APPENDIX III

Water Quality / Bioassessment Analysis
Interim Report, March 2010

Prepared by: Trout Unlimited
San Diego Chapter 920

Trout Unlimited-San Diego Chapter 920
Grant A07-S1 awarded from DFG & PSMFC
"Steelhead Habitat Restoration San Luis Rey River:
Water Quality / Bioassessment Analysis"
Interim Report, March 2010

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Background and Significance

Steelhead trout are an important part of the Pacific Coast ecosystem from a biological and recreational standpoint. Because they are anadromous, meaning that they spend part of their lives in the ocean and then return to fresh water to spawn, they experience very different environments in terms of water, predators and food sources. The fresh water part of their life cycle is key. Unlike Pacific salmon whose swim upstream is a one-way reproductive trip, steelhead do the round trip. Historically, thousands of steelhead returned to their native rearing grounds in fresh water streams and rivers.

Steelhead numbers have declined sharply in the last century. The National Marine Fisheries Service estimates that in California, Central Valley Steelhead runs were between 1 and 2 million prior to 1850, and are now about 3,600. South-Central Coast Steelhead populations have gone from 25,000 spawning adults to less than 500. Further south in our area, the numbers of Southern California Steelhead have declined to the point that they were listed as endangered in 1997 in the coastal area spanning San Luis Obispo County to the U.S.-Mexico border.

This decline has raised an awareness of the need for steelhead habitat recovery projects in California. Due to the complexity of land ownership and water rights, it takes a collaborative effort of the community to make headway. Financial support from governmental agencies and the public is available through fish restoration grant programs and state bonds. For example, the statewide approval of Prop 84 in 2006 allocated up to 45 million for coastal restoration projects. But now it takes the workers to get it done. Northern California is already well underway in steelhead restoration projects in an effort to augment existing populations. Southern California needs to establish a stable core population and grow from there.

The Trout Unlimited (TU) San Diego Chapter 920 received a grant of $20,000 from California Department of Fish and Game to perform water quality monitoring and steelhead habitat assessment in the San Luis Rey River in northern San Diego County. An important aspect of this work is that it coincides with ongoing water quality improvement programs by local governments, with an emphasis on identifying areas of the river that are fish friendly to help determine the feasibility of establishing a core population. A further goal is to identify cost effective in-stream projects facilitating steelhead return that can be reasonably pursued in the context of developed communities. Such partnerships can work well in finding the intersection between development and conservation while operating within regional Watershed Plans and Steelhead Recovery Plans.

The TU-San Diego Chapter has been affiliated with Golden State Flycasters (GSF) since 2004. This is the first grant that the TU-SD chapter has been awarded, and builds on stream monitoring protocols implemented in a previous grant awarded to GSF from the California Wildlands Grassroots Fund. GSF and TU volunteers collected water chemistry and stream habitat data in 2007 in Escondido Creek in collaboration with San Diego Coastkeeper and San Diego Stream Team. Many of these techniques have been used in our current studies of the San Luis Rey River.

Study Objective

The objective of this study is to perform a quantitative analysis of physical habitat, water quality conditions and benthic macroinvertebrate populations to provide data for effective steelhead habitat improvement projects in the San Luis Rey River in San Diego County. The virtual absence of steelhead in our regional water systems for over 50 years makes it unclear what present conditions they can tolerate. It is also unclear whether results of studies on northern steelhead can be extrapolated to their more southern relatives. The key factors appear to be water temperature, dissolved oxygen, adequate insect life, pools with adequate depth, gravel and cover.

The tasks set out in this proposal seek to quantify the existing state of some of these factors in doing a water chemistry survey at dispersed points along the SLR, and then focus in on just four sites to do more detailed analysis of habitat and insect life not only as indicators of water quality, but as a food source for fish. This report is a compilation of data collected from water chemistry, water temperature logging and bioassessment studies during the period of April 2008 to December 2009 in the San Luis Rey River.

•*Water chemistry* was monitored at nine sites every other month starting in April 2008 for water temp, pH, dissolved oxygen, conductivity, phosphate, nitrate, and bacterial populations. These studies were performed in close collaboration with San Diego Coastkeeper, who training volunteer monitors, equilibrated equipment and analyzed water samples in the lab for phosphate, nitrate and bacterial levels. All other measurements were recorded on-site, in addition to qualitatively determined flow rates and basic physical habitat observations.

•*Hobo water temperature loggers* were placed at seven sites in the San Luis Rey River to record continual water temperature data at dispersed sites generally from April 2008 – November 2008 and April 2009 – October 2009.

•*Bioassessmen*t sampling with macroinvertebrate collection was performed according to SWAMP protocols in November 2008 at four locations that coincided with a subset of water chemistry sites.

The studies described here provide scientific data to direct steelhead habitat improvement projects that are most cost effective and appropriately targeted to river habitats that will support trout viability and reproduction. The water chemistry data--particularly water temperature, flow rate, dissolved oxygen and nutrient levels--are considered in conjunction with location of candidate spawning and rearing areas in the SLR mapped by California Department of Fish and Game. The physical habitat assessment with macroinvertebrate population analysis is important in further characterizing suitable trout rearing conditions in selected pools and the availability of insects as food source for migrating steelhead and their offspring. Candidate spawning sites that have water quality characteristics consistent with trout survival can then be further improved through in-stream habitat enhancement projects such as gravel and boulder placement and bank stabilization if necessary.

Study Context

The San Luis Rey River watershed is a remarkable mixture of developed and wild land covering over 565 square miles. The river itself flows over 50 miles from Palomar and Hot Springs Mountains in the Cleveland National Forest (which receive an average of 45 inches of rain annually, compared to 12 inches coastally) into the Pacific Ocean in the city of Oceanside. The river has one dam forming Lake Henshaw, one of the larger reservoirs in the region.

Like many Southern California streams, the San Luis Rey River flows intermittently in some of the upper reaches depending on a variety of factors: previous winter rainfall totals, season, location, water releases from Lake Henshaw, irrigation withdrawls and public water consumption. The river characteristics to the east of Interstate 15 (I-15) are particularly important in considering steelhead habitat improvement projects because water conditions, pool depths and flow rates are more variable. As groundwater and run-off water accumulate to the west of I-15, the San Luis Rey River flows as a perennial river. However, the non-native plant *Arundo donax* has taken hold downstream and has become a major problem in disrupting natural riverine habitat ecology. Due to its extensive growth, *Arundo* removal is essential for the long-term health of the river ecosystem, but may have a significant sediment impact on the river in the short term until native vegetation provides adequate ground cover

Local conservation groups have been instrumental in both maintaining the existing trout populations and planning for future ones. San Diego Trout and San Diego Fly Fishers have actively worked to preserve the resident rainbow population in Pauma Creek near Palomar Mountain and throughout San Diego County for years. Low-cost stream improvements are possible and for example, they installed a fish net at the outlet of Doane Pond to retain trout and prevent non-native species of bullfrog and catfish from entering Doane Creek during significant winter and spring rains. The healthy rainbow trout population in Pauma Creek and its tributaries are notable indicators that trout can survive year-round in a San Luis Rey River tributary. Just to the north of San Diego, the Trout Unlimited-South Coast Chapter is actively working in San Mateo, San Juan and Trabuco Creeks in Orange County on steelhead recovery projects. They are collaborating with California Dept. of Fish and Game and contractors to build a fish passage ladder on Trabuco Creek.

A comprehensive synthesis of 2007 field surveys and parameters influencing the San Luis Rey River has been recently published by the Dept. of Fish and Game, Pacific State Marine Fisheries Commission and the Coastal Watershed Planning and Assessment Program (Downie and Kajtaniak, 2010). This report tracked seasonal water flow, identified physical barriers to fish passage and characterized candidate spawning areas that have sufficient gravel and deep pools with vegetation cover to keep water temperatures in line with trout survival through the summer and fall months. The San Luis Rey River basin hosts a patchwork of land ownership and uses. Progress in restoring steelhead to the river depends on cooperative interactions with city and tribal communities, private landowners and public land and water resource agencies.

Overall, steelhead recovery projects in Southern California are in their infancy. Three questions highlight both the possibilities and the challenges of doing this successfully. First, if we build it, will they come? Positive feedback will probably be

incremental with increased sightings of steelhead in S. California rivers. In cases where fish barriers are eliminated, the response should be faster. But we need cost effective ways of measuring steelhead presence. Current approaches are fish weirs, redd counting, snorkel diving, electroshocking and tagging. More eyes on the water will also help. There have been two documented sightings of candidate steelhead: one in San Luis Rey River in May 2007 and one in San Juan Creek in 2008. Given that sightings have been so infrequent in our area, this is exciting.

It also brings up the second question. Do we know they are steelhead and not resident rainbows? The relatively large size and color are visual clues, but unambiguous identification is difficult. Rainbow DNA genotyping from fin-clips does not clearly distinguish ocean and fresh water history. The gold standard is histologic analysis of trout otolith (bone), which gives a record of time spent in the ocean. However, this assay means sacrificing the fish, so this is not an option here. A different assay needs to be devised that uses a snippet of tissue or scale that does not harm the fish when clipped or monitors their movement through telemetry.

A third question is, will there be enough water? It is an open question whether water flows in S. California rivers and streams can meet trout requirements outside of a few discrete reaches. One feature that works in the steelhead's favor is that they migrate between fresh and salt water during high flows. Once in a suitable fresh water habitat, they can reside for extended periods. This is a critical point for S. California steelhead survival as low water flows cause sedimentation and low dissolved oxygen levels. Two of the most important water quality parameters studied here that are closely related to water flow are water temperature and dissolved oxygen. We find that water temperature even in summer months is not apparently a critical limiting factor for steelhead at sites tested in the San Luis Rey River, while dissolved oxygen levels are extremely low throughout the river, particularly during summer and fall months. A detailed discussion of the data compiled in this report is present in the Study Discussion section following the data sections.

Acknowledgments

We wish to thank California Department of Fish and Game for funding and assistance; in particular Mary Larson, project manager and senior fisheries biologist in the Los Alamitos office, and Dave Kajtaniak, the PSMFC fisheries biologist and team leader for the DFG San Luis Rey River Steelhead Field Survey who we worked closely with throughout the study. We also wish to thank Pacific States Marine Fisheries Commission for funding, and California Wildlands Grassroots Fund / Tides Foundation for their 2009 funding support.

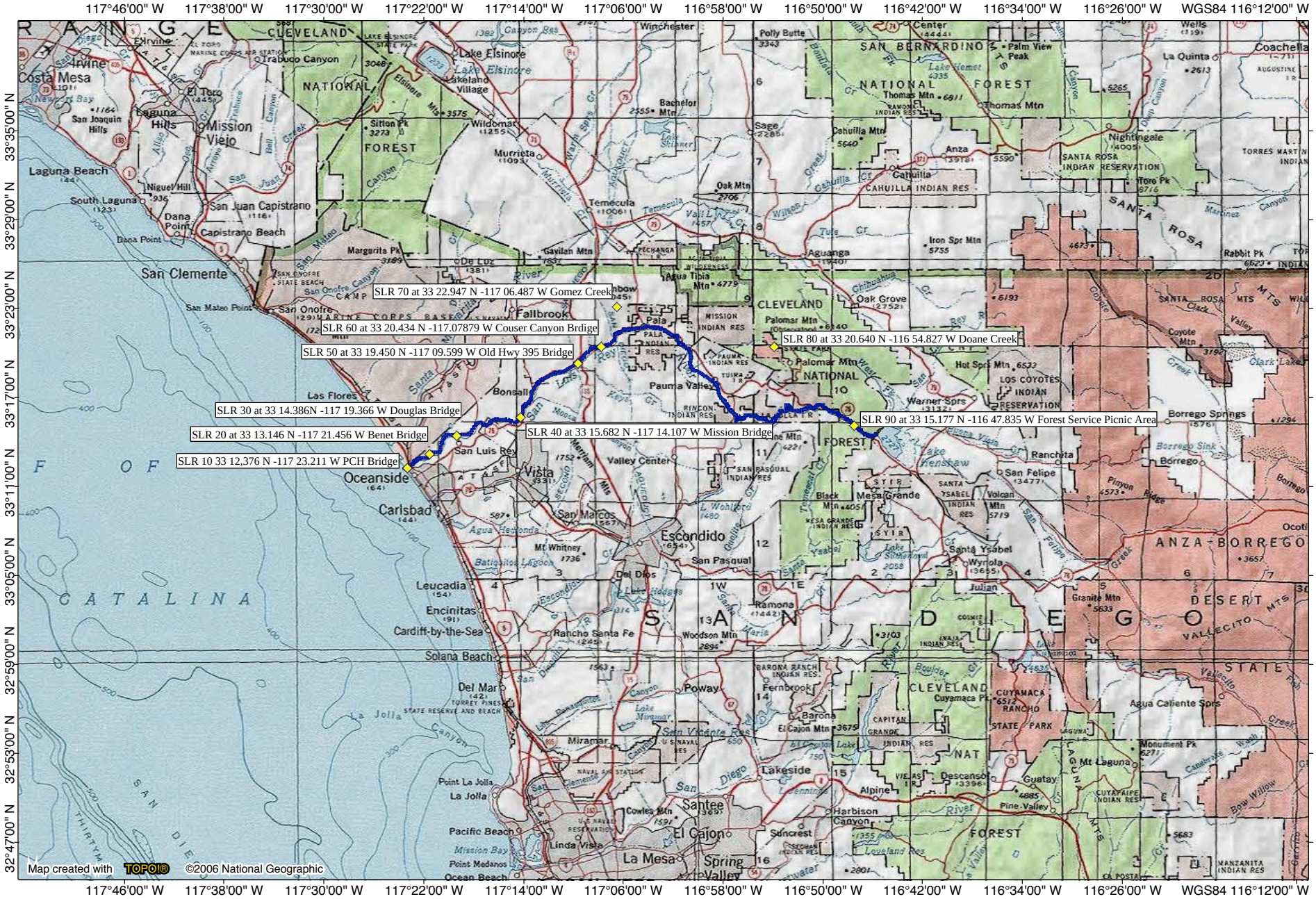
We thank TU-SD project team leaders: conservation co-chairs Frank Kawasaki and Jack Marshall, and previous conservation chair Sandi Jacobson for the many hours rounding up volunteers and feeding them, doing water quality monitoring, tracking water temp loggers, and reviewing and discussing data.

We thank the many volunteers from Golden State Flycasters and Trout Unlimited-San Diego who participated on weekends, and sometimes weekdays, to travel throughout the San Luis Rey River watershed doing water chemistry and bioassessment sampling. Your efforts are what made this project possible and we greatly appreciate your time, talents and interest. Rich Leibig, Tom Schiff, Jerry Wilson, Dave Kerr, Carol McCabe, Bob Hillestad, Barb Pentoney, Linda Ivor, Chris Steinhardt, Bruce Granquist, Joe Sarnecky, Jim Brown, Tom French, Dan Hober, Mac McCollum, Wayne Johnson, Pierce Flynn, Terry Charboneau, John Charboneau, Mike McVey, Mike Hamilton, Don Brooks, Rod Hendrickson, Jay Hood, Bruce Jenkinson, Bruce Hendershot, Beth Hendershot, Frank Grant, Brandon Grant, Michael Andre, Dale Dalrymple, and team leaders Frank Kawasaki, Jack Marshall, Sandi Jacobson and Skip Price (who unfailingly did the long trip and hike into Pauma Creek). Please forgive any unintentional omissions of those that participated.

San Luis Rey Water Chemistry Data
April 2008 - Dec 2009

Site 10: Estuary
Site 20: Benet Bridge
Site 30: Douglas Bridge
Site 40: Mission Road Bridge
Site 50: Old Hwy 395 / I-15
Site 60: Couser Canyon Bridge
Site 70: Gomez Creek
Site 80a: Doane Creek
Site 80b: Pauma Creek
Site 90: Forest Service Picnic Ground

TOPO! map printed on 01/12/09 from "SanLuisReyWaterChemistrySites.tpo"



NATIONAL GEOGRAPHIC

0 5 10 15 20 miles
0 5 10 15 20 25 30 km

TN MN
12.5°
01/12/09

High resolution topos of sites are available for viewing at:

http://www.california-fly-fishing.org/GSF-CMS/index.php?page=slr-interim-report

San Luis Rey River Water Chemistry Sites (Section I, SLRR Interim Report)

10 (Estuary) and Site 20 (Benet Bridge)	p. 10
30 (Douglas Bridge)	p. 11
40 (Mission Rd. Bridge)	p. 12
50 (Old Hwy 395/ I-15) and 60 (Couser Canyon)	p. 13
70 (Gomez Creek)	p. 14
80a (Doane Creek) and 80b (Pauma Crreek)	p. 15
90 (Forest Service Picnic Ground near Lake Henshaw)	p. 16

Water Chemistry Parameter Descriptions

From the Community Clean Water Institute, Mid Russian River Water Quality Results, 2004 at http://www.ccwi.org/issues/MidRussianRiver04pdf. Below are descriptions of water chemistry parameters relevant to this study, and concise discussions of factors that impact these parameters. Two parameters (water temperature and dissolved oxygen) also have short discussions regarding recommended ranges for salmonid survival. CCWI references two sources for their information: a) EPA: Volunteer Stream Monitoring: A Methods Manual and b) State Water Resource Control Board Fact Sheets.

Water temperature

Temperature is the measure of the average kinetic energy of water molecules. Temperature changes are caused by weather, removal of shading vegetation, alterations to stream flow by dams and other barriers, storm water runoff, cooling water discharges from industries, and suspended sediment as it absorbs heat. Both biological and chemical processes are affected by temperature. For fish, there are two main limitations. There are those that can be tolerated for short periods and weekly average temperatures that vary with the different life cycles. Adult salmon can survive temperatures up to 22 degrees Celsius* for short periods of time, but longer exposure may result in death. Growth impairment begins around weekly averages of 18 for juveniles and embryo mortality can occur at 13 degrees Celsius. The optimum temperature for spawning is around 10 degrees Celsius. Temperature influences the amount of dissolved oxygen in the water, pH, conductivity, the rate of photosynthesis, metabolic rates of organisms, and sensitivity of organisms to toxic elements, parasites, and disease.

**These values may be more applicable to N. California salmonids, populations that have been studied in more detail. In contrast, a report by Spina (2007) demonstrates that for juvenile steelhead in S. California, "Steelhead held focal points at temperatures (17.4°C -24.8°C) that were at times higher than the temperature preferences and heat tolerances reported for the species...Analyses of achievable body temperatures, an index of observed body temperatures, and behavioral time budgets, indicate steelhead did not behaviorally thermoregulate. Oversummering juvenile steelhead accept an elevated body temperature and remain active and forage throughout the day, apparently as a means for coping with warm water at the southern extent of their range. " Anthony Spina (2007) Thermal ecology of juvenile steelhead in a warm-water environment. In Environ. Biol. Fish. Streams studied were Arroyo Sequit, Solstice Creek and Topanga Creek: small coastal streams originating in the Santa Monica Mountains, Los Angeles County, California.*

Dissolved oxygen

Dissolved oxygen is essential for the survival of most aquatic organisms. Dissolved oxygen has two main sources. At the air-water interface oxygen is dissolved into the water through processes like turbulence. Oxygen is also produced through plant photosynthesis. Dissolved oxygen has an inverse relationship to water temperature. As water temperature increases dissolved oxygen levels decrease.

Another factor that leads to decreased DO is an increase in animal waste and human waste from sewage. Bacteria will use up more oxygen in order to decompose the

increased levels of organic material. Low dissolved oxygen levels can impair growth and survival of the salmonids that inhabit the creek. Adult salmonids require less oxygen than the embryo and larval stages. For adults and juveniles growth begins to become impaired below 8 mg/L and for embryo and larval stages growth is affected at levels below 11 mg/L. Acute mortality occurs at 6 mg/L and below for embryo stages and adult mortality can occur at 3 mg/L and below.

Conductivity

Conductivity is the measure of water's ability to conduct an electrical current through dissolved ions. These ions include sodium, calcium, potassium, magnesium, iron, aluminum, chloride, sulfate, carbonate, and bicarbonate. The recommended conductivity for streams supporting good mixed fisheries is between 150 and 500 uS. The main impact of increased conductivity is a decline in dissolved oxygen levels. The natural causes of conductivity include granite bedrock, clay soils, and evaporation. Granite bedrock will lower conductivity because it does not ionize easily. Clay soils will increase conductivity because the clay will ionize when it contacts the water resulting in the production of more ions to conduct electrical current. Also evaporation of water increases the concentration of dissolved solids and salts which in turn will elevate conductivity during the summer months. Rain will dilute the ions resulting in lower conductivity during the winter months. Some human related factors that increase conductivity are failing sewage and septic systems. These malfunctions will dump chloride, phosphate, and nitrate into the waters. Another factor is that agricultural runoff contains high levels of dissolved salts. Organic compounds like oil, phenol, alcohol, sugar and other less conductive materials will decrease conductivity. These compounds will enter the water column through urban runoff.

pH

pH represents the concentration of hydrogen ions. It measures how acidic or basic the water is. According to the Regional Water Board, the pH should remain between 6.5 and 8.5 for fresh water communities in order to protect the organisms. Many aquatic organisms can only survive between this narrow pH range. Changes in the pH may elevate the concentrations of other elements to higher toxicity and amplify their effects. Some factors that may result in more basic waters (>7 pH) , are algal growth, limestone, marble, and bleach. Excess nutrient levels due to anthropogenic pollutants cause increased algae growth which in turn raises pH levels. Some factors that produce more acidic waters (<7 pH), are acid rain, acid mine drainage, and sulfur fertilizers. Decomposing organic matter and root respiration also decreases the pH because the carbon dioxide byproduct of these processes forms a weak organic acid in water. In the winter months pH tends to be slightly higher due to increased nutrient levels as a result of runoff from winter storms. The warmer temperatures during the summer months produce lower pH levels.

Nitrate

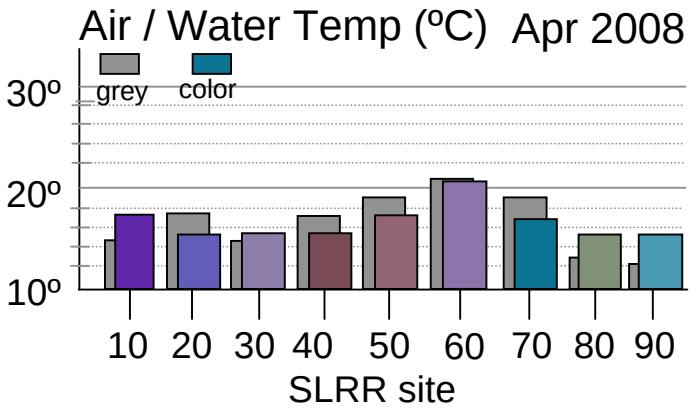
Nitrogen is found in several forms as it cycles through the water column. It moves from organic matter to ammonium (NH_4), to nitrite (NO_2), and then to nitrate (NO_3) as bacteria break down the organic matter. Increased levels of nitrate are caused by fertilizers,

sewage disposals, (ie septic systems and wastewater treatment plants), livestock facilities, and industrial discharge. Natural levels in surface waters are less than 1 mg/L but wastewater treatment runoff can be as high as 30 mg/L. Excess levels maybe toxic to warm blooded animals at concentrations of 10 mg/L or higher. High levels may also result in eutrophication which is a condition where the increased nutrients lead to increased production. This causes algal blooms and decreases in dissolved oxygen due to elevated decomposition.

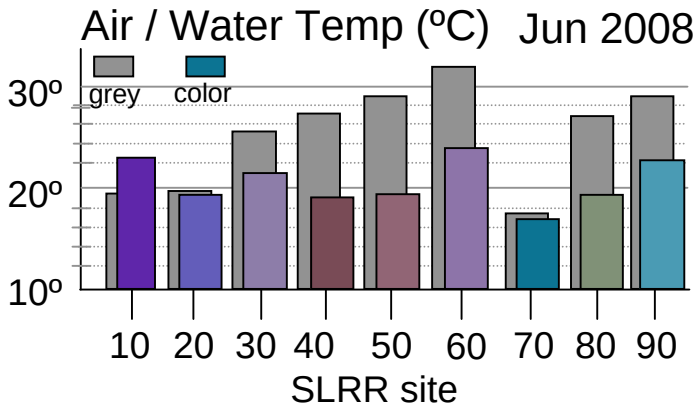
Phosphate

Phosphate (PO_4) is converted to phosphorus by plants. Phosphorus can be found as three different types. Orthophosphorus is produced by sewage. Polyphosphorus is used in detergents and organic phosphorus is produced in the break down of pesticides. The USEPA recommends that phosphate levels for streams not be higher than 0.1 mg/L. Increased levels can result in algal blooms, eutrophication and decreased oxygen.

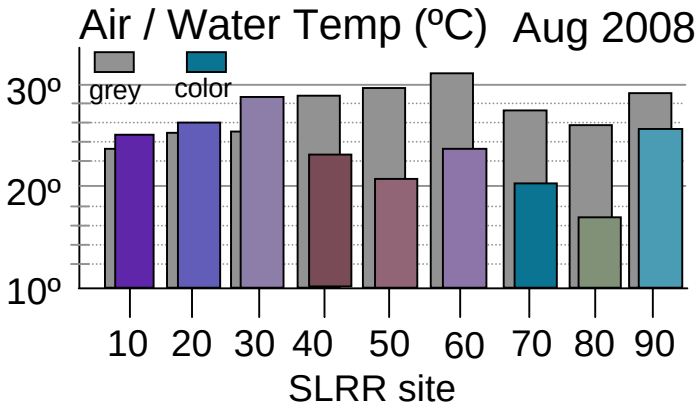
San Luis Rey River 2008 Air / Water Temp (ºC)



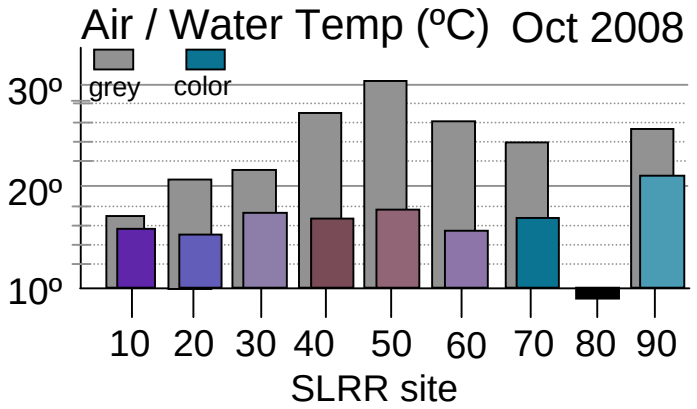
H_20	16.7	15.8	15.8	15.8	17.3	20.4	16.9	15.7	15.7
Air	14.5	17.2	14.7	17.3	18.5	20.5	19.0	13.0	12.8



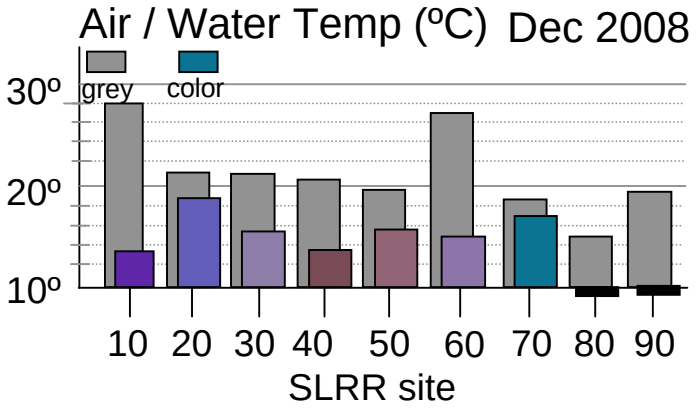
H_20	22.1	18.9	20.8	18.6	19.2	23.5	16.5	18.5	22.0
Air	19.5	19.7	24.7	27.0	28.6	33.0	17.6	26.4	28.5



H_20	24.3	25.9	28.2	22.5	20.5	23.1	20.1	16.2	25.0
Air	23.3	24.9	25.3	28.5	29.7	31.3	26.7	25.8	28.8



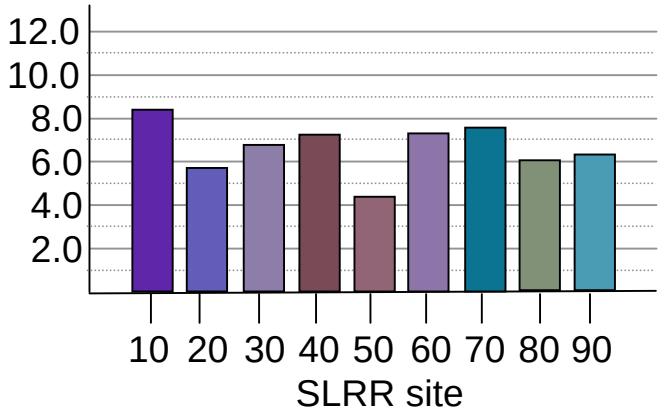
H_20	15.5	15.1	17.1	16.8	17.7	15.5	16.5	dnm	20.9
Air	17.2	20.5	21.3	27.0	30.3	26.0	24.0	dnm	25.3



H_20	13.5	18.3	15.3	13.4	15.5	14.5	16.3	9.8	8.4
Air	28.0	20.7	21.0	20.5	19.7	26.8	18.2	14.5	19.8

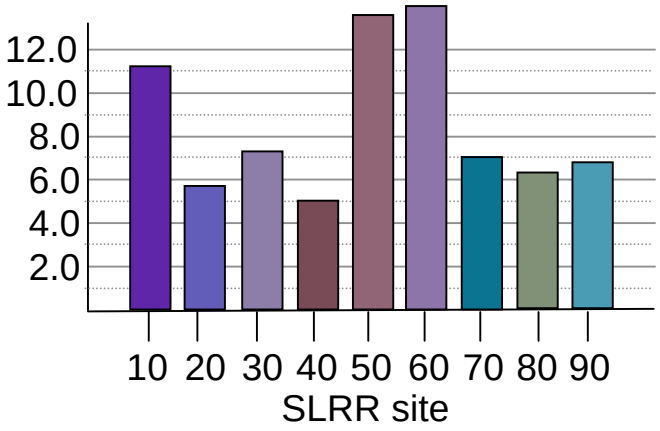
San Luis Rey River 2008 Dissolved Oxygen (mg/L)

DO (mg/L) Apr 2008



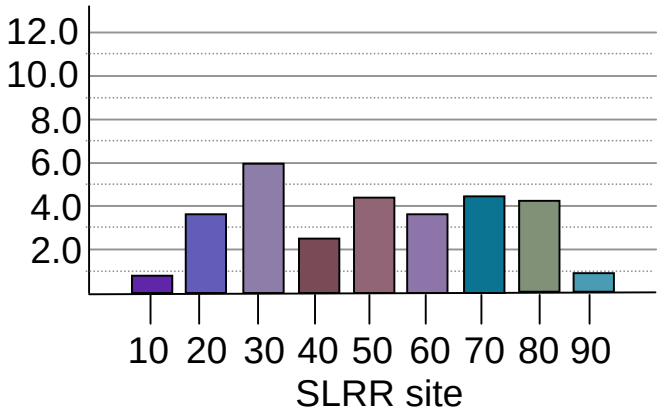
8.3	5.7	6.6	7.2	4.3	7.1	7.3	6.0	6.1

DO (mg/L) Jun 2008



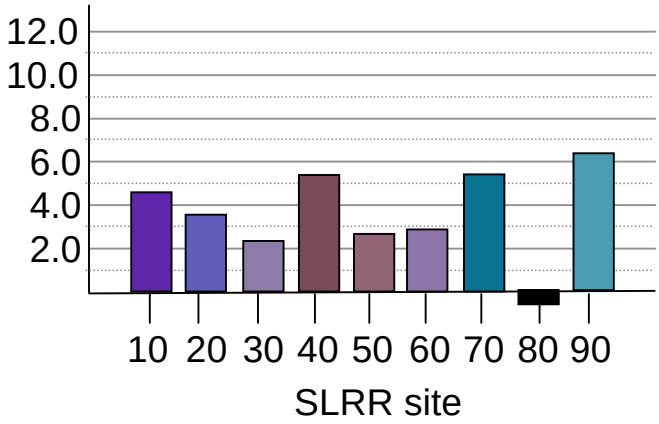
11.2	5.7	7.2	4.8	13.8	14.2	7.0	6.1	6.7

DO (mg/L) Aug 2008



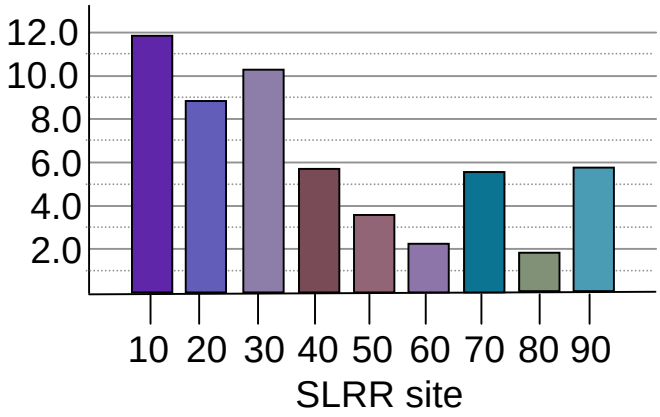
0.5	3.3	6.0	2.3	4.5	3.6	4.4	4.2	.83

DO (mg/L) Oct 2008



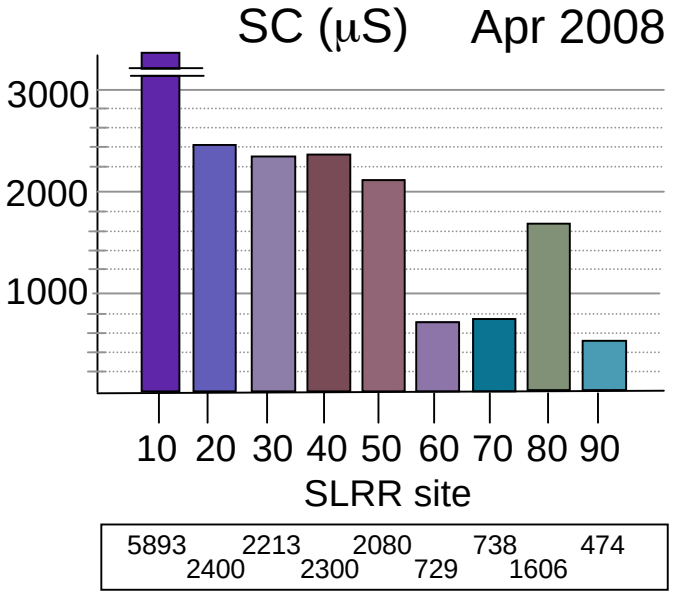
4.4	3.3	2.3	5.3	2.6	2.9	5.3	dnm	6.4

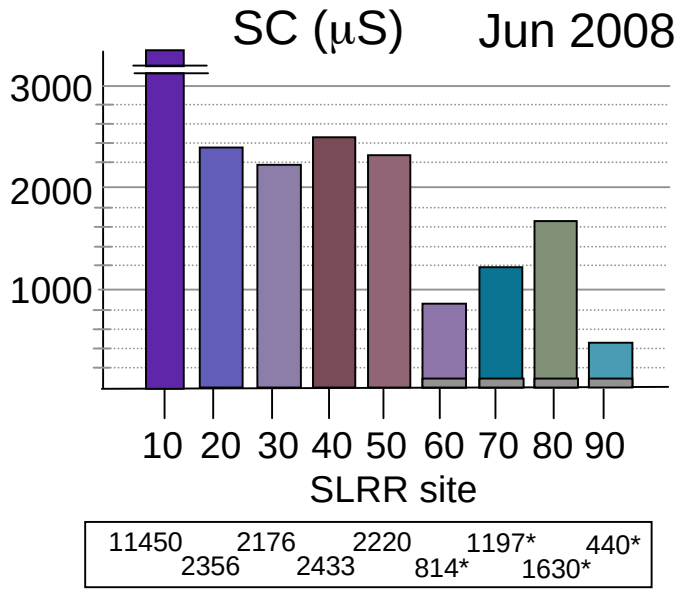
DO (mg/L) Dec 2008

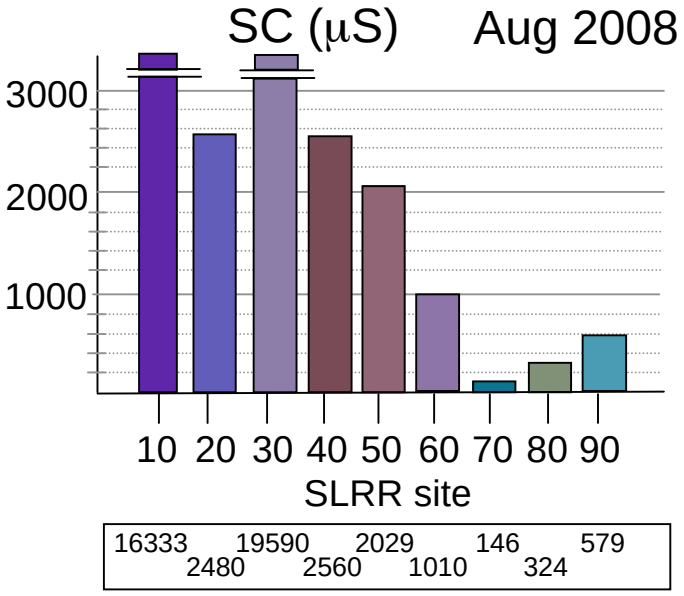


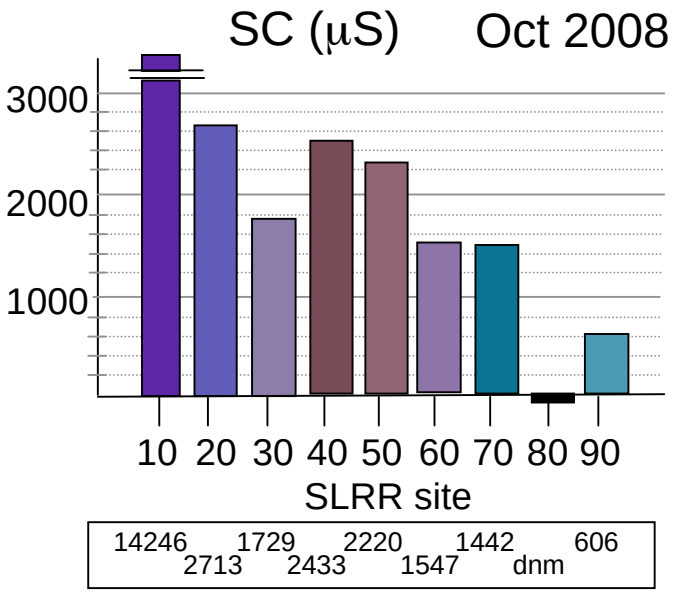
11.8	8.8	10.1	5.6	3.4	2.0	5.3	1.9	5.7

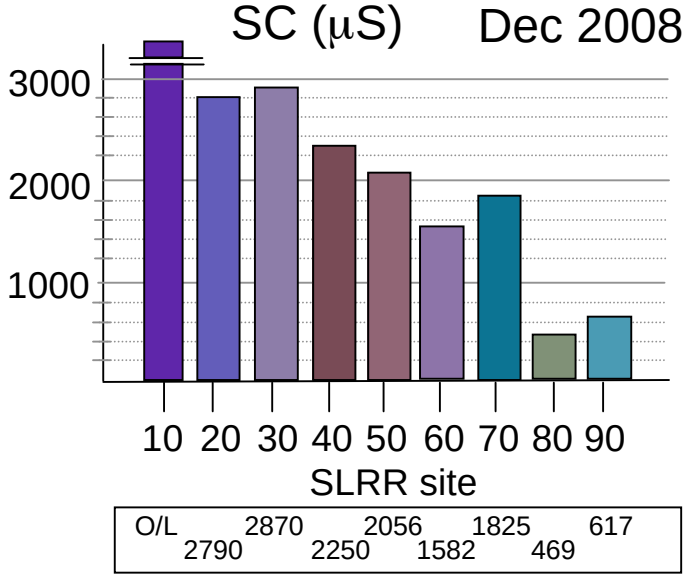
San Luis Rey River 2008 Specific Conductivity (µS)





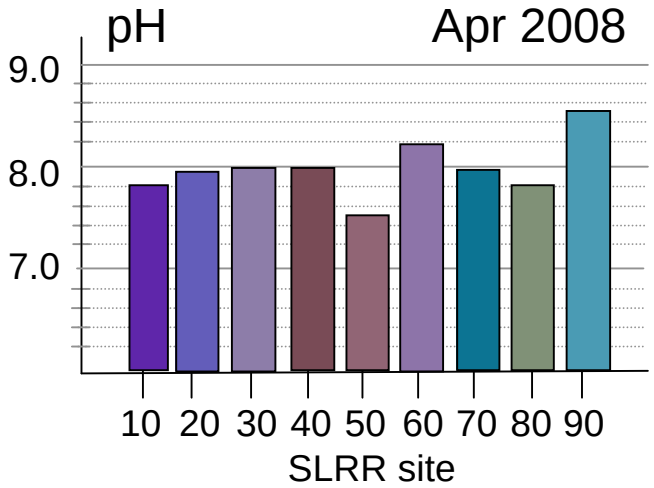




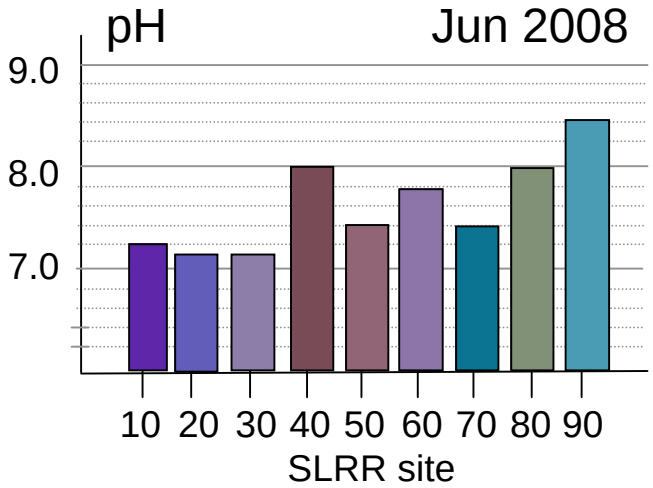


*Jun 2008 Conductivity Readings Sites 60-90 Average SC values likely transcription error, so not included in spreadsheet, but shown here with orig values in grey; unit-adjusted values in color. For example: Site 60 recorded as 8.14 uS, s/b 814 uS.

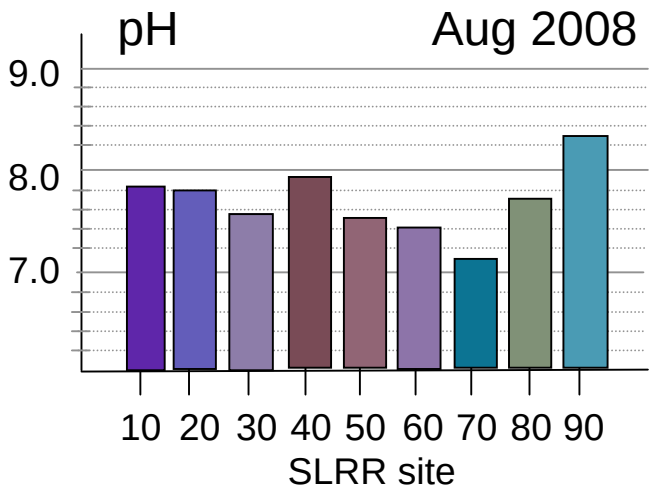
San Luis Rey River 2008 pH



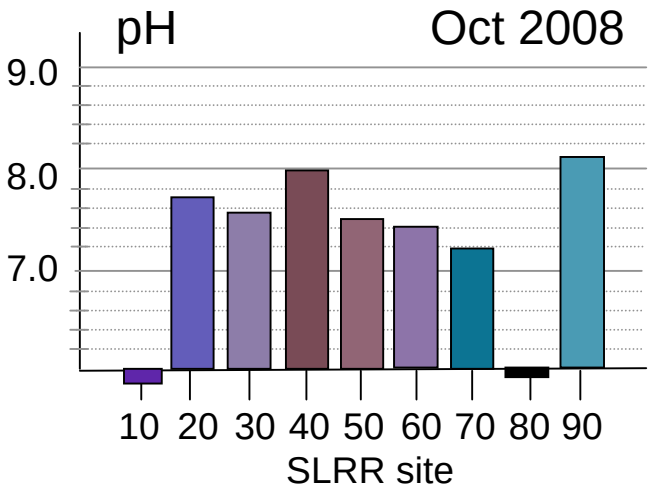
8.0	7.9	8.0	8.0	7.5	8.2	8.0	7.8	8.5



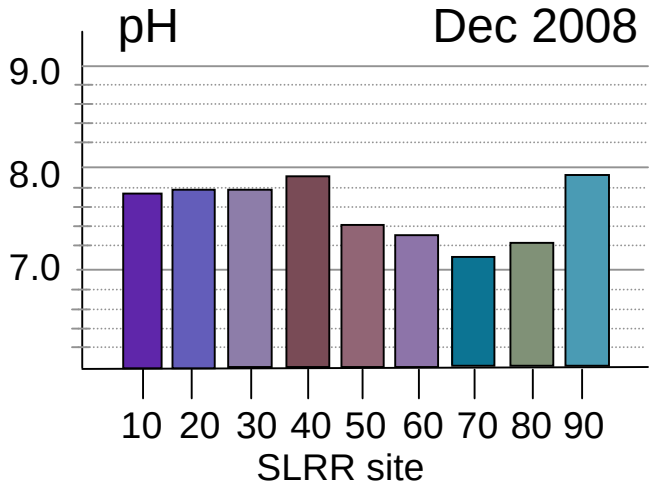
7.2	7.1	7.1	8.0	7.4	7.8	7.4	8.0	8.4



7.8	7.8	7.5	7.9	7.5	7.4	7.1	7.7	8.3



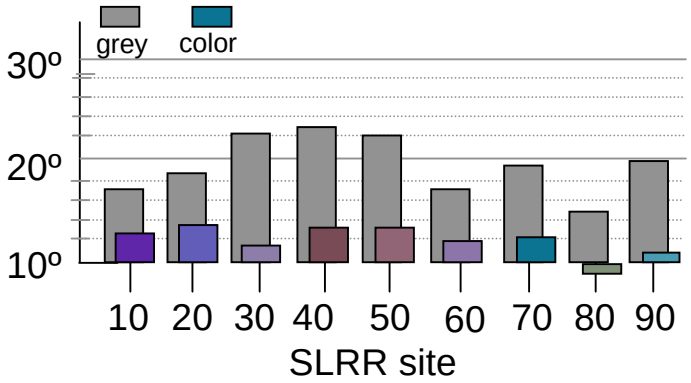
5.3	7.7	7.5	8.0	7.5	7.4	7.2	dnm	8.1



7.7	7.8	7.8	7.9	7.4	7.3	7.1	7.2	7.9

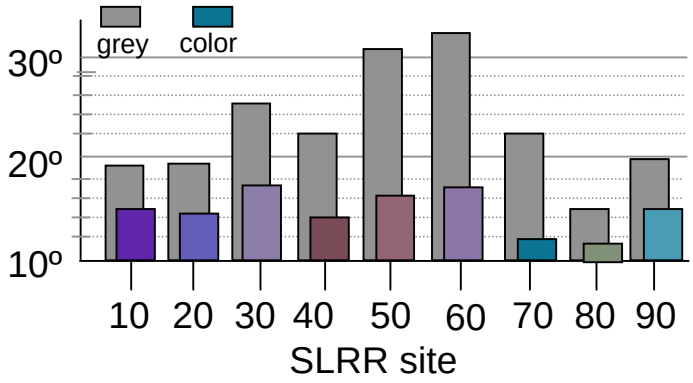
San Luis Rey River 2009 Air / Water Temp (ºC)

Air / Water Temp (ºC) Feb 2009



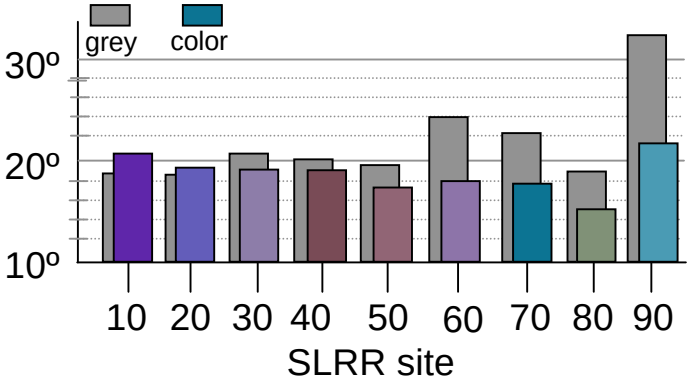
H_2O	12.2	12.8	10.9	12.1	13.1	11.5	12.1	5.7	9.9
Air	16.7	18.3	22.0	23.0	22.0	17.2	19.0	15.0	20.0

Air / Water Temp (ºC) Apr 2009



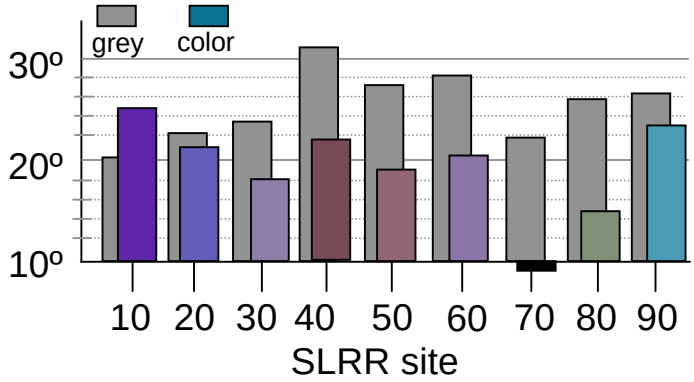
H_2O	14.2	14.0	17.6	13.8	15.8	17.1	11.8	11.5	15.1
Air	19.7	19.8	24.8	22.0	31.0	33.0	22.0	15.2	20.0

Air / Water Temp (ºC) Jun 2009



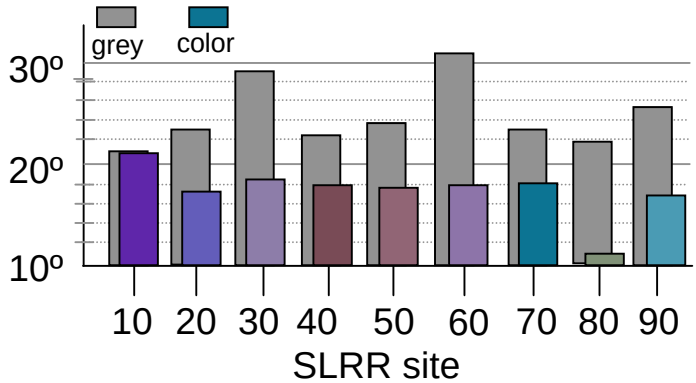
H_2O	20.2	18.9	19.0	18.7	17.3	17.8	17.9	15.1	21.8
Air	18.5	18.1	20.2	20.0	19.7	24.0	22.0	19.5	34.0

Air / Water Temp (ºC) Aug 2009



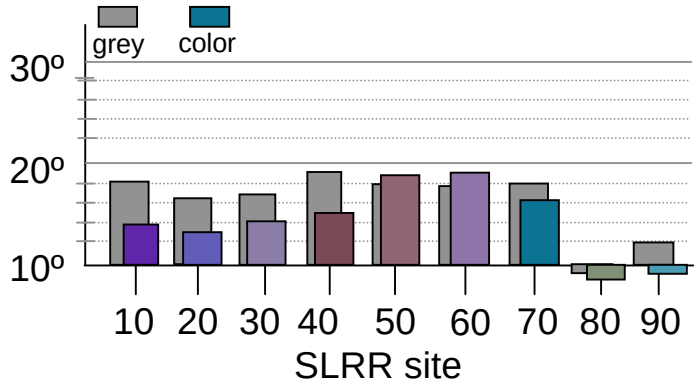
H_2O	25.1	20.9	17.9	20.8	18.9	20.0	dnm	14.1	23.5
Air	20.0	22.0	23.1	32.0	27.3	28.0	22.0	24.9	26.0

Air / Water Temp (ºC) Oct 2009



H_2O	20.8	17.2	17.9	17.2	17.3	17.9	18.0	10.8	14.9
Air	21.3	23.0	29.5	22.3	24.0	32.0	23.0	21.9	24.9

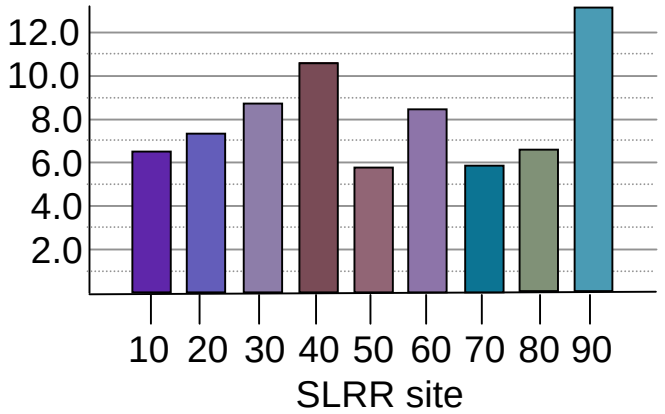
Air / Water Temp (ºC) Dec 2009



H_2O	13.6	12.5	14.0	15.1	18.2	18.8	16.1	7.1	8.1
Air	18.0	16.0	17.0	19.3	17.6	17.5	18.0	8.7	12.0

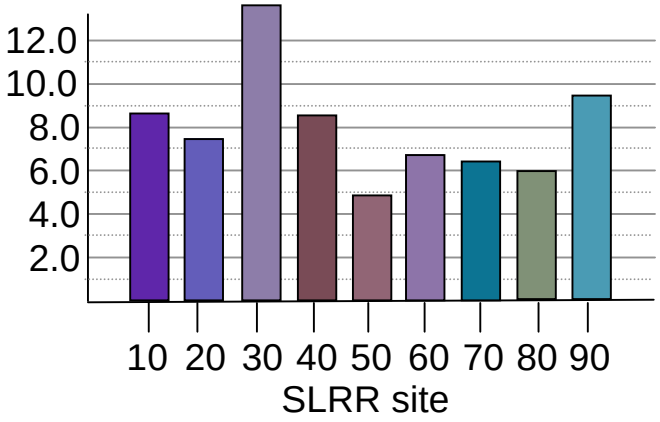
San Luis Rey River 2009 Dissolved Oxygen (mg/L)

DO (mg/L) Feb 2009



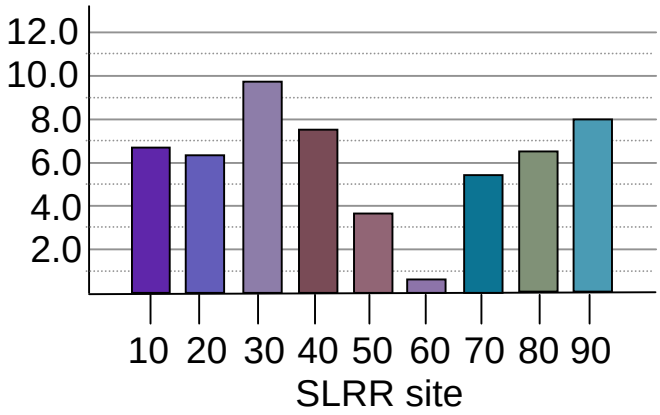
6.4	7.6	8.7	10.5	5.8	8.4	5.9	6.5	13.3

DO (mg/L) Apr 2009



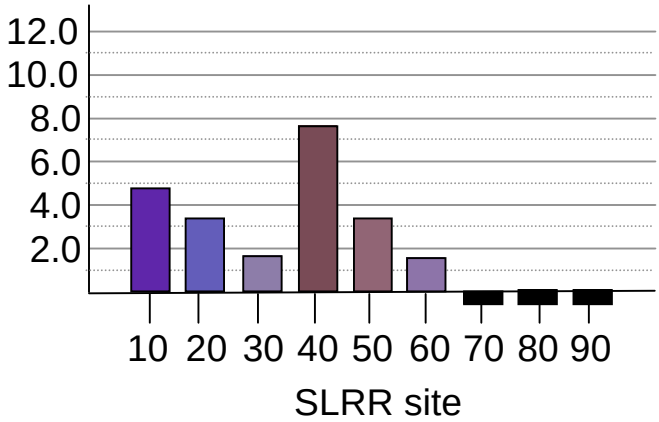
8.6	7.4	14.4	8.6	4.7	6.9	6.3	5.9	9.1

DO (mg/L) Jun 2009



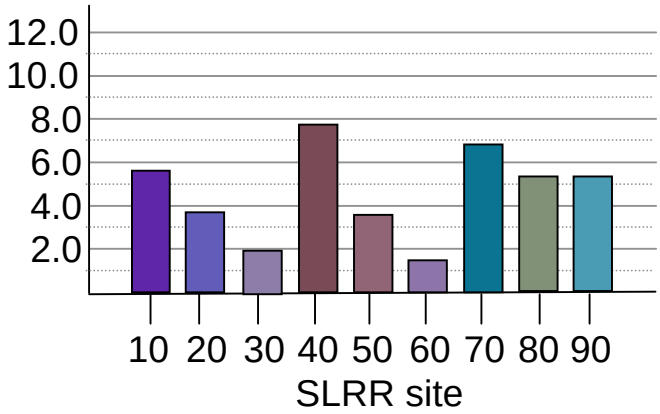
6.6	6.4	9.5	7.4	3.5	0.6	5.6	6.7	8.0

DO (mg/L) Aug 2009



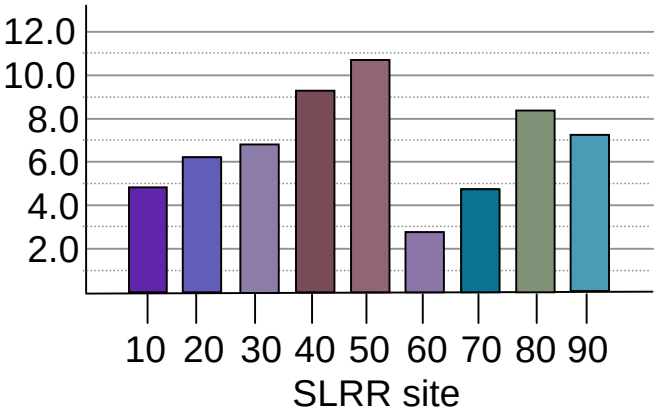
4.8	3.1	1.4	7.5	3.2	1.6	n/a	n/a	n/a

DO (mg/L) Oct 2009



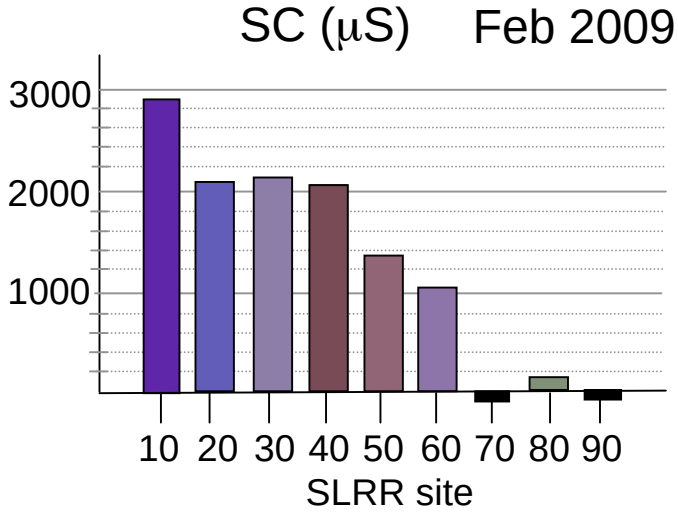
5.3	3.6	1.9	7.8	3.3	1.2	6.9	5.5	5.5

DO (mg/L) Dec 2009

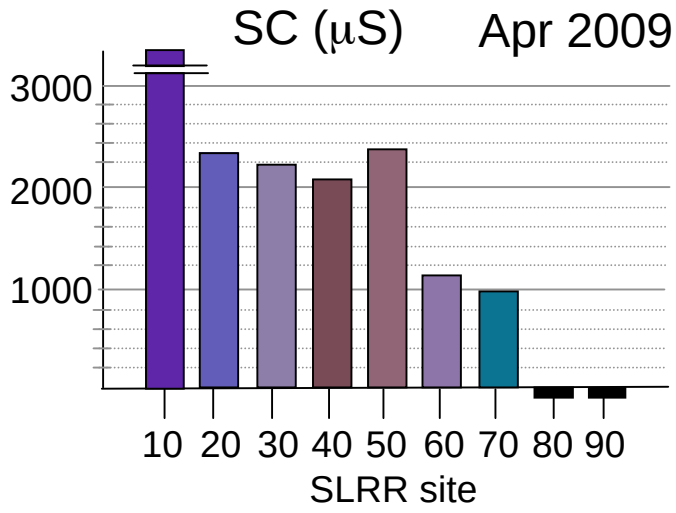


4.6	6.2	6.8	9.3	10.8	2.6	4.8	8.2	7.1

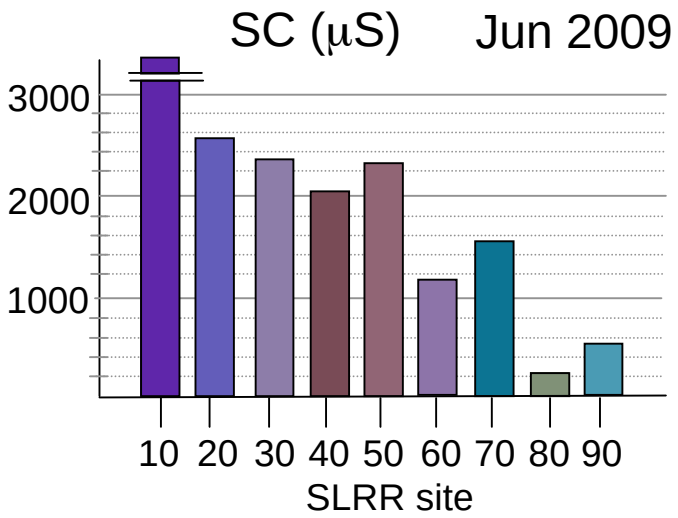
San Luis Rey River 2009 Specific Conductivity (µS)



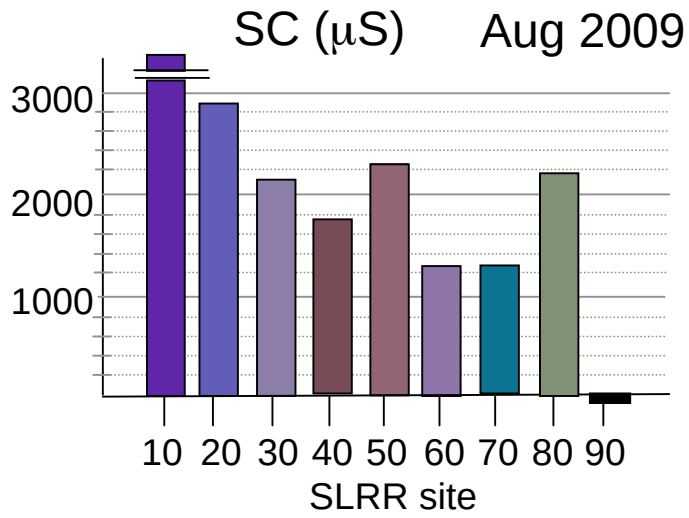
2863 2053 1364 n/a n/a
2043 2030 1052 170



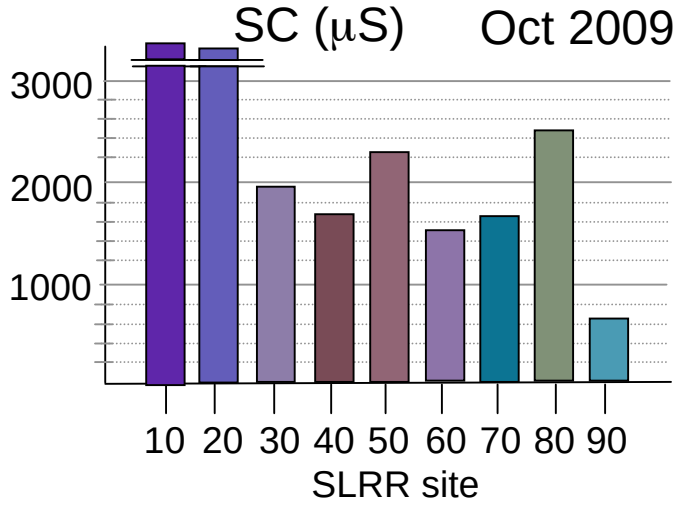
3530 2200 2361 1004 n/a
2300 2135 1093 n/a



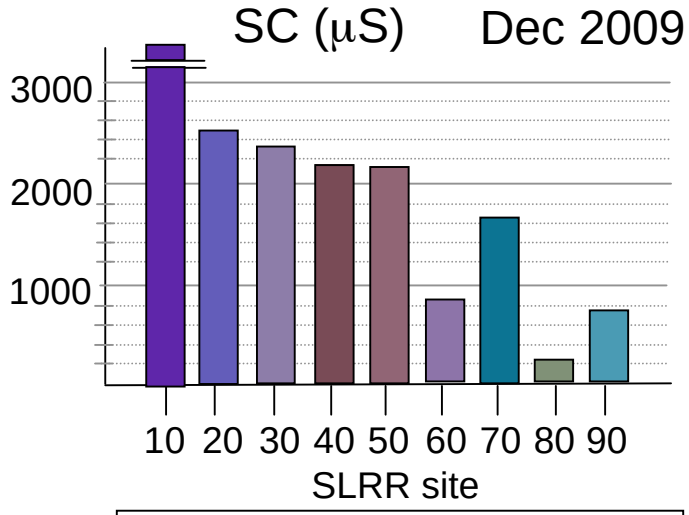
10417 2340 2263 1570 550
2440 2004 1183 207



23233 2145 2243 1365 n/a
2880 1786 1365 2190

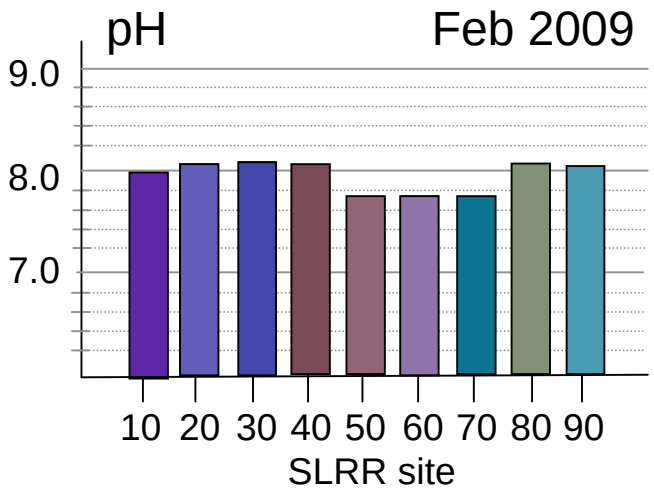


15653 1964 2259 1610 644
3367 1611 1511 2433

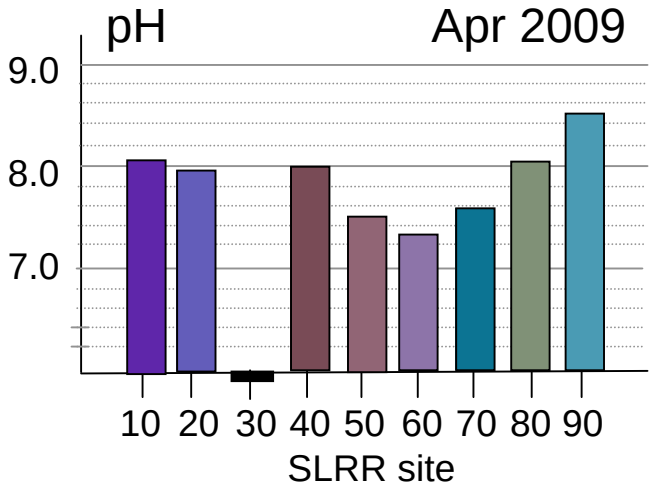


6550 2353 2110 1649 770
2487 2150 861 239

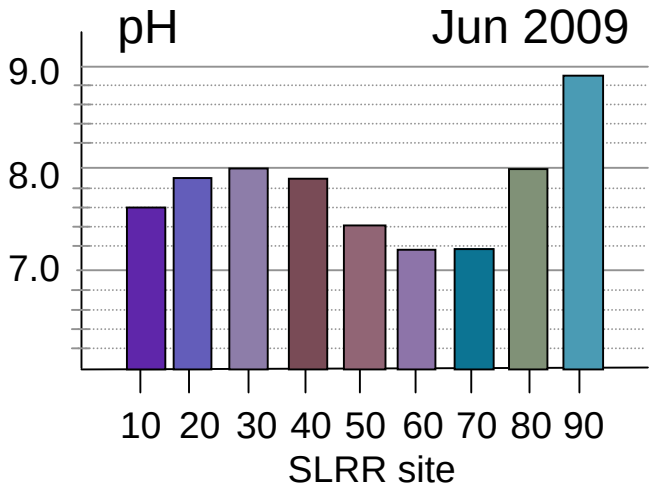
San Luis Rey River 2009 pH



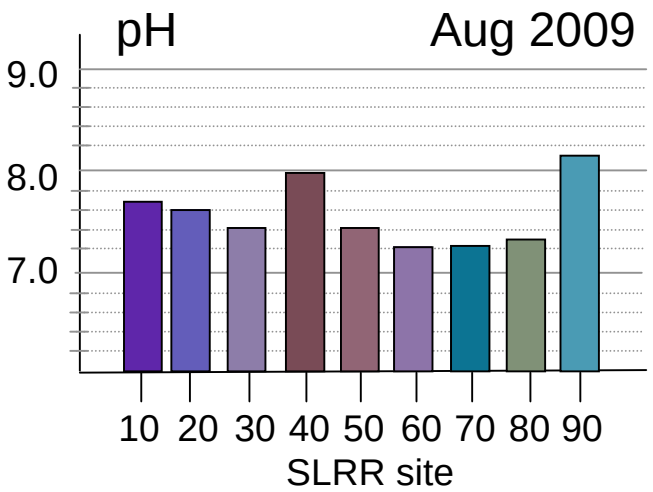
8.0	8.1	8.1	8.1	7.7	7.7	7.7	8.1	8.0



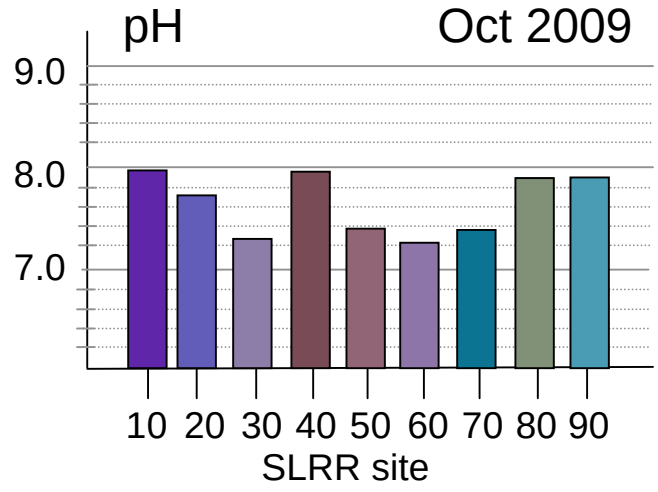
8.1	7.9	n/a	8.0	7.5	7.3	7.6	8.1	8.5



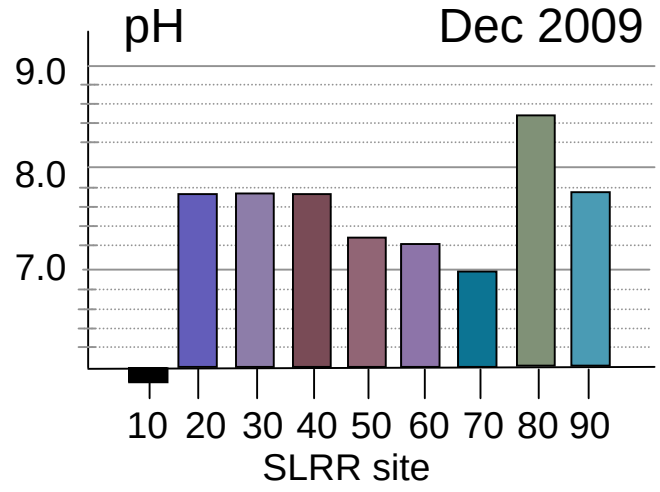
7.6	7.9	8.0	7.9	7.4	7.2	7.2	8.0	8.9



7.7	7.6	7.4	8.0	7.4	7.2	7.2	7.3	8.2



7.9	7.7	7.3	7.9	7.4	7.2	7.4	7.9	7.9

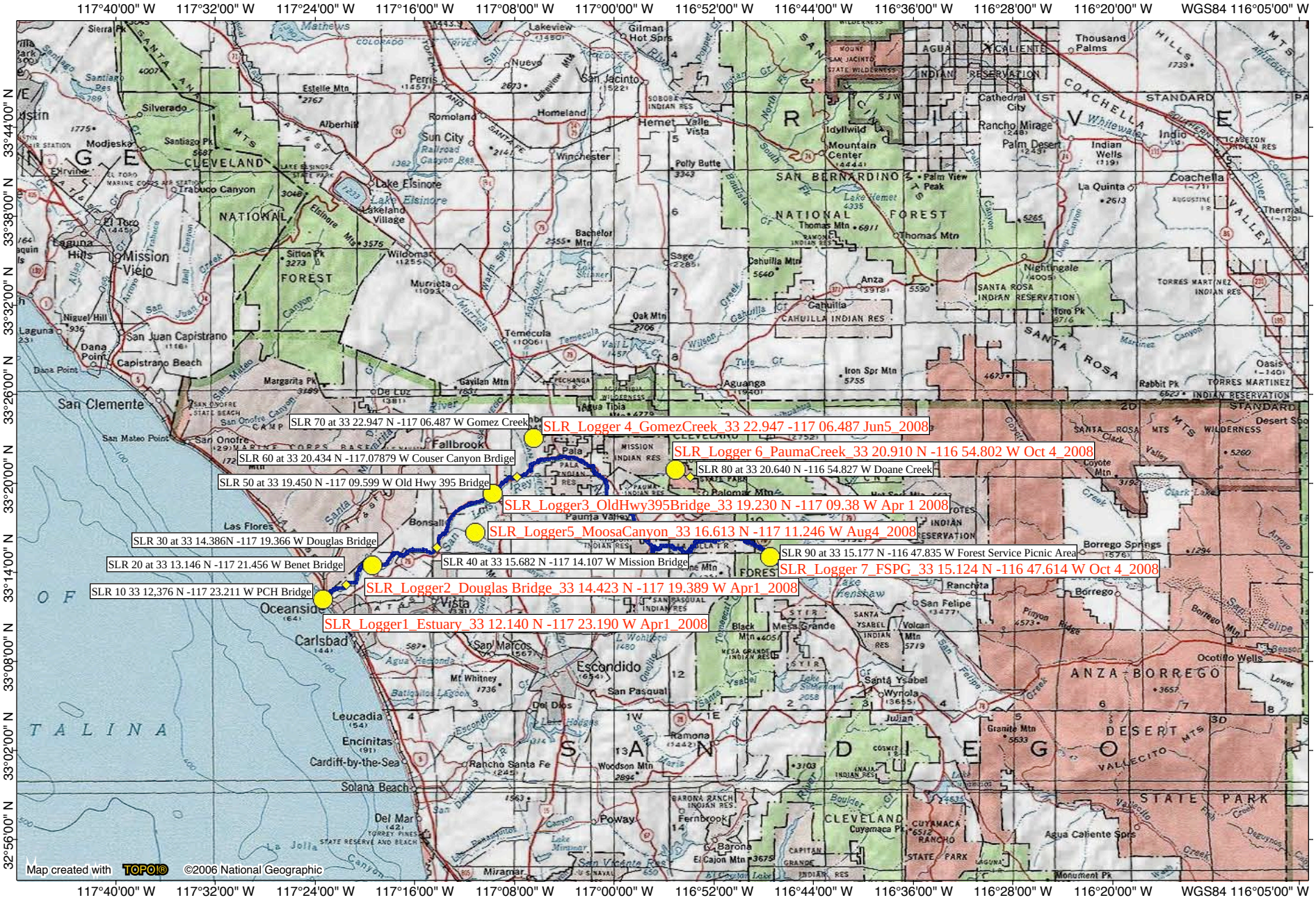


n/a	7.8	7.8	7.8	7.3	7.2	7.0	8.5	7.7

San Luis Rey River
Water Temperature Loggers
April 2008 - Dec 2009

Logger 1: Estuary
Logger 2: Douglas Bridge
Logger 3: Old Hwy 395 / I-15
Logger 4: Gomez Creek
Logger 5: Moosa Canyon
Logger 6: Pauma Creek
Logger 7: Forest Service Picnic Gd.

TOPO! map printed on 01/12/09 from "SanLuisReyWaterChemistrySites.tpo"



NATIONAL GEOGRAPHIC

0 5 10 15 20 miles
0 5 10 15 20 25 30 km

TN MN
12.5°
01/12/09

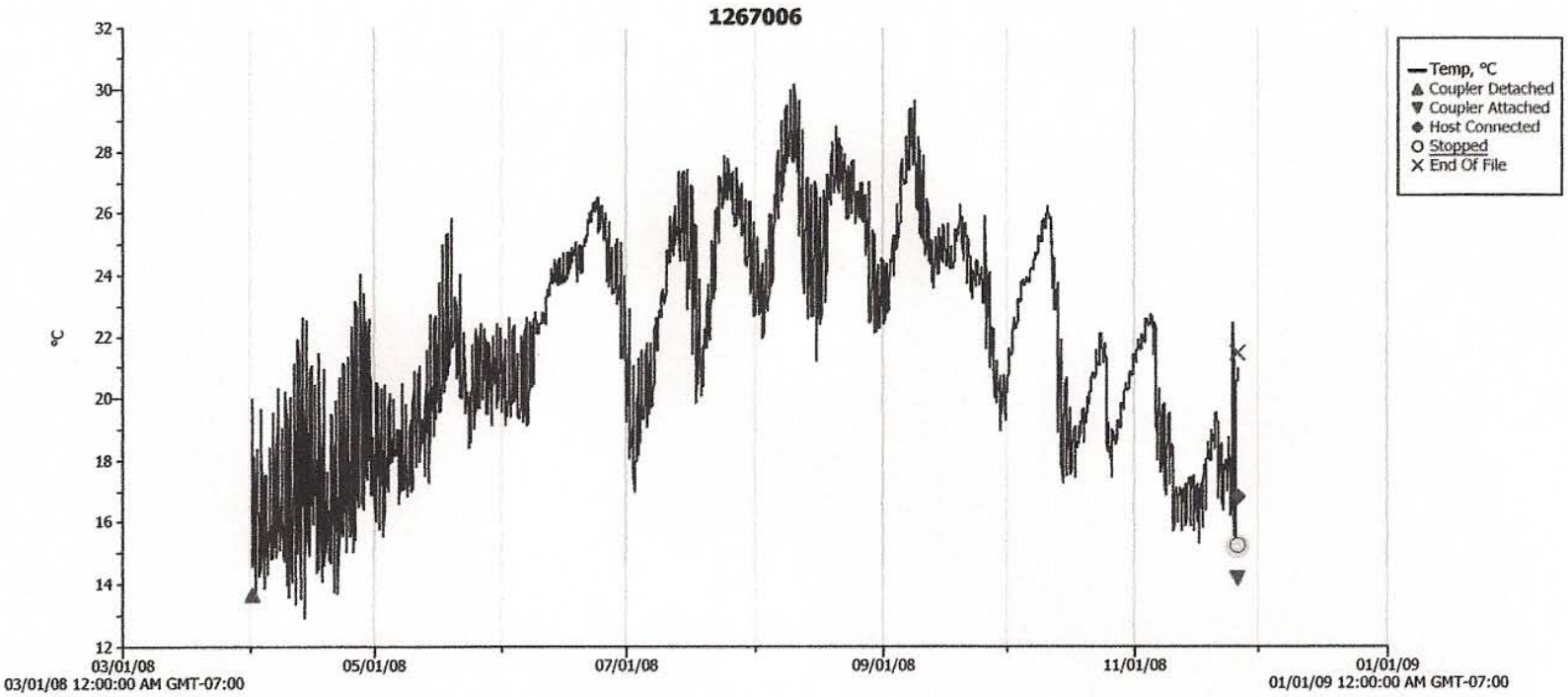
High resolution topos of sites are available for viewing at:

http://www.california-fly-fishing.org/GSF-CMS/index.php?page=slr-interim-report

San Luis Rey River Water Temperature Logger Sites (Section 2, SLRR Interim Report)

Logger 1 (Estuary) and Logger 2 (Douglas Bridge)	p. 40
Logger 3 (Old Hwy 395/I-15) and Logger 5 (Moosa Canyon Creek)	p. 41
Logger 4 (Gomez Creek)	p. 42
Logger 6 (Pauma Creek)	p. 43
Logger 7 (Forest Service Picnic Ground near Lake Henshaw)	p. 44

1_San Luis Rey River 2008 Estuary



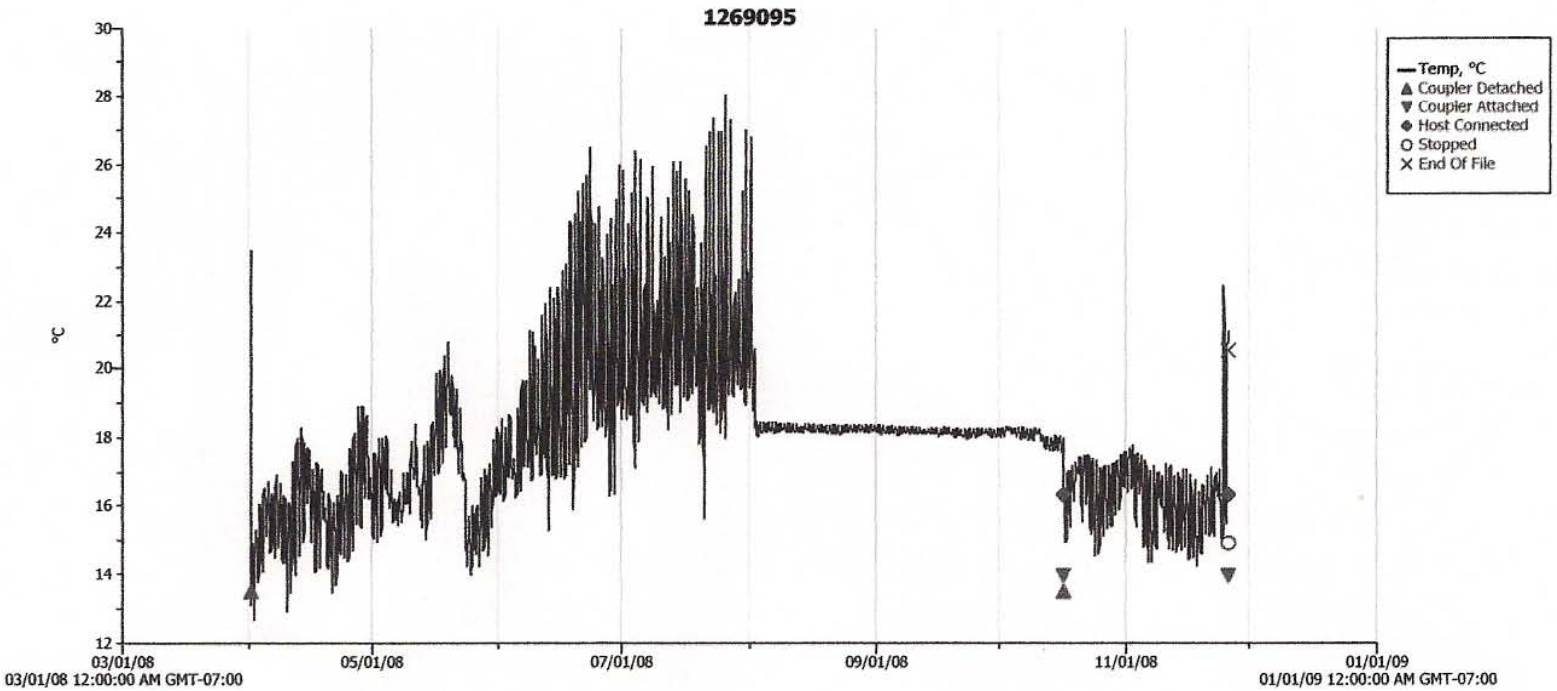
Logger placed

In estuary, logger housing and location (varying water depth and no canopy cover) may affect water temp readings especially during summer months due to sun exposure.

Logger stopped

For all graphs, diurnal temp change with temp min at about 4:00 a.m. and temp max at about 4:00 p.m.

2_San Luis Rey River 2008 Douglas Bridge



Logger placed 4/1/08

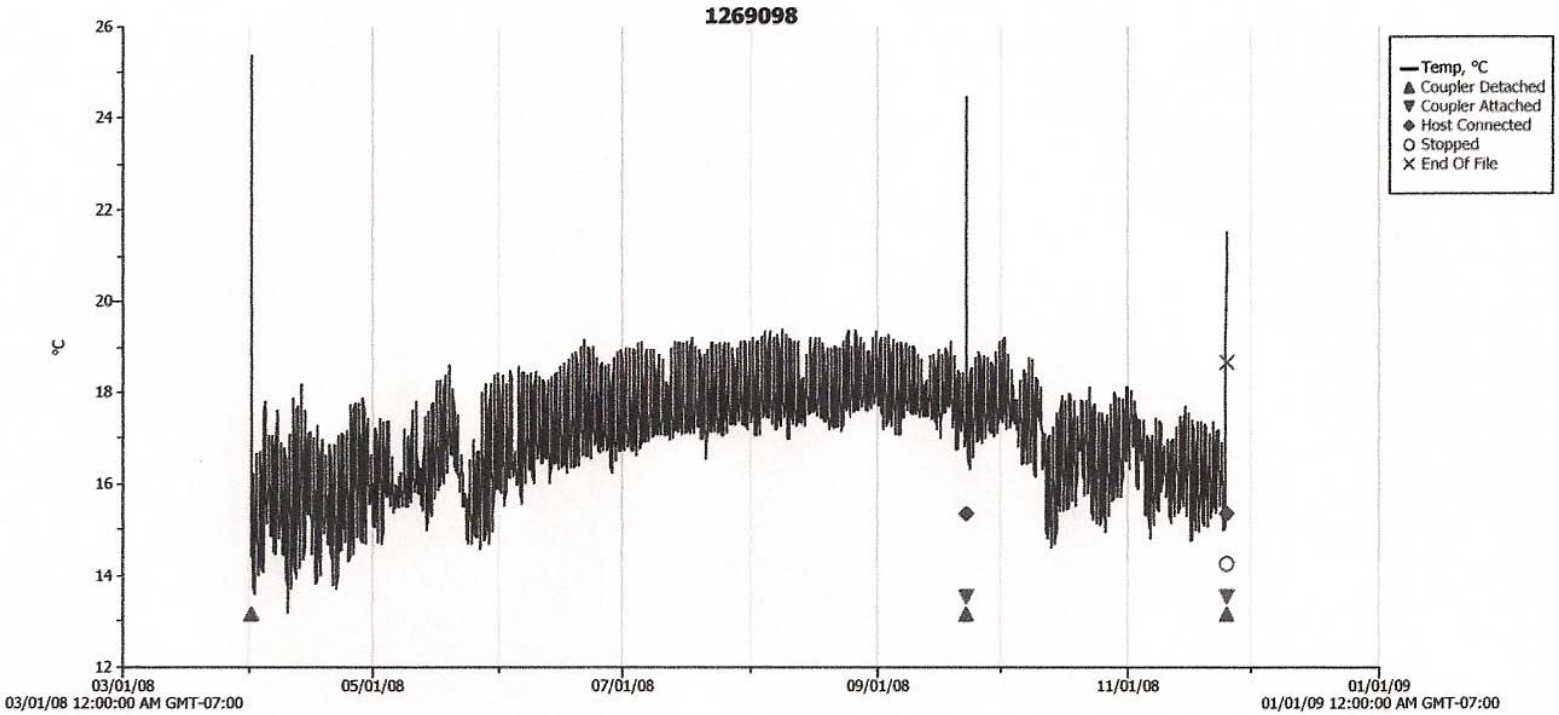
Channel gradually went drier; logger buried in mud and exposed to air for undetermined amt time

8/2/08; Logger repositioned 15 m downstream in pool 0.7m deep

10/16/08; Logger data downloaded, and placed back into pool at same location

Logger removed 11/24/08; read and stopped 11/25/08

3_San Luis Rey River 2008 Old Hwy 395 / I-15

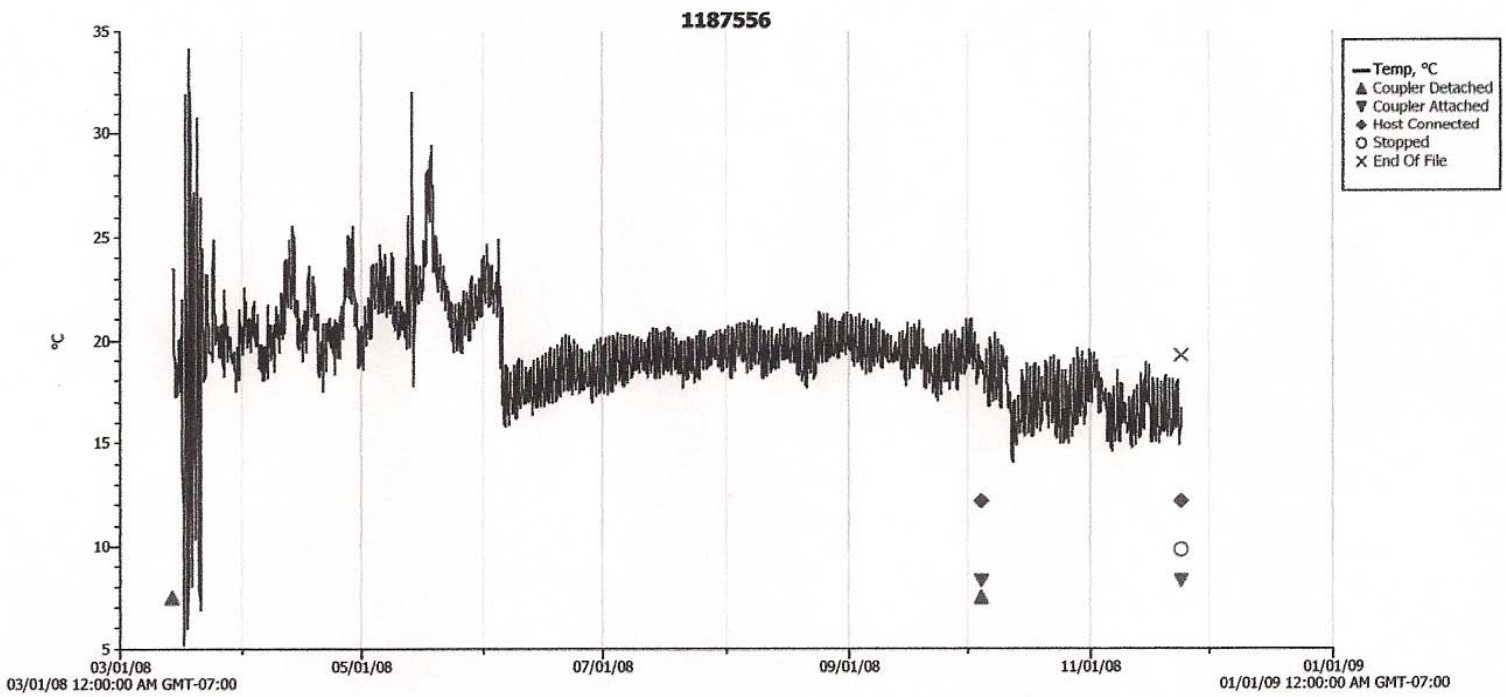


Logger placed 4/1/08

9/22/08; Logger data downloaded, and placed back Into same location

Logger removed, read and stopped 11/24/08

4_San Luis Rey River 2008 Gomez Creek



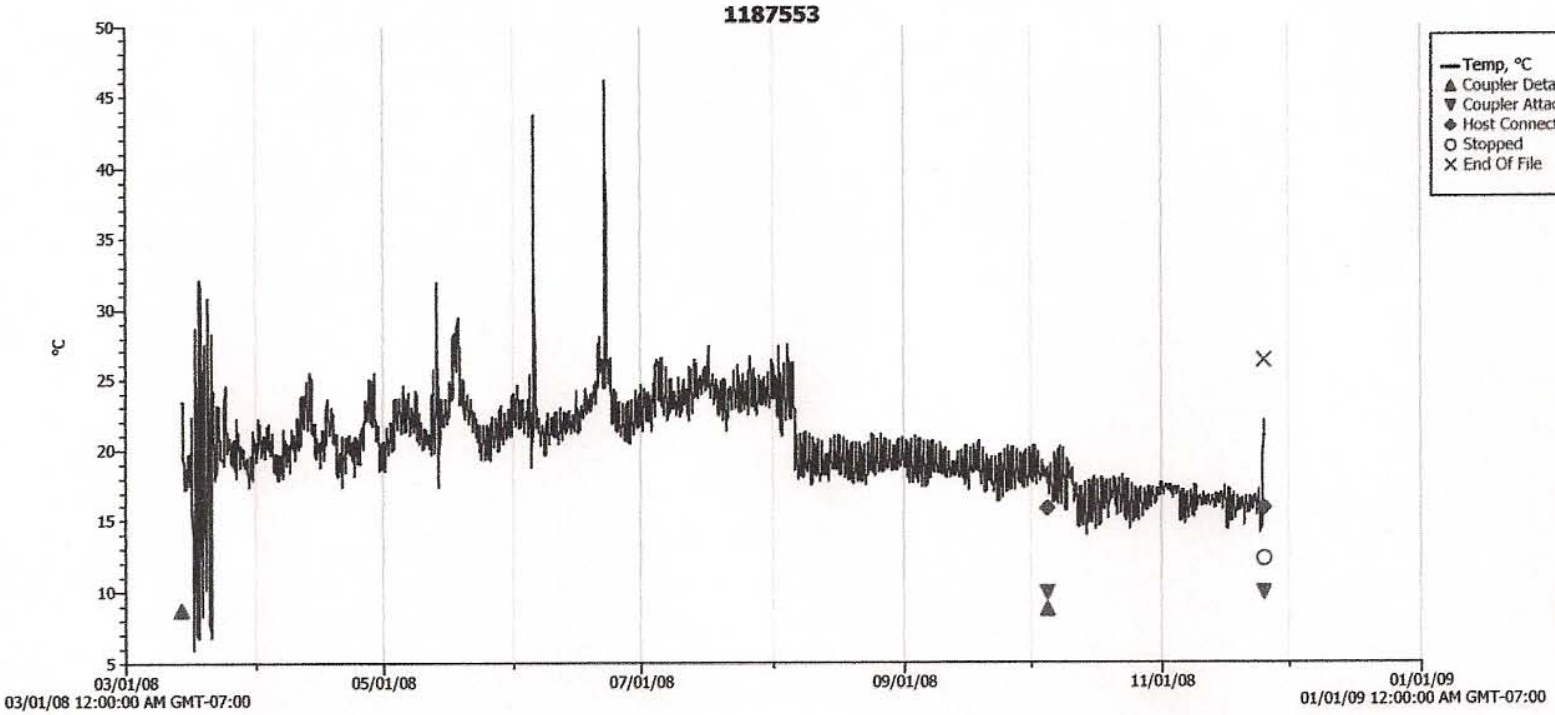
Device activated,
but not placed in water

Logger
placed
6/5/08

10/4/08 Logger
data downloaded,
and placed back
Into same location

Logger
removed,
read and
stopped
11/23/08

5_San Luis Rey River 2008 Moosa Canyon Creek



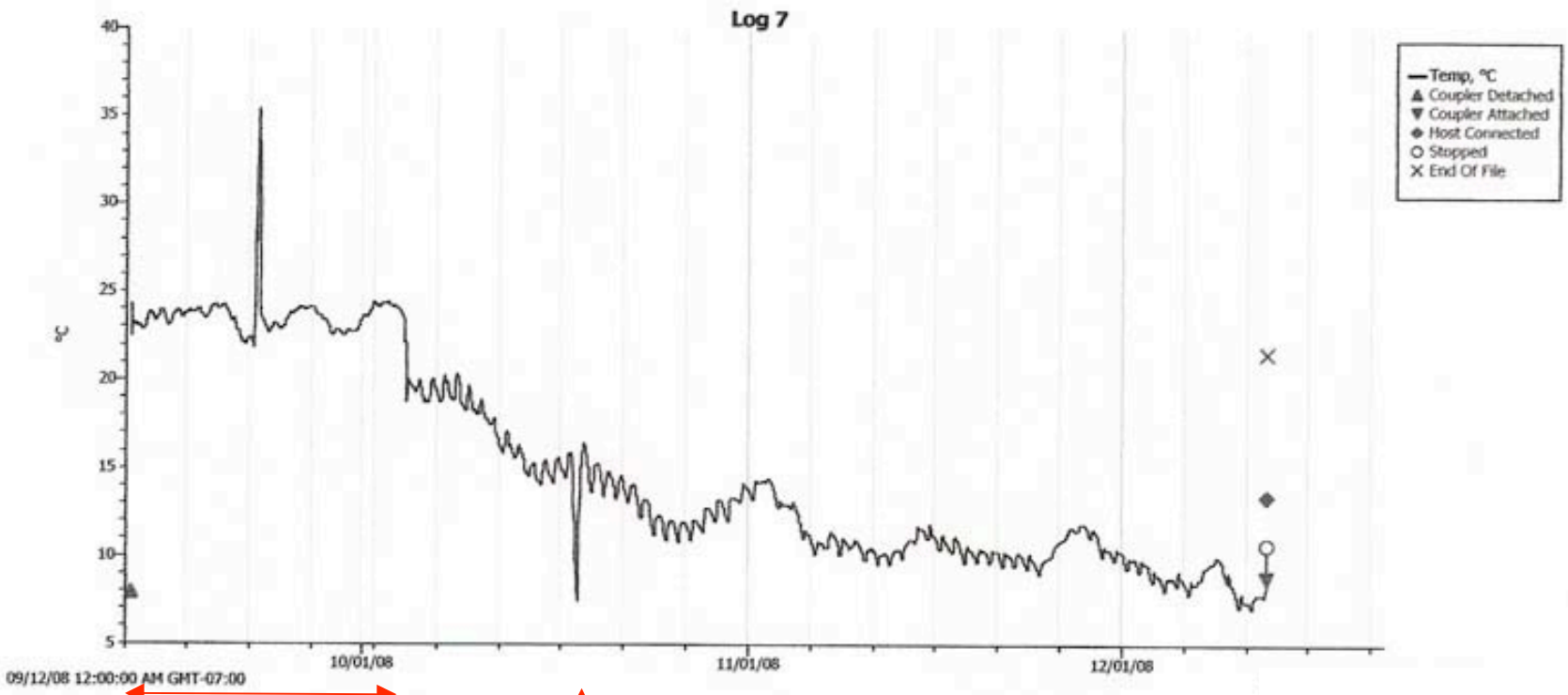
Device activated, but not placed in water

Logger placed 8/4/08

10/4/08; Logger data downloaded, and placed back Into same location

Logger removed read and stopped 11/24/08

7_San Luis Rey River 2008 Forest Service Picnic Area_Henshaw



Device activated,
but not placed in water

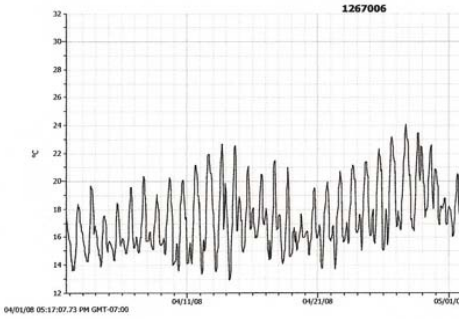
Logger
placed
10/4/08

Logger repositioned; found dry on
10/18/08 due to reduced water
release from Lake Henshaw; put
~10m downstream in pool near bank
with canopy cover;
0.2m deep; 2.5m wetted width

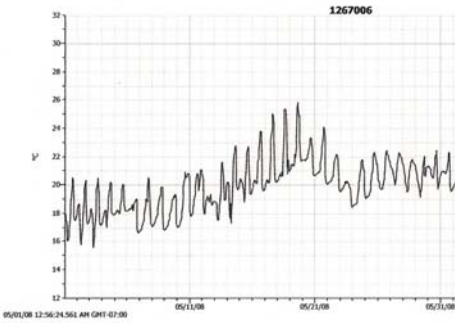
Logger
removed,
read and
stopped
12/12/08

San Luis Rey Logger 1 Estuary

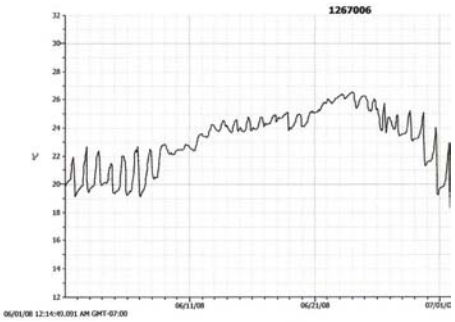
Apr 2008



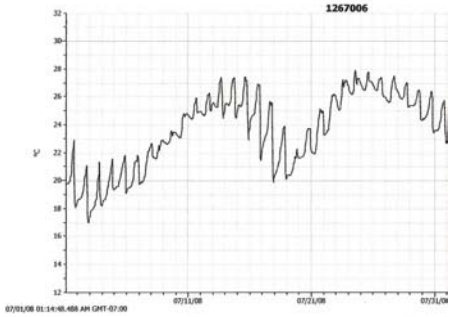
May 2008



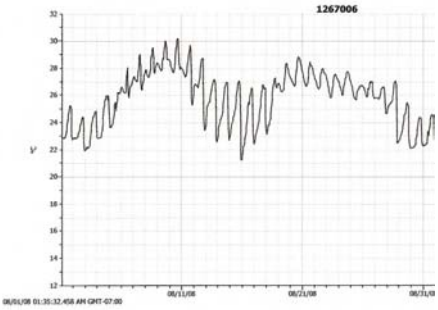
Jun 2008



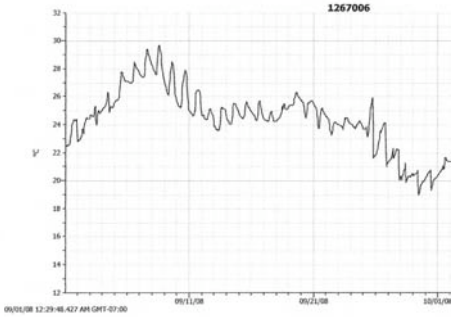
Jul 2008



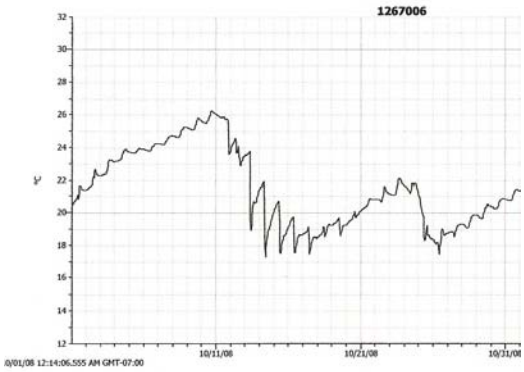
Aug 2008



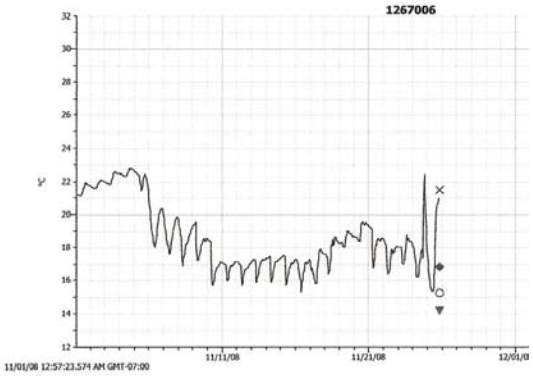
Sep 2008



Oct 2008



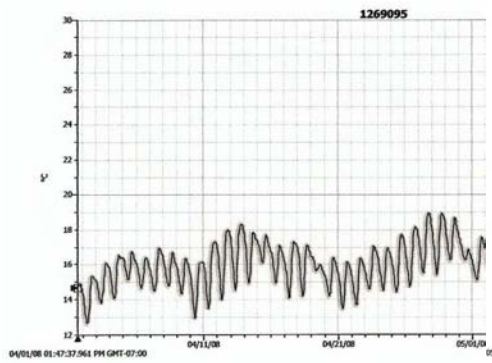
Nov 2008



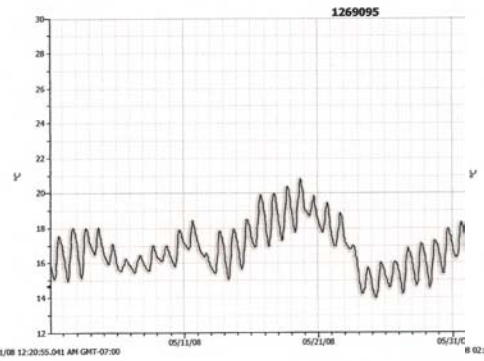
see note on pg. 45 graph re: high water temps in summer months.

San Luis Rey Logger 2 Douglas Bridge

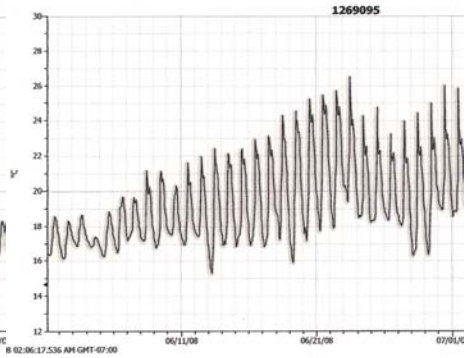
Apr 2008



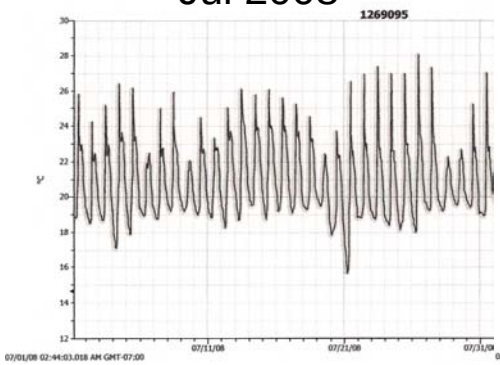
May 2008



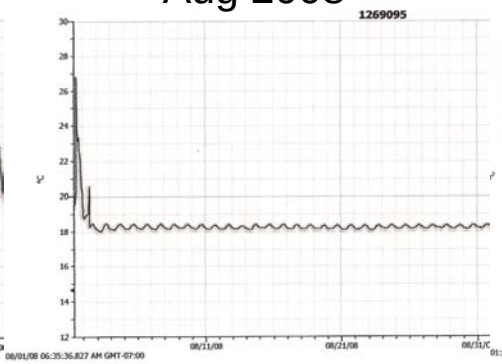
Jun 2008



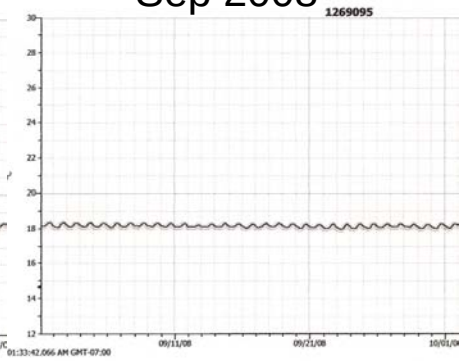
Jul 2008



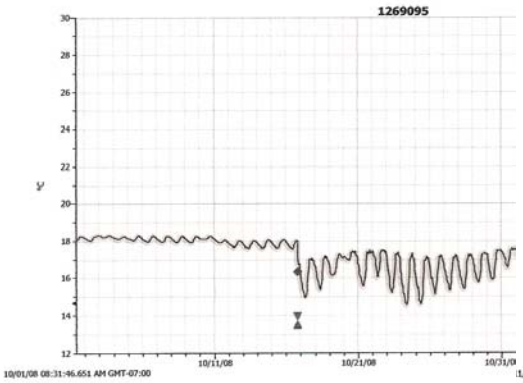
Aug 2008



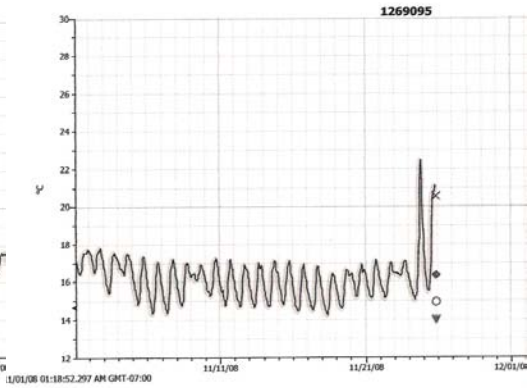
Sep 2008



Oct 2008



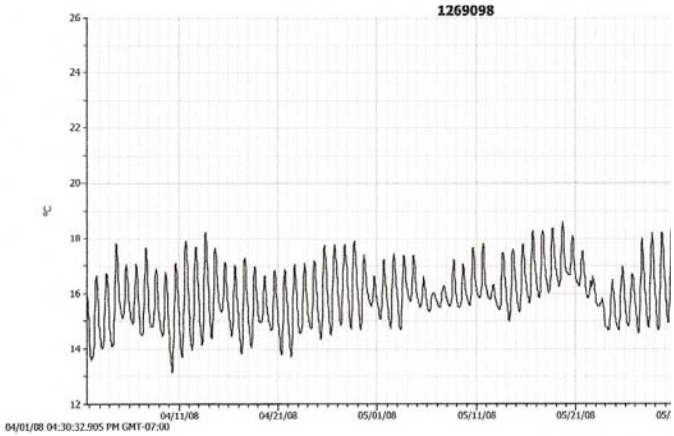
Nov 2008



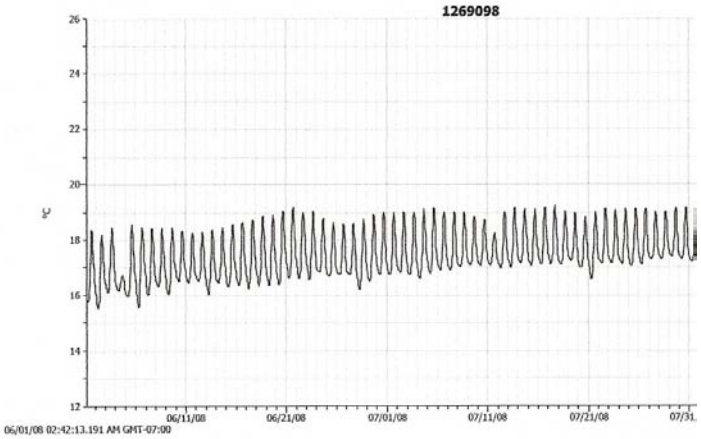
Logger dry in mid-June to Aug see pg. 46 for details,aberrant reading Aug to mid Oct. Data from these months not included in analysis

San Luis Rey Logger 3 Old Hwy 395

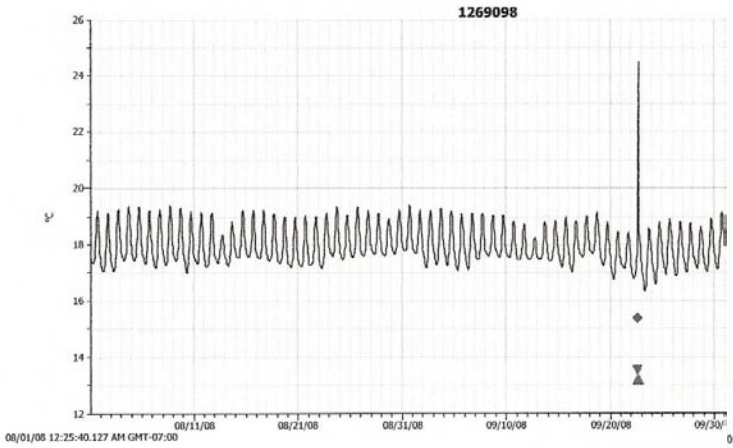
Apr & May 2008



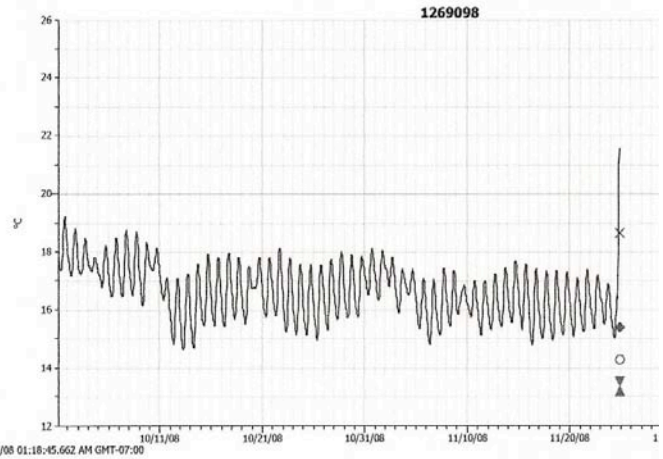
Jun & Jul 2008



Aug & Sep 2008

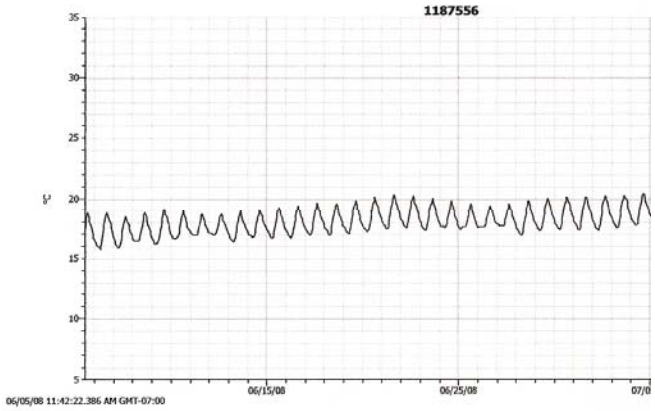


Oct & Nov 2008

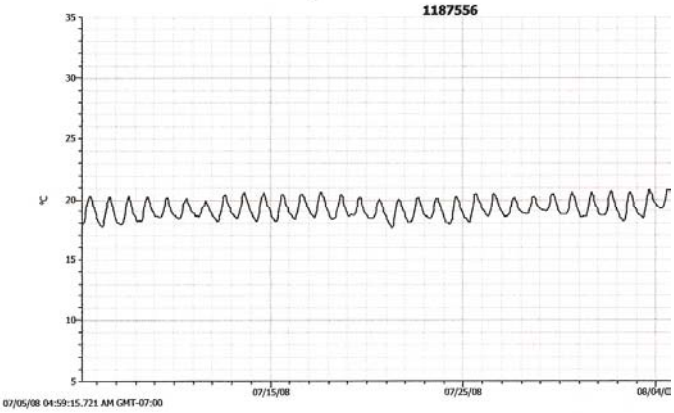


San Luis Rey Logger 4 Gomez Creek

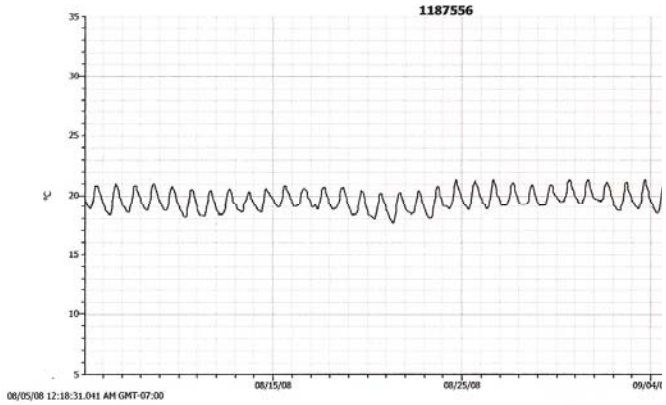
Jun 2008



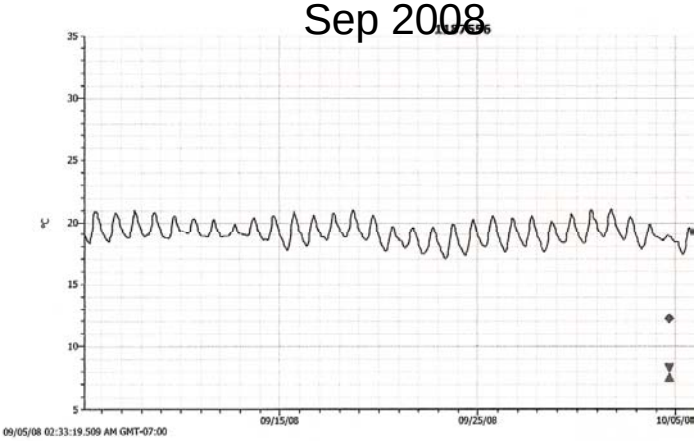
Jul 2008



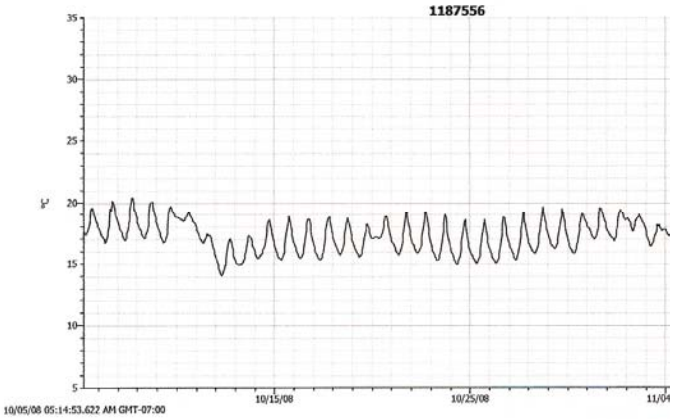
Aug 2008



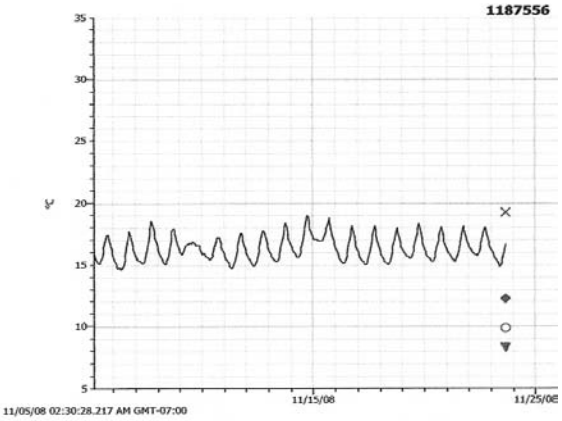
Sep 2008



Oct 2008

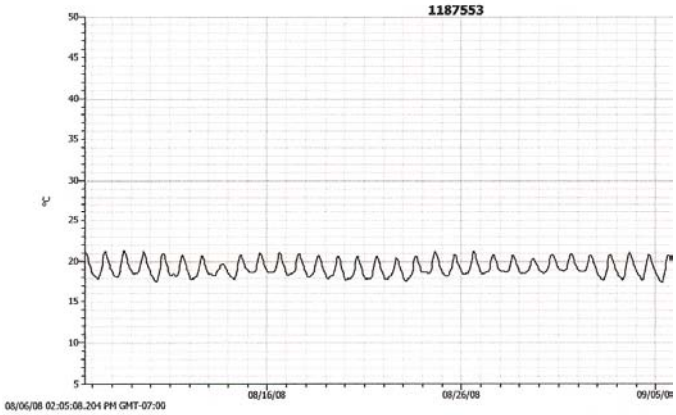


Nov 2008

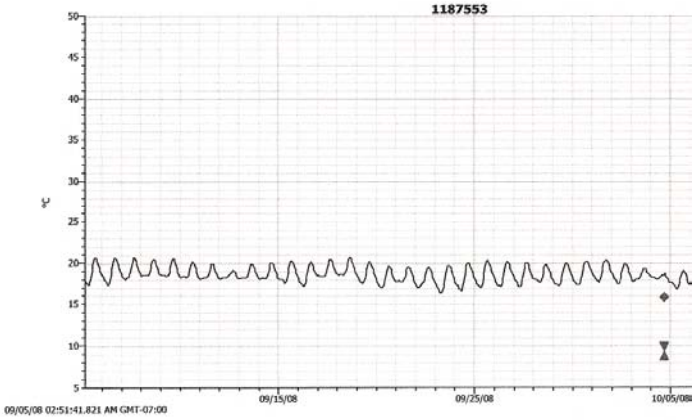


San Luis Rey Logger 5 Moosa Canyon Creek

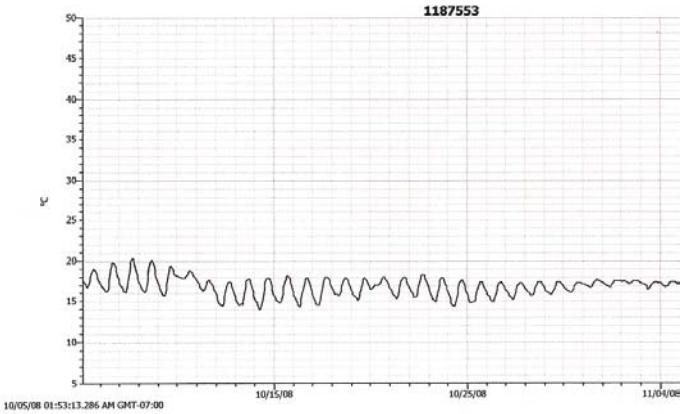
Aug 2008



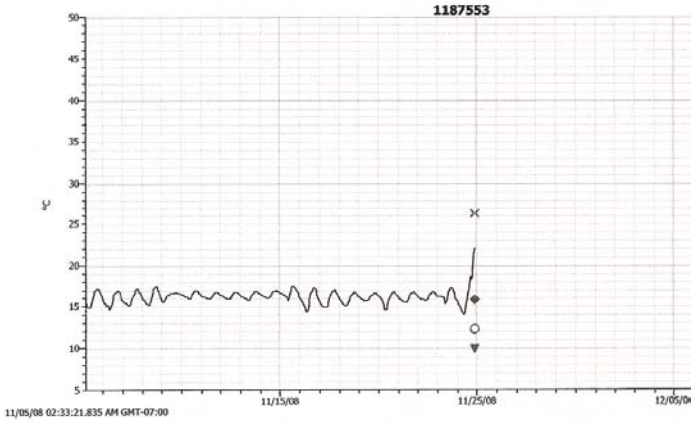
Sep 2008



Oct 2008

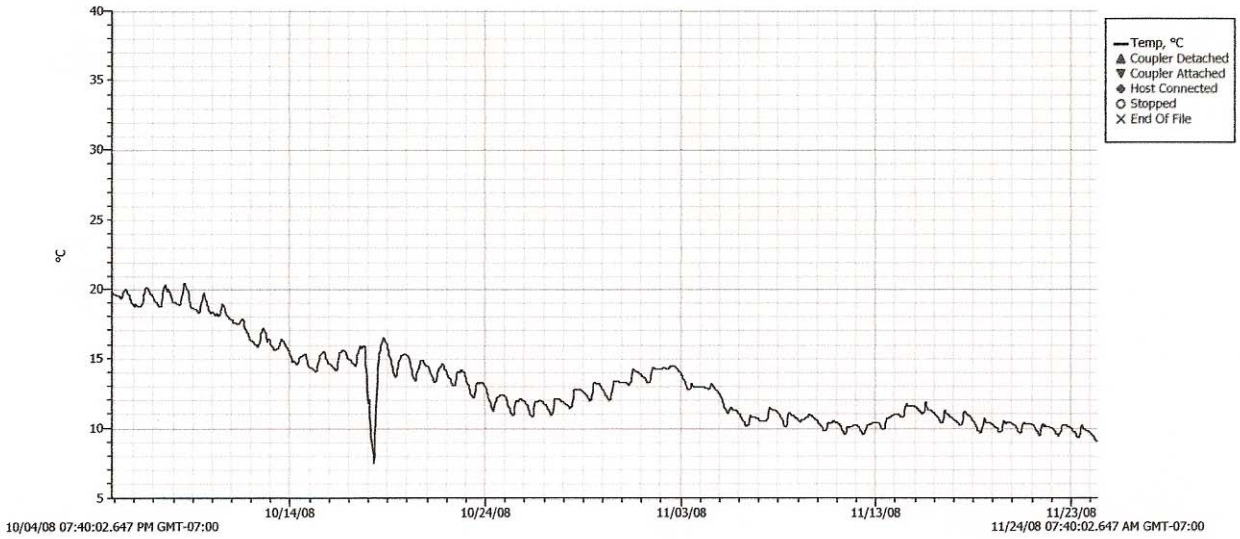


Nov 2008

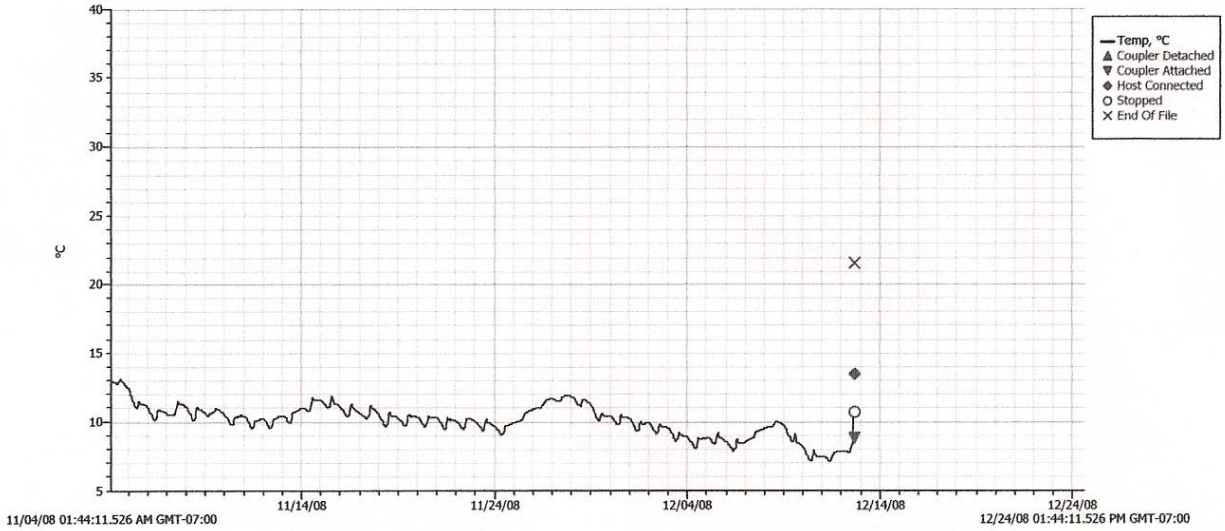


San Luis Rey Logger 7 FS Picnic Area

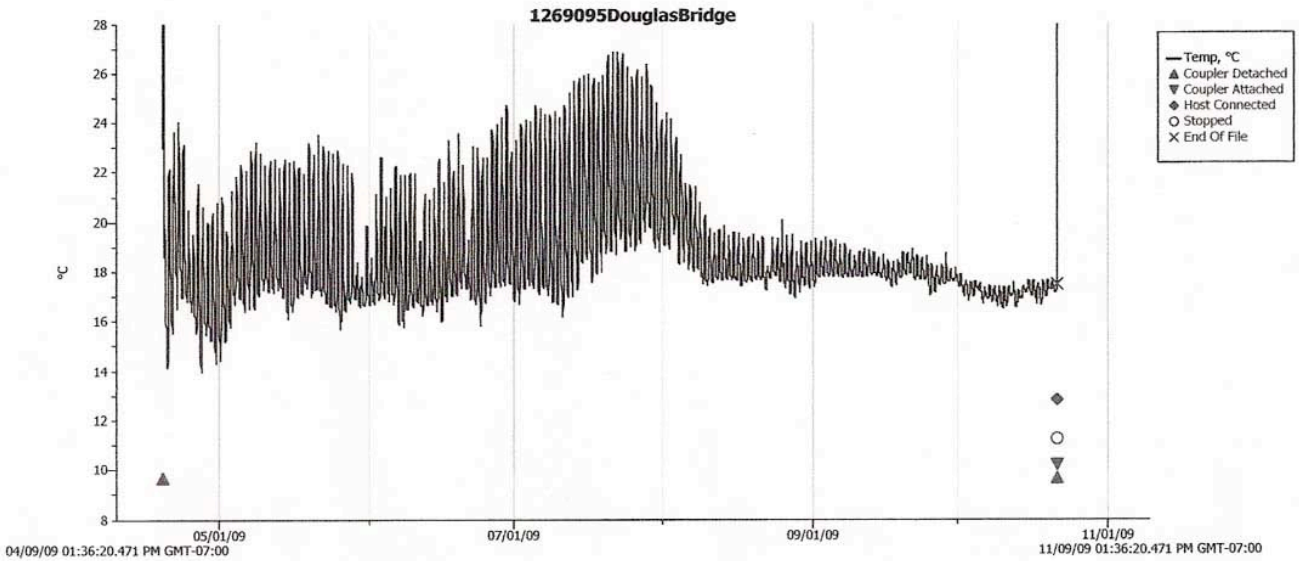
Oct & Nov 2008



Nov & Dec 2008



2_San Luis Rey River Douglas Bridge 2009

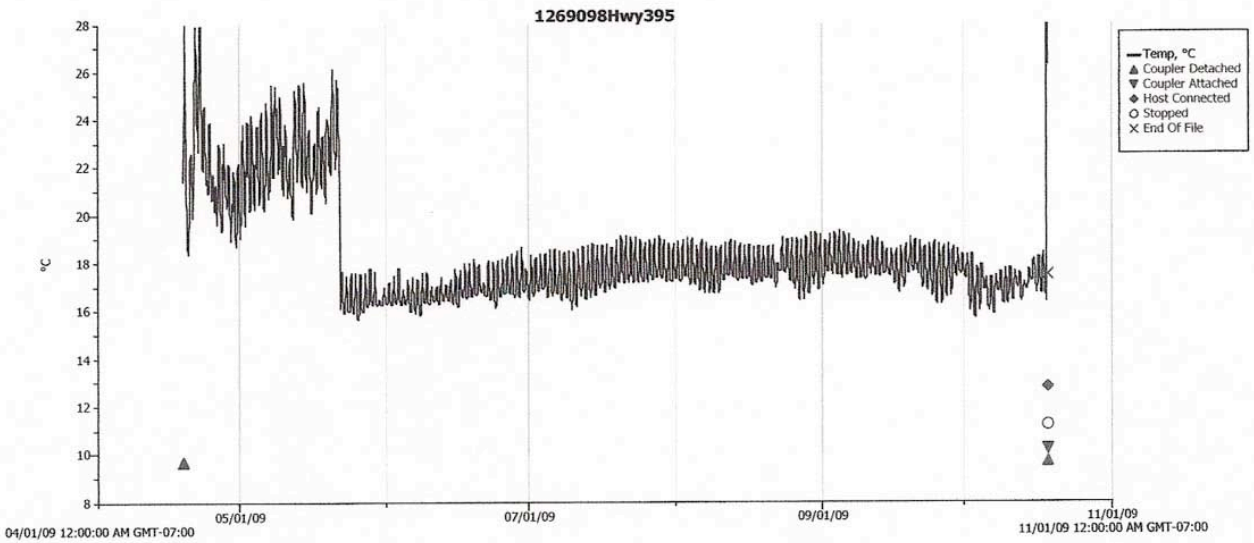


Device activated, but not placed in water

Logger placed 4/18/09

Logger retrieved, read and stopped 10/19/09

3_San Luis Rey River Hwy 395 2009

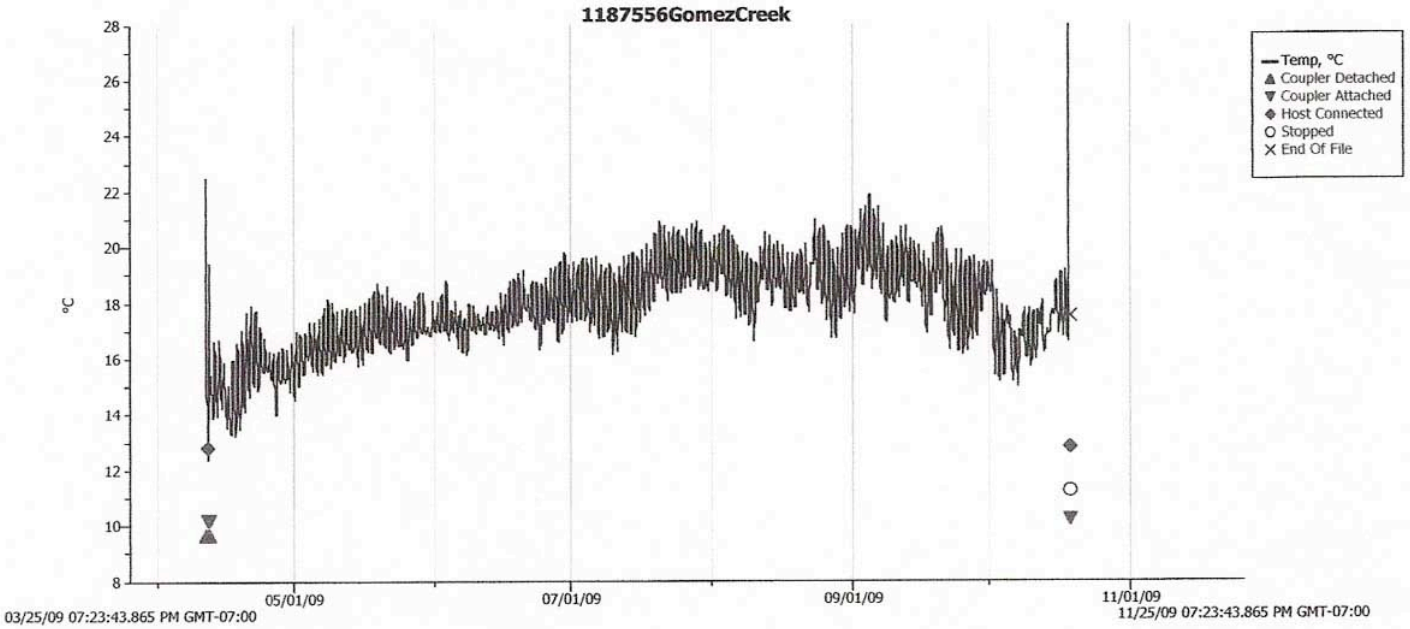


Device activated, but not placed in water

Logger placed 5/21/09

Logger retrieved, read and stopped 10/17/09

4_San Luis Rey River Gomez Creek 2009

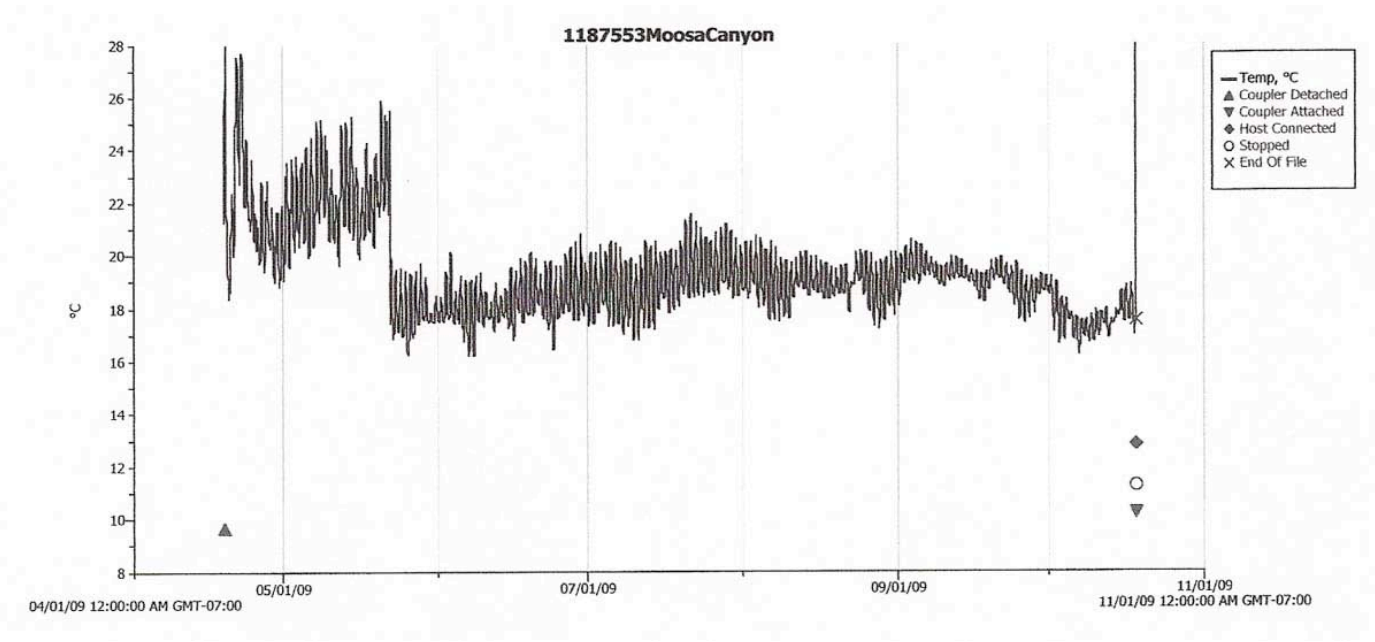


Device activated, but not placed in water

Logger placed 4/11/09

Logger retrieved, read and stopped 10/17/09

5_San Luis Rey River Moosa Canyon 2009

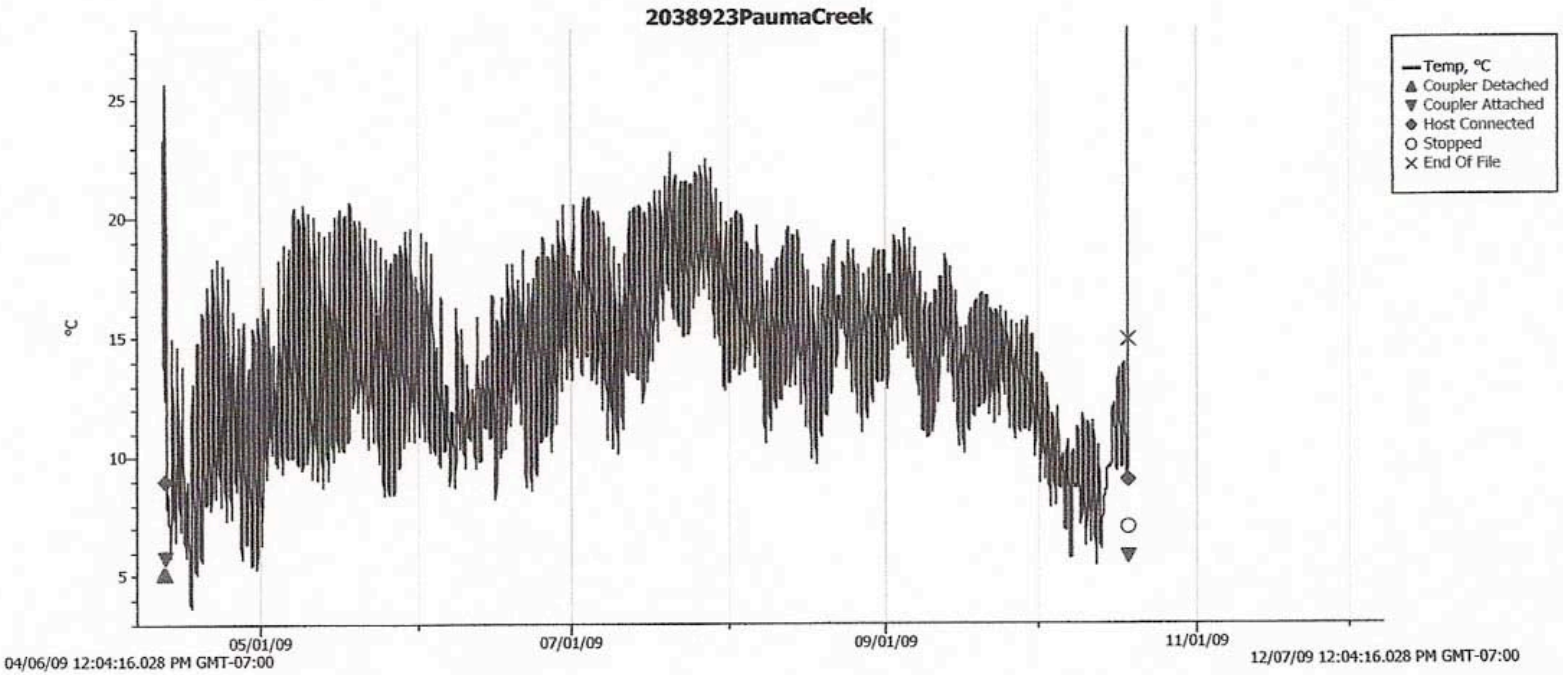


Device activated, but not placed in water

Logger placed 5/21/09

Logger retrieved, read and stopped 10/17/09

6_San Luis Rey River Pauma Creek 2009

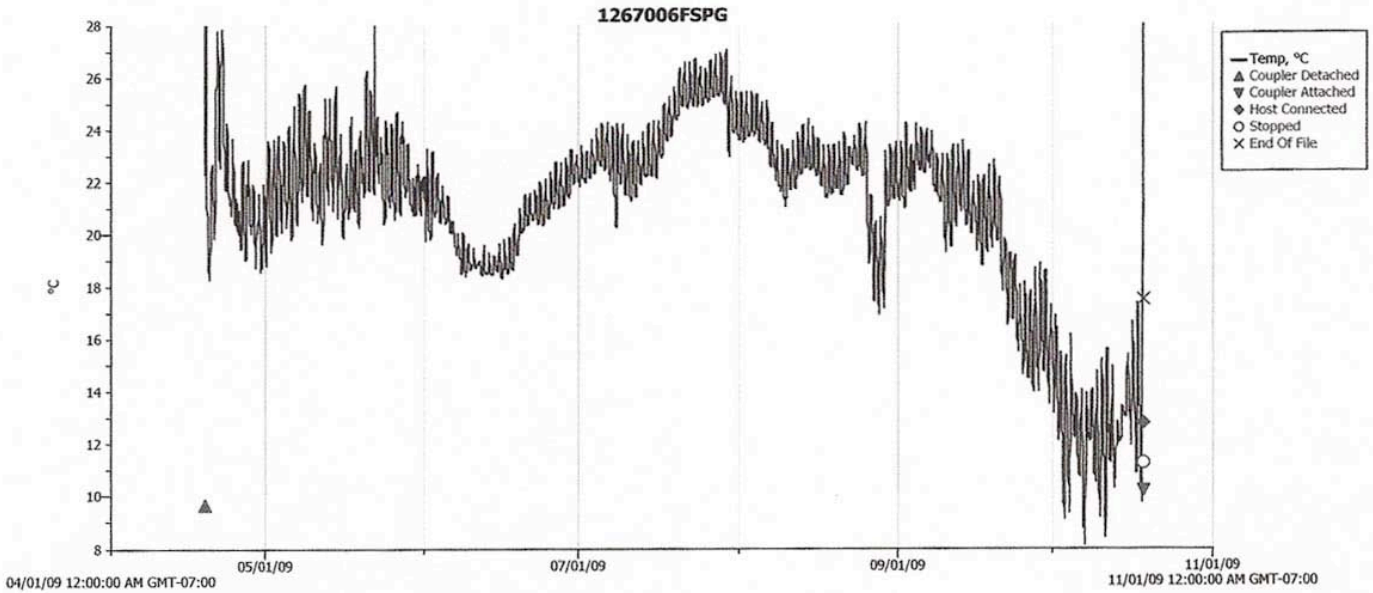


Device activated, but not placed in water

Logger placed 4/11/09

Logger retrieved, read and stopped 10/17/09

7_San Luis Rey River FS Picnic Ground 2009



Device activated, but not placed in water

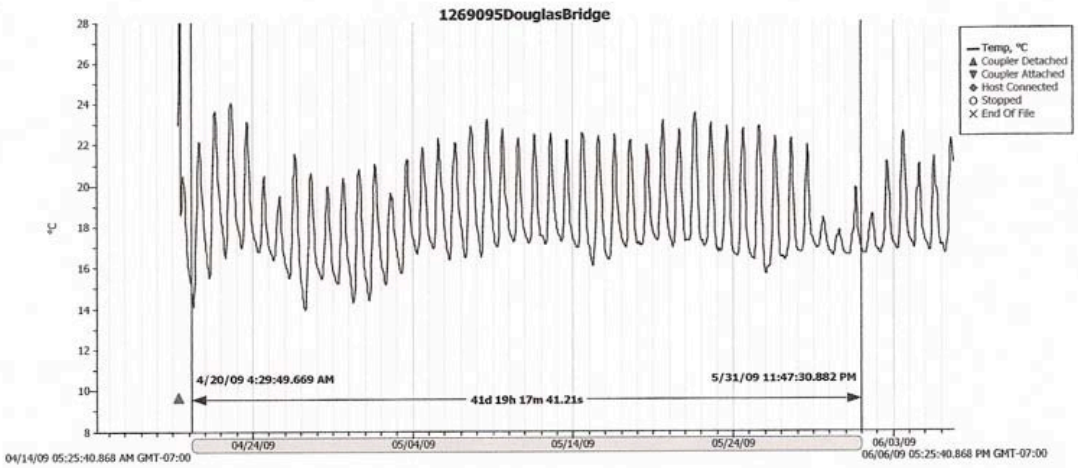
Logger placed 6/08/09

Logger retrieved, read and stopped 10/17/09

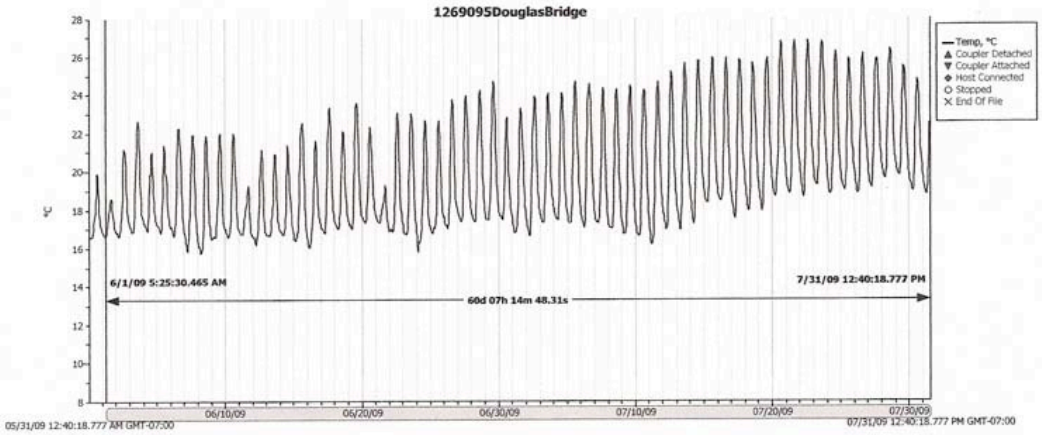
Note: logger found just above wetted width in bank; Data may include temperatures of dry logger due to variable water releases from Lake Henshaw

San Luis Rey River Logger 2
Douglas Bridge 2009

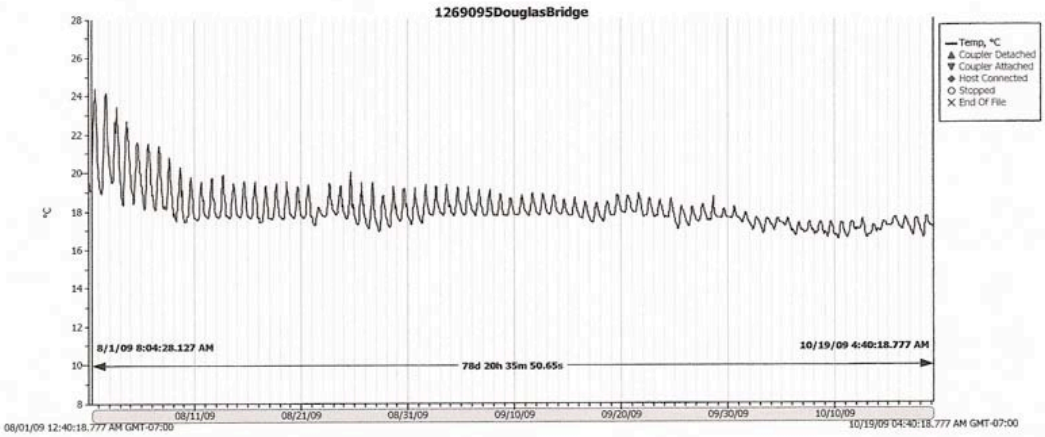
Apr - May



Jun-Jul

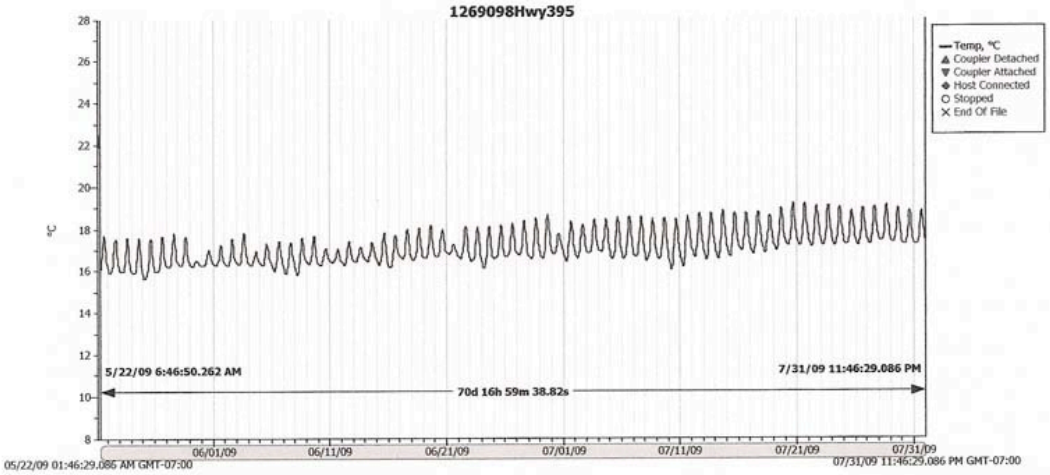


Aug-Oct

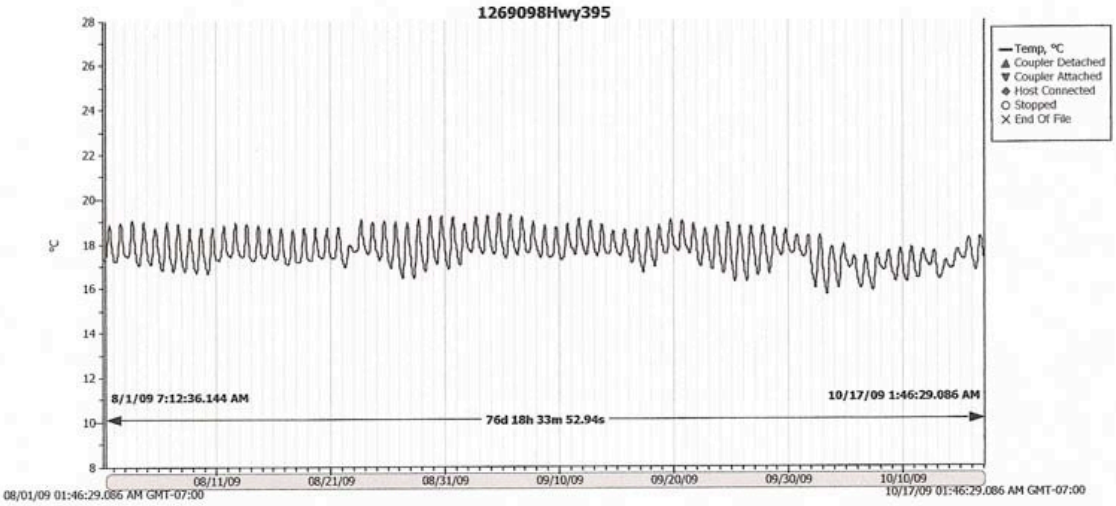


San Luis Rey River Logger 3
Hwy 395 at Hwy 76 2009

May-Jul

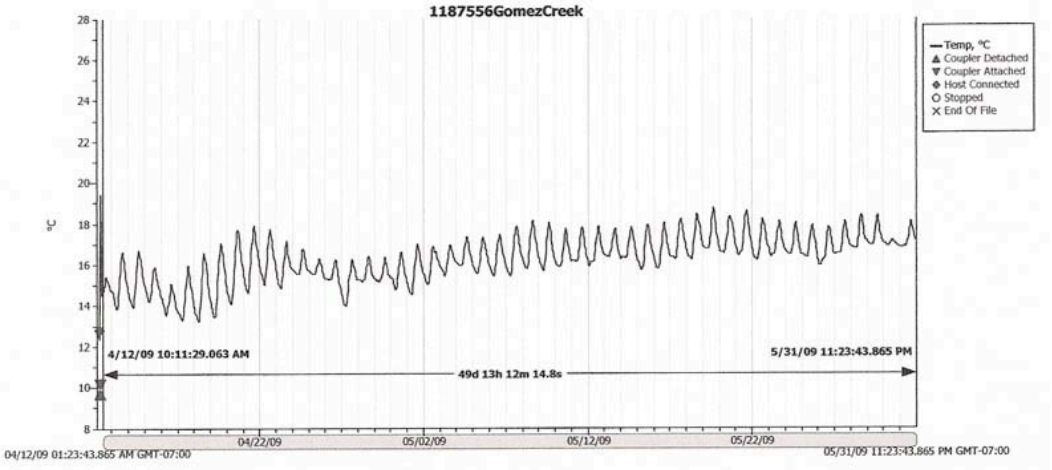


Aug-Oct

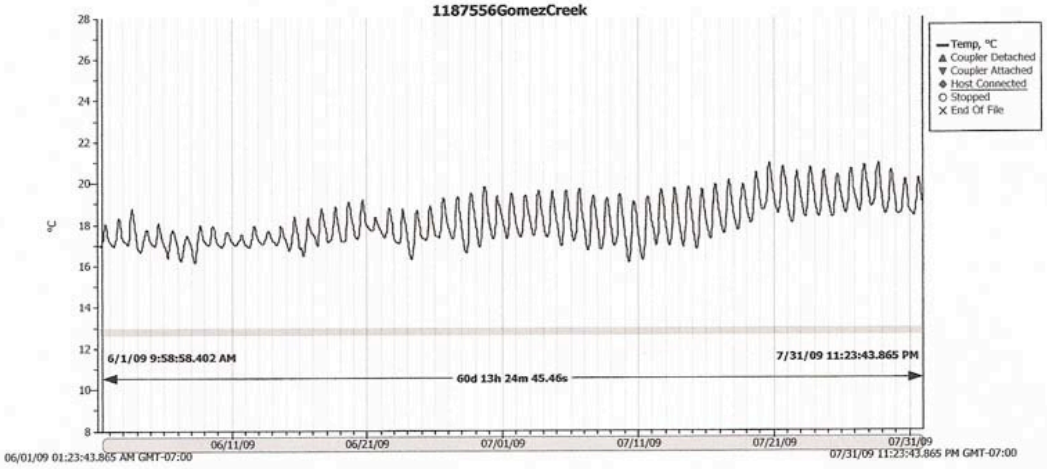


San Luis Rey River Logger 4
Gomez Creek 2009

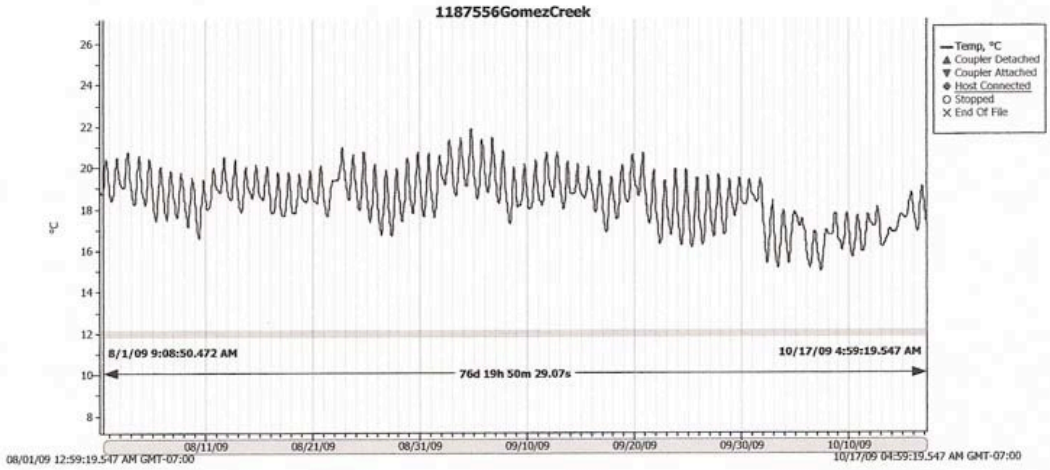
Apr-May



Jun-Jul

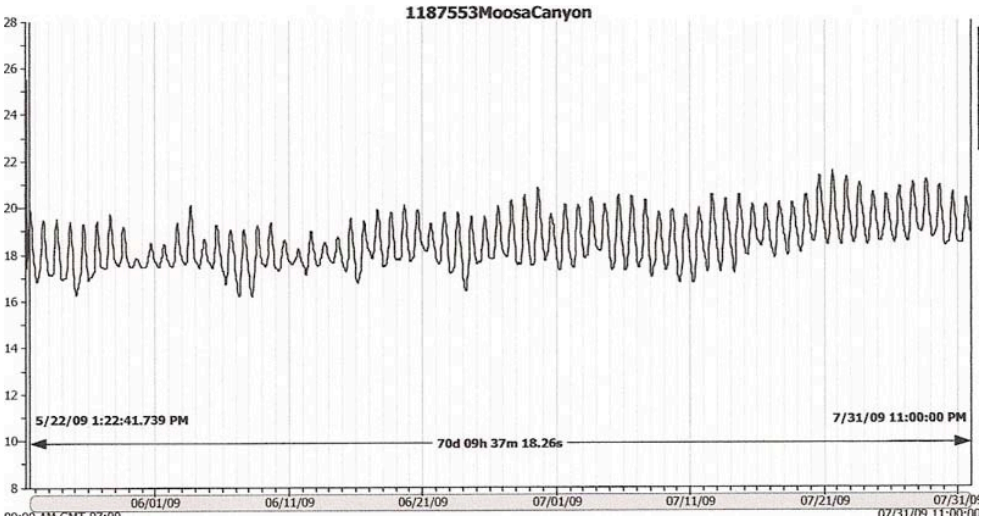


Aug-Oct

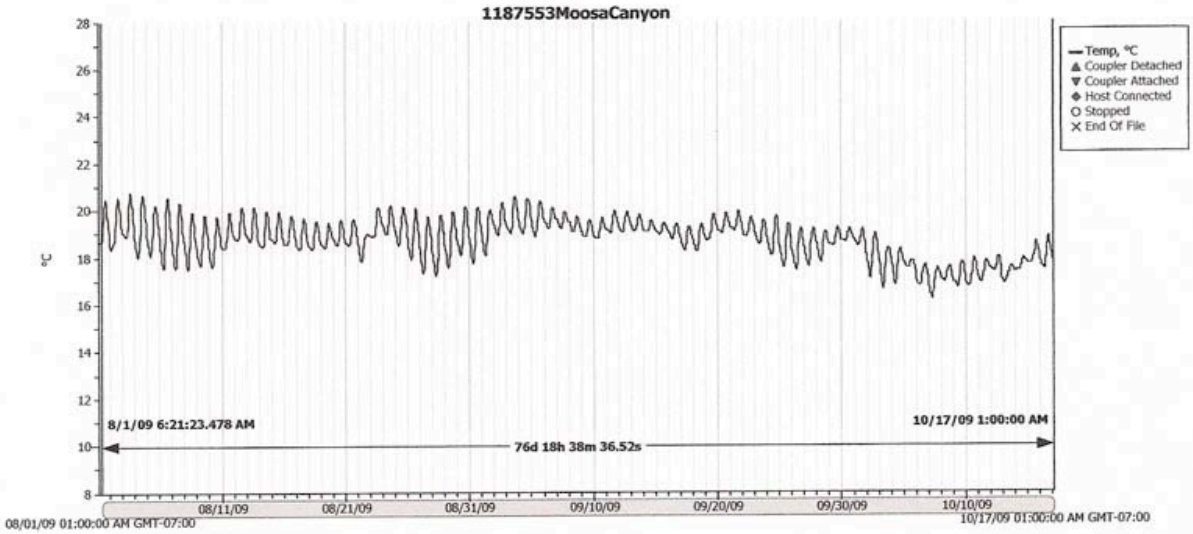


San Luis Rey River Logger 5
Moosa Canyon 2009

May-Jul

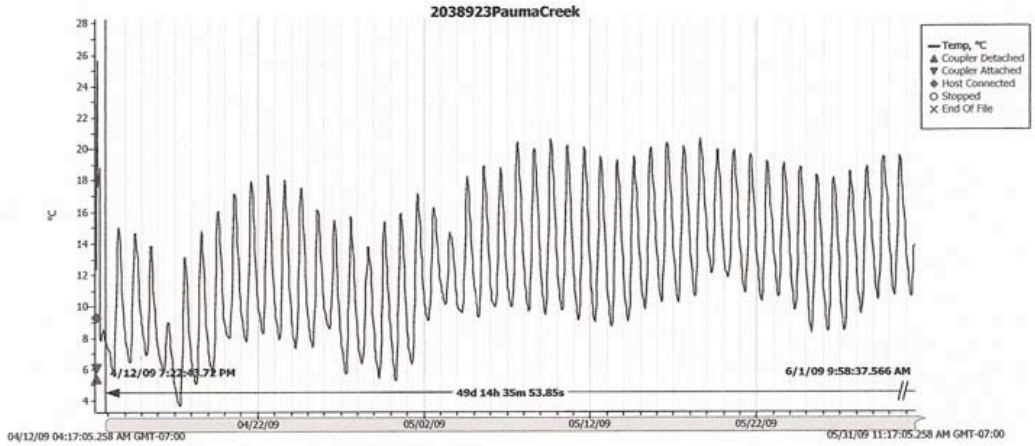


Aug-Oct

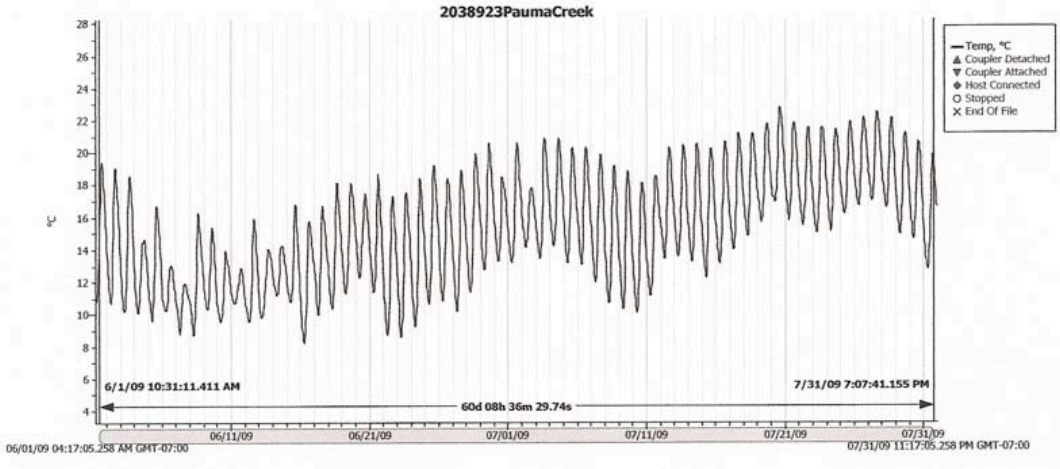


San Luis Rey River Logger 6
Pauma Creek 2009

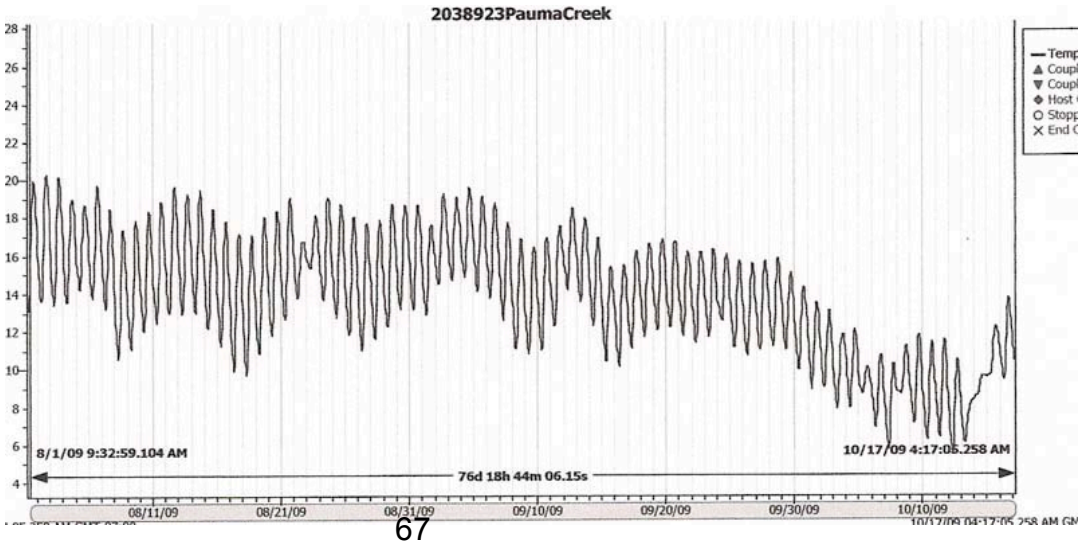
Apr-May



Jun-Jul



Aug-Oct



San Luis Rey River Temp Logger Sites

Photos from 2008

Logger 2 Douglas Bridge
0.5m deep pool, willows

Logger 3 Hwy 395/ Hwy 76
0.2m deep, willows/reeds

Logger 4 Gomez Creek
0.3m deep, oak

Logger 5 Moosa Canyon
0.3m deep, pool/riffle

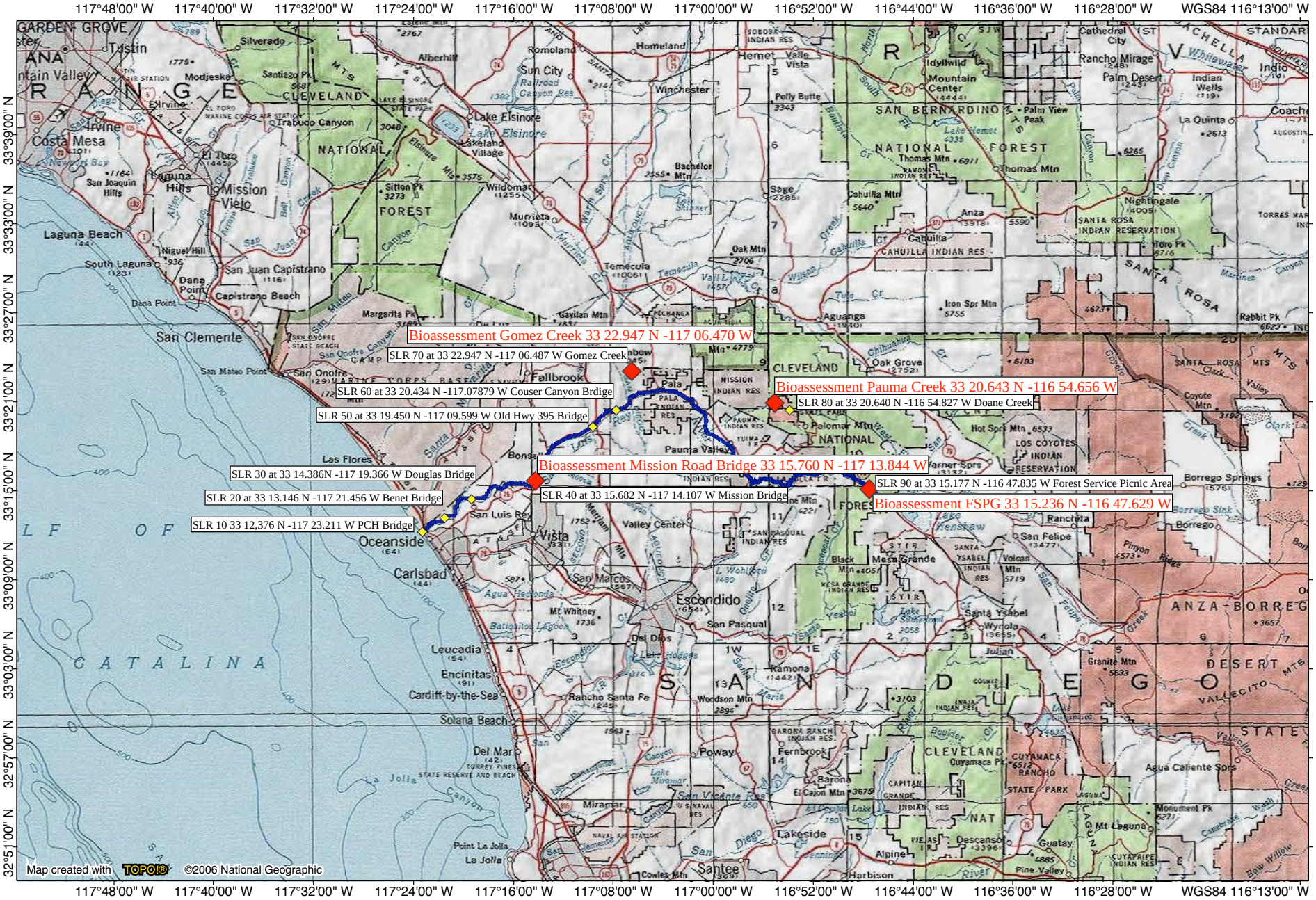
Logger 6 Pauma Creek
0.32m deep, pool/rock

Logger 7 FS Picnic Ground
0.2m deep, bank, willows

San Luis Rey Bioassessment Sites
November 2008

BA Site 1: SLRR-MR (Mission Rd)
BA Site 2: SLRR-GC (Gomez Creek)
BA Site 3: SLRR-PC (Pauma Creek)
BA Site 4: SLRR-FSPG (Forest Service)

TOPO! map printed on 01/12/09 from "SanLuisReyWaterChemistrySites.tpo"



NATIONAL GEOGRAPHIC

0 5 10 15 20 miles
0 5 10 15 20 25 30 km

TN MN
12.5°
01/12/09

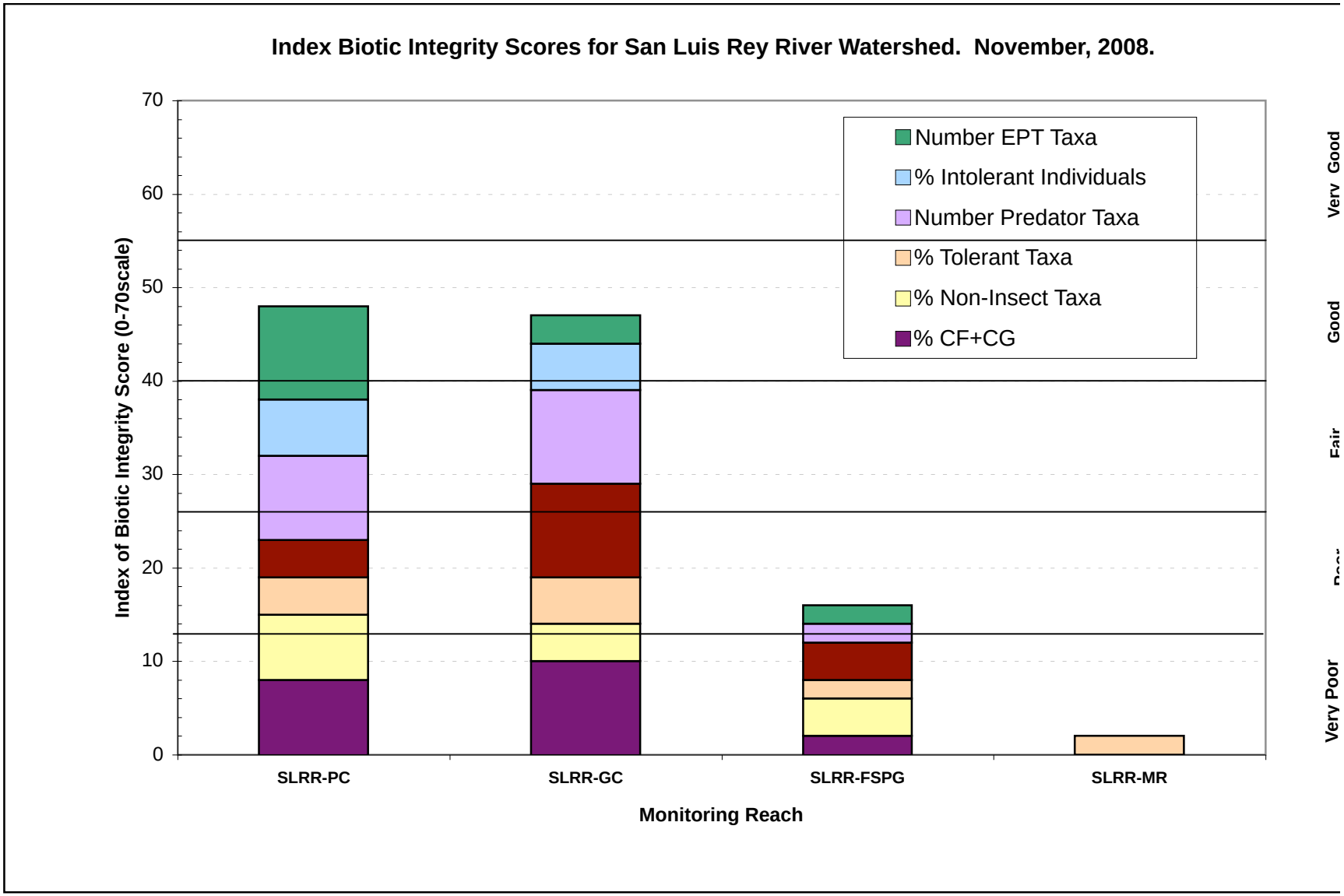
High resolution topos of sites are available for viewing at:

http://www.california-fly-fishing.org/GSF-CMS/index.php?page=slr-interim-report

San Luis Rey River Bioassessment Sites (Section 3, SLRR Interim Report)

BA Site SLRR-MR (near Old Mission Road Bridge)	p. 71
BA Site SLRR-GC(Gomez Creek)	p. 72
BA Site SLRR-PC (Pauma Creek)	p. 73
BA Site SLRR-FSPG (Forest Service Picnic Ground near Lake Henshaw)	p. 74

Macroinvertebrate identification and data compilation performed by Weston Solutions, Carlsbad CA



Macroinvertebrate identification and data compilation performed by Weston Solutions, Carlsbad

Table 4: Index of Biotic Integrity Scores for San Luis Rey River Watershed. November, 2008.

Monitoring Reach	Total IBI Score (0-70 Scale)	IBI Rating	% CF+CG		% Non-Insect Taxa		% Tolerant Taxa		Number Coleoptera Taxa		Number Predator Taxa		% Intolerant Individuals		Number EPT Taxa	
			Metric value	IBI score	Metric value	IBI score	Metric value	IBI score	Metric value	IBI score	Metric value	IBI score	Metric value	IBI score	Metric value	IBI score
SLRR-PC	**48**	**Good**	67%	**8**	21%	**7**	24%	**4**	2	**4**	12	**9**	18%	**6**	19	**10**
SLRR-GC	**47**	**Good**	49%	**10**	31%	**4**	22%	**5**	9	**10**	15	**10**	15%	**5**	5	**3**
SLRR-FSPG	**16**	**Poor**	89%	**2**	31%	**4**	31%	**2**	2	**4**	5	**2**	0%	**0**	4	**2**
SLRR-MR	**2**	**Very Poor**	99%	**0**	67%	**0**	33%	**2**	0	**0**	1	**0**	0%	**0**	1	**0**

Macroinvertebrate identification and data compilation performed by Weston Solutions, Carlsbad CA
Sample collection according to SWAMP 2007 bioassessment protocol performed by TU/GSF

Taxonomic Listing of Macroinvertebrates Collected from San Luis Rey River Watershed. November, 2008.

TV=Tolerance Value: range is 0-10; 0 is intolerant to impairment, 10 is highly tolerant to impairment. FFG=Functional Feeding Group: cg=collector gatherer, cf=collector filterer, sc=scraper, sh=shredder, p=predator, ph=piercer herbivore

	TV	FFG	SLRR-FSPG	SLRR-GC	SLRR-MR	SLRR-PC
PHYLUM ARTHROPODA						
Insecta						
Ephemeroptera (mayflies)						
Baetidae						
Baetis sp	5	cg	19			9
Fallceon quilleri	4	cg	3	1		1
Ephemerellidae	1	cg				1
Heptageniidae						
Ironodes sp	3	sc				15
Leptophlebidae						
Paraleptophlebia sp	4	cg				1
Odonata (dragonflies, damselflies)						
Coenagrionidae	9	p	1			
Argia sp	7	p		43		6
Cordulegastridae						
Cordulegaster dorsalis	3	p		3		
Libellulidae						
Brechmorhoga mendax	9	p	1			2
Paltothemis lineatipes	9	p				2
Plecoptera (stoneflies)				1		
Capniidae	1	sh				7
Nemouridae						
Malenka sp	2	sh				15
Taeniopterygidae						
Taenionema sp	2	om				20
Trichoptera (caddisflies)						
Brachycentridae						
Micrasema sp	1	mh		40		7
Glossosomatidae						
Agapetus sp	0	sc				18
Hydropsychidae						
Cheumatopsyche sp	5	cf	91			2
Hydropsyche sp	4	cf	128		16	13
Hydroptilidae						
Ochrotrichia sp	4	ph				2
Lepidostomatidae						
Lepidostoma sp	1	sh				35
Limnephilidae						
Hesperophylax sp	3	om				1
Polycentropodidae						
Polycentropus sp	6	p		1		
Psychomyiidae						
Tinodes sp	2	sc		2		3
Rhyacophilidae						
Rhyacophila sp	0	p				3
Sericostomatidae						
Gumaga sp	3	sh				6
Uenoidae						
Neophylax sp	3	g				1
Coleoptera (beetles)						
Dryopidae						
Helichus sp	5	sh		1		
Dytiscidae						
Sanfillipodytes sp	5	p		1		
Stictotarsus sp	5	p		1		1
Elmidae						
Heterelmis sp	4	cg	23			
Microcylloepus sp	4	cg	5			
Zaitzevia sp	4	sc		5		

Haliplidae							
Peltodytes sp	5	mh		1		
Hydraenidae						
Hydraena sp	5	p		2		
Ochthebius sp	5	p		1		
Hydrophilidae						
Cymbiodyta sp	5	p		3		
Psephenidae						
Eubrianax edwardsi	4	sc		1		9
Diptera (true flies)						
Ceratopogonidae						
Bezzia/Palpomyia	6	p		3		2
Dasyhelea sp	6	cg		83		1
Chironomidae	6	cg	65	4		237
Culicidae	8	cg		1		
Empididae						
Hemerodromia sp	6	p	1			4
Muscidae	6	p		1		
Psychodidae						
Maruina lanceolata	2	sc				1
Pericoma/Telmatoscopus	4	cg				2
Simuliidae						
Simulium sp	6	cf	1	1		17
Stratiomyidae						
Caloparyphus/Euparyphus	8	cg		17		3
Myxosargus sp	8	cg		1		
Tabanidae						
Tabanus sp	5	p				3
Tipulidae						
Tipula sp	4	om		1	3	
PHYLUM CHELICERATA						
Arachnida						
Acari (water mites)						
Eylaidae						
Eylais sp		p		1		
Lebertiidae						
Lebertia sp	8	p				3
Sperchontidae						
Sperchon sp	8	p	49	2		8
Sperchonopsis sp	8	p				1
Torrenticolidae						
Torrenticola sp	5	p		2		
PHYLUM ARTHROPODA						
Malacostraca						
Amphipoda (scuds)						
Gammaridae						
Gammarus sp	4	cg			525	
Decapoda (crayfish)						
Cambaridae	8	sh	1			
Ostracoda (seed shrimp)	8	cg		10		116
PHYLUM PLATYHELMINTHES						
Turbelleria (flatworms)	4	p	15	3		
PHYLUM NEMERTEA						
Enopla (tongueworms)						
Hoplonemertea						
Tetrastemmatidae						
Prostoma sp	8	p		5	1	4
PHYLUM ANNELIDA						
Oligochaeta (earthworms)	5	cg	196	3	57	8
PHYLUM MOLLUSCA						
Gastropoda (snails)						
Pulmonata						
Ancylidae						
Ferrissia sp	6	sc		10		
Lymnaeidae						
Lymnea sp	6	sc		1		
Physidae						

				Physa sp	8	sc		2		22
			Planorbidae							
				Helisoma sp	6	sc				2
	Bivalvia (clams)									
		Veneroida								
			Corbiculidae							
				Corbicula sp	10	cf	13		29	
		Pelecypoda								
			Sphaeriidae							
				Pisidium sp	8	cf		13		1

Macroinvertebrate identification and data compilation performed by Weston Solutions, Carlsbad CA

Table 2: Ranked Abundance and Percent Composition of Benthic Macroinvertebrates Collected in San Luis Rey River Watershed. November, 2008.

Taxon	SLRR-FSPG		SLRR-GC		SLRR-MR		SLRR-PC		Grand Total
	Abundance	Percent Composition	Abundance	Percent Composition	Abundance	Percent Composition	Abundance	Percent Composition	
Gammarus sp					525	83.2%			525
Chironomidae	65	10.6%	4	1.5%			237	38.5%	306
Oligochaeta	196	32.0%	3	1.1%	57	9.0%	8	1.3%	264
Hydropsyche sp	128	20.9%			16	2.5%	13	2.1%	157
Ostracoda			10	3.7%			116	18.9%	126
Cheumatopsyche sp	91	14.9%					2	0.3%	93
Dasyhelea sp			83	30.6%			1	0.2%	84
Sperchon sp	49	8.0%	2	0.7%			8	1.3%	59
Argia sp			43	15.9%			6	1.0%	49
Micrasema sp			40	14.8%			7	1.1%	47
Corbicula sp	13	2.1%			29	4.6%			42
Lepidostoma sp							35	5.7%	35
Baetis sp	19	3.1%					9	1.5%	28
Physa sp			2	0.7%			22	3.6%	24
Heterelmis sp	23	3.8%							23
Caloparyphus/Euparyphus			17	6.3%			3	0.5%	20
Taenionema sp							20	3.3%	20
Simulium sp	1	0.2%	1	0.4%			17	2.8%	19
Agapetus sp							18	2.9%	18
Turbellaria	15	2.5%	3	1.1%					18
Ironodes sp							15	2.4%	15
Malenka sp							15	2.4%	15
Pisidium sp			13	4.8%			1	0.2%	14
Eubrianax edwardsi			1	0.4%			9	1.5%	10
Ferrissia sp			10	3.7%					10
Prostoma sp			5	1.8%	1	0.2%	4	0.7%	10
Capniidae							7	1.1%	7
Gumaga sp							6	1.0%	6
Bezzia/Palpomyia			3	1.1%			2	0.3%	5
Fallceon quilleri	3	0.5%	1	0.4%			1	0.2%	5
Hemerodromia sp	1	0.2%					4	0.7%	5
Microcylloepus sp	5	0.8%							5
Tinodes sp			2	0.7%			3	0.5%	5
Zaitzevia sp			5	1.8%					5
Tipula sp			1	0.4%	3	0.5%			4
Brechmorhoga mendax	1	0.2%					2	0.3%	3
Cordulegaster dorsalis			3	1.1%					3
Cymbiodyta sp			3	1.1%					3
Lebertia sp							3	0.5%	3
Rhyacophila sp							3	0.5%	3
Tabanus sp							3	0.5%	3
Helisoma sp							2	0.3%	2
Hydraena sp			2	0.7%					2
Ochrotrichia sp							2	0.3%	2
Paltothemis lineatipes							2	0.3%	2
Pericoma/Telmatoscopus							2	0.3%	2
Stictotarsus sp			1	0.4%			1	0.2%	2
Torrenticola sp			2	0.7%					2
Cambaridae	1	0.2%							1
Coenagrionidae	1	0.2%							1
Culicidae			1	0.4%					1
Ephemerellidae							1	0.2%	1
Eylais sp			1	0.4%					1
Helichus sp			1	0.4%					1
Hesperophylax sp							1	0.2%	1
Lymnea sp			1	0.4%					1
Maruina lanceolata							1	0.2%	1
Muscidae			1	0.4%					1
Myxosargus sp			1	0.4%					1
Neophylax sp							1	0.2%	1
Ochthebius sp			1	0.4%					1
Paraleptophlebia sp							1	0.2%	1
Peltodytes sp			1	0.4%					1
Plecoptera			1	0.4%					1
Polycentropus sp			1	0.4%					1
Sanfillipodytes sp			1	0.4%					1
Sperchonopsis sp							1	0.2%	1
Grand Total	612	100.0%	271	100.0%	631	100.0%	615	100.0%	2129

Macroinvertebrate identification and data compilation performed by Weston Solutions, Carlsbad CA

Bioassessment Metric Values for Benthic Macroinvertebrates in San Luis Rey River Watershed. November, 2008.

Metric	SLRR-FSPG	SLRR-GC	SLRR-MR	SLRR-PC
Taxa Richness	16	36	6	42
Ephemeropteran Taxa	2	1	0	5
Plecopteran Taxa	0	1	0	3
Trichopteran Taxa	2	3	1	11
EPT Taxa	4	5	1	19
Dipteran Taxa	3	9	1	9
Non Insect Taxa	5	11	4	9
% EPT	39.4%	16.6%	2.5%	26.0%
Sensitive EPT %	0.0%	15.5%	0.0%	21.5%
Shannon Diversity	1.94	2.47	0.64	2.40
Margalef Diversity	2.34	6.25	0.78	6.38
Tolerance Value	5.19	5.59	4.37	5.44
% Dominant Taxon	32.0%	30.6%	83.2%	38.5%
% Chironomidae	10.6%	1.5%	0.0%	38.5%
% Intolerant	0.0%	15.5%	0.0%	17.9%
% Tolerant	10.6%	18.8%	4.8%	26.3%
% Collector Gatherer	50.8%	44.3%	92.2%	61.6%
% Collector Filterer	38.1%	5.2%	7.1%	5.4%
% Predator	10.9%	26.6%	0.2%	6.3%
% Shredder	0.2%	0.4%	0.0%	10.2%
% Scraper	0.0%	7.7%	0.0%	11.4%
% Other	0.0%	15.5%	0.5%	4.9%
Estimated Total Abundance	10200	271	2629	1922

Discussion and Conclusions

Study Overview

This study focuses on water quality parameters potentially impacting the viability of steelhead trout in the San Luis Rey River. Currently, there is not a known stable population of steelhead in the river, although resident rainbow trout exist within the river and its tributaries—particularly in the upper reaches of Pauma Creek on Palomar Mountain. However, the San Luis Rey is included in a compilation of historic and current ranges of steelhead trout in Southern California (NMFS Federal Recovery Outline for the Distinct Population Segment of Southern California Coast Steelhead (2007); Table 1) based on anecdotal historic populations and a candidate steelhead sighting in 2007.

The main stem of the San Luis Rey extends approximately 50 miles from the ocean (in the city of Oceanside) to Lake Henshaw. Numerous tributaries flow into the river throughout its course, most of which are dry for most of the year except during periods of significant rain. The situation is characteristic of many S. California rivers and streams in being low or intermittent with increased flow during the rainy season from about December to April. Palomar Mountain, which drains into the San Luis Rey at multiple points receives about 45 inches of rain a year, compared to 12 inches at the coast. Water flow in the river is also impacted by releases from Lake Henshaw, diversion of mainstem water through a flume draining eastward to Lake Wohlford near Escondido, agricultural operations largely in Pauma Valley to the east of Interstate 15, and public water consumption in rural and urban areas through which it flows.

The water quality studies described below fit into a larger picture of factors that limit steelhead recovery as presented in The San Luis Rey Watershed Assessment (Downie and Kajtaniak, 2010), a collaborative field study conducted by the California Dept. of Fish and Game, Pacific States Marine Fisheries Commission and the Coastal Watershed Planning and Assessment Program. These factors include lack of hydrologic connectivity and inadequate stream flows in the main stem and tributaries; barriers to fish passage on the main stem and important tributaries; loss of estuarine habitat; high levels of fine sediments in streams; competition with warm water game fish, crayfish and bullfrogs; displacement of native riparian vegetation with exotic vegetation; and limited areas with suitable spawning gravels in main stem and tributaries.

The variable flows in the San Luis Rey, and in particular low flows during summer season, impact not only the connectivity of the river, but result in increased sedimentation and loss of gravel beds, seasonal increased concentration of nutrients and salts, and low dissolved oxygen levels in the water. Water temperature and dissolved oxygen are two parameters that are of particular interest due to their central importance in trout survival.

Study parameters

The sites selected for three independent but related water quality studies (water chemistry, continuous water temperature recording by data logger, and bioassessment) were chosen based on physical habitat characteristics and geographic location within the San Luis Rey Watershed. For water chemistry analysis, the Water Chemistry Site Overview Map (p. 9) and high-resolution topo maps (p. 10-16) show details of sampling locations.

The three *urban* sites are Site 10 in the estuary, Site 20 at Benet Bridge and Site 30 at Douglas Bridge. These sites span 6 miles of river in the City of Oceanside and have year-round flow, although Site 30 exhibits significant seasonal fluctuation. Sites 10-30 are located in the coastal Mission Groundwater Basin – one of several basins included in this study. They partly overlap with sampling locations by the City of Oceanside and collaborators in their on-going water quality analysis program, allowing comparison of our data with an historical data set (San Luis Rey Watershed Urban Runoff Management Program (WURMP) Annual Reports, 2006 and 2008).

The three *middle section* sites are Site 40 at Mission Road at 10 miles inland, Site 50 at Old Hwy 395/I-15 at 17 miles inland, and Site 60 to the east of I-15 at Couser Canyon bridge at 20 miles inland. Site 40 lies at the eastern end of the Mission Basin, while Sites 50 and 60 are in the adjacent Bonsall Basin. These sites are in less urbanized areas. They receive water from multiple sources, including runoff from agricultural operations, and flow year-round.

The three *upper* sites are Site 70 on Gomez Creek about 23 miles inland, Site 80 on Doane Creek (80a, sampled in 2008) or nearby Pauma Creek (80b, sampled in 2009) about 40 miles inland and site 90 in the main stem just below Lake Henshaw at the Forest Service Picnic Area about 47 miles inland. Sites 70 and 80 lie in the Pauma and Pala Basins, and Site 90 lies just to the west of the Warner Basin that drains into Lake Henshaw. The three upstream sites are rural and variably impacted by development. Site 70 is in an agricultural zone, Site 80 is in a remote area of Palomar Mountain, and Site 90 is subject to flow fluctuations from Lake Henshaw. Site 80 is important as a positive control for these studies since it supports a stable trout population; it forms at the confluence of Doane Creek and French Creek.

Water chemistry sampling reported here was performed every other month, starting in April 2008 and ending in December 2009. Sampling was done in close collaboration with San Diego Coastkeeper (SDCK). Their rigorous field testing protocol was followed by trained volunteers who took on-site measurements of designated water chemistry parameters (described in Appendix D) and recorded physical habitat features, and water flow rate. Water samples were also collected on site for processing in the SDCK lab for phosphate, nitrate and bacterial levels.

Seven water temperature loggers were placed at sites spanning more than 50 miles along the main stem and tributaries (see pages 39-44). All but one logger location coincided with water chemistry sites. The exception was in the perennial Moosa Canyon Creek about 13 miles inland (p. 41). This creek was the only southern tributary included in the study, for comparison with tributaries at Sites 70 and 80 which drain from Palomar Mountain into the main stem from the north. Hobo ProV2 Loggers were placed at sites to record water temperature from spring to fall of 2008 and 2009. The seasonal deployment was designed to record temperatures spanning the summer season during which maximum water temps are expected. The loggers recorded water temperature every hour for 24 hours per day. With the exception of the estuary logger, the devices were placed in pools about 0.2m to 0.5m deep with good canopy cover and adequate flow to keep the loggers submerged (see p. 68).

Bioassessment with macroinvertebrate sampling was performed in Nov/Dec 2008 at four sites that aligned with water chemistry and temperature logger sites (see pp. 70-74). Bioassessment was performed according to the most recent Surface Water Ambient

Monitoring Program full protocol (SWAMP 2007, available on-line at http://swamp.mpsl.mlml.calstate.edu/resources-and-downloads/standard-operating-procedures) developed by State Water Resources Control Board, California Department of Fish and Game, and collaborators. Analysis of macroinvertebrate populations is important in gauging long-term water quality, because of the differential sensitivities that various benthic macroinvertebrates exhibit in response to water quality characteristics and toxins.

The four bioassessment sites included one middle site (at Site 40 Mission Road), two northern tributaries (at Site 70 Gomez Creek and Site 80 Pauma Creek downstream of confluence of Doane Creek and French Creek on Palomar Mountain), and one upper main stem location (at Site 90 Forest Service Picnic Ground). Lower reaches of the San Luis Rey River have been analyzed by bioassessment for years by the San Diego Regional Water Quality Control Board, San Diego Stream Team and private contractors. The Index of Biotic Integrity (IBI) scores usually fall within the Very Poor to Poor range in the lower stretches of the River. Pauma Creek was selected as a positive control because it holds resident trout in the upper reaches and thus is an indicator of benthic macroinvertebrate populations supporting trout survival. IBI scores for sites in this area have previously been in the Fair to Good range.

Results and Discussion

Water Temperature

Water temperature has been a principal concern in steelhead recovery efforts in S. California streams. Limited data exists that defines temperatures and times of exposure that S. California trout can withstand. As noted in the Amended Preliminary Draft Environmental Assessment Attachment 1 prepared by Southern California Edison (2007): "A large range of temperature preferences for rainbow trout/steelhead has been reported in the literature, with substantial regional variability. The preferred water temperatures for rearing juvenile steelhead on the American River are reported to range from 12.8ºC to 15.6ºC (CDFG 1991), while Bell (1986) reports a somewhat lower preferred range of 10 – 12.8ºC for steelhead in the Pacific Northwest. In contrast, hatchery-reared Central Valley steelhead consistently selected temperatures of 18 to 19ºC, while wild fish selected temperatures of about 17ºC (Myrick and Cech 2000). This lends support for the idea that *O. mykiss* populations in the southern portion of their range may have higher temperature preferences than those in northern regions."

In support of the idea that S. California trout can withstand higher water temperatures, Spina (2007) found that juvenile steelhead in S. California streams maintained normal behavior at temperatures in a range from 17.4°C to 24.8°C. This study focused on small coastal streams originating in the Santa Monica Mountains in Los Angeles County. Spina concluded that "Oversummering juvenile steelhead accept an elevated body temperature and remain active and forage throughout the day, apparently as a means for coping with warm water at the southern extent of their range." Based on these observations of trout behavior in a geographically similar range, and lack of data from other S. California streams, we here consider 25˚C as a possible upper value for water temperature that can support trout viability.

Water temperature at nine sites tested during water chemistry sampling in 2008 generally increased from 16ºC in April 2008 to a peak at 24-26ºC during August, and then declined to about 16ºC in December (p. 20). With the exception of Site 30 at Douglas Bridge, which reached 28.2ºC, water temperatures were less than 26ºC during August. Water temperatures at the same sites in 2009 (p. 29) were lowest in February at 12˚C, then rose to 14-17˚ C in April, peaked at about 21˚C in August (sites 20-80), then decreased in the fall. Water temperatures in the upper site 80 were generally lower than downstream sites for a given month during the summer season (5-15˚C in 2009), and temperatures throughout the watershed became more homogeneous during spring, fall and winter months. The exception was Site 90 just downstream of Lake Henshaw, which usually had higher water temperature than the other upstream sites during June and August 2009.

The water temperature loggers recorded temperatures hourly each day and provided a more detailed view of minimum and maximum temperatures at sites for each month. The loggers were placed in black PVC pipe and anchored beneath rocks in pools with adequate canopy cover and flow (see logger spreadsheet in Appendix F and photos at http://picasaweb.google.com/SanLuisReyPhotos). The temperature profiles showed the expected diurnal swing with minimum temperature at about 4:00 a.m. and maximum temperature at about 4:00 p.m.

The logger in the estuary (2008) had the additional variable of tidal fluctuations. The high temperatures in August and September recorded in the estuary are likely a combination of neap tides and mid-day sun (see Appendix G for additional information), given the proximity to the ocean. The placement plan and logger PVC housing was redesigned during 2009, and although no loggers were deployed in the estuary in 2009, multiple units will be placed at various depths and locations in spring of 2010.

With the exception of the estuary and Site 30, temperatures did not exceed 22º C as monitored in 2008 (p. 45-56), well below a possible upper limit for juvenile trout survival of 24.8ºC (Spina 2007, see below). In 2009, Site 30 Douglas Bridge had the highest water temperature of about 27˚C in July, with a diurnal swing of 8-10˚ which tapered off in fall months (p. 63). The diurnal swing was most pronounced at Douglas Bridge and Pauma Creek (2009), while the other sites at Old Hwy 395, Gomez Creek and Moosa Canyon Creek showed less intra-day variation (p. 64-66).
Overall, the water temperature in these latter pools did not fluctuate more than about 2-3ºC during a 24-hour period.

Water temperatures at different locations and habitats showed surprisingly similar characteristics. Logger 3 in the main stem near Interstate 15 at Old Hwy 395, located in a pool of 0.2 m deep and 0.5 m/sec flow, recorded similar temperatures (2008) to Logger 4 in a small northern tributary Gomez Creek, located in a pool also about 0.2-0.3 m deep, but with minimal flow through it (p. 54). The minimum temperature at Old Hwy 395 (2008) increased by about 1ºC each month from April through August, then decreased into the fall months. Likewise for Logger 4 at Gomez Creek (2008), temperature increased 1-1.5ºC through August, then decreased as expected. In 2009, Gomez Creek showed higher water temperature in August and September of 18-20˚C, peaking in September at 22˚C (p. 65).

Water temperature at Moosa Canyon Creek was similar to that of Old Hwy 395 and Gomez Creek sites (2008, 2009; p. 53-55 and 64-66). During May through October,

recorded temperatures were consistently between 15-22˚C, with about 4˚C of diurnal swing. Water temperatures at Moosa Canyon Creek tapered off to about 17-18˚C in October. This suggests that in this one case, northern vs. southern tributary was not a significant factor in summer water temperature ranges.

Two sites that showed the highest peak temperatures and diurnal swing were Logger 2 at Douglas in Oceanside and Logger 6 at Pauma Creek at Palomar Mountain (p. 63 and 67). Data retrieved from Logger 2 at Douglas Bridge in 2008 was not considered due to drying of the unit during June and July and an apparent recording malfunction in August-October. However, data from Logger 2 in 2009 showed gradually increasing temperatures near 23˚C in May and June, peaking at 27˚C in July, then decreasing to a constant 17-19˚ range in September and October (p. 63). Spring and summer water temperatures at this site also showed a high diurnal swing up to about 10˚C. Data retrieved from Logger 6 at Pauma Creek in 2009 showed a peak of about 22˚C during July and diurnal swing of 10˚ during spring and summer months (p. 67). This temperature fluctuation in Pauma Creek is noteworthy considering the existing trout population in this area and relatively high IBI score from bioassessment studies.

Data retrieved from Logger 7 at the Forest Service Picnic Ground near Lake Henshaw, placed in October 2008, recorded min temp of 10.8ºC and max temp of 20.4ºC during October, and min temp of 8.9ºC and max temp of 14.4ºC during November (p. 56). A longer recording period in 2009 allowed monitoring of temperatures through the summer months (p. 62) that ranged from about 8˚C to 27˚ C. This data is not considered further here due to the fact that the unit may have been intermittently dry due to variable releases from Lake Henshaw.

Logger sites:

Logger number	Site description	Associated chemistry site
1	Estuary	Near 10
2	Douglas Bridge	Near 30
3	Hwy 395 / Interstate 15	Near 50
4	Gomez Creek	70
5	Moosa Canyon Creek	none
6	Pauma Creek	Near 80
7	F.S. Picnic Ground	Near 90

Summary of 2008 data (all temperatures in ºC)

Hobo log	Apr min	Apr max	May Min	May Max	Jun min	Jun max	Jul min	Jul max	Aug min	Aug Max	Sep min	Sep Max	Oct max
1	12.9	24.0	15.5	25.8	19.1	26.5	17.0	27.8	21.2	29.7	19.1	29.7	26.2
2	12.6	18.9	13.9	20.8	Dry	dry	dry	dry	18.1	18.5	17.9	18.3	17.5
3	13.1	18.1	14.5	18.6	15.5	19.2	16.5	19.2	17.0	19.4	16.3	19.3	19.2
4					15.5	19.8	17.2	20.6	17.6	21.3	17.0	21.3	21.0
5									17.4	21.1	16.3	21.0	20.2
6												No	read
7													20.4

Conclusion: Based on our observations in the context of observations from the Spina study (2007), water temperatures upstream of the estuary do not appear to be in and of themselves a primary obstacle to steelhead survival. Temperatures recorded in the lower main stem at Douglas Bridge transiently exceeded a 25˚C threshold during July, but this area of the river is anticipated to be a migration corridor during high flows in winter months, and not a rearing area throughout the year. In contrast, upstream water temperatures recorded in 2009 in the main stem (near Old Hwy 395) in a southern tributary (Moosa Canyon Creek) and a northern tributary (Gomez Creek) where trout may oversummer, showed temperatures well below a 25˚C threshold even during summer months. The positive control at Pauma Creek, where trout are known to live, showed the highest degree of overall temperature variation (from about 6˚C to 22˚C) and diurnal swing (8-10˚ within a12-hour period), indicating that trout survival in S. California may indeed be compatible with summer water temperatures above 20˚C, although the extent of refuge in nearby lower temperature water was not evaluated here.

Dissolved Oxygen

Dissolved oxygen (DO) is a second important factor in considering trout habitat and the prospect for their long-term survival. As outlined in the State Water Resources Control Board Fact Sheet (2004, FS 3.1.1.0), DO has two main sources. Aeration of water occurs when oxygen from the air is mixed with water at its surface. For example, water tumbling over rocks or wave action increases DO levels. A second source is plant photosynthesis in which plants generate oxygen through this process, and DO levels in the water are generally highest in the afternoon. DO levels and water temperature are inversely correlated. DO levels decrease as water temperature increases and vice versa. Factors that further decrease DO levels are algal blooms, sedimentation, bacteria from human and animal waste, and other chemical oxidation events.

Acceptable levels of dissolved oxygen for steelhead depend on their geographic range, stage of maturity, and water temperature conditions. Levels above 8 mg/L are generally accepted as sufficient to not cause impairment; levels from 5 to 8 cause growth impairment, especially in juveniles; levels from 3 to 5 mg/L are near lethal (SWQRCB 2004, FS 3.1.1.0) and below 3 mg/L is considered lethal for adult and juvenile rainbow trout (Dourdoff and Shumway, 1970; Raleigh et al, 1984). S. California steelhead that can survive higher water temperatures may be able to tolerate lower dissolved oxygen levels. In the 1998 U.S. Fish and Wildlife study entitled “Southern Steelhead *Onchorynchus mykiss* Habitat Suitability Survey of the Santa Margarita, San Mateo and San Onofre Creeks on Marine Corps Base Camp Pendleton, California” (USFWS, 1998) the authors state that “Based on the available literature, southern steelhead are relatively adaptable, able to survive in modest habitat and withstand higher stream temperatures and lower dissolved oxygen concentrations than their northern counterparts. Rainbow trout have been observed surviving water temperatures as high as 29ºC, but prolonged exposure to temperatures greater than 25ºC would likely be lethal. In intermittent streams, trout will tolerate low dissolved oxygen in order to escape high water temperatures.” A study from Matthews and Berg (1997) investigating DO levels in two

pools in Sespe Creek in Ventura County reported between 1 mg/L and 5 mg/L at the bottom of inhabited pools.

Whatever the variation among studies reported in the literature, this study finds that dissolved oxygen in the San Luis Rey River is inadequate over large stretches of the river main stem during late summer and fall months. Dissolved oxygen levels measured in this study at nine sites generally varied according to season as expected due to decreased water flows and increased water temperatures in summer and fall. Additional funding received early in 2009 from the California Wildlands Grassroots Fund allowed us to purchase HachHQ40D digital meters that record DO and conductivity levels directly into the meter for permanent storage. These meters were used starting in April 2009.

In 2008 (p. 21), DO levels in April were between 4.3 mg/L (Site 50) and 8.3 mg/L (Site 10). DO levels in June were similar, between 4.8 mg/L (Site 40) and 7.2 mg/L (Site 30), with significant increases in the estuary (Site 10) of unknown cause and at Sites 50 and 60 which were above 12 mg/L possibly due to algal photosynthesis. DO levels declined during August (1 mg/L to 6 mg/L) and October (2.3 mg/L to 6.4 mg/L) and were variable in December.

In 2009 (p. 30), DO levels were highest in February, correlating with lower water temperatures, and ranged between acceptable levels of 5.8 and 13.3. DO levels were likewise near or above 6.0 in April 2009, except for Site 50 which consistently had lower DO levels. Main stem flow rate does not change significantly throughout the year at Site 50, due in part to water contributed perennially from the Keys Creek drainage. DO levels in June were near or above 6.0 at most sites, with the exception of Sites 50 and 60 which are within two miles of each other on the main stem. Site 60 at Couser Canyon Bridge east of Interstate 15 is particularly susceptible to seasonal flow variations, and forms a large pool with little water movement in summer and fall months.

DO levels decreased notably in August and October, with very low levels below 4.0 mg/L recorded in the main stem upstream of the estuary at sites 20, 30, 50 and 60. Only Site 40 maintained DO levels above 7.5 in late summer and fall. Site 40 is near Mission Bridge in the main stem and has significant flow year-round but also significant sedimentation.

In contrast, the upper sites 70 (Gomez Creek) and 80 (Pauma Creek) in tributaries and a main stem site 90 (near Lake Henshaw) maintained a relatively constant DO level of 6.0 mg/L throughout 2009 (p. 30), although data from August at these sites is absent. The constant DO levels near 6.0 mg/L at Site 80 (Pauma Creek) are particularly interesting because a) a stable trout population exists in this area of the river, suggesting that this DO level may be sufficient for trout survival and b) the water temperature ranged from 5.7˚C in February, 2009 to 15.1˚C in June, 2009. Water temperatures monitored by data logger in a pool just downstream of the water chemistry site showed high diurnal variation near Site 80 in spring and summer, and a range between 6˚C (April and October) and 22˚C (July) as discussed above.

Conclusion: Dissolved oxygen levels are below 4.0 mg/L at lower main stem sites tested during late summer and fall, except for Site 40 near Mission Road Bridge. Site 50 was particularly low from April through October. This site has several characteristics that support trout survival such as relatively constant flow and adequate canopy cover, but the DO levels and lack of gravels suitable for spawning are likely incompatible with a

sustainable trout population. The DO levels present at candidate and existing trout habitats upstream in tributaries (e.g. Sites 70 and 80) generally are more consistent with supporting trout viability.

Overall, the DO levels are low enough during August, October and December in the main stem to consider this a primary threat to long-term survival of steelhead. Additional water flow might alleviate the problem through increasing turbulence in canyon sections of the main stem and perhaps elsewhere in the watershed, and more dissolved oxygen in the headwaters might carry over to the lower section of the river. The few tributaries tested here show adequate DO levels throughout the year and are likely sufficient for trout survival.

Specific Conductivity

Specific conductivity is a measure of ionic strength of water. The most common positively charged dissolved ions are sodium (Na+), calcium (Ca++), potassium (K+) and magnesium (Mg++), while the most common negatively charged ions are chloride (Cl-), sulfate (So_4^{-2}), carbonate (Co_3^{-2}), and bicarbonate (HCO_3^-). Nitrates and phosphates are minor contributors to conductivity (State Water Resources Control Board, Fact Sheet 3.1.3.0).

Conductivity varies with the water source and amount, ground water quality, agricultural drainage, municipal wastewater processing, and rockbed minerals. Two additional factors that figure prominently in Southern California river conductivity levels are rainfall, which dilutes ionic concentration and therefore decreases conductivity, and proximity to the ocean, which can increase conductivity in urban coastal watersheds. In the first case, low rainfall during May-December decreases river flows and essentially concentrates the dissolved ions, giving high conductivity readings in late summer and fall. In the second case, urban S. California rivers and streams may have high conductivity levels extending inland arising in part from ocean salt water mixing into the groundwater due to a net imbalance of water extraction rate from aquifers compared to replenishment rate.

Conductivity is related to another common measurement of suspended ions and solids in the water called Total Dissolved Solids (TDS). The conversion between these two related parameters is TDS = .68 Conductivity (San Luis Rey WURMP (2006) p. 156 of pdf /TDS and Chloride Study section p. 6). The Basin Plan Objective for TDS in the San Luis Rey is 500 ppm (mg/L). These Objectives are based on beneficial use criteria, including water taste and irrigation use where high TDS levels cause leaf burn (San Luis Rey WURMP (2006) TDS and Chloride Study section, p. 1).

Conductivity measured at the nine sites in this study showed both geographic and seasonal characteristics. Sites 10-50 had the highest conductivity levels generally of > 2,000 µS extending inland about 17 miles. There was a sharp transition to lower conductivity at Site 60 at Couser Canyon Creek of 729 µS in April 2008 (p. 22), which continued through the upper sites 70-90. The difference between Sites 10-50 and 60-90 was most pronounced in April, June and August. During low water flow months of October and December, conductivity increased at Sites 60 and 70. Conductivity also increased surprisingly to levels above 2000 µS in August and October 2009 at Site 80 in Pauma Creek (p. 31), which should not be impacted by urban or agricultural runoff.

The highest conductivity occurred as expected in the estuary at Site 10 where levels ranged from 6,000 µS to 16,000 µS in 2008 (p. 22), and ranged from 3,000 to 23,000 µS in 2009 (p. 31). This site is significantly influenced by ocean water salinity, which is about 55 mS or 55,000 µS (State Water Resources Control Board, Fact Sheet 3.1.3.0), and the variability is likely due to whether the tide is in-coming or out-going at the time of sampling. The high conductivity at sites 20-50 of >2,000 µS could be due to ocean influences, but also reflects accumulation of water solutes throughout the watershed. Considering that imported water supplies approximately 90% of local water demand (Issue Paper: An Analysis of the Proposed 303(d) Listings for Total Dissolved Solids in San Diego County Watershed, p. 11) and imported water TDS levels in 2001 were 590 mg/l (roughly equivalent to 823 µS conductivity) from Colorado River Supply and 290 µS (roughly equivalent to 426 µS conductivity) from the State Water Project Aquaduct (Issue Paper above, p. 15, Table 3-1), watershed activities and water dynamics impact the existing conductivity levels.

The decrease in conductivity at Sites 60-90 to levels closer to that of the Basin Plan Objective of 500 ppm TDS may relate to influences from natural springs (Site 70, personal communication), being part of groundwater basins different than Mission Basin (Sites 60-90), and/or water releases from Lake Henshaw, which has TDS level below 500 ppm (San Luis Rey WURMP 2006). The conductivity levels reported in this study are consistent with TDS levels reported in the San Luis Rey WURMP annual reports (2003, 2006) where sampling extended eastward to Shearer Crossing (about 19 miles inland) which is about 1 mile west of Site 60 at Couser Canyon.

High conductivity levels may also impact steelhead habitat in terms of whether high ionic concentrations reduce benthic macroinvertebrate population diversity, and therefore decrease Index of Biotic Integrity (IBI) scores, and whether high levels of certain charged ions like Na+ and Ca+ may adversely impact spawning ability and rearing success of steelhead (Weber-Scannell and Duffy, 2007). Given that TDS levels are an important consideration in watershed management, and that the San Luis Rey and other San Diego rivers and streams have been listed as 303(d) impaired water bodies since 2002 due to exceedance of TDS Basin Plan Objectives, best management practices and possible increase water flow through the San Luis Rey to reduce TDS and conductivity levels are desirable from both a biological and economic perspective.

Conclusion: Specific conductivity is greater than the TDS equivalent Basin Plan Objective at every lower and middle sampling site (10-60) on every date. It is unclear the extent to which the overall TDS/conductivity levels or presence of specific ions may adversely affect steelhead survival. Adding more water to the river from Lake Henshaw may improve TDS levels and thereby decrease exceedance events, especially if pulse releases are done in fall and early winter months when conductivity levels are higher throughout the lower watershed.

pH

pH represents the concentration of hydrogen ions, and indicates how acidic or basic the water is. According to the Regional Water Board, the pH should remain between 6.5 and 8.5 for fresh water communities in order to protect the organisms. Many aquatic

organisms can only survive between this narrow pH range. In this study, pH levels consistently fell within the 7.2-8.4 range (p 23 and 32), with the exception of one time at Site 90 in June 2009 that recorded a pH of 8.9.

Conclusion: pH levels at all sites tested are well within acceptable range for steelhead survival.

Phosphate and Nitrate levels

Phosphate is converted to phosphorus by plants. Phosphorus can be found as three different types. Orthophosphorus is produced by sewage. Polyphosphorus is used in detergents and organic phosphorus is produced in the breakdown of pesticides. The USEPA recommends that phosphate levels for streams not be higher than 0.1 mg/L. Increased levels can result in algal blooms, eutrophication and decreased dissolved oxygen levels.

In this study (p. 24 and 33), phosphate levels generally ranged from .02 mg/L to 1.7 mg/L with occasional spikes $\geq$ 2.0 mg/L at Site 60 (Aug. and Oct. 2008; June 2009), Site 80 (Apr 2009) and Site 20 (Apr. and Aug. 2009). There were unusually high phosphate levels at all sites measured in August 2009.

Conclusion: Although phosphate concentrations were generally 2-10 fold higher than USEPA recommended levels, it is not clear that this fold increase is sufficient to alter stream habitat or impair steelhead survival either directly or indirectly

Nitrate is found in several forms as it cycles through the water column. It moves from organic matter to ammonium, nitrite, and then to nitrate as bacteria break down organic matter. Increased levels of nitrate are caused by fertilizers, sewage disposals, livestock facilities and industrial discharge. Natural levels in surface waters are less than 1 mg/L, but wastewater treatment runoff can be as high as 30 mg/L. High levels may also result in eutrophication which is a condition where the increased nutrients can lead to increased microbe concentrations, algal blooms and decreased dissolved oxygen due to elevated decomposition.

In this study (p. 25 and 34), nitrate levels generally ranged from .01 mg/L to 0.9 mg/L with occasional spikes $\geq$ 2 mg/L at Site 50 and Site 70.

Conclusion: Nitrate concentrations were generally below natural levels in surface waters with the exception of Sites 50 and 70 which were somtimes above 2 mg/L. This factor is apparently not a limiting factor for steelhead survival; especially in the case of Site 70 which yielded a relatively high IBI score (see below) comparable to the positive control at Pauma Creek which has consistently low nitrate concentrations.

Bioassessment with Macroinvertebrate Analysis

The bioassessment data (p. 75-76) indicated that Pauma Creek and Gomez Creek have the highest IBI scores of 48 and 47 respectively, falling within the Good range. These are both tributaries on the north side of the San Luis Rey River, under

the influence of rainfall on Palomar Mountain. The relatively high IBI score for Pauma was anticipated from previous bioassessments in this area, but the Good rating for Gomez Creek surprisingly demonstrated that a similar quality benthic macroinvertebrate community can exist in a tributary with low flow and intermittent standing pools of 0.3m maximum depth. The water temperature logger data from a device placed midway in the Gomez Creek sampling reach showed constant water temperature, with a maximum of 22ºC during September 2009, and about a 4ºC fluctuation over a 12-hour period (p. 65).

The Mission Road site IBI score was 2, falling within the Very Poor range. Large numbers of scuds and crayfish were observed. This site has extensive siltation and a predominantly sand bottom. These conditions are consistent with decreased macroinvertebrate species diversity and therefore a low IBI score. Additional water quality parameters may adversely impact this site, although the water chemistry studies did not indicate an obvious unique problem. This site features adequate water flow year-round and good canopy cover throughout the reach analyzed. In its current state, it is poor trout habitat but may benefit from in-stream improvements to reduce sand accumulation and increase water oxygenation.

The Forest Service Picnic Ground site IBI score was 16, falling within the Poor range. This site is far upstream of urban development and has relatively good physical habitat quality with good canopy cover. The water flow is highly variable due to water releases from Henshaw, and has higher than anticipated water temperature. Trout have been stocked here in the past, but it is unknown whether they over-summered.

Summary

This study focused on assessing water quality parameters potentially impacting the viability of steelhead trout in the San Luis Rey River. The parameters studied here fit into a larger picture of factors that limit steelhead recovery as presented in The San Luis Rey Watershed Assessment (Downie and Kajtaniak, 2010). These factors include inadequate water flow; the presence of fish passage barriers; loss of estuarine habitat; high levels of fine sediments in streams; and limited areas with suitable spawning gravels in the main stem and tributaries. The variable water flow in the San Luis Rey, and in particular low flow during summer season, impacts not only the connectivity of the river, but results in increased sedimentation and loss of gravel beds, seasonal increased concentration of nutrients and salts, and low dissolved oxygen levels in the water. Water temperature and dissolved oxygen are two parameters that are of particular interest due to their central importance in trout survival.

Based on our observations of water temperature in the context of observations from the Spina study (2007), water temperatures upstream of the estuary do not appear to be in and of themselves a primary obstacle to steelhead survival. Dissolved oxygen levels are low enough during August, October and December in the main stem to consider this a primary threat to long-term survival of steelhead. Additional water flow might alleviate the problem through increasing turbulence in canyon sections of the main stem and perhaps elsewhere in the watershed, and more dissolved oxygen in the headwaters might carry over to the lower section of the river. The few tributaries tested here show adequate dissolved oxygen levels throughout the year and are likely conducive to trout survival. Specific conductivity is greater than the TDS equivalent Basin Plan Objective at every lower and middle sampling site (10-60) on every date. However, it is unclear the extent to

which the overall TDS/conductivity levels or presence of specific ions may adversely affect steelhead survival. Other water quality parameters such as pH, nitrate and phosphate levels do not show values indicative of being limiting factors for trout.

Bioassessment at four dispersed sites in the San Luis Rey and tributaries yielded varying results, depending on location. IBI scores fell within the Very Poor range at a main stem site in the lower section of the river as had been previously shown, and within the Poor range at a site just downstream of Lake Henshaw. Although the latter site is far upstream of urban development and has apparently good physical habitat, the water flow is highly variable due to water releases from Henshaw, and has higher than anticipated water temperature which could alter the integrity of benthic macroinvertebrate populations. The two remaining sites in tributaries tested yielded a Good rating at Pauma Creek near Palomar Mountain (the positive control for existing rainbow trout populations) and at Gomez Creek about 20 miles inland. Pauma Creek IBI scores have consistently ranked among the highest in San Diego County in past years, but this is the first known bioassessment of Gomez Creek. Data from Gomez Creek surprisingly demonstrated that a high quality benthic macroinvertebrate community can exist in a tributary with very low flow and intermittent standing pools of 0.3m maximum depth.

Proposed projects for the San Luis Rey River

1. Increase instream water flow in the San Luis Rey River
2. Improve steelhead passage by removing two physical barriers on the San Luis Rey
    a) reconfigure boulders at Douglas bridge 6 miles inland in Oceanside to allow fish passage during low to medium flows
    b) modify concrete buttress below bridge where Pauma Creek crosses Hwy 76 to allow fish passage during medium and high flows
3. Improve habitat for trout viability
    a) place boulders, gravel and woody debris at sites that have promising trout habitat to increase dissolved oxygen; track how gravel persists through time. Mission Road (near Site 40) and Hwy 395 / I-15 (near site 50) stretches are priorities as first tests.
    b) plant willows and other native vegetation on stretches of San Luis Rey that are currently undergoing extensive *Arundo donax* removal starting near Douglas bridge and proceeding downstream.
4. Monitor estuary water temperatures

    Expand monitoring of estuary and promote communication with City of Oceanside on water chemistry data there. Observations from Bond (2006) suggest important role of estuary conditions in enhancing sustainable steelhead populations. The high August/September estuary temperatures measured by Logger 1 need to be confirmed as they would constitute a significant problem for acclimating steelhead. Suggest placing additional 2 loggers nearby--one in the estuary, but different location, and one logger upstream about ¼ mile.

What follows (Appendix A) is a letter submitted by members of the Trout Unlimited Chapter (4/16/10) summarizing steelhead recovery efforts in the San Luis Rey River.

A Case for the San Luis Rey River

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Trout Unlimited - San Diego Chapter 920
Appendix A

This note is submitted by members of the Trout Unlimited-San Diego chapter 920 in support of restoration efforts for the endangered steelhead trout in the San Luis Rey River in San Diego County. Acting under the umbrella of Trout Unlimited-National, we have worked in the San Luis Rey since April 2008 assessing water quality as a component of steelhead habitat, supported by funding from the California Dept. of Fish and Game and the Pacific States Marine Fisheries Commission. We seek here to condense data collected on the San Luis Rey and review recent guidelines from federal and state agencies that identify the San Luis Rey River as a high priority watershed for steelhead recovery. We highlight features of the San Luis Rey that are conducive to accomplishing the goal of restoring runs of steelhead in the context of urbanized Southern California.

Summary

It has been estimated that annual runs of steelhead at the southern part of their range in California have declined from 32,000-46,000 returning adults to less than 500 today[1]. Steelhead were present in the San Luis Rey River until the 1940s[2], but their population has declined to a currently negligible level.

However, the San Luis Rey River remains one of the best candidates for steelhead recovery on the South Coast. Reasons for optimism include not only the sporadic sightings of steelhead in the San Luis Rey in 2007[3], but also the continued existence of stream reaches with summertime water quality and stream temperatures that are suitable or almost suitable even without increased instream flows, self-reproducing populations of rainbow trout in the Pauma Creek tributary and the West Fork of the San Luis Rey River, and the recent discovery and

[1] Good, T. P., R. S. Waples & P. B. Adams. 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-NWFSC-66. 598 pp.
[2] Downie, S.T. and D. Kajtaniak. 2010. San Luis Rey River Watershed Assessment. Coastal Watershed Planning and Assessment Program. Department of Fish and Game. Basin Profile section, pg. 1.
[3] Ibid. p. 51

genetic documentation of steelhead juveniles in the adjacent Santa Margarita River drainage[4]. In addition, the water needed to dramatically improve instream flows is but a small percent of the basin's water budget. All of these facts confirm the potential for re-establishing a stable steelhead population in the San Luis Rey River. Long-term viability and the eventual delisting of the Southern California steelhead depend upon mitigating factors that limit steelhead survival there and implementing a plan of action that is reasonable in the context of an extensively urbanized Southern California.

Background

Steelhead (*Oncorhynchus mykiss)* have historically populated coastal watersheds throughout Southern California. A sharp decline in their population started in the mid-1900s, leading to the listing of the Southern California Coast steelhead as a federally endangered species in 1997 from the Santa Maria River at the north end to Malibu Creek, currently the southernmost known, self-sustaining steelhead population. Following steelhead sightings and genetic documentation in watersheds south of Malibu Creek, the geographic boundary was extended southward to the U.S.-Mexico border in 2002. The expanded region including San Diego County was included in the ESA listing in 2006.

Limiting factors to steelhead recovery are tightly linked to features of their life history as an anadromous species. Steelhead live for at least one year in freshwater as juveniles before migrating to the ocean where they feed and grow for several years before returning to freshwater to spawn. Most steelhead survive the spawning run, returning to the ocean and repeat the cycle to fresh water once or twice more in future years. In this pattern of existence, they require passage through the main stem of a river during periods of high flow in winter months, and they need year-round refuge areas in the main stem and particularly in tributaries, which are favored spawning and rearing sites. They also require adequate estuarine habitat for smoltification, preparing them for the transition between fresh and salt water. Steelhead migration distinguishes them from the rainbow trout resident in fresh water (also *O. mykiss*) and defines their two main needs for survival as a species: areas of year-round water of suitable quality for spawning and

[4] Rodney McInnis, Regional Administrator, National Oceanic and Atmospheric Administration. Letter of March 12, 2010 to William Berry, Resource Management Division Head, Camp Pendleton Marine Corps Base.

rearing, and seasonal passage to and from the spawning and rearing areas, typically in upstream reaches of the river or its tributaries.

The Southern California Steelhead Recovery Plan draft published in 2009 by the National Marine Fisheries Service, part of the National Oceanic and Atmospheric Administration, articulates recovery guidelines and designates the San Luis Rey as a high priority watershed. Under this Steelhead Recovery Plan, the goal is to "prevent the extinction of Southern California steelhead in the wild and ensure the long-term persistence of viable, self-sustaining, harvestable, interacting wild populations of steelhead distributed across the DPS [distinct population segment]"[5] by addressing factors limiting the species' ability to survive and reproduce in the wild. The immediate objectives are to increase steelhead abundance and to preserve the expression of all life-history strategies that steelhead utilize. To meet these objectives, the Steelhead Recovery Plan uses a Threat Assessment Process to identify, prioritize and compare threats among the watersheds in which the Southern California steelhead are native and to examine the possibilities for mitigation. As a result of this process, the Steelhead Recovery Plan categorizes the San Luis Rey River as a high priority, or Core 1 basin.[6]

The Steelhead Recovery Plan designation is further supported by the findings of another group of agencies that studied the possibilities for restoring steelhead in the San Luis Rey River. A collaborative field study conducted by the California Department of Fish and Game, Pacific States Marine Fisheries Commission and the Coastal Watershed Planning and Assessment Program records its findings in the San Luis Rey Watershed Assessment.[7] Threats to steelhead viability identified in the Assessment are similar to those identified in the Steelhead Recovery Plan, and include dewatering and inadequate stream flows in the main stem and tributaries, barriers to fish passage in the river, loss of estuarine habitat, and lack of suitable spawning gravels in the main stem and important tributaries. However, the natural climatic, hydrological, geological and ecological advantages cited in the Assessment indicate that these limiting factors

[5] National Marine Fisheries Service, National Oceanic and Atmospheric Administration, "Southern Steelhead Recovery Plan" Draft, July 2009, pg. 47.

[6] Ibid, pg. 62 and pg. 64 Table 6.1. Core 1 population designation is based on several factors, including "the intrinsic potential of the population in an unimpaired condition, the role of the population in meeting the spatial and/or redundancy viability criteria, the conditions of the population, the severity of threats facing the populations, the potential ecological or genetic diversity the watershed and population could provide to the species, and the capacity of the watershed and population to respond to the critical recovery actions needed to abate those threats. Core 1 populations form the nucleus of the recovery strategy…"

[7] Downie, S.T. and D. Kajtaniak. 2010. San Luis Rey River Watershed Assessment. Coastal Watershed Planning and Assessment Program. Department of Fish and Game.

can be successfully mitigated, making the San Luis Rey River a prime candidate for steelhead restoration.

Factors Affecting Steelhead Recovery in the SLR Basin

Increasing Water Flow in the San Luis Rey

The San Luis Rey watershed is a mixture of developed and wild land covering over 565 square miles (see Figure 1). The river flows from Palomar and Hot Springs Mountains in the Cleveland National Forest into the Pacific Ocean in the city of Oceanside. It has a single dam, forming Lake Henshaw, one of the larger reservoirs in the region. The Henshaw Dam was completed in 1922 to store water for irrigation and municipal uses and for potential regulation of flood stage water levels. From Lake Henshaw the main stem runs approximately 50 river miles to the ocean.[8]

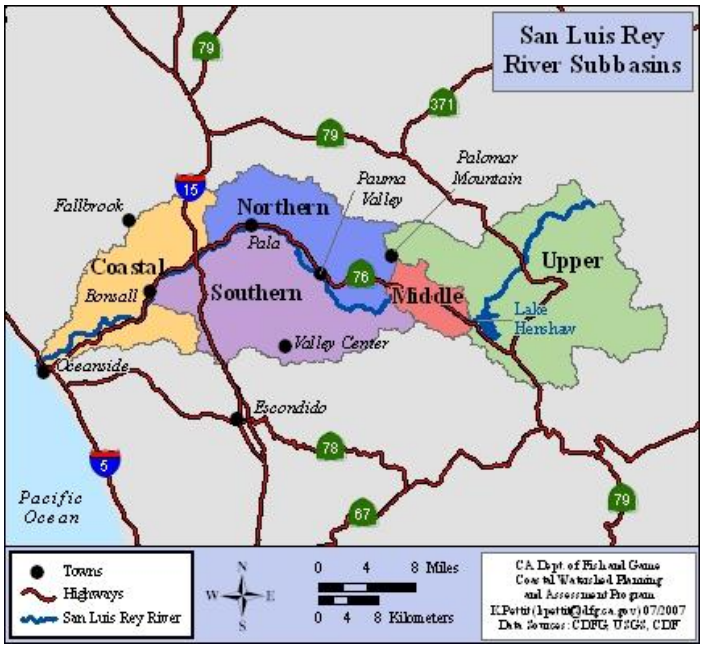

Figure 1A San Luis Rey Watershed in San Diego County,
large scale view showing sub-basins.

About 10 river miles below Lake Henshaw is the Escondido Canal diversion that draws virtually all of the river flow into the adjacent Escondido Creek watershed. For about 20 river miles below the diversion, the San Luis Rey River is mainly dry except during major winter rains. In this area, the riverbed runs through predominantly agricultural and rural areas. The river

[8] This and other distances were calculated using the ruler utility in Google Earth.

flows again perennially starting about 20 miles inland (near Interstate 15) due to contributions from run-off, ground water, and tributaries. The river is fed throughout its course by numerous tributaries, most of which are seasonal. Taken as a whole, the San Luis Rey collects the largest share of the run-off from the Palomar and Hot Springs mountains, the higher elevations receiving an annual rainfall around 45 inches, far above the coastal average of 12 inches. Relative to other Southern California rivers, the San Luis Rey watershed has capacity to produce and carry an abundance of water, and that fact is one of the clearest justifications for its classification as a Core 1 watershed for steelhead recovery.

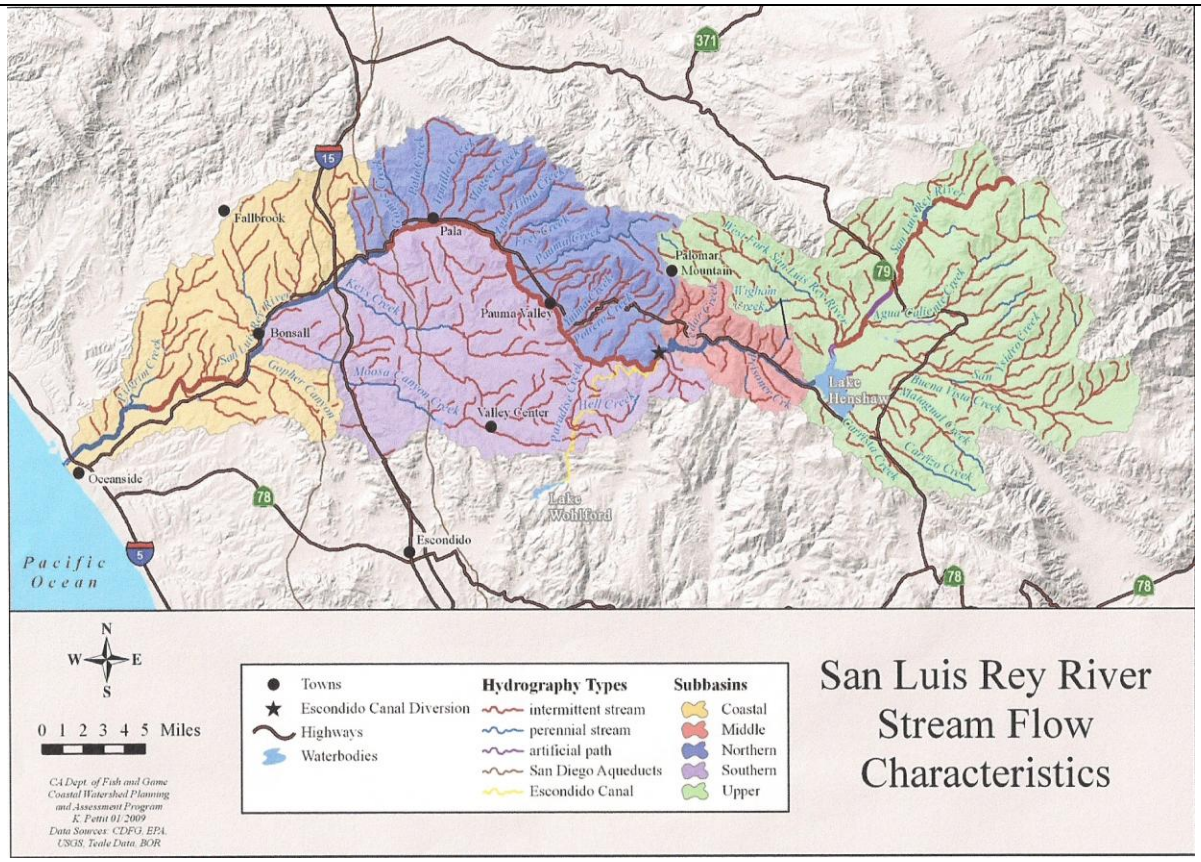

Figure 1B:. San Luis Rey River stream flow characteristics showing perennial and dry regions of the main stem and location of Lake Henshaw and Escondido Diversion Canal. From Downie and Kajtaniak (2010) San Luis Rey River Watershed Assessment, Basin Profile section, pg. 11.

In the San Luis Rey River, as in many other Southern California rivers and streams, a principal limiting factor to steelhead restoration is reduced instream water flow. Low water flow disrupts passage of fish through partial migration barriers, reduces the quantity and quality of dry season rearing habitat, and exacerbates problems of water quality. Increased concentrations of

salt, total dissolved solids (TDS), sediments, and nutrients such as phosphates and nitrates due to low water flow correlate with decreased gravels for spawning and reduced dissolved oxygen levels, a key factor in steelhead viability. In our trips to assess water quality, we have been struck by fact that even in low water flows, the characteristics of the water are nearly at the level needed for steelhead reproduction. Defects of water quality and water quantity, which are recognized as threats to steelhead recovery, can be reduced or eliminated by increasing water flow and implementing better management practices in agriculture and urban uses.

Feasibility of higher instream flows.

The San Luis Rey River is a Core 1 priority river despite the fact that much of the water is presently diverted to urban and rural interests in the adjacent Escondido Creek watershed. The diversion effectively dewaters the riverbed for 20 miles downstream, except for a three mile stretch at approximately river mile 36.5 to 39.5. Thus, this stretch of river is predominantly dry for most of the year, except after major rain events. Before the diversion was built, the river in this stretch ran perennially, sustained vigorous riparian habitat, and supported a steelhead run. The Escondido Canal diversion, operated by the Vista Irrigation District, carries almost all of water from the upper reaches of the river away to Lake Wohlford in the adjacent Escondido Creek drainage.

The presence of the diversion and of other existing users of water raises the question of whether water flows needed by steelhead can ever be realized in the river. The answer has three parts: the quantity needed by steelhead, the total available quantity, and water rights issues. The first two issues are considered here, in which we ask whether increased flows are feasible in a technical sense. We approach the feasibility question with caution because hydrology is complicated and the water law of California can produce anomalous incentives for water users. Nevertheless, a rough calculation shows that the water needed for steelhead recovery is at most a small part of the water budget of the San Luis Rey and its diverters. We start by considering the needed water and continue by considering the sources.

The needed flows can be estimated using the historical flows that supported steelhead. As reported in the SLR Watershed Assessment, data from 1912 to 1922 at the site of the present Henshaw dam, the upstream end of the area that is now of interest in steelhead recovery, show

monthly minimums of 1.4 cubic feet per second (CFS) in summer and 8 CFS in winter[9]. Average flows were greater in winter, some months reaching a monthly average of 240 CFS. This analysis focuses on the minimums. The 1.4 CFS at the dam site is similar to measurements taken 25 miles downstream at Wilderness Gardens, near Pala (see Figure 1), in the now-dry stretch of the river. Minimum summer flows measured from 1909 to 1915 in that location were 1.5 CFS[10], suggesting that water from the upstream site was not entirely lost into the ground, and supporting historical accounts of extensive riparian habitat in that area. Based on other research described in the SLR Watershed Assessment, it is unquestionable that the San Luis Rey was perennial and that steelhead entered, spawned, grew, and exited from the river in that era[11].

For purposes of the present rough calculations, let the standard for nine months of the year be a minimum flow of 1.5 CFS at Wilderness Gardens. Allowing for fifty percent losses to wells and minor diversions, this translates to 3 CFS *at the diversion*. During the three winter months the minimum would be 8 CFS *at the diversion*. Averaged over the year, that works out to $.25 \bullet 8 + .75 \bullet 3 = 4.25$ CFS.

The supply side of the water budget starts with groundwater. In the best available estimate, water availability as natural safe yield for San Luis Rey is 32,400 to 35,400 acre-feet/year (AFY), of which we focus on the midpoint, 33,900 AFY[12]. Add to that the 16,000 AFY contributed by the supplemental Colorado River water to the Native American Bands in the San Luis Rey from the amended Settlement Act of 2000. That brings the total of water in the budget to 49,900 AFY.

To complete the comparison of resources and requirements, a flow of one CFS over a year is 723.97 acre-feet. The required flow of 4.25 CFS is then equivalent to 3076.86 AFY. This amount is 6.2 % of the total water budget. A further consideration is that the water used to maintain instream flows would benefit other water users. Irrigators and consumers along the course of the river would inevitably get some benefits and the city of Oceanside would receive substantial benefits in its effort to improve water quality and counteract salt water intrusion into the water table. Given that TDS levels are an important consideration in watershed management,

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[9] Downie, S.T. and D. Kajtaniak. 2010. San Luis Rey River Watershed Assessment; Basin Profile section p. 12.
[10] Ibid. pgs. 12 and 14.
[11] Assessment, Basin Overview, pp. 51, 57, and Northern Subbasin, p. 16.
[12] San Diego Groundwater Basin Report, Chapter IV (2007), http://www.mwdh2o.com/mwdh2o/pages/yourwater/supply/groundwater/PDFs/SanDiegoCountyBasins/SanDiegoCountyOverview.pdf.

and that the San Luis Rey has been listed as a 303(d) impaired water body since 2002 due to exceeding the TDS Basin Plan Objectives, better management practices and increased water flow through the San Luis Rey are desirable from both a biological and an economic perspective. In summary, the water needed for steelhead restoration is about 6 percent of the water budget of the San Luis Rey watershed, a figure neither overwhelming nor impossible to contemplate in itself, and one that leaves out of account a significant range of benefits for watershed residents.

Water that would be in the San Luis Rey now flows to two water companies that are operators of the diversion and other facilities constituting the Escondido Water Project. At an operational level, water from the river is 18% or 19% of total water deployed by the two companies, a relatively small percentage of their overall water demand. The main supplier of water to these entities is the California Water Project. Modest decreases in water from the San Luis Rey could be recovered, wholly or in part, by bringing on line the unused capacity for water reclamation in the City of Escondido, or in many other ways.

Barriers to steelhead passage

Physical barriers to fish passage are a second major obstacle to steelhead recovery. Barriers can fragment fish populations and prevent access to suitable spawning sites upstream. Partial barriers preclude fish passage at normal water levels and are usually culverts, dirt road crossings, or large boulders buttressing overhead bridges. Complete barriers preclude fish passage even under high water flow, and are generally man-made concrete structures associated with major road arteries or dams, or large boulders and natural waterfalls in the riverbed. The San Luis Rey River is fortunate in this regard, having relatively few complete barriers, mostly in the upper sections of the river and tributaries, and some minor partial barriers in the lower main stem.

For instance, the first partial barrier is located about six miles upstream at the Douglas Bridge crossing in Oceanside. This barrier consists of a large collection of boulders across the riverbed below the bridge, and is navigable to fish during higher flows in winter at a time they would be utilizing the river for migration (see Figure 2). It is impassable during low water flow, and rearranging the boulders would be a matter of a few hours or days with standard earth-moving equipment. Of the 25 barriers documented in the SLR Watershed Assessment below

Lake Henshaw in the main stem[13], eleven are partial barriers which could be modified at relatively low cost. Two additional partial barriers of concern are the Cole Grade Road crossing at river mile at 30.6 and the Pauma Valley Country Club river channelization at river mile 32.7 that would make fish passage difficult under low and moderate water flow conditions.

Figure 2. San Luis Rey River at Douglas Bridge crossing six miles upstream of river mouth in Oceeanside
Low flow (partial barrier to fish passage, July 2008; left panel);
Medium flow (March 2008; middle panel;
High flow (January 2010; right panel)

The barrier of greatest significance in terms of access to spawning grounds and rearing habitat is a bridge on Highway 76 over Pauma Creek. This tributary currently sustains a healthy and substantial rainbow trout population, demonstrating its value as trout habitat. Stream reaches that can support the resident form of *O. mykiss* (rainbow trout) year round are also generally suitable for the anadromous form of *O. mykiss* (steelhead) if the fish have access to and from the ocean. The bridge at the lower end of Pauma Creek as it crosses Hwy 76 precludes passage of fish upstream even in exceptionally rainy years, and modifying it would open access for the steelhead to excellent spawning and rearing habitat. Removal coupled with increased flow in the main stem would dramatically improve the prospects for steelhead recovery.

Current river conditions

Water quality

Increased water quantity and improved water quality are related aspects of long-term steelhead survival. Increased flows promote hydro connectivity, create deeper pools, flush out sediment, increase dissolved oxygen, reduce TDS levels, and support a healthy vegetation mix, all of which will positively impact overall steelhead habitat. Data from ongoing water chemistry analysis at

[13] Downie, S.T. and D. Kajtaniak. 2010. San Luis Rey River Watershed Assessment. Coastal Watershed Planning and Assessment Program. Department of Fish and Game. Basin Profile section, p. 65-67.

multiple sites in the San Luis Rey River by the City of Oceanside and County of San Diego as part of the SLR Watershed Urban Run-off Management Program[14], and by the Trout Unlimited-San Diego Chapter[15], shows that the water quality parameters of primary concern are salinity, TDS and especially in summer and fall, levels of dissolved oxygen.

Water temperature

Continuous water temperature data logging in the San Luis Rey demonstrates that even now, water temperature in the main stem and tributaries of the San Luis Rey is not prohibitive for steelhead survival. Water temperature loggers deployed in 2008 and 2009 by the Trout Unlimited – San Diego Chapter at seven dispersed sites recorded water temperature hourly each day for months spanning April through October. Data from these devices showed that water temperatures are generally below 25°C even during summer months[16]. This upper limit of water temperature is consistent with data from Spina et al.[17] who found that juvenile steelhead in Southern California streams maintained normal behavior at temperatures ranging from 17.4°C to 24.8°C, well above temperatures at which steelhead are viable in Northern California[18].

Non-native vegetation

The Army Corps of Engineers has undertaken an eight-year San Luis Rey Flood Control Project to remove the extensive spread of the non-native plant *Arundo donax* in the lower seven miles of the River (see Figure 3). *Arundo* removal will increase flows of ground and surface water and improve riparian habitat in part because *Arundo* consumes about three times as much water as native vegetation.[19] Improved riparian habitat confers additional benefits of increased bank stabilization, increased groundwater storage during rains, enhanced filtration of urban

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[14] San Luis Rey Watershed Urban Runoff Management Program Reports (2008, 2006, 2003). Prepared by City of Oceanside, City of Vista, County of San Diego for California Regional Water Quality Control Board. On-line access at http://www.projectcleanwater.org/pdf/wurmp/slr_wurmp_2008.pdf

[15] Trout Unlimited – San Diego Chapter, San Luis Rey Water Quality Interim Report, online access at www.goldenstateflycasters.org, conservation section; data on pp. 20-37, discussion on pp. 85-94.

[16] Ibid. data pp. 45-67; discussion pp. 85-88.

[17] Spina, A. (2007) Thermal ecology of juvenile steelhead in a warm-water environment. *Environ Biol Fish* **80** (1) p. 23-34.

[18] Preliminary Draft Environmental Assessment (APDEA) (2007) FERC Project Nos. 2085, 2175, 67 and 120. "Attachment 1: Trout Temperature Requirements (Literature Review); Prepared by the S. California Edison Co.

[19] Ibid. Basin Profile section, p. 31.

runoff contaminants, and restoration of a single river channel conformation, all factors encouraging to the interests of steelhead.

Figure 3. San Luis Rey River at Murray Bridge/College Avenue in Oceanside; 8 mi upstream of river mouth

Upper panels: low flow conditions showing effect of *Arundo donax* removal; May 2007
Left upper panel, looking downstream from bridge, before *Arundo* and non-native vegetation removal;
Right upper panel, looking upstream from bridge, after recently removed *Arundo*

Lower panels: high flow conditions showing longer term effect of channel integrity upon *Arundo* removal at Murray Bridge; January 2010
Left lower panel: looking downstream from bridge
Right lower panel: looking upstream from bridge after *Arundo* removal (almost 3 yrs post removal)

Water flow measurement

A central issue in determining water flow is adequate measurement at key points in the San Luis Rey River. There is currently only one continuously functioning water flow gauge on the river, located near its entry into the ocean at the City of Oceanside. Multiple stakeholders would benefit from an earnest effort to quantify river flow by expanded monitoring. This could be done by placing at least two real-time sensors at strategic and publicly inaccessible locations

(e.g. below where Pauma Creek enters the San Luis Rey, and downstream of the proposed Gregory Landfill site) to record water flow rate and select water quality parameters. The value of such a sensing system is exemplified by the REMOT sensing system in the adjacent Santa Margarita River, which is operated by the Santa Margarita Ecological Reserve and San Diego State University, and supported by NOAA and the UCSD Supercomputing Center. The REMOT system relays water quantity and quality via satellite in real time, reflecting the technical capabilities of the 21st century.

Other projects as models for success

Increasing water flow and modification of barriers are reasonable actions that can be undertaken in the San Luis Rey River to meet the objectives of steelhead recovery efforts. Increasing steelhead numbers in the San Luis Rey also benefits nearby watersheds designated as critical habitat in the San Juan Hydrologic Unit primarily in Orange County, containing San Juan Creek, Trabuco Creek and San Mateo Creek. A draft Steelhead Recovery Plan for San Juan and Trabuco Creek watersheds has been prepared by the environmental consulting firm CDM in collaboration with the Trout Unlimited-South Coast Chapter, and a substantial fish passage project is underway near the mouth of Trabuco Creek to increase access to upstream spawning and rearing areas.

Conservation interests have had some notable successes in negotiating increased instream flows. Recovery of spawning habitat for the cutthroat trout in the headwaters of the North Fork of the Blackfoot River in Montana involved donation of capital improvements to privately-owned irrigation facilities, creative leasing of water for the trout, and pride in ownership by landowners that outweighed their wariness of outside interference.[20] The Klamath Basin Restoration Agreement in Northern California is a well known recent example of progress in protecting salmon and steelhead through complex agreements that balance of needs of many -- in this case more than 28 -- interested parties including tribal representatives, cities and counties, environmentalists, fishermen, farmers, and other private interests.[21] The case of the Carmel River in Northern California shows that success is still possible when steelhead numbers are severely depleted. In the early 1990's adult steelhead populations dropped to a handful and then

[20] Blackfoot River Water Lease Agreement at http://www.perc.org/articles/article886.php
[21] Klamath Basin Restoration Agreement Summary at http://www.edsheets.com/Klamathdocs.html

rebounded when water conditions were improved, achieving 400-800 spawning adults since 1997 and stabilizing after the upward trend during the recovery stage[22].

Conclusion

Restoring steelhead runs in the San Luis Rey River depends mainly on restoring instream flows in the reach from the diversion to a point twenty miles downstream where the river is today perennial. Restoration is feasible in the sense that it will not require the dissolution of any businesses or communities, and perhaps will not even increase the price of water to current users. Additionally, modification of fish passage barriers is needed to facilitate the movement of adult and juvenile steelhead. A critical question is whether the needed streamflows can be negotiated through some combination of persuasion, negotiation, regulatory mandate and outright purchase. Water quality at the moment is already suitable or close to suitable for steelhead in some parts of the river, and additional year-round stream flows are expected to yield notable improvements in water quality. The beneficiaries of increased instream flows include the communities and farms through which the river flows, the agencies with a stake in improving water quality, and future residents of the San Luis Rey River.

[22] Monterey Peninsula Water Management District & Carmel River Watershed Conservancy (2004) Environmental and Biological Assessment of Portions of the Carmel River Watershed, Monterey County, California. Executive Summary, p. 4 at http://www.mpwmd.dst.ca.us/programs/river/watershed_assessment/Summary.pdf

Appendix B

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