tissue was on the San Benito River at Y Road (305SAN), at 10.8 mg/kg, well under the MTRL but ten-fold higher than the State Mussel Watch EDL-95 for transplanted clams.

## **SILVER**

Water – No data was collected for this matrix.

Sediment – No data was collected for this matrix.

Tissue – No MTRLs, Median International Standards or other guideline values are available for evaluating silver concentrations in tissue. However, the State Mussel Watch Program Elevated Data Level at the 95<sup>th</sup> percentile for transplanted freshwater clams is 0.04 mg/kg. This is not an indication of impairment, but does provide statewide context for this data. Highest levels observed, from the Y Road (305SAN) site on the San Benito River were 0.445 mg/kg, approximately 10-fold higher than the EDL-95. Most other sites in the watershed ranged between 0.16 and 0.19 mg/kg.

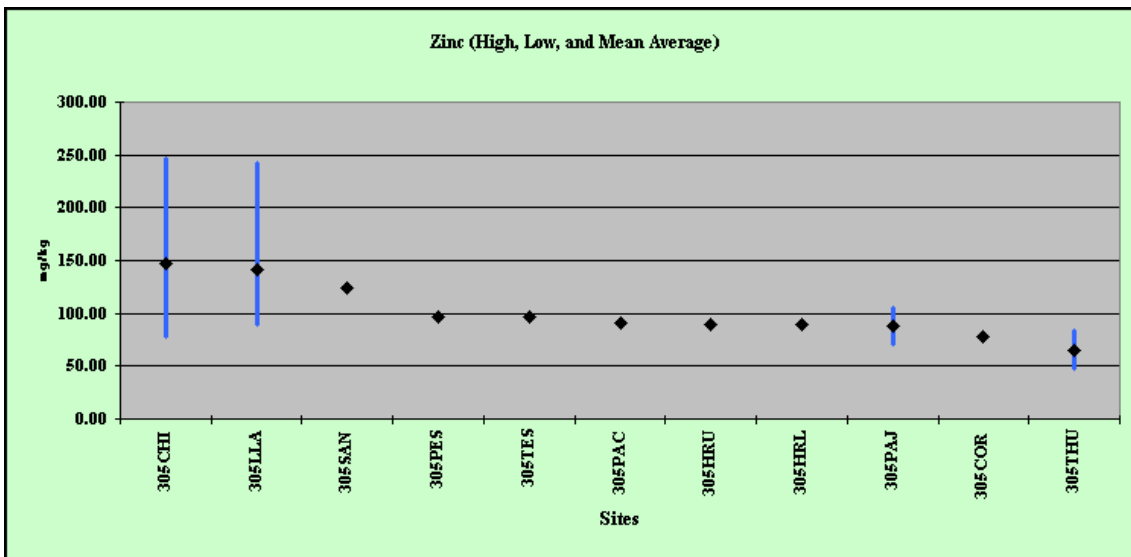
## **ZINC**

Water – The Basin Plan standards for zinc for cold and warm water fish habitat are both set at 0.2 mg/l. The only site where a sample exceeded this standard was the Betabel Road (305PAJ) site on the Pajaro River, at 0.25 mg/l. The next highest level, well under the standard, was found at the Y Road (305SAN) site on the San Benito River, at 0.049 mg/l.

Sediment – No sites exceeded the NOAA ERL for zinc of 150 mg/kg. The highest value measured was at Llagas Creek (305LLA), at 99.0 mg/kg.

Tissue – No MTRL levels are available for zinc. Zinc levels at most sites exceeded the Median International Standard for shellfish of 70 mg/kg. Highest average values were found at the Pajaro River at Chittenden Gap (305CHI) and Llagas Creek at Bloomfield Avenue (305LLA), which averaged 147.3 and 141.0 mg/kg, respectively ([Figure 4.56](#)). These two sites were also sampled for crayfish and roach; Zinc concentrations in the two roach samples collected were twice as high as any other sample; both exceeded 240 mg/kg. The next highest concentration, in freshwater clams, was found at Y Road (305SAN) on the San Benito River, at 124.0 mg/kg.

**Figure 4.56** – Mean and Range of Zinc concentrations in tissue samples (mg/kg) collected from the Pajaro River Watershed Characterization, 1998.



### C. SYNTHETIC ORGANICS CHEMICAL TESTING

Because of limited funding, organic chemical sampling in water, tissue and sediment was limited to a single sampling event for selected sites for each matrix type. For each matrix, applicable standards and objectives used to evaluate the data are described. Guideline values have not been established for all chemicals of concern.

Tissue - Eleven tissue sites were sampled through the State Mussel Watch Program at several locations in the Pajaro watershed. All sites were sampled using transplanted freshwater clams (*Corbicula fluminea*). At two of the tissue sites roach (*Hesperoleucus symmetricus*) were deployed and at five sites crayfish (*Procambarus clarkii*) were deployed, to get a better understanding of the range of chemical uptake in different species (designated here with an “R” or “C”, respectively). Tissue samples were placed at the Pajaro River at Thurwachter Road (305THU)<sup>C</sup>, Chittenden Gap (305CHI)<sup>R C</sup> and Betabel Road (305PAJ)<sup>C</sup>; Salsipuedes Creek (305COR)<sup>C</sup>, Llagas Creek (305LLA)<sup>R C</sup>, Pescadero Creek (305PES), Pacheco Creek (305PAC), San Benito River (305SAN and 305HRL), and Tequisquita Slough (305TES).

A number of synthetic organic chemicals were detected in clams deployed in the Pajaro watershed. Most chemicals detected were organochlorine pesticides, most of which have been banned for use in the last several decades. Chlorpyrifos and diazinon are two currently applied organophosphate pesticides that were detected in clam tissue.

Several tissue thresholds were applied in this analysis. Maximum Tissue Residual Levels (MTRLs) are established in the Policy for implementation of Toxics Standards for Inland

Surface Waters, Enclosed Bays and Estuaries of California (State Water Resources Control Board, 2000). These values are calculated using Water Quality Objectives and a bioaccumulation factor from the U.S. EPA Ambient Water Quality Criteria Documents for each substance (Rasmussen, 2000). These values are typically much lower than other threshold values that are commonly applied, such as the National Academy of Sciences Guidelines (1973) and U.S. Food and Drug Administration Action Levels (1984). For the purposes of this evaluation, the term “exceedence” is meant to imply a measurement over the guideline value being applied for discussion purposes. It is not meant to infer a regulatory exceedence as defined by the California Toxics Rule.

In many cases, MTRs from the California Toxics Rule (State Water Resources Control Board, 2000) are lower than the laboratory detection limits used for these samples. Because of this, non-detected chemicals are not shown on bar graphs, as they imply violations where none may exist. Also, two samples had significantly higher laboratory detection limits than other samples, because of the small amount of material available for the sample (crayfish samples from 305CHI and from 305SAN). Detection limits at these sites were typically higher than the measured values elsewhere. Because these high “non-detects” can misrepresent the data if used in calculations, they were flagged in the database and eliminated from consideration.

Sediment - Six sediment samples were collected by the Granite Canyon Marine Pollution Studies Laboratory on March 31, 1998; these samples were also tested for toxicity to *Hyalella*, a resident amphipod. Sediment sampling methods followed the Bay Protection and Toxic Cleanup Program Quality Assurance Document (Stephenson, et al., 1994). Unfortunately, sediment grain size was not collected.

Sediment samples were analyzed for organochlorine and organophosphate pesticides. Sites sampled included the Pajaro estuary (305PJE), the Pajaro River at Thurwachter Bridge (305THU), the Pajaro River at Betabel Road (305PAJ), Salsipuedes Creek upstream of Highway 129 (305COR), Llagas Creek at Bloomfield Road (305LLA), and San Benito River at Y Road (305SAN). As in tissue sampling, most chemicals that were detected were organochlorine pesticides, most of which are no longer applied, such as DDT compounds.

Sediment thresholds of concern used in this analysis include the NOAA Effects Range Median (ERM) and NOAA Effects Range Low (ERL) (Long and Morgan, 1990). These values were developed using existing datasets which include information on both toxic effects and chemical concentrations. The ERM is the median (or 50<sup>th</sup> percentile) concentration of all toxic samples. The ERL is calculated in the same fashion as the ERM, but represents the 10<sup>th</sup> percentile of the samples showing toxicity. More recent evaluations (Long, et al., 1998) indicate that a toxicity of approximately 38% is associated with the ERL level.

Water - One sampling round of water chemistry for organochlorine and organophosphate pesticides was conducted at ten conventional water quality sampling sites on March 31, 1998. Water chemistry analysis followed the Quality Assurance Plan for BC Analytical

Laboratories (1998). Results were limited, with only DDT compounds and diazinon found in any samples. Water Quality Objectives set by the California Toxics Rule (State Water Resources Control Board, 2000) were applied for DDT compounds, but no standards or criteria are available for diazinon. For context, recommended water quality criteria from the literature is cited below.

## **DIAZINON AND CHLORPYRIFOS**

Diazinon is an organophosphate insecticide used to control insects in soil, and on ornamental, fruit and vegetable crops. It is also used in residential environments to control house and garden pests. U.S. EPA is currently phasing out its domestic use over the next several years because of human health concerns. Chlorpyrifos is also an organophosphate pesticide that is still in use for termite control, tick treatment of farm animals, and crop treatment for pests.

Water – Diazinon was detected in water samples from the lower Pajaro River at Thurwachter Bridge (305THU) at 0.053 ug/l and from Salsipuedes Creek (305COR) at 0.023 ug/l. A recommended water quality criterion for diazinon from the literature is set at 0.080 ug/L (Menconi and Cox, 1994; IJCCUS 1987). Neither of these values exceeds this level.

Sediment - Diazinon was detected in a single sediment sample from Salsipuedes Creek (305COR), at 9.33 ug/kg. This value is lower than the reporting limit of 20 ug/kg and represents an estimation. At this same site, chlorpyrifos was detected, at 6.19 ug/kg, also at a value below the reporting limit. No toxicity was associated with this sample.

Tissue - Diazinon was not detected at most sites. It was measured at 95.9 ug/kg in clam tissue on the Pajaro River at the Betabel Road site (305PAJ), and at lower levels (38.6 ug/kg) downstream at the Chittenden Gap site (305CHI). Chlorpyrifos was measured on several tributaries in relatively low amounts. These included Tequisquita Slough (305TES) at 6.0 ug/kg, Pacheco Creek (305PAC) at 6.9 ug/kg and Salsipuedes Creek (305COR) at 3.6 ug/kg. No criteria are currently available for these chemicals in tissue. However, the 95<sup>th</sup> percentile of all State Mussel Watch Program data for transplanted freshwater clams (Elevated Data Level 95) for diazinon is 23.2 and for chlorpyrifos is 72.0 ug/kg (Rasmussen, 2000). Though these values are not good indications of impact, it is interesting to note that diazinon values in clams on the main stem of the Pajaro River far exceed the EDL95.

## **DDT AND ITS BREAKDOWN PRODUCTS**

DDT has been well documented as a persistent problem in the sediments of the central coast of California (Cotter and Strnad, 1997). It was used historically in agricultural and urban environments, and was commonly used directly in waterways for mosquito abatement. It is one of the chemicals associated with the Central Coast's largest "toxic hot spot" as defined by the Bay Protection and Toxic Cleanup Program (SWRCB, 1999). Concentrations at two sites in the Region (Santa Maria Estuary and upper Tembladero



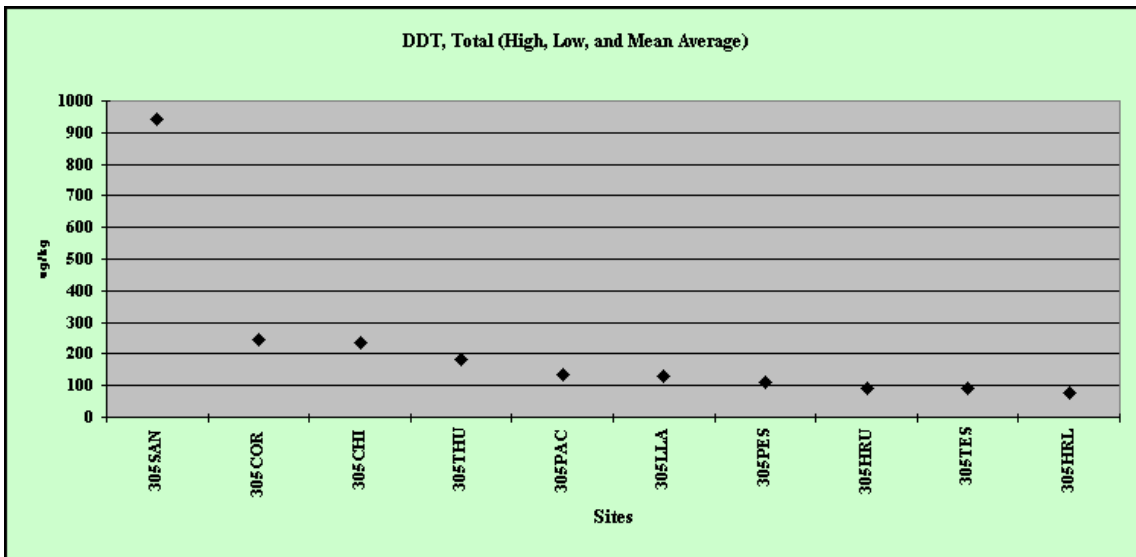
Slough) fell among the highest 5% of samples statewide. The State Mussel Watch Program and the Toxic Substances Monitoring Program have repeatedly detected DDT at elevated levels in mussel and fish tissue at a number of central coast sites.

Water – At Salsipuedes Creek (305COR), p, p'-DDT was detected only once, at 0.018 ppb. The water quality objective set by the California Toxics Rule for Inland Waters for Total DDT is 0.00059 ug/l (SWRCB, 2000), so values at this site exceeded that value by over ten-fold.

Sediment – DDT in its various forms was detected at most sites sampled, with the exception of the San Benito River site (305SAN). Total DDT at Salsipuedes Creek (305COR) was 131.49 ug/kg, considerably higher than the ERM value of 46.1 ug/kg. The most prevalent form, p, p' DDE, was also at its highest at Salsipuedes Creek (305COR) at 63.2 ug/kg, followed by the Pajaro Estuary (305PJE), at 21.6 ug/kg. The NOAA ERM value for p, p' DDE in sediment is 27.0 ug/kg.

Tissue - The most abundant of the DDT complex chemicals p, p'-DDE, was often found at levels approximately 10-fold that of p, p'-DDT. It was most abundant at the site on lower San Benito River at Y Road (305SAN), where it reached 811 ug/kg. This is interesting, given that no DDT was detected in sediment at this site. Values at all other sites were between 69 and 112 ug/kg, with lowest values in the upper San Benito watershed and more elevated values on the main stem of the Pajaro River and on Salsipuedes Creek (305COR). At Y Road (305SAN), p, p'-DDD was also elevated over other sites, at 62.8 ug/kg. Throughout the watershed p, p'-DDT was found at relatively low levels. The highest level of p, p'-DDT was 21.3 ug/kg at Salsipuedes Creek (305COR) and p, p'-DDT was not detected at all at the San Benito River (305SAN) site. Relatively low levels of p, p'-DDT indicate that DDT complex chemicals are fairly weathered in this watershed. Average Total DDT levels in tissue exceed California Toxics Rule MTRLs at all sites sampled, but never exceed the NAS guideline ([Figure 4.57](#)). The National Academy of Sciences recommended guideline for total DDT in freshwater shellfish is 1000 ug/kg. The Maximum Tissue Residual Level identified in the California Toxics Rule (2000) (and based on a water quality criterion of 0.0006 ug/l and a bioconcentration factor of 53,600) for total DDT is 32.0 ug/kg.

**Figure 4.57** – Mean and Range of total DDT concentrations in freshwater clams (ug/kg), sampled from the Pajaro River Watershed Characterization, 1998.



## DIELDRIN

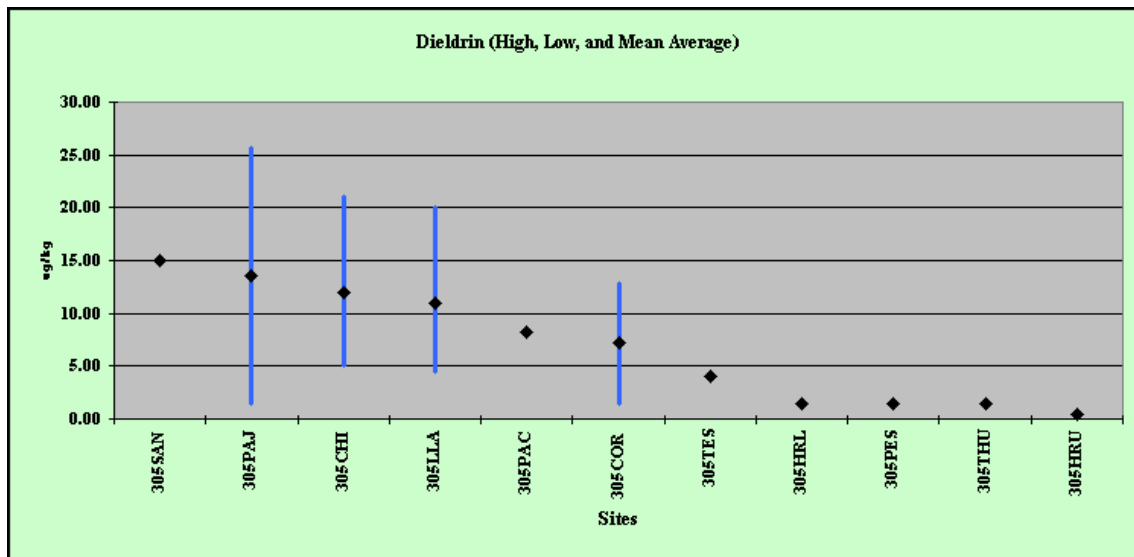
Prior to its ban in 1975, dieldrin was used for soil and seed treatment and for mosquito control. Dieldrin has also had veterinary use as a sheep dip and in treatment of wood and woolen products. It is no longer produced in or imported into the United States.

Water – Dieldrin was not detected in water at any of the sites sampled.

Sediment – Dieldrin was detected in sediment only at Salsipuedes Creek (305COR) with dieldrin concentrations of 2.14 ug/kg in the single sample collected. This is well below the NOAA Effects Range Median value of 8.0 ug/kg, but above the NOAA Effects Range Low threshold of 0.02 ug/kg.

Tissue - Dieldrin was found at its highest levels in tissue (at 25.7 ug/kg) on the main stem Pajaro River at Betabel Road (305PAJ) (Figure 4.58). Detection of dieldrin was relatively widespread, though at nowhere near the high values found historically by the State Mussel Watch Program at several lower watershed sites. All values measured exceed the Maximum Tissue Residual Levels (MTRLs). The MTRLs level is lower than the laboratory’s detection limit of 3.0 ug/kg, and at several sites the chemical was not detected. The Maximum Tissue Residual Level specified by the California Toxics Rule is 0.65 ug/kg. The Food and Drug Administration’s Action Level is much higher, at 300 ug/kg.

**Figure 4.58** – Mean and Range of Dieldrin concentrations (ug/kg) in tissue samples collected from the Pajaro River Watershed Characterization, 1998.

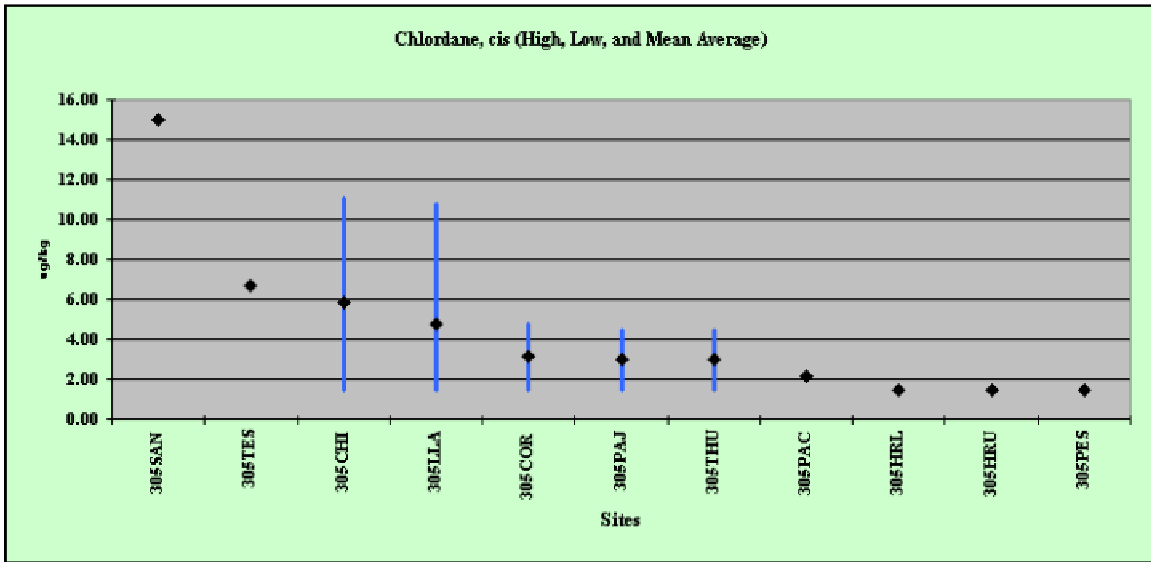


## TECHNICAL CHLORDANE COMPOUNDS

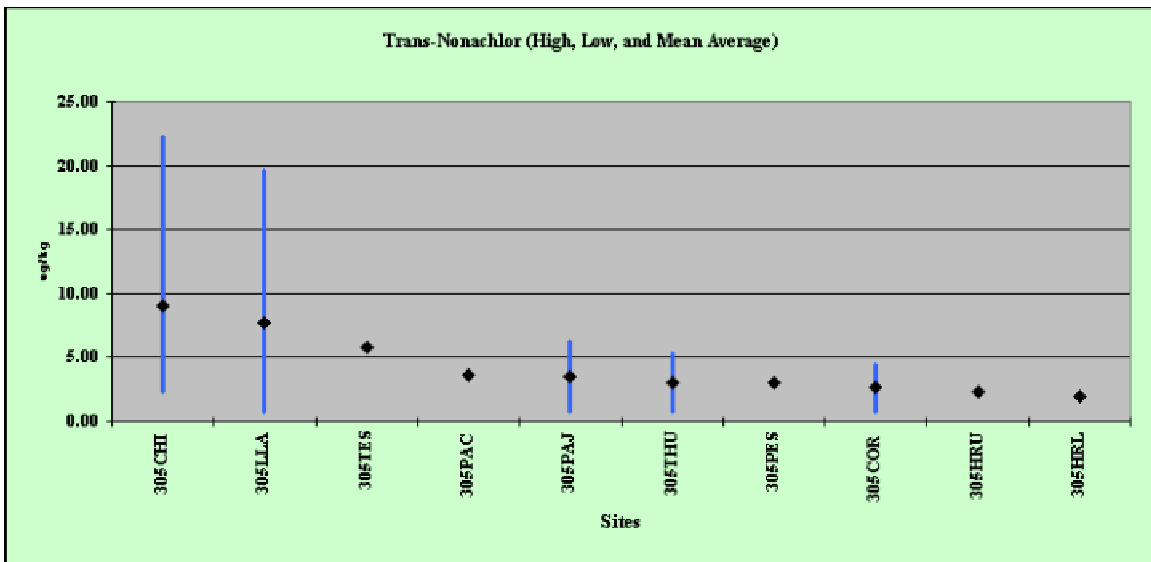
Chlordane was primarily used to control soil pests, and has been widely used as a termiticide and wood preservative, as well as an agricultural pesticide. Its use was limited primarily to termite control in 1974 and was banned entirely in 1988. Chlordane is a complex mixture of over 45 individual isomers and congeners (Mearns et al., 1991). It was found primarily in tissue samples, with the exception of one sediment sample from Salsipuedes Creek (305COR), where low levels of both cis- and trans-chlordane were present (at 2.17 and 2.22 ug/kg, respectively).

Tissue - Cis-chlordane was highest in clams collected from Chittenden Gap (305CHI), at 11.1 ug/kg ( [Figure 4.59](#)). This compound was not detected at the lower Pajaro River main stem sites, but was found at all major watershed tributaries at levels exceeding the MTRL for total Chlordane of 1.1 ug/kg. Trans-chlordane was similarly elevated at Chittenden Gap (305CHI) and in several tributaries, with highest values at Llagas Creek (305LLA) at 5.63 ug/kg. Oxychlordane was elevated at Llagas Creek (305LLA) and Chittenden Gap (305CHI), at 4.55 and 5.53 ug/kg, respectively. No criteria are available for this chemical specifically, but these values exceed the Total Chlordane MTRLs of 1.1 ug/kg. Trans-nonachlor was most elevated at the San Benito River at Y Road (305SAN) at 26.5 ug/kg, with Llagas (305LLA) and Chittenden (305CHI) sites following at lower levels ([Figure 4.60](#)). Again, no criteria are available for this chemical specifically, but the MTRLs for Total Chlordane applies. As mentioned earlier, some data from the San Benito site had to be disqualified because of extremely high detection limits. It is unclear whether other chlordane compounds would have been detected at elevated levels at this site had detection limits been adequate. Additional sampling at this site is warranted.

**Figure 4.59** - Mean and Range of Cis-chlordane concentrations (ug/kg) in tissue samples collected from the Pajaro River Watershed Characterization, 1998.



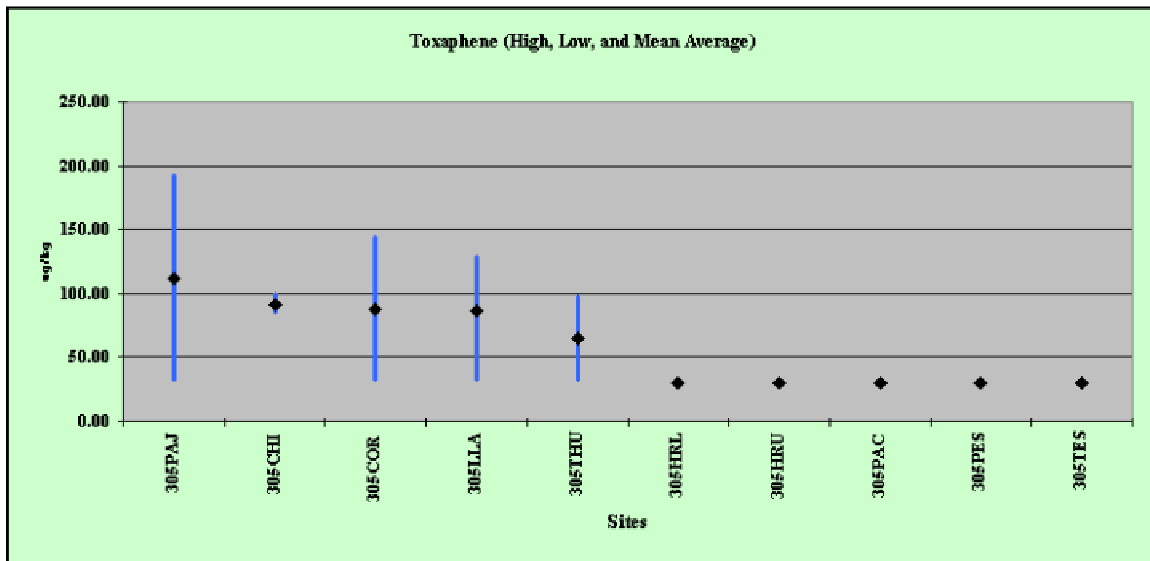
**Figure 4.60** - Mean and Range of Trans-nonachlor concentrations (ug/kg) in tissue samples collected from the Pajaro River Watershed Characterization, 1998.



## OTHER ORGANOCHLORINE PESTICIDES

Toxaphene was also found at elevated concentrations in clams at several sites, including main stem sites at Betabel Road (305PAJ), where it was highest (at 192 ug/kg), and downstream at Chittenden Gap (305CHI). It was also elevated above the MTRLs at Salsipuedes (305COR) and Llagas (305LLA) creeks. It should be noted, however, that all of the above values are far lower than historic levels found lower in the watershed. For example, toxaphene concentrations in stickleback collected in the mid-1980s from Watsonville Slough exceeded 7000 ug/kg on average. Values of toxaphene found in the watershed are shown in (Figure 4.61).

**Figure 4.61 - Mean and Range of Toxaphene concentrations (ug/kg) in tissue samples collected from the Pajaro River Watershed Characterization, 1998.**



Heptachlor was used as an agricultural insecticide and a termiticide. Heptachlor, like chlordane, was banned for all uses in 1988. Heptachlor-epoxide is a metabolite of Heptachlor. Heptachlor-epoxide was found at one tissue site only, Salsipuedes Creek (305COR), at 2.53 ug/kg. The MTRL for Inland Waters is 0.8 ug/kg.

Parathion is another chemical that has been restricted in use. U.S. EPA cancelled all uses of parathion on fruit, nut and vegetable crops in 1972 (U.S. EPA, 1992). Use is still permitted on alfalfa, barley, corn, cotton, sorghum, soybeans, sunflowers and wheat, but all application must cease by October 31 2003, and the use of ethyl parathion as a component in other pesticides ceased effective December 31, 2000 (U.S. EPA, 10/13/2000). Ethyl parathion was detected in clam tissue from all tributaries and the main stem, with clams from the Pacheco Creek (305PAC) site with highest concentrations of 23.4 ug/kg. Levels were also surprisingly high for Pescadero Creek (305PES) at 20.5 ug/kg that has little irrigated agriculture in its watershed. No tissue standards are available for comparison purposes for this chemical.

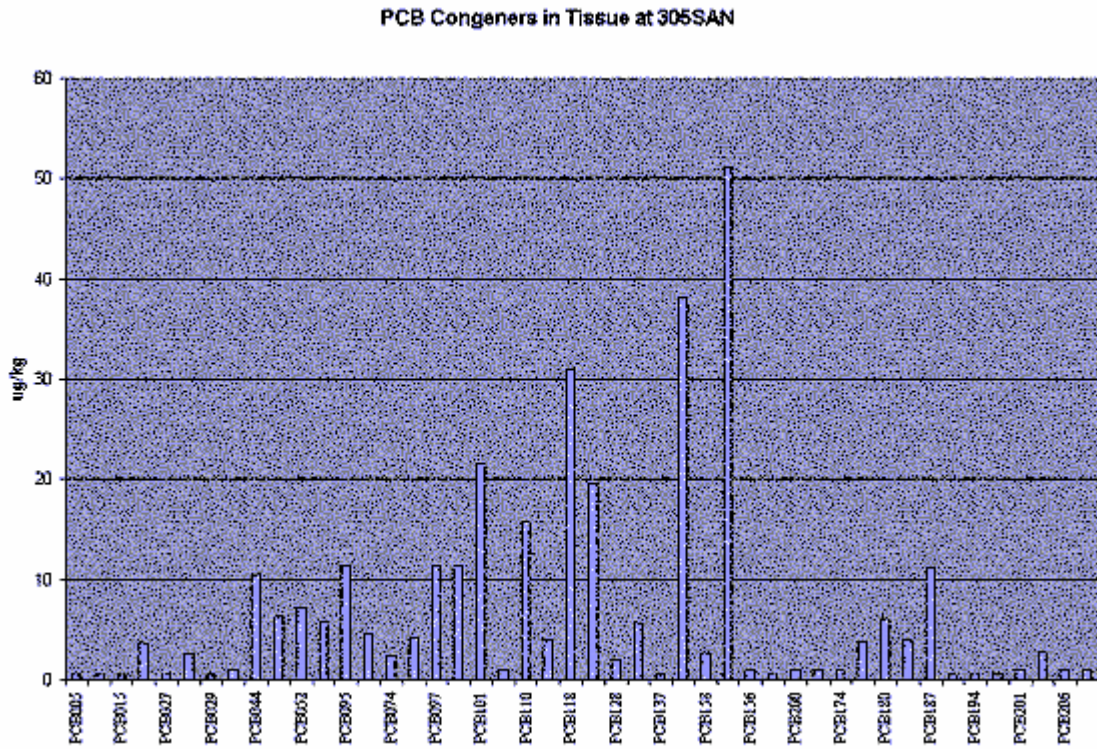
Oxadiazon is a constituent in a number of herbicide formulations. Oxadiazon was detected in clam samples from Pacheco Creek (305PAC) (at 13.4 ug/kg), but was at its highest levels in the watershed at Salsipuedes Creek (305COR) at 22.5 ug/kg. Again, tissue standards are not available for this chemical, but the EDL95 for transplanted freshwater clams is 61.6 ug/kg (Rasmussen, 2000). It was also detected in a single sediment sample from Salsipuedes Creek (305COR), at 3.25 ug/kg.

Dacthal is a pre-emergent phthalate herbicide used on annual grasses and broadleaf weed species. It is used both on agricultural crops and in homes and gardens. It is generally of low toxicity, but may have impurities that are highly toxic (such as dioxin) (EXTOXNET, 1996). Dacthal was detected at highest levels on the main stem of the Pajaro River at Betabel Road (305PAJ) and Chittenden Gap (305CHI) with lesser amounts on main tributaries. No values exceeded 19.07 ug/kg. Tissue standards are not available for this chemical, but the EDL 95 in transplanted freshwater clams is 378.0 (Rasmussen, 2000), far higher than these values. It was also detected in a single sediment sample on the main stem of the Pajaro River at Thurwachter Road (305THU), at 6.34 ug/kg.

## **PCB CONGENERS**

Clam tissue was analyzed for PCB congeners. PCBs were detected at most sites; they were highest at the Y Road site (305SAN), San Benito River. This site had total congeners of 314.03 ug/kg. The next highest site was on the Pajaro at Betabel Road (305PAJ), at 81.36 ug/kg. At the Y Road site (305SAN), San Benito River, highest concentrations were found of Congener 153 (at 51.2 ug/kg), followed by Congeners 138, 118, 149, 101, and 44 ([Figure 4.62](#)). The California Toxics Rule sets a tissue standard for Total PCBs in inland waters at 2.2 ug/kg, using a water quality criteria and a bioaccumulation factor. The National Academy of Sciences guideline value for shellfish is 500 ug/kg and the FDA action level for shellfish consumption is 2000 ug/kg. All sites exceeded the California Toxic Rule's calculated criteria for tissue. None exceeded the other two guideline values.

**Figure 4.62** – Concentration of PCB Congeners in tissue (ug/kg) at Y Road on the San Benito River (305SAN), Pajaro River Watershed Characterization, 1998.





## **CRITERIA EXCEEDENCE FACTOR**

A “Criteria Exceedence Factor” was developed using California Toxics Rule Maximum Tissue Residual Levels for synthetic organic chemicals. Each chemical measurement was divided by the MTRL for that chemical to develop a “criteria exceedence quotient”. These values were then summed for all chemicals that have MTRL criteria (MTRLs and other criteria have numeric values for only a small subset of all chemicals measured). The resulting value provides information about exceedence by multiple chemicals and provides a tool to compare multiple exceedences between sites. Criteria Exceedence Factors are shown for California Toxics Rule MTRLs for Inland Waters ([Figure 4.63](#)). MTRLs are far more conservative than many other guideline values; in fact, in most cases, if the chemical was above the detection limit it also exceeded the MTRL.

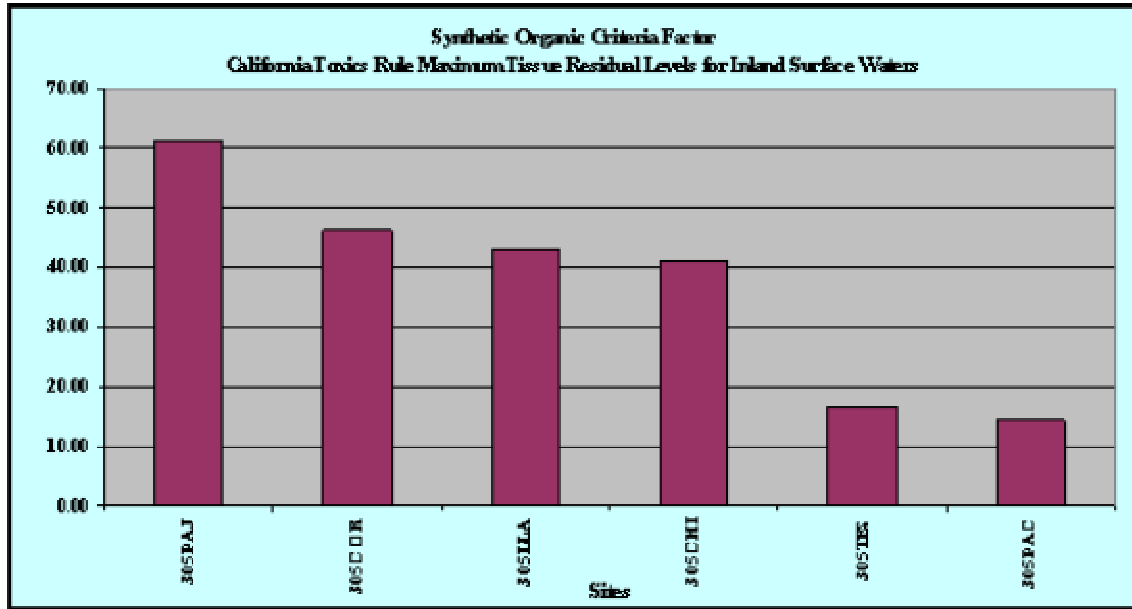
The Criteria Exceedence Factor for MTRLs was highest at the Pajaro River site at Betabel Road (305PAJ). Diazinon was also high at this site, and was not included in the calculation because MTRLs or other criteria do not exist for this chemical. Pacheco Creek (305PAC) scored relatively low, but the MTRL Criteria Exceedence Factor does not include a value for ethyl parathion, which was highest at this site.

The Criteria Exceedence Factor for MTRLs reached nearly 60 at the Betabel Road (305PAJ) site, implying chemicals in tissue collected from this site cumulatively exceeded MTRL values by a factor of 60.

The weakness of this method arises when chemicals are measured which have no criteria or guideline values associated with them. In particular, many currently applied pesticides, such as diazinon and ethyl parathion do not have standards, so the chart shown below must be viewed with that in mind. This approach is primarily helpful when a number of organochlorine pesticides are present.



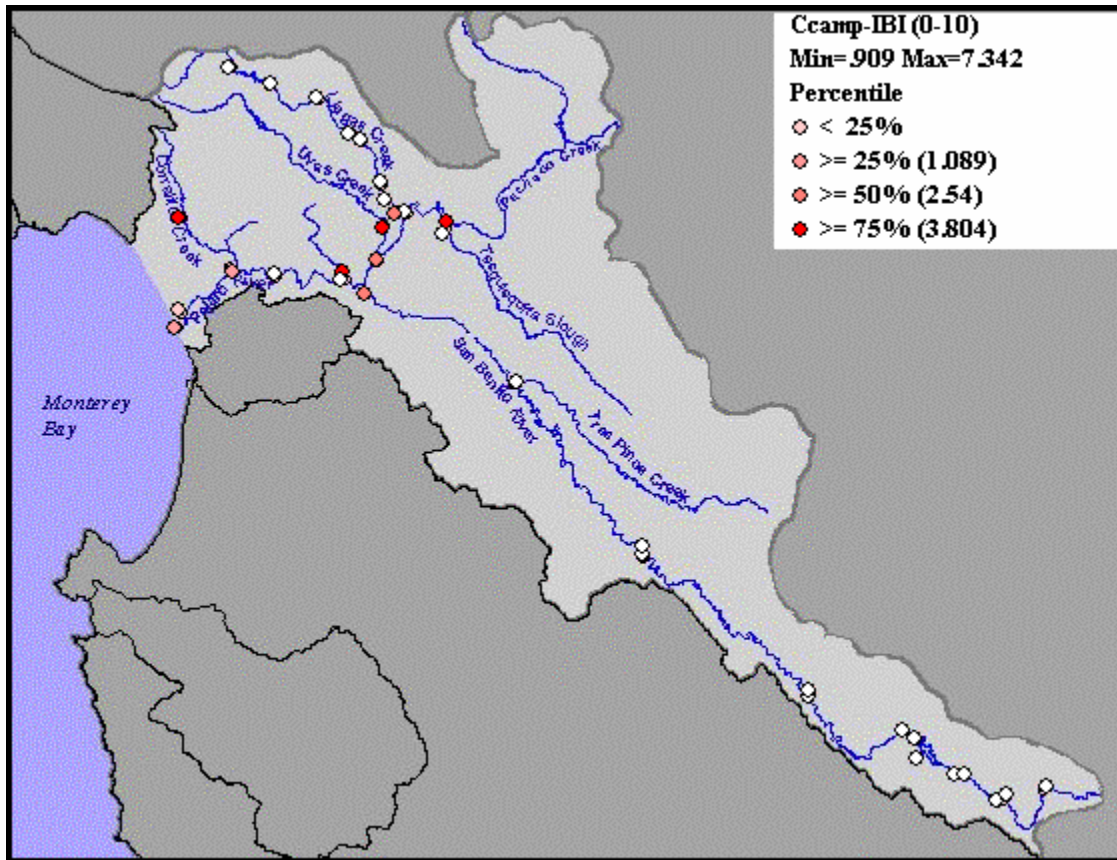
**Figure 4.63** - Synthetic Organic Chemical Criteria Exceedence Factor, developed from California Toxics Rule Maximum Tissue Residual Levels for Inland Surface Waters, for concentrations of chemicals in tissue collected from the Pajaro River Watershed Characterization, 1998.



## D. RAPID BIOASSESSMENT

Rapid bioassessment for benthic invertebrate assemblages and habitat was conducted at eight sites in the Pajaro watershed, Pajaro River Watershed Characterization, 1998. These included two in the Salsipuedes watershed; one at Lakeview Road (305COR), which was also a conventional water quality site, and one farther upstream on Corralitos Creek (305COR2) at Brown Valley Road. This upper watershed site was selected because of its relatively undisturbed habitat, and was intended as an indication of reference condition. Another site selected for the same purpose was on Pescadero Creek just upstream of the Pajaro River (305PES). Other sites included the Pajaro River at Betabel Road (305PAJ), Llagas Creek at Bloomfield Road (305LLA), Pacheco Creek at Highway 156 (305PAC), San Benito River at Y Road (305SAN), and Uvas Creek at Bloomfield Road (305UVA). One additional site, at the Pajaro estuary (305PJE) was sampled as part of a coastal lagoon study undertaken by the Department of Fish and Game during the same time period; that data is included here as well. A map of the site locations is shown in ([Map 4.5](#)).

**Map 4.5** – Sampling sites for benthic invertebrate assemblages collected from the Pajaro River Watershed Characterization, 1998.



Sample collection was conducted along a reach of stream including five riffle sequences, upstream from each site. Three riffles were selected randomly from within the reach for sampling. In each of the three riffles, a sample was collected from a transect randomly established in the upper third of the riffle. Therefore, each site is represented by three samples from three different riffles.

## BENTHIC INVERTEBRATE DATA

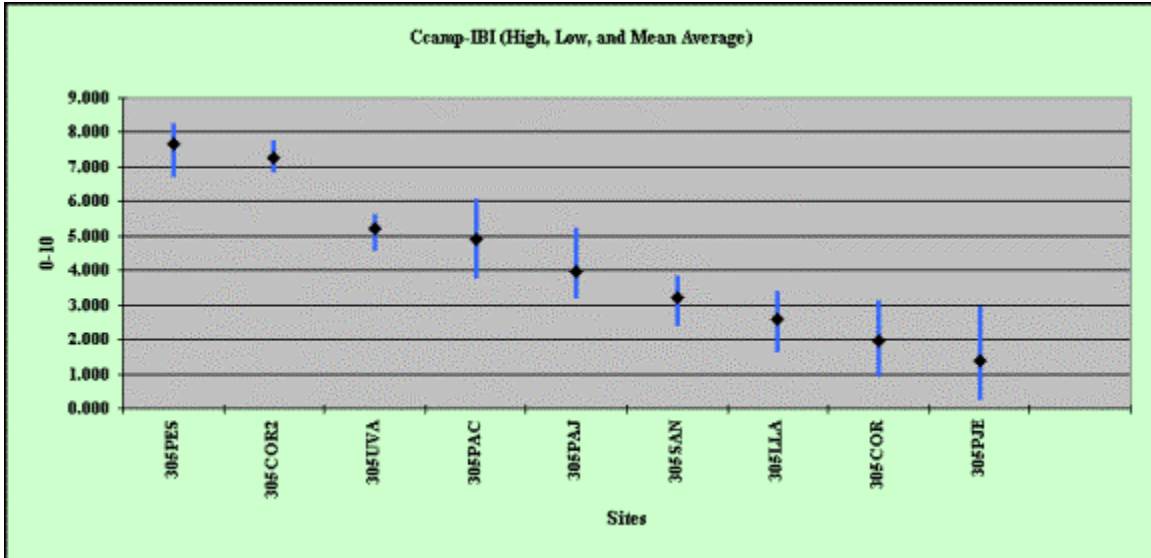
After benthic invertebrates were sorted and identified, several metrics were developed from the data. These included:

% Collectors	% of individuals which feed by collecting detrital particles
% Dominant Taxon	% of all individuals represented by most numerous taxa
% Filterers	% of individuals which filter detrital particles
% Grazers	% of individuals which graze on substrate surface
% Predators	% of individuals which prey on other insects
% Shredders	% of individuals which feed by shredding material
% Tolerant Species	Percent of taxa given a tolerance score of 8, 9, or 10
Ccamp-IBI	An index combining scores from several metrics (see text)
Ephemeroptera Taxa	Number of mayfly taxa
Ept Index(%)	Percent of total individuals which are mayflies, stoneflies or caddisflies
Ept Taxa	Number of taxa which are mayflies, stoneflies or caddisflies
Intolerant Individual Count	Individuals given a tolerance score of 0, 1, or 2
Plecoptera Taxa	Number of stonefly taxa
Taxa Diversity(Richness)	Number of different taxa
Tolerant Individual Count	Number of individuals given a tolerance score of 8, 9, or 10
Total Organisms	Total organism count
Trichoptera Taxa	Number of caddisfly taxa

The CCAMP Index of Biotic Integrity (CCAMP-IBI) is a sum of several ranked metric scores, including taxonomic richness, number of Ephemeroptera taxa, number of Trichoptera taxa, number of Plecoptera taxa, percentage of intolerant individuals (with tolerance scores of 0, 1, or 2), percentage of tolerant individuals (with tolerance scores of 8, 9 or 10), percent dominant taxon, and percent predators. This index includes all metrics utilized by Karr and Chu (1999) in his Index of Biotic Integrity, with the exception of "clinger taxa count" and "long-lived taxa count".

CCAMP-IBI scores vary widely for the sites evaluated, ranging from 1.364 at the Pajaro estuary site (305PJE) to 7.658 at Pescadero Creek (305PES) ([Figure 4.64](#)). The other high scoring site was on upper Corralitos Creek (305COR2), at 7.241. Other sites in Region 3 have scored as high as 9.056 and as low as 0.038. Score variability within sites was fairly low.

**Figure 4.64** - CCAMP Index of Biotic Integrity (mean and range) for Pajaro River watershed Rapid Bioassessment sites, Pajaro River Watershed Characterization, 1998.



Both of the high scoring sites were selected with the intention of characterizing higher quality “reference conditions”. Both are in classic “riffle-pool” habitat, and are at locations where habitat is relatively undisturbed. Unfortunately, neither site was sampled regularly for conventional water quality, so water quality conditions are not characterized at these locations. Both sites are in higher gradient stream areas than other sites, so they help characterize benthic assemblages typical of higher quality habitat in the Pajaro watershed and provide context for this discussion. These higher gradient stream sites are not directly comparable to the lower gradient sites sampled elsewhere. It is difficult, if not impossible, to find low gradient creek habitats that have not been impacted by human activities. The Pescadero Creek (305PES) site had by far the highest number of intolerant organisms present, implying that habitat and water quality conditions were favorable. These were represented primarily by the large numbers of the Plecopteran *Sweltsa*, which has a tolerance value of “1”.

By far the lowest scoring site was at the Pajaro estuary (305PJE), implying that habitat and water quality conditions were not favorable. This site experiences some tidal influence and is not readily comparable to other sites in the upper watershed. Most sites sampled as part of the coastal lagoon study conducted by California Department of Fish and Game (which included thirteen other lagoons in the Central Coast region) had relatively low CCAMP-IBI scores, particularly when compared to more upstream sites, even in watersheds that are considered fairly pristine. No river mouth sites in the coastal lagoon study scored higher than 4.7. This site scored relatively low compared to the other estuarine sites in that study.

The Pajaro River estuary site (305PJE) was dominated (75%) by the family Cyprididae. These ostracods are fairly tolerant of pollution (ranked 8) and are found in both fresh and brackish water. Also abundant were Corophium, a brackish water amphipod, and Corixidae, a predatory bug. Corophium in particular is not found in freshwater sites and is an indication of the brackish nature of the site.

Other sites characterized were at relatively similar locations in the “river continuum”, with most being at the lower ends of tributary watersheds to the Pajaro River. For example, the Uvas Creek (305UVA) and Llagas Creek (305LLA) sites were sampled very near to each other on Bloomfield Road. These two streams are of the same order, and are of similar gradient at the sampling location. Therefore, the much higher score on Uvas Creek was likely a result of better habitat and/or water quality conditions, rather than of location in the watershed. The Pajaro River site at Betabel Road (305PAJ) is located between the inputs of Llagas Creek and the San Benito River. This main stem site scored similarly to these two tributary creeks.

Excluding the estuary site, the Salsipuedes site (305COR) scored the lowest overall, followed by the Llagas Creek site (305LLA). Both of these sites have been channelized and have extremely poor in-stream habitat quality. Both also have relatively poor water quality. The Salsipuedes Creek site (305COR) had the lowest taxonomic diversity, with an average of only 10 taxa present. The Pajaro River site on Betabel Road (305PAJ) also received low scores. This site had a number of water quality issues, including presence of pesticides and metals, but had also been highly disturbed by El Nino storms.

Uvas Creek (305UVA) and Pacheco Creek (305PAC) scored much higher than these sites. They both had relatively high diversity of the “EPT” taxa. These are the Ephemeroptera, Plecoptera, and Tricoptera orders, which include a number of sensitive taxa. Uvas and Pacheco creeks had 7 and 8 EPT taxa, respectively. Pacheco Creek (305PAC) had relatively high overall diversity, with an average of 20 taxa represented, second only to upper Corralitos Creek (305COR2), at 21.2 taxa.

Percent predators is one of the metrics included in the CCAMP-IBI. This metric did not follow the pattern set by many of the other metrics; the Salsipuedes Creek (305COR) site scored highest, at 16%, followed Pescadero Creek (305PES) (one of the reference sites) and Pacheco Creek (305PAC), with all other sites scoring considerably lower. There were a large number of Corixidae at the Salsipuedes Creek site, the extremely tolerant predatory bug that was also abundant at the estuary site.

## HABITAT EVALUATION

Physical habitat scores for a number of parameters were assessed at each Rapid Bioassessment site. Habitat scores for both the April and August sampling events are shown in [Table 4.2](#).

**Table 4.2 - Habitat Scores for Rapid Bioassessment sampling in the Pajaro River watershed, April and August 1998, Pajaro River Watershed Characterization, 1998.**

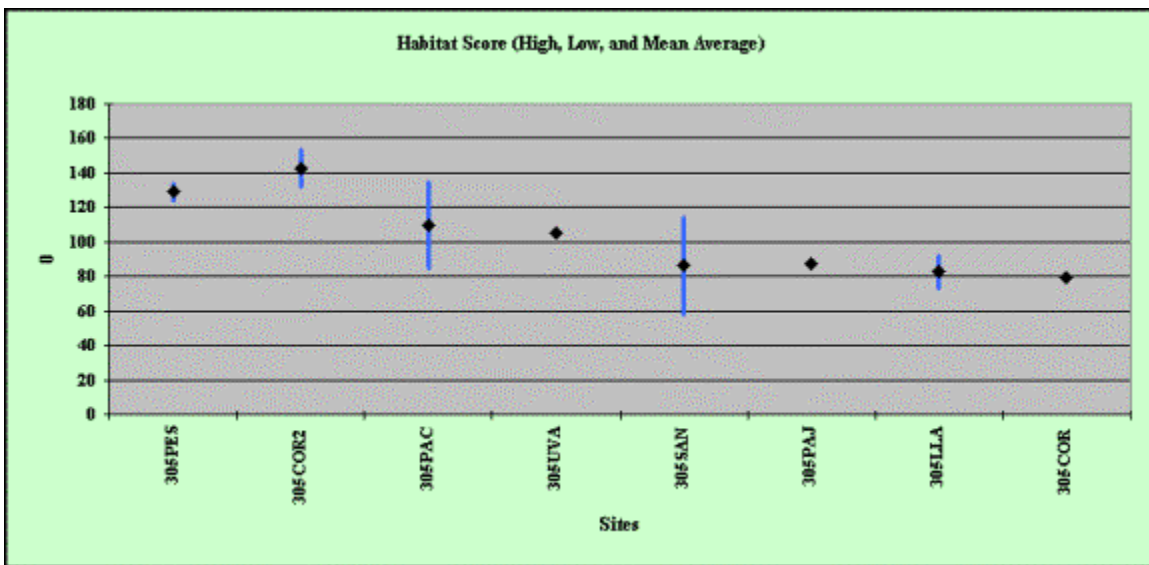
Habitat Parameter	Date	COR	PES	COR2	SAN	PAJ	LVA	LLA	PAC
<b>April</b>									
Instream Cover	Apr-98	5	14	14	2	10	9	11	12
Epifaunal Substrate	Apr-98	6	10	18	2	2	11	2	14
Embeddedness	Apr-98	6	9	8	4	3	6	2	13
Channel Flow	Apr-98	15	14	10	9	15	13	10	10
Channel Alteration	Apr-98	12	19	19	18	18	10	5	18
Sediment Deposition	Apr-98	4	8	10	1	1	8	2	13
Riffle Frequency	Apr-98	10	16	18	5	1	12	1	15
Bank Vegetation	Apr-98	7	12	18	3	12	11	12	12
Bank Stability	Apr-98	6	12	18	4	6	13	12	12
Riparian Zone	Apr-98	6	20	20	10	20	10	16	16
<b>Combined Total</b>		<b>79</b>	<b>134</b>	<b>153</b>	<b>58</b>	<b>88</b>	<b>105</b>	<b>73</b>	<b>135</b>
<b>Condition Ranking</b>		<b>Fair</b>	<b>Good</b>	<b>Excellent</b>	<b>Fair</b>	<b>Fair</b>	<b>Good</b>	<b>Fair</b>	<b>Good</b>
<b>August</b>									
Instream Cover	Aug-98	4	8	16	14	4		2	15
Epifaunal Substrate	Aug-98	5	14	14	12	10		11	2
Embeddedness	Aug-98	6	8	8	12	4		2	4
Channel Flow	Aug-98	4	6	7	5	5		10	2
Channel Alteration	Aug-98	12	20	17	18	20		12	18
Sediment Deposition	Aug-98	5	7	8	9	3		2	5
Riffle Frequency	Aug-98	10	16	18	5	1		1	15
Bank Vegetation	Aug-98	12	14	13	11	11		18	10
Bank Stability	Aug-98	10	11	15	12	9		18	4
Riparian Zone	Aug-98	12	20	16	16	20		16	10
<b>Combined Total</b>		<b>80</b>	<b>124</b>	<b>132</b>	<b>114</b>	<b>87</b>	<b>0</b>	<b>92</b>	<b>85</b>
<b>Condition Ranking</b>		<b>Fair</b>	<b>Good</b>	<b>Good</b>	<b>Good</b>	<b>Fair</b>		<b>Fair</b>	<b>Fair</b>

The California Aquatic Bioassessment Laboratory has assigned rankings of poor, fair, good and high to total scores as follows: 0 - 50 (Poor), 51 - 100 (Fair), 101 - 150 (Good),

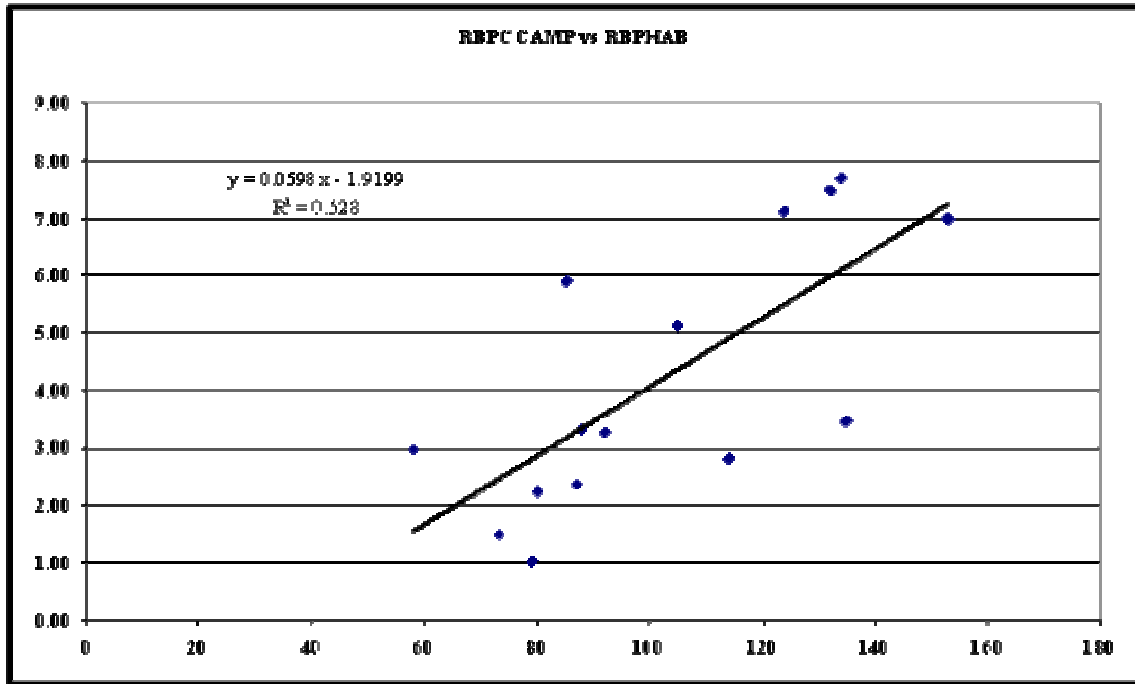
151 - 200 (Excellent). The two sites selected for their relatively good habitat (305COR2 and 305PES) scored highest overall. Uvas Creek (305UVA) and Pacheco Creek (305PAC) also scored as "Good" quality. Llagas Creek at Bloomfield Avenue (305LLA), Salsipuedes Creek (305COR), San Benito River at Y Road (305SAN), and Pajaro River at Betabel Road (305PAJ) all scored as "Fair" quality.

Overall site scores are shown in [Figure 4.65](#). Site order shown in the figure reflects the CCAMP Index of Biotic Integrity order ([Figure 4.64](#)), from highest to lowest score. The site order of the two parameters is almost identical. A significant correlation ( $r$ -squared = 0.528) is present between the IBI and the overall habitat score ([Figure 4.66](#)). This implies the obvious, that habitat quality impacts the biotic integrity of the invertebrate communities. However, habitat degradation does not necessarily include impacts due to water quality impairments. Therefore, conclusions about causality cannot be drawn in relation to habitat impacts alone.

**[Figure 4.65](#) - Average and range of site scores for habitat evaluation in the Pajaro River watershed, ranked in the same site order as the CCAMP Index of Biotic Integrity, Pajaro River Watershed Characterization, 1998.**



**Figure 4.66** - Regression of CCAMP Index of Biotic Integrity against overall habitat scores for Pajaro River watershed Rapid Bioassessment sites, Pajaro River Watershed Characterization, 1998.



Several habitat metrics have been developed from the habitat data that reflect areas of specific concern: In-channel habitat value, sediment impacts, and riparian habitat quality. These metrics represent averages of the following habitat scores:

**In-channel Habitat**

- Instream Cover
- Epifaunal Substrate
- Channel Flow
- Channel Alteration
- Velocity Depth

**Riparian Habitat**

- Vegetative Protection
- Bank Stability
- Riparian Zone Width

**Sediment Impacts**

- EmbeddednessSediment
- Deposition
- Riffle Frequency

In-channel habitat scores most closely reflect the CCAMP Index of Biotic Integrity site ranking, with lower Llagas Creek (305LLA) and Salsipuedes Creek (305COR) scoring lowest. These low scores certainly reflect the impacts resulting from channelization and other alterations at these sites. Sediment impact scores were also similar in order, with the exception of a very low score for the Pajaro River at Betabel Road (305PAJ). A large amount of erosion adjacent to this site was documented during the "El Nino" winter rains. Riparian habitat scores were the least directly related to benthic invertebrate site integrity, with the Llagas Creek site (305LLA) scoring quite high, relative to the IBI scores. Riparian vegetation at this site currently dominates the flood channel bottom, and will undoubtedly be cleared at some point in the future. Regressions of in-channel habitat,



sediment impact, and riparian habitat index scores against the CCAMP-IBI result in correlation coefficients of 0.4849, 0.4195, and 0.1819, respectively. The latter score, for the riparian habitat index, was not significant.

## 5. CONCLUSIONS

All the analysis and conclusions contained in this report are based on one year of data. The number of samples collected at an individual site range between eight and twenty-four.

1. Exceedences of Basin Plan pH criterion (instantaneous values greater than objective of 8.3 pH units) were observed at all sites in the Pajaro River watershed except two sites on Llagas Creek (Bloomfield Avenue (305LLA) and Lucchessa Avenue (305LUC)).

On the Pajaro River (all sites) and Tequisquita Slough (305TES), pH levels appear to be influenced by biological activity (aquatic plant growth). This is supported by Chlorophyll *a*, dissolved oxygen, and oxygen saturation data. As Chlorophyll *a* levels increased at these sites, dissolved oxygen and oxygen saturation exhibited wide fluctuations, resulting in increased day time pH levels.

On the San Benito River Y Road (305SAN) and Tres Pinos Creek (305TRE), pH excursions over the Basin Plan objective appear to be a consequence of geologic conditions. There was very little Chlorophyll *a* measured at these sites. Similarly, dissolved oxygen and oxygen saturation levels remained relatively constant throughout the year, resulting in stable pH levels that did not appear to be heavily influenced by biological activity.

2. Portions of the Pajaro River watershed with limited cover (riparian corridor and shade) exhibited the greatest variation in water temperature. All sites exhibited seasonal temperature variation.

Data collected in the Pajaro River watershed imply that temperature changes are having both direct and indirect impacts on beneficial uses. Direct impacts include temperatures in the stress range for cold water fisheries. During the collection of CCAMP data, temperature levels (above 24°C) capable of seriously stressing cold water fish (steelhead trout) were measured at Llagas Creek sites (Monterey Road (305MON) and Chesbro Reservoir (305CHE)) and the Pacheco Creek (305PAC) site.

Indirect impacts include temperatures at levels that increase biotic activity (aquatic plant growth) and decrease the solubility of oxygen in the water column. On the Pajaro River at the Frazier Lake Road (305FRA) site, temperatures exceeded 23°C during July and August 1998. At this site, dissolved oxygen levels below 7.0 mg/L and oxygen saturation values below the 85% saturation objective were recorded during summer 1998. This site also had the highest and most sustained levels of chlorophyll *a*, reaching 150 ug/L in July 1998.

Exceedences of Basin Plan dissolved oxygen standard for the COLD beneficial use (minimum values less than standard of 7.0 mg/L) were observed at twelve

sites in the Pajaro River watershed. Over 45 exceedences were recorded, with Pajaro River sites Frazier Lake Road (305FRA), Betabel Road (305PAJ), and Thurwachter Bridge (305THU) and lower Llagas Creek sites Lucchessa Avenue (305LUC) and Bloomfield Avenue (305LLA) each having at least five exceedences.

3. Exceedence of Basin Plan dissolved oxygen standard for the WARM beneficial use (minimum values less than standard of 5.0 mg/L) was observed at the Tequisquita Slough (305TES) site in the Pajaro River watershed. The three exceedences observed occurred during a period (July through September) of increased temperature and aquatic plant growth, measured as Chlorophyll *a*.

With the exception of Tres Pinos Creek (305TRE) and Uvas Creek (305UVA), all other sites sampled in the Pajaro River watershed exceeded the Basin Plan oxygen saturation objective of 85 percent at some point during 1998. Many of the sites had multiple exceedences with the Tequisquita Slough (305TES) site and the Pajaro River sites at Betabel Road (305PAJ) and Thurwachter Bridge (305THU) exceeding the oxygen saturation objective 50 percent of the time.

Changes in dissolved oxygen and oxygen saturation at sites throughout the Pajaro River watershed were often associated with increased Chlorophyll *a* concentrations and elevated temperatures.

4. Conductivity levels in Tequisquita Slough (305TES) and the San Benito River at Y Road (305SAN) system were often elevated above 1800 uS/cm, nearing recommended Basin Plan levels (3000 uS/cm) indicative of “severe problems” for agriculture. Average conductivity at all Pajaro River sites, two lower Llagas Creek sites, San Benito River Y Road site, Tres Pinos Creek site, and Tequisquita Slough site exceeded levels (750 Us/cm) known to cause increasing problems for irrigated crops.
5. Average Total Dissolved Solids (TDS) levels at all Llagas Creek sites exceeded the site-specific Basin Plan water quality objective of 200 mg/L (annual average).

Individual samples at lower Pajaro River sites of Chittenden Gap (305CHI), Murphy’s Crossing (305MUR), and Thurwachter Bridge (305THU) reached or exceeded Basin Plan water quality objective of 1000 mg/L for TDS in August, September, and October 1998.

At the San Benito River at the Y Road (305SAN) site, individual TDS values exceeded the Basin Plan water quality objective of 1400 mg/L in September and October 1998. The San Benito River watershed appears to be a source of total dissolved solids to the main stem of the Pajaro River.

6. At all sites in the Pajaro River watershed, turbidity was typically highest during winter months, reflecting turbidity associated with runoff during rain events.

Winter turbidity levels on the lower and middle Pajaro River (sites from Chittenden Gap (305CHI) to the Pajaro River mouth) appear to be influenced by sediment associated with inflow from the San Benito River.

Turbidity levels at sites on the upper Pajaro River (Betabel Road (305PAJ) and Frazier Lake Road (305FRA)), and Tequisquita Slough (305TES) behaved similarly over the course of the year. The turbidity at these sites appears to be influenced by sediment associated with wet weather flows during winter months and aquatic plant growth in summer months.

7. Total Suspended Solid (TSS) levels in the lower/middle Pajaro River and the Betabel Road (305PAJ) site on the upper reach of the Pajaro River follow expected seasonal patterns, with elevated levels in the winter. Winter TSS levels on the lower and middle Pajaro River appear to be influenced by inflow from the San Benito River.

The lower San Benito River, Y Road (305SAN) and Tres Pinos Creek (305TRE) sites, had two of the highest average concentrations of TSS. TSS levels in the lower San Benito River follow expected seasonal patterns with winter TSS levels above 1000 mg/L and summer TSS levels below 10 mg/L.

Data collected during this 1998 watershed study imply that the San Benito River watershed was a chronic source of sediment to the Pajaro River watershed in 1998. The lower and middle reaches of the Pajaro River had elevated total suspended solids (TSS) and turbidity levels coincident with elevated levels in the San Benito River. Other than the Salsipuedes Creek (305COR) site, which had high TSS concentrations during January, TSS and turbidity contributions from other tributaries were relatively low. Failure of a sediment basin berm during El Nino storms may have been a primary source of sediment delivery on the San Benito River.

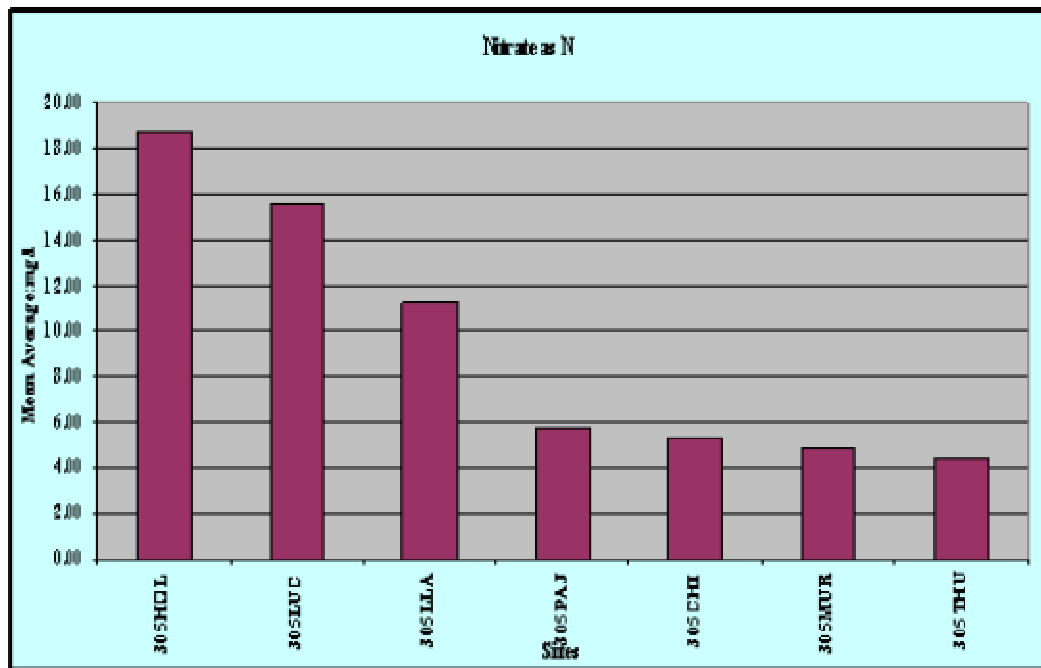
8. Elevated concentrations of Total Volatile Solids (TVS) were observed in the San Benito River (Y Road (305SAN)) and the Pajaro River (Chittenden Gap (305CHI) and Thurwachter Bridge (305THU)) through most of the year. At Thurwachter Bridge (305THU) TVS peaks coincided with peaks in TDS and conductivity, suggesting sea water influence. Chittenden Gap (305CHI) TVS values generally tracked San Benito River values, suggesting the San Benito River is contributing to increases in TVS along the main stem of the Pajaro River downstream of their confluence.
9. Pajaro River and Llagas Creek are included on the 303(d) list as impaired by nutrients; nitrate concentrations form the basis for this listing. Data on nitrate collected by this study support this listing.

Three sites in lower Llagas Creek (Holsclaw Road (305HOL), Lucchessa Avenue (305LUC), and Bloomfield Avenue (305LLA)) have mean nitrate levels that

exceed drinking water standards of 10 mg/L NO<sub>3</sub> as N. At these three sites greater than 70% of all samples analyzed exceeded the drinking water standards of 10 mg/L NO<sub>3</sub> as N.

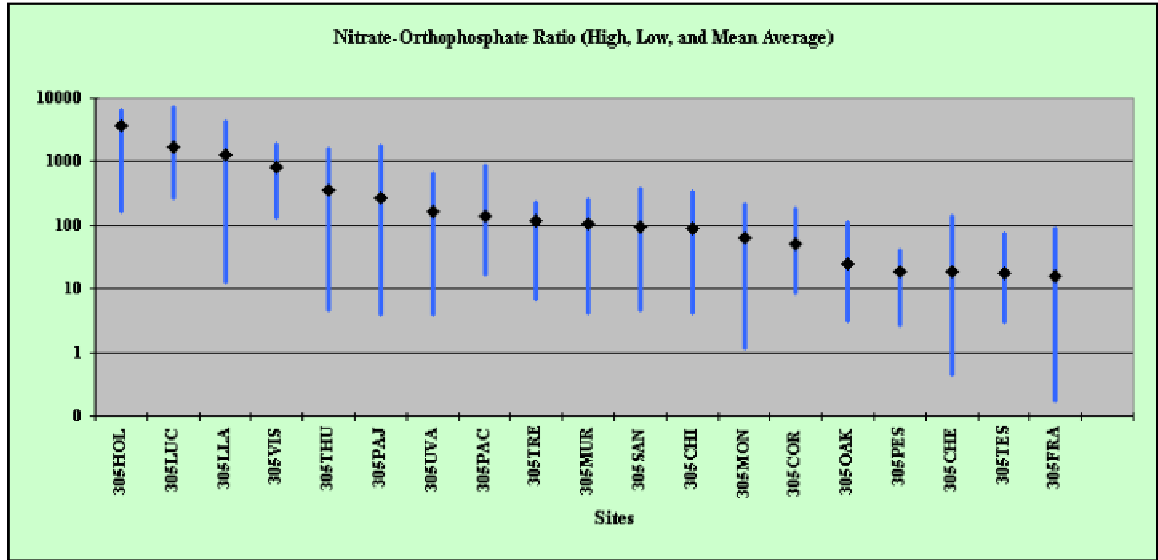
Mean concentrations are at their highest at the Holsclaw Road (305HOL) site, and then decline at Lucchessa (305LUC) and Bloomfield Road (305LLA) sites. The highest nitrate concentrations in the Pajaro River are below its confluence with Llagas Creek at Betabel Road (305PAJ), with concentrations at sites farther downstream declining to the sea. Llagas Creek is a primary source of nitrate to the Pajaro River. Mean nitrate concentrations from the Holsclaw Road site on Llagas downstream to Thurwachter Bridge on the Pajaro River are shown in (Figure 5.1).

**Figure 5.1 - Mean concentrations of nitrate from the Holsclaw Road site on Llagas downstream to Thurwachter Bridge on the Pajaro River, Pajaro River Watershed Characterization, 1998.**



The opposite is true for the Pajaro River at the Frazier Lake Road (305FRA) site. Upstream of Llagas Creek the Pajaro River has extremely high chlorophyll *a* levels, while nitrates are quite low. High concentrations of phytoplankton at Frazier Lake Road (305FRA) correlate with elevated nitrate levels entering from Pacheco Creek (Figure 4.39). In this case, it appears that inorganic nitrogen is being converted to biomass in the reach upstream of Frazier Lake Road (305FRA). This biomass conversion is lowering nitrate concentrations from both upstream tributaries by a factor of 500%. Ratios of nitrate to orthophosphate at this site are often under five (Figure 5.2), indicating that nitrogen, rather than phosphorus, is the factor limiting algal growth.

**Figure 5.2** - Average ratio of nitrate (mg-N/L) to orthophosphate (mg-P/L) at Pajaro River Watershed Characterization, 1998.



Most other sites in the Pajaro River watershed have very high nitrate to orthophosphate ratios as shown in [Figure 5.2](#), with the ratio at Holsclaw Road (305HOL) exceeding 5000. Throughout much of this nitrogen dominated system, phosphorus is the limiting nutrient. However, from a watershed management standpoint, controlling nitrate is still of critical importance as nitrate concentrations are present at levels which represent potential toxicity to aquatic organisms.

Though winter nitrate concentrations are lower than summer concentrations, higher winter flows may actually be conveying higher loads of nitrogen to nearshore ocean waters. Total Maximum Daily Load assessments currently being developed using this data will quantify actual seasonal loads.

Excessive algal growth (measured as Chlorophyll *a*) and accompanying dissolved oxygen problems are commonly associated with excessive nutrient levels. Data collected by this study at various locations on Llagas Creek and Pajaro River reveals evidence of excessive nutrient levels, large amounts of phytoplankton and filamentous algae, and dissolved oxygen deficiencies.

10. Only one site in the Pajaro River watershed had nitrite concentrations above the recommended literature value of 0.1 mg/L NO<sub>2</sub> as N. The Tequisquita Slough (305TES) site had a mean nitrite value of 0.1 mg/L NO<sub>2</sub> as N and five nitrite measurements at the site exceeded 0.1 mg/L NO<sub>2</sub> as N.
11. Toxicity related to unionized ammonia (NH<sub>3</sub> as N) does not appear to be a problem in the Pajaro River watershed. The Basin Plan objective of 0.025 mg/L

NH<sub>3</sub> as N was exceeded only once at the Tequisquita Slough (305TES) site reaching 0.072 mg/L NH<sub>3</sub> as N in December 1998.

High total ammonia levels at the Tequisquita Slough (305TES) site were observed in winter months. These levels corresponded with elevated nitrite and orthophosphate levels.

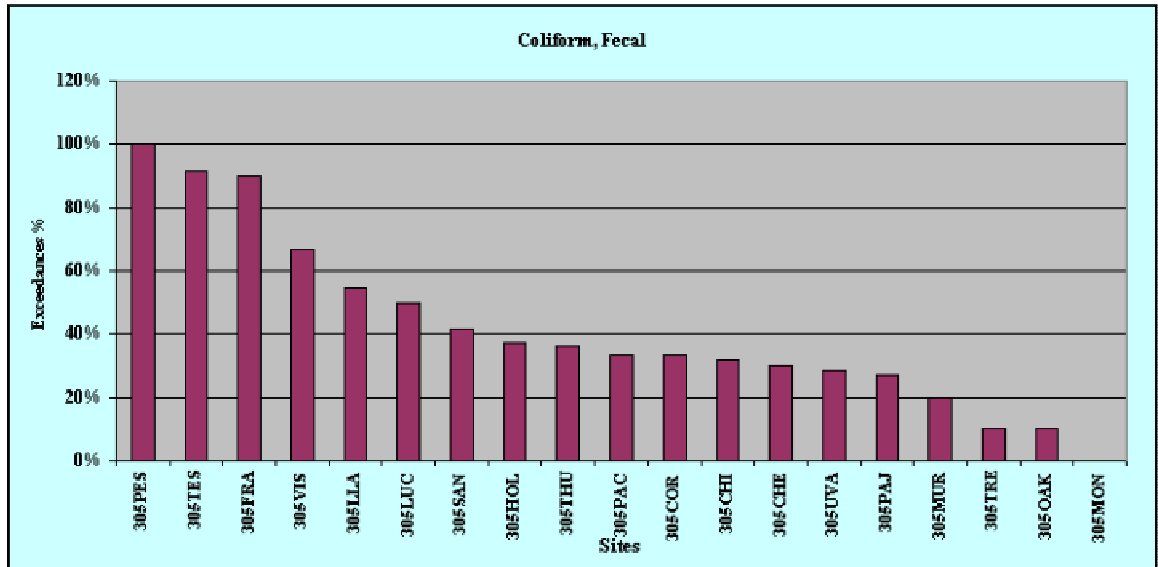
Total ammonia levels at the Oak Glen Road (305OAK) site on upper Llagas Creek were elevated in summer months. These elevated total ammonia levels were highly correlated with orthophosphate concentrations ( $r=0.91$ ) (Figure 4.30). At the Tequisquita Slough (305TES) site nitrite was also correlated with these parameters. Nitrite is an intermediate nitrogen compound in the conversion of ammonia to nitrate.

12. Four sites (Tequisquita Slough (305TES), Salsipuedes Creek (305COR), Chittenden Gap (305CHI), and Murphy's Crossing (305MUR)) had orthophosphate levels that exceeded the CCAMP attention level of 0.16 mg/L orthophosphate as P.
13. Total phosphate levels in the Pajaro River system are elevated, with all sites except Llagas Creek at Chesbro Reservoir (305CHE) having total phosphate levels that exceed the CCAMP attention level of 0.17 mg /L (as P). Highest mean total phosphate concentrations were found primarily in the San Benito River and downstream. Total phosphate levels peaked during winter and were typically associated with high suspended solids levels.
14. All five sites on the main stem of the Pajaro River exhibited maximum chlorophyll *a* concentrations over 40 ug/L, over twice the adopted CCAMP attention level (15 ug/L).

Of the six tributaries entering the Pajaro River, only Salsipuedes Creek (305COR) and Tequisquita Slough (305TES) exhibited chlorophyll *a* concentrations over 15 ug/L.

15. Fecal coliform levels in excess of 200 MPN/100ml were common in the Pajaro River watershed. More than 10% of coliform samples exceeded 400 MPN/100 ml at many sites, indicating that water body contact standards are exceeded frequently in the watershed ([Figure 5.3](#)).

**Figure 5.3 - Percent of samples exceeding CCAMP action levels (400 MPN/100 ml) for fecal coliform during the Pajaro River Watershed Characterization, 1998.**



16. Metals were investigated in the Pajaro River watershed, using tissue bioaccumulation, sediment and water trace element analysis. A single round of sampling was performed for each.

In the single set of water column samples taken at each site, metals were clearly a problem at San Benito River at Y Road (305SAN) and Pajaro River at Betabel Road (305PAJ). Both sites exceeded Basin Plan standards for Aquatic Life for copper and lead. The Betabel Road (305PAJ) site also exceeded the Aquatic Life standards for cadmium, nickel, and zinc. The Y Road (305SAN) site exceeded Aquatic Life standards for chromium. Water samples from Clear Creek at Halfway Hill (305HAH) also exceeded the chromium standard. The San Benito River below Hernandez Reservoir (305HRL) exceeded standards for chromium and copper. From multiple samples of mercury, the Y Road (305SAN) site stands out, with average values exceeding the California Toxics Rule water quality objective and over 50% of the samples exceeding this standard.

Tissue data from the San Benito River Y Road (305SAN) site had the highest values of all sites for several different metals, including aluminum, cadmium, chromium, copper, mercury, nickel, silver, and zinc. Chromium, copper and zinc levels in tissue were high throughout the watershed when compared to Median International Standards.



Manganese levels in tissue were high throughout the watershed overall compared to the Mussel Watch EDL 95 for transplanted freshwater clams. For Llagas Creek manganese levels in clams samples were particularly high.

Limited data indicates that different species accumulate different metals at different rates. Roach had comparatively high levels of zinc and low levels of copper. Crayfish were very effective bioaccumulators of mercury. In general, neither species appeared to be as effective as clams for bioaccumulation of cadmium and silver.

Elevated levels of nickel were common in sediment samples, and were measured at highest levels on the San Benito River below Hernandez Reservoir (305HRL). Samples collected from the upper San Benito River and Clear Creek area exceeded the Effects Range Low value for mercury.

17. Legacy organochlorine pesticides and several currently applied organophosphate pesticides were found in most tributaries of the Pajaro River system. DDT compounds were widespread, with levels in clam tissue exceeding the MTRL in all samples.

Several main stem sites had elevated levels of DDT, dieldrin, and chlordane compounds. The Betabel Road (305PAJ) site had the highest values of Dieldrin and Toxaphene. Chittenden Gap (305CHI) had relatively high levels of Dieldrin and Toxaphene as well as Chlordane compounds. Llagas Creek also had levels of Chlordane compounds which exceeded the MTRL.

Salsipuedes Creek (305COR) stands out for the relatively large number of chemicals that are present. DDT compounds were found at levels exceeding several criteria at this site in sediment, water and tissue. Relatively low levels of diazinon and chlorpyrifos were found in sediment, water, and/or tissue. Other chemicals detected included dieldrin, chlordane, and oxadiazon (in both sediment and tissue); and toxaphene, heptachlor epoxide, and ethyl parathion (in tissue only).

Though tests were not conducted for most currently applied pesticides, several were detected in tissue at levels which are high when compared to Elevated Data Levels from the State Mussel Watch database (at the 95<sup>th</sup> percentile). Findings include relatively high values of diazinon in clam tissue collected at several main stem Pajaro River sites, particularly at Betabel Road (305PAJ). Pacheco Creek (305PAC) also had somewhat elevated levels of ethyl parathion, which though being phased out, is still applied to certain crops.

18. Benthic assemblages and associated habitat are heavily impacted at lower Llagas (305LLA) and Salsipuedes (305COR) creeks. Though high correlations are shown between habitat quality (particularly related to in-stream habitat and sedimentation impacts), poor water quality at these sites may also be contributing

to community impacts. The main stem Pajaro River and San Benito River sites scored somewhat higher, both in terms of benthic assemblages and habitat. Though scoring lower than the two “reference sites”, Uvas (305UVA) and Pacheco (305PAC) creeks are in relatively good condition, both in terms of benthic assemblages and habitat scores. Of these two creeks, Uvas Creek probably enjoys better water quality conditions, as Pacheco Creek has elevated levels of nitrate (averaging 2.94 as N).

The Pajaro River estuary (305PJE) area scored very low, even when evaluated in the context of other lagoon data from the CCAMP Coastal Confluences program.

## 6. RECOMMENDATIONS

It is recognized that a variety of actions at the state and local level will need to be taken to address impacts and threatened impacts to water quality and associated beneficial uses. In some cases it is clear that water quality has been impacted and implementation of management practices is required. In other cases there is a need to reevaluate current state standards to determine if impacts truly exist or if the current standards are not representative of historic watershed conditions. To address these issues, the following Regional Board actions are recommended:

### 1. Basin Planning (review and revise as needed)

- Evaluate existing Basin Plan regional and site specific objectives to determine appropriateness:
  - pH
  - Temperature
  - Total dissolved solids
  - Nitrogen (total, organic, nitrate, nitrite, ammonia) as N
  - Conductivity
  - Metals
  - Organic synthetic chemicals
- Evaluate the need for new regional objectives or water body specific objectives:
  - Turbidity
  - Numeric nutrient objective for protection of aquatic life
  - Total suspended solids
  - Total volatile solids
  - Total volatile dissolved solids
  - Phosphorus (total, organic, phosphate, polyphosphate, orthophosphate) as P
  - Chlorophyll *a*
- Riparian protection policy – Develop a policy to support region-wide riparian corridor protection.
- New/revised beneficial use designations e.g.
  - Aquifer/Ground water recharge – Revise to show connectivity between surface and ground water quality
  - Biocriteria to support in-stream protection

### 2. Nonpoint Source Management - Develop and implement watershed wide management measures for the protection and enhancement of beneficial uses. Specific management measures should be implemented to:

- a. Manage nutrient sources. Priority areas to consider include Lower Llagas Creek, the main stem of Pajaro River, Salsipuedes Creek, Tequisquita Slough, and Pacheco Creek.
- b. Manage sediment sources. Priority areas to consider include the San Benito River watershed.

- c. Manage dissolved oxygen and temperature levels. Priority areas to consider include in the main stem Pajaro River, Llagas Creek, and Tequisquita Slough watersheds.
  - d. Manage for riparian corridor protection. Priority areas to consider include the Llagas Creek, upper Pajaro River, Salsipuedes Creek, Tres Pinos Creek, and San Benito River watersheds.
  - e. Manage metal sources. Priority areas to consider include the Pajaro River watershed (particularly the vicinity of the Betabel Road (305PAJ), Clear Creek and San Benito River.
  - f. Manage synthetic organic chemical sources. Priority areas to consider include the Pajaro River, Salsipuedes Creek, lower San Benito River, and Pacheco Creek.
  - g. Manage salt sources. Several winter surface water diversions are proposed for groundwater recharge, including one at Chittenden Gap. Elevated levels of dissolved solids in surface waters should be taken into account during the planning process.
- 3. Nonpoint Source Monitoring** – Add monitoring requirements for nonpoint source projects that include the following parameters:
- Nutrients
  - Turbidity
  - Temperature
  - Dissolved oxygen (concentration and percent saturation)
  - Metals (mercury and manganese)
  - Synthetic organic chemicals
  - Riparian corridor health
  - Erosion and sedimentation
  - Total dissolved solids
- 4. Orders** – Revise National Pollutant Discharge Elimination System permits, Waste Discharge Requirements, Water Quality Certifications, etc. to:
- Manage nutrient source/discharge
  - Manage sediment source/discharge
  - Manage for riparian corridor protection
  - Manage for dissolved oxygen and temperature levels
  - Manage metal sources
  - Manage synthetic organic chemicals sources
  - Manage total solids (dissolved, suspended, volatile dissolved, and volatile suspended)
- 5. Order Monitoring** – Revise monitoring programs for Board Orders (e.g. National Pollutant Discharge Elimination System permits, Waste Discharge Requirements, Water Quality Certifications, etc.) to include:
- pH
  - Temperature (24 hour duration)

- Dissolved oxygen (concentration and percent saturation) (24 hour duration)
- Total dissolved solids
- Total suspended solids
- Total volatile suspended solids
- Total volatile dissolved solids
- Nitrogen (total, organic, nitrate, nitrite, ammonia) as N
- Conductivity
- Turbidity
- Phosphorus (total, organic, phosphate, polyphosphate, orthophosphate) as P
- Chlorophyll *a*
- Metals (mercury in the entire Pajaro River Watershed and manganese in the Llagas watershed)
- Synthetic organic chemicals
- General minerals
- Longitudinal elevation profile (for gravel mining operations)
- Biocriteria

**6. Data Analysis** - Develop an index relating the various surface water quality parameters (Nutrients, Chlorophyll *a*, Dissolved Oxygen, Temperature, etc.) which is capable of ranking sites with respect to nutrient risk or impact, and which accommodates the multiple forms in which nutrients are present. Examine Pajaro River watershed data in the context of the larger regional framework.

**7. Ambient Monitoring**

- Conduct flow as a regular component of conventional water quality monitoring
- Conduct 24-hour monitoring of dissolved oxygen (concentration and percent saturation), pH and temperature periodically during low flow periods.

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