FRIENDS OF
CORTE MADERA CREEK
WATERSHED

2016 Water Quality Report

Corte Madera Creek Watershed

Prepared by

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Thanks to the Marin County Fish & Wildlife Commission for funding the purchase of most of our loggers. Thanks also to Parker Pringle and Andrew Bartshire for installing the loggers and visiting them throughout the summer.

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1: Background

The purpose of the monitoring is to characterize the temperature regimes and document dissolved oxygen (DO) at various locations in creeks in the Corte Madera Creek watershed. We have installed loggers in Ross Creek each year beginning in 2008. In 2009 we added loggers in Bill Williams Creek and Phoenix Creek, tributaries to Phoenix Lake. In 2012, we added loggers in Corte Madera Creek, San Anselmo Creek, Fairfax Creek, and Sleepy Hollow Creek. Typically the loggers are installed in March or April and removed when the site dries or when winter rains start. In 2016 we did not have loggers in Phoenix Lake or its tributaries. We removed the loggers near the mouth of Ross Creek because Corte Madera Creek at the mouth of Ross Creek is infested with New Zealand mud snails; they are easily carried on boots and equipment and we did not want to spread the infestation into the upstream reaches of Ross Creek.

2: Water Temperature and Dissolved Oxygen in Salmonid Habitat

Temperature is one of the most important environmental influences on salmonid biology. Water temperature determines the metabolism of steelhead and salmon. Temperature influences the availability of food, as well as growth and feeding rates; metabolism; development of embryos and alevins; and timing of life history events such as upstream migration, spawning, freshwater rearing, and seaward migration. Elevated temperatures can cause stress and lethality. Temperatures at sub-lethal levels can effectively block migration, lead to reduced growth, stress fish, affect reproduction, inhibit smoltification, create disease problems, and alter competitive dominance. Further, the impact of elevated water temperature on salmonids is cumulative, positively correlated to duration and severity of exposure. The longer the salmonid is exposed to thermal stress, the less chance it has for long-term survival.

Tables 1 and 2 provide the temperature requirements for different life stages of steelhead trout and when those life stages are likely to occur.

Table 1: Some habitat requirements for steelhead trout

Life Stage	**Optimal Water Temperatures**	**Dissolved Oxygen (mg/l)**
Immigration, Spawning, Incubation	7.8 - 11.2 °C	≥7 at ≤15°C ≥9 at >15°C
Fry Emergence	8.9 - 11.2 °C	
Rearing	12.8 – 15.6 °C	
Smoltification, Emigration	7.0 - 11.3 °C	

Source: A.A. Rich and Associates 2000

Table 2: Steelhead trout life stage periodicities in the Corte Madera Creek Watershed

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Immigration	———	~~~										
Spawning	———	———	~~~									
Egg/Alevin Incubation	———	———	———	~~~								
Fry Emergence	———	———	———									
Fry/Juvenile Rearing	———	———	———	———	———	———	———	———	———	———	———	———
Smoltification, Emigration				———	———	———						
				~~								

——— Range of Periodicity

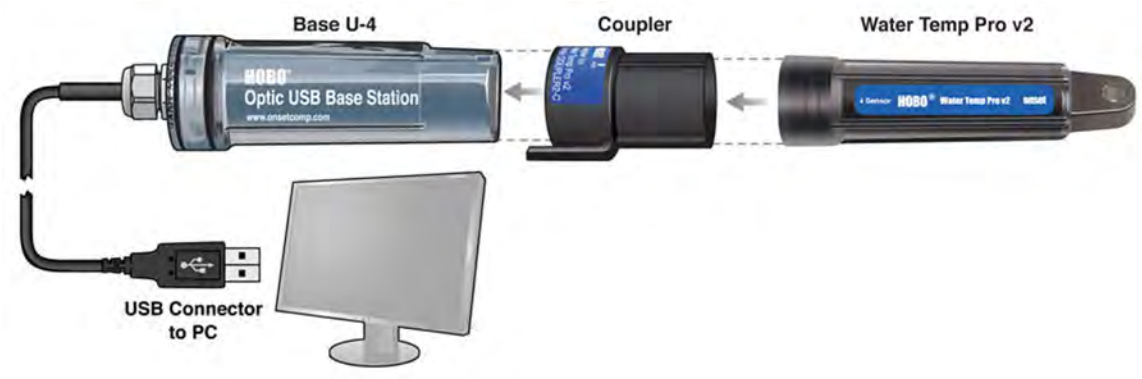
~~~ Peak Periodicity

Source: A.A. Rich and Associates 2000

3: Equipment

We use Onset Computer's HOBO Water Temp Pro v2 loggers (Figure 1). They are downloaded in the field using a waterproof data shuttle (base station) to collect the data and launch the logger. In the office, we connect the shuttle to a computer and transfer the data. During each visit when loggers are installed, downloaded, or removed, we measure temperature and DO using a YSI Pro20 instrument.

Figure 1: Diagram of logger, shuttle, and computer used in data collection and transfer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4: Logger Installation

Figure 2 shows the locations of loggers in Ross Creek. Figure 3 shows the logger locations further upstream. Table 3 lists locations of loggers and Table 4 provides the dates they were deployed.

The temperature loggers are designed for long-term deployment and are relatively robust. In creeks, each logger is attached to a stainless steel cable with a shackle; the cable is fastened to a rock or tree root. We are careful to hide the cable and logger, but they are not completely invisible. These loggers are vulnerable to damage from rocks in the water or curious passers-by. To provide some protection, we place the loggers in protective plastic covers (boots). Unfortunately, areas where people have easy access to the creek have proved problematical. Two loggers have been stolen and some loggers have been removed from the water. It is easy to detect when a logger has been removed from the water, as it continues to record, and air temperatures are more extreme than water temperature.

We attempt to locate sites with relatively deep, moving water; the deepest pools are not selected, because we want to measure the temperature of water moving in the creek. Unfortunately, it is inevitable that as water levels drop, some loggers are in stratified pools with little or no current.

Figure 2: Temperature logger locations in Ross Creek

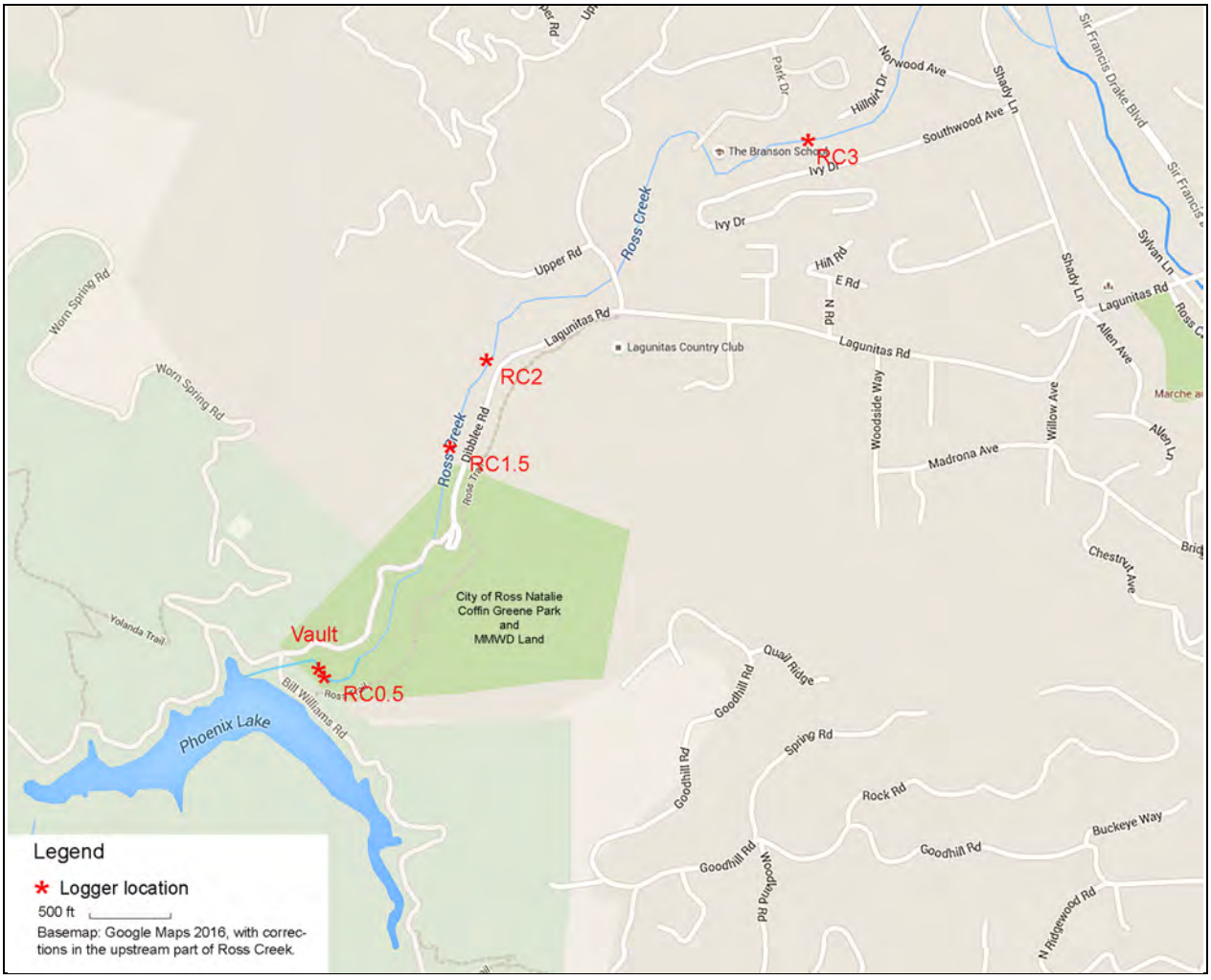


Figure 3: Temperature logger locations in San Anselmo, Fairfax, and Sleepy Hollow creeks

Table 3: Logger locations, shown on Figure 1 and Figure 2

Location	Creek	Miles from Mouth	Latitude Longitude	Years in Place	Notes
Vault	Ross	2.39	37.955889 -122.575074	2008-2016	Located on right bank near base of vault.
RC0.5	Ross	2.38	37.955862 -122.574989	2008-2016	Located on right bank ~15 ft. downstream of vault
RC1.5	Ross	1.80	37.959370 -122.572398	2013-2016	On right bank under large root wad.
RC2	Ross	1.60	37.960875 -122.571561	2008-2016	Just upstream of first house along Ross Creek on right bank.
RC3	Ross	0.93	37.964685 -122.564746	2008-2016	End of Southwood, adjacent to Branson Field on left bank
FC10	Fairfax		37.996175 -122.599255	2012-2016	Downstream of 300 Olema Road, left bank
FC20	Fairfax		37.98758 -122.592675	2012-2016	Behind Fairfax Lumber, left bank
SA10	San Anselmo		37.983665 -122.589934	2012-2016	Downstream of confluence with Deer Park Creek, right bank
Lansdale	San Anselmo		37.982329 -122.576429	2012-2016	Downstream of fishway, left bank
SH10	Sleepy Hollow		38.008964 -122.583877	2012-2016	17 Katrina Lane, left bank
SH20	Sleepy Hollow		37.991839 -122.576247	2012-2016	Firehouse 20, left bank

Table 4: Deployment of loggers in 2016

Location	Logger ID	Installed	Removed	Notes
Near Vault	10094555	4/19/16 15:07	10/21/16 17:23	
RC0.5	10094558	4/19/16 15:29	10/21/16 17:33	
RC1.5	10094552	4/19/16 16:05	10/21/16 17:47	
RC2	10094560	4/19/16 16:22	10/21/16 16:22	
RC3	1292334	4/19/16 16:53	7/8/16 15:33	Site dry before logger removed
FX10	10094561	4/13/14 13:20	10/30/16 14:35	
FX20	1281280	4/13/14 13:03	10/30/16 14:51	
SA10	1292335	4/13/14 12:30	10/30/16 15:05	
Lansdale (SA20)	1292332	4/13/14 14:25	10/30/16 15:24	
SH10	1292333	4/13/14 14:00	10/30/16 13:56	
SH20	10094560	4/13/14 13:45	10/30/16 14:18	

5: Data Gathering and Analysis

Before each logger is downloaded, the YSI unit is used to measure and record temperature and DO. The YSI unit is accurate for DO only in moving water. Where the water is still, the sensor must be kept moving so that the oxygen immediately adjacent to the sensor is not depleted before the reading stabilizes. This works only moderately well later in the summer when water levels are low and some of the pools have stratified. Readings for both temperature and DO vary significantly within one pool when the water is mixed by the moving probe.

Loggers were set to record data points every 15 minutes. Loggers in creeks were downloaded periodically. During a download, each logger is connected to the data shuttle, which reads and then empties the logger memory. During May, one of the YSI probes failed, and we were unable to measure DO.

6: Water Temperature and Dissolved Oxygen

During 2016, loggers were installed at five locations in Ross Creek. Plots of temperature of these loggers and temperature and DO recorded by the YSI probe are in Figure 4 through Figure 8.

Two loggers were installed in Fairfax Creek, one (FC10) just downstream of 300 Olema Road; the second (FC20), downstream of Scenic Road, behind Fairfax Lumber. The times series for those loggers the YSI data are shown in Figure 9 and Figure 10, respectively.

Two loggers were installed in San Anselmo Creek, one just below the confluence of Deer Park Creek and San Anselmo Creek (SA10) and one just downstream of the Lansdale pool-and-drop structure (Lansdale, SA20). Time series for these two loggers and YSI data are in Figure 11 and Figure 12 respectively.

Two loggers were installed in Sleepy Hollow Creek. Data gathered in the creek behind 17 Katrina Lane (SH10) are shown in Figure 13. Data gathered behind the fire station on Butterfield Road (SH20) are in Figure 14. Both locations suffer from high temperatures and, by late summer, very low DO.

7: Discussion

Ross Creek: Ross Creek is perennial within Natalie Coffin Greene Park, where no water is diverted from the creek. In residential areas below RC2, the typically creek dries by mid-May at RC3. Although we have no proof that groundwater pumping is the cause of this early drying, most parcels downstream of the park have wells and we suspect that pumping for irrigation of large gardens and playing fields at Branson School is lowering the groundwater and causing the creek to dry very early in the summer. Unless smolts move into the mainstem before lower Ross Creek is dry, they are not able to leave the creek.

The two upstream loggers (Figure 4 [Vault] and Figure 5 [RC0.5]) show the effect on Ross Creek of water flowing over the spillway at Phoenix Lake. Warm water flowing over the spillway in late spring, further warmed by the sun shining on the spillway, dominates flow in the upstream portion of Ross Creek; both temperature and DO are high. After the lake level drops and water stops flowing over the spillway, the water temperature and DO drop dramatically; at that point, Ross Creek flow is dominated by leakage from the low-level release valve and groundwater. This suggests that when water in upper Ross Creek

becomes too warm for salmonids, releasing water from the low-level release valve until spillway flow ceases has the potential to benefit salmonids in Ross Creek, particularly if the water is aerated near the low-level release valve. The added flow might also encourage smolts to move downstream before lower Ross Creek dries.

Upper Ross Creek in Natalie Coffin Greene Park has great potential for improvement as salmonid habitat. The removal of two barriers to passage (Taylor 2006), enhancement of riparian vegetation, and addition of structure are recommended.

Figure 4: Temperature and DO at Logger Near Vault

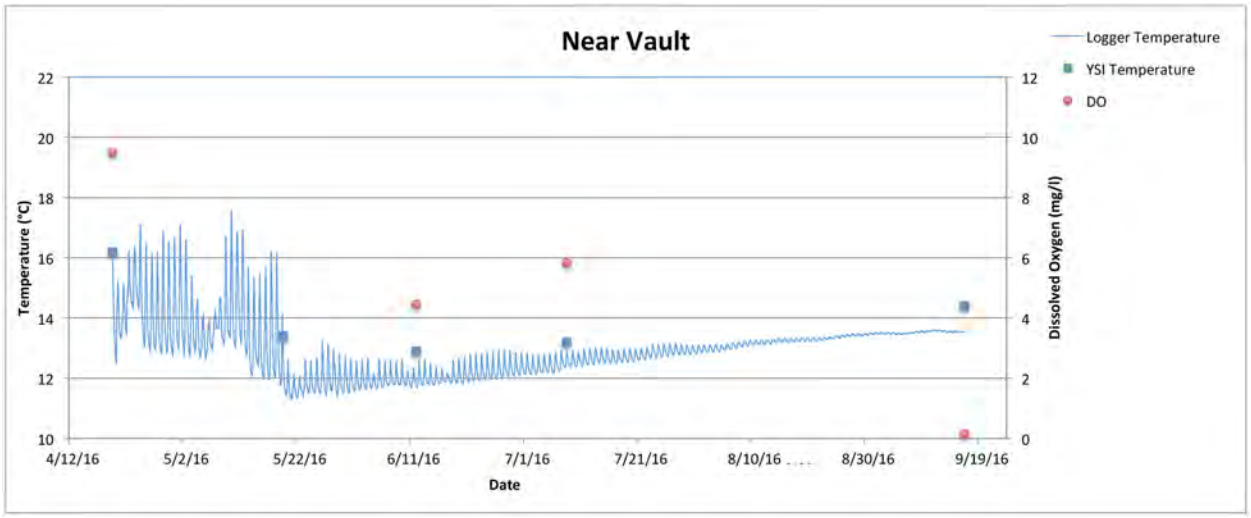
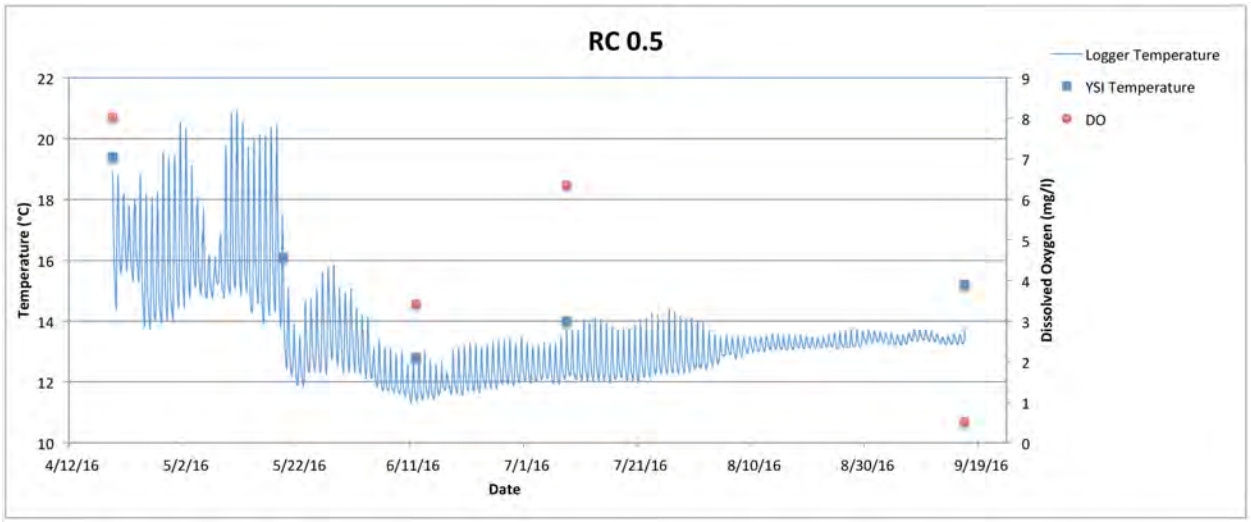


Figure 5: Temperature and DO at Logger RC 0.5



These two loggers are located in Natalie Coffin Greene Park where the flow in Ross Creek is perennial. The next two downstream loggers (Figure 6 [RC1.5] and Figure 7 [RC2]) show strong diurnal variations in temperature, with typically high daytime and lower nighttime temperatures. This reach of the creek has some deep pools and structures that provide summer rearing habitat for salmonids. DO is relatively high.

Figure 6: Temperature and DO at Logger RC 1.5

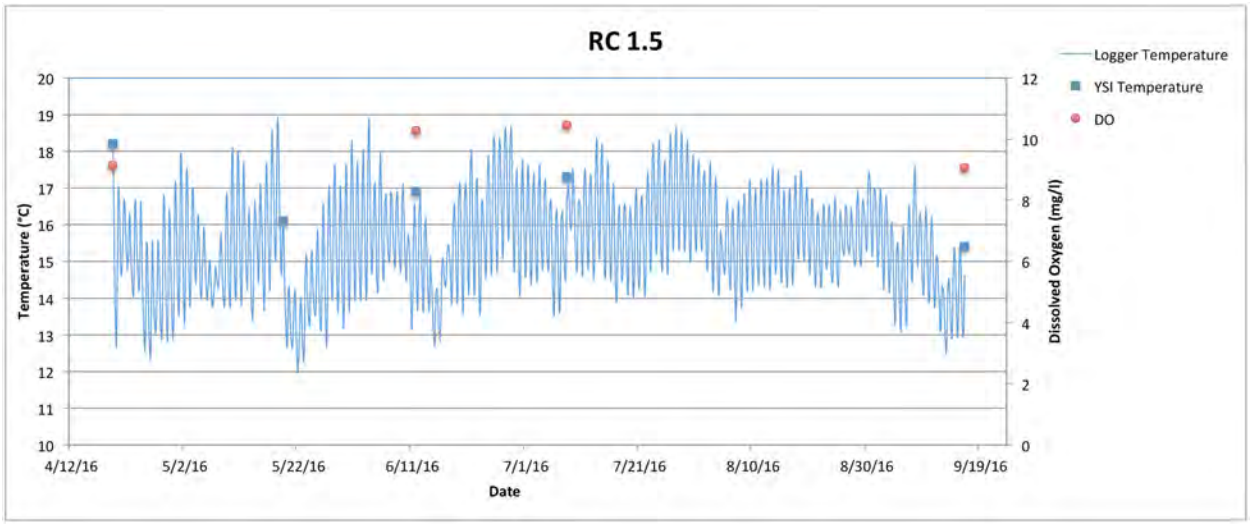
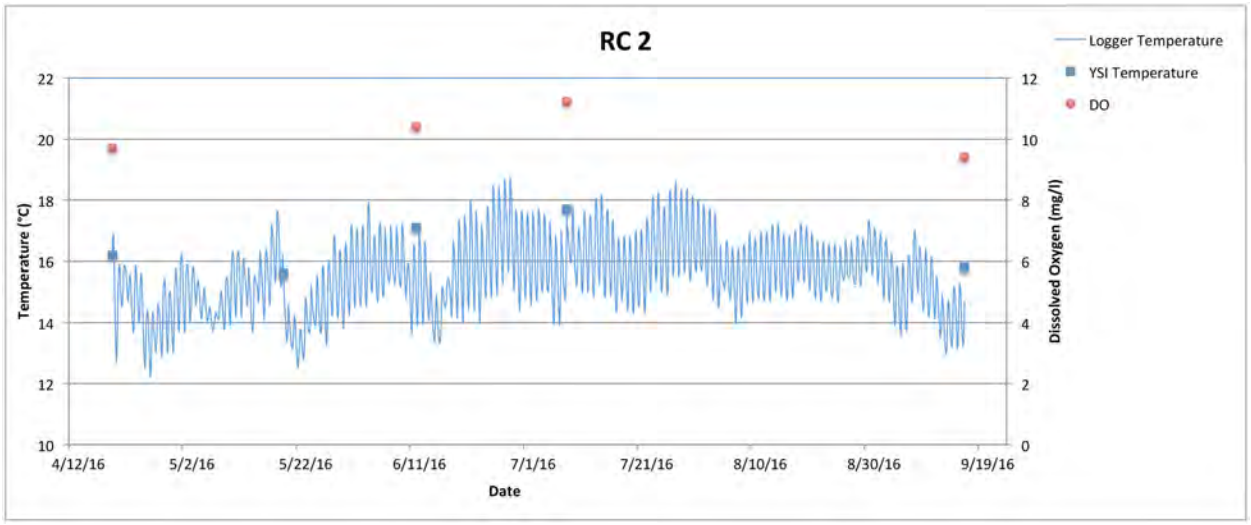
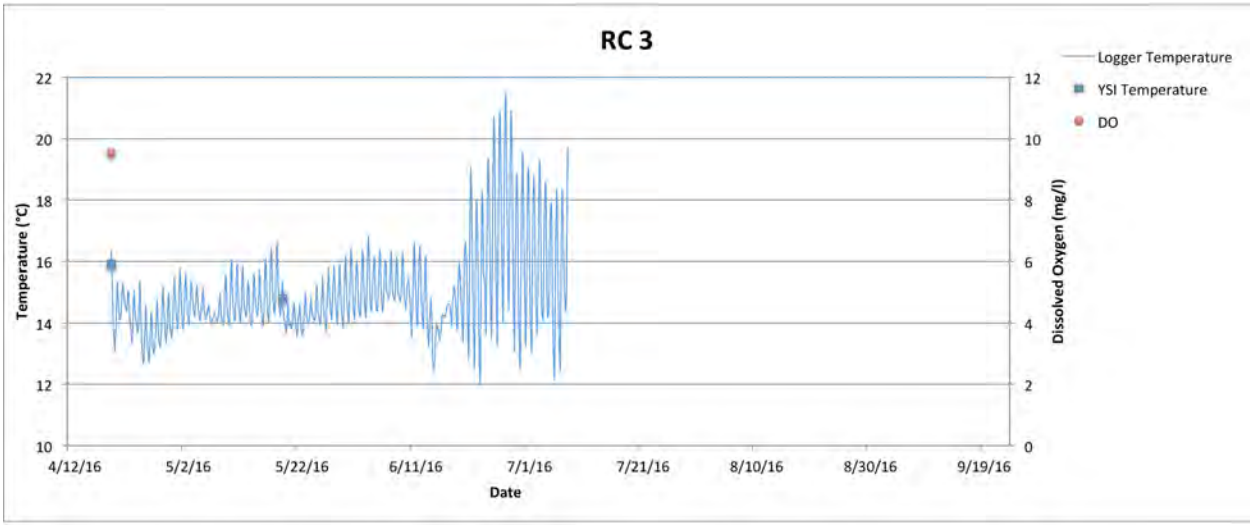


Figure 7: Temperature and DO at Logger RC 2



Logger RC3 is located in the developed section of Ross Creek. There is abundant riparian vegetation and the water temperature is suitable for steelhead. However, most parcels have wells. There is no information about the amount of pumping, but it is reasonable to assume that significant water is withdrawn from the groundwater directly connected to Ross creek baseline flow for irrigation in this reach. Throughout the developed reach, which extends from Natalie Coffin Greene Park to its confluence with Corte Madera Creek, Ross Creek dries early in the year. The plot of temperatures in Figure 8 show that this occurred on 6/21/16, when the recorded temperatures began to reflect air temperature. The logger was removed on 7/18/16.

Figure 8: Temperature and DO at Logger RC 3



Fairfax Creek: At both logger locations (FX10 [Figure 9} and FX20 [Figure 10]), temperatures tended to be high for salmonids. Fairfax Creek has a culvert at its mouth that is a total barrier to salmonid passage. The barrier also causes major flooding in downtown Fairfax; treating both problems was identified in the Capital Improvement Program for the Ross Valley Watershed Program. Unfortunately, it is not likely to be implemented unless the Town of Fairfax makes major efforts to obtain funding. There is a second dam, just downstream of 300 Olema Road. If both barriers to salmonid passage could be treated, then it would be prudent to work on adding riparian vegetation and structure to improve salmonid habitat.

Logger FX10 is located on Fairfax Creek between 300 Olema Road and the upstream dam. This reach is relatively accessible, and it appears that the logger may have been taken out of the water on a couple of occasions.

Figure 9: Temperature and DO at Logger FX10

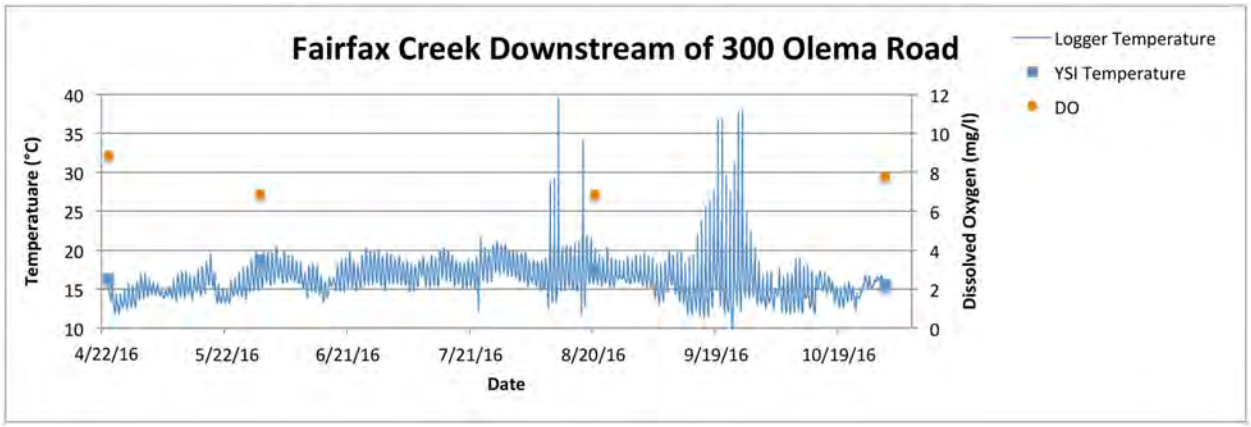
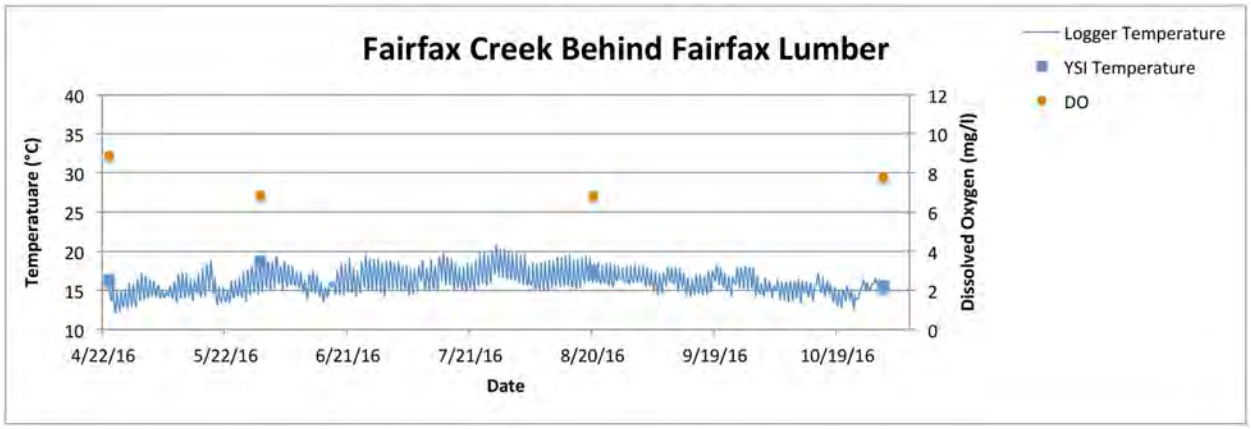


Figure 10: Temperature and DO at Logger FX20



San Anselmo Creek: San Anselmo Creek is the longest named creek in the watershed, reaching from its confluence with Ross Creek upstream into the Cascade Canyon Open Space Preserve. Some sections, especially through downtown San Anselmo and the older neighborhoods with small lots, have considerable concrete rubble, hardened banks, and limited creek capacity. Although there is perennial flow in these areas, they are characterized by a lack of summer rearing habitat and the near absence of high-flow refugia. A section of high-quality spawning gravels upstream of its confluence with Fairfax Creek dries in the summer. AA Rich and Associates assessed habitat and measured temperature during 1999. The report (AAR 2000) states:

> For steelhead trout, thermal conditions in San Anselmo Creek: (1) were stressful to incubation and fry emergence, beginning in May; (2) depending upon the habitat type and location, there were a number of times when juvenile rearing conditions were stressful; and, (3) with regard to smolt emigration, thermally stressful conditions began in May. For rainbow trout, thermal conditions were generally acceptable, provided the fish could find thermal refuge areas during the hot summer months.

During 2016, Logger SA10, located just downstream of the confluence with Deer Park Creek, recorded fairly warm temperatures, but nighttime cooling provided some respite and the DO levels were adequate. At Lansdale there are significant groundwater inputs, demonstrated during construction of the pool-and-drop structure during summer 2012, when water poured into the excavated work area and a major dewatering effort was needed to complete construction.

Salmonid habitat in San Anselmo Creek would benefit from more structure and riparian vegetation.

Figure 11: Temperature and DO at Logger SA10

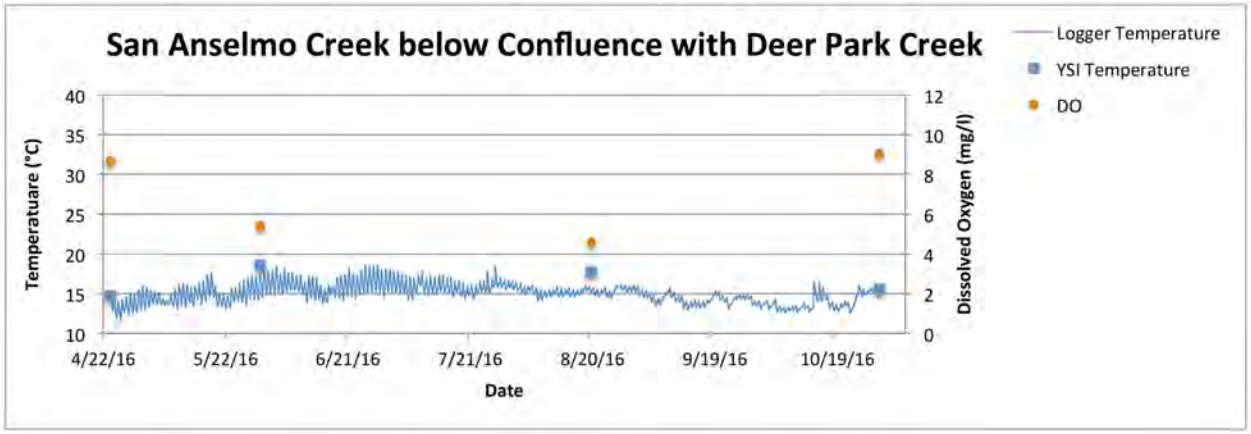
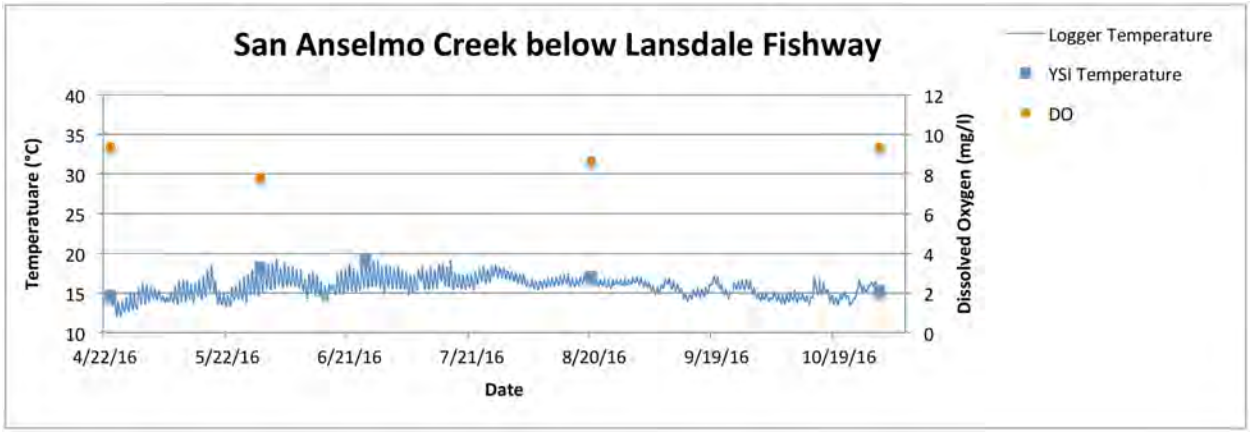


Figure 12: Temperature and DO at Logger Lansdale



Sleepy Hollow Creek: Loggers in Sleepy Hollow Creek (SH10 [Figure 13] and SH20 [Figure 14]) show temperatures similar to those in Fairfax Creek. AAR also measured temperature in Sleepy Hollow Creek in 1999. The report (AAR 2000) states:

> Thermal conditions in Sleepy Hollow Creek were generally satisfactory for all life stages of both steelhead and rainbow trout, with the exception of the lowest reaches near Sir Francis Drake High School. There were many areas that had dried up throughout this drainage.

The observations for the last few years suggest that conditions have deteriorated in this watershed since 1999. In 2016, temperatures were similar to those observed in 2013 – 2015: above 15°C beginning in July and extending into September. This was a very dry period with low flow, which likely contributed to the higher temperatures.

Figure 13: Temperature and DO at Logger SH10

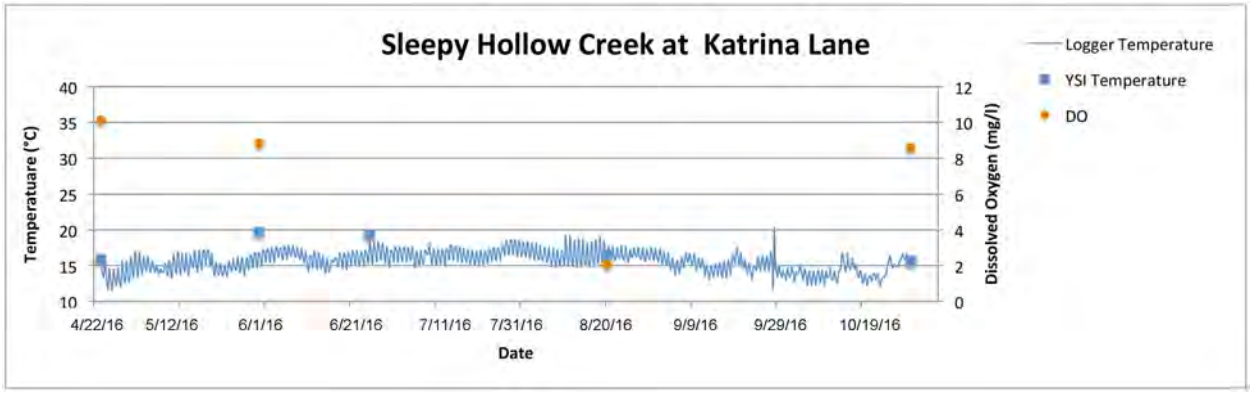
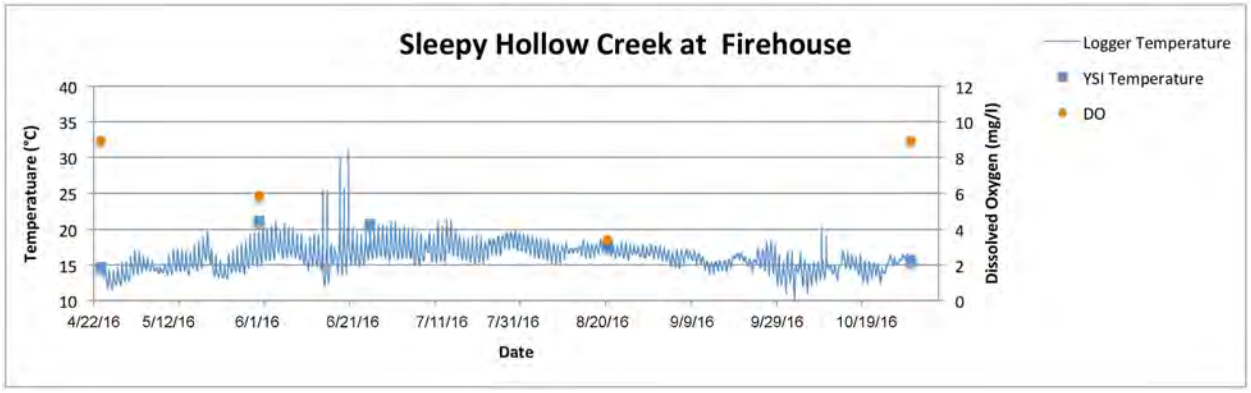


Figure 14: Temperature and DO at Logger SH20

This logger is located on Sleepy Hollow Creek, behind Fire Station 20, another easily accessible location.



8: References

AAR 2000

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