SAN LORENZO RIVER LONGITUDINAL FLOW ACCRETION AND HYDROCHEMISTRY RECONNAISSANCE, SUMMER OF WATER YEAR 2019 SANTA CRUZ COUNTY, CALIFORNIA

ALSO CONTAINS THE HYDROLOGIC SUMMARY FOR STREAM GAGES, 2017-2019, FOR BEAN CREEK ABOVE ITS MOUTH AT MOUNT HERMON CAMP, ZAYANTE CREEK AT WOODWARDIA, AND NEWELL ABOVE ITS MOUTH.

Report prepared for:
County of Santa Cruz,
Health Services – Environmental Health

Prepared by:
Jason Parke
Barry Hecht, CEG, CHg

Balance Hydrologics, Inc.

June 8, 2022

A report prepared for:

County of Santa Cruz, Health Services – Environmental Health
700 Ocean Street, Room 312
Santa Cruz, California 95062
John Ricker, Water Resources Division Director
john.ricker@santacruzcounty.us
Sierra Ryan, Water Resources Planner
Sierra.Ryan@santacruzcounty.us

San Lorenzo River Longitudinal Flow Accretion and Hydrochemistry Reconnaissance, Sumer of Water Year 2019, Santa Cruz County, California

 Project Assignment: 218109 (part)
by

Jason Parke *(jparke@balancehydro.com)*
Hydrologist / Geologist

Barry Hecht, CEG, CHg *(bhecht@balancehydro.com)*
Senior Principal

Balance Hydrologics

800 Bancroft Way, Suite 101
Berkeley, California 94710
(510) 704-1000

224 Walnut Avenue, Suite E
Santa Cruz, California 95060
(831) 457-9900

June 8, 2022

TABLE OF CONTENTS

LIST OF FORMS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

Appendix 1 Technical Memo: Sampling and analysis plan (SAP) for measurements of flow and water quality through the San Lorenzo River watershed on June 13, 2019

Appendix 2 Santa Cruz County Environmental Health Lab Results from June 19, 2019 sampling

Note: A Separate report has been prepared regarding accretion of flow in the Eagle Creek sub-watershed. Please refer to the references section.

1. INTRODUCTION

The goal of this study is to identify where water, salinity, warmth and nutrients may be entering the San Lorenzo River in the mainstem reach between Boulder Creek and Big Trees stream gage (USGS 11160500) in Felton. The emphasis is on contributions to the river from the Santa Margarita formation and related water-bearing consolidated sediments found in the Scotts Valley syncline, on the eastern side of the river. The Santa Margarita groundwater basin (SMGB) is a candidate for aquifer management, including use of aquifer storage and recovery (ASR) approaches. Data from this study will be useful for future efforts to calibrate baseflow models and calculate aquifer recharge. The agencies sponsoring the overall investigation are the County of Santa Cruz Division of Environmental Health, the San Lorenzo Valley Water District, the Scotts Valley Water District, and the City of Santa Cruz. The present study is actively sponsored by Santa Cruz County Department of Health, Environmental Health Division

The sponsors and other stakeholders in the San Lorenzo Valley surface and groundwater system recognize that changes in use of water resources are to be done with careful consideration of the benefits to the ecosystem. Management of aquifers usually entails taking 'surplus' water from surface sources and storing the water for release during drier periods. Effects of withdrawing water from streams and likely effects of leaking of stored water into the river and its tributaries can be complex. These effects can also involve sediment transport and deposition, channel stability. Of particular concern on the San Lorenzo system has been water temperature, particularly its range during the rearing life stage of the low-flow summer months, where cooler water emanating from the aquifer can be particularly helpful in carrying through juvenile fish and amphibians of concern into the late fall or winter, when water temperature is no longer a potential threat. Therefore, we also made some concurrent observations of ambient temperatures during our field work, and the location and presence/absence of thermal stratification in the deeper pools, as well as other incidental measurements which may help guide the assessment of managed aquifer viability.

The data presented in this memo represents a coordinated effort amongst the staffs of Balance Hydrologics and the Santa Cruz County Health Department, including its laboratory. The San Lorenzo Valley Water District has contributed to the project by providing valuable supporting flow data from a number of year-round and seasonal flow gages throughout the San Lorenzo River as well as the western tributaries. The City of Santa Cruz has also aided this effort by providing flow data from the gage its staff maintains on Newell Creek downstream of Loch Lomond as well as supporting the real-

time stream gage on the San Lorenzo River at Big Trees which is operated by the United States Geological Survey's (USGS) Water Resources Division.

This report emphasizes changes in seasonal flows over time, and what changes with distance downstream using a range of field evidence including measurements as detailed as can be supported by the field conditions and our knowledge and capabilities to portray them. Flow rates, water temperature and field water-quality data shaped our findings. In the realm of water quality, we also use preliminary results of nitrate (as N) analyses. The results for nitrite, (NO2 as N), ammonium (NH4) fluoride, bromide, chloride, sulfate, phosphate (as P) are presented for completeness and to establish reasonableness of the data. These data are being collected in part because: they affect the beneficial uses (including community water supply) of these waters, and whether the results are consistent with the other beneficial use of the San Lorenzo River system. The County is primarily responsible for making such conclusions as part of its ongoing monitoring and management of the watershed for all of its multiple uses, and (b) the water-quality results can also be used to the infer the paths followed by recharging waters, and characterize where these groundwaters "come from" --which aquifer(s) and/or watershed uses have been influencing the waters emanating from groundwater into the river system.

This accretion study draws on information developed over several decades. During prior summers, the staffs of the County (Ricker, 1976; Aston, 1976; Ricker, 1979), USGS (Sylvester and Covay, 1978), Balance Hydrologics (Hecht, White and Flaschka, 1991; White and Hecht, 1994, Hecht and Kittleson, 1998; Lear, Woyshner and Hecht , 2010, and Parke and Hecht, 2018), among others have measured and sampled the river system at numerous points using standard methods and depth-integrated sampling. This body of experience, as well as significant work by others (cited individually in Chapter 8) has provided working estimates of likely concentrations of major ions and trace elements, nitrogen species and isotopes, stable isotopes, and potability metrics such as MBAS, dissolved oxygen in various forms, silica, and certain microbiota, which all help to underpin and interpret the synoptic data collected this year.

2. GENERAL STUDY DESIGN

In order to prepare for the late summer synoptic sampling maps were prepared based on initial topographic and geologic interpretation. These maps served as the base for identifying possible springs, seeps, and swales through which water may emanate from the aquifers now, and presumably once they are managed. These initial planning maps are available upon request. Sampling analysis protocols outline how we selected sampling sites, how the samples were handled, preserved, and analyzed are attached in **Appendix 1**.

The river from above the town of Boulder Creek to below Big Trees was analyzed by specific reaches (**Figure 1**). Much of the emphasis was on areas within the outcrop of the Santa Margarita sandstone, which contributes water to the river and its tributaries from Love Creek to downstream of the Big Trees gages, including portions of the Bean Creek and Zayante Creek watersheds. During water year 2019 this reach was walked twice by Jason Parke of Balance Hydrologics with the specific purpose of mapping places where the Santa Margarita aquifer was contributing to stream system, as well as identifying points of deep pools and investigating the potential for temperature stratification. Other Balance staff went to sampling and measuring points on the same day. On a later date that month we also visited several tributary locations to supplement the main-stem sampling that we had done on July 10, including Spring Creek, Huckleberry Creek and to search for deep pools on the San Lorenzo downstream of Clear Creek.

The water year 2019 the study focused more on the specific places where accretion of flow was found in the previous study as well as the providing additional resolution in flow on the river as it approaches the town of Felton.

In preparation for this effort that focuses on the main stem, stream gages on the eastern tributaries were re-installed at the beginning of the summer season at Bean Creek at near its mouth in Mount Hermon and Zayante Creek at the Woodwardia weir. The SLVWD had previously (WY15-18) operated a number of gages upstream and downstream of their diversions as well as temporary gages on the San Lorenzo River downstream of Boulder Creek, Clear Creek and Fall Creek. Although some of these gages have been removed the measurements made during water year 2019 were performed at the measurement sections previously established at these gages and associated tributaries.

3. BACKGROUND

3.1 Water Quality: Nitrate Nitrogen

The California Water Resources Control Board Division of Water Quality and the EPA define the maximum concentration allowed in sources for community drinking water for 10.0 N-mg/L. Nitrate in 'pristine' groundwater is considered to be less than 2 mg-N/L[1] ; in fact, stream nitrate values below 0.11 mg/L-N (0.50 mg/L NO_3)are usually found in the pristine 'parkland' aquatic environments of the central Santa Cruz Mountains.[2]

The sources of nitrogen above these levels in the San Lorenzo River system are well known, in general terms, much of the nitrate-nitrogen traces to septic tanks and other onsite wastewater disposal treatments units widely dispersed throughout the watershed. The nitrogen disproportionately reaches the water table beneath areas of coarse-grained Zayante soils developed from the Santa Margarita formation. While there are other sources such as stables, urban runoff, fertilization and even from some areas of native vegetation, septic systems, , which allow percolation of effluent more rapid than the soils can treat (Ricker and others,1976 and 1979; Hecht and others, 1992) allow nitrate to move rapidly to the water table, and thence to the stream system. The effluent richer in nitrate can migrate more rapidly through the sandstones than through alluvium, granitic, or shaley rock units before reaching the water table (Johnson and others, 1984), where it can seep out into the river and the main tributary creeks (Hecht and others, 1991; Ricker and others, 1994). Thus, it has been known for 30 years or more that nitrate is one marker, or tracer, of water entering the river system selectively from the Santa Margarita aquifer. The Santa Margarita is, of course, not the only aquifer through which nitrate reaches the river. Nonetheless, establishing a quantitative base for where, when, and how much nitrate emanates from this formation is an important way of denoting – and monitoring – where and how much water how much water may enter the river through this source at present, and how management of the aquifer may change where and when nitrogen enters the river system. in the future from a managed aquifer.

The 2019 field work, in fact, shows that considerable nitrate enters the river during a representative summer day as it flows downstream (**Figure 19**). Concentrations increase several-fold through the reaches where the Santa Margarita aquifer

[1] https://www.waterboards.ca.gov/gama/docs/coc_nitrate.pdf

[2] Nitrate values given as mg/L nitrate to conform with State Board nomenclature as above. All subsequent values in this report are expressed as mg/L-N. 1.0 mg/L-N = 4.4 mg/L-NO_3

contributes directly to the river, from Love Creek at Ben Lomond to Eagle Creek, a short distance downstream of the Big Trees gage. And on Zayante Creek, discharge from the Santa Margarita raises nitrate levels from the Zayante Store (just upstream of the Santa Margarita outcrop) to Graham Hill Road, just above its confluence with the San Lorenzo River. Bean Creek also shows consistent downstream increases in reaches where it is incised into the Santa Margarita.

As noted above, summer nitrate in excess of the pristine parkland threshold concentrations is not exclusive to the Santa Margarita. It enters from multiple sources and passes through many kinds of geologic materials, although these materials tend to attenuate, absorb, or convert the nitrate to other forms of nitrogen. So, measuring the concentrations of other potentially diagnostic ions seeping into the river system is another, complementary approach to tracing where and when groundwater gradually enters the stream system. This year, we sampled for – and the County laboratory analyzed for – concentrations of sulfate, chloride, phosphate, bromide, fluoride, and nitrate. Results are presented in Appendix 2. Once a sufficient set of data have been collected to allow interpretation, these supplement ions (or 'solutes') can help fingerprint the sources of the seepage which gradually builds flow in the river system.

There are also questions of whether nitrate concentrations have changed over the past 40 years in response to evolving groundwater development, changing land use, and the not-inconsiderable on-going management efforts by the County and the Cities of Scotts Valley and Santa Cruz to reduce nitrogen loadings from onsite systems and other uses of the land which add nutrients to the sandy aquifers and to the creeks. While this report is not the forum for assessing historical changes in San Lorenzo Valley nutrient levels, it appears that concentrations at a given flow have been gradually decreasing, suggesting that control measures are being effective.

3.2 Conditions During WY2017, 2018 and WY2019

Flow conditions for lower Bean Creek at Mount Hermon Camp, Zayante Creek at Woodwardia, and Newell Creek at its mouth (150 feet upstream of the San Lorenzo River) for water years 2017 to 2019 can respectively be seen in the hydrograph figures 12, 14, and 16 for as well as in the **Tables 1 through 8**.

During WY2017, the San Lorenzo River averaged 309 percent of the mean annual flow. Rainfall in Santa Cruz was 177 percent of the long-term average and rainfall in Boulder Creek was 163 percent of the annual average (see **Figure 18**). Water year 2017 was the

first wet year since 2011. Water years 2012 through 2015 had been much drier than normal, and WY 2016 was a year of near-average conditions, but one in which water levels did not fully return to pre-existing norms While there was likely substantial aquifer recharge during WY 2017, it is possible that water levels in the Santa Margarita may not have fully recovered. This seems to have been true at the regional scale, as the Santa Cruz County Water Resources Report for 2017[3] which notes that "...2017 had substantially above normal rainfall amounts, leading to recovery of watersheds and stream flows. Major groundwater basins showed significant recovery, but still show long-term depletion."

WY 2018 was a dry year with the San Lorenzo River at 36 percent of the mean annual flow. Rainfall in Santa Cruz was 68 percent of the average and rainfall in Boulder Creek was 47 percent of the annual average (see **Figure 26**).

WY 2019 was a wet year with the San Lorenzo River at 163 percent of the mean annual flow. Rainfall in Santa Cruz was 127 percent of the average and Boulder Creek was 112 percent of the annual average (see **Figure 26**). In Santa Cruz approximately 34 percent of that rainfall was late in the season with 20 percent of that rain in March, 2 percent in April, and 12 percent in May, including about 4.0 to 4.5 inches of rain on May 15th through 23rd. This late season rainfall contributed to higher baseflow going into the dry season. It is also likely that end-of-season flows were relatively higher in 2019 due to carryover persistence from two near-consecutive wet years (2017 and 2019).

Table 1. Relative base flow for the end of the water year Bean Creek, Zayante Creek at Woodwardia, Newell Creek at mouth and San Lorenzo River at Big Trees

Date	Bean Creek Mt Hermon Camp (cfs)	Bean Creek at Mt Hermon Road (cfs)	Zayante Creek at Woodwardia (cfs)	Newell Creek at mouth[1] (cfs)	San Lorenzo River at Big Trees[2] (cfs)
September 30, 2017 (and 2017 Sept monthly avg.)	3.4 (3.56)		3.71 (3.93)	-	22.8 (25.0)
September 30, 2018 (and 2018 Sept. monthly avg.)	2.24 (2.19)		2.02 (2.32)	1.45 (1.57)	12.2 (12.8)
September 30, 2019 (and 2019 Sept. monthly avg.)	3.72 (3.37)	2.55 (2.56)	3.22 (3.52)	1.73 (1.71)	19.8 (20.8)

1. 1.00 cfs is released at Loch Lomond Dam on Newell Creek

[3] Santa Cruz County Water Resources Management Status Report for 2017 http://scceh.com/Portals/6/2017WaterStatusReportFinal.pdf

2. San Lorenzo River at Big Trees mean monthly flow for September (1938-2020) is 18 cfs

For the month of September, water year 2019 mean monthly flow on Bean Creek at Mt. Hermon Camp was 0.19 cfs, or 5 percent lower than water year 2017. For water year 2019 San Lorenzo River, the mean monthly flow was 4.2 cfs, or 17 percent lower from WY 2017. Flow in Zayante Creek at Woodwardia averaged approximately 0.41 cfs or 10 percent lower during WY 2019 than WY 2017.

4. WHAT WE FOUND IN THE FIELD

We conducted the flow accretion study on the San Lorenzo River primarily during September 2017, then again during July 2019 and September 2019.

During WY 2017, total annual flows at the Big Trees gage were among the very highest recorded for the period of record since 1936 (**Figure 26**). Following the relative dry WY 2018, 2019 was also a wet year. Recognizing that WY2017 and 2019 were among the 6 above-average runoff years since 1998, conditions during the two years give a disproportionately wet-year perspective. The overall study reach with relative downstream changes in flow, nitrate and specific conductance can be seen in **Figures 19, 20 and 21**. **Tables 2, 3 and 4** (see below) display the data in numerical form. **Figures 1 to 11** provide location and results for water quality samples on June 19, 2019 as well as measured flow on in July and September 2019.

The accretion of flow can be seen in each reach in **Figure 21**. The input of groundwater can be readily seen in each data set as a break in slope in horizontal of each line. An up-trending slope from each set of points signifies accretion of flow apart from the tributary, likewise a down-trending slope indicates a flow loss in between each tributary.

During WY 2019, measurements show more accretion of flow between each reach evident in the July 10, 2019 measurements than later in the season on September 25, 2019. The September 25, 2019 set of measurements show the reach downstream of Fall Creek and upstream of Bull Creek changing to a losing reach. The September 25, 2019 measurements show the reach losing 0.64 cfs, another set of measurements were made on October 3, 2019 to confirm this trend and showed the reach to be losing 0.50 cfs.

Notable accretion of flow on the San Lorenzo River was noticed in WY 2017 and WY 2019 within the reach downstream of Love and upstream of Newell Creek:

- Sept 18, 2017: 1.50 cfs
- Nov 11, 2018: 0.30 cfs (late dry season, just prior to rain)
- May 2, 2019: 0.40 cfs (higher flow conditions, turbulent velocity profile)
- July 10, 2019: 1.42 cfs (mid-dry season, baseflow elevated from about 4 to 5 inches of rain in late May)
- Sept 25, 2019: 0.93 cfs

At Newell Creek, for comparable time periods, mean daily flow at the gage 150 ft upstream of the SLR is 0.54 cfs higher than at the gage downstream of Loch Lomond. Rancho Rio flow measurements were on average 0.25 cfs lower than the recorded flow at the gage downstream of Loch Lomond. These measurements suggest that a portion of the releases from Loch Lomond may flow through alluvium or fractures in the Monterey formation bedrock before re-entering the channel upstream of the confluence with the San Lorenzo River.

Along Bean Creek, flows averaged 0,94 cfs higher at the mouth (Mount Hermon Camp gage) than further upstream at the Mount Hermon Road gage. We believe that the difference in primarily outflow from the Graham Hill Road/Eagle Creek uplands south of the creek. Much of the inflow is discharge from Redwood and Ferndell springs, as well as other springs and seeps in the compound landslide area along the Bean Creek fault. A smaller contribution from beneath the ridge north of Bean Creek probably enters the creek, although a substantial part of such flows likely are now directed to pond storage and to Zayante Creek through interception of pre-quarrying flow lines in the Olympia Quarry pit. Diurnal fluctuations at both gages are approximately 0.5 cfs, with little difference between hot days and foggy days; this suggests that much of the flow entering Bean Creek in the intervening reach is fairly deep, unaffected by daily differences in the weather. Speculatively, it may be that much of inflow to Bean Creek in this reach moves within slide masses and along glide planes at their bases.

In general, nitrate levels on the San Lorenzo River on September 18, 2017 appeared to increase in the downstream direction from less than 0.1 N-mg/L to 0.58 – 0.78 mg/L between Love Creek and Newell Creek (**Figure 19**). This same pattern was observed on June 16, 2019 with average nitrate on the San Lorenzo River upstream of Love Creek being 0.064 N-mg/L increasing to 0.21 N-mg/L downstream of Love Creek/upstream of Newell Creek. The Newell Creek concentration just upstream of the confluence of the San Lorenzo River was 1.0 N-mg/L. On September 18, 2017 nitrate at this location was 1.56 (N-mg/L). These higher concentrations are likely observed in part due to a relict plume from the former Ben Lomond Landfill, closed and converted to a transfer station about 20 years ago. Newell Creek contributed approximately 10 percent of the mid-summer flow to the San Lorenzo River on July 10, 2019 and 15 percent September 25,

2019, and likely close to 20 percent of the mainstem flow at the end of the dry season as observed on November 20, 2018.[4]

The highest concentration of nitrate during WY 2019 was found in a seep emanating from the Monterey formation near the mouth of Fall Creek. The seep draws from a slope whose main source of water is thought to a septic tank, and was chosen to be representative of such settings (see **Figure 19**).

This is the first-year sulfate has been included in the suite of water quality analysis (see Appendix 2). Eastern tributaries, especially those draining watershed underlain by the Monterey shale and Santa Margarita sandstone, contain much higher concentrations of sulfate and phosphate (**Table 2**) than do tributaries entering the San Lorenzo River from the west, beneath crystalline Ben Lomond Mountain (**Table 4**). Previous studies have made the same point. The San Lorenzo River (**Table 3**) contains intermediate concentrations of all three anions. It may be helpful to collect another year of samples prior to discussing results, as well as those for fluoride, bromide, and nitrite,

Deep pools, or refuges from the heat of the river on a warm day, are an important part of salmonid bed habitat in the river and its tributaries. High peak flows during the of winter of 2017 appear to have mobilized the San Lorenzo River bed between Boulder Creek and Big Trees, filling most of the pre-existing pools. The pools can be expected to gradually be exhumed – deepened to their more typical depths – as the channel is re-established over the coming years. Only a very few pools deeper than 6 to 9 feet – our experience is that stratified pools are at least that deep in the river.-- were found o No temperature stratification was noted in pools measured during WY 2017 when the reach between Felton and Glen Arbor was walked by Balance. Similarly, we did not observe temperature stratification in the formerly deep pool near the mouth of Fall Creek in 2019.

[4] Summer flows in Newell Creek are augmented by 1.0 cfs released by the City of Santa Cruz from Loch Lomond as mitigation for habitat lost above the dam.

Table 2. Summary of eastern-tributary inflow to the San Lorenzo River, nitrate, phosphate, sulfate, specific conductance and water temperature WY 2019[5]

Location Description	Nitrate (N-mg/L)	Phosphate (P-mg/L)	Sulfate (mg/L)	Water T °C, SCT 25°C	Flow (cfs); 7/10/19	Flow (cfs); 9/25/19	9/25/19 Trib. Percent of SLR flow[6]
Bear Cr at Old Bear Cr Rd	0.024	0.037	137	17.4, 556			
Spring Cr Gulch	0.325	0.116	49.4	15, 315	0.001	0.012	
Seep at Larkspur Br. Brookdale	0.604	0.058	83.4	15.7, 609	0.001	0.001	
Love Cr US SLR	0.178	0.096	49.4	15.1, 358	0.77	0.21	3%
Newell Cr DS Loch Lomond - City of Santa Cruz gage				16.6, 409		1.01	5%
Newell Cr US Rancho Rio Br	0.227	0.04	83.7	17.1, 307	1.73	0.94	
Newell Cr US SLR	1.004	0.137	57.5	15.1, 375	2.4	1.41	15%
Zayante Cr. at Store	0.047	0.066	154	15.1, 630			
Zay. Cr.Tsm sprg at Woodwardia	0.526	0.222	9.6	15.7, 453		0.003	
Zayante Cr. at Woodwardia	0.333	0.085	93.2	16.3, 126	5.14	2.80	
Lompico Creek at LCWD diversion below Mill Cr.	0.01	0.06	19.8	17.2, 399	0.34	0.14	
Lompico Creek 50 feet upstream of Zayante Creek	0.22	0.07	42.5	15.1, 588	0.62	0.41	2%
Zayante Cr. DS Graham Hill Rd	0.458	0.118	87.7	15.5, 466	9.29	6.48	33%
Lockhart Gulch above mouth	0.403	0.154	67	15.5, 457	0.2	0.3	
Bean Cr US Lockhart Gulch Rd	0.211	0.134	130.8	14.9, 420	1.18	0.5	
Bean Creek at Mt Hermon Rd	0.4660.403	0.155	92	15, 133	2.87	2.28	
Ferndell Spring	0.54	0.158	85.3	15, 533	0.33	0.28	

[5] Water quality analysis performed by Santa Cruz County Environmental Health

[6] This calculation represents the tributary percent contribution of to the San Lorenzo River downstream of the confluence; tributary flow / flow on the SLR downstream of the tributary.

Bean Cr at Mt Hermon Camp	0.506	0.162	86.2	15.2, 445	3.77	3.14	16%
Eagle Cr US SLR	0.468	0.026	12.7	13.8, 115		0.4	2%

Table 3. Summary of synoptic nitrate, phosphate, sulfate specific conductance at 25C, water temperature, and flow measurements taken on the San Lorenzo River WY 2019[7]

Location Description	Nitrate (N-mg/L)	Phosphate (P-mg/L)	Sulfate (mg/L)	Water °C, SCT at 25C	Flow (cfs); 7/10/19	Flow (cfs); 9/25/19
SLR upstream of Boulder Cr	0.038	0.039	120.8	17.4, 340		
SLR downstream of Boulder Cr	0.069	0.031	88.6	17.5, 532	14.69	5.27
SLR upstream of Pacific St/Huckleberry Island	0.068	0.028	82	17.7, 442		
SLR Downstream of Clear Creek	0.064	0.029	77.3	16.8, 427	17.21	6.74
SLR upstream of Love Cr	0.076	0.031	71.6	17.3, 412	19.9	6.86
SLR upstream of Newell	0.207	0.043	68.8	18.9, 409	22.1	8
SLR at Glen Arbor Br	0.291	0.049	67.7	17.0, 399		9.72
SLR Upstream of Manson	0.291	0.046	67.4	16.9, 398		
SLR Downstream of Manson	0.28	0.05	66.6	17.2, 400		
SLR Downstream of "S" bend (0.37 miles US of Fall Creek 0.78 miles DS of Manson Creek)				16.6, 409		10.67
SLR just upstream of Fall Cr	0.273	0.05	67.4	17.4, 404		
SLR DS of Fall Creek	0.232	0.043	56.7	16.5, 377	30.9	13.63, 13.48
SLR upstream of Bull Cr	0.22	0.041	56.7	16.7, 380	31.97	13.24, 12.99
SLR at Big Trees Gage	0.305	0.056	63.5	16.5, 400	40.1	19.3
San Lorenzo downstream of Big Trees	0.287	0.055	62.6	16.5, 389		

This calculation represents the tributary percent contribution of to the San Lorenzo River downstream of the confluence; tributary flow / flow on the SLR downstream of the tributary.

[7] Water quality analysis performed by Santa Cruz County Environmental Health

Table 4. Summary of western tributary in-flow to the San Lorenzo River, nitrate, phosphate, sulfate specific conductance at 25C, water temperature, and flow WY 2019

Location Description	Nitrate (N-mg/L)	Phosphate (P-mg/L)	Sulfate (mg/L)	Water °C, SCT 25°C	Flow (cfs); 7/10/19	Flow (cfs); 9/25/19	9/25/19 Percent SLR flow (trib+SLR)
Boulder Cr upstream of SLR	0.141	0.014	24	15.7, 228	5.85	2.38	31%
Clear Cr at HWY 9	0.051	0.006	4.6	15.1, 183	1.12	0.31	4%
Alba Creek at HWY 9						0.2 (est.)	3%
Manson Cr	0.07	0.053	26.5	14.2, 262	0.15	0.08	3%
Fall Cr just upstream of SLR confluence	0.014	0.01	9.5	17.3, 412	6.71	3.11	19%
Western seep	1.868	0.032	74.5	15.4, 318	0.002	0.001	
Bull Cr at SLR confluence	0.282	0.017	10.8	14.6, 391	0.58	0.31	2%

5. TENTATIVE CONCLUSIONS

1. Streams flowing through the Santa Margarita formation in the San Lorenzo Valley all share common traits of elevated baseflows, low solute loads (measured as specific conductance), very low chloride contributions and elevated nitrate loads. Through-flowing streams such as the San Lorenzo River, Zayante Creek and Bean Creek, aquifer these traits as they pass through the portions of the watershed influenced by the Santa Margarita formation.

2. Baseline nitrate conditions were successfully sampled during WY 2017 and allowed for the reach by reach comparison of nitrate trends during WY 2019. Notably the nitrate levels for both water years tended to increase with distance downstream from Love Creek, the upstream-most point where the Santa Margarita aquifer contributes significantly to the San Lorenzo River.

3. Nitrate levels in all major streams draining the Santa Margarita aquifer were nearly twice as high in 2017 than in 2019, both years of well above-average precipitation (**Figure 19**).

4. . The five years preceding 2017 had been quite dry, such that nitrate may have accumulated in the water table and in the vadose zone above it. Conversely, only one dry year preceded the 2019 wet year drainage. It is likely that nutrients (especially nitrogen) accumulate in the aquifer during dry years, then are flushed from during wet and very wet seasons. We note that it had also been 19 years since a very wet winter (1998) prior to the 2017 washout, while the 2019 drainage had been preceded by only one intervening year. No such patterns were noticed in data for drainage from other rock types in the watershed, although we did not systematically search for nitrogen flushes elsewhere in the Valley.

5. Following discovery of stratified pools on Boulder Creek in 2015 and 2016, we inquired into whether deep pools may affect habitat metrics – such as temperature or water quality -- on the San Lorenzo and major tributaries as well. During WY 2017, pools were unusually shallow at most places in the watershed in response to very heavy sediment transport during the very wet 2017 winter[8]. Some of the deeper 10+ foot deep pools we observed downstream of Clear

[8] During WY 2017 Very few pools deeper than 5 to 6 feet were found during in the reach between Felton and Glen Arbor. The common stream bed through this reach consisted of sand bottom, low velocity runs that were 200 ft.+ long, and approximately 1.5 ft. deep with a high degree of sun exposure (low canopy cover). Similar conditions prevailed in 2019. As with many sand and gravel channels, the pools will eventually reform and re-articulate with passage of time following with the 2017 storms.

Creek near Brookdale did not exhibit temperature stratification. Don Alley, fisheries biologist, has been monitoring these pools on the San Lorenzo and has data from the drier years of 2015 and 2016 that show significant temperature stratification during the summer months at these pools. Initial review of the 2017 data suggests that pools don't stratify during summers following years of substantial flow and sediment transport. Beyond confirming the lack of stratification of the deep pool downstream of Fall Creek the known pools were not visited during WY 2019. We recommend revisiting these pools during WY 2020 since the watershed received lower than average rainfall and higher velocities may not be mixing the water column. The cooler water may play an important role in fisheries habitat on warmest, low flow days in the summer.

6. The scope of work for this monitoring effort includes a reconnaissance assessment of accretion flow originating from the Santa Margarita sandstone in Eagle Creek area. Eagle Creek and its role in San Lorenzo Valley baseflows had not previously been considered, perhaps because it is not very accessible and because it is downstream from the quintessential Big Trees gage. As it turned out, substantial accretion from this subwatershed was recorded. Moreover, the late-summer accretion proves to be quite similar during both wet and dry summers. Much was learned about recharge and groundwater movements within the Santa Margarita which is perhaps more pertinent to other on-going studies. A separate draft report has been submitted describing baseflow dynamics in Eagle Creek so that the findings are more generally available.[9]

[9] Parke, J., and Hecht, B., Eagle Creek preliminary hydrogeologic reconnaissance, Santa Cruz County, California: June 2019 to June 2020, Client discussion draft consulting report by Balance Hydrologics for the County of Santa Cruz Department of Environmental Health, August 2020. 14p. + appendix.

6. ACKNOWLEDGMENTS

We are grateful for the cooperation and sharing of data between the County of Santa Cruz Environmental Health, the San Lorenzo Valley Water District, the City of Santa Cruz and look forward to future efforts. We are grateful to biologist Don Alley for his insight on water temperature relative to fish habitat and for his help calibrating the San Lorenzo gages during the summer months. We appreciate the opportunity to pursue our ongoing work on nitrates with Christina Richardson and her UCSC Earth Sciences colleagues, and with the staff of the Environmental Health Division.

Our own colleagues, Mark Woyshner, Zan Rubin and Denis Ruttenberg, contributed to this study with insights on where potential locations of stream inflow may be evident, as well as in the field work.

7. LIMITATIONS

Hydrologic calculations of low flows in coastal California streams and in the interconnected aquifers can be highly complex, often requiring considering many years of data collection. Our work conforms with the standard of care for such field work and analysis in the region; no other warranties are stated or implied.

8. REFERENCES CITED

Aston, R., and Ricker, J., 1979, Water quality technical section, San Lorenzo River watershed management plan: Office of Watershed Management, Santa Cruz County Planning Department Report, 116 p.

Goodridge, J. D., 1982, Precipitation data supplement for the storm of San Francisco Bay area on January 2-5, 1982: California Dept. of Water Resources Unpublished Report, 16 p.

Hecht, B., and Enkeboll, R., 1981, Channel and substrate conditions, sediment transport, and alternative approaches for sediment management in Zayante Creek below the proposed Zayante Dam: H. Esmaili & Associates report submitted to D.W. Kelley, Aquatic Biologist, 93 p.

Hecht, B., and Kittleson, G., 1998, An assessment of streambed conditions and erosion control efforts in the San Lorenzo River watershed, Santa Cruz County, California -- Update to the San Lorenzo Valley Watershed Plan, 1998: Balance Hydrologics, Inc. Technical Report prepared for the Santa Cruz County Health Department, Environmental Health Division. 71 p. + 7 tables +12 figures

Hecht, B., and Woyshner, M.R., 1984, Storm hydrology and definition of sand-hill recharge areas Pajaro Basin. Appendix E., 32 p ,in Hecht, B., Esmaili, H., and Johnson, N.M., 1984, Pajaro Basin Groundwater Management Study: HEA, a division of J.H. Kleinfelder Associates, consulting report, prepared for Association of Monterey Bay Area Governments, 237 p. + 8 appendices

Hecht, B , White, C.C., and Flaschka, I., 1991, A nitrate budget-based assessment of potential nonpoint -source control nitrate delivery to the San Lorenzo Water, Santa Cruz County, California: Balance Hydrologics, Inc consulting report prepared for Santa Cruz County Environmental Health Division, 101 p., tables, figures, 6 appendices

Hecht, B., Donaldson, E. and Krause, A.J., 2014, Bases for hydrologic analysis of Montara-type watersheds: San Vicente and Denniston Creeks, Moss Beach and Princeton areas, Coastside San Mateo County, California: Balance Hydrologics consulting report prepared for Analytical Environmental Services and Coastside County Water District, 17p., 2 tables and 6 figs.

Johnson, N.M., Hecht, B., and Esmaili, H., 1982, San Lorenzo Valley on-site wastewater disposal management study: HEA, a division of J.H. Kleinfelder & Associates. Oct. 1982, 185 p

Johnson, N.M., 2009, San Lorenzo Valley Water District water-supply master plan: Consulting report prepared for SLVWD. Multipaged.

Kennedy/Jenks Consultants, Santa Margarita Basin groundwater modeling technical study, Project No. 1264001*00, Consulting report prepared for Scotts Valley Water District. June 24 2015. 31 pages + 8 appendices.

Lear, J., Woyshner, M., and Hecht, B., 2009. Availability of water sources for a conjunctive use framework approach to water resources in the San Lorenzo watershed, Santa Cruz County, CA; Technical Report prepared for Kennedy/Jenks Consultants and the County of Santa Cruz Health Services Agency. 35 p. plus 2 tables, 41 figs. and 1 appendix.

Neill C., and Hecht B., 2020, Draft water year 2019 accretion assessment on Bean Creek and adjoining parts of lower Zayante Creeks, May 1, 2020, Draft Balance Hydrologics, Inc. memo prepared for: County of Santa Cruz, Health Services—Environmental Health**.** 5 p. plus forms, tables and figures

Parke, J., and Hecht, B., 2018, San Lorenzo River longitudinal accretion and hydrochemistry: Balance Hydrologics consulting report prepared for County of Santa Cruz, Health Services Agency- Environmental Health Div., 17p. plus appendices.

Parke, J., and Hecht, B., 2020, Eagle Creek preliminary hydrogeologic reconnaissance, Santa Cruz County, California, Summer of 2019, May 2020:, , Client discussion draft report by Balance Hydrologics project 219109, for the County of Santa Cruz, Department of Environmental Health, Environmental Health Division. 14pp p., 3 tables and 7 figures,+ 1 appendix

Rantz, S.E., 1986, Measurements and computation of streamflow, Volume 1, measurement of stage and discharge, USGS Water-Supply P-2175, Washington D.C., 284 p.

Ricker, J., 1979, Hydrology technical section, San Lorenzo River Watershed Management Plan: Office of Watershed Management, Santa Cruz County Planning Department Report, 77 p.

Santa Cruz County Water Resources Management Status Report for 2017 http://scceh.com/Portals/6/2017WaterStatusReportFinal.pdf Department, 2018. 22 p.

Santa Cruz County Water Resources Management Status Report for 2019 http://scceh.com/Portals/6/Env_Health/water_resources/Water%20Resources%20Documents/2019WaterStatusReportFINAL2.pdf

White, C., Hecht, B., Ricker, J., and Gill, P., 1994, Nitrogen movement through sandy soils beneath shallow and deep leachfields.: Report submitted to the Central Coastal Regional Water Quality Control Board by Balance Hydrologics and the Santa Cruz County Division of Environmental Health.

White, C., and Hecht, B., 1994, A comparative study of nitrate movement below a deep and a shallow leachfield in sandy (Zayante) soils, Glen Arbor area, Santa Cruz County: Balance Hydrologics, Inc., project 9127. Prepared for the Santa Cruz County Environmental Health Services Division. 51 p + tables, figures & appendices.

FORMS

Data preliminary, subject to revision

Water Year:	**2017**
Stream:	**Zayante Creek**
Station:	**Zayante Creek at Woodwardia Road**
County:	Santa Cruz County, CA

Form 1. Annual Hydrologic Record, WY2017

Station Location Map

approximate scale 1 in = 2,700 ft

Station Location

Latitude: 37° 03' 19.85" N, Longitude: 122° 03' 36.69" W (WGS84), Santa Cruz County, CA.Gage is located on the upstream side of the concrete weir just upstream of the Woodwardia Bridge 0.47 miles up E. Zayante Rd from the intersection with Graham Hill Rd. Site is almost directly under Mount Hermon Bypass bridge. Land use is primarily rural residential. Drainage area is approximately 16.76 sq. mi.

Mean Annual Flow (period of record)

Prior monitoring (2009-2010) focused on high-flow hydrograph and measurements.

Peak Flows (WY17)

Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)	Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)
Peak flows for WY 2017 were not estimated							
Extreme for Period of Record: WY2010 2647 cfs							

Period of Record

Seasonal gage was operated from 10/2/08 to 10/22/10 by Balance Hydrologics and included estimation of suspended sediment loads using turbidity instrumentation. Gage was seasonally reinstalled with the same datum from 7/14/17. Gaging sponsored by Santa Cruz County Environmental Health. Monitoring also occurred during the winter of 1980 by Hecht and Enkeboll.

WY 2017 Daily Mean Flow (cubic feet per second)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
1											4.97	3.75
2											4.64	3.42
3											4.57	3.35
4											4.44	3.64
5											4.46	3.65
6											4.49	3.99
7											4.65	4.03
8											4.70	4.22
9											4.57	3.93
10									Sensor installed 7/14/17		4.45	3.82
11											4.46	3.42
12											4.40	3.53
13											4.42	3.93
14										5.95	4.38	4.16
15										6.46	4.42	4.26
16										5.81	4.64	4.23
17										5.57	4.47	4.17
18										5.63	4.48	4.07
19										5.79	4.50	4.12
20										5.69	4.70	4.21
21										5.66	4.75	4.20
22										5.76	4.59	4.46
23										5.75	4.47	4.42
24										5.91	4.33	4.22
25										5.73	4.37	4.03
26										5.53	4.20	3.84
27										5.44	3.97	3.74
28										5.37	4.28	3.71
29										5.44	4.23	3.73
30					-					5.36	4.23	3.71
31					-		-		-	5.14	4.21	-
MEAN										5.67*	4.47	3.93
MAX. DAY										6.46*	4.97	4.46
MIN. DAY										5.14	3.97	3.35
cfs days										101.98*	138.43	117.92
ac-ft										202.28*	274.57	233.90

Monitor's Comments

1. Daily values with more than 2 to 3 significant figures result from electronic calculations. No additional precision is implied.
2. Mean daily values are based on 15-minute measurements of stage; several stage shifts have been applied to account for changes in bed conditions over the course of the monitoring program.
3. Data are subject to revision, should additional measurement or observer account warrant adjustment of the rating curve
4. Small spring on left bank floodplain is often monitored for flow and specific conductance (designated as Tsm spring).

* Partial month

Water Year 2017 Totals (partial):		
Mean flow	**-**	(cfs)
Max. daily flow	**6.5**	(cfs)
Min. daily flow	**3.35**	(cfs)
Total	**358**	(cfs-days)
Total Volume	**711**	(ac-ft)

Balance Hydrologics, Inc. 224 Walnut Ave., Suite E, Santa Cruz, CA 95060 (831) 457-9900; fax: (831) 457-8800
Balance Hydrologics, Inc. 800 Bancroft Way, Suite 101, Berkeley, CA 94710 (510) 704-1000; fax: (510) 704-1001

Water Year: **2018**
Stream: **Zayante Creek**
Station: **Zayante Creek at Woodwardia Road**
County: Santa Cruz County, CA

Form 2. Annual Hydrologic Record, WY2018

Station Location Map

approximate scale 1 in = 2,700 ft

Station Location

Latitude: 37° 03' 19.85" N, Longitude: 122° 03' 36.69" W (WGS84), Santa Cruz County, CA.Gage is located on the upstream side of the concrete weir just upstream of the Woodwardia Bridge 0.47 miles up E. Zayante Rd from the intersection with Graham Hill Rd. Site is almost directly under Mount Hermon Bypass bridge. Land use is primarily rural residential. Drainage area is approximately 16.76 sq. mi.

Mean Annual Flow (period of record)

Prior monitoring (2009-2010) focused on high-flow hydrograph and measurements.

Peak Flows (WY18)

Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)	Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)
not estimated							

Extreme for Period of Record: WY2010 2647 cfs

Period of Record

Seasonal gage was operated from 10/2/08 to 10/22/10 by Balance Hydrologics and included estimation of suspended sediment loads using turbidity instrumentation. Gage was seasonally reinstalled with the same datum from 7/14/17. Gaging sponsored by Santa Cruz County Environmental Health. Monitoring also occurred during the winter of 1980 by Hecht and Enkeboll.

WY 2018 Daily Mean Flow (cubic feet per second)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
1	3.86	3.86							5.13	4.03	2.75	2.58
2	3.89	4.15							4.78	3.94	2.75	2.63
3	4.13								4.68	4.14	2.70	2.58
4	4.15	Sensor removed 11/2/17							4.70	4.15	2.58	2.50
5	4.14								4.78	3.98	2.48	2.56
6	4.02								4.95	3.52	2.45	2.48
7	3.92								4.77	3.37	2.47	2.44
8	3.80								4.74	3.39	2.58	2.37
9	3.74								4.79	3.30	2.53	2.34
10	3.85								4.63	3.20	2.51	2.35
11	3.83								4.39	3.35	2.48	2.29
12	4.09								4.25	3.41	2.49	2.34
13	4.06								4.27	3.31	2.57	2.37
14	3.94								4.56	3.20	2.55	2.35
15	3.91								4.89	3.29	2.54	2.35
16	3.84								5.20	3.28	2.54	2.34
17	3.90								5.43	3.27	2.52	2.35
18	3.99						Sensor reinstalled 5/22/18		4.94	3.27	2.61	2.42
19	3.91								4.57	3.07	2.60	2.36
20	4.17								4.44	2.98	2.72	2.29
21	4.21								4.38	2.98	2.78	2.26
22	4.02							5.37	4.20	2.92	2.82	2.20
23	3.82							5.79	4.17	2.89	2.82	2.17
24	3.61							5.75	4.37	2.87	2.84	2.21
25	3.51							5.86	4.43	2.78	2.84	2.10
26	3.47							5.68	4.39	2.77	2.83	2.07
27	3.44							5.38	4.38	2.81	2.90	2.05
28	3.50							5.08	4.17	2.86	2.98	2.09
29	3.59							4.95	4.01	2.86	2.87	2.09
30	3.62				-			5.19	3.99	2.76	2.68	2.02
31	3.65				-		-	5.41	-	2.75	2.61	-
MEAN	3.86	4.00*						5.45*	4.58	3.25	2.66	2.32
MAX. DAY	4.21	4.15*						5.86*	5.43	4.15	2.98	2.63
MIN. DAY	3.44	3.86						4.95	3.99	2.75	2.45	2.02
cfs days	119.59	8.00*						54.45*	137.39	100.70	82.36	69.54
ac-ft	237.20	15.87*						108.01*	272.52	199.74	163.37	137.94

Monitor's Comments

1. Daily values with more than 2 to 3 significant figures result from electronic calculations. No additional precision is implied.
2. Mean daily values are based on 15-minute measurements of stage; several stage shifts have been applied to account for changes in bed conditions over the course of the monitoring program.
3. Data are subject to revision, should additional measurement or observer account warrant adjustment of the rating curve
4. Average daily fluctuation prior to removing the seasonal gage on 11/2/17 rain were approximately 1.7 cfs. We are not sure this amount of daily fluctuation is real or an artifact of temperature affecting the sensors
5. Small spring on left bank floodplain is often monitored for flow and specific conductance (designated as Tsm spring).

* Partial month

Water Year 2018 Totals (partial):		
Mean flow	-	(cfs)
Max. daily flow	**5.9**	(cfs)
Min. daily flow	**2.02**	(cfs)
Total	**572**	(cfs-days)
Total Volume	**1135**	(ac-ft)

Balance Hydrologics, Inc. 224 Walnut Ave., Suite E, Santa Cruz, CA 95060 (831) 457-9900; fax: (831) 457-8800
Balance Hydrologics, Inc. 800 Bancroft Way, Suite 101, Berkeley, CA 94710 (510) 704-1000; fax: (510) 704-1001

Data preliminary, subject to revision

Water Year: 2019
Stream: Zayante Creek
Station: Zayante Creek at Woodwardia Road
County: Santa Cruz County, CA

Form 3. Annual Hydrologic Record, WY2019

Station Location Map

approximate scale 1 in = 2,700 ft

Station Location

Latitude: 37° 03' 19.85" N, Longitude: 122° 03' 36.69" W (WGS84), Santa Cruz County, CA.Gage is located on the upstream side of the concrete weir just upstream of the Woodwardia Bridge 0.47 miles up E. Zayante Rd from the intersection with Graham Hill Rd. Site is almost directly under Mount Hermon Bypass bridge.
Land use is primarily rural residential. Drainage area is approximately 16.76 sq. mi.

Mean Annual Flow (period of record)

Prior monitoring (2009-2010) focused on high-flow hydrograph and measurements.

Peak Flows (WY19)

Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)	Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)
not estimated							

Extreme for Period of Record: WY2010 2647 cfs

Period of Record

Seasonal gage was operated from 10/2/08 to 10/22/10 by Balance Hydrologics and included estimation of suspended sediment loads using turbidity instrumentation. Gage was seasonally reinstalled with the same datum from 7/14/17. Gaging sponsored by Santa Cruz County Environmental Health. Monitoring also occurred during the winter of 1980 by Hecht and Enkeboll.

WY 2019 Daily Mean Flow (cubic feet per second)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
1	2.00	1.96	5.77	3.79	15.27		31.26	12.69	10.40	6.15	4.93	3.58
2	1.95	1.98	4.55	3.61			33.53	12.02	10.31	6.05	4.73	3.54
3	2.11	2.02	3.80	3.29			30.71	11.62	9.79	6.18	4.61	3.59
4	2.23	2.11	3.39	3.13	Flow not estimated above 40 cfs		29.39	11.52	9.28	6.08	4.46	3.49
5	2.42	2.09	4.30	5.46			32.16	11.34	9.09	6.13	4.51	3.57
6	2.29	2.15	3.80				29.42	11.34	8.96	6.05	4.59	3.58
7	2.14	2.21	3.48				26.83	11.21	8.78	5.95	4.47	3.73
8	2.06	2.20	3.29	18.98			24.90	11.00	8.26	5.88	4.45	3.63
9	2.15	2.22	3.19	18.88			24.38	11.05	7.81	5.77	4.32	3.65
10	2.15	2.33	3.12	13.72			23.16	10.75	7.43	5.58	4.25	3.70
11	2.01	2.37	3.19	11.85			22.45	10.54	7.25	5.44	4.26	3.61
12	2.03	2.41	3.03	11.09			21.14	10.35	7.37	5.46	4.14	3.51
13	1.99	2.39	3.05	9.09			20.09	10.17	7.63	5.44	4.07	3.36
14	1.98	2.32	2.81	8.28			19.40	10.16	7.63	5.39	3.99	3.35
15	2.07	2.40	2.80				19.49	13.76	7.59	5.23	3.93	3.50
16	2.06	2.04	6.63				19.45	21.41	7.48	5.24	4.06	3.68
17	2.07	2.10	23.46				17.99	13.18	7.37	5.42	4.40	3.83
18	2.06	2.16	7.15				16.93	15.87	7.47	5.51	4.61	3.77
19	2.00	2.21	5.02			39.36	16.70		7.40	5.72	4.63	3.80
20	1.98	2.23	4.39	34.94			16.51	20.16	7.58	5.55	4.39	3.72
21	2.00	5.84	3.93	29.76		38.55	15.85	16.57	7.35	5.39	4.11	3.52
22	2.06	5.21	3.94	23.62		35.67	15.35	14.79	7.10	5.28	3.84	3.47
23	2.13	7.56	3.77	20.28	38.57		14.52	13.63	6.87	5.15	4.18	3.43
24	2.16	3.71	4.00	17.76	33.60	36.76	14.06	12.58	6.75	4.94	4.05	3.42
25	2.07	3.27	4.97	15.92	31.40	35.15	14.16	12.20	6.50	4.92	3.93	3.32
26	2.04	2.93	4.30	14.37	34.89	37.43	14.13	12.56	6.49	4.98	3.84	3.56
27	1.98	2.78	3.96	12.86			14.13	11.98	6.43	4.89	3.82	3.02
28	1.96	5.75	3.90	11.96			13.93	11.24	6.37	4.98	3.84	3.15
29	2.11	34.42	3.96	11.31			13.91	11.04	6.39	4.94	3.72	3.17
30	2.11	7.94	3.68	10.94	-	37.34	13.29	10.70	6.27	4.86	3.73	3.22
31	2.09	5.77	3.65	18.70	-	33.73	-	10.21	-	5.05	3.69	-
MEAN	2.08	4.16	4.65	13.90*			20.64	12.59*	7.71	5.47	4.21	3.52
MAX. DAY	2.42	34.42	23.46	34.94*			33.53	21.41*	10.40	6.18	4.93	3.83
MIN. DAY	1.95	1.96	2.80	3.13			13.29	10.16	6.27	4.86	3.69	3.02
cfs days	64.48	129.08	144.30	333.60*			619.23	377.64*	231.42	169.58	130.54	105.46
ac-ft	127.89	256.02	286.22	661.69*			1228.24	749.06*	459.02	336.35	258.93	209.19

Monitor's Comments

1. Daily values with more than 2 to 3 significant figures result from electronic calculations. No additional precision is implied.
2. Mean daily values are based on 15-minute measurements of stage; several stage shifts have been applied to account for changes in bed conditions over the course of the monitoring program.
3. Data are subject to revision, should additional measurement or observer account warrant adjustment of the rating curve
4. Small spring on left bank floodplain is often monitored for flow and specific conductance (designated as Tsm spring).

* Partial month

Water Year 2019 Totals (partial):		
Mean flow	-	(cfs)
Max. daily flow	39.4	(cfs)
Min. daily flow	1.95	(cfs)
Total	2305	(cfs-days)
Total Volume	4573	(ac-ft)

Balance Hydrologics, Inc. 224 Walnut Ave., Suite E, Santa Cruz, CA 95060 (831) 457-9900; fax: (831) 457-8800
Balance Hydrologics, Inc. 800 Bancroft Way, Suite 101, Berkeley, CA 94710 (510) 704-1000; fax: (510) 704-1001

Water Year: **2017**
Stream: **Bean Creek**
Station: **Bean Creek above mouth at Mount Hermon Camp**
County: Santa Cruz County, CA

Form 4. Annual Hydrologic Record, WY2017

Station Location Map

approximate scale 1 in = 2,700 ft

Station Location

Latitude: 37.05246, Longitude: -122.05971 (WGS84), Santa Cruz County, CA.
Gage is located approximately 80 feet upstream of the abandoned foot bridge on the right bank.
Previously located (WY09-12) downstream of the current gage approximately 150 feet or about 70 feet downstream of the abandonded foot bridge on the left bank (facing downstream). Drainage area is approximately 9.64 square miles.

Mean Annual Flow (period of record)

Mean daily flow (MDQ) for water years 2009, 2010, and 2012 are not available due to incomplete records. WY 2011 mean daily flow; 17.4 cfs.

Peak Flows (WY17)

Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)	Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)
WY17	-	9.5 old staff 6.99 new staff *	-				

* Based on observed approximate high-water mark correlated to the staff plates.

Extreme for Period of Record: WY 2010: 474 cfs (1/20/10), WY 2011: 1,086 cfs (3/24/11)

Period of Record

Seasonal gage was operated from 10/3/08 to 10/13/12 by Balance Hydrologics and included estimation of suspended sediment loads and turbidity using turbidity instrumentation. Gage reinstalled with a new datum 7/13/17 approx.150 ft upstream from the previous gage. Flow and sediment also monitored in 1980 (Hecht and Enckeboll). Gaging sponsored by Santa Cruz County Environmental Health

WY 2017 Daily Mean Flow (cubic feet per second)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
1											4.40	3.65
2											4.51	3.59
3											4.51	3.54
4											4.36	3.60
5											4.16	3.57
6											4.15	3.61
7											4.14	3.63
8											4.00	3.65
9											4.06	3.60
10											3.92	3.59
11									Gage installed 7/13/17		4.12	3.52
12											3.76	3.55
13										4.63	3.80	3.65
14										4.81	3.89	3.63
15										4.74	3.87	3.62
16										4.66	3.98	3.63
17										4.61	3.96	3.61
18										4.55	3.95	3.57
19										4.65	3.99	3.55
20										4.42	4.01	3.58
21										4.49	3.96	3.53
22										4.51	3.90	3.61
23										4.50	3.88	3.57
24										4.53	3.83	3.53
25										4.54	3.84	3.51
26										4.66	3.80	3.47
27										4.69	3.81	3.43
28										4.70	3.76	3.42
29										4.60	3.76	3.40
30					-					4.58	3.75	3.40
31		-			-		-		-	4.44	3.71	-
MEAN										4.60*	3.99	3.56
MAX. DAY										4.81*	4.51	3.65
MIN. DAY										4.42	3.71	3.40
cfs days										87.32*	123.54	106.79
ac-ft										173.20*	245.05	211.82

Monitor's Comments

1. Daily values with more than 2 to 3 significant figures result from electronic calculations. No additional precision is implied.
2. Mean daily values are based on 15-minute measurements of stage; several stage shifts have been applied to account for changes in bed conditions over the course of the monitoring program.
3. Data are subject to revision, should additional measurement or observer account warrant adjustment of the rating curve
4. Occasional concurrent measurements Ferndell Creek (see Bean Creek station observer log).
5. Diurnal fluctuations recorded by the Bean Creek datalogger are minor relative to those shown by instrumentation at Zayante Creek at Woodwardia 1,100 feet to the north.

* Partial month

Water Year (partial) 2017 Totals:		
Mean flow	**-**	(cfs)
Max. daily flow	**4.8**	(cfs)
Min. daily flow	**3.40**	(cfs)
Total	**318**	(cfs-days)
Total Volume	**630**	(ac-ft)

Balance Hydrologics, Inc. 224 Walnut Ave., Suite E, Santa Cruz, CA 95060 (831) 457-9900; fax: (831) 457-8800
Balance Hydrologics, Inc. 800 Bancroft Way, Suite 101, Berkeley, CA 94710 (510) 704-1000; fax: (510) 704-1001

Water Year: 2018
Stream: Bean Creek
Station: Bean Creek above mouth at Mount Hermon Camp
County: Santa Cruz County, CA

Form 5. Annual Hydrologic Record, WY2018

Station Location Map

approximate scale 1 in = 2,700 ft

Station Location

Latitude: 37.05246, Longitude: -122.05971 (WGS84), Santa Cruz County, CA.
Gage is located approximately 80 feet upstream of the abandoned foot bridge on the right bank.
Previously located (WY09-12) downstream of the current gage approximately 150 feet or about 70 feet downstream of the abandonded foot bridge on the left bank (facing downstream). Drainage area is approximately 9.64 square miles.

Mean Annual Flow (period of record)

Mean daily flow (MDQ) for water years 2009, 2010, and 2012 are not available due to incomplete records. WY 2011 mean daily flow; 17.4 cfs.

Peak Flows (WY18)

Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)	Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)
not estimated							

Extreme for Period of Record: WY 2010: 474 cfs (1/20/10), WY 2011: 1,086 cfs (3/24/11)

Period of Record

Seasonal gage was operated from 10/3/08 to 10/13/12 by Balance Hydrologics and included estimation of suspended sediment loads and turbidity using turbidity instrumentation. Gage reinstalled with a new datum 7/13/17 approx.150 ft upstream from the previous gage. Flow and sediment also monitored in 1980 (Hecht and Enckeboll). Gaging sponsored by Santa Cruz County Environmental Health

WY 2018 Daily Mean Flow (cubic feet per second)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
1	3.37	3.03							3.30	3.17	3.04	2.33
2	3.35	3.03							3.06	3.13	3.10	2.33
3	3.38	3.47							3.09	3.33	2.85	2.28
4	3.37	3.18							3.12	3.20	2.71	2.25
5	3.33	3.15							3.17	2.98	2.71	2.21
6	3.30	3.17							3.23	2.75	2.76	2.16
7	3.26	3.16							3.06	2.70	2.87	2.12
8	3.23	3.22							3.03	2.78	3.02	2.09
9	3.18	7.48							3.07	2.87	2.86	2.13
10	3.20	3.63							3.07	2.98	2.77	2.17
11	3.19	3.55							2.97	3.03	2.78	2.15
12	3.21	3.53							2.88	3.09	2.75	2.15
13	3.21	3.54							2.94	3.00	2.84	2.19
14	3.18	3.59							3.05	2.96	2.72	2.18
15	3.16								3.13	3.02	2.56	2.17
16	3.12								3.27	3.02	2.55	2.19
17	3.11	Sensors removed 11/14/17						Sensors reinstalled 5/22/18	3.30	3.04	2.61	2.19
18	3.12								2.94	3.10	2.64	2.29
19	3.11								2.82	3.06	2.63	2.20
20	3.15								2.84	3.12	2.69	2.18
21	3.08								2.87	3.11	2.63	2.22
22	3.05							3.66	2.89	3.06	2.56	2.28
23	3.03							3.95	3.03	3.05	2.56	2.26
24	2.98							3.93	3.27	3.01	2.63	2.30
25	2.96							4.02	3.21	3.00	2.60	2.20
26	2.92							3.93	3.12	3.05	2.58	2.15
27	2.91							3.66	3.13	3.11	2.60	2.09
28	2.89							3.43	2.99	3.15	2.49	2.11
29	2.96							3.34	2.98	3.15	2.50	2.07
30	2.96				-			3.47	3.03	3.01	2.30	1.99
31	2.95	-			-		-	3.54	-	2.98	2.31	-
MEAN	3.14	3.62*						3.69*	3.06	3.03	2.68	2.19
MAX. DAY	3.38	7.48*						4.02*	3.30	3.33	3.10	2.33
MIN. DAY	2.89	3.03						3.34	2.82	2.70	2.30	1.99
cfs days	97.23	50.74*						36.93*	91.87	93.98	83.22	65.64
ac-ft	192.85	100.64*						73.24*	182.23	186.40	165.07	130.20

Monitor's Comments

1. Daily values with more than 2 to 3 significant figures result from electronic calculations. No additional precision is implied.
2. Mean daily values are based on 15-minute measurements of stage; several stage shifts have been applied to account for changes in bed conditions over the course of the monitoring program.
3. Data are subject to revision, should additional measurement or observer account warrant adjustment of the rating curve
4. Diurnal fluctuations recorded by the Bean Creek datalogger are minor relative to those shown by instrumentation at Zayante Creek at Woodwardia 1,100 feet to the north.

* Partial month

Water Year (partial) 2018 Totals:		
Mean flow	-	(cfs)
Max. daily flow	**7.5**	(cfs)
Min. daily flow	**1.99**	(cfs)
Total	**520**	(cfs-days)
Total Volume	**1031**	(ac-ft)

Balance Hydrologics, Inc. 224 Walnut Ave., Suite E, Santa Cruz, CA 95060 (831) 457-9900; fax: (831) 457-8800
Balance Hydrologics, Inc. 800 Bancroft Way, Suite 101, Berkeley, CA 94710 (510) 704-1000; fax: (510) 704-1001

Water Year: 2019
Stream: Bean Creek
Station: Bean Creek above mouth at Mount Hermon Camp
County: Santa Cruz County, CA

Form 6. Annual Hydrologic Record, WY2019

Station Location Map

approximate scale 1 in = 2,700 ft

Station Location

Latitude: 37.05246, Longitude: -122.05971 (WGS84), Santa Cruz County, CA.
Gage is located approximately 80 feet upstream of the abandoned foot bridge on the right bank.
Previously located (WY09-12) downstream of the current gage approximately 150 feet or about 70 feet downstream of the abandonded foot bridge on the left bank (facing downstream). Drainage area is approximately 9.64 square miles.

Mean Annual Flow (period of record)

Mean daily flow (MDQ) for water years 2009, 2010, and 2012 are not available due to incomplete records. WY 2011 mean daily flow; 17.4 cfs.

Peak Flows (WY19)

Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)	Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)
not estimated							

Extreme for Period of Record: WY 2010: 474 cfs (1/20/10), WY 2011: 1,086 cfs (3/24/11)

Period of Record

Seasonal gage was operated from 10/3/08 to 10/13/12 by Balance Hydrologics and included estimation of suspended sediment loads and turbidity using turbidity instrumentation. Gage reinstalled with a new datum 7/13/17 approx.150 ft upstream from the previous gage. Flow and sediment also monitored in 1980 (Hecht and Enckeboll). Gaging sponsored by Santa Cruz County Environmental Health

WY 2019 Daily Mean Flow (cubic feet per second)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
1	1.99	2.17	5.43	3.24	9.70		18.56	6.91	6.24	4.16	4.06	3.23
2	1.95	2.22	3.62	3.22			20.35	6.62	6.18	4.19	3.97	3.12
3	2.05	2.28	3.16	3.01			17.44	6.49	5.88	4.29	3.93	3.17
4	2.08	2.35	2.96	2.82			16.24	6.43	5.57	4.27	3.88	3.10
5	2.17	2.36	4.34	5.98			17.24	6.32	5.47	4.39	3.86	3.17
6	2.10	2.43	3.16	6.66			15.09	6.37	5.48	4.35	3.83	3.14
7	2.11	2.47	2.91				13.81	6.20	5.45	4.36	3.67	3.29
8	2.19	2.50	2.84	27.37			13.21	6.05	5.18	4.31	3.70	3.26
9	2.32	2.61	2.82	26.41			13.04	6.18	4.90	4.32	3.68	3.40
10	2.40	2.70	2.74	18.90			12.59	5.86	4.68	4.18	3.61	3.45
11	2.30	2.71	2.83	16.26			12.18	5.75	4.60	4.19	3.68	3.46
12	2.28	2.70	2.73	13.01			11.20	5.63	4.71	4.29	3.72	3.39
13	2.29	2.65	2.76	10.33			10.63	5.63	4.87	4.21	3.62	3.29
14	2.35	2.66	2.56	9.16			10.26	5.60	4.84	4.17	3.55	3.26
15	2.44	2.66	2.52	12.92			10.35	8.98	4.81	4.17	3.54	3.37
16	2.42	2.65	6.12			29.31	10.27	14.60	4.76	4.24	3.67	3.50
17	2.44	2.68	12.11			26.07	9.39	7.83	4.58	4.43	3.80	3.54
18	2.41	2.68	5.44			24.77	8.75	9.90	4.28	4.47	3.66	3.54
19	2.28	2.70	4.08			21.87	8.61	18.90	4.31	4.61	3.53	3.52
20	2.24	2.70	3.61			24.89	8.57	12.04	4.40	4.43	3.41	3.46
21	2.28	6.87	3.24			20.89	8.16	10.50	4.34	4.32	3.33	3.31
22	2.37	3.17	3.23	26.71	29.03	18.95	7.95	8.92	4.23	4.23	3.17	3.31
23	2.34	5.17	3.10	22.87	24.75	21.84	7.49	8.22	4.22	4.17	3.41	3.30
24	2.22	2.44	4.01	18.49	21.47	19.41	7.24	7.60	4.23	4.11	3.33	3.32
25	1.98	2.53	3.82	15.56	18.71	18.69	7.44	7.43	4.12	4.07	3.32	3.22
26	1.90	2.60	3.29	13.24	17.92	19.50	7.49	7.64	4.19	4.08	3.31	3.36
27	1.88	2.73	3.13	11.22		19.07	7.55	7.26	4.18	4.00	3.34	3.26
28	1.89	4.55	3.15	9.91		28.43	7.49	6.68	4.18	4.09	3.41	3.58
29	2.04	16.86	3.24	8.89		26.56	7.47	6.52	4.22	4.10	3.34	3.71
30	2.14	5.39	3.08	8.06	-	23.61	7.07	6.35	4.20	4.05	3.35	3.72
31	2.24	-	3.10	13.97	-	20.53	-	6.19	-	4.17	3.33	3.71
MEAN	2.20	3.44	3.71	12.84*	20.26*	22.77*	11.10	7.79	4.78	4.24	3.58	3.37
MAX. DAY	2.44	16.86	12.11	27.37*	29.03*	29.31*	20.35	18.90	6.24	4.61	4.06	3.72
MIN. DAY	1.88	2.17	2.52	2.82	9.70	18.69	7.07	5.60	4.12	4.00	3.17	3.10
cfs days	68.13	103.19	115.15	308.22*	121.58*	364.38*	333.13	241.60	143.31	131.41	111.04	104.47
ac-ft	135.13	204.67	228.39	611.36*	241.15*	722.75*	660.77	479.22	284.25	260.65	220.25	207.23

flow above 30 cfs not estimated

Monitor's Comments

1. Daily values with more than 2 to 3 significant figures result from electronic calculations. No additional precision is implied.
2. Mean daily values are based on 15-minute measurements of stage; several stage shifts have been applied to account for changes in bed conditions over the course of the monitoring program.
3. Data are subject to revision, should additional measurement or observer account warrant adjustment of the rating curve
4. Diurnal fluctuations recorded by the Bean Creek datalogger are minor relative to those shown by instrumentation at Zayante Creek at Woodwardia 1,100 feet to the north.

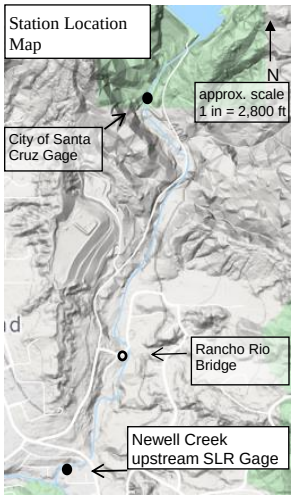
* Partial month

Water Year 2019 Totals:		
Mean flow	**-**	(cfs)
Max. daily flow	**29.3**	(cfs)
Min. daily flow	**1.88**	(cfs)
Total	**2146**	(cfs-days)
Total Volume	**4256**	(ac-ft)

Balance Hydrologics, Inc. 224 Walnut Ave., Suite E, Santa Cruz, CA 95060 (831) 457-9900; fax: (831) 457-8800
Balance Hydrologics, Inc. 800 Bancroft Way, Suite 101, Berkeley, CA 94710 (510) 704-1000; fax: (510) 704-1001

Water Year: 2018
Stream: Newell Creek
Station: Newell Creek approx. 150 feet upstream of San Lorenzo River
County: Santa Cruz County, CA

Form 7. Annual Hydrologic Record, WY2018



Station Location

Coordinates: 37.08204, -122.07973 (WGS84), Santa Cruz County, CA.
Gage is located approximately 150 feet upstream of the confluence with the San Lorenzo River. Drainage area is approximately 9.9 square miles. Land use in the watershed includes residential neighborhoods, Ben Lomond Transfer Station, Loch Lomond reservoir and recreation area. The City of Santa Cruz uses the reservoir as a water source and maintains 1.0 cfs bypass-flow just downstream of the impoundment.

Mean Annual Flow (period of record)

Not available.

Peak Flows (WY18)

Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)	Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)
Not available.							

Extreme for Period of Record: not available

Period of Record:
Seasonal gage installed on June 14, 2018. Gaging sponsored by Santa Cruz County Environmental Health.

WY 2018 Daily Mean Flow (cubic feet per second)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
1										1.56	1.55	1.55
2										1.56	1.55	1.57
3										1.62	1.55	1.58
4										1.60	1.55	1.57
5										1.54	1.54	1.59
6										1.50	1.56	1.55
7										1.49	1.55	1.54
8										1.51	1.52	1.55
9										1.50	1.49	1.57
10										1.53	1.50	1.57
11										1.55	1.50	1.58
12							Gage installed 6/14/2018			1.56	1.52	1.63
13										1.54	1.55	1.64
14									1.56	1.55	1.51	1.61
15									1.66	1.58	1.47	1.63
16									1.70	1.56	1.46	1.62
17									1.70	1.56	1.45	1.62
18									1.61	1.58	1.49	1.62
19									1.56	1.53	1.49	1.58
20									1.55	1.52	1.53	1.53
21									1.56	1.52	1.53	1.57
22									1.52	1.53	1.53	1.58
23									1.53	1.52	1.52	1.56
24									1.61	1.52	1.56	1.58
25									1.59	1.50	1.57	1.53
26									1.58	1.55	1.59	1.49
27									1.60	1.55	1.61	1.49
28									1.57	1.57	1.59	1.51
29									1.54	1.57	1.58	1.50
30					-				1.56	1.54	1.57	1.45
31		-			-		-		-	1.56	1.55	-
MEAN									1.59 *	1.54	1.53	1.57
MAX. DAY									1.70 *	1.62	1.61	1.64
MIN. DAY									1.52	1.49	1.45	1.45
cfs days									26.99*	47.89	47.52	46.97
ac-ft									53.54*	94.99	94.25	93.16

Monitor's Comments

1. Daily values with more than 2 to 3 significant figures result from electronic calculations. No additional precision is implied.
2. Mean daily values are based on 15-minute measurements of stage; several stage shifts have been applied to account for changes in bed conditions over the course of the monitoring program.
3. Data are subject to revision, should additional measurement or observer account warrant adjustment of the rating curve

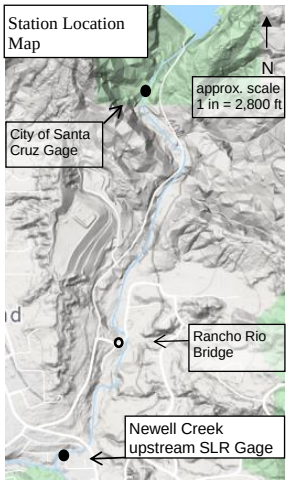
* Partial month

Water Year (partial) 2018 Totals:		
Mean flow	-	(cfs)
Max. daily flow	**1.7**	(cfs)
Min. daily flow	**1.45**	(cfs)
Total	-	(cfs-days)
Total Volume	-	(ac-ft)

Balance Hydrologics, Inc. 224 Walnut Ave., Suite E, Santa Cruz, CA 95060 (831) 457-9900; fax: (831) 457-8800
Balance Hydrologics, Inc. 800 Bancroft Way, Suite 101, Berkeley, CA 94710 (510) 704-1000; fax: (510) 704-1001

Water Ye 2019
Stream: Newell Creek
Station: Newell Creek approx. 150 feet upstream of San Lorenzo River
County: Santa Cruz County, CA

Form 8. Annual Hydrologic Record, WY2019



Station Location

Coordinates: 37.08204, -122.07973 (WGS84), Santa Cruz County, CA.
Gage is located approximately 150 feet upstream of the confluence with the San Lorenzo River. Drainage area is approximately 9.9 square miles. Land use in the watershed includes residential neighborhoods, Ben Lomond Transfer Station, Loch Lomond reservoir and recreation area. The City of Santa Cruz uses the reservoir as a water source and maintains bypass-flow just downstream of the impoundment.

Mean Annual Flow (period of record)

Not available.

Peak Flows (WY19)

Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)	Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)
Not available.							

Extreme for Period of Record: not available

Period of Record:
Seasonal gage installed on June 14, 2018. Gaging sponsored by Santa Cruz County Environmental

WY 2019 Daily Mean Flow (cubic feet per second)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
1	1.46	1.45							3.35	2.46	1.86	1.73
2	1.42	1.46						2.60	3.23	2.50	1.80	1.65
3	1.46	1.45						2.59	3.14	2.42	1.78	1.77
4	1.48	1.47						2.69	3.10	2.38	1.75	1.63
5	1.51	1.47						2.82	3.02	2.36	1.78	1.58
6	1.50	1.50						2.49	2.90	2.37	1.75	1.67
7	1.49	1.52						2.55	2.72	2.30	1.73	1.73
8	1.45	1.54						3.03	2.56	2.30	1.79	1.72
9	1.53	1.57						3.29	2.34	2.28	1.78	1.78
10	1.57	1.59						3.28	2.31	2.29	1.71	1.70
11	1.52	1.59						3.44	2.33	2.61	1.79	1.71
12	1.51	1.59						3.10	2.26	2.90	1.77	1.76
13	1.50	1.60						2.87	2.27	2.75	1.72	1.78
14	1.50	1.58						3.04	2.26	2.70	1.72	1.77
15	1.53	1.58						4.64	2.27	2.89	1.77	1.74
16	1.53	1.54						7.68	2.25	2.84	1.73	1.69
17	1.55	1.55						5.69	2.11	2.76	1.76	1.78
18	1.55	1.56						5.41	2.09	2.54	1.70	1.81
19	1.51	1.55						10.43	2.14	1.99	1.73	1.75
20	1.46	1.55						7.46	2.16	1.98	1.76	1.71
21	1.47	1.95						6.16	2.05	1.95	1.85	1.70
22	1.51	1.57						5.49	2.02	1.92	1.80	1.66
23	1.52	1.94						4.21	2.05	1.95	1.64	1.65
24	1.51	1.54						4.43	2.27	1.98	1.71	1.79
25	1.47	1.56						4.34	2.38	1.87	1.78	1.66
26	1.45	1.54						4.13	2.34	1.88	1.83	1.48
27	1.44	1.57						4.19	2.47	1.98	1.74	1.77
28	1.44		Sensor removed for the wet season					4.03	2.42	1.95	1.68	1.68
29	1.51							3.77	2.42	2.00	1.74	1.67
30	1.52				-			3.62	2.39	1.92	1.80	1.73
31	1.51	-			-		-	3.51	-	1.88	1.79	-
MEAN	1.50	1.57 *						4.23 *	2.45	2.29	1.76	1.71
MAX. DAY	1.57	1.95 *						10.43*	3.35	2.90	1.86	1.81
MIN. DAY	1.42	1.45						2.49	2.02	1.87	1.64	1.48
cfs days	46.37	42.39 *						126.98*	73.63	70.91	54.53	51.27
ac-ft	91.98	84.07 *						251.86*	146.04	140.65	108.16	101.70

Monitor's Comments

1. Daily values with more than 2 to 3 significant figures result from electronic calculations. No additional precision is implied.
2. Mean daily values are based on 15-minute measurements of stage; several stage shifts have been applied to account for changes in bed conditions over the course of the monitoring program.
3. Data are subject to revision, should additional measurement or observer account warrant adjustment of the rating curve

* Partial month

Water Year (partial) 2019 Totals:		
Mean flow	-	(cfs)
Max. daily flow	**10.4**	(cfs)
Min. daily flow	**1.42**	(cfs)
Total	-	(cfs-days)
Total Volume	-	(ac-ft)

Balance Hydrologics, Inc. 224 Walnut Ave., Suite E, Santa Cruz, CA 95060 (831) 457-9900; fax: (831) 457-8800
Balance Hydrologics, Inc. 800 Bancroft Way, Suite 101, Berkeley, CA 94710 (510) 704-1000; fax: (510) 704-1001

TABLES

Table 5. Station Observer Log; San Lorenzo River accretion study, July 10, 2019 (pg 1 of 2)
Santa Cruz County Environmental Health, Santa Cruz County, California

Site Information					Streamflow				Water Quality Observations			Remarks
Point Number	Site description	Date	Time	Observer(s)	Measured Flow	Estimated Flow	Method	Estimated Accuracy	Water Temperature	Specific Conductance at field temp.	Specific Conductance at 25C	
		(mm/dd/yr)	*(24hr)*		*(cfs)*	*(cfs)*		*(e/g/f/p)*	*(oC)*	*(µmhos/cm)*	*(at 25 oC)*	
1	Boulder Creek 500 ft upstream of HWY 9	7/11/19	14:57	cn	5.85	-	PY	g	17.2	193	227	Flow measured the next day by CN - gage was reinstalled. Gage dataum checked with old USGS: Stage 0.83 Balance, 0.87 old USGS equivalent
2	**San Lorenzo River**, downstream of Boulder Creek at seasonal gage (approx. 1700 ft downstream of confluence)	7/10/19	19:37	jp	14.69	-	PY	g	17.7	410	477	Fairly laminar bedrock cross section. Previous cross section was inundated with high flow conditions.
3	Clear Creek at 50 ft DS of HWY 9	7/10/19	18:40	jp	1.12	-	PY	f	16.5	167	200	Higher flow than previous encountered - turbulent cross section.
4	San Lorenzo River downstream of Clear Creek	7/10/19	17:30	jp	17.21	-	PY	f	18.8	397	451	Fair cross section - some turbulence.
5	Love Creek upstream of San Lorenzo River	7/10/19	15:40	jp	0.770	-	PY	g	17.4	317	372	Fairly laminar verticals.
6	**San Lorenzo River** upstream of Love Creek	7/10/19	16:30	jp	19.90	-	PY	g	20.3	395	435	Cobbles in cross section - some uneven spins.
7	Newell Creek upstream of San Lorenzo River	7/10/19	13:00	jp	2.40	-	PY	g	15.5	259	317	No obstructions downstream of gage.
8	Newell Creek at Rancho Rio Bridge	7/10/19	11:15	jp	1.73	-	PY	g	13.9	294	373	Diversion hose in stream downstream of cross section.
8a	Fall Creek upstream of San Lorenzo River	7/10/19	10:45	jp	-	6.71	V-notch slipstream visual est.	f	-	-	-	Upstream SLVWD real-time record upstream visual estimate of flow for trib coming into Fall Cr at HWY9.
9	**San Lorenzo River** downstream of Fall Creek	7/10/19	10:15	jp	30.90		PY	g	16.6	324	386	Unable to access Fall Cr at confluence with downed tree.
10	Bull Creek upstream of San Lorenzo River	7/10/19	8:45	jp	0.58		PY	g	14.3	317	399	Lots of 2-4 cm fish.

Observers: jp; Jason Parke; cn; Chelsea Neill
Stage: Water level observed on staff plate--arbitrary datum
Instrument: Typically made upstreaming a pygmy (PY) bucket-wheel ("Price-type") current meter. Extremely low flows are measured with a bag and graduated cylinder (B) If estimated, from rating curve (R) or visual (
Estimated measurement accuracy: Excellent (E) = +/- 2%; Good (G) = +/- 5%; Fair (F) = +/- 9%; Poor (P) estimated percent accuracy given
Other abbreviations: downstream=downstream; upstream=upstream, San Lorenzo River=San Lorenzo River; Tsm=Santa Margarita formation; upstreamGS= U.S. Geological Survey
Specific conductance: Measured in micromhos/cm in field; then upstream to 25degC by equation (1.8813774452 - [0.050433063928 * field temp] + [0.00058561144042 * field temp^2]) * Field specific conductance

Table 5. Station Observer Log; San Lorenzo River accretion study, July 10, 2019 (pg 2 of 2)
Santa Cruz County Environmental Health, Santa Cruz County, California

Site Information					*Streamflow*				*Water Quality Observations*			*Remarks*
Point Number	Site description	Date	Time	Observer(s)	Measured Flow	Estimated Flow	Method	Estimated Accuracy	Water Temperature	Specific Conductance at field temp.	Specific Conductance at 25C	
		(mm/dd/yr)	*(24hr)*		*(cfs)*	*(cfs)*		*(e/g/f/p)*	*(oC)*	*(µmhos/cm)*	*(at 25 oC)*	
11	**San Lorenzo River**, downstream of Boulder Cr at seasonal gage (approx. 1700 ft downstream of confluence)	7/10/19	9:30	cn	9.29	-	AA	g	15.7	379	461	No notes.
12	**San Lorenzo River** at Big Trees upstreamGS gage	7/10/19	10:00	-	-	41	-	15-min provisional data	-	-	-	No notes.
13	**San Lorenzo River** at Santa Cruz USGS gage 11161000	7/10/19	-	-	-	43.8 mean daily (44.6 to 42.4)	-	15-min provisional data	-	-	-	No notes.

Observers: jp; Jason Parke; cn; Chelsea Neill
Stage: Water level observed on staff plate--arbitrary datum
Instrument: Typically made upstreaming a pygmy (PY) bucket-wheel ("Price-type") current meter. Extremely low flows are measured with a bag and graduated cylinder (B) If estimated, from rating curve (R) or visual (V).
Estimated measurement accuracy: Excellent (E) = +/- 2%; Good (G) = +/- 5%; Fair (F) = +/- 9%; Poor (P) estimated percent accuracy given
Other abbreviations: downstream=downstream; upstream=upstream, San Lorenzo River=San Lorenzo River; Tsm=Santa Margarita formation; upstreamGS= U.S. Geological Survey
Specific conductance: Measured in micromhos/cm in field; then upstream to 25degC by equation (1.8813774452 - [0.050433063928 * field temp] + [0.00058561144042 * field temp^2]) * Field specific conductance

Table 6. Station Observer Log; San Lorenzo River Accretion study, September 24-26, 2019 (pg 1 of 2)
Santa Cruz County Environmental Health, Santa Cruz County, California

Site Information				***Streamflow***					***Water Quality Observations***			***Remarks***
Site description	Date *(mm/dd/yr)*	Time *(24hr)*	Observer(s)	Stage (staff plate) *(feet)*	Measured Flow *(cfs)*	Estimated Flow *(cfs)*	Method	Estimated Accuracy *(e/g/f/p)*	Water Temperature *(oC)*	Specific Conductance at field temp. *(µmhos/cm)*	Specific Conductance at 25C *(at 25 oC)*	
Boulder Creek 400 ft upstream of San Lorenzo River	9/26/19	12:30	jp	-	2.38	-	PY	g	15.8	-	220	
San Lorenzo River downstream of Boulder Creek	9/26/19	14:15	jp	-	5.27	-	PY	g	17.3	422	497	No notes.
Clear Creek approximaty 50 feet downstream of HWY 9	9/25/19	18:00	jp	-	0.31	-	PY	f/p	17.1	178	210	Very turbulent flow measurement section.
San Lorenzo River 50 feet downstream Clear Creek.	9/25/19	16:46	jp	-	6.74	-	PY	g	17.6	408	478	Seep at Larkspur flowing 5-10 gpm. Good measurement section.
Alba Creek at HWY 9	9/25/19	17:00	jp	-	-	0.2	vis est	f	-	-	-	Visual estimate of flow
San Lorenzo River upstream of Love Creek	9/25/19	16:15	jp	-	6.86	-	-	-	18	393	454	No notes.
Love Creek upstream of San Lorenzo River	9/25/19	15:29	jp	-	0.21	-	PY	g	17.9	361	417	No notes.
Newell Creek downstream of Loch Lomond - City of Santa Cruz gage	9/28/19	13:13	-	-	-	1.01	15-min provisional record	-	-	-	-	No notes.
Newell Creek 100 feet upstream of Rancho Rio Bridge	9/29/19	10:30	jp		0.94	-	PY	g	11.0	274	377	Some uneven velocity profiles.
Newell Creek 150 feet upstream of San Lorenzo River	9/25/19	14:15	jp	2.78	1.41	-	PY	g	16.2	242	291	No notes.
San Lorenzo River 100 feet upstream of Newell Creek	9/25/19	15:00	jp	-	8.00	-	PY	g	18	384	443	Very good measurement section with smooth velocity.
San Lorenzo River upstream Glen Arbor Bridge	9/25/19	13:20	jp	-	9.72	-	PY	g	17.6	331	387	Difficult to find a good measurement section.
Manson Creek upstream of San Lorenzo River	9/25/19	11:00	jp	-	-	0.08	visual est.	f/p	-	-	-	Visual estimate of flow from the road.
San Lorenzo River downstream of "S" bend and upstream of Fall Creek	9/25/19	11:20	jp	-	10.67	-	PY	g	16.6	343	409	Walked upstream from Fall Creek. Banks are steep, nearly rectangular. Sandstone banks are seeping into the river through macro pores. Most of the seeping banks are near homes and may be septic return flow.
Fall Creek upstream of San Lorenzo River	9/25/19	10:00	jp	-	-	3.11	SLVWD gage	f	14.8	218	271	Flow estimated using SLVWD v-notch record and visual estimate of flow at the tributary downstream near the high school. Section just upstream of SLR is very turbulent.

Observers: jp; Jason Parke; cn; Chelsea Neill

Stage: Water level observed on staff plate--arbitrary datum

Instrument: Typically made using a pygmy (PY) bucket-wheel ("Price-type") current meter. Extremely low flows are measured with a bag and graduated cylinder (B) If estimated, from rating curve (R) or visual (V).

Estimated measurement accuracy: Excellent (E) = +/- 2%; Good (G) = +/- 5%; Fair (F) = +/- 9%; Poor (P) estimated percent accuracy given

Other abbreviations: DS=downstream; US=upstream, SLR=San Lorenzo River; Tsm=Santa Margarita formation; USGS= U.S. Geological Survey

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

Table 6. Station Observer Log; San Lorenzo River Accretion study, September 24-26, 2019 (pg 2 of 2)
Santa Cruz County Environmental Health, Santa Cruz County, California

Site Information				*Streamflow*					*Water Quality Observations*			*Remarks*
Site description	Date	Time	Observer(s)	Stage (staff plate)	Measured Flow	Estimated Flow	Method	Estimated Accuracy	Water Temperature	Specific Conductance at field temp.	Specific Conductance at 25C	
San Lorenzo River downstream of Fall Creek	9/25/19	9:15	jp	-	13.63	-	PY	g	16.2	266	319	Some uneven spinning verticals
San Lorenzo River downstream from Fall Creek **(repeat 9/25/19 measurement)**	10/3/19	13:30	jp	-	13.48	-	PY	g	12.4	237	312	Repeat the 9/25/18 measurements downstream Fall and San Lorenzo River upstream Bull. Similar weather conditions.
San Lorenzo River upstream of Bull Creek	9/25/19	8:10	jp	-	12.99	-	PY	g	16	258	312	Good measurement section, very smooth verticals.
Bull Creek just upstream of San Lorenzo River	9/25/19	8:25	jp	-	0.31	-	PY	g	14.9	321	398	Good to fair measurement section.
San Lorenzo River upstream of Bull Creek **(repeat 9/25/19 measurement)**	10/3/19	12:15	jp	-	13.24	-	PY	g	13.1	207	268	Repeat the 9/25/18 measurements downstream Fall and San Lorenzo River upstream Bull. Similar weather conditions.
Bean Creek at Mount Hermon Camp near mouth	9/24/19	11:37	jp	1.28	3.14	-	PY	g	18.5	561	641	Some minor debris downstream of gage not likely affecting stage. Very smooth verticals in cross section.
Ferndell Creek just upstream of Bean Cr/Zayante confluence	9/24/19	12:41	jp	-	0.28	-	PY	g	15.8	173	210	Some crossing flow lines and turbulence. No odor or color.
(Tsm) Spring tributary into Zayante Creek at Woodwardia weir	9/24/19	15:33	jp	-	0.003	-	visual est.	f	17.9	131	152	No notes.
Zayante Creek at Woodwardia weir beneath Mt. Hermon Bypass	9/24/19	14:50	jp	0.63	2.8	-	PY	g	16.7	355	422	Measured downstream of weir - smooth verticals in section.
Zayante Creek downstream of Graham Hill Road	9/25/19	7:55	cn		6.48	-	PY	g	15.3	329	403	No notes.
San Lorenzo River at Big Trees, upstream gage 11160500. Provisional 15-min data.	9/25/19	9:30	-	-	-	19.30	-	-	-	-	-	Max flow was in the mooring at 19.3 cfs going to 18.4 at 13:00 and 17.5 at 18:45. Note that San Lorenzo River upstream Bull Creek+Zayante = 23.5 cfs
Eagle Creek just upstream of Graham Hill Road	9/24/19	10:45	jp	-	-	0.01	-	-	13.8	-	177	Visual estimate of flow.
Eagle Creek gage 150 feet upstream of the San Lorenzo River	9/24/19	11:04	jp	6.45	0.40	-	-	-	13.7	67	85	Measured SCT at gage and on San Lorenzo River upstream of Eagle Creek. Stage dropped from 6.53 to 6.45 after clearing debris from gaged pool.
San Lorenzo River just downstream of Eagle Creek	9/24/19	11:04	jp	-	-	19.7	-	-	16.6	334	398	Flow estimate using Eagle Cr + USGS Big Trees
San Lorenzo River at Tait Street, USGS gage 11161000	9/25/19	12:00	-	-	-	15.80	-	-	-	-	-	Note daily mean for 9/25/19 =15.5 cfs, daily max: 16.3 cfs, min: 14.7 cfs

Observers: jp; Jason Parke; cn; Chelsea Neill

Stage: Water level observed on staff plate--arbitrary datum

Instrument: Typically made using a pygmy (PY) bucket-wheel ("Price-type") current meter. Extremely low flows are measured with a bag and graduated cylinder (B) If estimated, from rating curve (R) or visual (V).

Estimated measurement accuracy: Excellent (E) = +/- 2%; Good (G) = +/- 5%; Fair (F) = +/- 9%; Poor (P) estimated percent accuracy given

Other abbreviations: DS=downstream; US=upstream, SLR=San Lorenzo River; Tsm=Santa Margarita formation; USGS= U.S. Geological Survey

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

Table 7. Station Observer Log, Love Creek upstream of the confluence of the San Lorenzo River, County of Santa Cruz, California, water years (partial) 2017 to 2020

Site Conditions				***Streamflow***				***Water Quality Observations***				***High-Water Marks***		***Remarks***
Date/Time	Observer(s)	Stage (staff plate)	Hydrograph	Measured Flow	Estimated Flow	Instrument Used	Estimated Accuracy	Water Temperature	Specific Conductance at field temp.	Specific Conductance at 25C	Additional sampling?	Estimated stage at staff plate	Inferred dates?	
(mm/dd/yr)		*(feet)*	*(R/F/S/B)*	*(cfs)*	*(cfs)*	*(AA/PY)*	*(e/g/f/p)*	*(oC)*	*(µmhos/cm)*	*(at 25 oC)*	*(Qbed, etc.)*	*(feet)*	*(mm/dd/yr)*	
9/18/17 12:20	dr, UCSC	-	B	0.48	-	PY	g	16.2	343	412	Nitrate (N) 0.10	-	-	Sampled nitrate. UCSC also sampled water quality.
8/23/18 17:23	jp	-	B	0.09	-	PY	g	17.8	393	456	-	-	-	Water is clear, no odor.
11/27/18 12:15	jp	-	B	0.18	-	PY	g	10.3	299	417	-	0.6 ft. above water level	-	Urban input probably influenced high-water mark.
5/2/19 15:15	jp	-	B	2.08	-	PY	g	13.5	243	324	-	-	-	Water is clear, no odor.
6/19/19 12:25	jp	-	B	-	2.0	visual est.	-	15.1	290	358	Nitrate (N) 0.178			Water quality sample only.
7/10/19 15:45	jp	-	B	0.77	-	PY	g	17.4	317	372	-	-	-	Fairly laminar verticals in cross section.
9/25/19 15:29	jp	-	B	0.21	-	PY	g	17.9	361	417	-	-	-	Measurement is part of a synoptic flow study. Flow on SLR upstream of Love Cr is 6.86 cfs SCT 454 uS at 25C.
10/28/19 13:45	jp	-	B	0.31	-	PY	g	10.1	307	431	-	-	-	No notes.

Stage: Water level observed at outside staff plate

Observers: (jp) Jason Parke, (dr) Denis Ruttenburg, (UCSC) Christina Richardson and Joe Fackrell

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

Instrument: If measured, typically made using a standard (AA) or pygmy (PY) bucket-wheel ("Price-type") current meter. Extremely low flows are measured with a bucket+stop watch (B) If estimated, from rating curve (R) or visual (V).

Estimated measurement accuracy: Excellent (E) = +/- 2%; Good (G) = +/- 5%; Fair (F) = +/- 9%; Poor (P) estimated percent accuracy given

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

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

Additional Sampling: Qbed = Bedload, Qss = Suspended sediment, Nutr = nutrients; other symbols as appropriate

Table 8. Station Observer Log, Newell Creek, County of Santa Cruz, California, water year 2017 to 2018

Site Conditions				*Streamflow*				*Water Quality Observations*				*High-Water Marks*		*Remarks*
Date/Time	Observer(s)	Stage (staff plate)	Hydrograph	Measured Flow	Estimated Flow	Instrument Used	Estimated Accuracy	Water Temperature	Specific Conductance at field temp.	Specific Conductance at 25C	Additional sampling?	Estimated stage at staff plate	Inferred dates?	
(mm/dd/yr)		*(feet)*	*(R/F/S/B)*	*(cfs)*	*(cfs)*	*(AA/PY)*	*(e/g/f/p)*	*(oC)*	*(µmhos/cm)*	*(at 25 oC)*	*(Qbed, etc.)*	*(feet)*	*(mm/dd/yr)*	
Newell Creek downstream of Loch Lomond - City of Santa Cruz 15-min gage record (avg of the hour prior to the gage visit upstream of the SLR)														
9/18/2017 10:00					1.06	15-minute record								15-minute provisional record.
Newell upstream of Rancho Rio Bridge														
9/19/17 10:33	jp, zr	-	B	1.25	-	PY	g	15.7	291	355	Nitrate (N) 0.22	-	-	This site is downstream of the landfill.
6/15/18 11:15	jp	-	B	1.03	-	PY	g	13.2	252	329	-	-	-	Diversion hose is in the channel downstream of the flow measurement.
8/23/18 0:00	jp	-	B	-	-	-	-	-	-	-	-	-	-	Did not measure flow - too many people present, dogs barking.
9/18/18 15:22	jp	-	B	1.07	-	PY	g	14.1	315	397	-	-	-	No notes.
11/27/2018 11:15	jp	-	B	0.92	-	PY	g	11.0	297	406	-	-	-	There are a lot of leaves in the channel. Water is moving slowly. Water is clear.
Newell gage 150ft upstream of SLR														
9/18/17 10:30	dr, UCSC	-	-	2.71	-	PY	g	15.0	235	291	Nitrate (N) 1.56	-	-	Synoptic measurements of water quality and flow.
6/14/18 12:50	jp	2.68	B	1.45	-	PY	g	15.5	224	273	-	2.98	-	**Installed sensor and staff plate** about 150 ft upstream of confluence with San Lorenzo River.
8/23/18 17:01	jp	2.64	B	1.32	-	PY	g	17.5	275..8	322	-	-	-	Heavy staining on the staff plate at 2.77
9/18/18 13:30	jp	2.64	B	1.46	-	PY	g	14.1	319	321	-	-	-	No notes.
11/27/18 10:15	jp	2.67	B	1.57	-	PY	g	11.6	246	331	-	-	-	Water is clear, removed sensor at 10:35 left the staff plate.

Stage: Water level observed at outside staff plate

Observers: (jp) Jason Parke, (dr) Denis Ruttenburg, (UCSC) Christina Richardson and Joe Fackrell

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

Instrument: If measured, typically made using a standard (AA) or pygmy (PY) bucket-wheel ("Price-type") current meter. Extremely low flows are measured with a bucket+stop watch (B) If estimated, from rating curve (R) or visual (V).

Estimated measurement accuracy: Excellent (E) = +/- 2%; Good (G) = +/- 5%; Fair (F) = +/- 9%; Poor (P) estimated percent accuracy given

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

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

Additional Sampling: Qbed = Bedload, Qss = Suspended sediment, Nutr = nutrients; other symbols as appropriate

Table 9. Station Observer Log, Newell Creek, County of Santa Cruz, California, water year 2019

Site Conditions				*Streamflow*				*Water Quality Observations*				*High-Water Marks*		*Remarks*
Date/Time	Observer(s)	Stage (staff plate)	Hydrograph	Measured Flow	Estimated Flow	Instrument Used	Estimated Accuracy	Water Temperature	Specific Conductance at field temp.	Specific Conductance at 25C	Additional sampling?	Estimated stage at staff plate	Inferred dates?	
(mm/dd/yr)		*(feet)*	*(R/F/S/B)*	*(cfs)*	*(cfs)*	*(AA/PY)*	*(e/g/f/p)*	*(oC)*	*(µmhos/cm)*	*(at 25 oC)*	*(Qbed, etc.)*	*(feet)*	*(mm/dd/yr)*	
Newell Creek downstream of Loch Lomond - City of Santa Cruz 15-min gage record (provisional)														
11/27/2018 9:00	-	-	-	1.98	-	15-minute record	-	-	-	-	-	-	-	Mean daily flow: 1.26 cfs, min 1.03 cfs, max 2.34 cfs
5/2/2019 12:00	-	-	-	1.09	-	15-minute record	-	-	-	-	-	-	-	Mean daily flow:1.09 cfs, minimum: 1.11 cfs , maximum 2.34 cfs
6/19/2019 13:00	-	-	-	1.34	-	15-minute record	-	-	-	-	-	-	-	Mean daily flow: 1.37 cfs, minimum: 1.33 cfs , 1.40 maximum cfs
7/10/2019 9:00	-	-	-	2.03	-	15-minute record	-	-	-	-	-	-	-	Mean daily flow; 2.04 cfs, minimum 2.03 cfs, maximum 2.05 cfs
9/25/2019 13:15	-	-	-	1.01	-	15-minute record	-	-	-	-	-	-	-	Mean daily flow; 1.02 cfs, minimum 1.0 cfs, maximum 1.03 cfs
10/28/2019 14:15	-	-	-	1.02	-	15-minute record	-	-	-	-	-	-	-	Mean daily flow; 1.02 cfs, minimum 1.02 cfs, maximum 1.04 cfs
Newell upstream of Rancho Rio Bridge (no staff plate)														
11/27/18 11:15	jp	-	B	0.92	-	PY	f	11.0	297	405	-	-	-	Lots of leaves in the channel. Slow moving water
5/2/19 14:15	jp	-	B	1.32	-	PY	g	13.4	289	370	-	-	-	Lots of 1-2 cm fish.
6/19/19 12:08	jp	-	B	-	-	-	-	15.1	305	375	Nitrate (N) 0.227			Water quality sample only.
7/10/2019 11:15	jp	-	B	1.73	-	PY	g/f	13.9	294	373	-	-	-	Diversion hose in the channel downstream of cross section.
9/29/2019 10:30	jp	-	B	0.94	-	PY	g	11.0	275	377	-	-	-	Some uneven velocity profiles.
10/28/2019 14:15	jp	-	B	0.95	-	PY	g	10.4	227	315	-	-	-	Diversion hose in the channel downstream of cross section.
Newell gage 150 ft upstream of SLR														
11/27/18 10:15	jp	2.67	B	1.57	-	PY	g	11.6	246	331	-	-	-	Water is clear, removed sensor at 10:35 left the staff plate.
5/2/19 13:00	jp	2.81	B	2.51	-	PY	g	14.1	233	294	-	5.3 to 5.6	WY19	Reinstalled sensor - stilling well and staff plate in good shape. Zero flow at about 2.09 ft stage. Staining at stage 2.57 ft. Some turbulence in the verticals in the cross section.
6/19/19 14:35	jp	2.80	B	2.30	-	15-min record	-	17.1	260	307	Nitrate (N) 1.004	-	-	Water quality sample and stage reading only. No debris downstream of gage
7/10/19 10:00	jp	2.82	B	2.40	-	PY	g	15.5	259	317	-	-	-	No obstructions downstream of gage.
9/25/19 14:15	jp	2.78	B	1.41	-	PY	g	16.2	242	291	-	-	-	No notes.
10/28/19 15:15	jp	2.78 drop to 2.74	B	1.52	-	PY	g	12.4	233	308	-	-	-	At 14:55 seems like there could be some back-water from debris blockage just downstream of gage. Measured flow upstream of gaged reach. High-water mark is about 1.5 ft above water level.

Stage: Water level observed at outside staff plate

Observers: (jp) Jason Parke,

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

Instrument: If measured, typically made using a standard (AA) or pygmy (PY) bucket-wheel ("Price-type") current meter. Extremely low flows are measured with a bucket+stop watch (B) If estimated, from rating curve (R) or visual (V).

Estimated measurement accuracy: Excellent (E) = +/- 2%; Good (G) = +/- 5%; Fair (F) = +/- 9%; Poor (P) estimated percent accuracy given

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

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

Additional Sampling: Qbed = Bedload, Qss = Suspended sediment, Nutr = nutrients; other symbols as appropriate

Table 10. Station Observer Log, Bean Creek at Mount Hermon Camp, County of Santa Cruz, California, water year 2017

Site Conditions				*Streamflow*				*Water Quality Observations*				*High-Water Marks*		*Remarks*
Date/Time	Observer(s)	Stage (staff plate)	Hydrograph	Measured Flow	Estimated Flow	Instrument Used	Estimated Accuracy	Water Temperature	Specific Conductance at field temp.	Specific Conductance at 25C	Additional sampling?	Estimated stage at staff plate	Inferred dates?	
(mm/dd/yr)		*(feet)*	*(R/F/S/B)*	*(cfs)*	*(cfs)*	*(AA/PY)*	*(e/g/f/p)*	*(oC)*	*(µmhos/cm)*	*(at 25 oC)*	*(Qbed, etc.)*	*(feet)*	*(mm/dd/yr)*	
6/16/17 12:45	jp	-	B	5.90	-	PY	g/e	17.3	227	263	-	approx. 5.75 ft above water level at cross section		Looking for a gage location. Reach has aggraded about 2-3 feet since 2012, old staff plate is partially buried and bent. Several trees downstream have likely created back water at high flow through the reach. Flow cross section is excellent with even sand bed and fairly laminar flow.
7/13/17 15:00	jp	1.24	B	4.70	-	PY	g/e	18.1	340	390	-	9.5 old staff 6.99 new staff	WY17	Installed gage today about 150 feet upstream of previous location WY10-12. Rock jams downstream may affect the gage if people build them up. Bed is at stage 0.32 on the staff plate. Aprox stage during previous visit was 1.26. Using the high-water mark and the trend of previous high flow measurements the approximate WY17 high flow was 800 to 900 cfs. Previous highest measured flow estimate was 1,088 cfs on 3/24/2011.
8/15/17 14:00	jp	1.45	B	3.92	-	PY	g/e	17.8	343	398		-	-	People have built up rock dam downstream and is causing about 0.25 ft of back water at the gage.
8/17/17 11:02	jp	1.20	B	-	-	-	-	-	-	-	-	-	-	Cleared rock dam downstream - stage dropped from 1.49 to 1.20 feet.
9/17/17 14:45	jp	1.18	B	3.64	-	PY	g/e	16.1	330	432	-	-	-	Rock jams have not been built back up. Rating curve should be stable.
11/2/17 13:30	jp	1.20	B	3.10	-	PY	g/e	-	-	-	-	-	-	No debris downstream influencing water levels. SCT meter appears to be misreading.
11/14/17 15:15	jp	1.18	B	3.50	-	PY	g/e	14.6	345	430	-	-	-	New leaf debris jam downstream may be causing some back water at the gage. Removed datalogger just prior to 2-3 inches of rain in the forecast.

Stage: Water level observed at outside staff plate

Observers: (jp) Jason Parke,

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

Instrument: If measured, typically made using a standard (AA) or pygmy (PY) bucket-wheel ("Price-type") current meter. Extremely low flows are measured with a bucket+stop watch (B) If estimated, from rating curve (R) or visual (V).

Estimated measurement accuracy: Excellent (E) = +/- 2%; Good (G) = +/- 5%; Fair (F) = +/- 9%; Poor (P) estimated percent accuracy given

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

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

Additional Sampling: Qbed = Bedload, Qss = Suspended sediment, Nutr = nutrients; other symbols as appropriate

Table 11. Station Observer Log, Bean Creek at Mount Hermon Camp, County of Santa Cruz, California, water years 2018 to 2020 (partial)

Site Conditions				*Streamflow*				*Water Quality Observations*				*High-Water Marks*		*Remarks*
Date/Time	Observer(s)	Stage (staff plate)	Hydrograph	Measured Flow	Estimated Flow	Instrument Used	Estimated Accuracy	Water Temperature	Specific Conductance at field temp.	Specific Conductance at 25C	Additional sampling?	Estimated stage at staff plate	Inferred dates?	
(mm/dd/yr)		*(feet)*	*(R/F/S/B)*	*(cfs)*	*(cfs)*	*(AA/PY)*	*(e/g/f/p)*	*(oC)*	*(µmhos/cm)*	*(at 25 oC)*	*(Qbed, etc.)*	*(feet)*	*(mm/dd/yr)*	
5/22/18 12:32	jp	1.23	B	3.61	-	float	f	14.3	357	460	-	-	-	Reinstalled sensor. Reach appears to have aggraded with sand since 2017. Float test performed through measured cross section - very smooth verticals.
8/23/18 13:45	jp	1.24	B	2.42	-	PY	g	17.3	397	467	-	-	-	Minimal obstructions downstream of gage. Baseflow staining on staff at 1.35. Very laminar verticals in cross section
9/18/18 11:00	jp	1.23	B	2.38	-	PY	g	13.0	323	461	-	-	-	Cleared some debris downstream - stage dropped from 1.27 to 1.23
11/27/18 14:15	jp	1.28	B	2.44	-	PY	g	12.4	367	484	-	-	-	Water is clear, no high water marks. Winter base-flow does not appear to have come up. Cleaned stilling well.
1/2/19 13:45	cn	1.25	B	1.50	-	PY	g	7.5	321	480	-	2.0	-	No notes.
1/30/19 14:30	jp	1.43	B	7.47	-	PY	g	12.8	309	403	-	5.3 old staff ds, 2.9 current staff	-	Thalweg has scoured locally in the thalweg and aggraded at the staff. Sediment at 0.88 on staff. Low levels of turbidity. Sensor was in good shape - dug out and re-secured.
2/25/19 16:30	jp	1.56	B	18.27	-	AA	g	11.1	243	331	-	7 ft old staff	-	Cleared sand that had aggraded to 1.2 stage, scour locally at the thalweg.
4/30/19 11:45	jp	1.37	B	6.89	-	PY	g	13.6	353	451	-	6.9-7.0 old staff ds, 2.4 current staff	-	Thalweg has scoured locally in the thalweg and aggraded at the staff. Sensor was in good shape - dug out and re-secured.
5/30/19 12:14	jp	1.35	B	6.11	-	PY	g	15.4	363	445	-	-	-	No debris in downstream riffle
6/19/19 10:16	cn	1.29 to 1.30	B	-	-	-	-	15.2	362	445	-	-	-	Nitrate sampled
7/10/19 13:04	cn	1.26	B	3.77	3.0	PY	g	16.4	315	376	-	-	-	Water is clear. Measured flow approximately 10 ft downstream of gage. lots of small fish in gage pool
9/24/19 11:45	jp	1.28	B	3.14	-	PY	g/e	15.2	345	426	-	-	-	Minor debris downstream of gage - probably not affecting stage. Very laminar verticals in the cross section.
11/1/19 14:00	jp	1.24	B	2.79	-	PY	f	9.6	316	448	-	-	-	Turbulence in the cross section, usual section is too deep and slow. Stage went from 1.44 to 1.24 after clearing debris downstream.

Stage: Water level observed at outside staff plate

Observers: (jp) Jason Parke, (cn) Chelsea Neill

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

Instrument: If measured, typically made using a standard (AA) or pygmy (PY) bucket-wheel ("Price-type") current meter. Extremely low flows are measured with a bucket+stop watch (B) If estimated, from rating curve (R) or visual (V).

Estimated measurement accuracy: Excellent (E) = +/- 2%; Good (G) = +/- 5%; Fair (F) = +/- 9%; Poor (P) estimated percent accuracy given

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

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

Additional Sampling: Qbed = Bedload, Qss = Suspended sediment, Nutr = nutrients; other symbols as appropriate

Table 12. Station Observer Log, Zayante Creek at Woodwardia, County of Santa Cruz, California, water year 2017

Site Conditions				*Streamflow*				*Water Quality Observations*				*High-Water Marks*		*Remarks*
Date/Time	Observer(s)	Stage (staff plate)	Hydrograph	Measured Flow	Estimated Flow	Instrument Used	Estimated Accuracy	Water Temperature	Specific Conductance at field temp.	Specific Conductance at 25C	Additional sampling?	Estimated stage at staff plate	Inferred dates?	
(mm/dd/yr)		*(feet)*	*(R/F/S/B)*	*(cfs)*	*(cfs)*	*(AA/PY)*	*(e/g/f/p)*	*(oC)*	*(µmhos/cm)*	*(at 25 oC)*	*(Qbed, etc.)*	*(feet)*	*(mm/dd/yr)*	
6/2/2017 16:00	jp	-	B	12.32	-	PY	g	15	391	482	-	approx. 6.5 ft above water level	WY17	Measured flow at Mnt Hermon (approx. 1400 ft downstream of Woodwardia) as part of Mnt Hermon Redwood Camp temporary dam during the summer months at 12.07 cfs. Cobbles in the cross section create turbulence. Staff plate from WY10-12 is missing. Tsm trib is flowing about 25 gpm.
6/13/2017 14:00	jp	0.825	B	11.66	-	PY	g	Zay: 13.3 Tsm: 16.3	Zay: 376 Tsm: 99	Zay: 480 Tsm: 118	-	-	-	Measured flow at Mnt Hermon (approx. 1400 ft downstream of Woodwardia) as part of Mnt Hermon Redwood Camp temporary dam during the summer months. Tsm spring just upstream is flowing about 25-20 gpm. Re-installed staff plate at Woodwardia
7/14/2017 11:30	jp	0.74	B	6.67	-	PY	g	Zay: 15.7 Tsm: 18.6	Zay: 360 Tsm: 96.4	Zay: 438 Tsm: 110	-	-	-	Pump hose is in the stream upstream of the gage - doesn't appear to be on at the moment.
8/15/2017 11:25	jp	0.705	B	4.48	-	PY	g	Zay: 18.0 Tsm: 17.0	Zay: 365 Tsm: 108	Zay: 430 Tsm: 121	-	-	-	Resident upstream on the left bank says that the surface water Tsm spring that she uses for water is no longer at surface level. She says that there are new wells located up gradient. Cobbles starting to influence flow measurement with lower water levels.
9/17/2017 12:30	jp	0.678	B	4.21	-	PY	g	Zay: 15.6 Tsm: 17.6	Zay: 348 Tsm: 110	Zay: 463 Tsm: 138	-	-	-	No debris influencing the gage. Flow measurement made day prior to water quality sampling event.
11/2/2017 14:50	jp	0.67	B	3.80	-	PY	g	-	-	-	-	-	-	Tsm seep/spring flow visual estimate 1-2 gpm. SCT meter appears to be misreading.

Stage: Water level observed at outside staff plate

Observers: (jp) Jason Parke,

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

Instrument: If measured, typically made using a standard (AA) or pygmy (PY) bucket-wheel ("Price-type") current meter. Extremely low flows are measured with a bucket+stop watch (B) If estimated, from rating curve (R) or visual (V).

Estimated measurement accuracy: Excellent (E) = +/- 2%; Good (G) = +/- 5%; Fair (F) = +/- 9%; Poor (P) estimated percent accuracy given

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

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

Additional Sampling: Qbed = Bedload, Qss = Suspended sediment, Nutr = nutrients; other symbols as appropriate

Table 13. Station Observer Log, Zayante Creek at Woodwardia, County of Santa Cruz, California, water year 2018

Site Conditions				*Streamflow*				*Water Quality Observations*				*High-Water Marks*		*Remarks*
Date/Time	Observer(s)	Stage (staff plate)	Hydrograph	Measured Flow	Estimated Flow	Instrument Used	Estimated Accuracy	Water Temperature	Specific Conductance at field temp.	Specific Conductance at 25C	Additional sampling?	Estimated stage at staff plate	Inferred dates?	
(mm/dd/yr)		*(feet)*	*(R/F/S/B)*	*(cfs)*	*(cfs)*	*(AA/PY)*	*(e/g/f/p)*	*(oC)*	*(µmhos/cm)*	*(at 25 oC)*	*(Qbed, etc.)*	*(feet)*	*(mm/dd/yr)*	
11/2/2017 14:45	jp	0.67	B	3.80	-	PY	g/f	Zay 13.1 Tsm -	Zay 324 Tsm 99	Zay 411 Tsm 100	-	-	-	Staining on staff at 0.72 ft, Tsm flow visual est 1-2 gpm. Temperature probe on meter malfunctioned.
5/22/2018 13:50	jp	0.70	B	-	-	-	-	Zay 14.5 Tsm 15.1	Zay 387 Tsm 130	Zay 484 Tsm 160	-	Unable to see hwm	-	Reinstalled sensor, Tsm flow visual est 4-5 gpm, lower than expected.
5/30/2018 15:30	jp	0.69	B	4.58	-	PY	g/f	Zay 16.1 Tsm 16.3	Zay 401 Tsm 128	Zay 479 Tsm 155	-	-	-	Cobbles in the cross section - some turbulence in verticals.
8/23/2018 15:30	jp	0.66	B	2.03	-	PY	g/f	Zay 17.9 Tsm 16.5	Zay 397 Tsm 211	Zay 458 Tsm 256	-	-	-	Moved cross section downstream of concrete - very smooth verticals. Tsm visual est 0.1 gpm - just a trickle.
9/18/2018 12:30	jp	0.59	B	2.03	-	PY	g	Zay 13.7 Tsm 13.0	Zay 344 Tsm 190	Zay 439 Tsm 240	-	-	-	Tsm seeping very low flow at approx.0.1 gpm
11/27/2018 16:00	jp	0.61	B	2.57	-	PY	g	Zay 11.1 Tsm 11.6	Zay 335 Tsm 178	Zay 457 Tsm 246	-	1.2	WY18	Tsm visual est 0.25 gpm. Good smooth verticals in cross section.

Stage: Water level observed at outside staff plate

Observers: (jp) Jason Parke

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

Instrument: If measured, typically made using a standard (AA) or pygmy (PY) bucket-wheel ("Price-type") current meter. Extremely low flows are measured with a bucket+stop watch (B) If estimated, from rating curve (R) or visual (V).

Estimated measurement accuracy: Excellent (E) = +/- 2%; Good (G) = +/- 5%; Fair (F) = +/- 9%; Poor (P) estimated percent accuracy given

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

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

Additional Sampling: Qbed = Bedload, Qss = Suspended sediment, Nutr = nutrients; other symbols as appropriate

Table 14. Station Observer Log, Zayante Creek at Woodwardia, County of Santa Cruz, California, water year 2019 to 2020 (partial)

Site Conditions				*Streamflow*				*Water Quality Observations*				*High-Water Marks*		*Remarks*
Date/Time	Observer(s)	Stage (staff plate)	Hydrograph	Measured Flow	Estimated Flow	Instrument Used	Estimated Accuracy	Water Temperature	Specific Conductance at field temp.	Specific Conductance at 25C	Additional sampling?	Estimated stage at staff plate	Inferred dates?	
(mm/dd/yr)		*(feet)*	*(R/F/S/B)*	*(cfs)*	*(cfs)*	*(AA/PY)*	*(e/g/f/p)*	*(oC)*	*(µmhos/cm)*	*(at 25 oC)*	*(Qbed, etc.)*	*(feet)*	*(mm/dd/yr)*	
9/18/2018 12:30	jp	0.59	B	2.03	-	PY	g	Zay 13.7 Tsm 13.0	Zay 344 Tsm 190	Zay 439 Tsm 240	-	-	-	Tsm seeping very low flow at approx.0.1 gpm
11/27/2018 16:00	jp	0.61	B	2.57	-	PY	g	Zay 11.1 Tsm 11.6	Zay 335 Tsm 178	Zay 457 Tsm 246	-	1.2	WY18	Tsm visual est 0.25 gpm. Good smooth verticals in cross section.
1/2/2019 15:45	cn	0.65	B	1.72	-	AA	g	Zay 6.0 Tsm 7.3	Zay 304 Tsm 105	Zay 477 Tsm 159	-	-	-	No notes.
1/30/2019 16:15	jp	0.88	B	10.2	-	PY	g	Zay 11.8 Tsm 13.3	Zay 362 Tsm 190	Zay 481 Tsm 245	-	2.5	-	Bay tree has fallen in channel coving about 1/3 of the gaged reach outlet.
2/25/2019 15:15	jp	1.12	B	30.5	-	AA	g	Zay 10.2 Tsm 12.4	Zay 307 Tsm 188	Zay 429 Tsm 234	-	4.3	WY19	Cleaned sediment from staff at 0.88 ft. Tsm flowing about 40 gpm (visual est). High-water mark is approximate.
4/30/2019 14:30	jp	0.87	B	12.09	-	PY	g	Zay13.9 Tsm 16.2	Zay 373 Tsm 93.2	Zay 474 Tsm 112	-	3.3-3.6	-	Dug out the gage which was locally buried in sand. There is a down tree in 1/3 of the gaged concrete channel. Tsm flow was 50+gpm - highest flow I have seen.
5/30/2019 14:30	jp	0.84	F	10.64	-	PY	g	Zay 15.1 Tsm 17.6	Zay 383 Tsm 99	Zay 470 Tsm 115	-	1.8	-	Tsm seep visual est 30 gpm
6/19/2019 8:26	jp	0.77	B	-	7.90	15-min record	-	Zay 15.7 Tsm 16.3	Zay 350 Tsm 105	Zay 457 Tsm 125	Nitrate (N): Zay 0.33, Tsm 0.53	-	-	Water quality sampled. Tsm flowing approx. 50 gpm.
9/24/2019 15:15	jp	0.63	B	2.80		PY	g	Zay 16.3 Tsm 17.9	Zay 355 Tsm 131	Zay 422 Tsm 152	-	-	-	Tsm seep visual est 1-2 gpm. Flow measured downstream of weir, slightly backwatered but laminar.
11/1/19 12:30	jp	0.62	B	2.84		PY	g	Zay 7.8 Tsm 9.2	Zay 291 Tsm -	Zay 433 Tsm 209	-	-	-	Tsm flow is about 0.3 to 0.5 gpm. Datalogger time was 1hr ahead of watch time - reset.

Stage: Water level observed at outside staff plate

Observers: (jp) Jason Parke, (cn) Chelsea Neill

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

Instrument: If measured, typically made using a standard (AA) or pygmy (PY) bucket-wheel ("Price-type") current meter. Extremely low flows are measured with a bucket+stop watch (B) If estimated, from rating curve (R) or visual (V).

Estimated measurement accuracy: Excellent (E) = +/- 2%; Good (G) = +/- 5%; Fair (F) = +/- 9%; Poor (P) estimated percent accuracy given

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

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

Additional Sampling: Qbed = Bedload, Qss = Suspended sediment, Nutr = nutrients; other symbols as appropriate

Table 15. Station Observer Log, Ferndell Creek just upstream of Bean Creek at Mount Hermon Camp County of Santa Cruz, California, water year 2018 to 2020 (partial)

Site Conditions				*Streamflow*				*Water Quality Observations*				*High-Water Marks*		*Remarks*
Date/Time	Observer(s)	Stage (staff plate)	Hydrograph	Measured Flow	Estimated Flow	Instrument Used	Estimated Accuracy	Water Temperature	Specific Conductance at field temp.	Specific Conductance at 25C	Additional sampling?	Estimated stage at staff plate	Inferred dates?	
(mm/dd/yr)		*(feet)*	*(R/F/S/B)*	*(cfs)*	*(cfs)*	*(AA/PY)*	*(e/g/f/p)*	*(oC)*	*(µmhos/cm)*	*(at 25 oC)*	*(Qbed, etc.)*	*(feet)*	*(mm/dd/yr)*	
5/30/18 13:00	jp	-	B	0.28	-	PY	g	15.1	149	184	-	-	-	Water level seems like it is about the same as 9/2017.
8/23/18 14:15	jp	-	B	0.27	-	PY	g	15.8	156	191	-	0.1 above wl	-	Some turbulent flow lines.
9/18/19 11:45	jp	-	B	0.21	-	PY	g	14.6	141	176	-	-	-	Note - surface drainage area is approximately 0.017 sq. mi.
11/27/18 15:14	jp	-	B	0.23	-	PY	g	14.3	149	188	-	-	-	No high-water mark, water feels warm to the touch.
1/2/19 14:45	cn	-	B	0.19	-	PY	f	12.3	140	190	-	-	-	
1/30/19 15:30	jp	-	B	0.28	-	PY	g	14.3	155	191	-	0.15 above wl		Some turbulent flow lines.
4/30/19 13:10	jp	-	B	0.34	-	PY	g	14.7	157	195	-	0.5 ft above wl - hard to see	WY18	Some crossing flow lines. Water feels surprisingly warm to the touch.
5/30/19 11:45	jp	-	B	0.36	-	PY	g	14.9	156	194	-	-	-	Water is clear
6/19/19 10:29	jp	-	B	-	-	PY	g	13.0	103	133	Nitrate	-	-	Nitrate sampled.
11/1/19 15:10	jp	-	B	0.25	-	PY	g	14.1	165	208	-	-	-	No high-water marks. Good velocity profile.

Stage: Water level observed at outside staff plate

Observers: (jp) Jason Parke, (cn) Chelsea Neill

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

Instrument: If measured, typically made using a standard (AA) or pygmy (PY) bucket-wheel ("Price-type") current meter. Extremely low flows are measured with a bucket+stop watch (B) If estimated, from rating curve (R) or visual (V).

Estimated measurement accuracy: Excellent (E) = +/- 2%; Good (G) = +/- 5%; Fair (F) = +/- 9%; Poor (P) estimated percent accuracy given

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

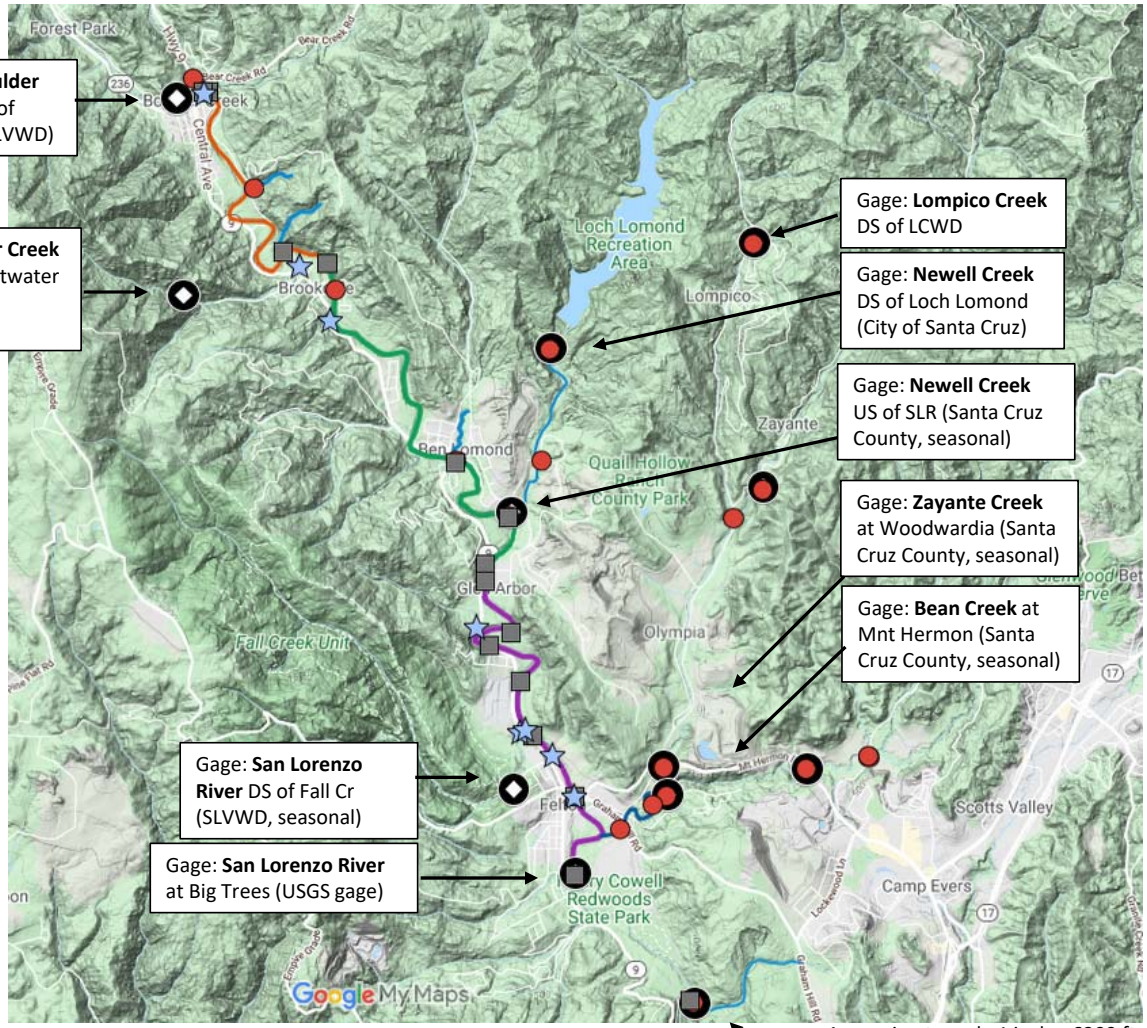
Specific conductance: Measured in micromhos/cm in field; then adjusted to 25degC by equation (1.8813774452 - [0.050433063928 * field temp] + [0.00058561144042 * field temp^2]) * Field specific conductance

Additional Sampling: Qbed = Bedload, Qss = Suspended sediment, Nutr = nutrients; other symbols as appropriate

FIGURES

Water quality and/or flow measurement locations:

- Eastern Tributary
- San Lorenzo River
- Western Tributary
- Gage



Gage: **Boulder Creek** US of HWY 9 (SLVWD)

Gage: **Clear Creek** US of Sweetwater confluence (SLVWD)

Gage: **Lompico Creek** DS of LCWD

Gage: **Newell Creek** DS of Loch Lomond (City of Santa Cruz)

Gage: **Newell Creek** US of SLR (Santa Cruz County, seasonal)

Gage: **Zayante Creek** at Woodwardia (Santa Cruz County, seasonal)

Gage: **Bean Creek** at Mnt Hermon (Santa Cruz County, seasonal)

Gage: **San Lorenzo River** DS of Fall Cr (SLVWD, seasonal)

Gage: **San Lorenzo River** at Big Trees (USGS gage)

Gage: **Eagle Creek** US of SLR (Santa Cruz County, seasonal)

Approximate scale 1 inch = 6300 ft

Boulder Creek to Clear Creek, (orange)

Clear Creek to Glen Arbor (green)

San Lorenzo River Big Trees gage to Glen Arbor Bridge, stream walk (purple)

Figure 1: Overall Study Reach and Gage Locations

Balance Hydrologics

Note: Water quality and specific conductance values measured on 6/19/2019. See observation logs for all available data.

Note: Figures 1 through 11 are preliminary, subject to revision

preliminary, subject to revision

Lat, long	37.12697, -122.12103
Station code	WY19-31
Location Description	**Boulder Cr upstream of SLR**
Nitrate, mg/L as N	0.14
Phosphate, mg/L as P	0.01
Sulfate, mg/L	24
SCT25 °C,Water °C	228, 15.7
Flow (cfs); 7/10/19	5.85 (measured at gage)
Flow (cfs); 9/25/19	2.38 (measured at gage)

Lat, long	37.12716, -122.12122	37.12721, -122.12066
Station code	WY19-32	WY19-33
Location Description	**SLR US Boulder Cr**	**SLR DS Boulder Cr**
Nitrate, mg/L as N	0.04	0.07
Phosphate, mg/L as P	0.04	0.03
Sulfate, mg/L	120.8	88.6
SCT25 °C,Water °C	532, 17.5	340, 17.4
Flow (cfs); 7/10/19	-	14.69
Flow (cfs); 9/25/19	-	5.27

Lat, long	37.12857, -122.12256
Station code	WY19-34
Location Description	**Bear Cr at Old Bear Cr Rd**
Nitrate, mg/L as N	0.02
Phosphate, mg/L as P	0.04
Sulfate, mg/L	137
SCT25 °C,Water °C	556, 17.4

Station code	WY19-30
Location Description	**Spring Cr Gulch**
Nitrate, mg/L as N	0.33
Phosphate, mg/L as P	0.12
Sulfate, mg/L	49.4
SCT25 °C,Water °C	315, 15
Flow (cfs); 6/19/19	0.08

Water quality and/or flow measurement locations:

- Eastern Tributary
- San Lorenzo River
- Western Tributary
- Gage

Approximate scale 1 inch = 780 ft

Balance Hydrologics

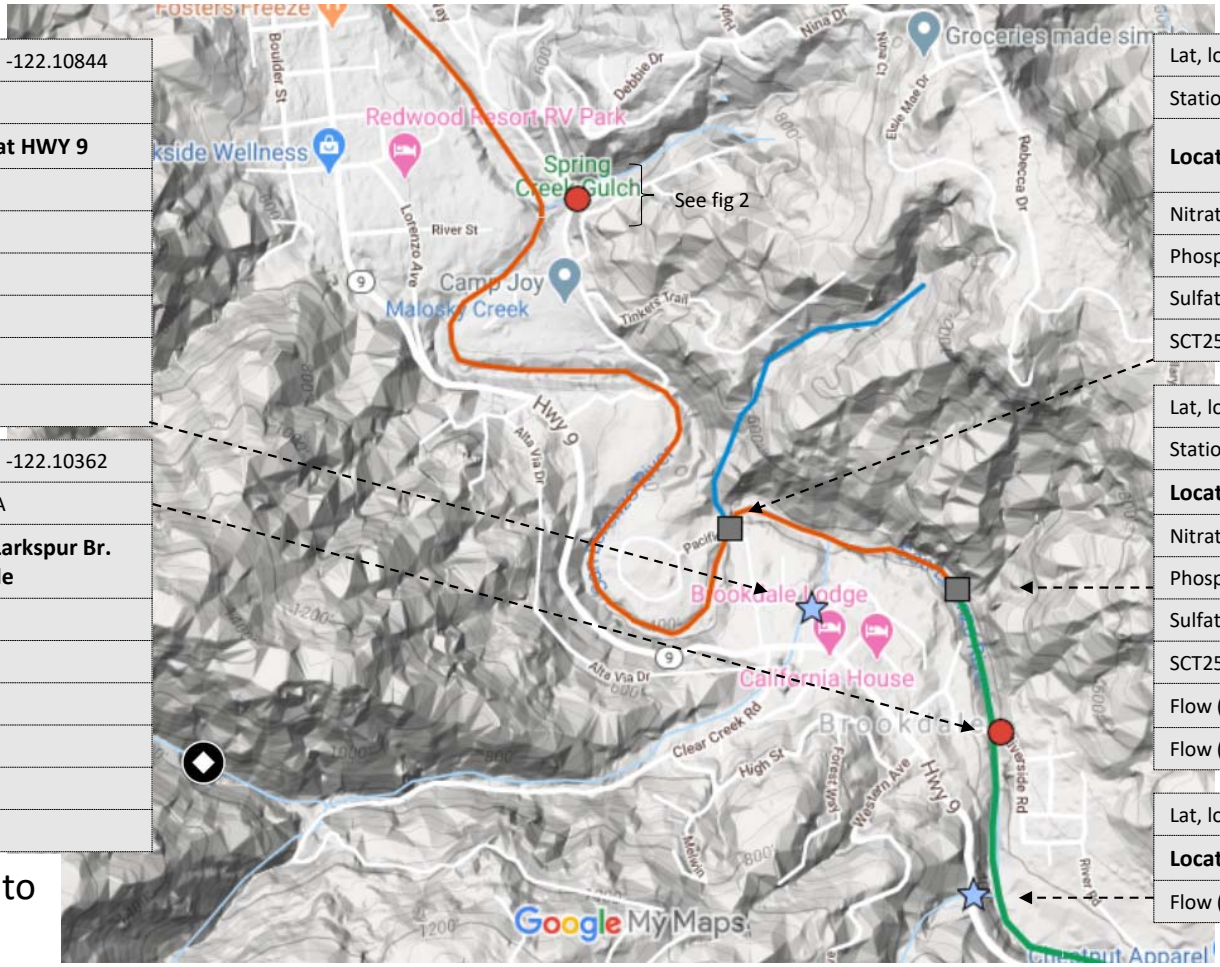
Figure 2: Bear Creek to Spring Creek Reach

Note: Water quality and specific conductance values measured on 6/19/2019. See observation logs for all available data.

preliminary, subject to revision

Lat, long	37.10861, -122.10844
Station code	WY19-27
Location Description	**Clear Cr at HWY 9**
Nitrate, mg/L as N	0.05
Phosphate, mg/L as P	0.01
Sulfate, mg/L	4.6
SCT25 °C,Water °C	183, 15.1
Flow (cfs); 7/10/19	1.12
Flow (cfs); 9/25/19	0.31

Lat, long	37.10611, -122.10362
Station code	WY19-27A
Location Description	**Seep at Larkspur Br. Brookdale**
Nitrate, mg/L as N	0.6
Phosphate, mg/L as P	0.06
Sulfate, mg/L	83.4
SCT25 °C,Water °C	609, 15.7
Flow (cfs); 6/19/19	0.02
Flow (cfs); 9/25/19	0.02



Lat, long	37.11026, -122.11056
Station code	WY19-28
Location Description	**SLR US Huckleberry Island**
Nitrate, mg/L as N	0.07
Phosphate, mg/L as P	0.03
Sulfate, mg/L	82
SCT25 °C,Water °C	442, 17.7

Lat, long	37.10902, -122.10477
Station code	WY19-27B
Location Description	**SLR DS Clear Cr**
Nitrate, mg/L as N	0.06
Phosphate, mg/L as P	0.03
Sulfate, mg/L	77.3
SCT25 °C,Water °C	427, 16.8
Flow (cfs); 7/10/19	17.21
Flow (cfs); 9/25/19	6.74

Lat, long	37.10281, -122.10434
Location Description	**Alba Creek at HWY 9**
Flow (cfs); 9/25/19	0.2 approx.

Figure 3: Spring Creek to Alba Creek Reach

Approximate scale 1 inch = 780 ft

Water quality and/or flow measurement locations:

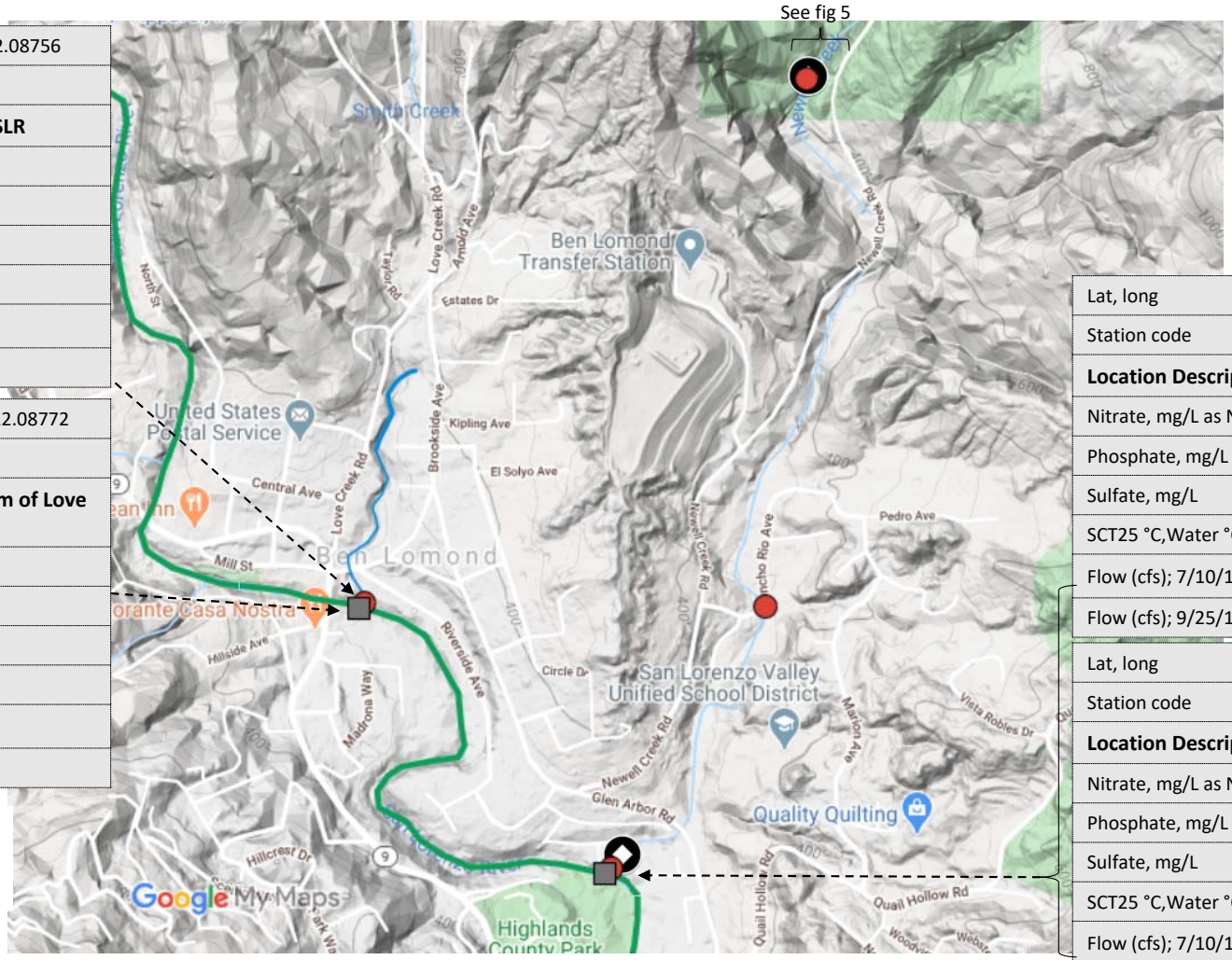
- Eastern Tributary
- San Lorenzo River
- Western Tributary
- Gage

Balance Hydrologics

Note: Water quality and specific conductance values measured on 6/19/2019. See observation logs for all available data.

Lat, long	37.0881, -122.08756
Station code	WY19-25
Location Description	**Love Cr US SLR**
Nitrate, mg/L as N	0.18
Phosphate, mg/L as P	0.1
Sulfate, mg/L	49.4
SCT25 °C,Water °C	358, 15.1
Flow (cfs); 7/10/19	0.77
Flow (cfs); 9/25/19	0.21

Lat, long	37.08798, -122.08772
Station code	WY19-26
Location Description	**SLR upstream of Love Cr**
Nitrate, mg/L as N	0.08
Phosphate, mg/L as P	0.03
Sulfate, mg/L	71.6
SCT25 °C,Water °C	412, 17.3
Flow (cfs); 7/10/19	19.9
Flow (cfs); 9/25/19	6.86



preliminary, subject to revision

Water quality and/or flow measurement locations:

- Eastern Tributary
- San Lorenzo River
- Western Tributary
- Gage

Lat, long	37.08201, -122.08081
Station code	WY19-23
Location Description	**SLR US Newell Cr**
Nitrate, mg/L as N	0.21
Phosphate, mg/L as P	0.04
Sulfate, mg/L	68.8
SCT25 °C,Water °C	409, 18.9
Flow (cfs); 7/10/19	22.1
Flow (cfs); 9/25/19	8.0

Lat, long	37.08212, -122.0806
Station code	WY19-22
Location Description	**Newell Cr US SLR**
Nitrate, mg/L as N	1.0
Phosphate, mg/L as P	0.14
Sulfate, mg/L	57.5
SCT25 °C,Water °C	307, 17.1
Flow (cfs); 7/10/19	2.40
Flow (cfs); 9/25/19	1.41

Approximate scale 1 inch = 780 ft

Figure 4: Love Creek to Newell Creek Reach

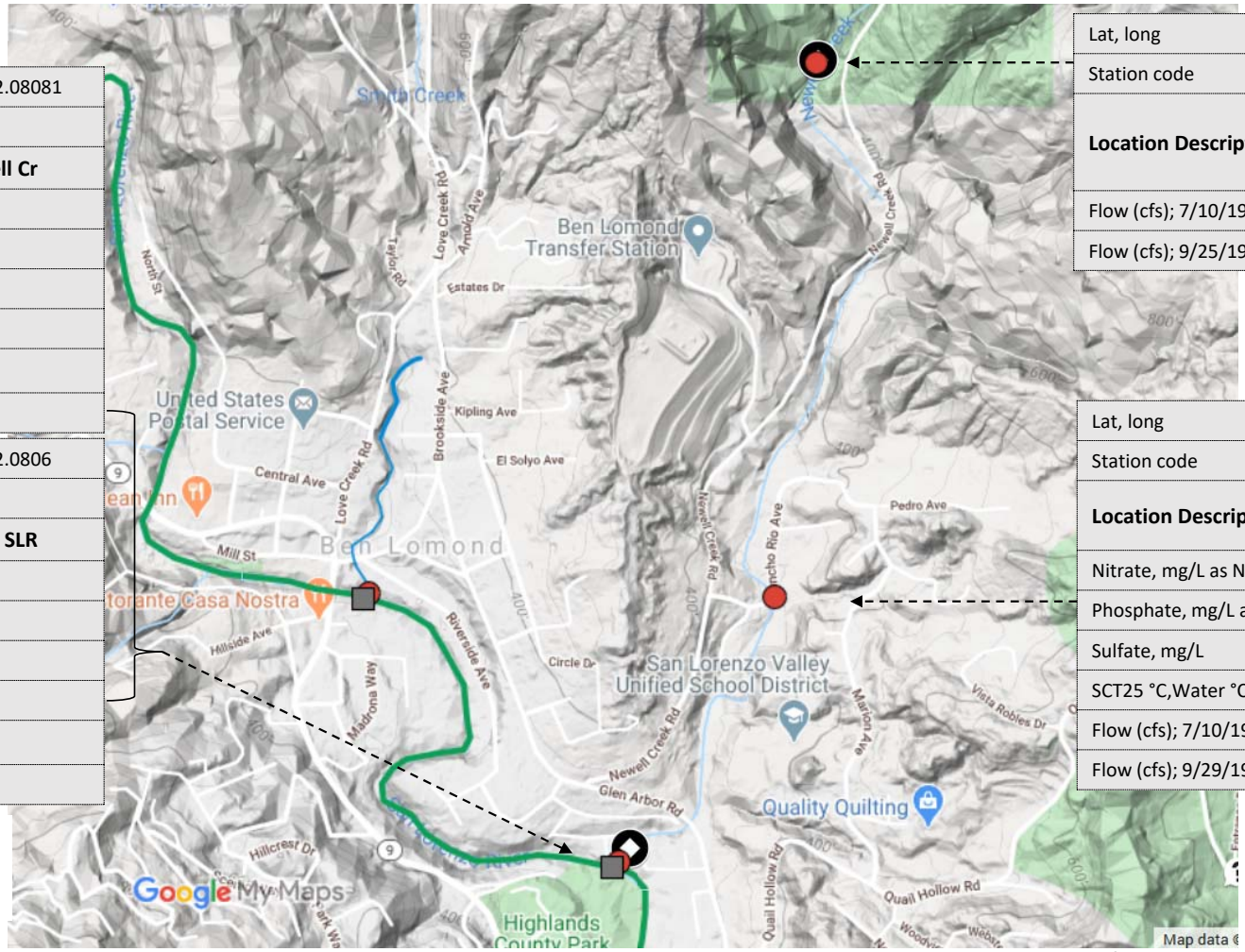
Balance Hydrologics

Note: Water quality and specific conductance values measured on 6/19/2019. See observation logs for all available data.

preliminary, subject to revision

Lat, long	37.08201, -122.08081
Station code	WY19-23
Location Description	**SLR US Newell Cr**
Nitrate, mg/L as N	0.21
Phosphate, mg/L as P	0.04
Sulfate, mg/L	68.8
SCT25 °C,Water °C	409, 18.9
Flow (cfs); 7/10/19	22.1
Flow (cfs); 9/25/19	8.0

Lat, long	37.08212, -122.0806
Station code	WY19-22
Location Description	**Newell Cr US SLR**
Nitrate, mg/L as N	1.0
Phosphate, mg/L as P	0.14
Sulfate, mg/L	57.5
SCT25 °C,Water °C	307, 17.1
Flow (cfs); 7/10/19	2.40
Flow (cfs); 9/25/19	1.41



Lat, long	37.09987, -122.07512
Station code	-
Location Description	**Newell Cr DS Loch Lomond - City of Santa Cruz gage**
Flow (cfs); 7/10/19	2.03
Flow (cfs); 9/25/19	1.01

Lat, long	37.08803, -122.07624
Station code	WY19-24
Location Description	**Newell Cr US Rancho Rio**
Nitrate, mg/L as N	0.23
Phosphate, mg/L as P	0.04
Sulfate, mg/L	83.7
SCT25 °C,Water °C	375, 15.1
Flow (cfs); 7/10/19	1.73
Flow (cfs); 9/29/19	0.94

Approximate scale 1 inch = 780 ft

Water quality and/or flow measurement locations:

- Eastern Tributary
- San Lorenzo River
- Western Tributary
- Gage

Figure 5: Newell Creek Reach

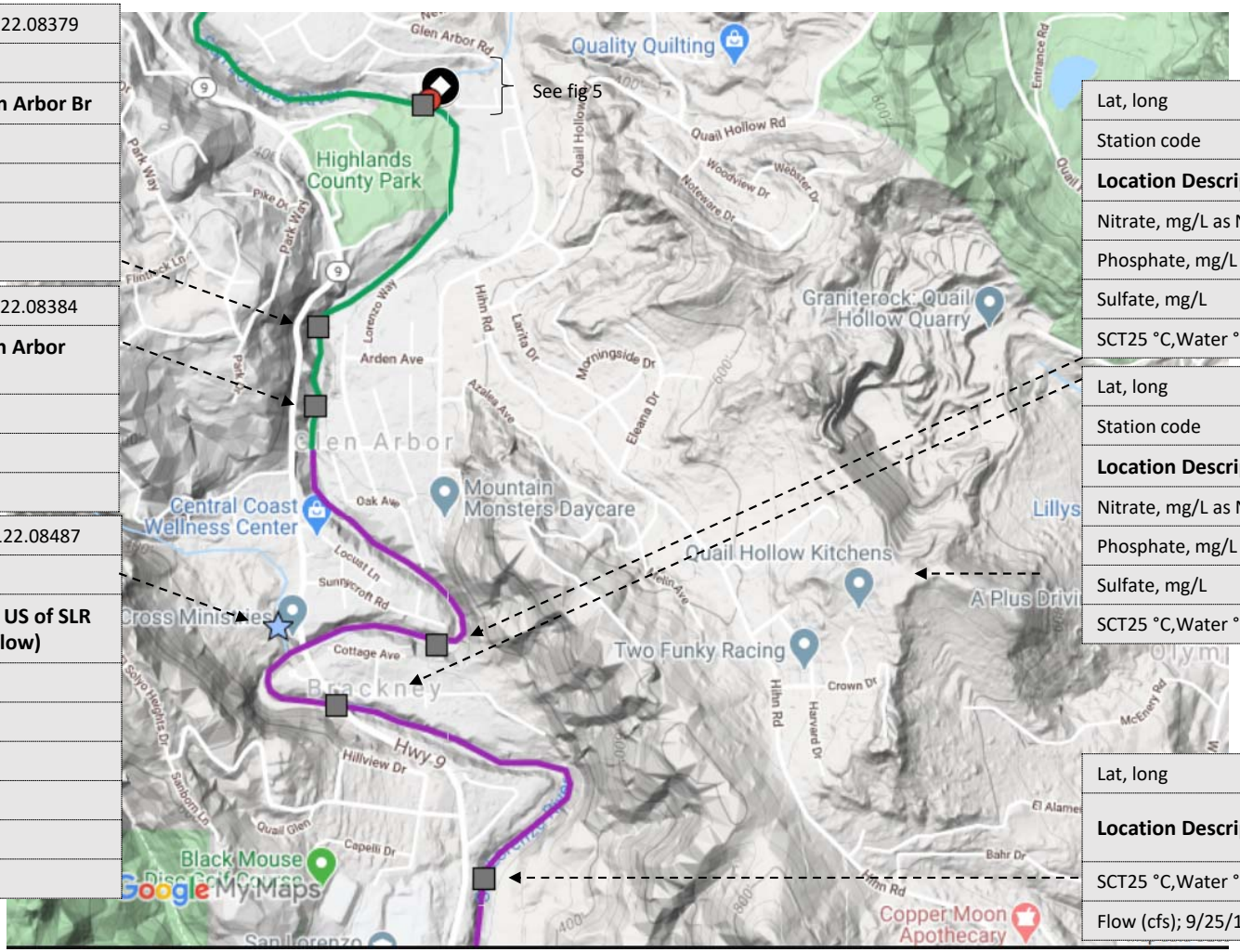
Balance Hydrologics

Note: Water quality and specific conductance values measured on 6/19/2019. See observation logs for all available data.

Lat, long	37.07703, -122.08379
Station code	WY19-21
Location Description	**SLR US Glen Arbor Br**
Nitrate, mg/L as N	0.29
Phosphate, mg/L as P	0.05
Sulfate, mg/L	67.7
SCT25 °C,Water °C	399, 17

Lat, long	37.07526, -122.08384
Location Description	**SLR US Glen Arbor Bridge**
SCT25 °C,Water °C	387, 17.6
Flow (cfs); 7/10/19	-
Flow (cfs); 9/25/19	9.72

Lat, long	37.07023, -122.08487
Station code	WY19-18
Location Description	**Manson Cr US of SLR (vis est of flow)**
Nitrate, mg/L as N	0.07
Phosphate, mg/L as P	0.05
Sulfate, mg/L	26.5
SCT25 °C,Water °C	262, 14.2
Flow (cfs); 7/10/19	0.15
Flow (cfs); 9/25/19	0.08



Lat, long	37.06986, -122.0804
Station code	WY19-20A
Location Description	**SLR US of Manson**
Nitrate, mg/L as N	0.29
Phosphate, mg/L as P	0.05
Sulfate, mg/L	67.4
SCT25 °C,Water °C	400, 17.2

Lat, long	37.0685, -122.08326
Station code	WY19-19A
Location Description	**SLR DS of Manson**
Nitrate, mg/L as N	0.28
Phosphate, mg/L as P	0.05
Sulfate, mg/L	66.6
SCT25 °C,Water °C	398, 16.9

Lat, long	37.0646, -122.07907
Location Description	**SLR DS of "S" bend, US of Fall Creek**
SCT25 °C,Water °C	409, 16.6
Flow (cfs); 9/25/19	10.67

Approximate scale 1 inch = 780 ft

Balance Hydrologics

Figure 6: Newell Creek to Brackney Reach

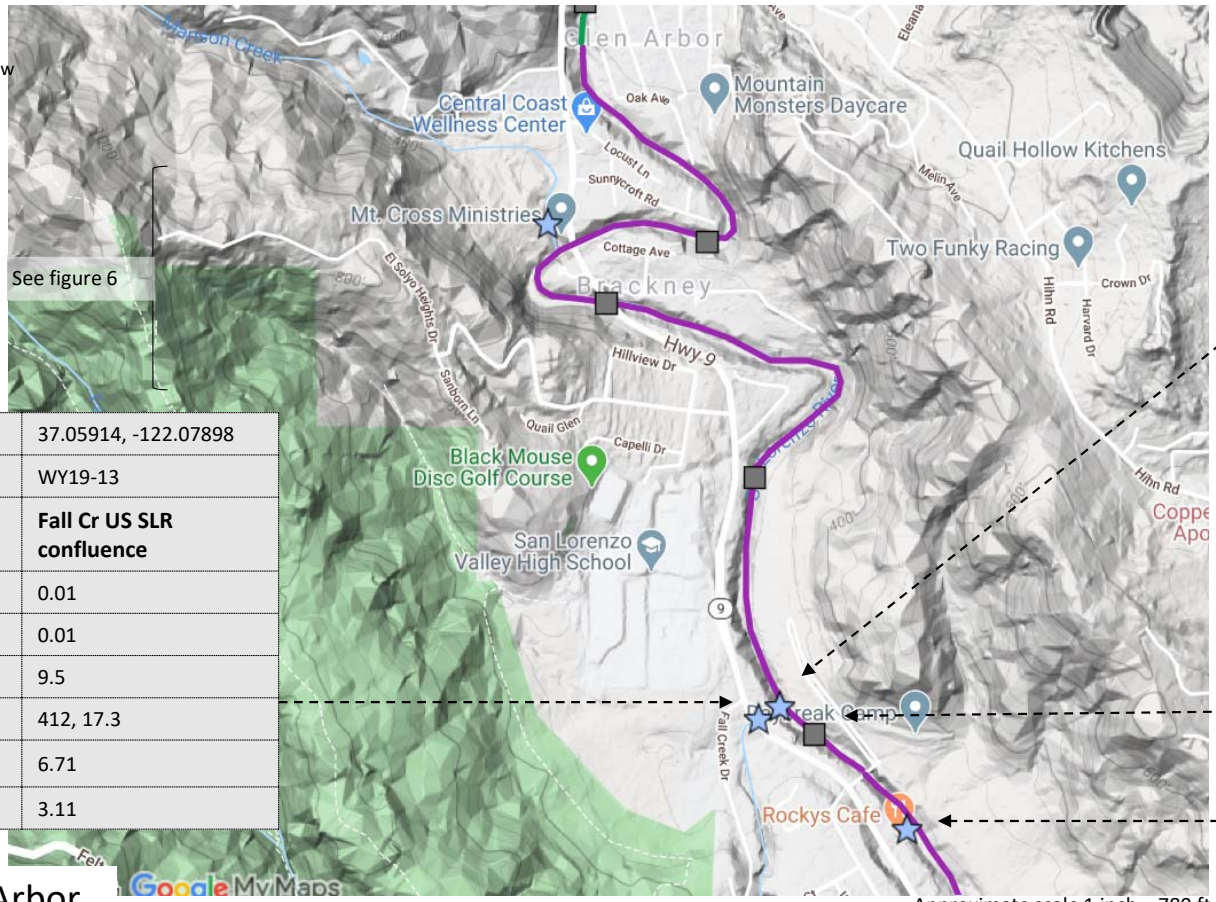
Note: Water quality and specific conductance values measured on 6/19/2019. See observation logs for all available data.

preliminary, subject to revision

preliminary, subject to revision

Water quality and/or flow measurement locations:

- Eastern Tributary
- San Lorenzo River
- Western Tributary
- Gage



Approximate scale 1 inch = 780 ft

Lat, long	37.05914, -122.07898
Station code	WY19-13
Location Description	**Fall Cr US SLR confluence**
Nitrate, mg/L as N	0.01
Phosphate, mg/L as P	0.01
Sulfate, mg/L	9.5
SCT25 °C,Water °C	412, 17.3
Flow (cfs); 7/10/19	6.71
Flow (cfs); 9/25/19	3.11

Lat, long	37.05944, -122.07836
Station code	WY19-14
Location Description	**SLR just upstream of Fall Cr**
Nitrate, mg/L as N	0.27
Phosphate, mg/L as P	0.05
Sulfate, mg/L	67.4
SCT25 °C,Water °C	404, 17.4

Lat, long	37.05883, -122.07743
Station code	WY19-14A
Location Description	**SLR DS of Fall Cr**
Nitrate, mg/L as N	0.23
Phosphate, mg/L as P	0.04
Sulfate, mg/L	56.7
SCT25 °C,Water °C	377, 16.5
Flow (cfs); 7/10/19	30.9
Flow (cfs); 9/25/19	13.63, 13.48 (repeat 10/3/19)

Lat, long	37.0567, -122.07479
Station code	WY19-15
Location Description	**Western seep**
Nitrate, mg/L as N	1.87
Phosphate, mg/L as P	0.03
Sulfate, mg/L	74.5
SCT25 °C,Water °C	318, 15.4
Flow (cfs); 6/19/19	0.002 (1 gpm)

Figure 7: Glen Arbor to Felton Reach

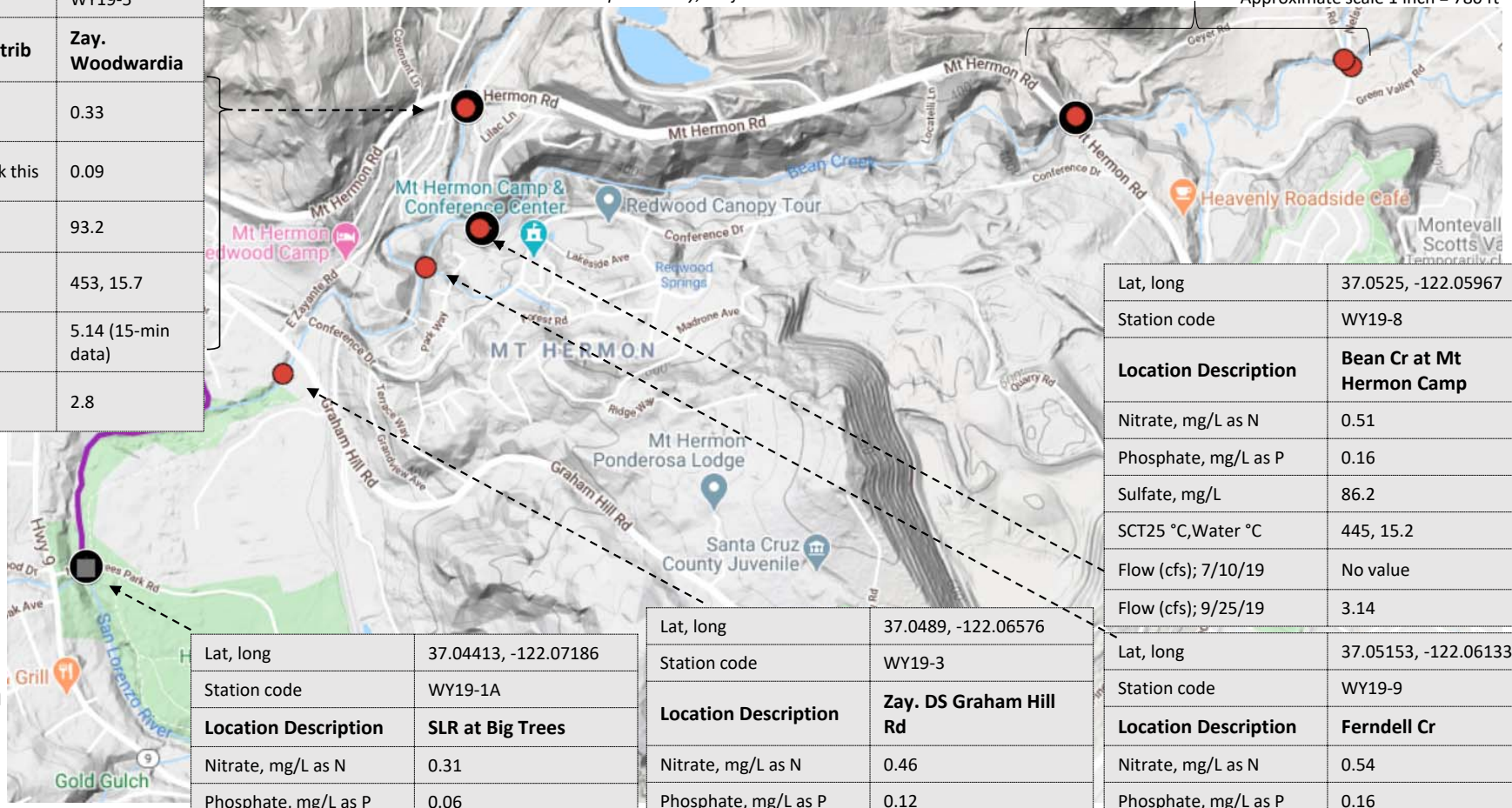
Balance Hydrologics

Note: Water quality and specific conductance values measured on 6/19/2019. See observation logs for all available data.

preliminary, subject to revision

See figure 9

Approximate scale 1 inch = 780 ft



Lat, long	37.05548, -122.06007	
Station code	WY19-4	WY19-5
Location Description	**Zay.Tsm trib**	**Zay. Woodwardia**
Nitrate, mg/L as N	0.53	0.33
Phosphate, mg/L as P	0.22 check this	0.09
Sulfate, mg/L	9.6	93.2
SCT25 °C,Water °C	126, 16.3	453, 15.7
Flow (cfs); 7/10/19	-	5.14 (15-min data)
Flow (cfs); 9/25/19	0.003	2.8

Lat, long	37.0525, -122.05967
Station code	WY19-8
Location Description	**Bean Cr at Mt Hermon Camp**
Nitrate, mg/L as N	0.51
Phosphate, mg/L as P	0.16
Sulfate, mg/L	86.2
SCT25 °C,Water °C	445, 15.2
Flow (cfs); 7/10/19	No value
Flow (cfs); 9/25/19	3.14

Lat, long	37.04413, -122.07186
Station code	WY19-1A
Location Description	**SLR at Big Trees**
Nitrate, mg/L as N	0.31
Phosphate, mg/L as P	0.06
Sulfate, mg/L	63.5
SCT25 °C,Water °C	400, 16.5
Flow (cfs); 7/10/19	40.1
Flow (cfs); 9/25/19	19.3

Lat, long	37.0489, -122.06576
Station code	WY19-3
Location Description	**Zay. DS Graham Hill Rd**
Nitrate, mg/L as N	0.46
Phosphate, mg/L as P	0.12
Sulfate, mg/L	87.7
SCT25 °C,Water °C	466, 15.5
Flow (cfs); 7/10/19	9.29
Flow (cfs); 9/25/19	6.48

Lat, long	37.05153, -122.06133
Station code	WY19-9
Location Description	**Ferndell Cr**
Nitrate, mg/L as N	0.54
Phosphate, mg/L as P	0.16
Sulfate, mg/L	85.3
SCT25 °C,Water °C	133, 15
Flow (cfs); 7/10/19	0.33
Flow (cfs); 9/25/19	0.28

Figure 8: Felton - Mnt. Hermon Reach, lower

(pg 1 of 3)

Balance Hydrologics

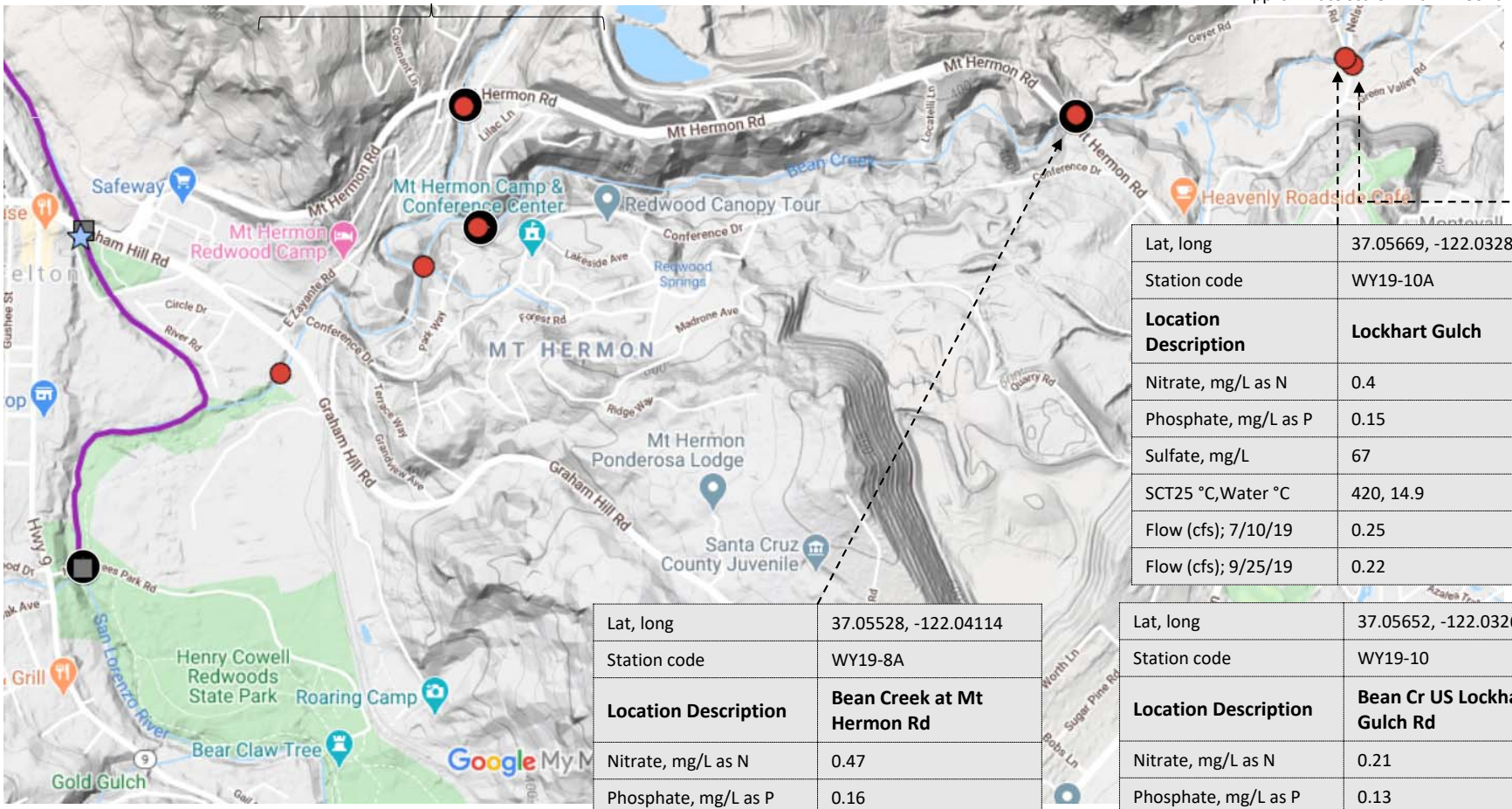
preliminary, subject to revision

Water quality and/or flow measurement locations:

- Eastern Tributary
- San Lorenzo River
- Western Tributary
- Gage

See figure 8

Approximate scale 1 inch = 780 ft



Lat, long	37.05669, -122.03281
Station code	WY19-10A
Location Description	**Lockhart Gulch**
Nitrate, mg/L as N	0.4
Phosphate, mg/L as P	0.15
Sulfate, mg/L	67
SCT25 °C,Water °C	420, 14.9
Flow (cfs); 7/10/19	0.25
Flow (cfs); 9/25/19	0.22

Lat, long	37.05528, -122.04114
Station code	WY19-8A
Location Description	**Bean Creek at Mt Hermon Rd**
Nitrate, mg/L as N	0.47
Phosphate, mg/L as P	0.16
Sulfate, mg/L	92
SCT25 °C,Water °C	457, 15.5
Flow (cfs); 7/10/19	2.87
Flow (cfs); 9/24/19	2.28

Lat, long	37.05652, -122.03262
Station code	WY19-10
Location Description	**Bean Cr US Lockhart Gulch Rd**
Nitrate, mg/L as N	0.21
Phosphate, mg/L as P	0.13
Sulfate, mg/L	130.8
SCT25 °C,Water °C	533, 15
Flow (cfs); 7/10/19	1.18
Flow (cfs); 9/25/19	0.50

Figure 9: Felton - Mnt. Hermon Reach, upper
(pg 2 of 3)

Balance Hydrologics

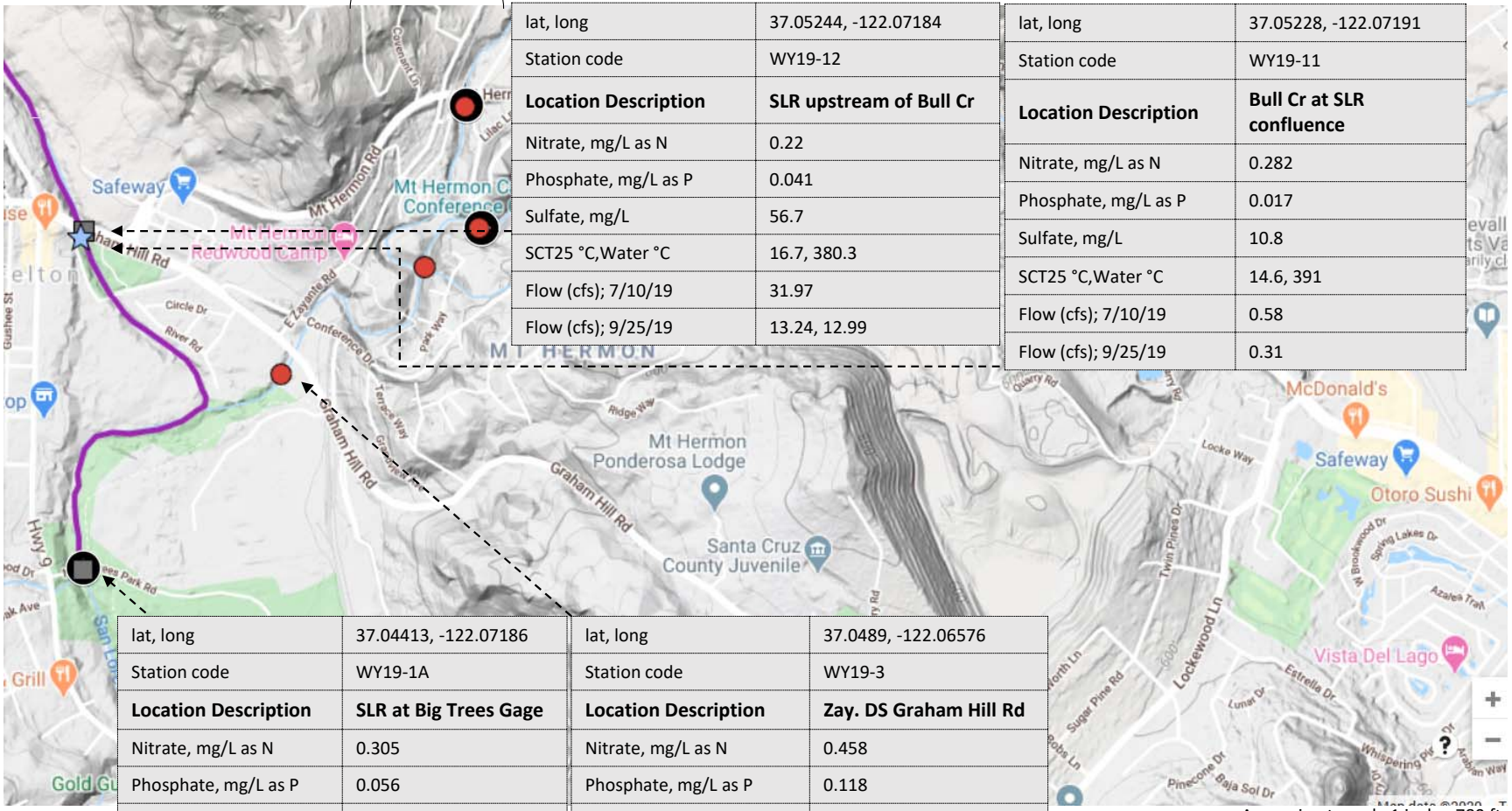
Note: Water quality and specific conductance values measured on 6/19/2019. See observation logs for all available data.

preliminary, subject to revision

Water quality and/or flow measurement locations:

- Eastern Tributary
- San Lorenzo River
- Western Tributary
- Gage

See figure 8



lat, long	37.05244, -122.07184
Station code	WY19-12
Location Description	**SLR upstream of Bull Cr**
Nitrate, mg/L as N	0.22
Phosphate, mg/L as P	0.041
Sulfate, mg/L	56.7
SCT25 °C,Water °C	16.7, 380.3
Flow (cfs); 7/10/19	31.97
Flow (cfs); 9/25/19	13.24, 12.99

lat, long	37.05228, -122.07191
Station code	WY19-11
Location Description	**Bull Cr at SLR confluence**
Nitrate, mg/L as N	0.282
Phosphate, mg/L as P	0.017
Sulfate, mg/L	10.8
SCT25 °C,Water °C	14.6, 391
Flow (cfs); 7/10/19	0.58
Flow (cfs); 9/25/19	0.31

lat, long	37.04413, -122.07186
Station code	WY19-1A
Location Description	**SLR at Big Trees Gage**
Nitrate, mg/L as N	0.305
Phosphate, mg/L as P	0.056
Sulfate, mg/L	63.5
SCT25 °C,Water °C	16.5, 400
Flow (cfs); 7/10/19	40.1
Flow (cfs); 9/25/19	19.3

lat, long	37.0489, -122.06576
Station code	WY19-3
Location Description	**Zay. DS Graham Hill Rd**
Nitrate, mg/L as N	0.458
Phosphate, mg/L as P	0.118
Sulfate, mg/L	87.7
SCT25 °C,Water °C	15.5, 466.3
Flow (cfs); 7/10/19	9.29
Flow (cfs); 9/25/19	6.48

Approximate scale 1 inch = 780 ft

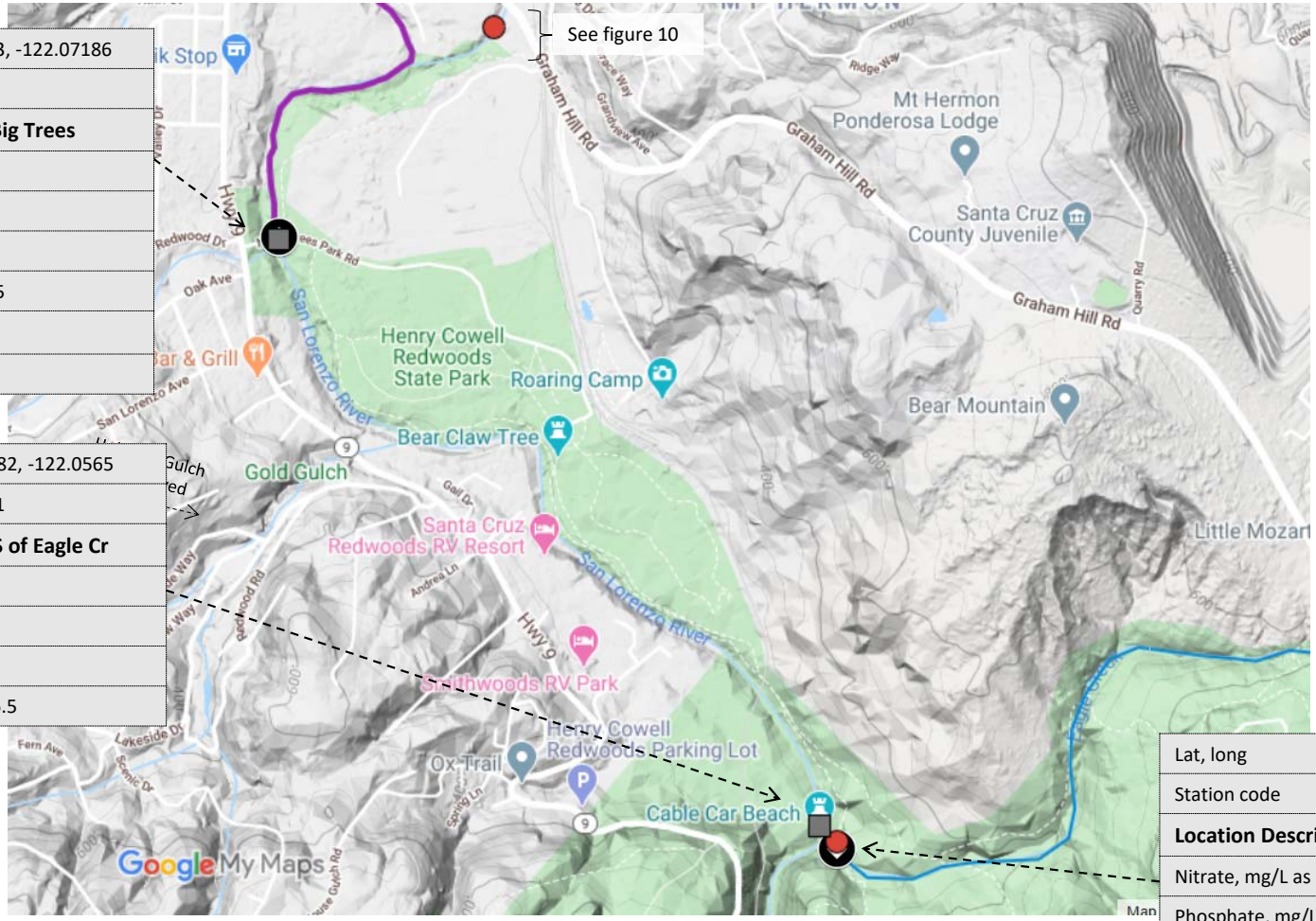
Note: Water quality and specific conductance values measured on 6/19/2019. See observation logs for all available data.

Figure 10: Felton - Mnt. Hermon Reach, upper (pg 3 of 3)

Balance Hydrologics

Lat, long	37.04413, -122.07186
Station code	WY19-3
Location Description	**SLR at Big Trees**
Nitrate, mg/L as N	0.31
Phosphate, mg/L as P	0.06
Sulfate, mg/L	63.5
SCT25 °C,Water °C	400, 16.5
Flow (cfs); 7/10/19	40.1
Flow (cfs); 9/25/19	19.3

Lat, long	37.03082, -122.0565
Station code	WY19-1
Location Description	**SLR US of Eagle Cr**
Nitrate, mg/L as N	0.29
Phosphate, mg/L as P	0.06
Sulfate, mg/L	62.6
SCT25 °C,Water °C	389, 16.5



preliminary, subject to revision

Water quality and/or flow measurement locations:

- Eastern Tributary
- San Lorenzo River
- Western Tributary
- Gage

Approximate scale 1 inch = 780 ft

Lat, long	37.03046, -122.05601
Station code	WY19-2
Location Description	**Eagle Cr US SLR**
Nitrate, mg/L as N	0.47
Phosphate, mg/L as P	0.03
Sulfate, mg/L	12.7
SCT25 °C,Water °C	115, 13.8
Flow (cfs); 7/10/19	-
Flow (cfs); 9/25/19	0.4

Figure 11: Felton to Eagle Creek Reach

Balance Hydrologics

Note: Water quality and specific conductance values measured on 6/19/2019. See observation logs for all available data.

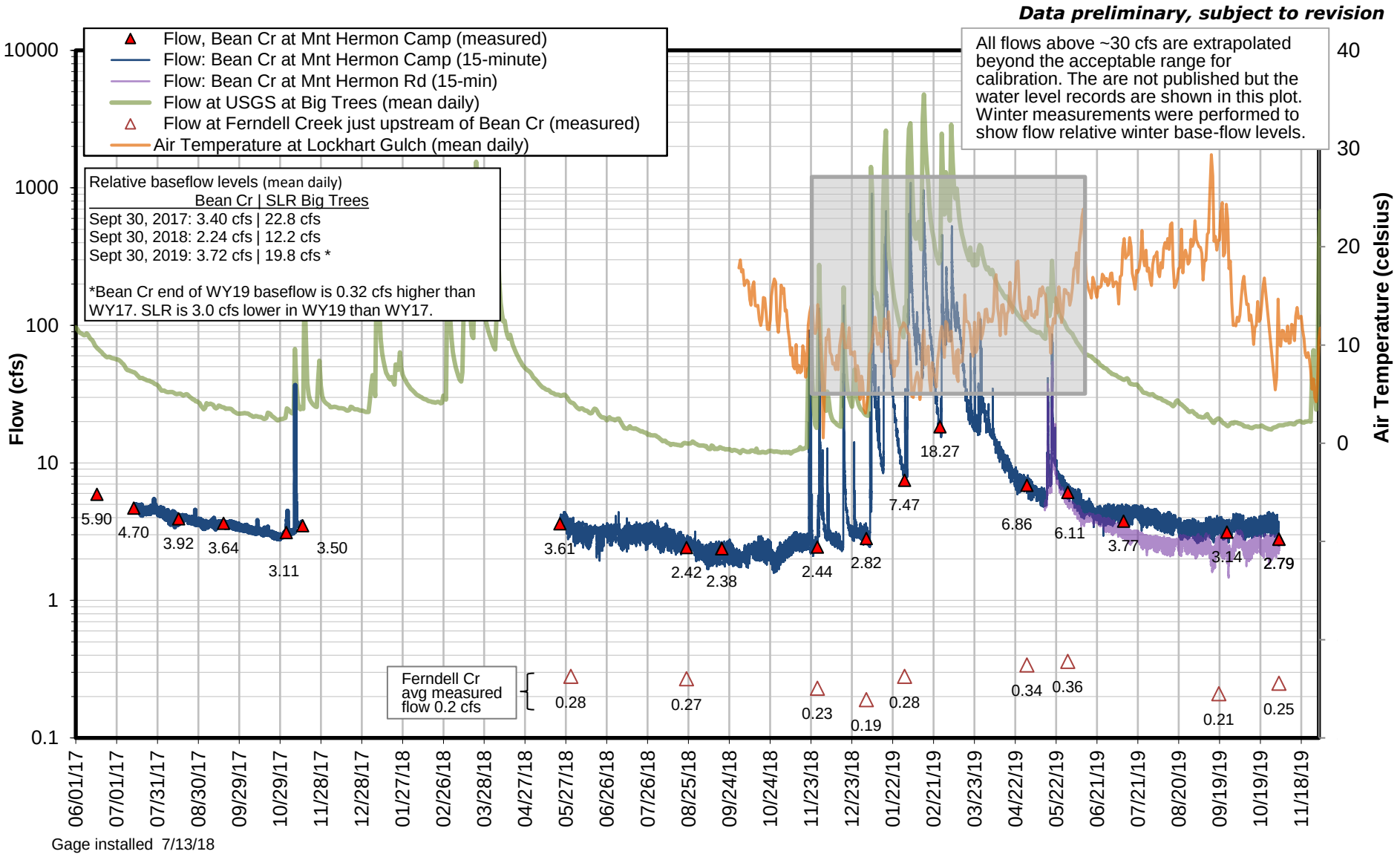
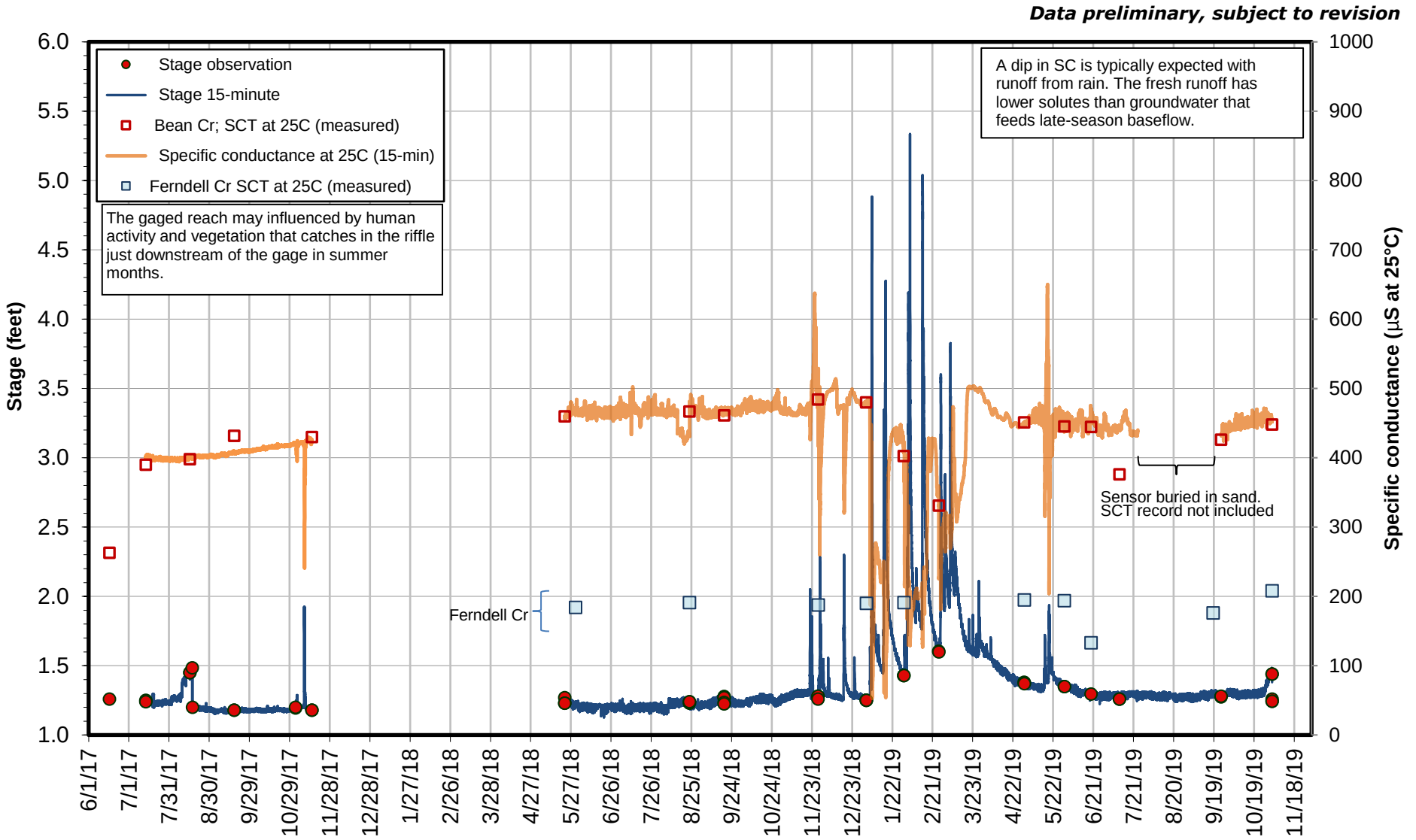


Figure 12. Flow: Bean Creek above mouth at Mount Hermon Camp, Santa Cruz County, California. June 1, 2017 through November 28, 2019

Diurnal fluctuations at the Mnt Hermon Road and Mnt Hermon Camp are about 0.5 cfs. The general rate of baseflow decline appears to behave independently of hot spells at both gages.

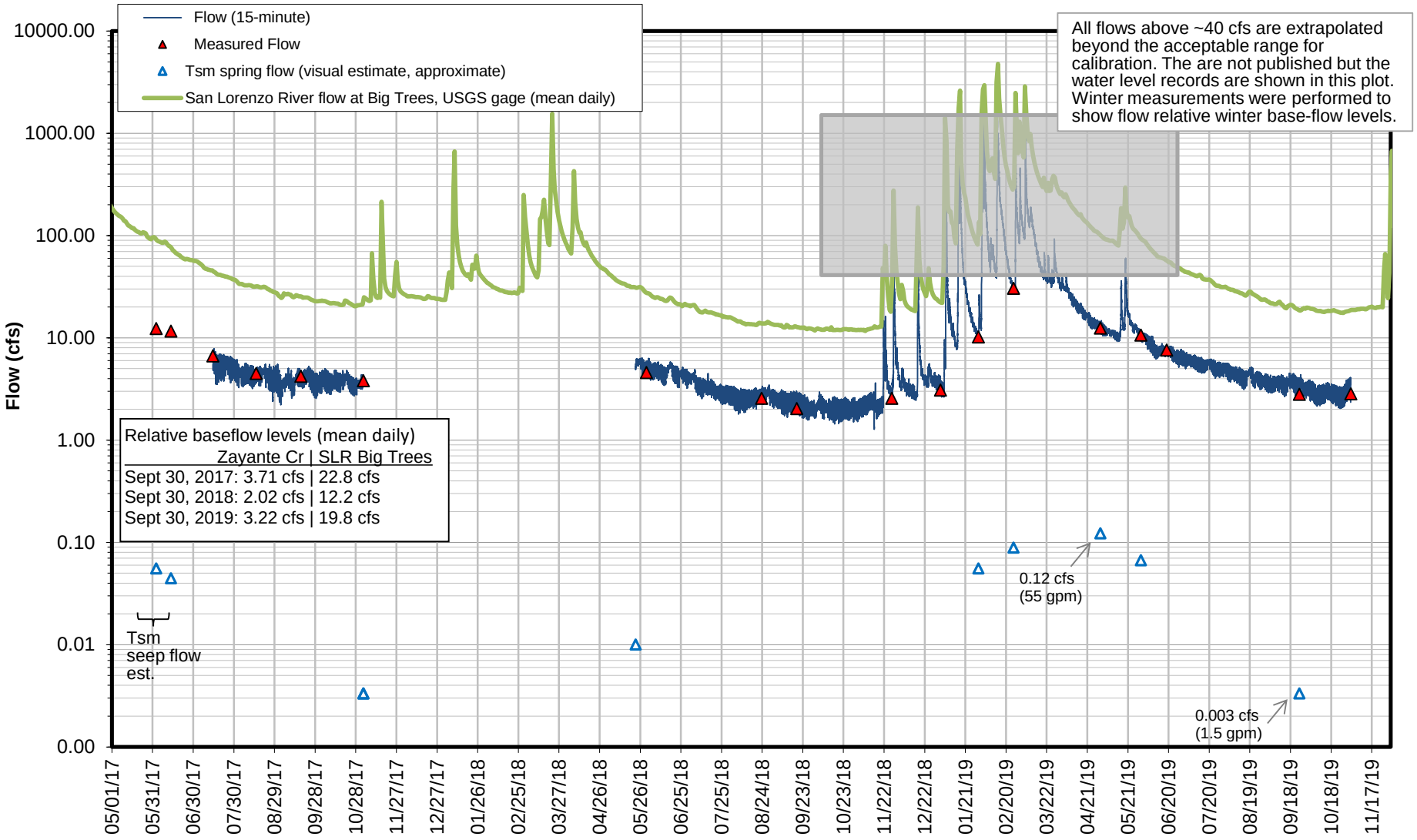
weather station: wunderground.com, KCASCOTT9



Gage installed 7/13/17

Figure 13. Stage and specific conductance: Bean Creek gage above Mouth at Mount Hermon Camp, Santa Cruz County, California. June 1, 2017 through November 28, 2019

Balance Hydrologics



Balance Hydrologics

Figure 14. Flow: Zayante Creek at Woodwardia weir, Santa Cruz County, California, June 2, 2017 through November 1, 2019

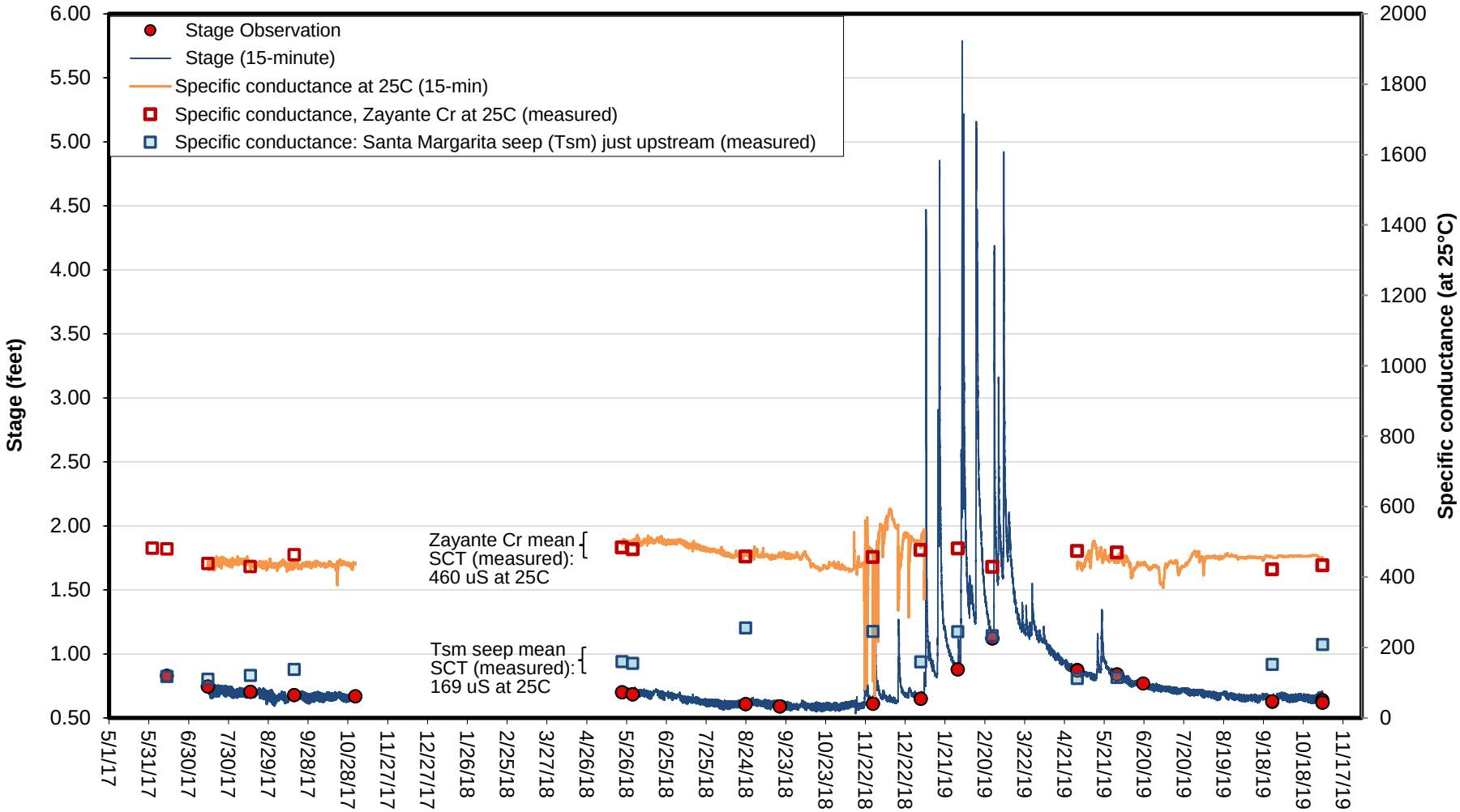


Figure 15. **Stage and specific conductance: Zayante Creek at Woodwardia weir, Santa Cruz County, California, June 2, 2017 through November 1, 2019**

Balance Hydrologics

Data preliminary, subject to revision

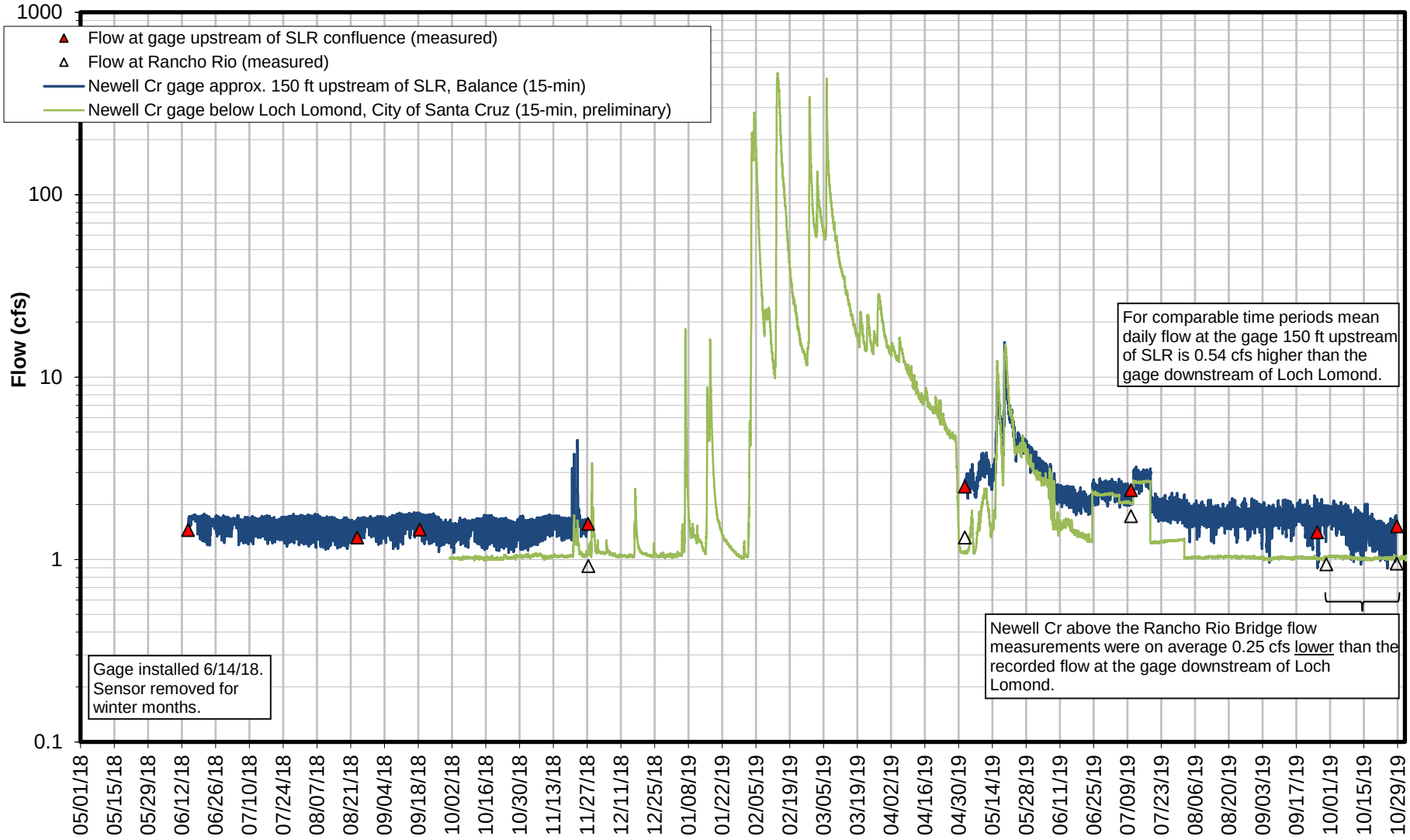
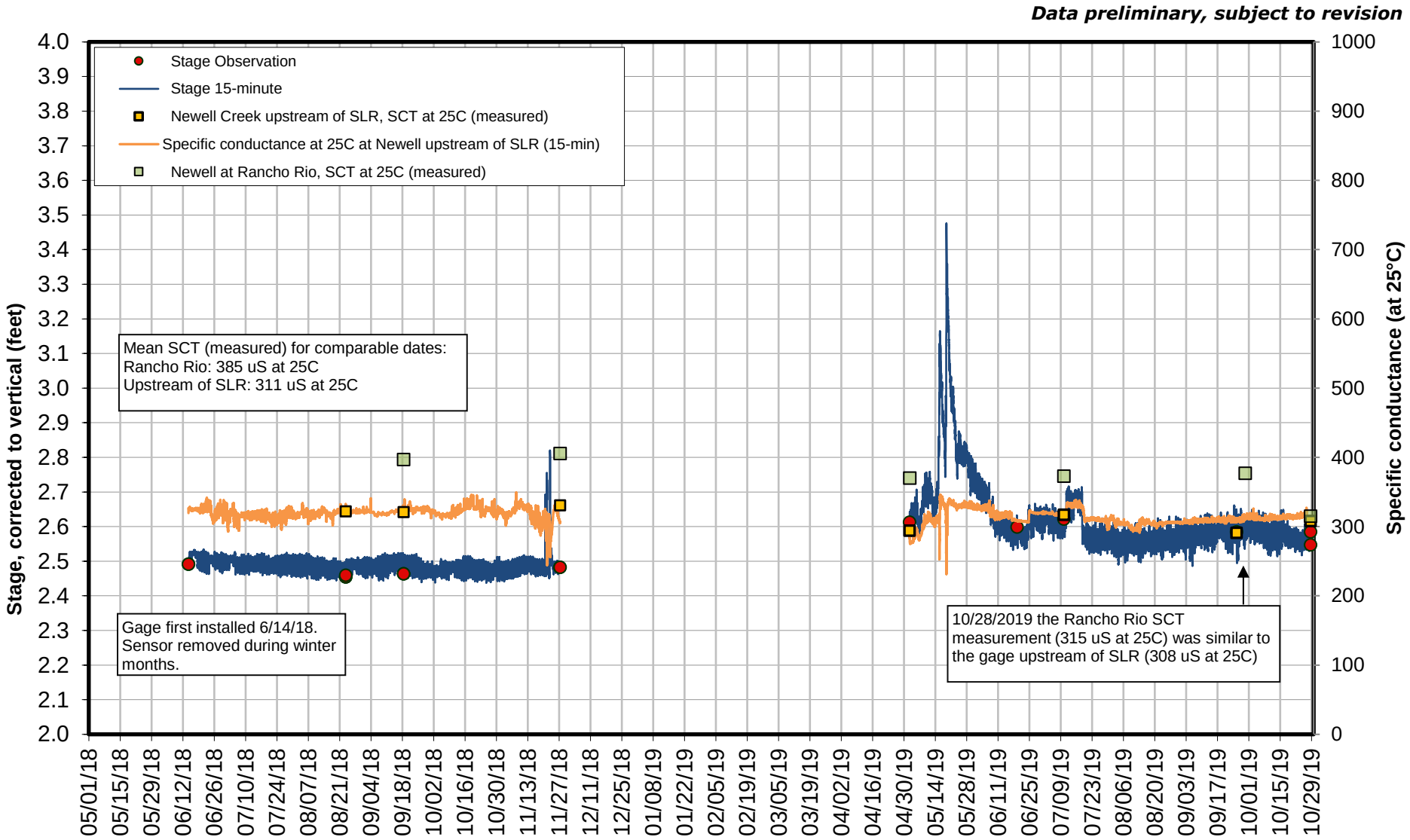


Figure 16. Flow: Newell Creek approximately 150 feet upstream from the San Lorenzo River, Santa Cruz County, California, June 14, 2019 through October 28, 2019

Balance Hydrologics



Balance Hydrologics

Figure 17. Stage and specific conductance: Newell Creek approximately 150 feet upstream from the San Lorenzo River, Santa Cruz County, California, June 14, 2019 through October 28, 2019

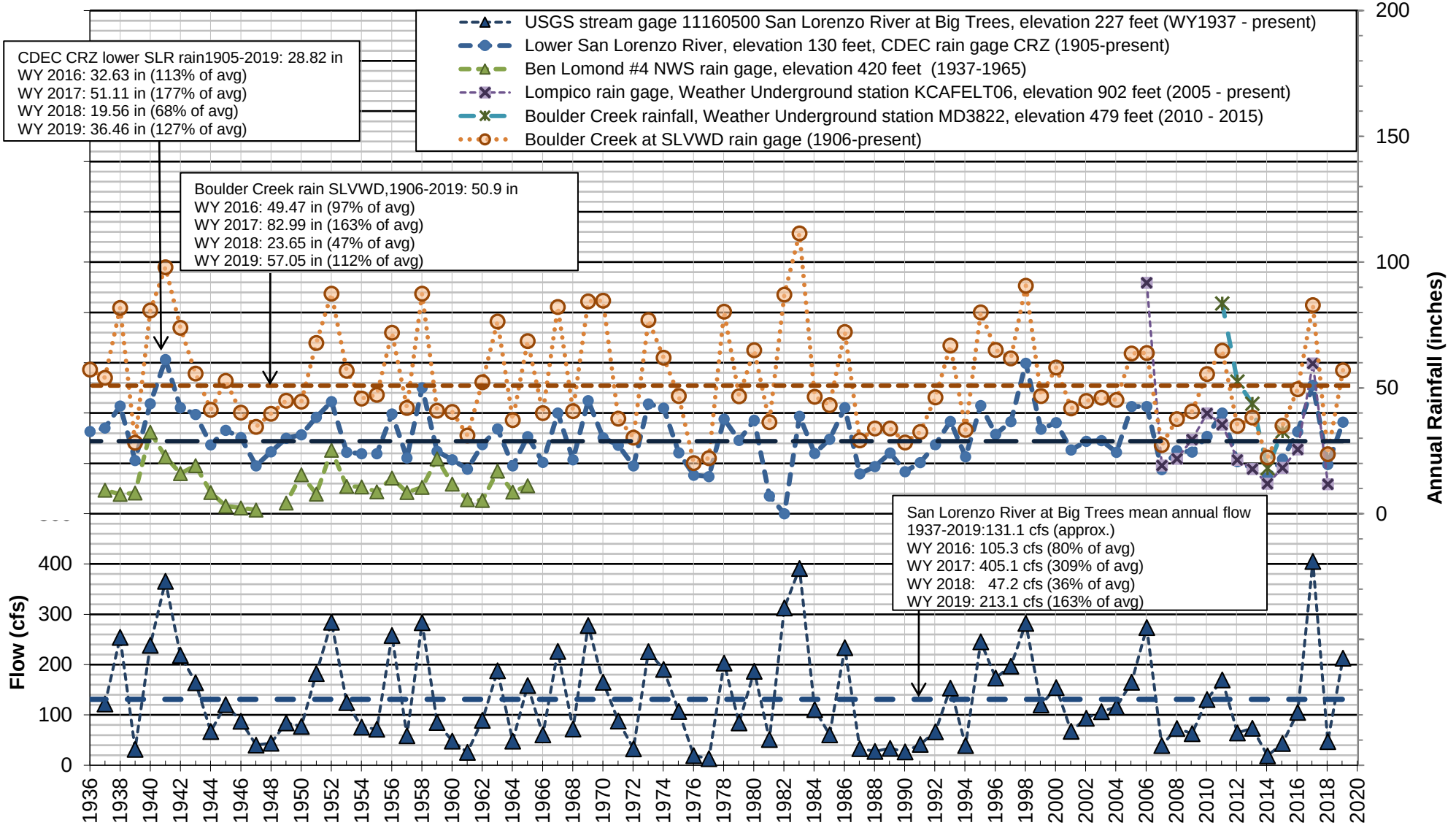


Figure 18. **Comparison of historic annual rainfall in San Lorenzo Basin to annual streamflow at USGS Gage 11160500, San Lorenzo River at Big Trees, Santa Cruz County, CA**

Balance Hydrologics

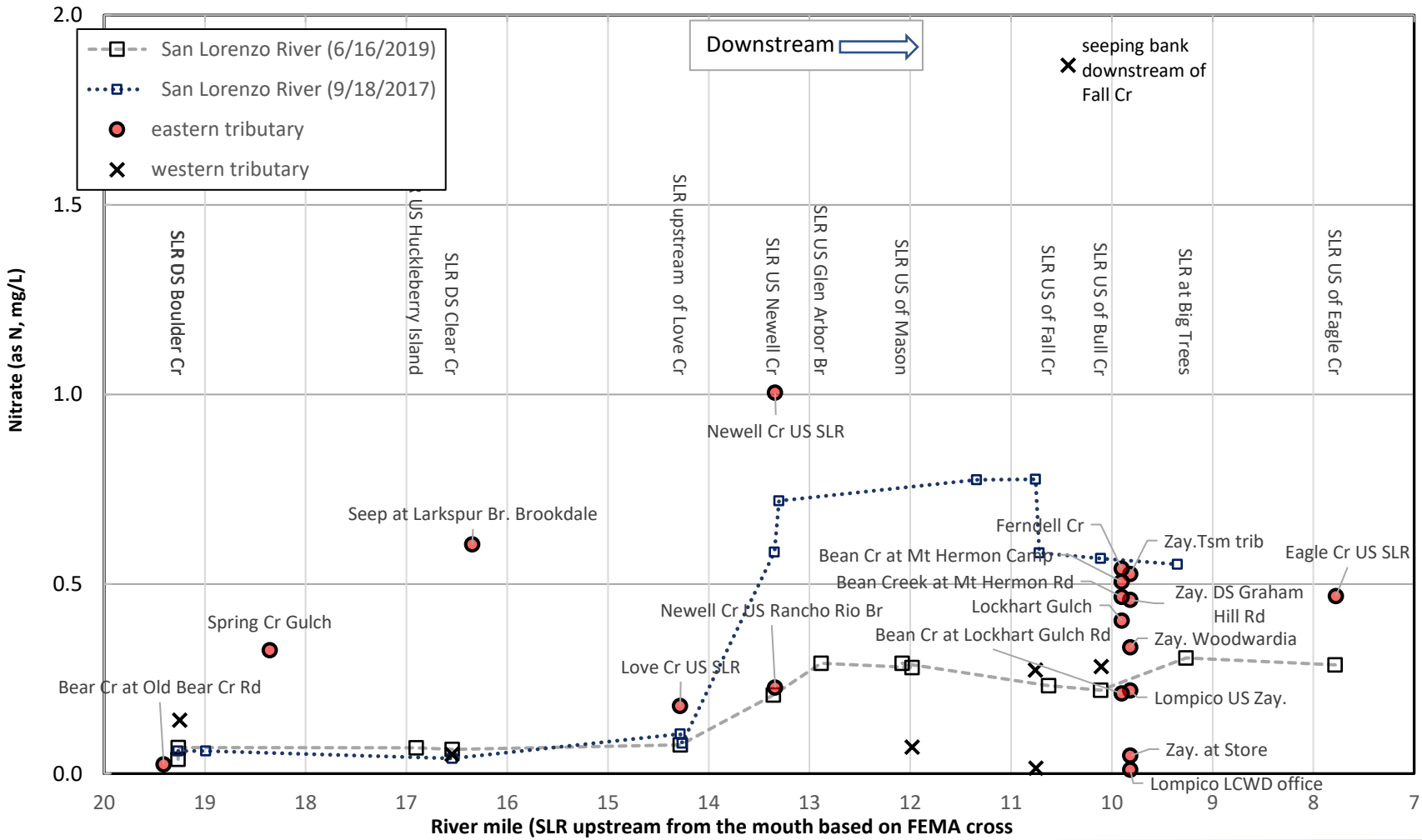


Figure 19: San Lorenzo River watershed downstream changes in nitrate (as N, mg/L), sampled on June 16, 2019, Santa Cruz County, CA. San Lorenzo River data points are connected to illustrate the influence of downstream contributions. Substantial inflow from the Santa Margarita comenses near Love Creek. Bean Cr and Zayante reach at same river mile.

Balance Hydrologics

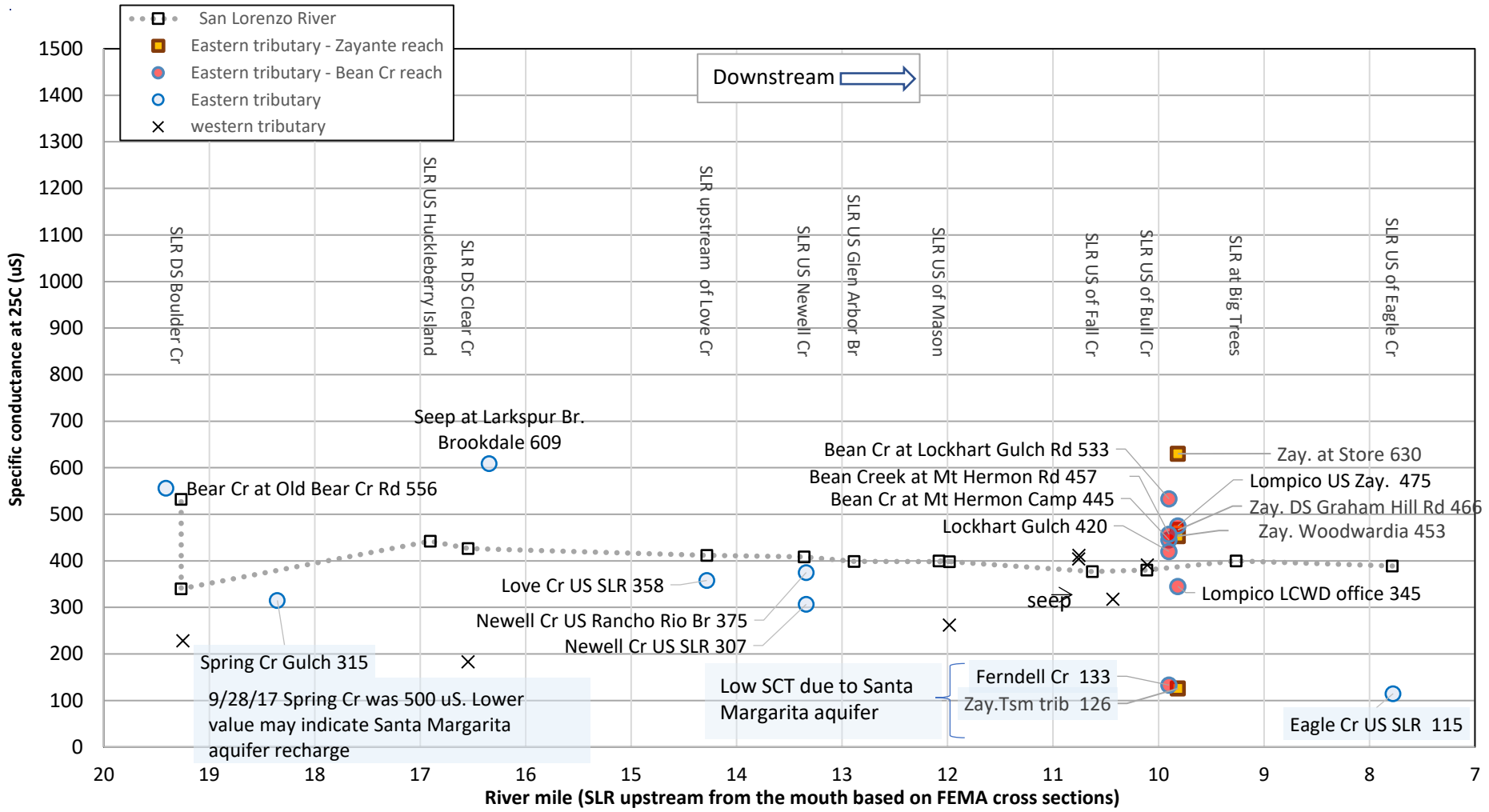


Figure 20: **San Lorenzo River watershed, downstream changes in specific conductance, June 16, 2019, Santa Cruz County, CA.** San Lorenzo River data points are connected to illustrate the influence of downstream contributions. Bean Cr and Zayante reach at same river mile.

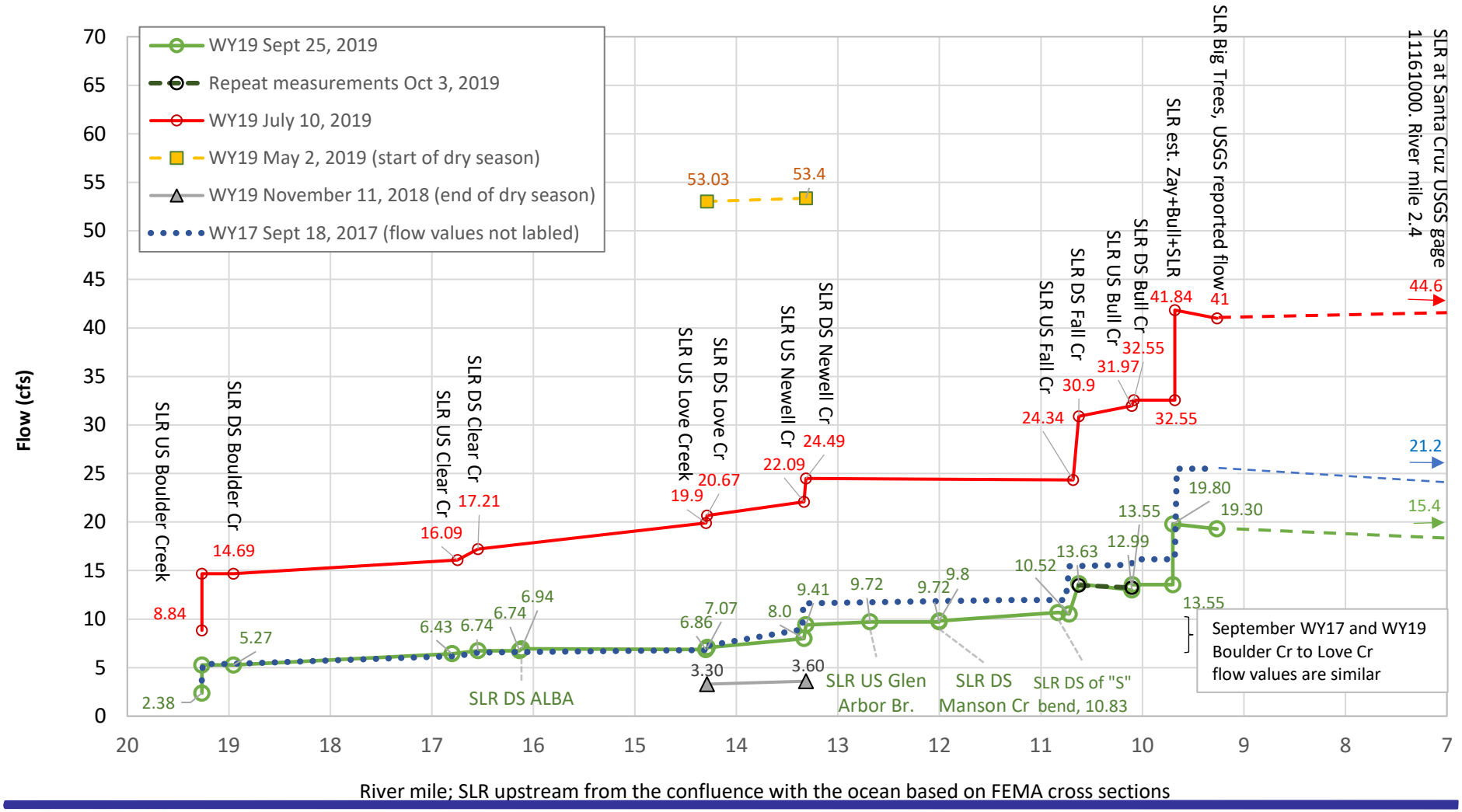


Figure 21: **San Lorenzo River downstream changes in flow, water years 2017 to 2019, Santa Cruz County, CA.** Points are based on measured or estimated flow values on the San Lorenzo River and tributaries.

APPENDICES

APPENDIX 1

Technical Memo: Sampling and analysis plan (SAP) for measurements of flow and water quality through the San Lorenzo River watershed on June 13, 2019

BALANCE HYDROLOGICS, Inc.

MEMO

To: John Ricker and Jen Michelsen
From: Jason Parke and Barry Hecht, CEG, CHg
Date: June 13, 2019

Subject: Technical Memo: Sampling and analysis plan (SAP) to be used for measurements of synoptic flow and water quality through the San Lorenzo River watershed 2017 to 2019

Goals:
Quantify and locate flow from eastern tributaries to the San Lorenzo River primarily from the Santa Margarita formation as well as locate stable "cool pools". Water quality samples will be gathered by the Balance be analyzed by the Santa Cruz County Environmental Health lab (nitrate NO3). These data are intended to provide additional insight to the likely interaction between the existing water table and adjacent land uses.

The following maps are intended to provide guidance in the field while finding sample locations.

Guidelines for Field Notes and Sampling:
Field notes need to include: Date, time, site description, sample name, and gps with datum.

Sample handling and protocol: Name convention will be set by the County Lab with additional samples noted with a number and letter 1A, 2A….. Polyethylene bottle and cap should be triple rinsed, with the cap on, and filled to the top with very little or no air space at the top. For wider channels use depth, width integration where each sub-sample 'dip' is approximately 1/3, 1/5, or 1/7 of the total sample volume. Sample bottles can be rinsed with the first sub-sample vertical. Sample priority should be: tributary, mainstem upstream of tributary and mainstem downstream of tributary as a last resort. At least one site for each sampling-day team should be a field duplicate and recorded as such in the field notes. Samples are to be stored in a closed, opaque cooler with ice and kept at or below 4˚C (39˚F). Hold times for samples are 48 hours. At the end of the day chain, of custody forms need to be filled out and samples taken immediately to the County of Santa Cruz Environmental Health Lab (and UCSC lab) or stored in a dedicated sample refrigerator at 4˚C and taken to the lab first thing the next day.

Date format on bottle is: yymmdd:24hr (example: 170918:1300, B1)

Specific conductance (SCT): With a calibrated specific conductance meter measure at field temperature and at 25 ˚C, measure in the thalweg or center of flow. At continuous stream gages, measure temperature at the sensor and at the thalweg.
Stage reading: Where available. See maps for gage locations.

Flow measurement: For low flow (less than 50 gpm) use bag with graduated cylinder or bucket measurement. Channel measurement use USGS protocol with each vertical approximately representing 5% of the total flow at each vertical. Flow meters must meet and exceed the required calibration test of that type of meter – pygmy meters must spin for greater than 60 second prior to measuring flow. Should the flow measurement become more approximate due to a discreet flow point not being available the flow methods will be described and assigned with potential error bands. Flow seeps from the Santa Margarita will likely be measured with a bucket and stop watch or Ziploc bag and graduated cylinder where appropriate.

Deep pools: SCT probe should be lowered through the water column to check for stratification of specific conductance and or temperature. If the pool is stratified measure SCT at the upstream inlet to the pool and the downstream outlet of pool.

Draw on the field maps provided or make a field map: Which will add clarity to field notes for others to understand your observations better.

APPENDIX 2

Santa Cruz County Environmental Health Lab Results from June 19, 2019 sampling

Appendix 2. Santa Cruz County Environmental Health Lab Results from June 19, 2019 sampling

StaNumID	Station Code	Location Description	Collection Date and Time	Fluoride, mg/L	Bromide, mg/L	Chloride, mg/L	Nitrate,mg/L as N	Nitrite, mg/L as N	Phosphate, mg/L as P	Sulfate, mg/L
Eastern Tributaries										
239	WY19-2	Eagle Cr US SLR	6/19/2019 7:59	0.06	0.04	9.5	0.47	≤0.001	0.03	12.7
240	WY19-3	Zay. DS Graham Hill Rd	6/19/2019 8:05	0.22	0.08	26.3	0.46	≤0.001	0.12	87.7
242	WY19-5	Zay. Woodwardia	6/19/2019 8:26	0.24	0.06	22.9	0.33	≤0.001	0.09	93.2
241	WY19-4	Zay.Tsm trib	6/19/2019 8:38	0.27	0.02	6.5	0.53	≤0.001	0.22	9.6
243	WY19-6	Zay. at Store	6/19/2019 9:02	0.31	0.07	25.8	0.05	≤0.001	0.07	154.0
253	WY19-7A	Lompico LCWD office	6/19/2019 9:23	0.19	0.06	19.5	0.01	0.002	0.06	19.8
244	WY19-7	Lompico US Zay.	6/19/2019 9:48	0.20	0.06	20.7	0.22	≤0.001	0.07	42.5
245	WY19-8	Bean Cr at Mt Hermon Camp	6/19/2019 10:16	0.20	0.08	29.6	0.51	≤0.001	0.16	86.2
246	WY19-9	Ferndell Cr	6/19/2019 10:29	0.20	0.08	29.4	0.54	0.002	0.16	85.3
247	WY19-10	Bean Cr US Lockhart Gulch Rd	6/19/2019 11:11	0.25	0.08	27.2	0.21	0.002	0.13	130.8
254	WY19-10A	Lockhart Gulch	6/19/2019 11:14	0.17	0.04	18.3	0.40	≤0.001	0.15	67.0
256	WY19-8A	Bean Creek at Mt Hermon Rd	6/19/2019 11:36	0.21	0.07	23.4	0.47	≤0.001	0.16	92.0
261	WY19-24	Newell Cr US Rancho Rio Br	6/19/2019 12:08	0.24	0.03	12.2	0.23	0.002	0.04	83.7
259	WY19-22	Newell Cr US SLR	6/19/2019 14:35	0.21	0.04	12.0	1.00	≤0.001	0.14	57.5
262	WY19-25	Love Cr US SLR	6/19/2019 12:25	0.19	0.07	19.4	0.18	0.003	0.10	49.4
273	WY19-27A	Seep at Larkspur Br. Brookdale	6/19/2019 12:50	0.19	0.14	47.3	0.60	≤0.001	0.06	83.4
267	WY19-30	Spring Cr Gulch	6/19/2019 14:02	0.17	0.04	15.6	0.33	≤0.001	0.12	49.4
271	WY19-34	Bear Cr at Old Bear Cr Rd	6/19/2019 14:11	0.28	0.06	22.1	0.02	≤0.001	0.04	137.0
San Lorenzo River										
238	WY19-1	San Lorenzo downstream of Big Trees	6/19/2019 7:52	0.18	0.07	21.1	0.29	0.003	0.06	62.6
274	WY19-1A	SLR at Big Trees Gage	6/19/2019 8:20	0.18	0.06	21.0	0.31	≤0.001	0.06	63.5
249	WY19-12	SLR upstream of Bull Cr	6/19/2019 12:02	0.17	0.06	19.1	0.22	≤0.001	0.04	56.7
275	WY-14A	SLR DS of Fall Creek	6/19/2019 9:30	0.17	0.05	19.4	0.23	≤0.001	0.04	56.7
257	WY19-19A	SLR Downstream of Mason	6/19/2019 10:30	0.19	0.06	21.0	0.28	0.002	0.05	66.6
266	WY19-20A	SLR Upstream of Mason	6/19/2019 11:11	0.19	0.06	21.1	0.29	≤0.001	0.05	67.4
258	WY19-21	SLR at Glen Arbor Br	6/19/2019 11:30	0.19	0.06	21.2	0.29	0.002	0.05	67.7
260	WY19-23	SLR upstream of Newell	6/19/2019 14:30	0.19	0.06	21.1	0.21	0.002	0.04	68.8
263	WY19-26	SLR upstream of Love Cr	6/19/2019 12:30	0.19	0.06	21.6	0.08	≤0.001	0.03	71.6
272	WY19-27B	SLR Downstream of Clear Creek	6/19/2019 12:55	0.20	0.07	22.5	0.06	≤0.001	0.03	77.3
265	WY19-28	SLR upstream of Pacific St/Huckleberry Island	6/19/2019 13:40	0.21	0.07	23.2	0.07	0.002	0.03	82.0
269	WY19-32	SLR upstream of Boulder Cr	6/19/2019 13:48	0.27	0.09	30.9	0.04	≤0.001	0.04	120.8
270	WY19-33	SLR downstream of Boulder Cr	6/19/2019 13:54	0.22	0.07	24.7	0.07	≤0.001	0.03	88.6
Western Tributaries										
248	WY19-11	Bull Cr at SLR confluence	6/19/2019 12:04	0.10	0.04	11.8	0.28	≤0.001	0.02	10.8
252	WY19-15	Western seep DS Fall Cr	6/19/2019 9:02	0.07	0.11	41.6	1.87	0.004	0.03	74.5
250	WY19-13	Fall Cr just upstream of SLR confluence	6/19/2019 12:30	0.08	0.04	9.0	0.01	≤0.001	0.01	9.5
251	WY19-14	SLR just upstream of Fall Cr	6/19/2019 12:34	0.19	0.07	22.0	0.27	0.003	0.05	67.4
255	WY19-18	Manson Cr at SLR	6/19/2019 10:45	0.12	0.03	10.6	0.07	≤0.001	0.05	26.5
264	WY19-27	Clear Cr 50 ft DS HWY 9	6/19/2019 13:22	0.08	0.02	7.1	0.05	≤0.001	0.01	4.6
268	WY19-31	Boulder Cr upstream of SLR	6/19/2019 13:43	0.10	0.03	11.8	0.14	≤0.001	0.01	24.0