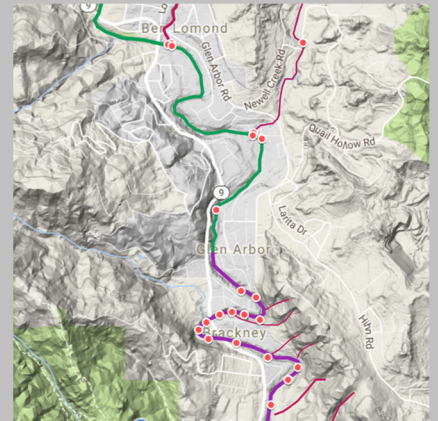
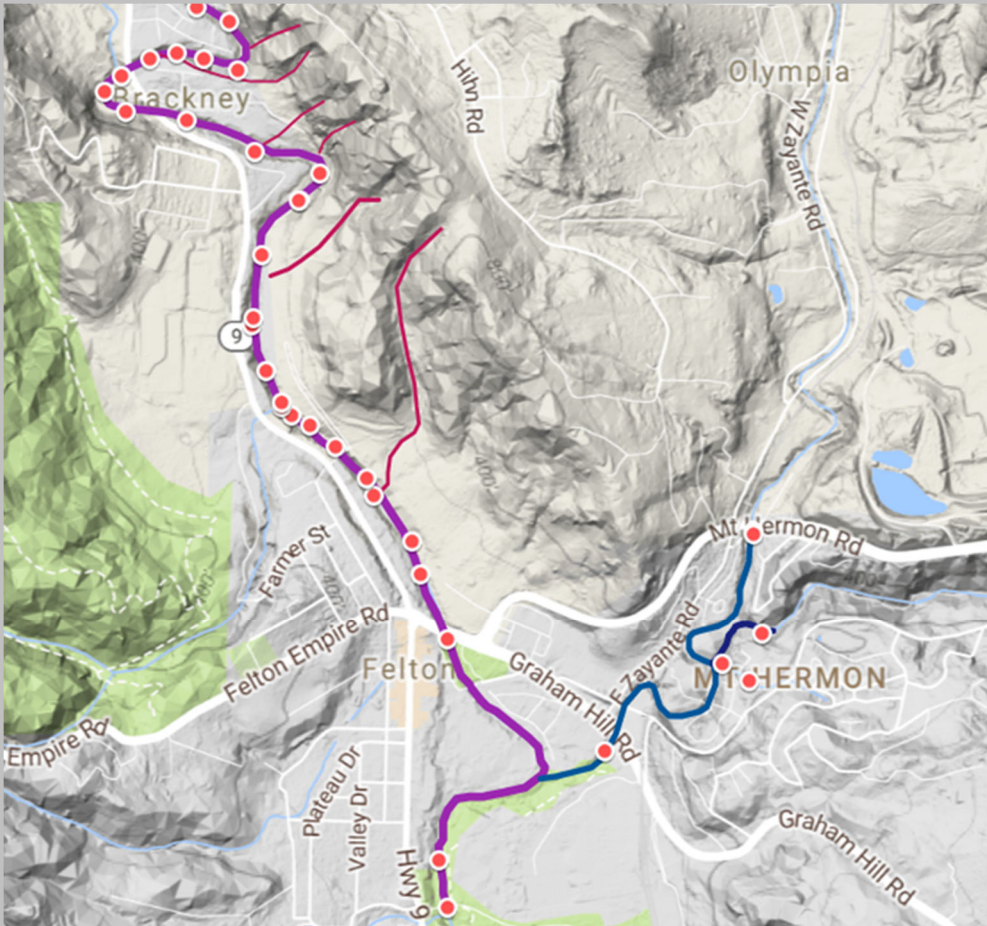


San Lorenzo River Longitudinal Accretion and Hydrochemistry Reconnaissance



Prepared for:
County of Santa Cruz, Health Services—Environmental Health
700 Ocean Street, Room 312
Santa Cruz, California 95062


June 8, 2022

A REPORT PREPARED FOR:

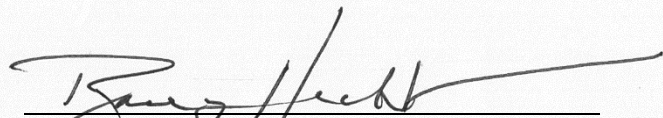
County of Santa Cruz, Health Services – Environmental Health

John Ricker
Water Resources Division Director
700 Ocean Street, Room 312
Santa Cruz, California 95062
(831) 454-2750

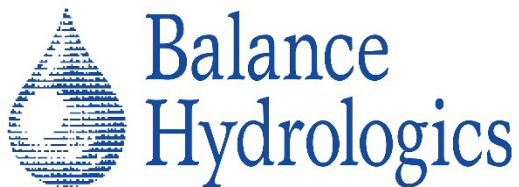
by



Jason Parke
Hydrologist / Geologist



Barry Hecht, CEG, CHG
Senior Principal



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Project Assignment: 209153

800 Bancroft Way, Suite 101 ~ Berkeley, California 94710-2251 ~ (510) 704-1000 ~ office@balancehydro.com
224 Walnut Avenue, Suite E ~ Santa Cruz, California 95060 ~ (831) 457-9900

SAN LORENZO RIVER LONGITUDINAL ACCRETION AND HYDROCHEMISTRY
RECONNAISSANCE

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TABLE OF CONTENTS

1	INTRODUCTION	1
2	GENERAL STUDY DESIGN	3
3	BACKGROUND	4
3.1	<i>Water Quality Pertaining to Nitrate</i>	4
3.2	<i>Ground Water and Recharge to the Santa Margarita Groundwater Basin</i>	5
3.3	<i>Conditions During WY2017</i>	5
4	WHAT WE FOUND IN THE FIELD	6
5	TENTATIVE CONCLUSIONS	12
6	RECOMMENDATIONS	14
7	CONCLUDING REMARKS	15
7.1	<i>Acknowledgments</i>	15
7.2	<i>Limitations</i>	15
7.3	<i>Wet and Dry Years</i>	15
8	REFERENCES CITED	17

LIST OF FORMS

Form A1.	Station Observer Log; San Lorenzo River accretion study, water year 2017, Santa Cruz County Environmental Health, Santa Cruz County, California
Form A2.	Station Observer Log; Boulder Creek upstream of San Lorenzo River
Form A3.	Station Observer Log; Clear Creek upstream of the San Lorenzo River
Form A4.	Station Observer Log; Fall Creek upstream of the San Lorenzo River
Form A5.	Station Observer Log, Zayante Creek at Woodwardia, County of Santa Cruz, California, water year 2017
Form A6.	Station Observer Log, Bean Creek at Mount Hermon, County of Santa Cruz, California, water year 2017

LIST OF TABLES

Table 1	Mean summer NO ₃ (mg/L) concentrations for the San Lorenzo River at Big Trees	4
Table 2	Summary of eastern tributary in-flow to the San Lorenzo River, NO ₃ , specific conductance and water temperature from September 2017	7
Table 3	Summary of synoptic NO ₃ , specific conductance at 25C and water temperature measurements taken on the San Lorenzo River on September 18, 2017	8
Table 4	Summary of western tributary in-flow to the San Lorenzo River, NO ₃ , specific conductance and water temperature from on September 18, 2017	10

LIST OF FIGURES

Figure 1.	Overall study reach
Figure 2.	Sample locations and results: Downtown Boulder Creek Reach
Figure 3.	Sample locations and results: Irwin Way Reach
Figure 4.	Sample locations and results: Huckleberry Island Reach
Figure 5.	Sample locations and results: Brookdale Reach
Figure 6.	Sample locations and results: South Brookdale Reach
Figure 7.	Sample locations and results: California Drive Reach
Figure 8.	Sample locations and results: Ben Lomond Reach
Figure 9.	Sample locations and results: Glen Arbor Reach (1 of 2)
Figure 10.	Sample locations and results: Glen Arbor Reach (2 of 2)
Figure 11.	Sample locations and results: Sunnycroft Reach
Figure 12.	Sample locations and results: Brackney Reach (1 of 2)
Figure 13.	Sample locations and results: Brackney Reach (2 of 2)

SAN LORENZO RIVER LONGITUDINAL ACCRETION AND HYDROCHEMISTRY RECONNAISSANCE

- Figure 14. Sample locations and results: Highschool Reach
- Figure 15. Sample locations and results: Fall Creek to Bull Creek Reach
- Figure 16. Sample locations and results: Lower Zayante and Bean Creeks Reach
- Figure 17. Sample locations and results: Fall to Bull Creek Reach
- Figure 18. Sample locations and results: Bull Creek to Big Tress Reach
- Figure 19. Flow, temperature, and precipitation: Bean Creek gage above mouth at Mount Hermon, Santa Cruz County, California, water year 2017 to 2018 (partial)
- Figure 20. Stage and specific conductance: Bean Creek gage above mouth at Mount Hermon, Santa Cruz County, California, water year 2017 and 2018 (partial)
- Figure 21. Flow, temperature, and precipitation: Zayante Creek at Woodwardia, Santa Cruz County, California, water year 2017 to 2018 (partial)
- Figure 22. Stage and specific conductance: Zayante Creek at Woodwardia weir, Santa Cruz County, California, water year 2017 to 2018 (partial)
- Figure 23. Flow, temperature, and precipitation; Boulder Creek upstream of HWY 9 and San Lorenzo River downstream of Boulder Creek, Santa Cruz County, CA, water year 2017 to 2018 (partial)
- Figure 24. Flow, temperature, and precipitation; San Lorenzo River downstream of Clear Creek, Santa Cruz County, CA, water year 2017 to 2018 (partial)
- Figure 25. Flow, temperature, and precipitation; San Lorenzo River downstream of Fall Creek, Santa Cruz County, CA water year 2017 to 2018 (partial)
- Figure 26. 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
- Figure 27. San Lorenzo River downstream changes in flow, nitrate and specific conductance from samples taken on September 18, 2017, water year 2017, Santa Cruz County, CA

ATTACHMENTS

- Attachment 1 Technical Memo: Sampling and analysis plan (SAP) for measurements of flow and water quality through the San Lorenzo River watershed on September 18, 2017
- Attachment 2 QA/QC and paired duplicate sample comparison for NO₃ sampled September 2017, Santa Cruz County, CA
- Attachment 3 Lab Results

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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 is a candidate for aquifer management, including use of aquifer storage and recovery (ASR) approaches. The agencies immediately sponsoring the investigation are the County of Santa Cruz Division of Environmental Health, the San Lorenzo Valley Water District, and the Scotts Valley Water District.

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, and growth of potentially harmful or beneficial organisms of various types along the stream. 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 and its Laboratory, and graduate student Christina Richardson of the UCSC Earth Science department. 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 gage on the San Lorenzo River at Big Trees which is maintained by the USGS.

SAN LORENZO RIVER LONGITUDINAL ACCRETION AND HYDROCHEMISTRY RECONNAISSANCE

This report emphasizes changes in flows over time, and distance downstream using a range of field evidence including measurements as detailed as can be supported by the field conditions. 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 (NO_3) analyses. The results for nitrite (NO_2), ammonium (NH_4^+), phosphate (PO_4^{3-}), and dissolved silica presented in the results, however, are presented for completeness and to establish reasonableness of the data. They will be revised and interpreted by others who have received separate grants for this work, and are not the focus of this memo. The samples presented in the observation logs in (Attached Table A1, Figures 1 to 18) are also currently being analyzed by UCSC for stable isotopes (hydrogen and oxygen), $\delta^{15}\text{N}$ -nitrate, $\delta^{18}\text{O}$ -nitrate, $\delta^{13}\text{C}$ -DIC, and will be presented by UCSC in a separate but complementary report at a later date.

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 managed aquifers. 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 1¹.

The study was broken in to specific reaches (Figure 1) with special interest in the reach between the USGS Big Trees gage and the Glen Arbor Road bridge. This reach was walked by Jason Parke and Zan Rubin of Balance Hydrologics with the specific purpose of quantifying the input of the Santa Margarita aquifers as well as identifying points of deep pools and investigating the potential for temperature stratification. The 'non-walked' reaches were mapped out and driven to on the same day with follow up visits that month to Spring Creek, Huckleberry Creek and deep pools on the San Lorenzo downstream of Clear Creek.

In preparation for this effort that focuses on the main stem, stream gages on the eastern tributaries were 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 currently operates 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. These gages are operated by Balance for the District and have had monthly synoptic calibration visits for the summer of WY 2017 and occasionally during the prior summers of WY2015 and WY2016. These measurements are made with the help of fisheries biologist Don Alley (Figures 23-26, Attached Tables A2-A4) who has made about half of the measurements. During these visits, flow is measured at the gage and on the respective tributary just upstream.

¹ Sample analysis at the UCSC Earth Science Laboratory were performed using a colorimetric Lachat AA3 AutoAnalyzer. Santa Cruz County Environmental Health performed analysis on the samples using standard methods 4110B, ion chromatography. Except where otherwise indicated, all results of nitrates tests are report as nitrate NO₃, not at nitrate-N. This practice follows long-established Santa Cruz County lab practice. The MCL for nitrate (NO₃) is 45 mg/L (equivalent to 10 N-mg/L). For further quality assurance data, see Attachment 2.

3 BACKGROUND

3.1 Water Quality Pertaining to Nitrate

For reference the California Water Resources Control Board Division of Water Quality and the EPA defines the maximum contamination allowed in sources for community drinking water for NO₃ nitrate as 45 mg/L (10 N-mg/L). Nitrate in “pristine” ground water is considered to be less than 8.8 mg/L NO₃ (2 mg-N/L)²; in fact, values below 0.5 mg/L NO₃-N are usually found in the pristine ‘parkland’ aquatic environments of the central Santa Cruz Mountains.

The Coast Ambient Monitoring Program (CCAMP) set a tentative ‘need for action’ concentration of NO₃ at 10 mg/L or greater however, based on the San Lorenzo River TMDL (2000) for nitrate.³ Santa Cruz County Environmental Health has established a protective numeric target for the mean summer concentration of nitrate at the Big Trees gage site of 1.5 mg/L NO₃ by the year 2020. The following table from the TMDL (table 2, pg 11) are the mean summer NO₃ concentrations for the San Lorenzo River at Big Trees.

Table 1 Mean summer NO₃ (mg/L) concentrations for the San Lorenzo River at Big Trees⁴

Location	1952 - 62	1963 - 75	1976 - 77	1978- 79	1980- 81	1982- 83	1986- 87	1988- 89	1990- 91	1992 -93	1994- 95
SLR; Big Trees	0.37	0.53	2.02	1.84	1.76	2.64	2.38	1.36	1.76	2.51	2.28
Water Year Classification Based on San Lorenzo River based on SLR			Critically dry	Wet	Wet	Wet	Wet	Critically dry	Critically dry	Dry	Critically dry

² https://www.waterboards.ca.gov/gama/docs/coc_nitrate.pdf

³ https://www.waterboards.ca.gov/rwqcb3/board_decisions/adopted_orders/2000/2000_0003_slr_nitrate_tmdl_proj_rpt.pdf (pages 10-11)

⁴ Water year classification data is from a presentation to the Santa Cruz Water Supply Advisory Committee, September 25, 2015 (Figure 1, page 13). <https://www.slideshare.net/RobertSingleton/water-supply-advisory-committee-draft-agreement-on-new-supply-options>.

3.2 Ground Water and Recharge to the Santa Margarita Groundwater Basin

A large portion of the area between Felton and Boulder Creek on the eastern side of the watershed is influenced by the Santa Margarita ground water basin, which is an important aquifer for water supply and habitat in the watershed. Recent efforts are under way to coordinate management efforts amongst the local water agencies and the County to manage this aquifer system to enhance sustainability in the aquifer⁵. Contributions from various portions of the aquifer during different seasons and during wet and dry years just are not known. Data collected during this study are intended for quantitative descriptions of baseline conditions for as many of stream conditions as we thought might be pertinent.

3.3 Conditions During WY2017

We conducted this analysis primarily during September 2017. Water year 2017 was the first wet year since 2011 (see figure 26). Water years 2012 through 2015 had been much drier than normal, and WY 2016 was a year of near-average conditions. While there was likely substantial aquifer recharge during WY 2017, it is likely that the Santa Margarita may not have fully recovered as mentioned in the Santa Cruz County Water Resources Report for 2017⁶ which states “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. We anticipate that baseflow conditions during WYs 2018 and 2019 will help shed light on the degree to which static water levels in the San Lorenzo Valley ‘recovered’ from this atypically long drought.

Pool depth, or refuges from the heat of the river on a warm day, are an important part of bed habitat in the river and its tributaries. High peak flows during the previous winter appear to have mobilized the San Lorenzo River bed between Boulder Creek and Big Trees several times during 2017. It is likely that a number of deep pools, which are thought to have a considerable role in summer ecology of the key fish species, may have filled with coarse sediment. The pools can be expected to gradually be exhumed – deepened to their more typical depths – as the channel is reestablished over the next few years.

⁵ <https://www.svwd.org/sites/default/files/documents/reports/SantaMargaritaGroundwaterBasinRevisionRequest.pdf>

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

4 WHAT WE FOUND IN THE FIELD

In general, we didn't find as much inflow from the Santa Margarita as we had anticipated given the substantial amount of rainfall total annual flows at the Big Trees gage being among the very highest measured recorded for the period of record since 1936 (Figure 26). The overall study reach with relative downstream changes in flow, nitrate and specific conductance can be seen in Figure 27. Tables 2, 3 and 4 (see below) display this data in numerical form. Figures 1 to 18 provide location and results for each sample point.

In general, nitrate levels on the San Lorenzo River on September 18, 2017 appeared to increase from less than 1 mg/L to 2-3 mg/L between Love Creek and Newell Creek (Figure 27). This nitrate level appeared to be sustained downstream through the study reach downstream from Newell Creek, where higher concentrations are observed in large part due to a plume from the former Ben Lomond Landfill, closed and converted to a transfer station about 20 years ago. The highest nitrate levels encountered were from the lower portion of Newell Cr (point near the confluence with the San Lorenzo River at 6.91 mg/L (point 16, Table 2) and Ferndell Creek, at 10.01 mg/L (point 60, Table 2 and Figure 16), which receives drainage from a dense cluster of on-site waste disposal systems.

The influence of the Santa Margarita formation, with a typically low specific conductance, was noticeable on the eastern tributaries even at the sample locations with higher nitrate levels. At the mid-portion of Newell Creek at Rancho Rio Bridge (point 14, Figure 10) the specific conductance was 354 uS with a nitrate value of 0.98 mg/L. At lower Newell Creek (point 16, Figure 10) just up from the confluence with San Lorenzo River specific conductance was 291 uS with nitrate value of 6.91 mg/L. Ferndell Creek had the highest level of nitrate encountered and had a specific conductance of 204 uS. The seep upstream of the Zayante at Woodwardia gage (point 56, Figures 16 and 22), had an average specific conductance value through the summer of 122 uS and a nitrate value of 2.15 mg/L.

In the reach between Big Trees and Glen Arbor Bridge there were a number of places observed that looked like have had persistent ground water seepage with deep staining/mottling patterns; however, very few places were noted to be dry or not flowing. Likewise, topographic patterns noticed in the preliminary planning of field activities that would have indicated some amount of persistent flow were not flowing either.

It is possible that the Santa Margarita formation hasn't recharged to the point where we could observe maximum delivery of water and constituents to the San Lorenzo. Many of

SAN LORENZO RIVER LONGITUDINAL ACCRETION AND HYDROCHEMISTRY
RECONNAISSANCE

the wet banks noticed during the stream walk were down gradient from homes that were visible from the river making it seem likely that the wet banks were due in large part to residential influence. Further correlation with monitoring wells in the Santa Margarita could be correlated to summer WY 2017 and used to plan similar field efforts in the future.

Table 2 Summary of eastern tributary in-flow to the San Lorenzo River, NO₃, specific conductance and water temperature from September 2017

Point	Eastern Tributary	Flow (cfs)	Percent of SLR flow (trib+SLR)	NO ₃ (mg/L)	Water Temperature (°C)	SC at 25 °C (µS)
5	Spring Creek (9/28/17)	0.012	0.2 %	0.43	12.8	500
6	Huckleberry Island (9/28/17)	0.025	0.5 %	0.58	13.8	397
9	Trib/Seep at Larkspur Bridge	0.001	0.02 %	2.45	-	-
11	Love Creek US SLR	0.48	7 %	0.48	16.2	412
14	Newell Creek at Rancho Rio Bridge (9/19/17)	1.25	-	0.98	15.7	355
16	Newell Creek US SLR	2.71	30 %	6.91	15	291
38	Eastern trib seep. Possibly Tsm.	0.0001	-	-	17.3	403
57	Zayante Cr US of SLR (Bean +Zayante + Ferndell)	9.31	36.5 %	2.94	15.7	427
55	Zayante at Woodwardai gage	4.52	17.7 %	1.86	15.8	438
56	Trib. US of gage at Zayante Woodwardia	0.004	-	2.15	15.1	133
59	Bean Creek at Mnt Hermon gage	3.71	14.5 %	2.86	14.47	409

SAN LORENZO RIVER LONGITUDINAL ACCRETION AND HYDROCHEMISTRY
RECONNAISSANCE

60	Ferndell Cr (trib to Zayante at Bean Zay confluence)	0.33	1.3 %	10.01	15	393
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Table 3 Summary of synoptic NO₃, specific conductance at 25C and water temperature measurements taken on the San Lorenzo River on September 18, 2017

Point Number	San Lorenzo River location	Flow (cfs)	Nitrate (NO ₃) Santa Cruz County Lab	Water Temperature (°C)	Specific Conductance at 25C
4	SLR, downstream of Boulder Cr at seasonal gage	5.38	0.27	17.4	499.6
8	SLR, downstream of Clear Cr at seasonal gage	6.57	0.18	17.9	483.7
10	SLR, 75 ft upstream of Love Cr	6.82	0.46	17.8	465.5
12	SLR, 20 ft downstream of Love Cr	-	0.35	-	-
13	SLR, 40 ft upstream of Newell Cr	8.93	2.59	17.2	448.5
17	SLR, 200 ft downstream of Newell Cr	-	3.18	-	-
18	SLR about 200 ft US of the Glen Arbor Bridge (field duplicate)	-	3.95	-	-
19	SLR about 200 ft US of the Glen Arbor Bridge	-	3.94	18.2	395.7
22	SLR just upstream of Tsm outcrop.	-	-	18.1	397

SAN LORENZO RIVER LONGITUDINAL ACCRETION AND HYDROCHEMISTRY
RECONNAISSANCE

27	SLR US of Manson Cr	-	3.77	-	-
29	SLR 6-7ft deep pool at bedrock notch at seep about 150 ft long, 30 ft wide. Not stratified.	-	-	17.9	-
31	SLR Tsm Tm contact about 50 ft DS of Glen Arbor bridge. Can see 200 ft+ tall white sand out crop on right bank upstream - no wet or seeping features.	-	-	17.8	397.5
32	SLR just US of ponded water	-	4.28	17.6	399.4
35	SLR sampled water quality. Concerned we may not see Tsm flowing tribs as expected	11.97	3.43	17.5	403.2
39	SLR end of steep banks 'slot canyon'	-	-	17.3	405.5
40	SLR Seeping steep banks start US of Fall Cr. Long run about 1.5 ft deep for about 200 ft.	-	-	17.1	408
41	SLR, 20 ft upstream of Fall Cr	-	3.44	-	-
42	SLR just US of Fall Cr	-	-	17.2	407
45	SLR pool about 120 feet Downstream of Fall Cr.	-	-	16.7 top 16.5 bottom of pool	376
47	SLR DS of Fall Cr at gage (seasonal)	15.44	2.58	16.1	379.7

SAN LORENZO RIVER LONGITUDINAL ACCRETION AND HYDROCHEMISTRY
RECONNAISSANCE

48	SLR at San Lorenzo Way Bridge	-	-	16.7	375
53	SLR US of Bull Cr.	15.61	2.51	16.3	374
61	SLR DS Big Trees gage just DS of inflatable dam	25.5	2.44	15.7	394.6
62	SLR DS Big Trees gage at bridge (start walk)	25.5	-	15.7	392
63	SLR at USGS Santa Cruz downtown gage	21.2	2.10 (UCSC lab)	16.1	393.4

Flow patterns from the western tributaries during the summer of WY17 can be found in Figures 24-25. Results of the influence of these tributaries on the September 18, 2017 sample date are below in Table 4.

Table 4 Summary of western tributary in-flow to the San Lorenzo River, NO₃, specific conductance and water temperature from on September 18, 2017

Point number	Western Tributary	Flow (cfs)	Percent of SLR flow (trib+SLR)	NO ₃ (mg/L)	Water Temperature (°C)	Specific Conductance at 25°C
2	Boulder Cr 100 ft. US of SLR	1.7	31 %	0.00	16.9	218
1	Clear Cr. US of SLR, downstream of HWY9	0.36	5 %	0.00	16.3	201
28	Mason Cr just US of SLR and the bedrock pool	0.14	1 %	0.50	17.9	395
44	Fall Cr just US of SLR confluence	3.33	22 %	0.22	14.2	266
50	Western trib. Seeping bank	0.006	0.04 %	9.33	16.5	489

SAN LORENZO RIVER LONGITUDINAL ACCRETION AND HYDROCHEMISTRY
RECONNAISSANCE

	near houses (near Felton)					
54	Bull Creek, western trib, at HWY9 Gram Hill Rd overpass,	0.56	4 %	0.94	14.7	402

5 TENTATIVE CONCLUSIONS

1. One major purpose of this project is documenting conditions in 2017, such that future changes in flow and hydrochemistry may be distinguishable relative to the effects of managed recharge in the Santa Margarita and other aquifers. We believe that this project has been able to do so. The baseline value may be most effective at the scale of the named tributaries, rather than individual springs or the larger flows in the main river.
2. Baseline nitrate conditions were successfully sampled. Using coordinated sampling and analysis plans, UCSC staff and laboratory found very similar results to those sampled by Balance staff and analyzed by the County lab.
3. Banks and swales that looked like they should be seeping were often dry, even in this season of high rainfall and mean annual flow. at the Big Trees gage being the highest recorded during the period of record (see Figure 27). Future observations and measurements at these targeted locations may provide valuable insight to as to how much flow from the Santa Margarita aquifer system feeds the San Lorenzo River at various levels of recharge in the system.
4. Every time wet or moist stream banks (with no discrete flow path) were observed there were houses just upgradient of that location. If this study, or similar, is repeated in the future care must be taken to make the distinction between the water from residential influence and the expression of water from the Santa Margarita aquifers.
5. One of more index wells should be identified, and followed (continuously, or monthly) to characterize how the aquifer is responding to multi-year droughts and wet periods.
6. We suggest considering a periodic monitoring of about a dozen representative seeps to distinguish contributions from local point sources such as on-site waste-disposal systems from aquifer-wide influences to better under the effectiveness of the managed recharged system in enhancing habitat. Potential constituents which may be used to distinguish septic-system return flows from those emanating from the managed aquifer might be specific conductance ("conductivity"), MBAS (methylene active blue substances), rhodamine WT (or other fluorescent dyes) widely used for tracing septic-system return flows.
7. Another location where very low specific conductance is diagnostic of the Santa Margarita aquifer is a spring on the east abutment of the Woodwardia weir,

where value of about average 117 μS at 25C even as flow receded from approximately 25 gpm to 2 gpm through the course of the summer.

Conductivity measurements, or continuous monitoring, at this location (or similar) in the future may provide insight to changing baseline conditions in the Santa Margarita aquifer. Ferndell Creek, at the confluence of Bean and Zayante, was also quite low at 200 μS during the sampling event on September 18, 2017 which showed this tributary having elevated nitrate of 10 mg/L NO_3 .

8. Following discovery of stratified pools on Boulder Creek in 2015 and 2016, we inquired into whether deep pools may affect temperature or water quality on the San Lorenzo and major tributaries as well. Pools were unusually shallow at most places in the watershed in response to very heavy sediment transport during the very wet 2017 winter⁷. Some of the deeper 10+ foot deep pools we observed downstream of Clear 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.

⁷ 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).

6 RECOMMENDATIONS

We hope that this effort further allows a common core of basic data to be shared as future questions and analyses develop. Further analysis from the UCSC is expected shortly after this memo is released and should shed further light on the various residence time and sources of the water that were sampled.

Going forward it will be compelling to create a correlation of the Santa Margarita aquifer levels with flow conditions during WY 2017. This study could be repeated as the aquifer recharges above the summer 2017 level with a focus on identified locations that will likely be contributing flow.

Coordinated stream gage efforts in the eastern tributaries between the County of Santa Cruz and the San Lorenzo Valley Water District may provide valuable data on how the San Lorenzo River changes with recharge in the Santa Margarita aquifer. SLVWD has on-going gages on Zayante at the Zayante Store (USGS 11160300), Lompico Creek downstream of Old Mill Ave.

Continued monitoring of specific conductance at key locations on eastern tributaries such as the seep just upstream of the Zayante at Woodwardia gage, and Ferndell Creek may also serve as important baselines as the Santa Margarita groundwater basin changes over time.

Monitoring of the managed recharge program should include an integrated set of piezometers, specific conductance and solutes (esp. nitrates), a reduced version of the baseline monitoring network described in this report, possibly lysimeters (e.g. White and Hecht, 1994). Integration of surface and groundwater observations is key.

Analysis of 2017 isotope data from the UCSC is expected shortly after this report is released and should shed further light on the various residence time and sources of the water that were sampled. Future integration and cooperation with the university and data produced by Balance for local agencies will likely provide very compelling insights.

The semi-continuous units of the Santa Margarita near Eagle Creek/Pasattiempo in the south and Spring Creek in the north deserve basic characterization in a manner such that adding them to this (or a similar) program may answer important questions about the edges of the aquifer.

7 CONCLUDING REMARKS

7.1 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 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. Although mentioned only a few times in this report it should be noted that Denis Rutenburg and Zan Rubin of Balance Hydrologics contributed substantially to this study both in providing insight into effects of pools temperature, and in terms personal effort.

7.2 Limitations

Hydrologic calculations of low flows in coastal California are very complex, often requiring consideration of many years of data collection. Our work conforms with the standard of care for such work in coastal northern California; no other warranties are stated or implied.

7.3 Wet and Dry Years

It is likely that processes and when they occur will vary appreciably from year to year. Application of these findings may be best done years with late, above-average seasonal recharge. Early recommendations indicated that much of the managed recharge is likely to occur during such years. It may prove helpful to future efforts to note that the above-average recharge-potential years with substantial March and April rainfall in the San Lorenzo Valley are **WYs 1978, 1982, 1983, and 1998**. Amongst the studies of which we are aware that present representative data from these years are:

The reports and publications of the Santa Cruz County Watershed Manager's Office such as:

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

Aston, R., and Ricker, J., 1979, Water quality technical section, San Lorenzo River watershed management plan: 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.

SAN LORENZO RIVER LONGITUDINAL ACCRETION AND HYDROCHEMISTRY RECONNAISSANCE

- 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.
- Hecht, B., and Woysner, 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
- Johnson, N.M., 2009, San Lorenzo Valley Water District water-supply master plan: Consulting report prepared for SLVWD. Multipaged.
- 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., 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.
- 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.
- Swanson Hydrology and Geomorphology, 2001, Technical Addenda to Zayante area sediment-source study: Consulting report to County of Santa Cruz, Department of Environmental Health. Collated multiple appendices.

8 REFERENCES CITED

In addition to the citations below, a number of the references listed at the end of Chapter 7 are referenced in the report or are pertinent to the issues discussed.

Johnson, N.M., 1975, Water quality near the Ben Lomond landfill, Santa Cruz County, CA. U.C. Santa Cruz senior thesis.

Lear, J., Woysner, 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.

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

White, C., and Hecht, B., 1994, A comparative study of nitrate movement below a deep and shallow leachfield in Zayante Soils, Glen Arbor, Santa Cruz County, California: Balance Hydrologics, Inc. consulting report prepared for John Ricker, Santa Cruz County Environmental Health Division. 51 p. 9 tables 7 figures, 1 research appendix

FORMS

Form A1. Station Observer Log; San Lorenzo River accretion study, water year 2017 (pg 1 of 6) Santa Cruz County Environmental Health, Santa Cruz County, California

Site Information						Streamflow					Water Quality Observations								Remarks	
Point Number	Site description	Sample number	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	Nitrate (NO3) Santa Cruz County Lab 1,2	Nitrate (NO3) UCSC lab 1,2	Nitrite (NO2) UCSC lab 1	Ammonium (NH4+) UCSC lab 1	Phosphate (PO43-) UCSC lab 1	Dissolved silica (SiO44-) UCSC lab 1	
1	SLR, 50 ft upstream of Boulder Cr. Slow/ponded water	15U-A, 15B-A	9/18/17	17:25	DR, UCSC	-	-	-	-	-	16.8	551	653	0.27	0.06	0.00	0.03	0.68	36.28	Water is ponded and too deep and slow to measure flow.
2	Boulder Cr 100 ft. US of SLR	14U-A, 14B-A	9/18/17	17:15	DR, UCSC	-	1.7	-	PY	g	16.9	184	218	0.72	0.92	0.01	0.01	0.34	37.57	-
3	Boulder Cr 100 ft. US of SLR - field duplicate	16U-A, 16B-A	9/18/17	17:32	DR, UCSC	-	-	-	-	-	-	-	-	0.92	0.01	0.02	0.34	34.07	-	
4	SLR, downstream of Boulder Cr at seasonal gage (approx. 1400 ft DS of confluence)	13U-A, 13B-A	9/18/17	16:05	DR, UCSC	1.1	5.38	-	PY	g	17.4	427	500	0.27	0.33	0.00	0.03	0.54	33.61	-
5	Spring Creek Gulch at Irwin Way (eastern trib)	Spring Cr	9/28/17	11:06	jp	-	0.012	-	bag	g/f	12.8	442	589	0.43	0.92	0.00	0.01	3.56	45.67	-
6	Huckleberry Island drainage about 450 ft US of SLR (eastern trib)	Huckleberry	9/28/17	11:36	jp	-	0.025	-	bkt	f	13.8	306	397	0.53	0.36	0.00	0.02	2.68	52.03	-
7	Clear Cr. US of SLR, downstream of HWY9	12U-A, 12B-A	9/18/17	15:35	DR, UCSC	-	0.36	-	PY	g	16.3	168	201	0.79	0.66	0.00	0.02	0.14	37.85	-
8	SLR, downstream of Clear Cr at seasonal gage	11U-A, 11B-A	9/18/17	14:30	DR, UCSC	-	6.57	-	PY	g	17.9	411	484	0.18	0.19	0.00	0.03	0.48	32.78	-
8a	SLR DS Clear Cr. three deep pools (10 ft+) temperature profile 9/28/17	-	9/28/17	12:00	jp, da	-	-	-	-	-	14.2 top 14.0 bottom of pool	-	374	-	-	-	-	-	-	Follow up temperature profile on two of three 10 ft+ deep pools. Minor to no stratification.
9	Eastern Trib/seep at Larkspur Bridge	10U-A, 10B-A	9/18/17	14:10	DR, UCSC	-	-	0.001	float	f/p	-	-	-	2.45	2.64	0.00	0.02	0.77	57.92	-
10	SLR, 75 ft upstream of Love Cr	8U-A, 8B-A	9/18/17	13:05	DR, UCSC	-	6.82	-	PY	g	17.8	401	466	0.46	0.44	0.01	0.03	0.51	34.35	-

1) Converted to NO3 from N (N*4.428).

2) Where indicated NO3, NO2, Ammonium, phosphate and dissolved silica are courtesy of UCSC earth science lab. UCSC did paired NO3 analysis with most samples. Results having a linear regression of 1.15x+.077, R2=0.9916.

Observers: jp: Jason Parke; dr: Denis Ruttenburg, zr: Zan Rubin PhD, UCSC: Christina Richardson and Joe Fackrell

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

Form A1. Station Observer Log; San Lorenzo River accretion study, water year 2017 (pg 2 of 6)
Santa Cruz County Environmental Health, Santa Cruz County, California

Site Information			Streamflow					Water Quality Observations										Remarks		
Point Number	Site description	Sample number	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	Nitrate (NO3) Santa Cruz County Lab ^{1,2}	Nitrate (NO3) UCSC lab ^{1,2}	Nitrite (NO2) UCSC lab ¹	Ammonium (NH4+) UCSC lab ¹	Phosphate (PO43-) UCSC lab ¹	Dissolved silica (SiO44-) UCSC lab ¹	Remarks
			(mm/dd/yr)	(24hr)		(feet)	(cfs)	(cfs)		(e/g/l/p)	(oC)	(umhos/cm)	(at 25 oC)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	
11	Love Cr 50 ft. upstream of SLR	7U-A, 7B-A	9/18/17	12:20	DR, UCSC	-	0.48	-	PY	g	16.2	343	412	0.43	0.60	0.00	0.01	1.42	51.75	-
12	SLR, 20 ft downstream of Love Cr	9U-A, 9B-A	9/18/17	13:15	DR, UCSC	-	-	-	-	-	-	-	-	0.35	0.47	0.01	0.03	0.71	38.31	Estimate flow using upstream flow measurements.
13	SLR, 40 ft upstream of Newell Cr	5U-A, 5B-A	9/18/17	11:15	DR, UCSC	-	8.93	-	PY	g	17.2	382	449	2.59	2.96	0.01	0.01	0.63	35.17	-
14	Newell Cr at Rancho Rio Bridge. Follow-up measurement day after main water quality sampling.	U14,B14	9/19/17	10:33	jp	-	1.25	-	PY	g	15.7	291	355	0.98	1.09	0.01	0.01	0.51	33.43	This site is downstream of the Ben Lomond landfill. Can not see outcrops.
15	Newell Creek DS of Loch Lomond reservoir. City of Santa Cruz gage	-	9/18/2017	10:00	-	-	-	1.06	15-minute record	provisional	-	-	-	-	-	-	-	-	-	Provisional 15-minute provisional. stream flow record by the City of Santa Cruz.
16	Newell Creek just upstream of the confluence with the SLR	4U-A, 4B-A	9/18/17	10:30	DR, UCSC	-	2.71	-	PY	g	15.0	235	291	6.91	7.66	0.01	0.03	2.02	41.34	-
17	SLR, 200 ft downstream of Newell Cr	6U-A, 6B-A	9/18/17	11:30	DR, UCSC	-	-	-	-	f	-	-	-	3.18	3.62	0.01	0.03	0.85	36.28	Estimate flow using upstream flow measurements.
18	SLR about 200 ft US of the Glen Arbor Bridge (field duplicate)	U13,B13	9/18/17	18:11	jp, zr	-	-	-	-	-	-	-	-	3.95	4.74	0.01	0.02	1.03	37.85	Field duplicate.
19	SLR about 200 ft US of the Glen Arbor Bridge	U12,B12	9/18/17	18:10	jp, zr	-	-	-	-	-	18.2	343	396	3.94	4.61	0.01	0.03	1.00	37.38	Several access points for adjacent houses and recreation in the river with only one general public entry point.
20	Eastern Trib. at a fairly deep pool 4-6 ft deep, 200+ft long with about 40% cover. Used for recreation by house on the right bank. Bedrock looks like mudstone/shale.	U11,B11	9/18/17	17:40	jp, zr	-	-	-	-	-	18.2	343	394	8.17	9.09	0.38	0.36	0.77	66.57	-

1) Converted to NO3 from N (N*4.428).
 2) Where indicated NO3, NO2, Ammonium, phosphate and dissolved silica are courtesy of UCSC earth science lab. UCSC did paired NO3 analysis with most samples. Results having a linear regression of 1.15x+.077, R2=0.9916.
 Observers: jp: Jason Parke; dr: Denis Rutenburg, zr: Zan Rubin PhD; UCSC: Christina Richardson and Joe Fackrell
 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

Form A1. Station Observer Log; San Lorenzo River accretion study, water year 2017 (pg 3 of 6)
Santa Cruz County Environmental Health, Santa Cruz County, California

Site Information				Streamflow				Water Quality Observations										Remarks			
Point Number	Site description	Sample number	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	Nitrate (NO3) Santa Cruz County Lab ^{1,2}	Nitrate (NO3) UCS lab ^{1,2}	Nitrite (NO2) UCS lab ¹	Ammonium (NH4+) UCSC lab ¹	Phosphate (PO43-) UCSC lab ¹	Dissolved silica (SiO4-) UCSC lab ¹	Remarks	
			(mm/dd/yr)	(24hr)		(feet)	(cfs)	(cfs)		(e/g/l/p)	(oC)	(µmhos/cm)	(at 25 oC)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)		
21	Seeps on left bank - wet but not flowing. Houses are on the top of the bank and may be the sources of wet banks.	-	9/18/17	17:15	jp,zr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	SLR just upstream of Tsm outcrop.	-	9/18/17	16:56	jp,zr	-	-	-	-	-	18.1	345	397	-	-	-	-	-	-	-	-
23	Potential seep at sharp bend in stream path with Tsm outcrop that looks like it should be flowing with staining/mottling. Measured SCT on stagnant pond in the outcrop face.	-	9/18/17	16:56	jp, zr	-	-	-	-	-	16.4	595	711	-	-	-	-	-	-	-	-
24	SLR pool about 300 ft long about 3 ft deep average, 40 ft wide. Upstream end has wet and not flowing Tsm exposed to about 6 ft above current water level.	-	9/18/17	16:50	jp, zr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Mostly sand bottom. Fairly exposed to sun and appears to be used frequently for recreation.
25	Seeping wet banks on the left bank - not flowing. About 6 sprinklers are on the right bank.	-	9/18/17	16:44	jp, zr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	SLR pool about 3 ft. deep, 70 ft long 30 ft wide not stratified.	-	9/18/17	16:36	jp, zr	-	-	-	-	-	17.9 top bottom	-	-	-	-	-	-	-	-	-	-
27	SLR US of Manson Cr	U9,B9	9/18/17	16:23	jp, zr	-	-	-	-	-	-	-	-	3.77	4.52	0.01	0.03	0.97	36.74	-	-
28	Manson Cr just US of SLR and the bedrock pool	U10,B10	9/18/17	16:25	jp, zr	-	0.14	-	PY	g	17.9	341	395	0.50	0.25	0.00	0.01	1.00	50.92	-	-
29	SLR 6-7ft deep pool at bedrock notch at seep about 150 ft long, 30 ft wide. Not stratified.	-	9/18/17	15:57	jp, zr	-	-	-	-	-	17.9	-	-	-	-	-	-	-	-	-	-
30	Seep on right bank (west side of SLR) upstream of tall Tsm outcrop.	U8,B8	9/18/17	15:57	jp, zr	-	0.0022	-	bag	g	15.3	374	458	2.15	2.47	0.00	0.00	5.80	54.42	-	-

1) Converted to NO3 from N (N*4.428).
 2) Where indicated NO3, NO2, Ammonium, phosphate and dissolved silica are courtesy of UCSC earth science lab. UCSC did paired NO3 analysis with most samples. Results having a linear regression of 1.15x+.077, R2=0.9916.
 Observers: jp; Jason Parke; dr; Denis Ruttenburg, zr; Zan Rubin PhD, UCSC: Christina Richardson and Joe Fackrell
 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).
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 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

Form A1. Station Observer Log; San Lorenzo River accretion study, water year 2017 (pg 4 of 6)
Santa Cruz County Environmental Health, Santa Cruz County, California

Site Information				Streamflow				Water Quality Observations										Remarks		
Point Number	Site description	Sample number	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	Nitrate (NO3) Santa Cruz County Lab ^{1,2}	Nitrate (NO3) UCSC lab ^{1,2}	Nitrite (NO2) UCSC lab ¹	Ammonium (NH4+) UCSC lab ¹	Phosphate (PO43-) UCSC lab ¹	Dissolved silica (SiO44-) UCSC lab ¹	Remarks
			(mm/dd/yr)	(24hr)		(feet)	(cfs)	(cfs)		(e/g/f/p)	(cC)	(umhos/cm)	(at 25 cC)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	
31	SLR Tsm Tm contact about 50 ft DS of bridge. Can see 200 ft+ tall white sand out crop on right bank upstream - no wet or seeping features.		9/18/17	15:31	jp, zr	-	-	-	-	-	17.8	343	398	-	-	-	-	-	-	-
32	SLR just US of ponded water	U7,B7	9/18/17	15:05	jp, zr	-	-	-	-	-	17.6	343	399	4.28	4.32	0.01	0.03	0.94	36.92	-
33	Seep with ponded water on stream bank about 1 ft deep, 4 ft wide, 12 ft long. WQ sampled however may not be representative of flowing water.	U6,B6	9/18/17	15:05	jp, zr	-	-	-	-	-	16	228	276	0.31	0.36	0.02	0.16	0.17	43.19	-
34	No Tsm trib	-	9/18/17	~14:10	jp, zr	-	-	-	-	-	17.6	345	401	-	-	-	-	-	-	Tributary not found based on preliminary topographic interpretation.
35	SLR sampled water quality. Concerned we may not see Tsm flowing trib as expected. Accidentally repeated U5, B5 sample number.	U5,B5 13:49	9/18/17	13:49	jp, zr	-	11.97	-	PY	g	17.5	346	403	3.43	4.15	0.01	0.03	0.94	37.11	-
36	Vertical Tsm exposed face. No flow only just barely wet.	-	9/18/17	13:34	jp, zr	-	-	-	-	-	17.7	349	406	-	-	-	-	-	-	This reach is another long 1.5 ft deep run.
37	SLR end of long run about 1.2 ft deep	-	9/18/17	~13:15	jp, zr	-	-	-	-	-	17.6	349	406	-	-	-	-	-	-	-
38	Eastern trib seep. Possibly Tsm. Start another long run about 1.5 ft deep	-	9/18/17	13:00	jp, zr	-	0.0001	-	bag	g	17.3	343	403	-	-	-	-	-	-	-
39	SLR end of steep banks 'slot canyon'	-	9/18/17	12:53	jp, zr	-	-	-	-	-	17.3	346	406	-	-	-	-	-	-	-
40	SLR Seeping steep banks start US of Fall Cr. Long run about 1.5 ft deep for about 200 ft.	-	9/18/17	12:35	jp, zr	-	-	-	-	-	17.1	346	408	-	-	-	-	-	-	-

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 Observers: jp, Jason Parke; dr, Denis Ruitenburg, zr, Zan Rubin PhD, UCSC: Christina Richardson and Joe Fackrell
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 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
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Form A1. Station Observer Log; San Lorenzo River accretion study, water year 2017 (pg 5 of 6)
Santa Cruz County Environmental Health, Santa Cruz County, California

Site Information			Streamflow				Water Quality Observations										Remarks			
Point Number	Site description	Sample number	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	Nitrate (NO3) Santa Cruz County Lab ^{1,2}	Nitrate (NO3) UCSC lab ^{1,2}	Nitrite (NO2) UCSC lab ¹	Ammonium (NH4+) UCSC lab ¹	Phosphate (PO43-) UCSC lab ¹	Dissolved silica (SiO44-) UCSC lab ¹	Remarks
			(mm/dd/yr)	(24hr)		(feet)	(cfs)	(cfs)		(e/g/f/p)	(oC)	(umhos/cm)	(at 25 oC)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	
41	SLR, 20 ft upstream of Fall Cr	2U-A, 2B-A	9/18/17	9:00	DR, UCSC	-	-	-	-	-	-	-	-	3.44	4.45	0.02	0.04	0.94	37.75	-
42	SLR just US of Fall Cr	-	9/18/17	12:35	jp, zr	-	-	-	-	-	17.2	346	407	-	-	-	-	-	-	-
43	Fall Cr just US of SLR confluence	-	9/18/17	12:35	jp, zr	-	-	-	-	-	15	213	262	-	-	-	-	-	-	-
44	Fall Cr just US of SLR confluence	1U-A, 1B-A	9/18/17	8:15	DR, UCSC	-	3.33	-	PY	g	14.2	217	266	0.22	0.11	0.00	0.00	0.23	39.96	-
45	SLR pool about 120 feet downstream of Fall Cr. Sand bottom	-	9/18/17	11:56	jp, zr	-	-	-	-	-	16.7 top 16.5 bottom of pool	315	376	-	-	-	-	-	-	Pool is about 5-6 ft deep, 70 ft long and 25ft wide.
46	SLR DS of Fall Cr at gage (seasonal)	-	9/18/17	11:51	jp, zr	1.62	-	15.0	15-minute gage record	f	16.7	316	376	-	-	-	-	-	-	Stage observation only - flow measured earlier.
47	SLR DS of Fall Cr at gage (seasonal)	3B-A, 3U-A	9/18/17	9:21	DR, UCSC	1.64	15.44	-	PY	g	16.1	315	380	2.58	3.40	0.01	0.03	0.77	36.37	-
48	SLR at San Lorenzo Way Bridge	-	9/18/17	11:44	jp, zr	-	-	-	-	-	16.7	315	375	-	-	-	-	-	-	End of eastern seeping bank
49	Eastern trib. large culvert in Tsm about 12 ft elevated off bed. Stagnate pool.	-	9/18/17	11:20	jp, zr	-	-	no flow, ponded water	-	-	15.1	225	277	-	-	-	-	-	-	Culvert diameter is about 5 feet. No signs of recent flow. No scour on SLR gravel bar only at the base of culvert.
50	Western seep. Seeping bank near houses	U5,B5	9/18/17	11:05	jp, zr	-	-	0.006	bag	f/p	16.5	409	489	9.33	10.42	0.02	0.07	0.23	63.08	Seeping western bank, residential buildings on bank. Flow is measurement is approximate.

1) Converted to NO3 from N (N*4.428).
 2) Where indicated NO3, NO2, Ammonium, phosphate and dissolved silica are courtesy of UCSC earth science lab. UCSC did paired NO3 analysis with most samples. Results having a linear regression of 1.15x+0.77, R2=0.9916.
 Observers: jp; Jason Parke; dr; Denis Ruttenburg, zr; Zan Rubin PhD, UCSC: Christina Richardson and Joe Fackrell
 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

Form A1. Station Observer Log; San Lorenzo River accretion study, water year 2017 (pg 6 of 6)
Santa Cruz County Environmental Health, Santa Cruz County, California

Site Information							Streamflow				Water Quality Observations									Remarks	
Point Number	Site description	Sample number	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	Nitrate (NO3) Santa Cruz County Lab ^{1,2}	Nitrate (NO3) UCSC lab ^{1,2}	Nitrite (NO2) UCSC lab ¹	Ammonium (NH4+) UCSC lab ¹	Phosphate (PO43-) UCSC lab ¹	Dissolved silica (SiO44-) UCSC lab ¹		
			(mm/dd/yr)	(24hr)		(feet)	(cfs)	(cfs)		(e/g/f/p)	(oC)	(umhos/cm)	(at 25 oC)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	
51	SLR outside bend pool, left bank. Sandy bed.	-	9/18/17	10:55	jp, zr	-	-	-	-	-	16.4 top and bottom of pool	313	374	-	-	-	-	-	-	-	Sandy bottom pool, about 80% canopy.
52	SLR shallow pool, man made about 1.5 ft deep, ~200 ft long	-	9/18/17	10:47	jp, zr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Shallow pool, man made about 200 ft long
53	SLR US of Bull Cr.	U4,B4	9/18/17	9:59	jp, zr	-	15.61	-	-	e	16.3	313	374	2.51	3.35	0.01	0.01	0.77	38.03		Very good cross section, laminar, smooth bed.
54	Bull Creek, western trib. at HWY9 Graham Hill Rd overpass,	U3,B3	9/18/17	9:51	jp, zr	-	-	0.56	15-min record upstream	f	14.7	323	402	0.94	0.51	0.00	0.00	0.31	41.80		Bull Cr at confluence with SLR. Retuned next day to measure flow at 0.47 cfs
55	Zayante Cr. at Woodwardia gage (seasonal)	17U-A, 17B-A	9/19/17	9:15	UCSC	0.68	-	4.52	15-min record	f	15.79	356	438	1.86	2.06	0.01	0.04	1.54	47.05		Gage was calibration visit was on 9/17/17 at 12:20 stage: 0.68 ft, flow: 4.21
56	Trib. US of gage at Zayante Woodwardia, likely Tsm flow ~6 L/min	18U-A, 18B-A	9/19/17	9:25	UCSC	-	-	0.004	visual est.	f	15.1	107.6	132.9	2.15	2.87	0.01	0.03	1.94	46.04		-
57	Zayante Cr US SLR, 300 ft DS of Graham Hill Rd	U2,B2	9/18/17	9:04	jp, zr	-	9.31	-	PY	g	15.7	324	427	2.94	3.34	0.01	0.02	1.94	54.60		approx. 300 ft DS of Gram Hill Rd
58	Bean Cr. at Mnt Hermon gage (seasonal) - prior to sampling event	-	9/17/17	14:45	jp	1.18	3.64	-	PY	g/e	16.1	330	431	-	-	-	-	-	-	-	No debris jams influencing record.
59	Bean Cr. at Mnt Hermon gage (seasonal)	20U-A, 20B-A	9/19/17	11:00	UCSC	1.18	-	3.71	15-minute record	f	14.47	321	409	2.86	3.29	0.01	0.03	2.28	60.31		-
60	Ferndell Cr at Mnt Hermon	19U-A, 19B-A	9/19/17	10:10	UCSC	-	-	0.33	measured on 9/17/17 with PY	f	15	164.8	203.5	10.01	11.86	0.00	0.01	3.13	49.54		Flow is assumed to be approximately the same as measured on 9/17/17 at 15:15. SCT was 12.4C,162 uS and 214 uS at 25C
61	SLR DS Big Trees gage just DS dam	U1,B1	9/18/17	8:42	jp, zr	-	-	25.5	USGS 15min flow provisional	-	15.7	324	395	2.44	3.20	0.01	0.01	1.11	43.28		Sampled just downstream of inflatable weir
62	SLR DS Big Trees gage at bridge	-	9/18/17	8:31	jp, zr	-	-	25.5	USGS 15min flow provisional	?	15.7	322	392	-	-	-	-	-	-	-	Start of in-stream walk.
63	SLR at USGS Santa Cruz downtown gage	21U-A	9/19/17	8:37	UCSC	-	-	21.2	USGS 15min flow provisional	-	16.1	326	393	-	2.10	0.01	0.06	0.91	39.96		Note that flow is taken from 9/19/17, a day after main sampling event

1) Converted to NO3 from N (N*4.428).
 2) Where indicated NO3, NO2, Ammonium, phosphate and dissolved silica are courtesy of UCSC earth science lab. UCSC did paired NO3 analysis with most samples. Results having a linear regression of 1.15x+.077, R2=0.9916.
 Observers: jp, Jason Parke; dr, Denis Ruttenburg, zr; Zan Rubin PhD, UCSC: Christina Richardson and Joe Fackrell
 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

Form A2. Station Observer Log: Boulder Creek upstream of San Lorenzo River

Site Conditions					Streamflow			Water Quality Observations				High-Water Marks		Remarks
Date/Time	Observer(s)	Stage (staff plate)	Alternate staff plate (old USGS)	Hydrograph	Measured flow	Instrument Used	Estimated Accuracy	Water Temperature	Specific Conductance at field temp.	Specific Conductance at 25°C	Estimated stage at staff plate	Inferred dates?	Remarks	
(mm/dd/yr)		(feet)		(R/F/S/B)	(cfs)	(AA/PY/MM)	(e/g/f/p)	(oC)	(µmhos/cm)	(at 25 °C)	(feet)	(mm/dd/yr)		
Lower Boulder Creek at gage approximately 500 feet upstream of HWY 9														
5/2/17 0:00	jp	7.82	1.28	F	23.2	AA	g	15.4	153	188	12.2 Balance, 6.62 former USGS		USGS high water mark is more approximate. Several trees down in the channel between the USGS gage and the Balance gage. Adjusted Balance staff that was bent in slightly. Water temperature was the same at sensor and thalweg.	
7/17/17 15:15	jp, dr	7.27	-	B	3.81	PY	g/f	18.7	180	204	Winter base flow staining at 8.3 ft.	-	Had to clear some cobbles from cross section just downstream of the gage. Noticed localized scour at the staff plate.	
8/15/17 15:15	dr	7.18	-	B	3.20	PY	f	14.4	171	215	-	-	No notes	
9/18/17 17:30	dr, cr, jf	na	-	B	1.70	PY	g/f	16.9	184	218	-	-	Measured flow just upstream of Junction Park - use gage record for stage. Sampled water quality 14B-A, 16B-A	
10/19/17 16:30	da	7.05	-	B	1.70	PY	g	11.1	129	164	-	-	No notes	
San Lorenzo River approximately 1,400 ft. downstream of Boulder Creek														
7/17/17 17:30	dr, jp	1.325	-	B	11.41	PY	g	20.0	415	459	-	-	Reinstalled staff plate and sensor which was taken out last winter.	
8/15/17 17:45	da	1.22	-	B	8.41	MM	g	18.0	415	479	-	-	No notes.	
9/18/17 16:45	dr, cr, jf	1.10	-	B	5.38	PY	g	17.4	427	499	-	-	Measured flow at bedrock constriction. Sampled water quality 13B-A.	
10/19/17 15:15	da	1.03	-	B	3.82	MM	g	11.1	283	358	-	-	SCT temperature not working well.	
11/1/17 15:40	dr	1.05	-	B	-	-	-	-	-	-	-	-	Removed sensor and stilling well.	

Notes:

Observer Key: jp = Jason Parke; zr= Zan Rubin, dr= Denis Ruttenburg, da= Don Alley, cr and jf=Christina Richardson and Joe Fackrell (UCSC)

Stage: Water level observed at outside staff plate

Hydrograph: Describes stream stage as rising (R), at peak (P), falling (F), steady (S), baseflow (B), diversion (D), not spilling (NS) or uncertain (U).

Instrument: If measured, typically made using a standard (AA) or pygmy (PY) bucket-wheel ("Price-type") current meter, Marsh McBirny meter (MM), or 5 gallon bucket (bkt), plastic bag (bag), 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 $(1.8813774452 - [0.050433063928 * \text{field temp}] + [0.00058561144042 * \text{field temp}^2]) * \text{Field specific conductance}$

Form A3. Station Observer Log: Clear Creek upstream of the San Lorenzo River

Date/Time (mm/dd/yr)	Site Conditions			Streamflow			Water Quality Observations			Remarks	
	Observer(s)	Stage (staff plate) (feet)	Stage corrected to vertical	Hydrograph (R/F/S/B)	Measured flow (cfs)	Instrument Used AA/PY/MM	Estimated Accuracy (e/g/f/p)	Water Temperature (°C)	Specific Conductance at field temp. (µmhos/cm)		Specific Conductance at 25°C (at 25 °C)
Clear Creek upstream of San Lorenzo River just DS HWY 9											
7/17/17 13:45	jp,dr	-	-	B	0.90	PY	g	17	159	188	Measured flow near the second foot bridge downstream of HWY 9.
8/15/17 14:15	da	-	-	B	0.54	PY	g	15.7	165	200	Measured flow near the second foot bridge downstream of HWY 9.
9/18/17 15:45	dr, jf, cr	-	-	B	0.36	PY	g	16.3	168	201	Sampled water quality 1D, 12B-A
10/19/17 11:00	da	-	-	B	2.34	MM	g	12.2	116	152	No notes.
San Lorenzo River downstream of Clear Creek											
7/17/17 13:10	jp, dr	8.46	7.76	B	14.97	PY	f	19.5	388	433	Reinstalled stilling well and sensor. Sensor is in the thalweg. Water temperature is the same in the thalweg and at the sensor.
8/15/17 15:45	da	8.31	7.62	B	9.15	MM	g/f	18.5	400	456	Substrate is irregular.
9/18/17 14:55	dr, jf, cr	8.17	7.49	B	6.57	PY	g/f	17.9	411	483	Sampled water quality 1D, 11B-A
10/19/17 12:45	da	8.10	7.43	B	4.54	MM	g/f	12.2	277	362	No notes.
11/2/17 12:15	jp	8.14	7.46	B	-	-	-	11.8	364	489	Removed staff plate, sensor and stilling well.

Notes:

Observer Key: jp = Jason Parke; zr= Zan Rubin, dr= Denis Ruttenburg, da= Don Alley, cr and jf=Christina Richardson and Joe Fackrell (UCSC)

Stage: Water level observed at outside staff plate

Hydrograph: Describes stream stage as rising (R), at peak (P), falling (F), steady (S), baseflow (B), diversion (D), not spilling (NS) or uncertain (U).

Instrument: If measured, typically made using a standard (AA) or pygmy (PY) bucket-wheel ("Price-type") current meter, Marsh McBirny meter (MM), or 5 gallon bucket (bkt), plastic bag (bag). 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 $(1.8813774452 - [0.050433063928 * \text{field temp}] + [0.00058561144042 * \text{field temp}^2]) * \text{Field specific conductance}$

Form A4. Station Observer Log: Fall Creek upstream of the San Lorenzo River

Site Conditions				Streamflow			Water Quality Observations			Remarks
Date/Time (mm/dd/yr)	Observer(s)	Stage (staff plate) (feet)	Hydrograph (R/F/S/B)	Measured flow (cfs)	Instrument Used (AA/PY/MM)	Estimated Accuracy (e/g/f/p)	Water Temperature (oC)	Specific Conductance at field temp. (µmhos/cm)	Specific Conductance at 25°C (at 25 °C)	
Fall Creek just upstream of San Lorenzo River										
7/17/17 11:00	jp, dr		B	5.40	PY	g	15.2	198	243	Reach is fairly turbulent.
8/15/17 12:40	da		B	4.35	MM	g	15.1	206	254	Flagged cross section.
9/18/17 8:35	dr, jf, cr		B	3.33	PY	g	14.2	217	266	Sampled water quality 1D, 1B-A. Water velocity is slow.
10/19/17 11:10	da		-	2.34	MM	g	-	-	-	SCT meter temperature does not appear to be working.
San Lorenzo River downstream of Fall Creek										
7/17/17 10:30	dr, jp	1.89	B	28.99	PY	g	17.9	308	357	Water temperature at the thalweg was 17.8C. Reinstalled the staff plate and sensor in the calm run about 100 ft downstream of the pool that people frequently use for recreation.
8/15/17 11:30	da	1.74	B	22.85	MM	g/e	17.5	315	367	No notes.
9/18/17 9:40	dr, jf, cr	1.64	B	15.44	PY	g	16.1	315	380	Sampled water quality 3B-A
9/18/17 11:51	jp, zr	1.65	B	-	-	-	16.1	314	380	Stage and SCT measurement on synoptic stream walk. Flow and water quality was measured earlier.
10/19/17 10:10	da	-	-	12.09	MM	e	-	208	221	SCT meter temperature does not appear to be working.
11/2/17 11:34	jp	-	B	-	-	-	11.8	284	379	Reach is still a slow moving run. Bedrock on left bank is still oozing and wet. Removed staff plate and stilling well.

Notes:

Observer Key: jp = Jason Parke; zr= Zan Rubin, dr= Denis Ruttenburg, da= Don Alley, cr and jf=Christina Richardson and Joe Fackrell (UCSC)

Stage: Water level observed at outside staff plate

Hydrograph: Describes stream stage as rising (R), at peak (P), falling (F), steady (S), baseflow (B), diversion (D), not spilling (NS) or uncertain (U).

Instrument: If measured, typically made using a standard (AA) or pygmy (PY) bucket-wheel ("Price-type") current meter, Marsh McBirny meter (MM), or 5 gallon bucket (bkt), plastic bag (bag), 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 $(1.8813774452 - [0.050433063928 * \text{field temp}]$

$+ [0.00058561144042 * \text{field temp}^2]) * \text{Field specific conductance}$

**Form A5. 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 (mm/dd/yr)	Observer(s)	Stage (staff plate) (feet)	Hydrograph (R/F/S/B)	Measured Flow (cfs)	Estimated Flow (cfs)	Instrument Used (AA/PY)	Estimated Accuracy (e/g/f/p)	Water Temperature (oC)	Specific Conductance at field temp. (µmhos/cm)	Specific Conductance at 25oC (at 25 oC)	Additional sampling? (Qbed, etc.)	Estimated stage at staff plate (feet)	Inferred dates? (mm/dd/yr)	Remarks
6/2/17 16:00	jp	-	B	12.32	-	PY	g	15.1	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.
6/13/17 14:00	jp	0.83	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 trib just upstream is flowing about 25-20 gpm. Re-installed staff plate at Woodwardia
7/14/17 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.
8/15/17 11:25	jp	0.71	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.
9/17/17 12:30	jp	0.68	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.
11/2/17 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

Form A6. Station Observer Log, Bean Creek at Mount Hermon, 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	1.250	B	5.90	-	PY	g/e	17.3	227	263	-	approx. 5.75 ft above water level	WY17	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	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.
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).

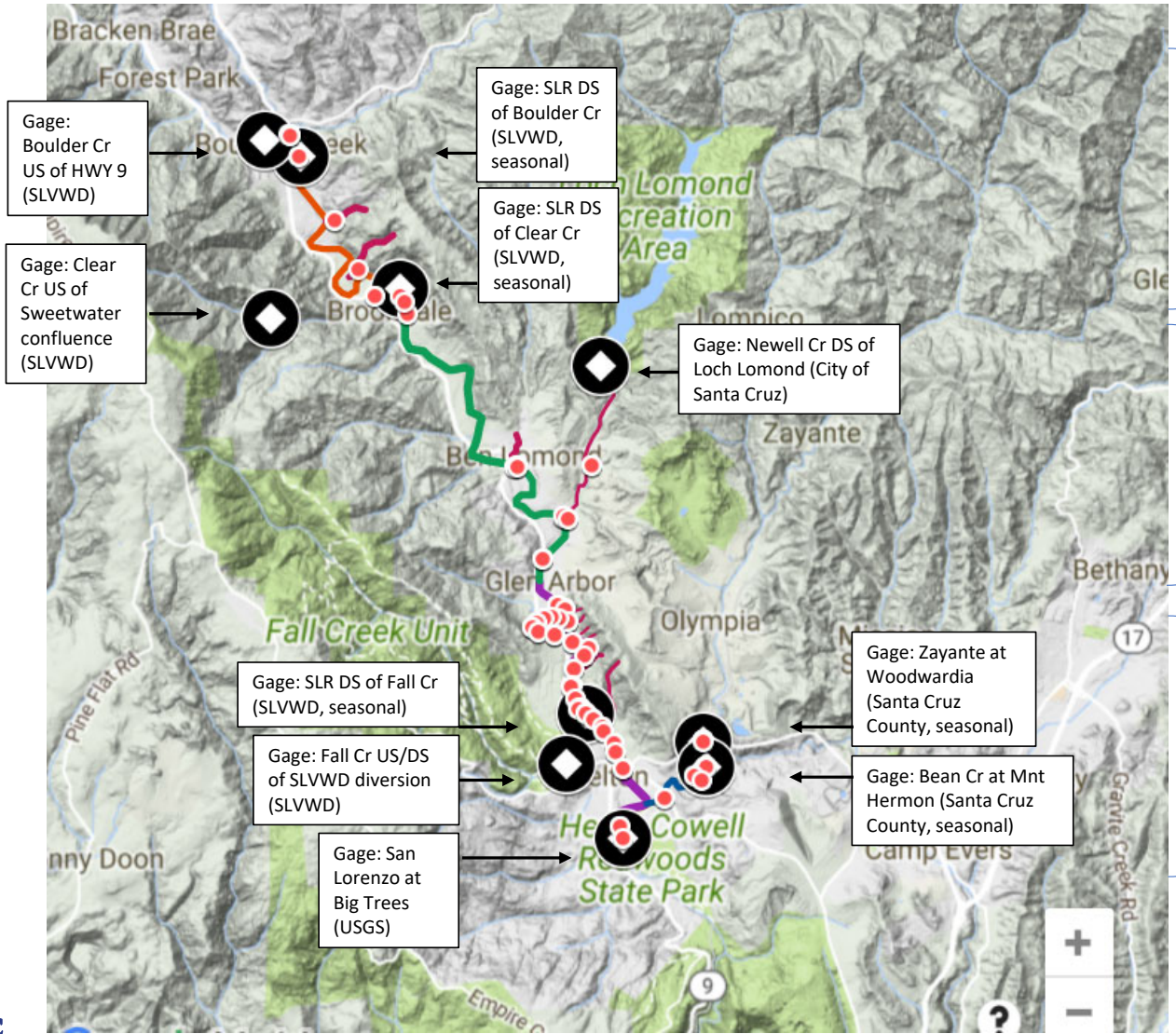
Estimated measurement accuracy: Excellent (E) = +/- 2%; Good (G) = +/- 5%; Fair (F) = +/- 9%; Poor (P) estimated percent accuracy given

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

FIGURES



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)

Note: Red lines are tributaries or potential tributaries of interest. Red dots are water quality sampling points.

Figure 1: Overall study reach



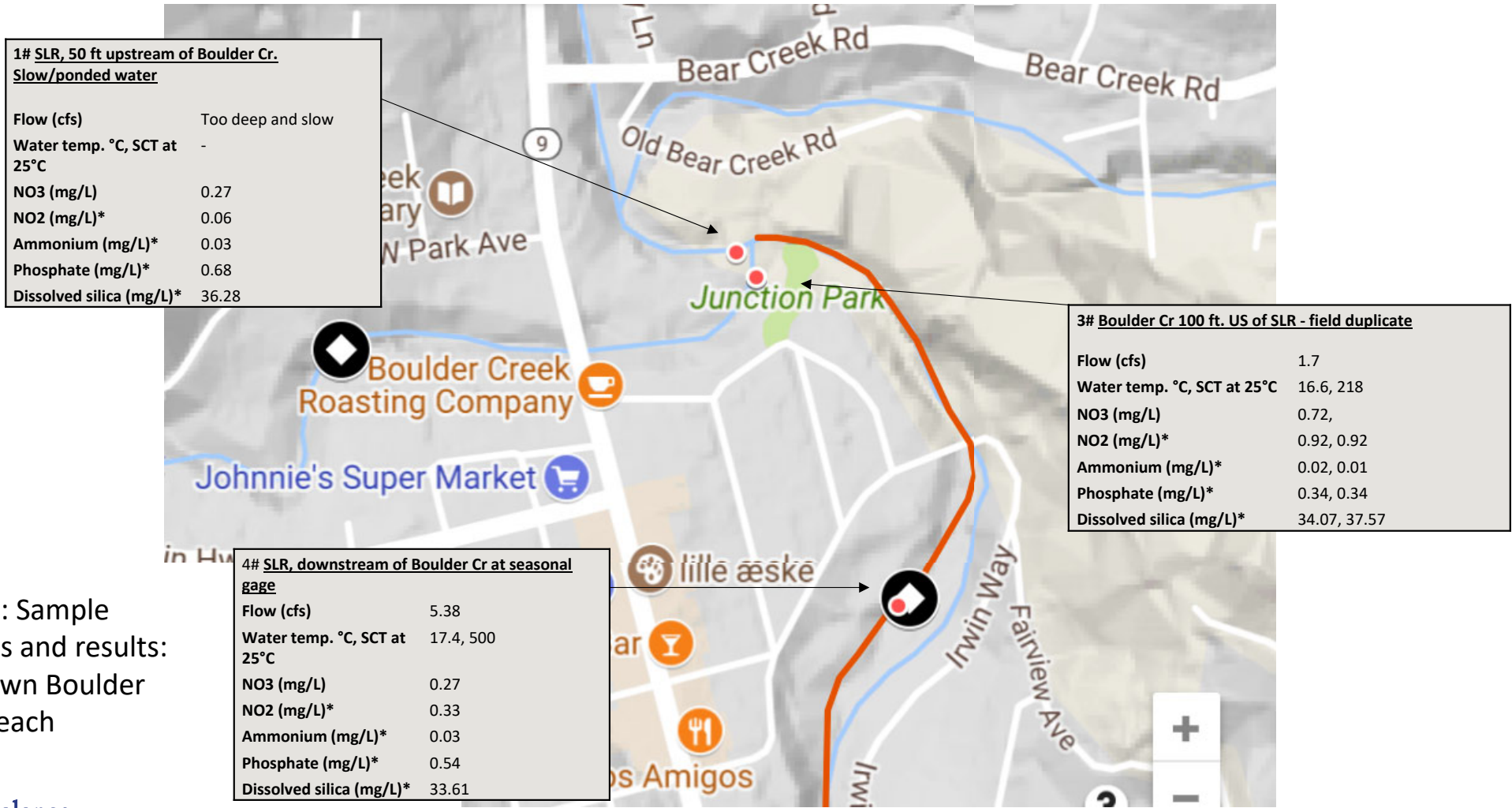


Figure 2: Sample locations and results: Downtown Boulder Creek Reach



*Note: NO2, dissolved silica, ammonium, phosphate are courtesy of UCSC earth science lab. UCSC did paired NO3 analysis with most samples. Results are available in the observation log (Table A1) .



4# SLR, downstream of Boulder Cr at seasonal gage

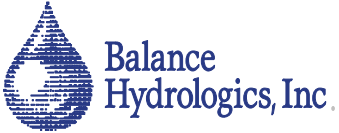
Flow (cfs)	5.38
Water temp. °C, SCT at 25°C	17.4, 500
NO3 (mg/L)	0.27
NO2 (mg/L)*	0.33
Ammonium (mg/L)*	0.03
Phosphate (mg/L)*	0.54
Dissolved silica (mg/L)*	33.61

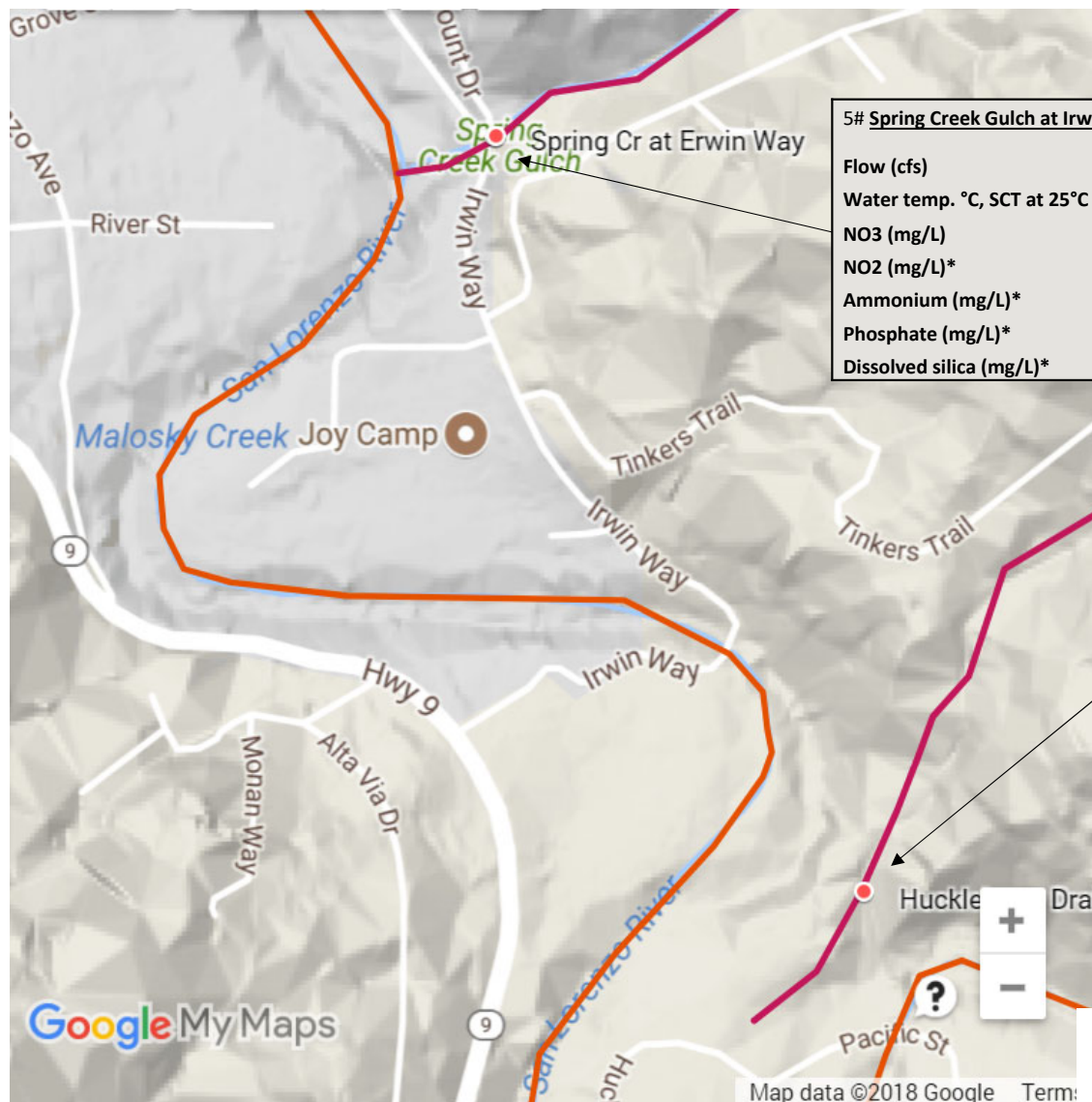
5# Spring Creek Gulch at Irwin Way

Flow (cfs)	0.01
Water temp. °C, SCT at 25°C	12.8, 589
NO3 (mg/L)	<0.1
NO2 (mg/L)*	0.92
Ammonium (mg/L)*	0.01
Phosphate (mg/L)*	3.56
Dissolved silica (mg/L)*	45.67

*Note: NO2, dissolved silica, ammonium, phosphate are courtesy of UCSC earth science lab. UCSC did paired NO3 analysis with most samples. Results are available in the observation log (Table A1).

Figure 3: Sample locations and results: Irwin Way Reach





5# Spring Creek Gulch at Irwin Way

Flow (cfs)	0.01
Water temp. °C, SCT at 25°C	12.8, 589
NO3 (mg/L)	<0.1
NO2 (mg/L)*	0.92
Ammonium (mg/L)*	0.01
Phosphate (mg/L)*	3.56
Dissolved silica (mg/L)*	45.67

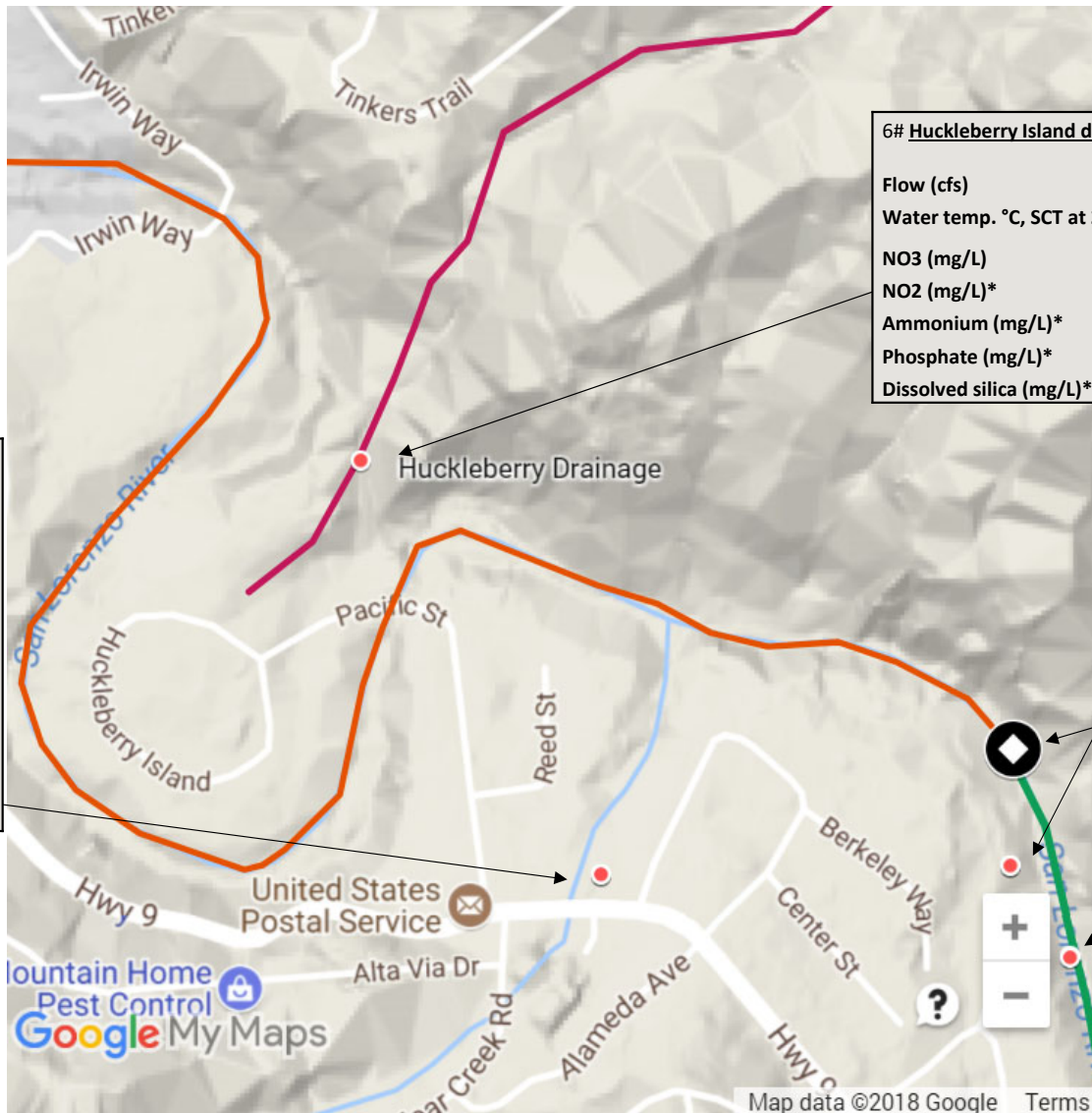
6# Huckleberry Island drainage about 450 ft US of SLR

Flow (cfs)	0.02
Water temp. °C, SCT at 25°C	13.8, 397
NO3 (mg/L)	0.13
NO2 (mg/L)*	0.36
Ammonium (mg/L)*	0.02
Phosphate (mg/L)*	2.68
Dissolved silica (mg/L)*	52.03

*Note: NO2, dissolved silica, ammonium, phosphate are courtesy of UCSC earth science lab. UCSC did paired NO3 analysis with most samples. Results are available in the observation log (Table A1).

Figure 4: Sample locations and results: Huckleberry Island Reach





6# Huckleberry Island drainage about 450 ft US of SLR

Flow (cfs)	0.02
Water temp. °C, SCT at 25°C	13.8, 397
NO3 (mg/L)	0.13
NO2 (mg/L)*	0.36
Ammonium (mg/L)*	0.02
Phosphate (mg/L)*	2.68
Dissolved silica (mg/L)*	52.03

7# Clear Cr. US of SLR, downstream of HWY9

Flow (cfs)	0.36
Water temp. °C, SCT at 25°C	16.3, 201
NO3 (mg/L)	0.79
NO2 (mg/L)*	0.66
Ammonium (mg/L)*	0.02
Phosphate (mg/L)*	0.14
Dissolved silica (mg/L)*	37.85

8# SLR, downstream of Clear Cr at seasonal gage

Flow (cfs)	6.57
Water temp. °C, SCT at 25°C	17.9, 484
NO3 (mg/L)	0.18
NO2 (mg/L)*	0.19
Ammonium (mg/L)*	0.03
Phosphate (mg/L)*	0.48
Dissolved silica (mg/L)*	32.78

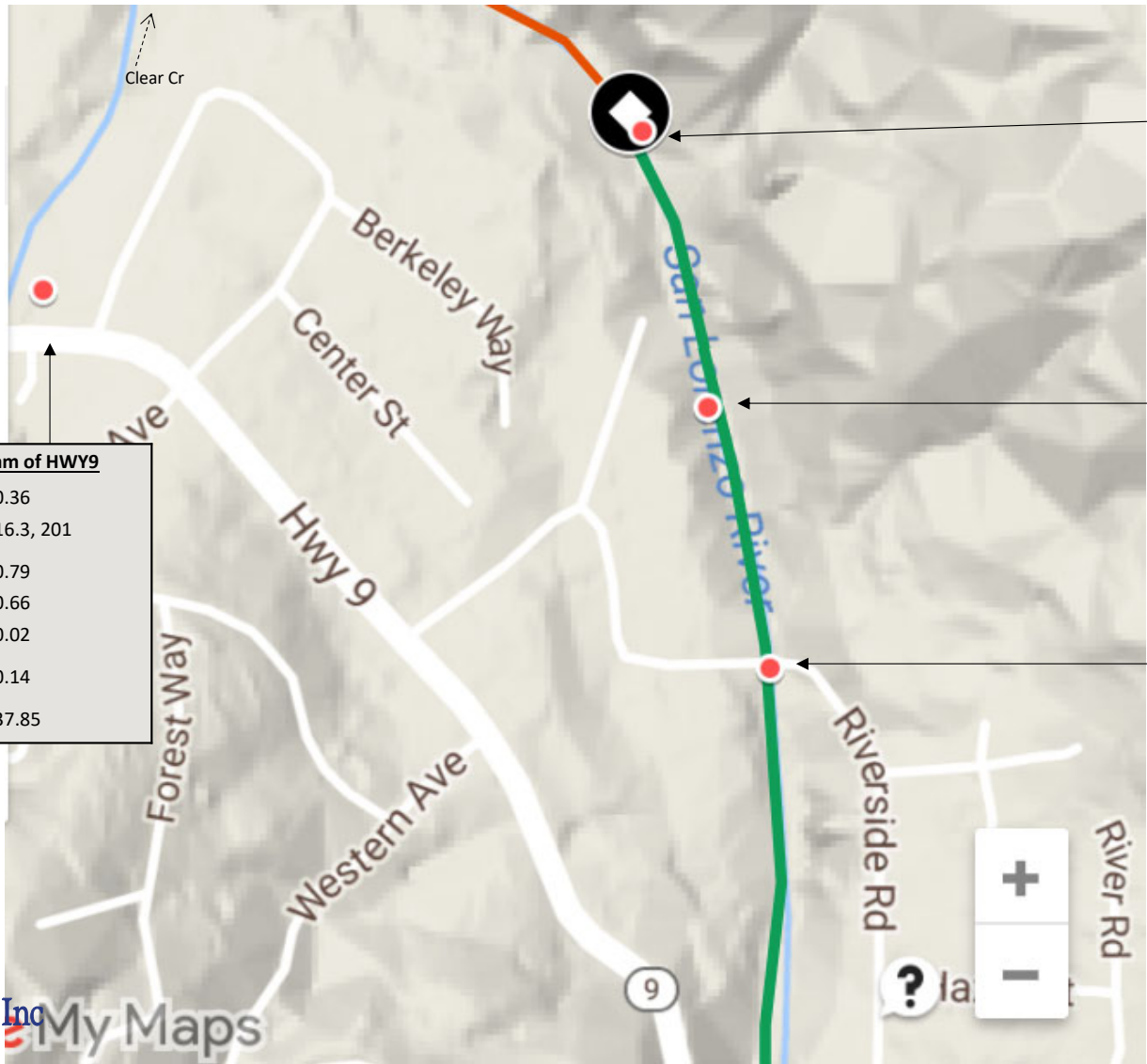
8a# SLR DS Clear Cr: three deep pools (10 ft+) temperature profile 9/28/17

Water temp. °C, SCT at 25°C	14.2 top 14.0 bottom, 374
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*Note: NO2, dissolved silica, ammonium, phosphate are courtesy of UCSC earth science lab. UCSC did paired NO3 analysis with most samples. Results are available in the observation log (Table A1).

Figure 5: Sample locations and results: Brookdale Reach





8# SLR, downstream of Clear Cr at seasonal gage

Flow (cfs)	6.57
Water temp. °C, SCT at 25°C	17.9, 484
NO3 (mg/L)	0.18
NO2 (mg/L)*	0.19
Ammonium (mg/L)*	0.03
Phosphate (mg/L)*	0.48
Dissolved silica (mg/L)*	32.78

8a# SLR DS Clear Cr: three deep pools (10 ft+) temperature profile 9/28/17

Water temp. °C, SCT at 25°C	14.2 top 14.0 bottom, 374
-----------------------------	---------------------------

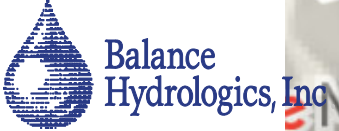
9# Eastern Trib/seep at Larkspur Bridge

Flow (cfs)	0.001
Water temp. °C, SCT at 25°C	-
NO3 (mg/L)	2.45
NO2 (mg/L)*	2.64
Ammonium (mg/L)*	0.02
Phosphate (mg/L)*	0.77
Dissolved silica* (mg/L)	57.92

7# Clear Cr. US of SLR, downstream of HWY9

Flow (cfs)	0.36
Water temp. °C, SCT at 25°C	16.3, 201
NO3 (mg/L)	0.79
NO2 (mg/L)*	0.66
Ammonium (mg/L)*	0.02
Phosphate (mg/L)*	0.14
Dissolved silica (mg/L)*	37.85

Figure 6: Sample locations and results: South Brookdale Reach



*Note: NO2, dissolved silica, ammonium, phosphate are courtesy of UCSC earth science lab. UCSC did paired NO3 analysis with most samples. Results are available in the observation log (Table A1) .

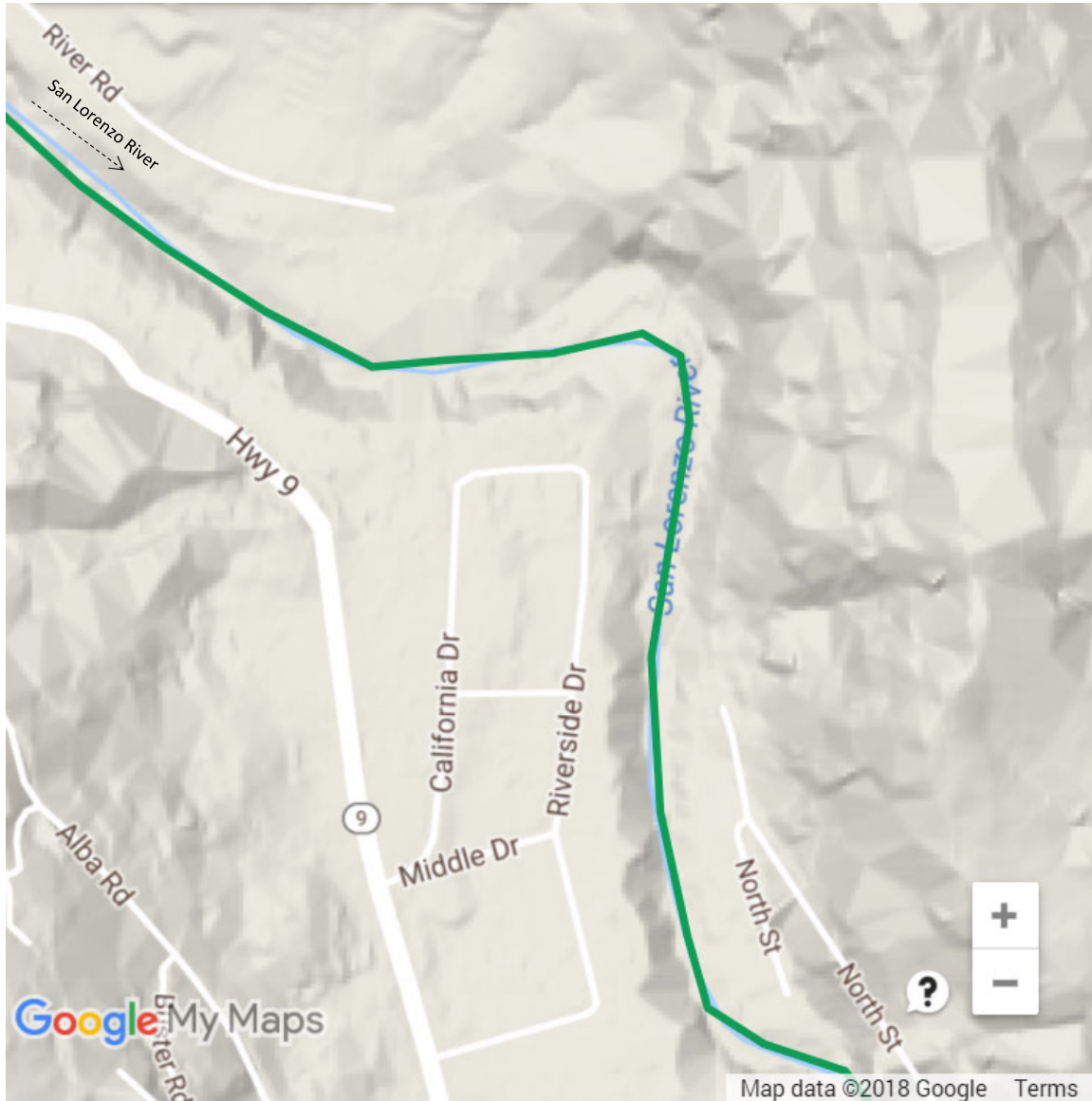


Figure 7: Sample locations and results: California Drive Reach



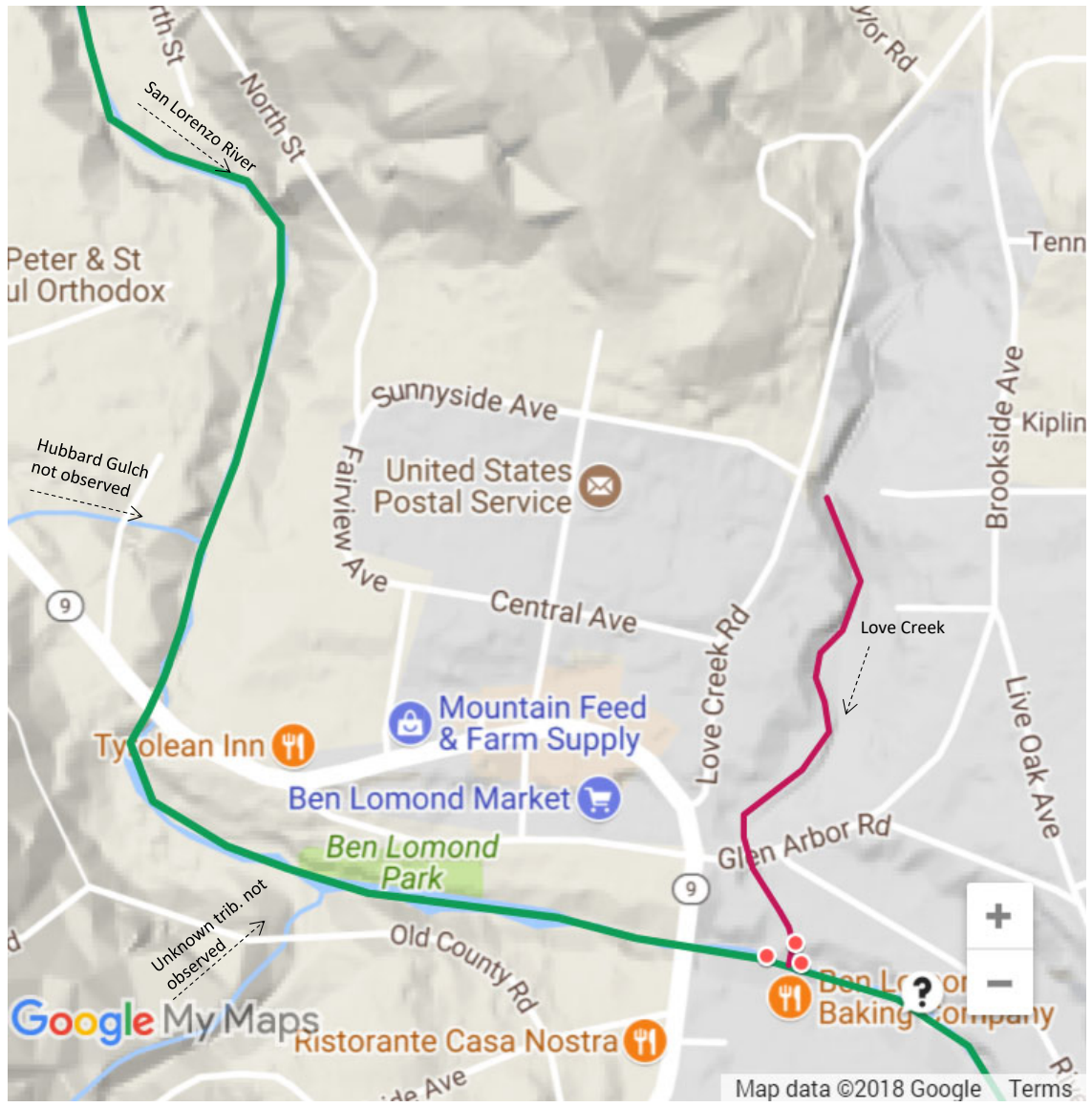
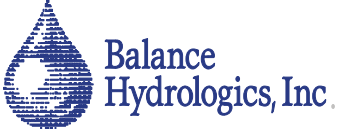


Figure 8: Sample locations and results: Ben Lomond Reach



*Note: NO2, dissolved silica, ammonium, phosphate are courtesy of UCSC earth science lab. UCSC did paired NO3 analysis with most samples. Results are available in the observation log (Table A1).

10# SLR, 75 ft upstream of Love Cr	
Flow (cfs)	6.82
Water temp. °C, SCT at 25°C	17.8, 466
NO3 (mg/L)	0.46
NO2 (mg/L)*	0.44
Ammonium (mg/L)*	0.03
Phosphate (mg/L)*	0.51
Dissolved silica (mg/L)*	34.35

11# Love Cr 50 ft. upstream of SLR	
Flow (cfs)	0.48
Water temp. °C, SCT at 25°C	16.2, 412
NO3 (mg/L)	0.43
NO2 (mg/L)*	0.60
Ammonium (mg/L)*	0.01
Phosphate (mg/L)*	1.42
Dissolved silica (mg/L)*	51.75

12# SLR, 20 ft downstream of Love Cr	
Flow (cfs)	7.3 (estimate)
NO3 (mg/L)	0.35
NO2 (mg/L)*	0.47
Ammonium (mg/L)*	0.03
Phosphate (mg/L)*	0.71
Dissolved silica (mg/L)*	38.31

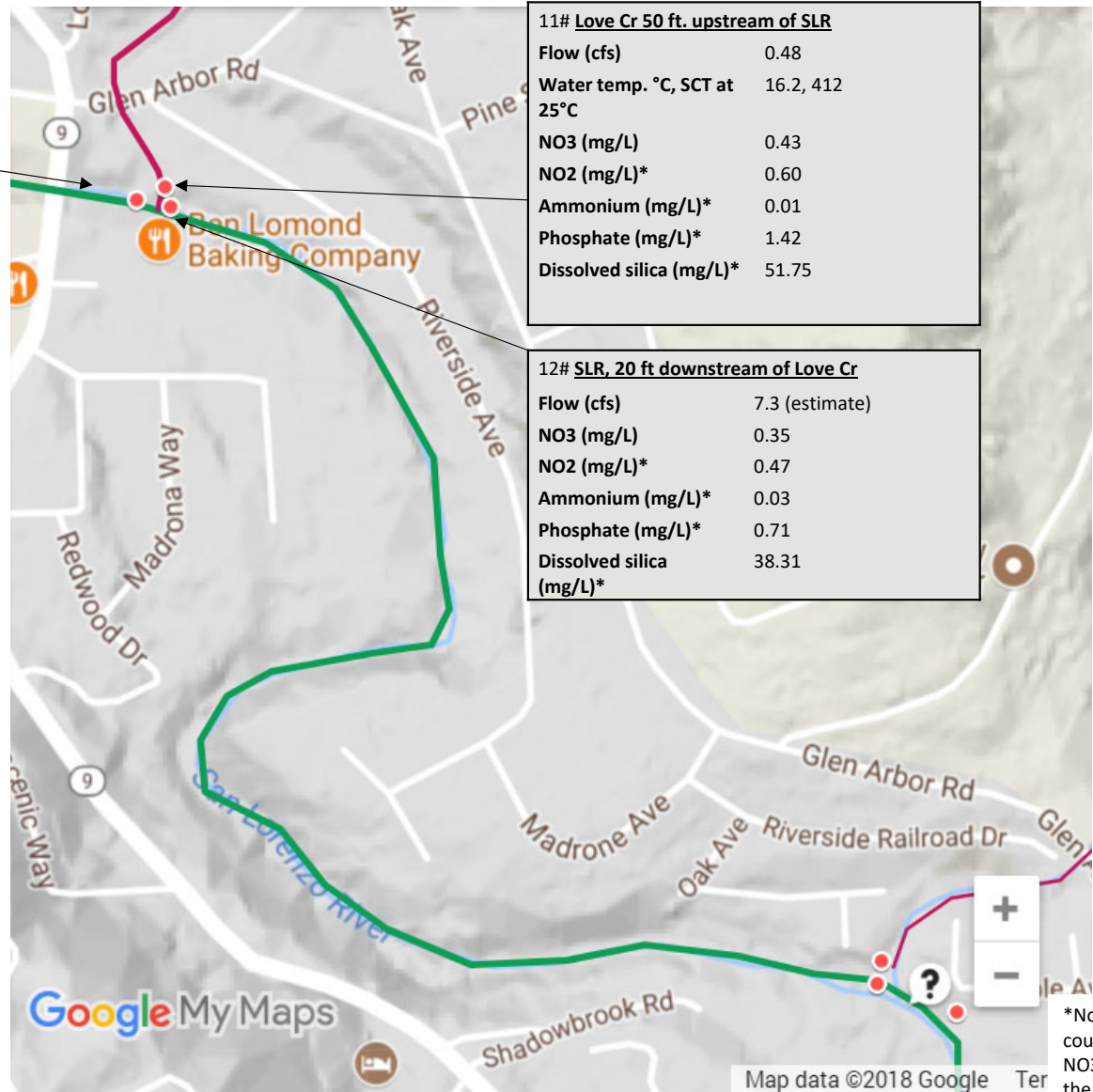


Figure 9: Sample locations and results: Glen Arbor Reach (1 of 2)



*Note: NO2, dissolved silica, ammonium, phosphate are courtesy of UCSC earth science lab. UCSC did paired NO3 analysis with most samples. Results are available in the observation log (Table A1).

16# Newell Creek just upstream of the confluence with the SLR

Flow (cfs)	2.71
Water temp. °C, SCT at 25°C	15, 291
NO3 (mg/L)	6.91
NO2 (mg/L)*	7.66
Ammonium (mg/L)*	0.03
Phosphate (mg/L)*	2.02
Dissolved silica (mg/L)*	41.34

13# SLR, 40 ft upstream of Newell Cr

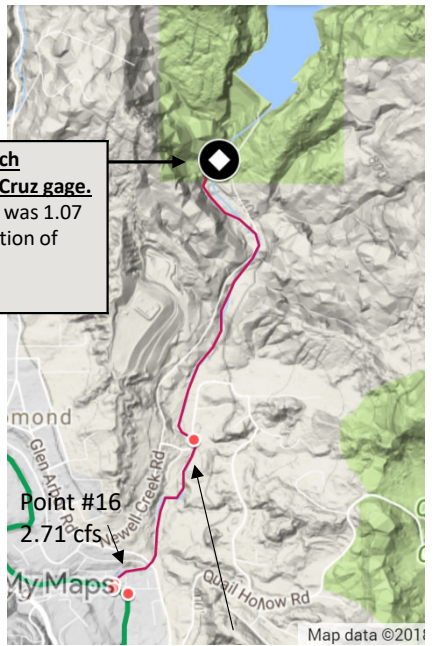
Flow (cfs)	8.93
Water temp. °C, SCT at 25°C	17.2, 449
NO3 (mg/L)	2.59
NO2 (mg/L)	2.96
Ammonium (mg/L)	0.01
Phosphate (mg/L)	0.63
Dissolved silica (mg/L)	35.17

17# SLR, 200 ft downstream of Newell Cr

Flow (cfs)	-
Water temp. °C, SCT at 25°C	-
NO3 (mg/L)	3.18
NO2 (mg/L)*	3.62
Ammonium (mg/L)*	0.03
Phosphate (mg/L)*	0.85
Dissolved silica (mg/L)*	36.28

15# Newell Cr DS of Loch Lomond, City of Santa Cruz gage.
average for September was 1.07 cfs with standard deviation of 0.01 cfs

Flow (cfs)	1.07
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14# Newell Cr at Rancho Rio Bridge. Follow-up measurement 9/19/18 after main water quality sampling.

Flow (cfs)	1.25
Water temp. °C, SCT at 25°C	15.7, 355
NO3 (mg/L)	0.98
NO2 (mg/L)*	1.09
Ammonium (mg/L)*	0.01
Phosphate (mg/L)*	0.51
Dissolved silica (mg/L)*	33.43

*Note: NO2, dissolved silica, ammonium, phosphate are courtesy of UCSC earth science lab. UCSC did paired NO3 analysis with most samples. Results are available in the observation log (Table A1) .



Figure 10: Sample locations and results: Glen Arbor Reach (2 of 2)



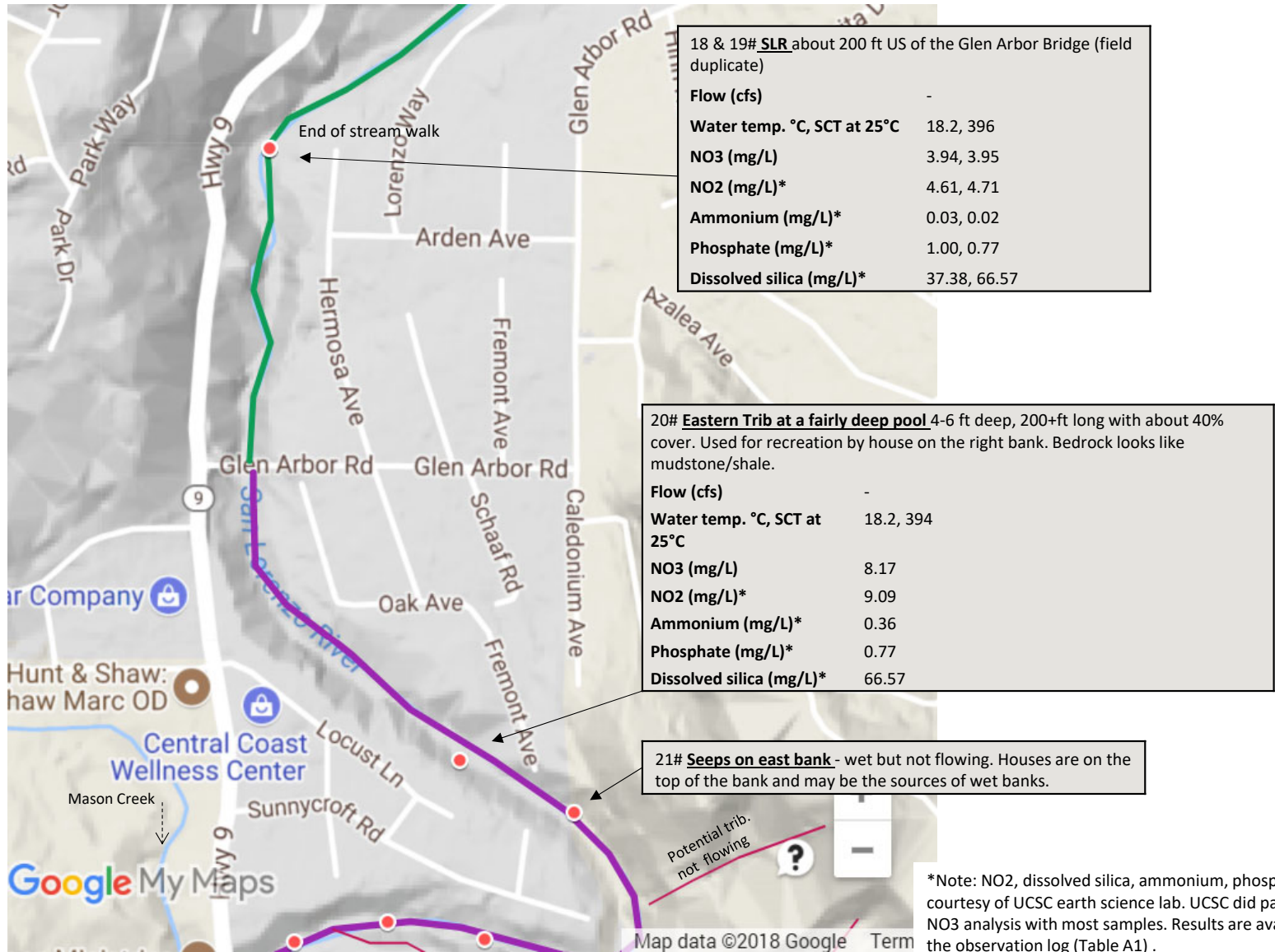
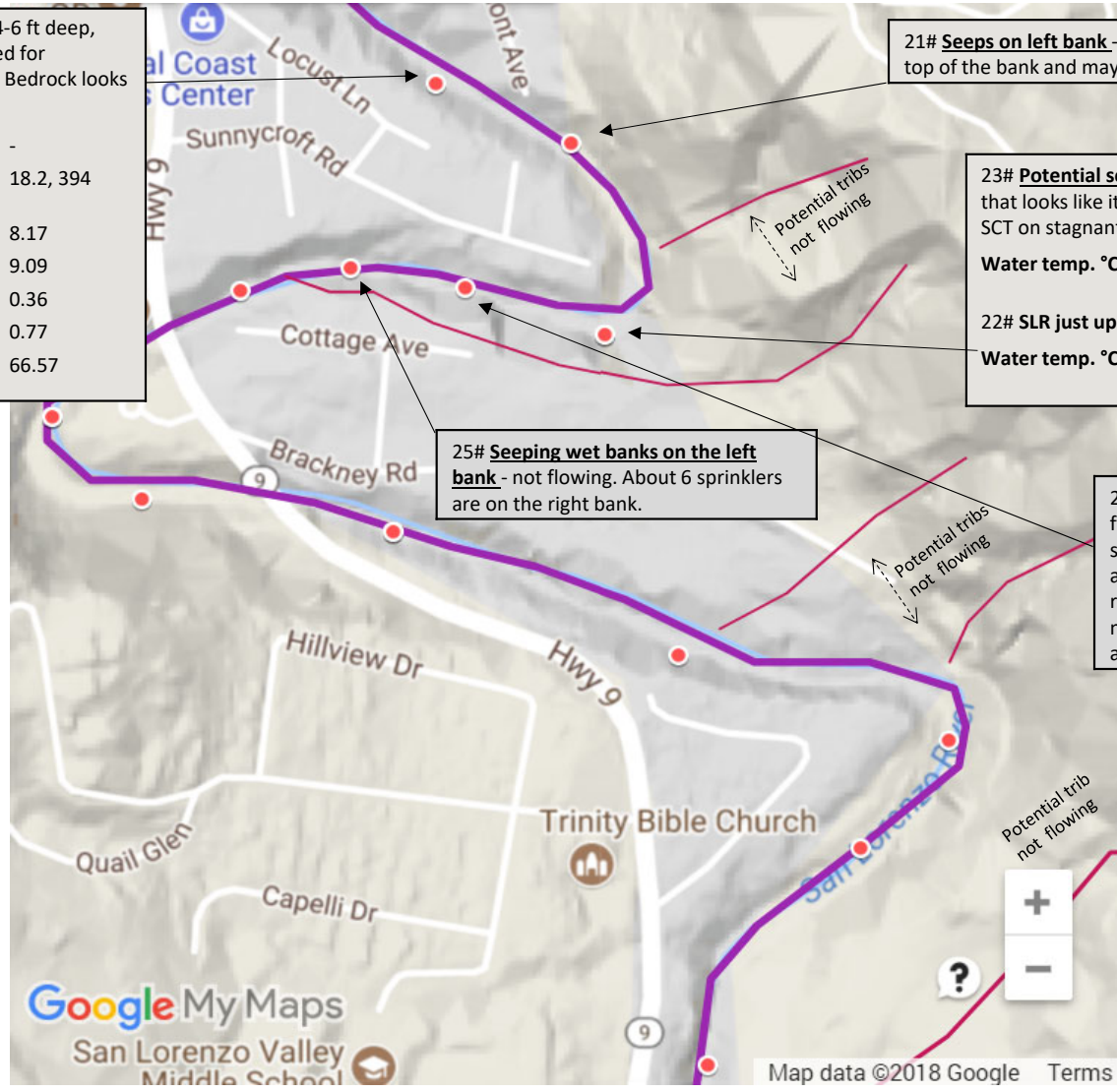


Figure 11: Sample locations and results: Sunnycroft Reach



20# **Eastern Trib** at a fairly deep pool 4-6 ft deep, 200+ft long with about 40% cover. Used for recreation by house on the right bank. Bedrock looks like mudstone/shale.

Flow (cfs)	-
Water temp. °C, SCT at 25°C	18.2, 394
NO3 (mg/L)	8.17
NO2 (mg/L)*	9.09
Ammonium (mg/L)*	0.36
Phosphate (mg/L)*	0.77
Dissolved silica (mg/L)*	66.57



21# **Seeps on left bank** - wet but not flowing. Houses are on the top of the bank and may be the sources of wet banks.

23# **Potential seep** at Sharp bend in stream path with Tsm outcrop that looks like it should be flowing with staining/mottling. Measured SCT on stagnant pond in the outcrop face.
 Water temp. °C, SCT at 25°C 16.4, 711

22# **SLR just upstream of Tsm outcrop**
 Water temp. °C, SCT at 25°C 18.1, 397

25# **Seeping wet banks on the left bank** - not flowing. About 6 sprinklers are on the right bank.

24# **SLR pool** about 300 ft long about 3 ft deep average, 40 ft wide. Mostly sand bottom. Fairly exposed to sun and appears to be used frequently for recreation. Upstream end has wet and not flowing Tsm exposed to about 6 ft above current water level.

Figure 12: Sample locations and results: Brackney Reach (1 of 2)



*Note: NO2, dissolved silica, ammonium, phosphate are courtesy of UCSC earth science lab. UCSC did paired NO3 analysis with most samples. Results are available in the observation log (Table A1).

28# Manson Cr just US of SLR and the bedrock pool

Flow (cfs)	0.14
Water temp. °C, SCT at 25°C	17.9, 395
NO3 (mg/L)*	0.50
NO2 (mg/L)*	0.25
Ammonium (mg/L)*	0.01
Phosphate (mg/L)*	1.00
Dissolved silica (mg/L)*	50.92

27# SLR US of Manson Cr

NO3 (mg/L)	3.77
NO2 (mg/L)*	4.52
Ammonium (mg/L)*	0.03
Phosphate (mg/L)*	0.97
Dissolved silica (mg/L)*	36.74

30# Seep on right bank (west side of SLR) upstream of tall Tsm outcrop.

Flow (cfs)	0.0022
Water temp. °C, SCT at 25°C	15.3, 458
NO3 (mg/L)*	2.15
NO2 (mg/L)*	2.47
Ammonium (mg/L)*	0.00
Phosphate (mg/L)*	5.80
Dissolved silica (mg/L)*	591.00

29# SLR 6-7ft deep pool at bedrock notch at seep about 150 ft long, 30 ft wide. Not stratified.
Water temperature °C 17.9C

33# Seep with ponded water on stream bank about 1 ft deep, 4 ft wide, 12 ft long. WQ sampled however may not be representative of flowing water.

Water temp. °C, SCT at 25°C	16, 276
NO3 (mg/L)	0.31
NO2 (mg/L)*	0.36
Ammonium (mg/L)*	0.16
Phosphate (mg/L)*	0.17
Dissolved silica (mg/L)*	43.19

31# SLR Tsm Tm contact about 50 ft DS of bridge. Can see 200 ft+ tall white sand out crop on right bank upstream - no wet or seeping features.

Water temp. °C, SCT at 25°C	17.8, 398
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34# No Tsm trib as expected based on topo

Water temp. °C, SCT at 25°C	17.6, 401
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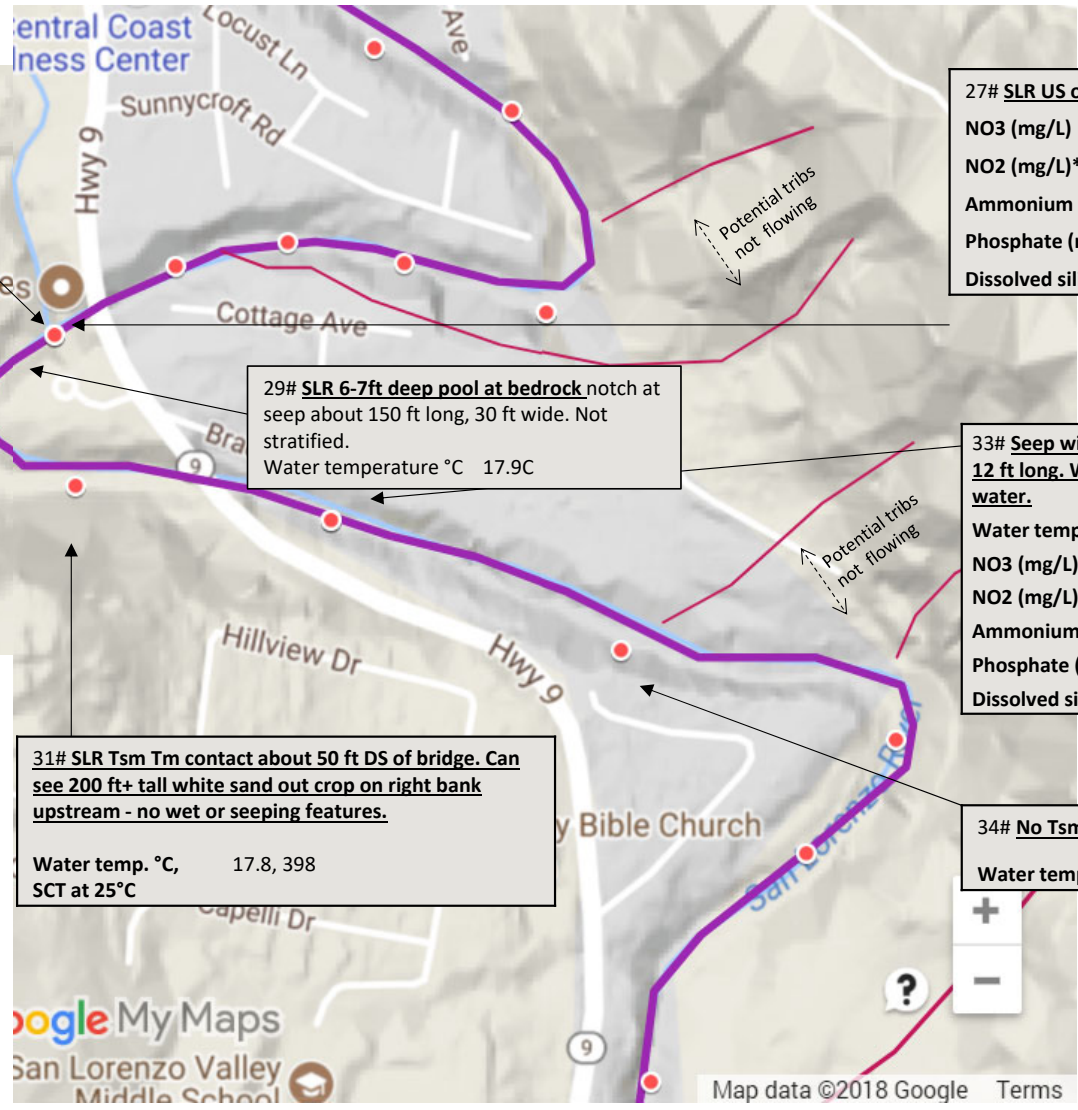
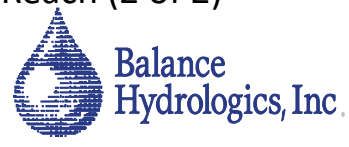
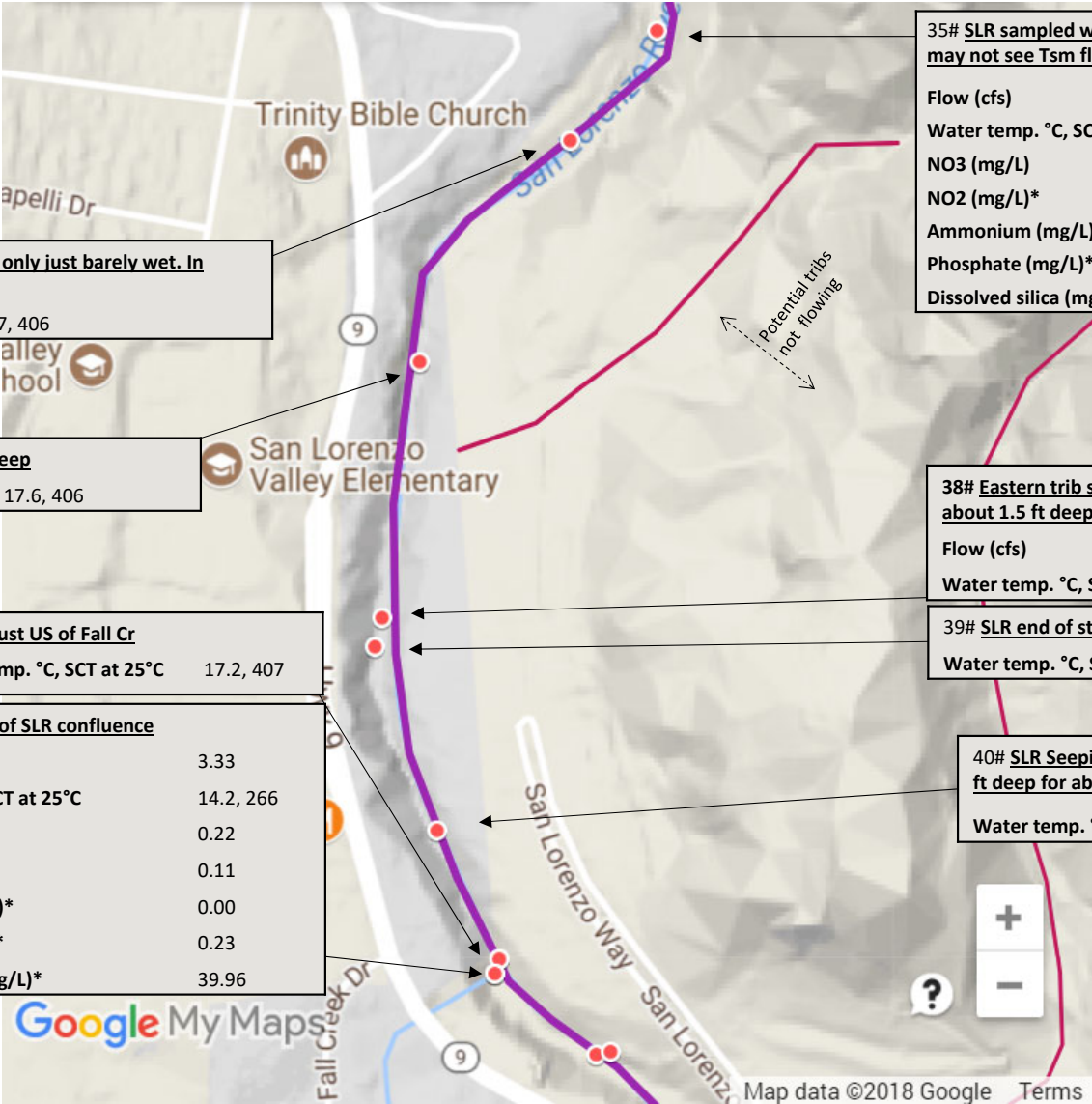


Figure 13: Sample locations and results: Brackney Reach (2 of 2)



*Note: NO2, dissolved silica, ammonium, phosphate are courtesy of UCSC earth science lab. UCSC did paired NO3 analysis with most samples. Results are available in the observation log (Table A1).



35# SLR sampled water quality. Concerned we may not see Tsm flowing tribs as expected.

Flow (cfs)	11.97
Water temp. °C, SCT at 25°C	17.5, 403
NO3 (mg/L)	3.43
NO2 (mg/L)*	4.15
Ammonium (mg/L)*	0.03
Phosphate (mg/L)*	0.94
Dissolved silica (mg/L)*	37.11

36# Vertical Tsm exposed face. No flow only just barely wet. In another 1.5 ft long deep run.

Water temp. °C, SCT at 25°C	17.7, 406
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37# SLR end of long run about 1.2 ft deep

Water temp. °C, SCT at 25°C	17.6, 406
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38# Eastern trib seep. Possibly Tsm. Start another long run about 1.5 ft deep

Flow (cfs)	-
Water temp. °C, SCT at 25°C	17.3, 403

39# SLR end of steep banks and run

Water temp. °C, SCT at 25°C	17.3, 406
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42# SLR just US of Fall Cr

Water temp. °C, SCT at 25°C	17.2, 407
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44# Fall Cr just US of SLR confluence

Flow (cfs)	3.33
Water temp. °C, SCT at 25°C	14.2, 266
NO3 (mg/L)	0.22
NO2 (mg/L)*	0.11
Ammonium (mg/L)*	0.00
Phosphate (mg/L)*	0.23
Dissolved silica (mg/L)*	39.96

40# SLR Seeping steep banks start US of Fall Cr. Long run about 1.5 ft deep for about 200 ft.

Water temp. °C, SCT at 25°C	17.1, 408
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Figure 14:
Sample locations and results:
Highschool Reach



*Note: NO2, dissolved silica, ammonium, phosphate are courtesy of UCSC earth science lab. UCSC did paired NO3 analysis with most samples. Results are available in the observation log (Table A1).

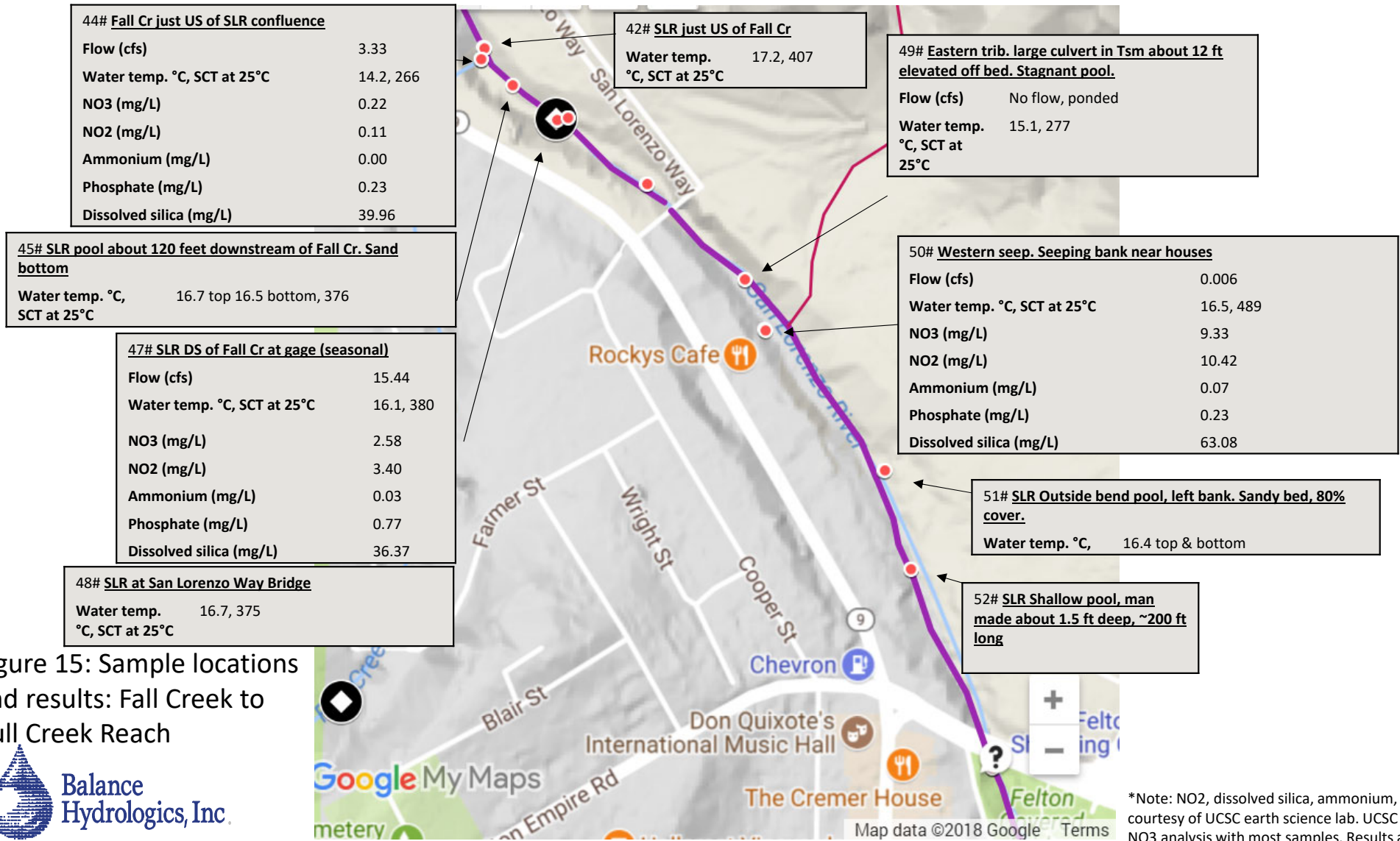
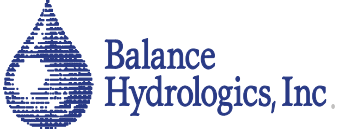
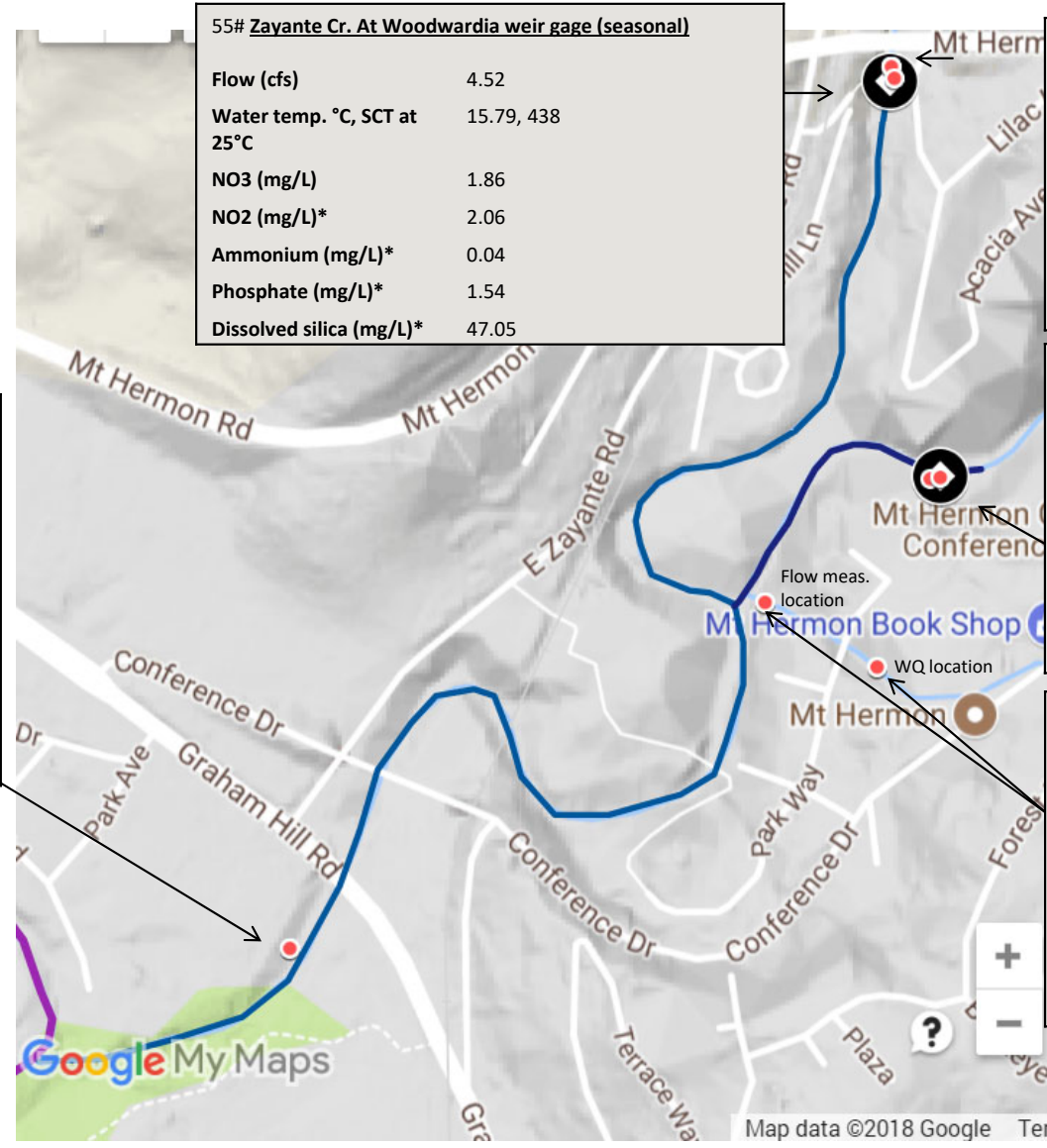
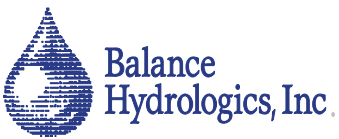


Figure 15: Sample locations and results: Fall Creek to Bull Creek Reach



*Note: NO2, dissolved silica, ammonium, phosphate are courtesy of UCSC earth science lab. UCSC did paired NO3 analysis with most samples. Results are available in the observation log (Table A1).



55# Zayante Cr. At Woodwardia weir gage (seasonal)

Flow (cfs)	4.52
Water temp. °C, SCT at 25°C	15.79, 438
NO3 (mg/L)	1.86
NO2 (mg/L)*	2.06
Ammonium (mg/L)*	0.04
Phosphate (mg/L)*	1.54
Dissolved silica (mg/L)*	47.05

56# Tsm trib at Zayante Woodwardia weir

Flow (cfs)	0.004
Water temp. °C, SCT at 25°C	15.1, 133
NO3 (mg/L)	2.15
NO2 (mg/L)*	2.87
Ammonium (mg/L)*	0.03
Phosphate (mg/L)*	1.94
Dissolved silica (mg/L)*	46.04

57# Zayante Cr US SLR, 300 ft DS of Graham Hill Rd

Flow (cfs)	9.31
Water temp. °C, SCT at 25°C	15.7, 427
NO3 (mg/L)	2.94
NO2 (mg/L)*	3.34
Ammonium (mg/L)*	0.02
Phosphate (mg/L)*	1.94
Dissolved silica (mg/L)*	54.60

59# Bean Cr. At Mnt Hermon gage (seasonal)

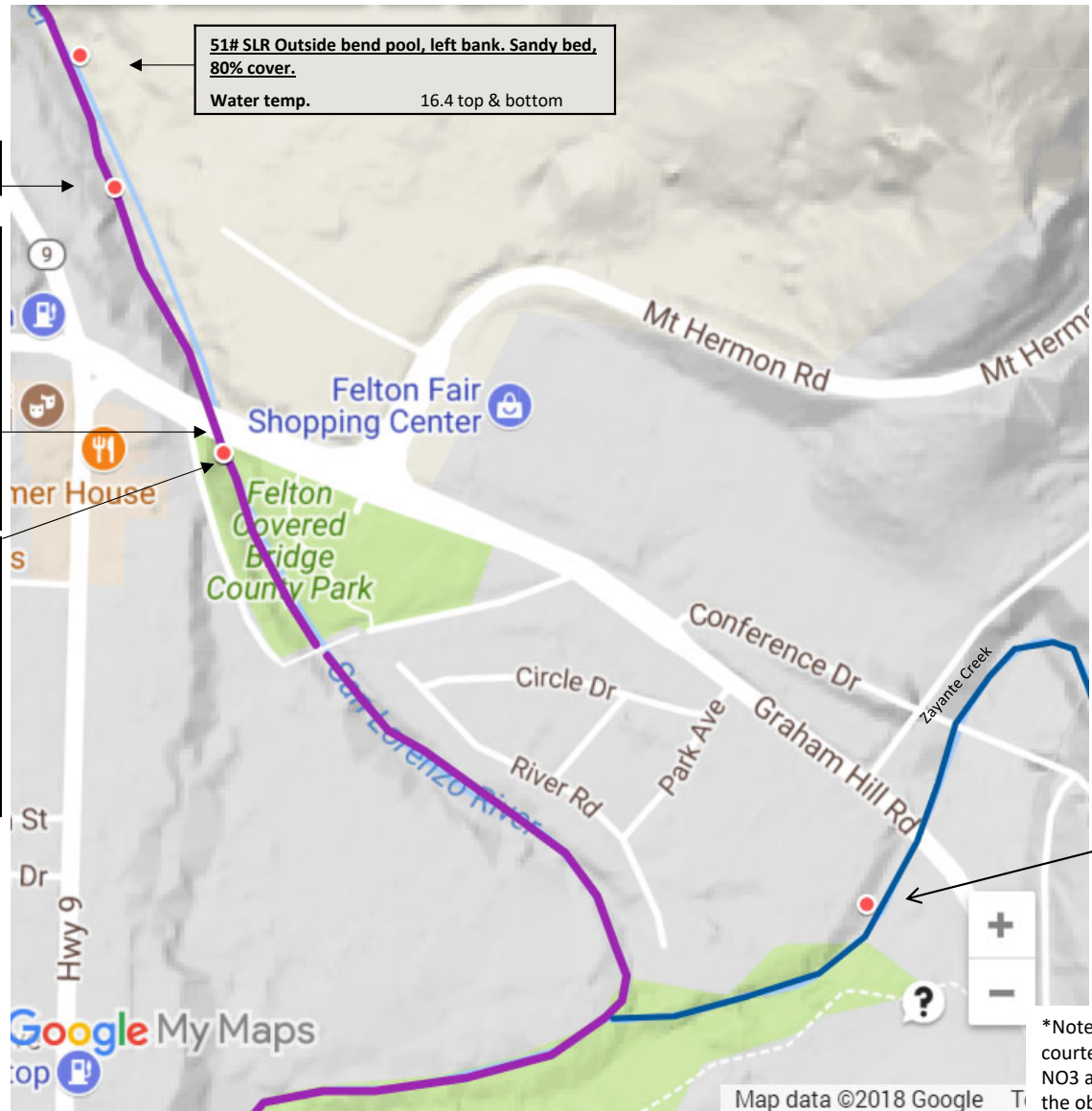
Flow (cfs)	3.71
Water temp. °C, SCT at 25°C	14.5, 409
NO3 (mg/L)	2.86
NO2 (mg/L)*	3.29
Ammonium (mg/L)*	0.03
Phosphate (mg/L)*	2.28
Dissolved silica (mg/L)*	60.31

60# Ferndell Cr at Mnt Hermon

Flow (cfs)	0.33
Water temp. °C, SCT at 25°C	15, 204
NO3 (mg/L)	10.01
NO2 (mg/L)*	11.86
Ammonium (mg/L)*	0.01
Phosphate (mg/L)*	3.13
Dissolved silica (mg/L)*	49.54

Figure 16: Sample locations and results: Lower Zayante and Bean Creeks Reach

*Note: NO2, dissolved silica, ammonium, phosphate are courtesy of UCSC earth science lab. UCSC did paired NO3 analysis with most samples. Results are available in the observation log (Table A1).



51# SLR Outside bend pool, left bank. Sandy bed, 80% cover.
 Water temp. 16.4 top & bottom

52# SLR Shallow pool, man made about 1.5 ft deep, ~200 ft long

53# SLR US of Bull Cr

Flow (cfs)	15.61
Water temp, SCT 25C	16.3C, 374uS
NO3	2.51 mg/L
NO2*	3.35 mg/L
Ammonium*	0.01 mg/L
Phosphate*	0.77 mg/L
Dissolved silica*	38.03 mg/L

54# Bull Cr at HWY9 Graham Hill Rd overpass,

Flow (cfs)	0.56
Water temp, SCT 25C	14.7C, 402 uS
NO3 (mg/L)	0.94 mg/L
NO2 (mg/L)*	0.51 mg/L
Ammonium (mg/L)*	0.00 mg/L
Phosphate (mg/L)*	0.31 mg/L
Dissolved silica (mg/L)*	41.80

57# Zayante Cr US SLR, 300 ft DS of Gram Hill Rd

Flow (cfs)	9.31
Water temp. °C, SCT at 25°C	15.7, 427
NO3 (mg/L)	2.94
NO2 (mg/L)*	3.34
Ammonium (mg/L)*	0.02
Phosphate (mg/L)*	1.94
Dissolved silica (mg/L)*	54.60

*Note: NO2, dissolved silica, ammonium, phosphate are courtesy of UCSC earth science lab. UCSC did paired NO3 analysis with most samples. Results are available in the observation log (Table A1) .

Figure 17: Sample locations and results: Fall to Bull Creek Reach



53# SLR US of Bull Cr

Flow (cfs)	15.61
Water temp, SCT 25C	16.3C, 374uS
NO3	2.51 mg/L
NO2*	3.35 mg/L
Ammonium*	0.01 mg/L
Phosphate*	0.77 mg/L
Dissolved silica*	38.03 mg/L

54# Bull Cr, western trib at HWY9 Gram Hill Rd overpass

Flow (cfs)	0.56 (15-min record)
Water temp. °C, SCT at 25°C	14.7, 402
NO3 (mg/L)	0.94
NO2 (mg/L)*	0.51
Ammonium (mg/L)*	0.00
Phosphate (mg/L)*	0.31
Dissolved silica (mg/L)*	41.80

57# Zayante Cr US SLR, 300 ft DS of Gram Hill Rd

Flow (cfs)	9.31
Water temp. °C, SCT at 25°C	15.7, 427
NO3 (mg/L)	2.94
NO2 (mg/L)	3.34
Ammonium (mg/L)	0.02
Phosphate (mg/L)	1.94
Dissolved silica (mg/L)	54.60

61# SLR DS Big Trees gage just DS dam

Flow (cfs)	25.5
Water temp. °C, SCT at 25°C	15.7, 395
NO3 (mg/L)	2.44
NO2 (mg/L)	3.20
Ammonium (mg/L)	0.01
Phosphate (mg/L)	1.11
Dissolved silica (mg/L)	43.28

Site: #62, SLR DS Big Trees gage at bridge
 SCT at 25C : 392 uS, Water temperature: 15.7C

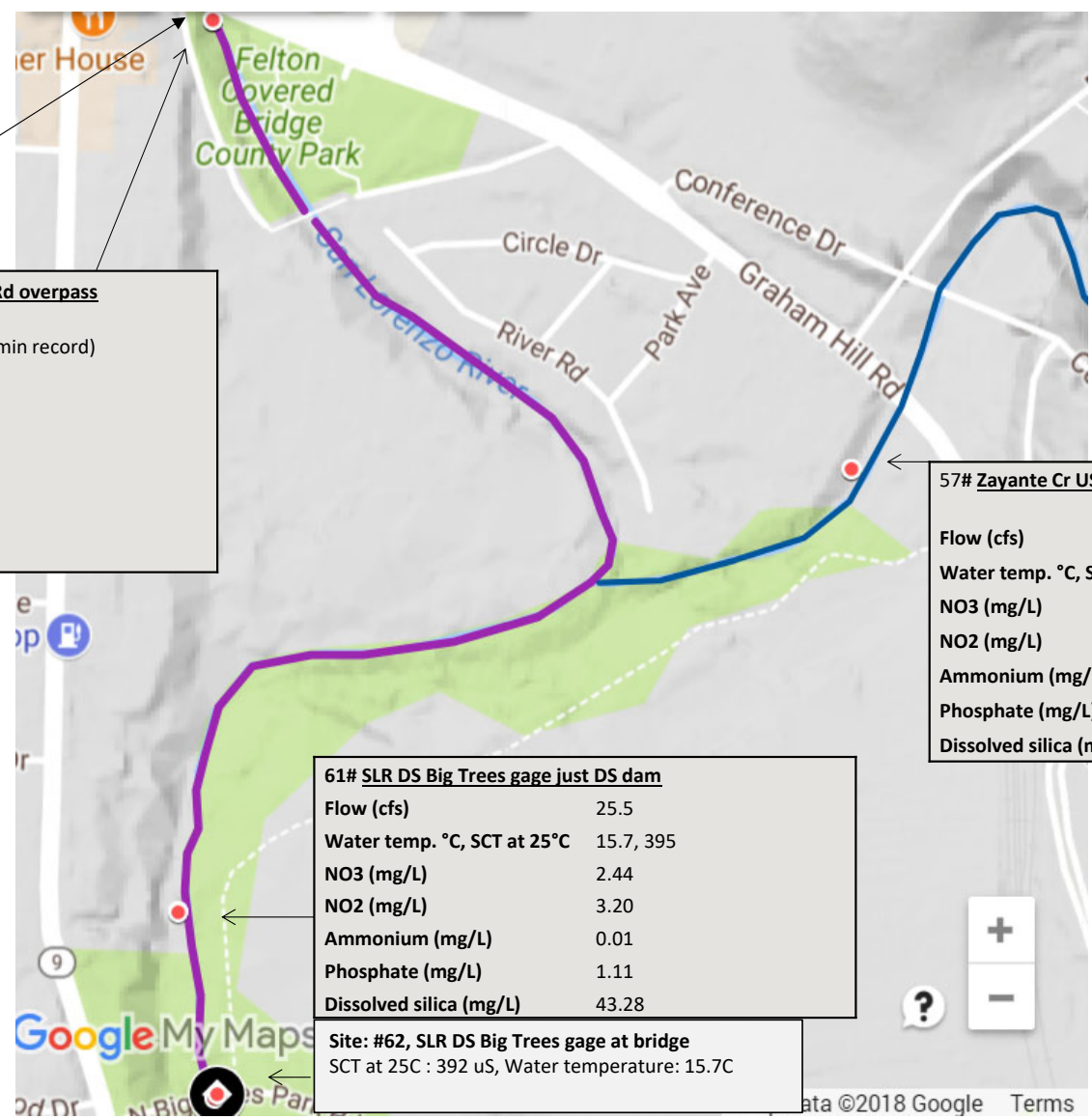


Figure 18: Sample locations and results: Bull Creek to Big Tress Reach



*Note: NO2, dissolved silica, ammonium, phosphate are courtesy of UCSC earth science lab. UCSC did paired NO3 analysis with most samples. Results are available in the observation log (Table A1) .

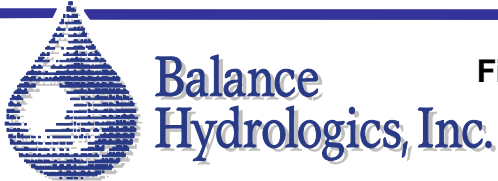
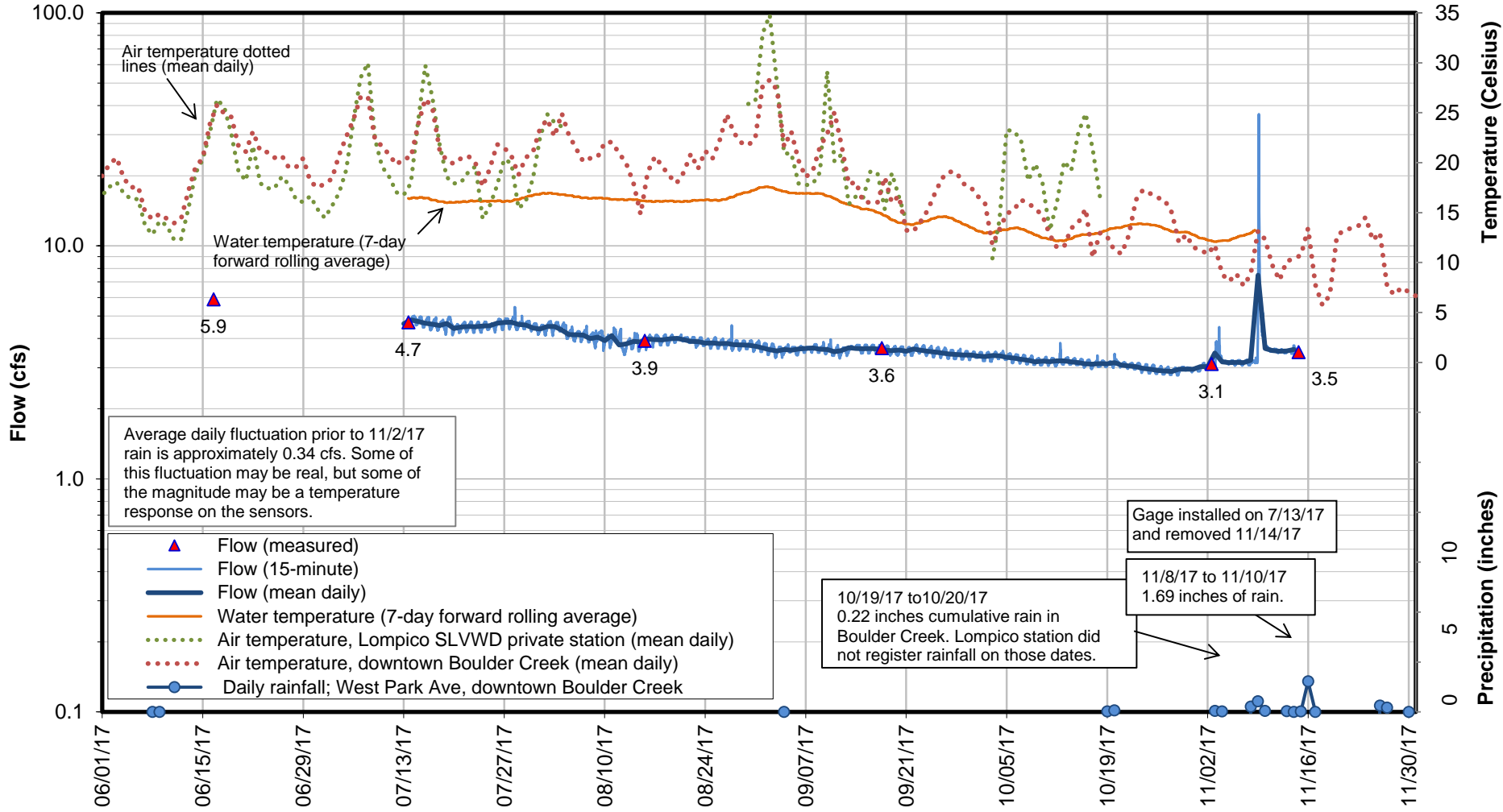


Figure 19. Flow, temperature, and precipitation: Bean Creek gage above mouth at Mount Hermon, Santa Cruz County, California, water year 2017 to 2018 (partial).

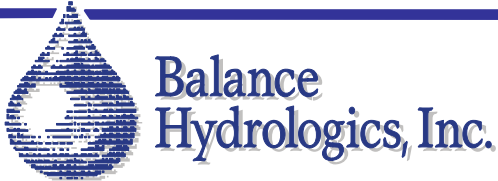
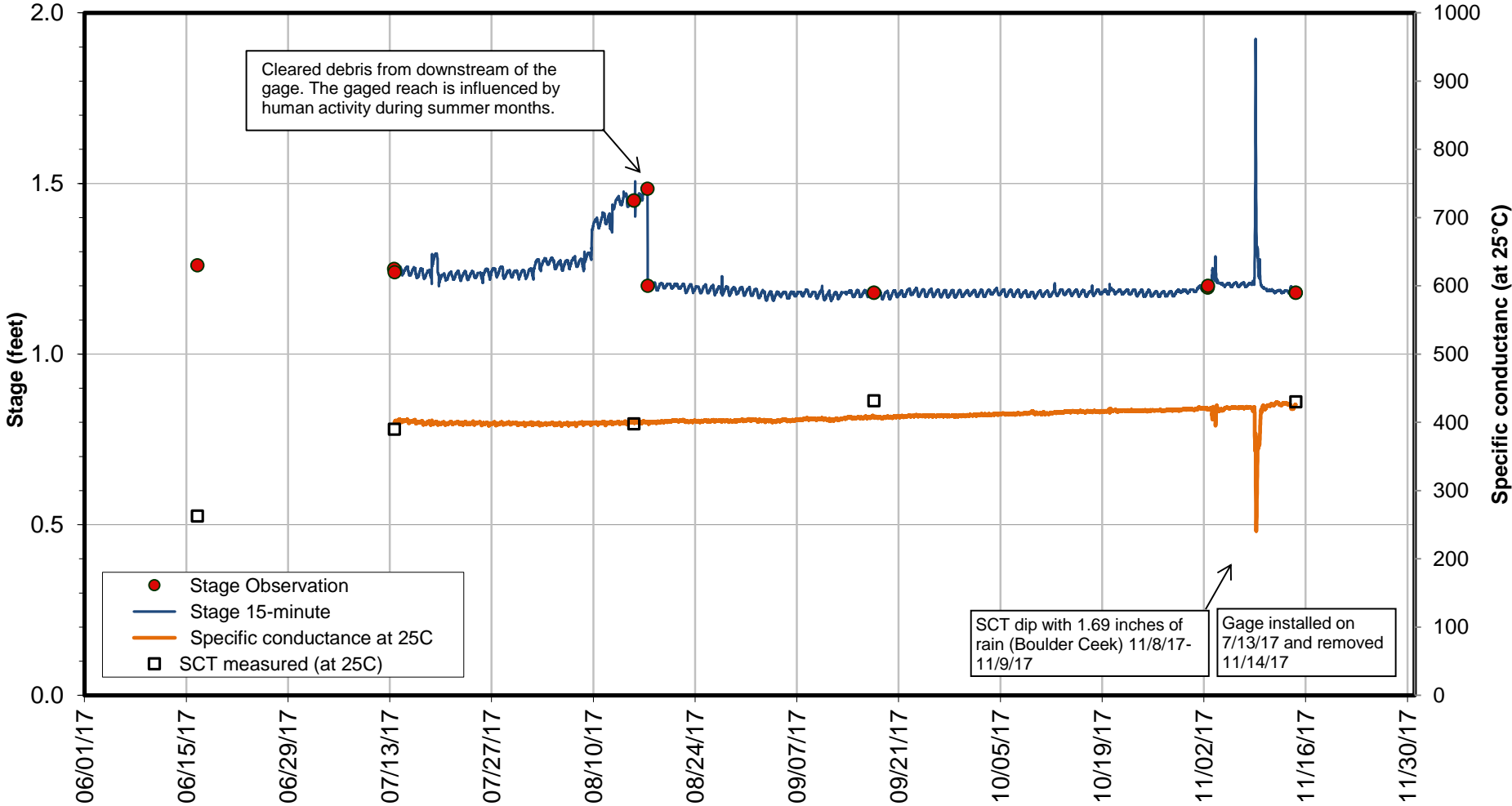


Figure 20. Stage and specific conductance: Bean Creek gage above mouth at Mount Hermon, Santa Cruz County, California, water year 2017 and 2018 (partial).

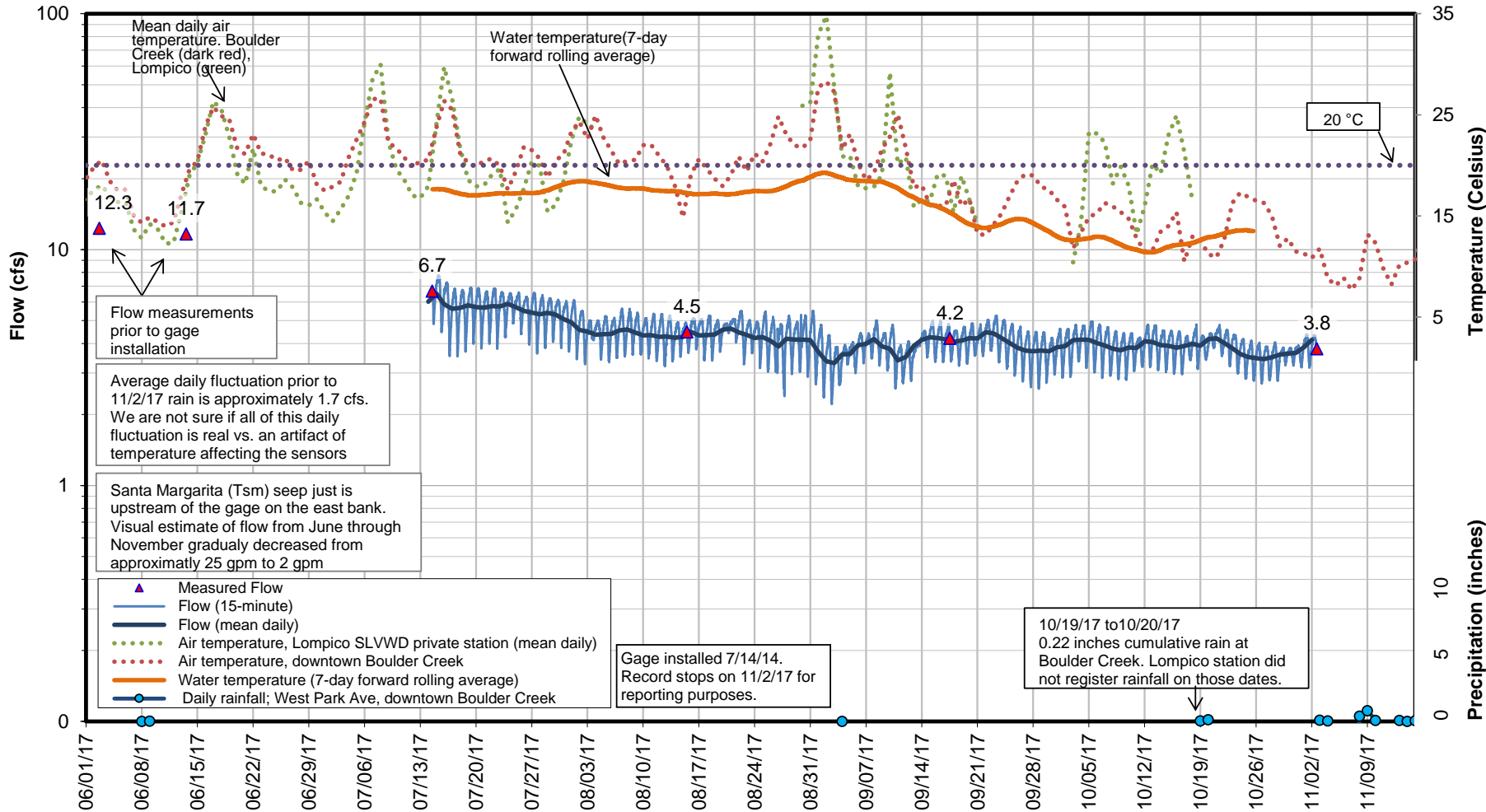
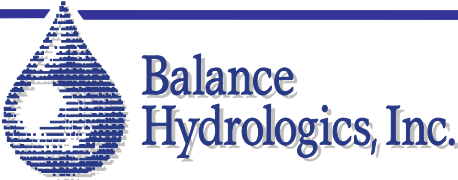


Figure 21. Flow, temperature, and precipitation: Zayante Creek at Woodwardia, Santa Cruz County, California, water year 2017 to 2018 (partial).



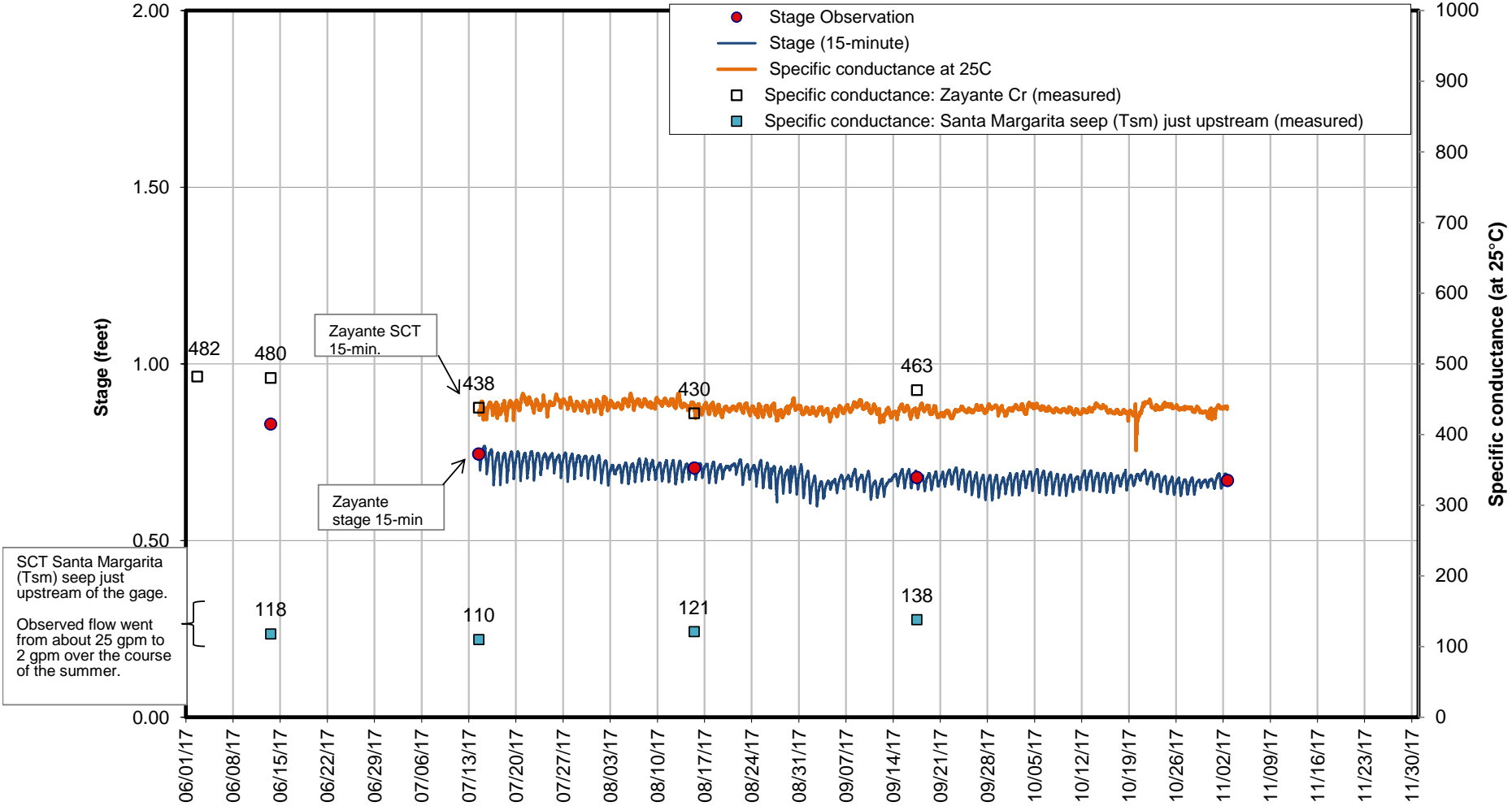


Figure 22. Stage and specific conductance: Zayante Creek at Woodwardia weir, Santa Cruz County, California, water year 2017 to 2018 (partial).



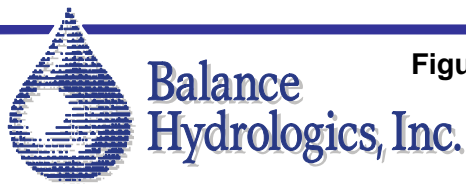
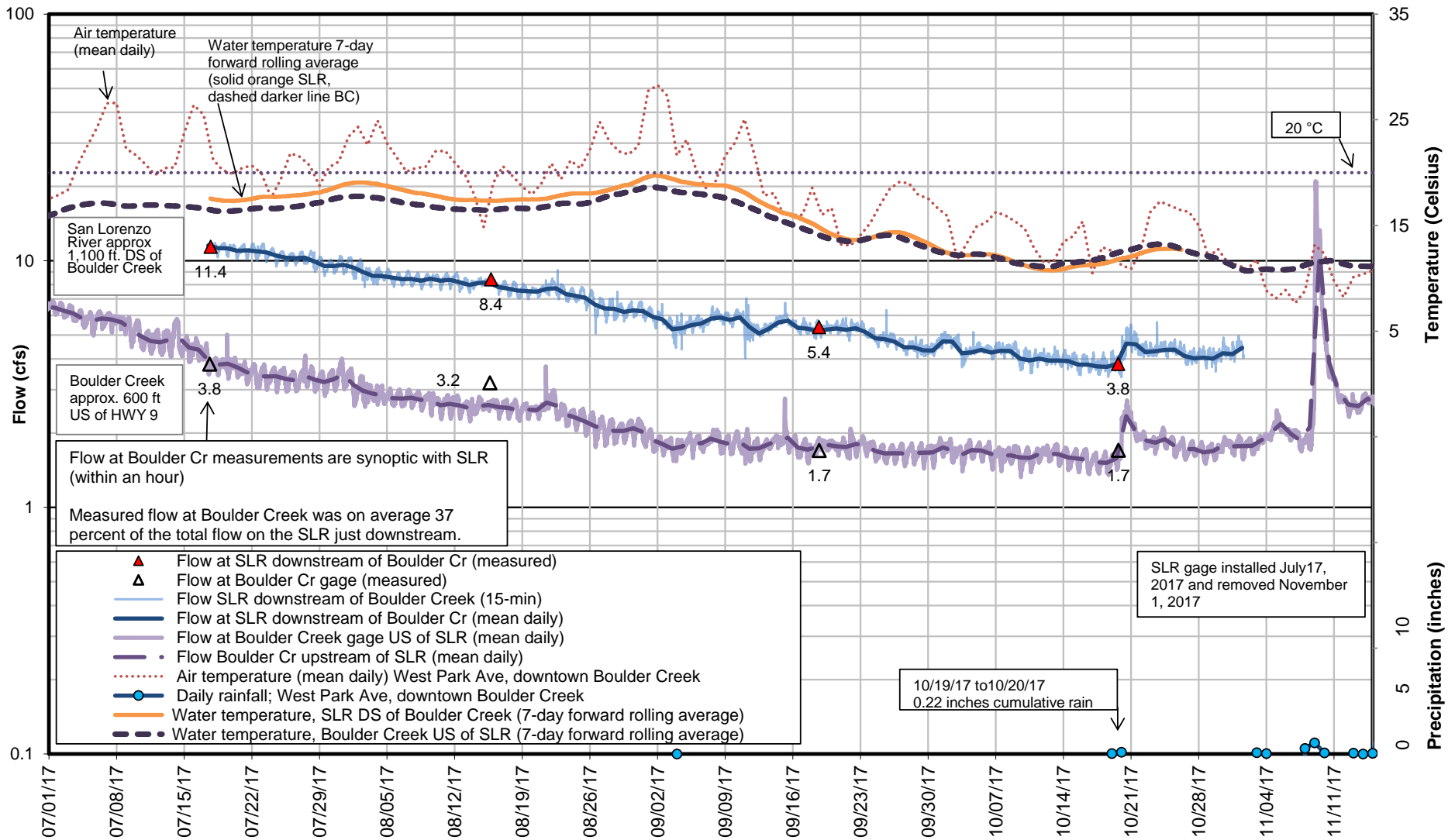


Figure 23: Flow, temperature, and precipitation; Boulder Creek upstream of HWY 9 and San Lorenzo River downstream of Boulder Creek, Santa Cruz County, CA, water year 2017 to 2018 (partial)

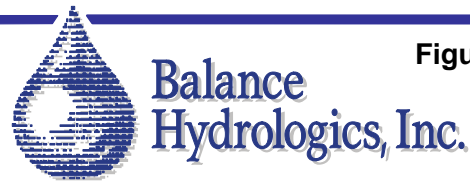
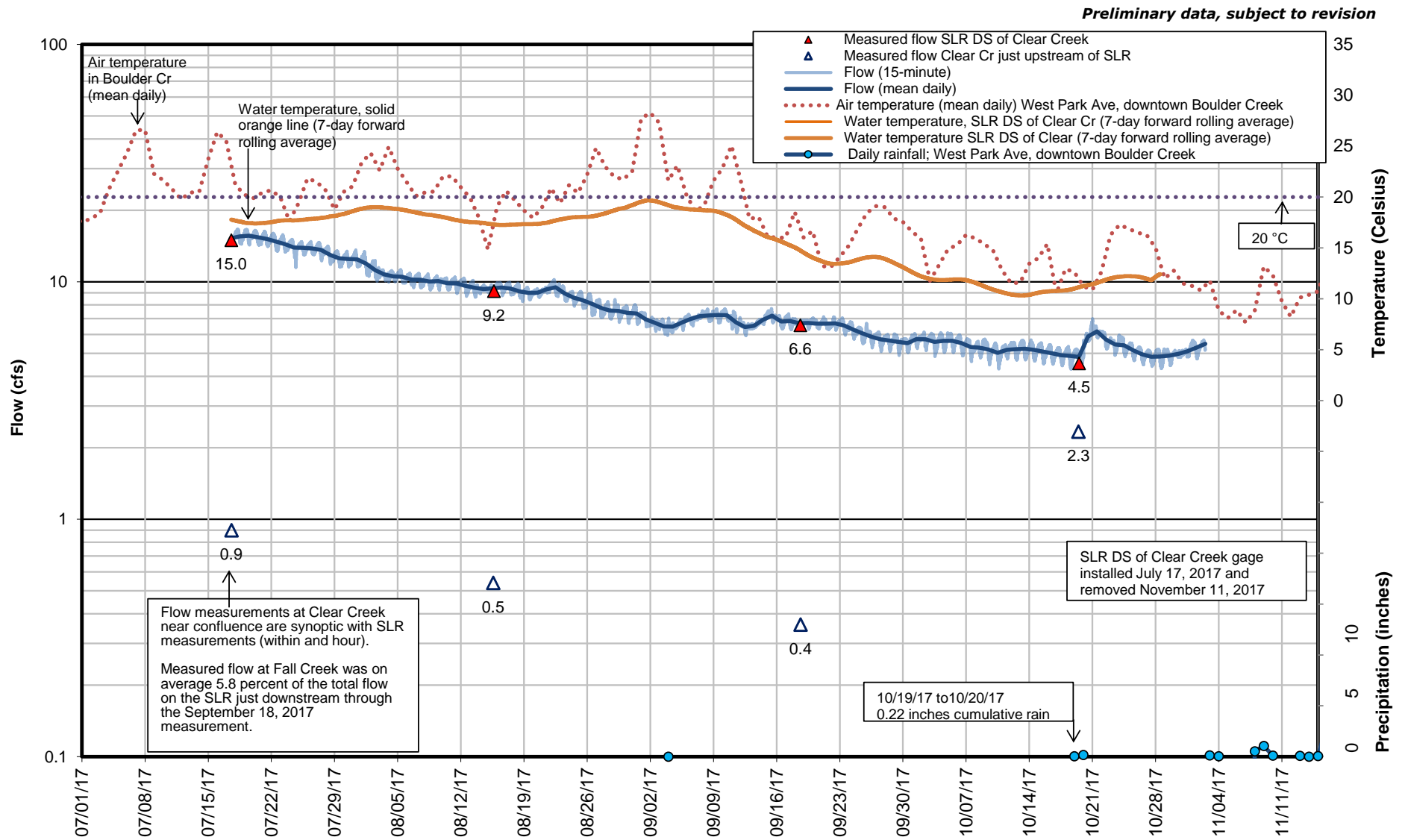


Figure 24: Flow, temperature, and precipitation; San Lorenzo River downstream of Clear Creek, Santa Cruz County, CA, water year 2017 to 2018 (partial)

Preliminary data, subject to revision

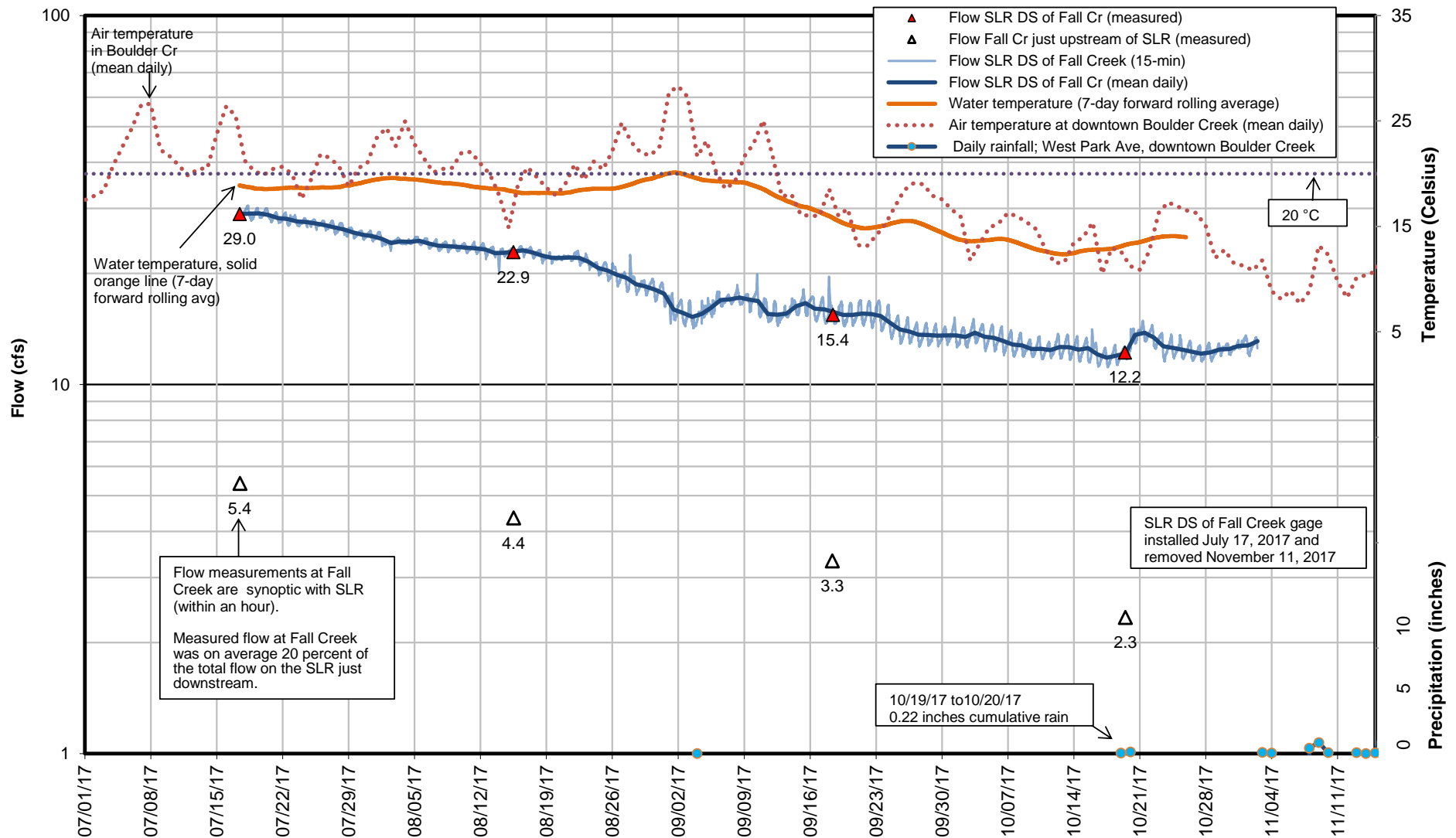
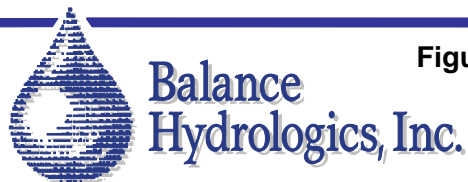


Figure 25: Flow, temperature, and precipitation; San Lorenzo River downstream of Fall Creek, Santa Cruz County, CA water year 2017 to 2018 (partial)



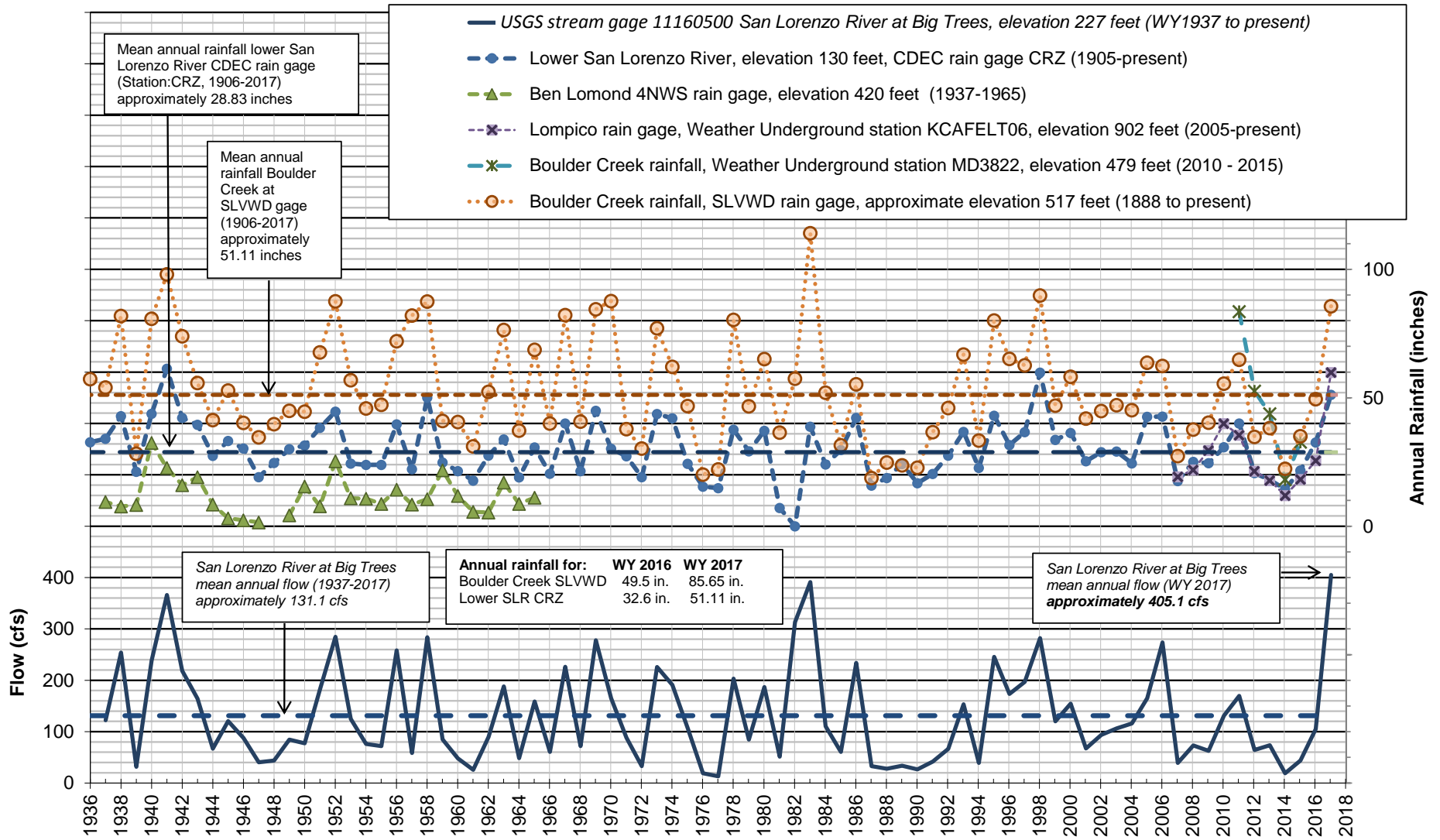
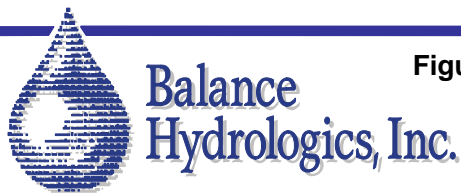


Figure 26: Comparison of historic annual rainfall in San Lorenzo Basin to annual streamflow at USGS Gage 11160500, San Lorenzo River at Big Trees, Santa Cruz County, CA
 No adjustment made for movement of the gage from the Glengarry Road location to Big Trees Road in 1972.



Preliminary, subject to revision

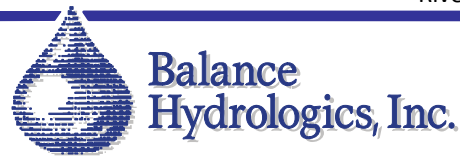
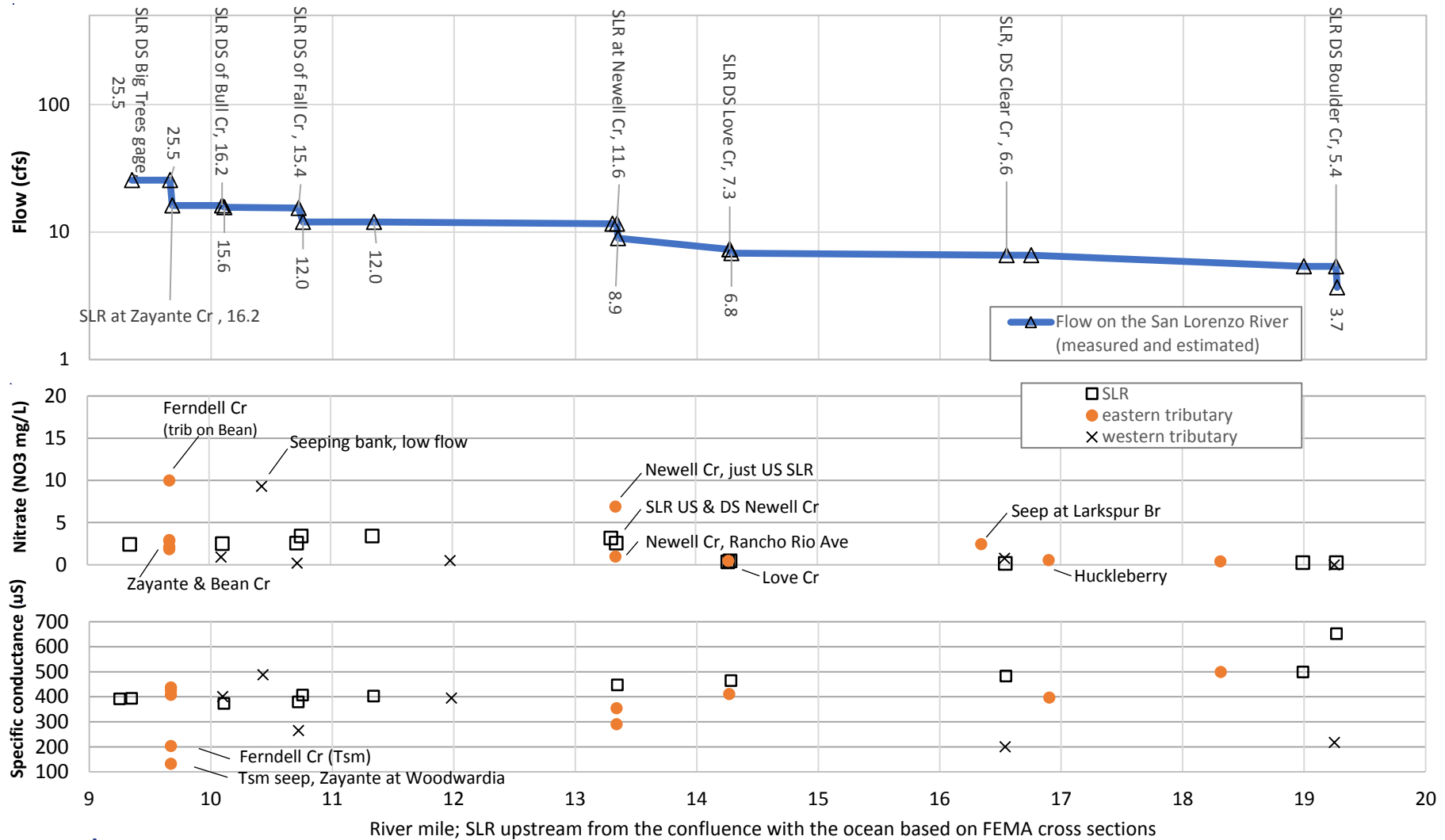


Figure 27: San Lorenzo River downstream changes in flow, nitrate and specific conductance from samples taken on September 18, 2017, water year 2017, Santa Cruz County, CA

ATTACHMENTS

ATTACHMENT 1

**Technical Memo: Sampling and analysis plan (SAP) for
measurements of flow and water quality through the San
Lorenzo River watershed on September 18, 2017**

MEMO

To: John Ricker and Jen Michelsen
From: Jason Parke and Barry Hecht, CEG, CHg
Date: June 13, 2018

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 on September 18, 2017

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 and secondarily by UCSC teams and be analyzed by both the Santa Cruz County Environmental Health lab (nitrate NO₃) and by the UCSC earth science department (water stable isotope, nitrate, nitrite, ammonium, phosphate). 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 :1U, 2U... etc. for UCSC samples, 1B, 2B.... for Balance samples. 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.

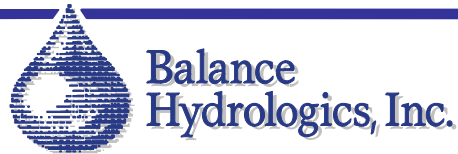
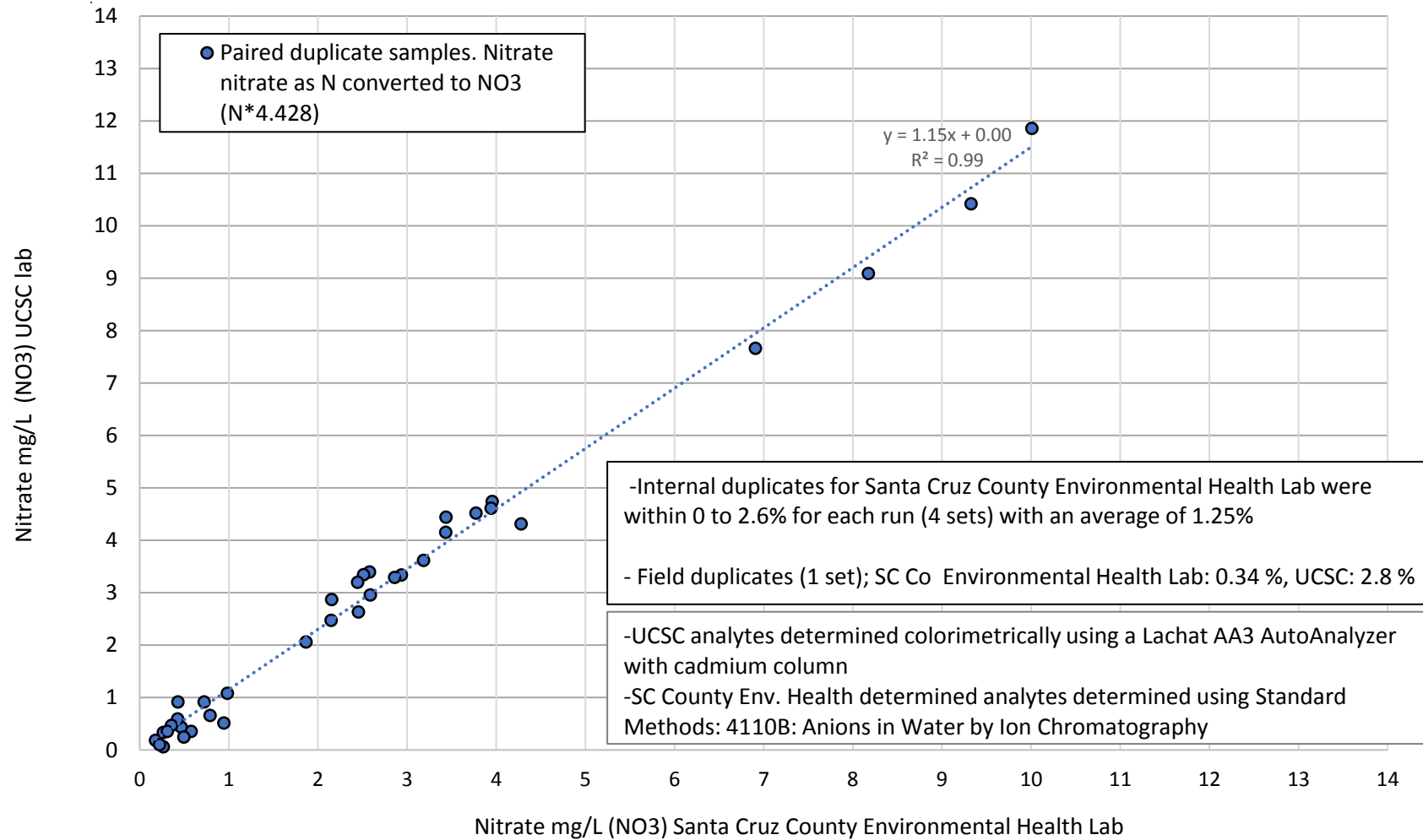
Flow measurement: For low flow (less than 50 gpm) use bag with graduated cylinder or bucket measurement. Channel measurement use USGS protocol with each vertical approximately representing 5% of the total flow at each vertical. Flow meters must meet and exceed the required calibration test of that type 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.

ATTACHMENT 2

**QA/QC and paired duplicate sample comparison for NO₃
sampled September 2017, Santa Cruz County, CA**



Attachment 2: QA/QC and paired duplicate sample comparison for NO3 sampled September 2017, Santa Cruz County, CA

ATTACHMENT 3

Lab Results

Balance Hydrologics Nitrate Project
 224 Walnut Avenue Suite E
 Santa Cruz, CA 95060

Sampled by Jason Parke (212-1800) and Zan Ruben
 Submitted 19 September 2017
 Analysis and Report by D. A. Steinbruner, County of Santa Cruz Water Quality Lab
 454-4624 david.steinbruner@santacruzcounty.com

QC

Santa Cruz County Public Health Laboratory
 Date of Analysis: 19 September 2017
 Method: Standard Methods 4110B
 Analytes detected but not requested on report: Fluoride (F), Chloride (Cl),
 ortho-Phosphate o-PO4), Sulfate (SO4)
 Time run started: 16:27
 Lowest Standard: 0.1 ppm NO3-N

Date Sampled	Time	ID	Nitrate as N	Comments
1	20170919	9:25	18B-A	0.49
2	20170918	8:15	1B-A	<0.1 Raw value 0.05
3	20170918	9:21	3B-A	0.58
4	20170918	15:35	12B-A	0.18
5	20170919	11:00	20B-A	0.65
6	20170918	13:15	9B-A	<0.1 Raw value 0.08
7	20170918	11:15	5B-A	0.58
8	20170918	17:32	16B-A	0.17
9	20170919	12:20	7B-A	0.10
10	20170919	10:10	19B-A	2.60 Not bracketed by standards.
11	20170918	17:25	15B-A	<0.1 Repeated next run.
12	20170918	17:15	14B-A	0.16 Raw value 0.06
13	20170919	9:15	17B-A	0.42
14	20170918	10:30	4B-A	1.56
15	20170918	13:05	8B-A	0.11
16	20170918	16:05	13B-A	<0.1 Raw value 0.06
17	20170918	11:30	6B-A	0.72
18	20170918	9:00	2B-A	0.78
19	20170918	14:10	10B-A	0.55
20	20170918	14:30	11B-A	<0.1 Raw value 0.07

SRM Value	Reported	% Recovery
1	0.979	98
Filter Blank	0.016	
Replicates		Rep RPD (%)
19B-A	2.6	2.1
19B-A	2.39	
11B-A	0.067	0
11B-A	0.067	
Spike	Reported	% Recovery
19B-A	2.39	103.9
11B-A	1.1	101.7
Spike value: 1.00 ppm NO3-N		
Units reported are mg/L (ppm)		

Units are milligrams per liter (ppm).

Balance Hydrologics Nitrate Project
 224 Walnut Avenue Suite E
 Santa Cruz, CA 95060

Sampled by Jason Parke (212-1800) and Christina Richardson
 Submitted 19 September 2017
 Analysis and Report by D. A. Steinbruner, County of Santa Cruz Water Quality Lab
 454-4624 david.steinbruner@santacruzcounty.com

Date Sampled	Time	ID	Nitrate as N	Comments
1	20170919	10:33	B14	0.22
2	20170918	8:42	B1	0.55
3	20170918	9:04	B2	0.66
4	20170918	9:51	B3	0.21
5	20170918	9:59	B4	0.57
6	20170918	11:05	B5:1105	2.11 Over high standard but < 10%
7	20170918	13:49	B5:1349	0.78
8	20170918	15:11	B6	<0.1 Raw value 0.07
9	20170918	15:15	B7	0.97
10	20170918	15:57	B8	0.49
11	20170918	16:23	B9	0.85
12	20170918	16:25	B10	0.11
13	20170918	17:40	B11	1.85
14	20170918	18:10	B12	0.89
15	20170918	18:11	B13	0.89
16	20170919	10:10	19B-A	2.26 Repeat from previous run

Units are milligrams per liter (ppm).

QC

Santa Cruz County Public Health Laboratory
 Date of Analysis: 20 September 2017
 Method: Standard Methods 4110B
 Analytes detected but not requested on report: Fluoride (F), Chloride (Cl),
 ortho-Phosphate o-PO4), Sulfate (SO4)
 Time run started: 16:30
 Lowest Standard: 0.1 ppm NO3-N

SRM Value	Reported	% Recovery
1	0.974	97
Filtre Blank		ND
<u>Replicates</u>		<u>Rep RPD (%)</u>
B8	0.485	0.31
B8	0.491	
<u>Spike</u>	<u>Reported</u>	<u>% Recovery</u>
B8	1.283	103.26
Spike value: 1.00 ppm NO3-N		
Units reported are mg/L (ppm)		

Balance Hydrologics Nitrate Project
 224 Walnut Avenue Suite E
 Santa Cruz, CA 95060

Sampled by Jason Parke (212-1800)
 Submitted 29 September 2017

Analysis and Report by D. A. Steinbruner, County of Santa Cruz Water Quality Lab
 454-4624 david.steinbruner@santacruzcounty.com

Date Sampled	Time	ID	Nitrate as N	Comments
1	20170928 11:36	Huckleberry Cr.	<0.1	Raw Value 0.097
2	20170928 11:06	Spring Cr.	0.13	

QC

Santa Cruz County Public Health Laboratory
 Date of Analysis: 02 October 2017
 Method: Standard Methods 4110B
 Analytes detected but not requested on report: Fluoride (F), Chloride (Cl),
 ortho-Phosphate o-PO4), Sulfate (SO4)
 Time run started: 17:35
 Lowest Standard: 0.1 ppm NO3-N

SRM Value	Reported	% Recovery
1	1.04	104
<u>Filtre Blank</u>	ND	
<u>Replicates</u>		<u>Rep RPD (%)</u>
Spring Cr.	0.129	2.57
Spring Cr.	0.143	
<u>Spike</u>	<u>Reported</u>	<u>% Recovery</u>
Spring Cr.	1.18	111
Spike value: 1.00 ppm NO3-N		
Units reported are mg/L (ppm)		

Units are milligrams per liter (ppm).