

French Creek Flow Accounting Study



Juvenile coho salmon and rainbow trout rearing in a pool habitat on Lower French Creek – July 2019.

Photo by C. Voigt

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For the

Scott River Water Trust

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Appendix I: Water Year 2018 – Water Supply Data

Appendix II: Water Year 2019 – Water Supply Data

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Introduction

The Scott River Water Trust (SRWT) has been working with adjudicated water-users in Scott Valley since 2007 to develop opportunities for stream flow enhancement through temporary leases or long-term/permanent dedications of surface water rights. Under the seasonal Water Leasing Program, the SRWT contracts with voluntary agricultural producers to temporarily forbear all or part of their decreed water right(s) during the irrigation season in exchange for fair financial compensation. The purpose of the seasonal Water Leasing Program is to improve conditions for anadromous fish in priority stream reaches during critical life stages and time periods. The Siskiyou Resource Conservation District (SRCD) has been integrally involved with implementation of the seasonal Water Leasing Program since its inception and particularly with the monitoring component. Monitoring of seasonal transactions is generally limited to ensuring compliance with the lease terms and confirming stream response. However, in 2016 the SRWT proposed expanding the scope of effectiveness monitoring associated with the Water Leasing Program based on suggestions from Andrew Purkey and Rankin Holmes of the National Fish and Wildlife Foundation and their experience monitoring transactions in the Columbia River Basin (Holmes, et al., 2013). Under funding from the California Flow Restoration Accounting Fund managed by the National Fish and Wildlife Foundation, the SRWT contracted with the SRCD to explore several additional effectiveness monitoring techniques on French Creek including instream water level/discharge monitoring, wetted-perimeter analysis and alluvial connectivity surveillance. The purpose of this additional monitoring was to evaluate the applicability and effectiveness of these techniques to stream flow enhancement in Scott Valley and determine whether it would make sense for the SRWT adopt these practices into its programs. The specific components and objectives of the work completed on French Creek included:

- Evaluate the instream effect of forbearance agreements performed by SRWT
- Establish and maintain monitoring stations throughout French Creek to determine the downstream extent that returned water from various leases had on stream flow and temperature
- Perform wetted perimeter analysis on French Creek to develop a relationship between instream flows and aquatic habitat conditions
- Conduct periodic fisheries surveys through French Creek to evaluate the relative abundance of salmonids influenced by the transactions
- Conduct periodic foot surveys through lower French Creek to establish the temporal and spatial connectivity to the Scott River

This report summarizes the monitoring and analysis conducted by the SRCD during the 2018 and 2019 water leasing seasons under the *French Creek Flow Accounting Study* and provides conclusions related to the applicability of these methods to the SRWT.

Scott River Watershed - Water Year Summary

2018 Water Year Conditions – Dry

The Scott River drains a 520,184-acre (813 square mile) watershed with the quality of the water year being largely dependent upon fluctuations in snowpack. The 2018 water year was characterized by below average water supply across all metrics measured (Appendix I). Apart from anomalous and significant storms in April and May, precipitation was generally below the recorded average at the weather station in Fort Jones (46-year dataset). Precipitation levels as of April 1st and for the entire water year were 46% and 56% of normal, respectively. Similarly, Scott River basin snowpack as of April 1st was found to be only 42% of the recorded average (49-year dataset). Low snowpack-derived water supply was reflected in Scott River discharge, which was well below the 77-year average, particularly during the summer and irrigation season. Summer minimum discharge ran under 10 cfs and the Scott River was disconnected or dry through many sections of the valley (including the historic mining tailings) in August and September. Using the water

year classification methodology developed by the Scott River Water Trust, Water Year 2018 has been classified as a “Dry Year”. For more details, refer to Appendix I.

2019 Water Year Conditions – Wet

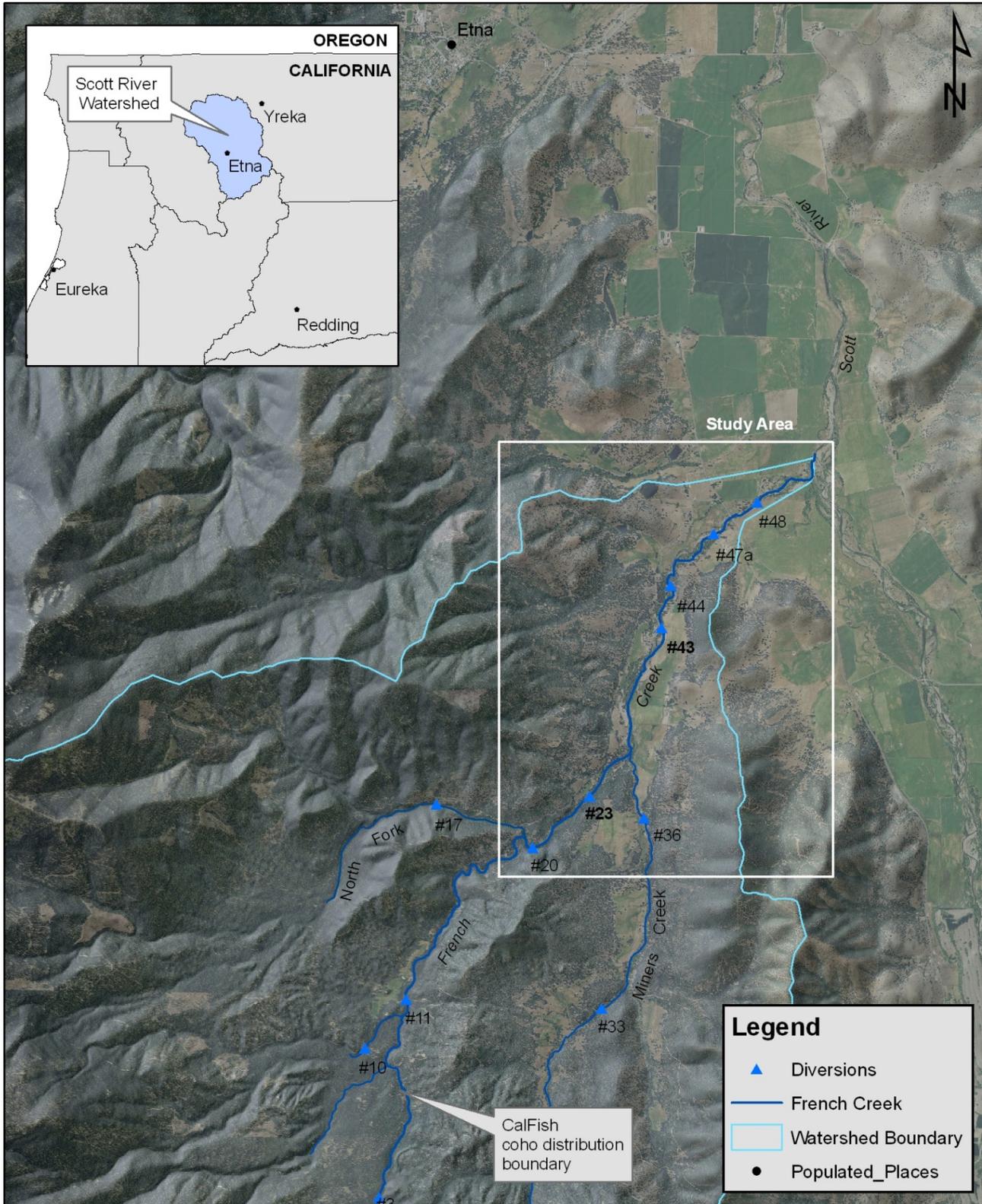
The 2019 water year was notably wetter than the previous year (Appendix II). Precipitation at the Fort Jones weather station was near the recorded average (46-year dataset). Precipitation levels as of April 1st and for the entire water year were 94% and 95% of normal, respectively. Further, the Scott River basin snowpack was found to be greater than recorded averages at 129% on April 1st and 137% on May 1st (49-year dataset). Greater precipitation and snowpack were reflected in Scott River discharge, which tracked or exceeded the 78-year historic median daily discharge from approximately January 2018 through July 2019. However, despite these favorable factors, river discharge still exhibited a relatively rapid decline, ultimately dropping below historic median discharge during the late summer and irrigation season. Summer minimum discharge was approximately 10 cfs. Despite this, the Scott River is believed to have remained fully connected through the valley, with the exception of the historic mining tailings. Using the water year classification methodology developed by the Scott River Water Trust, Water Year 2019 has been classified as a “Wet Year”. For more details, refer to Appendix II.

Study Location

French Creek is a tributary that originates in the western mountains of the Scott River watershed and enters the mainstem Scott River at river mile 47 (Map 1). French Creek is a crucial resource for anadromous fish within the basin and is known to support runs of the three anadromous salmonids endemic to the area: steelhead trout (*Oncorhynchus mykiss*), chinook salmon (*Oncorhynchus tshawytscha*), and coho salmon (*Oncorhynchus kisutch*). The National Marine Fisheries Service has identified French Creek as one of the eleven most productive tributaries in the watershed for Southern Oregon, Northern California Coast (SONCC) coho salmon, which were listed as threatened in 1997 (NMFS, 2014). French Creek has a number of advantageous characteristics for salmonid rearing including a stable thermal regime, complex instream shelter and high macroinvertebrate diversity (Quigley, 2003). Although French Creek collectively provides high quality rearing habitat for salmonids, portions of the lower reach experience seasonally limiting conditions, particularly during years with low levels of precipitation. Sediment deposition and diminished flow result in physical barriers to fish movement, the degradation of water quality, and crowding. The development of stream flow enhancement opportunities has the potential to reduce the extent of surface water disconnections through these regions of French Creek (both spatially and temporally) by increasing the volume of the wetted channel. Reducing the occurrence of fragmented instream habitat will allow fish to preferentially access and utilize rearing grounds and promote their survival. As such, the SRWT has focused flow enhancement efforts on the lower 4-miles of French Creek from the North Fork to the confluence with the Scott River (Map 1).

All rights in and to the waters of French Creek and its tributaries were adjudicated by the Siskiyou County Superior Court in 1958. Beneficial uses of diverted water include irrigation, stockwater and domestic purposes. Currently, there are 12 active diversions that supply surface irrigation on an annual basis for pasture and hay production (Map 1). Under the *French Creek Flow Accounting Study*, the SRWT secured a temporary water leases on Diversion 23 in 2018 and Diversions 43 and 23 in 2019 (Map 1).

French Creek Flow Accounting Study - Project Area



Map 1: Study Area.

Methods

The SRCD employed various methods to monitor stream and fisheries response from the water transactions conducted by the SRWT in French Creek over the 2018 and 2019 seasons. These included stream flow and temperature monitoring, wetted-perimeter analysis, fisheries surveys and alluvial connectivity surveillance.

Stream Flow Monitoring

The SRCD established various monitoring stations along French Creek in order to develop a surface water balance surrounding the involved leases. The purpose of this network was to document the water returned instream and assist in defining the “zone-of-influence” of the leased water. Monitoring stations utilized instream pressure transducers in combination with barometers (Onset HOBO U20-001-01 and/or U20L-01 Water Level Loggers) to measure water levels and water temperatures at the selected gaging locations. Pressure transducers were deployed in stilling wells made of vented PVC pipe with an external staff gage secured to a T-post. Pressure transducers recorded absolute pressure and water temperature data on 15-minute intervals at each location. The collected data was converted to stage (feet) using the “barometric compensation” function in the associated device software (Onset Computer Corporation HoboWare Pro). Barometric data was collected adjacent to river-mile 0.55 of French Creek.

Two independent elevation benchmarks were used to establish the reference gage datum for several of the monitoring stations to allow for repeatability. A benchmark for the French Creek river-mile 3.59 station was set in a cedar tree on the river right bank. A benchmark for the French Creek river-mile 2.50 station was set in a cottonwood tree on the river left bank. Differential level-loop surveys were completed to determine the elevation of the pressure transducer zero-point relative to the staff plate.

Instream discharge measurements were conducted at appropriate control points directly below the gage locations. Instantaneous streamflow was measured using the FlowTracker Handheld ADV (Acoustic Doppler Velocimeter) by SonTek/YSI. This flowmeter is the same model used by the California Department of Water Resources to perform discharge measurements for its gages and Watermaster Service. The FlowTracker features high precision in low velocity ranges (down to 0.001 m/s). Flow measurements were conducted at hydrologic control points (e.g., pool tail out) with uniform laminar water velocities along a cross-section, following USGS standard methods (Rantz, 1982). Selected transects were broken into cells in which the depth and velocity were measured. The discharges of the individual cells (q) were kept to less than 5% of the entire discharge (Q) when possible by reducing cell size. In some locations this desired condition ($q/Q < 0.05$) was impossible to meet due to low flows and/or a high percent of the flow occurring in the stream’s thalweg. Rating curves were developed using log-log equations for each flow regime per USGS methods. Recordings made by the California Department of Water Resources streamflow gaging station on French Creek at river-mile 0.86 (FCC) were used as a reference throughout the study period.

Stream Temperature Monitoring

Onset HOBO Water Temperature Pro v2 Data Loggers and/or U20L-01 Water Level Loggers were used to collect water temperature data at various locations on 15-minute intervals. The water temperature loggers were tested for accuracy in both an ice bath and ambient air conditions and the calibration data was analyzed to ensure each device’s accuracy before being deployed. Attempts were made to deploy devices associated with specific water leases a minimum of 7 days prior to the initiation of the transaction in order to collect one full week’s worth of data; however, this ended up not being possible at all sites. Microsoft Excel spreadsheets were used to develop daily minimum, maximum, and average water temperature records as needed.

Wetted Perimeter Method

The influence of flow augmentation on aquatic habitat condition was defined through the wetted perimeter method (WPM). The WPM relies on the fact that food chain productivity in riffles is correlated to the wetted length of a channel cross-section as measured along the bottom of the streambed (referred to as the *wetted perimeter*). The SRCD followed

the California Department of Fish and Wildlife Standard Operating Procedure for the Wetted Perimeter Method (CDFW, 2013). Cross-sections (transects) with typical rectangular channel profiles were established at 4-5 representative riffles within a reach. Transect lengths and water depths were targeted for measurement a minimum of ten times under different flow conditions ranging from base-flow to bank-full. French Creek discharge was either directly measured or calculated based on nearby flow station data. Microsoft Excel spreadsheets were used to manage the collected data and produce wetted perimeter-discharge curves. In 2018, five transects were established within representative riffles of middle French Creek between river-mile 2.35 and 2.70 for WPM analysis (Map 4). Then in 2019, an additional four transects were established through lower French Creek between river-mile 0.65-0.80 for a separate analysis (Map 4).

Fish Observation Dives

Direct observation surveys are widely used to monitor salmonid populations, as they are a simple and cost-effective method for estimating abundance, distribution, and species diversity with minimal disturbance. SRCD field technicians trained in species identification and direct observation techniques snorkeled through habitat units and enumerated fish by species and age class according to the methods employed by the California Department of Fish and Wildlife (Thurow, 1994). Despite efforts to standardize dive surveys, they have inherent limitations due to the complexity of the aquatic environment and individual bias; therefore, it is important that biological data presented in this report is interpreted with that understanding. Dive surveys conducted by the SRCD were sometimes coordinated in anticipation of specific water leases to inform the SRWT of habitat conditions within the reach that could potentially benefit from flow augmentation and justify the finalization of a particular forbearance agreement. Surveys were also conducted after water transactions were initiated to quantify populations benefitting from ongoing flow enhancement. It is important to point out that dive surveys did not cover the entirety of habitats influenced by the water leases. Juvenile coho surveys completed as part of this project were permitted through the NOAA Fisheries ESA Section 4(d) permit held by the Scott River Watershed Council (File #21569 and #22473).

Alluvial Connectivity Surveillance

Finally, the SRCD routinely completed foot surveys through the alluvial portion of French Creek to document temporal and spatial changes in connectivity through the base flow period. The foot surveys involved walking the lower 0.6 river-miles of French Creek on a near weekly basis through the low-flow period and taking GPS coordinates of disconnected segments. In 2019, the surveys were accompanied by the deployment of water temperature devices (Onset HOBO Water Temperature Pro v2 Data Loggers) at shallow locations anticipated to go dry so that the timing of these potential events could be better defined.

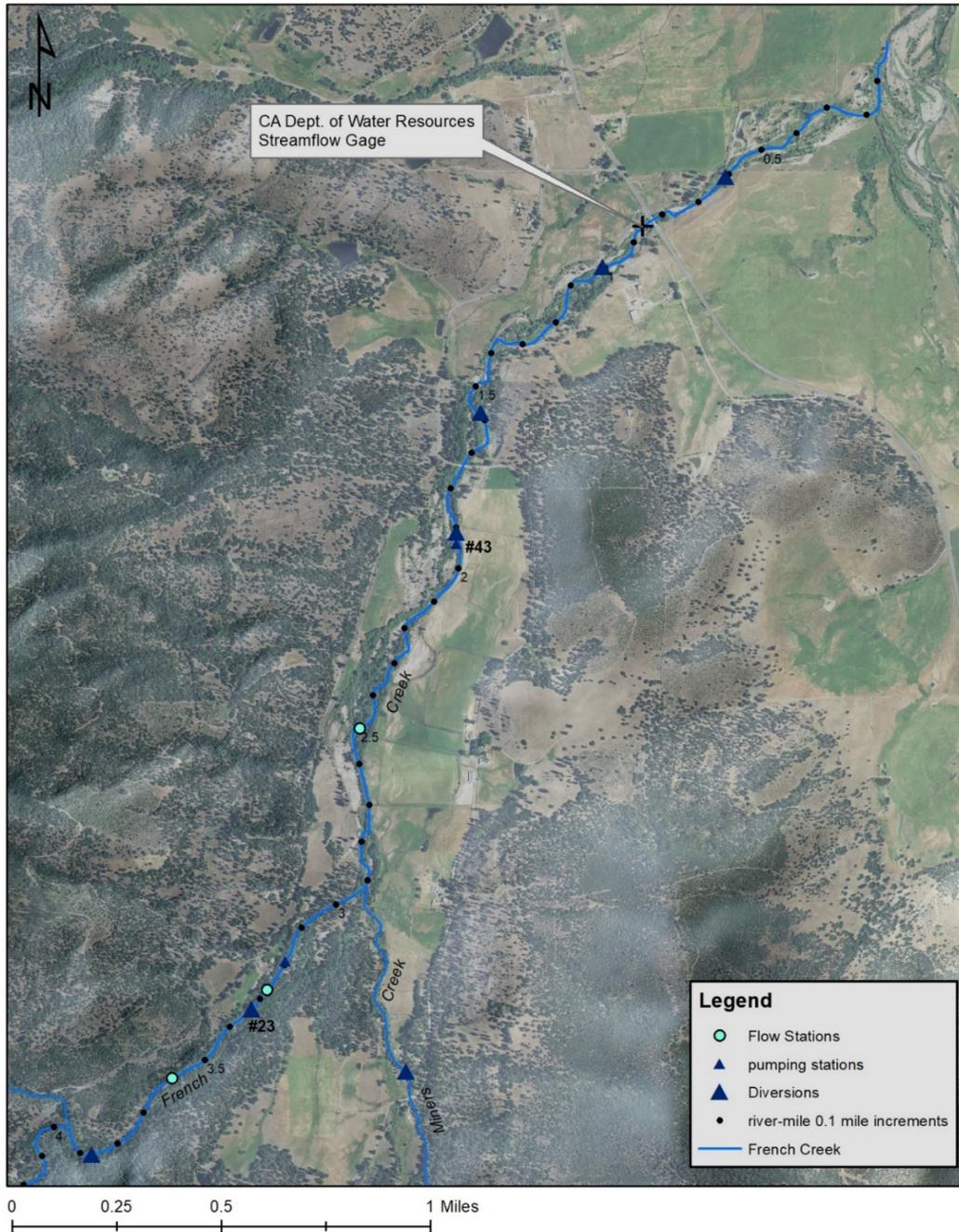
Results

This section covers the processing and interpretation of data collected by the SRCD for the *French Creek Flow Accounting Study*.

2018 Leasing Season

The SRWT entered into a single water lease on French Creek during the 2018 irrigation season. Negotiations resulted in the incremental return of water from Diversion 23 at river-mile 3.33 of French Creek over the month of September (Map 2).

French Creek Flow Accounting -- 2018 Data Collection



Map 2: 2018 Data Collection Sites.

French Creek Diversion 23 Transaction – 2018

Diversion Site: French Creek river-mile 3.33, French Creek Decree Diversion No. 23

Water Right: 1.66 cfs, 1st Priority

Water Right Availability:

9/10/2018: 70% of 1st priority rights = 1.16 cfs

Beginning 9/13/2018: 64% of 1st priority rights = 1.06 cfs

Beginning 9/21/2018: 86% of 1st priority rights = 1.43 cfs

Beginning 9/28/2018: 100% of 1st priority rights = 1.66 cfs

Lease Period: September 11th, 2018 – September 30th, 2018

Duration: 20 days

Leased Amount:

9/11/18 - 9/19/18 = 0.5 cfs

9/20/2018 = 1.06 cfs

9/21/18 - 9/27/18 = 1.43 cfs

9/28/18 - 9/30/18 = 1.66 cfs

Stream discharge before Lease was initiated (9/10/2018): 0.74 cfs

Stream discharge after Lease was Initiated: 1.53 cfs

Net Instream Gain: 0.79 cfs

Stream discharge before Lease was revised (9/20/2018): 2.02 cfs

Stream discharge after Lease was revised: 2.71 cfs

Net Instream Gain: 0.69 cfs

Zone of Influence: From Diversion 23 down to the next point of extraction, Diversion 43 and 39 pump station (1.42 miles)

The 2018 water transaction at Diversion 23 was unique due to the incremental nature of the lease agreement as well as the extremely rare restrictions on first priority water availability by the Watermaster. The SRWT had negotiated the lease of 0.5 cfs from September 11th to September 19th and then the lease of the full water right from September 20th to September 30th. Therefore, the SRCD initiated the transaction on September 10th in preparation for compensation beginning the following day. On the morning of September 10th, flow through Diversion 23 was determined to be 1.19 cfs from measurements taken off the rectangular weir. Additionally, a discharge measurement taken on French Creek immediately below Diversion 23 recorded 0.74 cfs. The SRWT Executive Director and the SRCD then modified rocks along the boulder weir to reduce flow entering the headgate and meet the intended 0.5 cfs lease target. Subsequent measurement over the rectangular weir confirmed that only 0.77 cfs was still being diverted, resulting in 0.42 cfs which remained in the creek. After the stream had sufficient time to acclimatize, flow along the same cross-section of French Creek was measured to be 1.53 cfs, a net gain of 0.79 cfs. The fact that stream response (+0.79 cfs) was greater than the diversion reduction (-0.42 cfs) could be attributed to factors such as natural diurnal fluctuations or leaks through the measuring weir.

On September 20th, the terms of the lease changed to involve the return of the full Diversion 23 water right to French Creek. At that time, the Watermaster had set the availability of all first priority water rights on French Creek to 64%,

meaning that only 1.06 cfs of the 1.66 cfs water right at Diversion 23 was accessible (0.5 cfs of which was already being leased). On the morning of September 20th 2018, in preparation for this adjustment, flow on French Creek at the established transect below Diversion 23 was measured to be 2.02 cfs, while diversion through the rectangular weir was measured to be 0.62 cfs. The SRCD then reduced flow through Diversion 23 by removing flash-boards from the fish screen bypass pipeline and adding flash-boards behind the paddlewheel at the entrance to the ditch until flow was no longer passing over the rectangular weir. Streamflow on French Creek was subsequently re-measured and recorded 2.71 cfs, a net gain of 0.69 cfs. Stream response (+0.69 cfs) and diversion reduction (-0.62 cfs) were comparable.

Through the remainder of the 2018 irrigation season, the Watermaster periodically updated the availability of all first priority water rights on French Creek. The amount of water being returned under the Diversion 23 lease changed accordingly. For example, on September 21st, the availability of first priority water rights increased to 86%, so the available water right at Diversion 23 that could have been diverted but that was already returned instream increased from 1.06 cfs to 1.43 cfs (86% of 1.66). Similarly, on September 28th, all first priority water rights were fully restored, so the volume of the lease was increased from 1.43 cfs to 1.66 cfs and stayed at that amount until the end of the irrigation season on September 30th.



Photo 1: Diversion 23 headgate and boulder weir on French Creek during the water lease.

Instream Flow Monitoring – 2018

Under the *French Creek Flow Accounting Study*, the SRCD established three stream discharge gaging stations on French Creek surrounding Diversion 23 in order to monitor the effect the forbearance agreement in terms of the spatial and temporal influence on the hydrograph. The locations of these stations included below the confluence of the North Fork of French Creek at river mile 3.59, below Diversion 23 at river mile 3.27, and below the Miners Creek confluence at river mile 2.50 (Map 2).

French Creek river-mile 3.59

The most upstream gaging station was established below the North Fork of French Creek between Diversion 20 and 23, in order to monitor flow entering the 2018 focus reach (Map 2, Photo 2). Monitoring equipment was deployed in a pool on June 29th 2018 and field technicians completed four periodic discharge measurements across a range of flows exhibited by the stream from July through October 2018. Discharge measurements were taken at a cross-section established along the tail-out of the gaged pool (Photo 2).

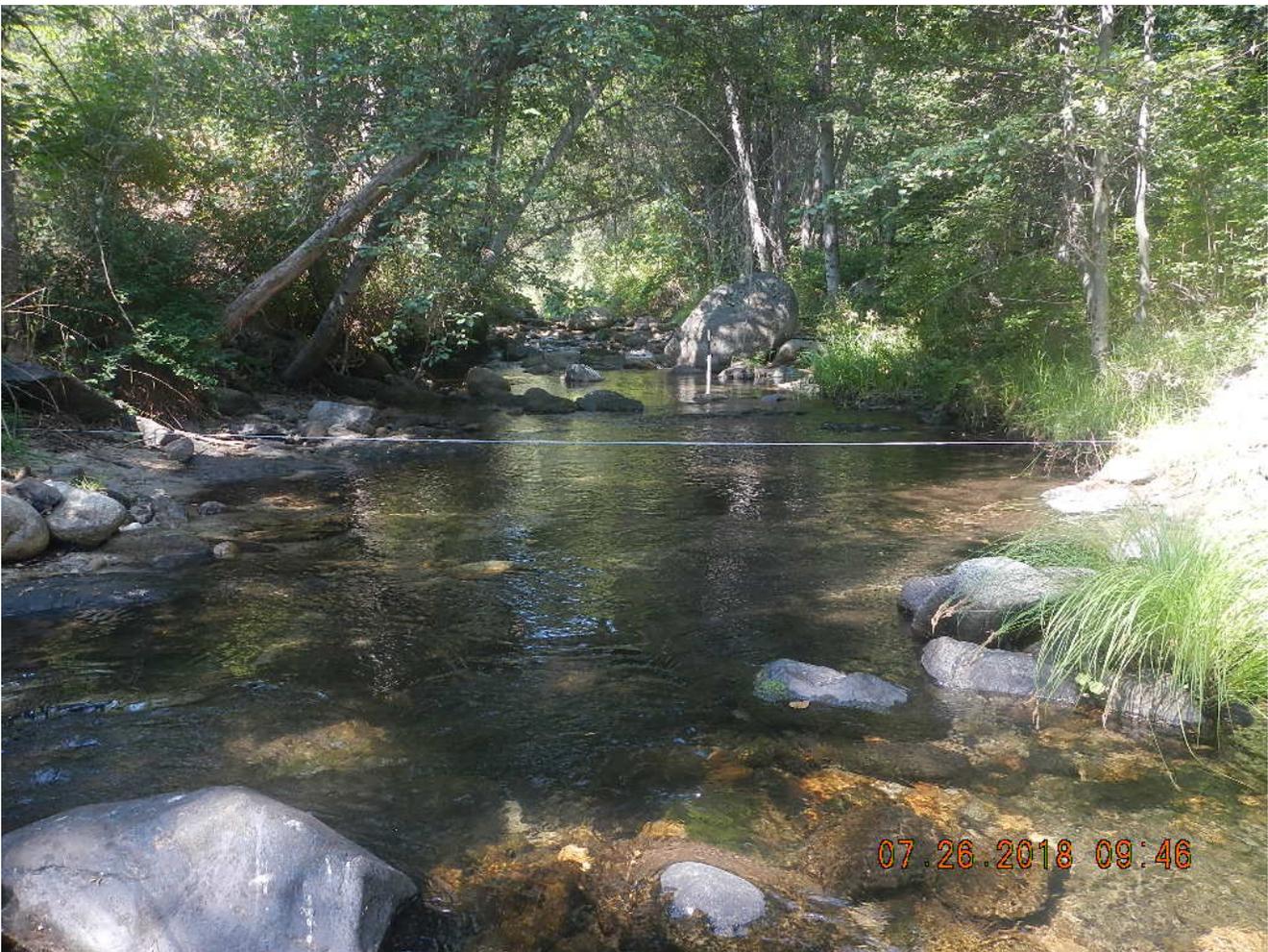


Photo 2: Streamflow gaging station on French Creek at river mile 3.59 showing flow measurement cross section.

A stage-discharge relationship was developed with water level defined by the staff gage on the stilling well. All periodic discharge measurements completed in 2018 (along the same cross-section) were considered in the development of the rating curve. The relationship between stage (y) and discharge (x) was determined to be best defined by the following equation: $y = 1.4947x^{0.1124}$ when $y \leq 1.86\text{ft}$ $R^2 = 0.9804$. The resulting hydrograph relative to measured discharge values is shown in Figure 1.

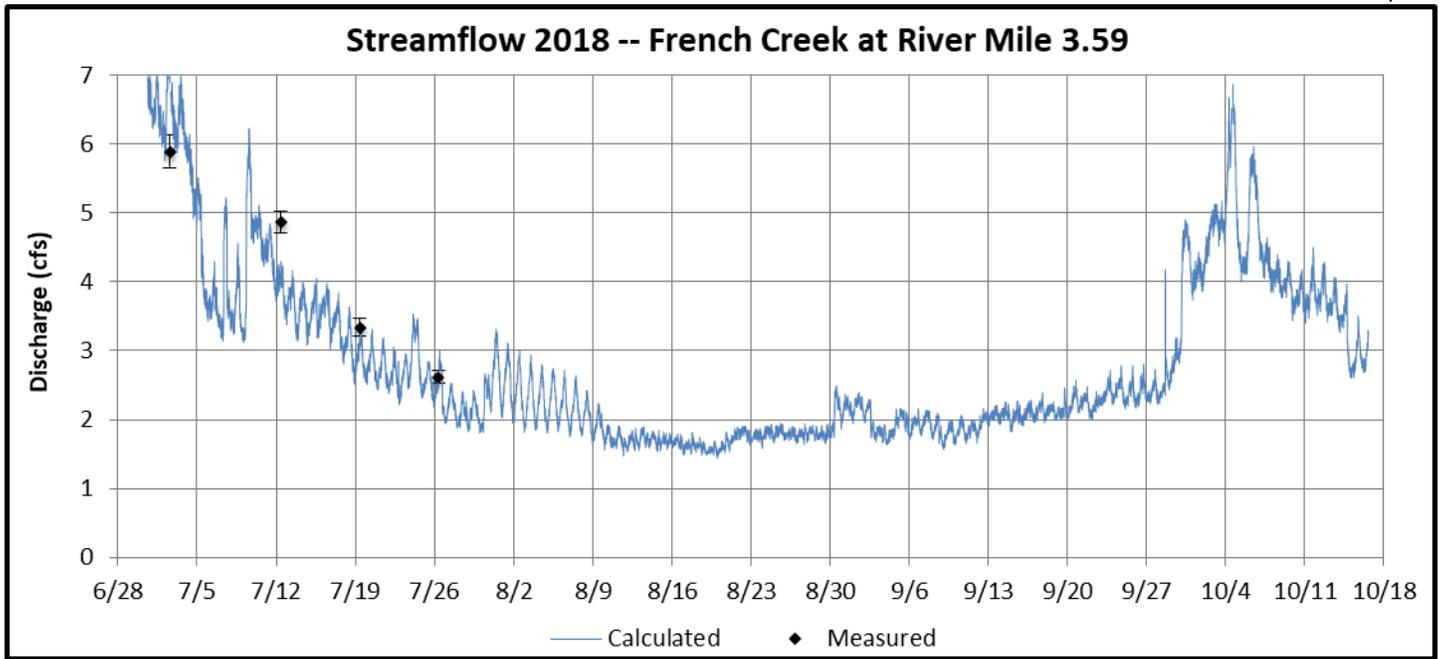


Figure 1: French Creek discharge from flow station below the North Fork at river-mile 3.59.

French Creek river mile 3.27

A second flow station was established on French Creek approximately 100 yards downstream from the Diversion 23 fish-screen bypass pipeline in order to record flow influenced by diversion activity (Map 2, Photo 3). Monitoring equipment was deployed in a step-pool on June 29th 2018 and field technicians completed nine periodic discharge measurements across a range of flows exhibited by the stream from July through October 2018. Discharge measurements were taken at a cross-section established along the tail-out of a flatwater habitat unit approximately 40 yards downstream of the flow station.



Photo 3: Streamflow gaging station on French Creek below Diversion 23 at river mile 3.27.

A stage-discharge relationship was developed with water level defined by the staff gage on the stilling well. All periodic discharge measurements completed in 2018 (along the same cross-section) were considered in the development of the rating curve except for the highest measurement (Q = 6.594) because it was inconsistent with other values perhaps due to channel morphology at higher stages. The relationship between stage (y) and discharge (x) was determined to be best defined by the following equation: $y = 1.1569x^{0.1541}$ when $y \leq 1.43$ ft $R^2 = 0.9875$. The resulting hydrograph relative to measured values is shown in Figure 2 and 3.

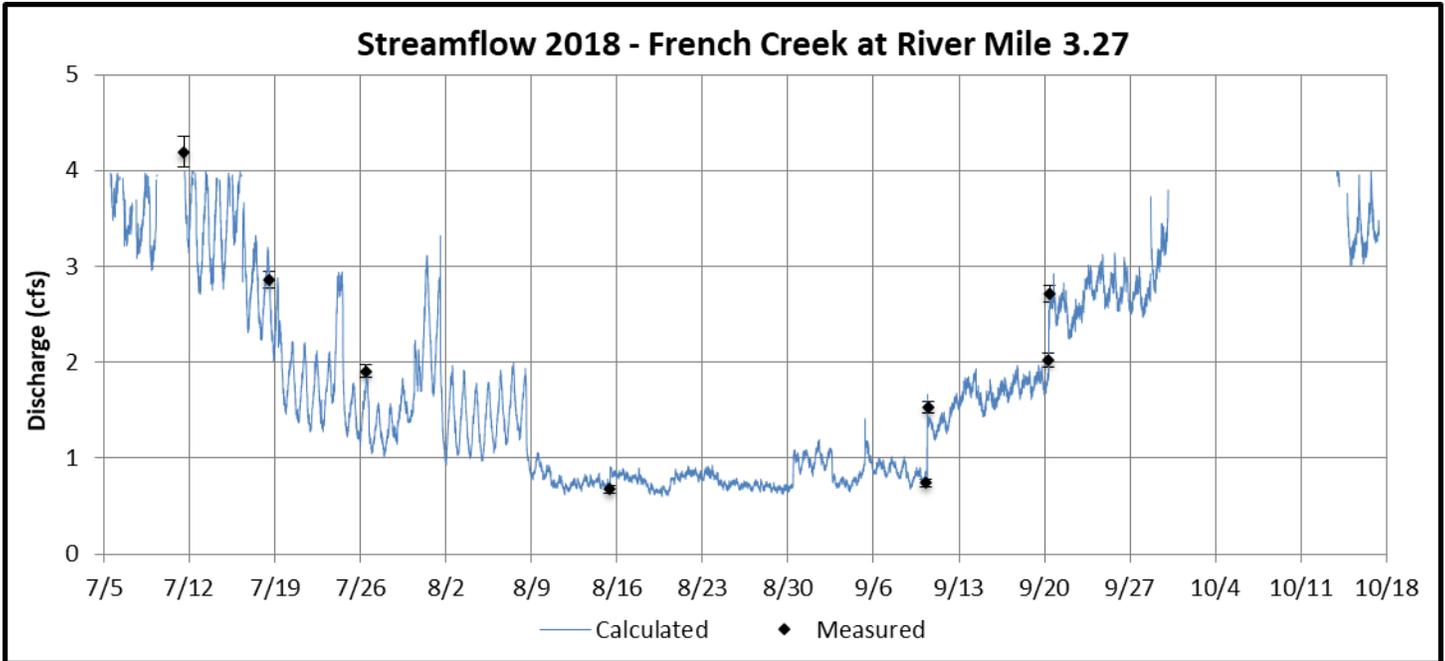


Figure 2: French Creek discharge from flow station at river mile 3.27, below Diversion 23.

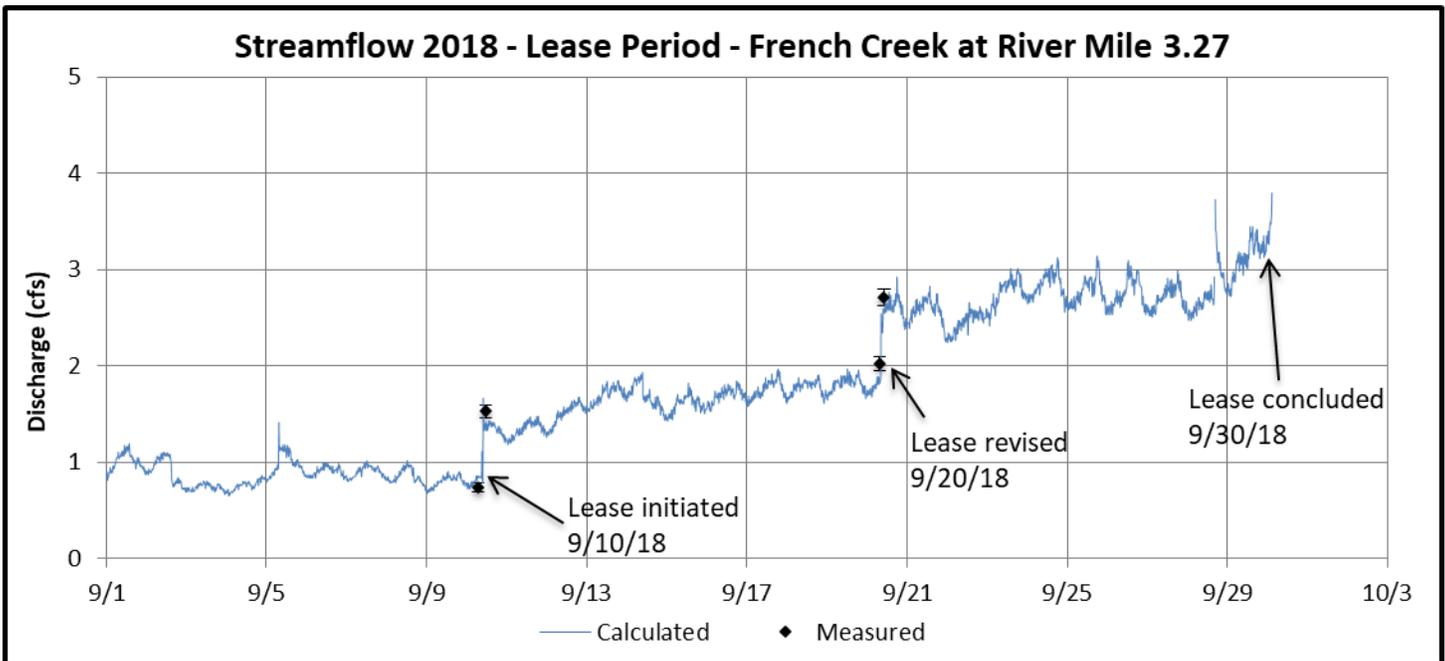


Figure 3: French Creek discharge from flow station at river mile 3.27, below Diversion 23 for the water lease period only.

French Creek river mile 2.50

A third flow station was established on French Creek at river-mile 2.50 in order to determine whether the water lease could be detected beyond the pumping station at river mile 3.19 and below the confluence with Miners Creek (Map 2, Photo 4). Although the confluence of Miners Creek was likely dry during the 2018 study period, it is possible that there remained subsurface inputs to French Creek. This station also supported a wetted perimeter analysis through mid-French Creek. Monitoring equipment was deployed in a pool on July 16th 2018 and field technicians completed three periodic discharge measurements across a range of flows exhibited by the creek from July through October 2018. Discharge measurements were taken at a cross-section established in a tail-out of a flatwater habitat unit approximately 20 yards downstream of the gaged pool.



Photo 4: Streamflow gaging station on French Creek below the confluence of Miners Creek at river mile 2.50.

A stage-discharge relationship was developed with water level defined by the staff gage on the stilling well. All periodic discharge measurements completed in 2018 were considered in the development of the rating curve with the exception of the two highest measurements ($Q = 17.53$ cfs and $Q = 33.97$ cfs). These were not included because they were taken at significantly higher flows after the irrigation season had ended. The relationship between stage (y) and discharge (x) was determined to be best defined by the following equation: $y = 1.7028x^{0.0647}$ when $y \leq 1.86$ ft $R^2 = 0.9986$. The resulting hydrograph relative to measured values is shown in Figure 4 and 5.

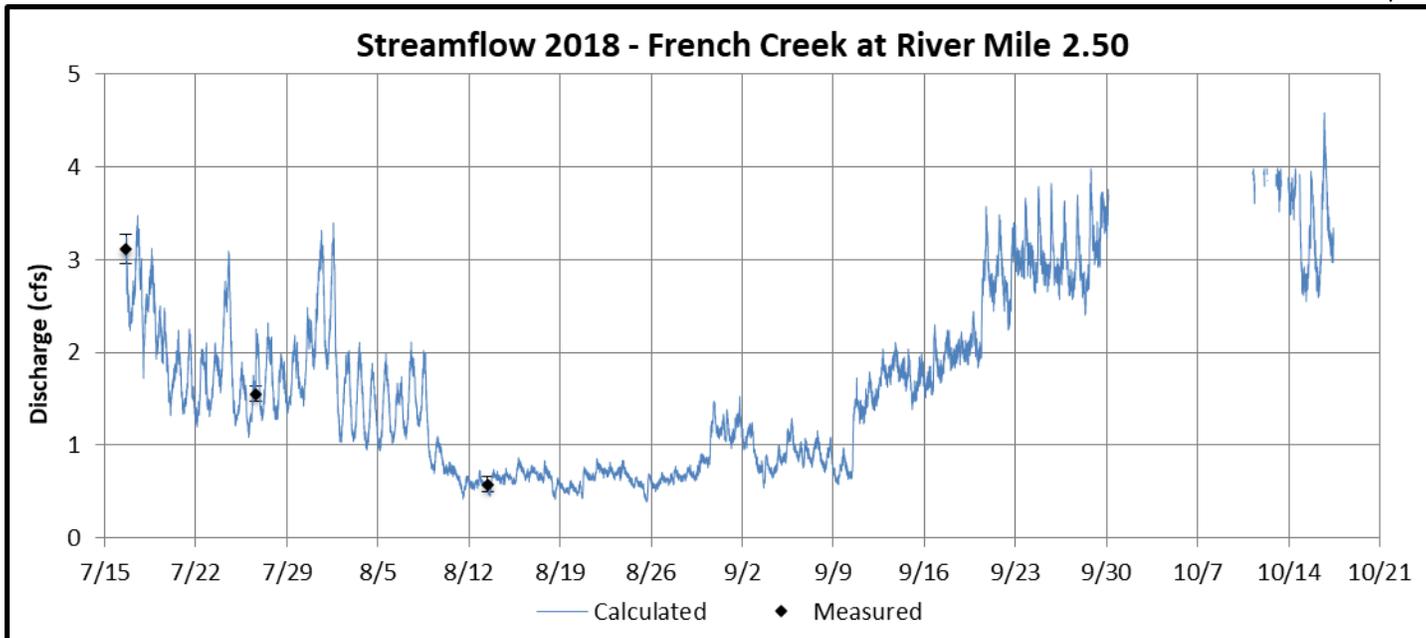


Figure 4: French Creek discharge from flow station below Miners Creek at river mile 2.50.

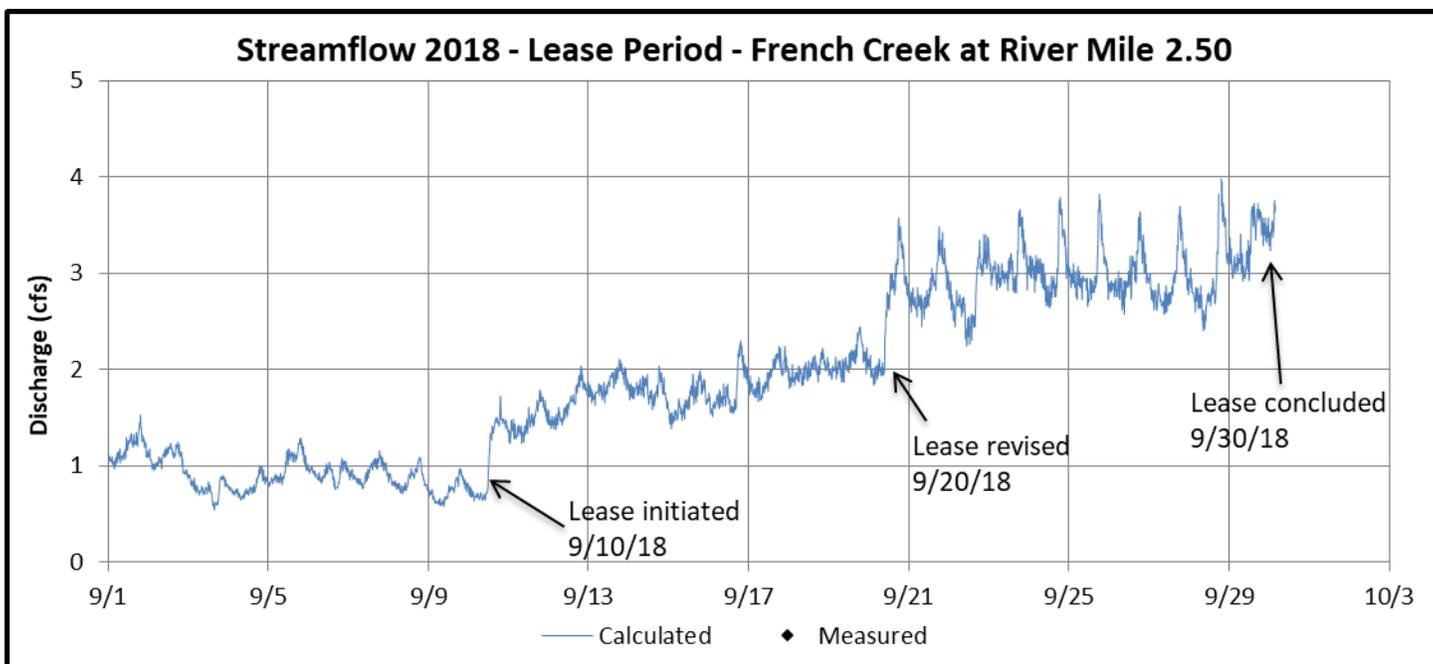


Figure 5: French Creek discharge from flow station below Miners Creek at river mile 2.50 for the water lease period only.

Hydrograph Analysis

The purpose of the flow monitoring network was to understand how French Creek responded to the water transaction at Diversion 23. Analysis of the hydrographs from the three stations has allowed the SRCD to determine the extent to which the incremental water lease at Diversion 23 effected stream flow in terms of linear length (miles), magnitude (cfs) and timing (hours or days).

The uppermost flow station was located below the North Fork of French Creek at river mile 3.59 between Diversion 20 and 23. This site represents stream discharge entering the study area and is not affected by lease activity at Diversion 23. Comparison of the records from that flow station and the one below Diversion 23 at river mile 3.27 shows that the water lease dramatically altered the hydrograph (Figure 6). The flow station at river mile 3.27 was located just downstream (approximately 100 yards) from the Diversion 23 bypass return and was immediately affected by lease activity. It shows stream discharge increasing by 0.53 cfs between 9:45-10:15 am when the lease was initiated on 9/10/2018 and then again by 0.54 cfs between 8:15 and 8:45 am when the lease was revised on 9/20/2018. Due to its proximity to Diversion 23 this flow station responded quickly (within 15 – 30 minutes) to changes at the diversion and the full amount of leased water was confirmed to be instream at this location.

Review of the records from the lowest flow station on French Creek at river mile 2.50 verified that the leased water passed the pumping station at river mile 3.19 and extended beyond Miners Creek to a point at least 0.83 miles downstream from Diversion 23 (Figure 7). The flow station at river mile 2.50 shows stream discharge increasing on 9/10/2018 between 11:45am-12:45pm in the amount of 0.38 cfs after the lease was initiated and again on 9/20/2018 between 9:30 and 10:00am in the amount of 0.34 cfs after the lease was revised. This site responded approximately 1.25 to 2.0 hours after changes were made at Diversion 23. Most, but not the full volume, of leased water made it to this flow station. On 9/10/2018, 0.38 cfs of the full 0.42 cfs amount returned instream was recorded at river mile 2.50, and on 9/20/2018, 0.34 cfs of the full 0.37 cfs additional amount returned to stream was recorded at that flow station. This discrepancy is within the margin of error for the flow measurements; however, the phenomenon could also be due to fluctuation in the leased water pulse, as the modification to diversion infrastructure necessary to meet the transaction terms cannot be completed instantaneously and is completed over a period of time, sometimes up to an hour.

For all practical purposes, the data suggests that the leased water passed beyond both the pumping station (river mile 3.19) and Miners Creek relatively unimpeded.

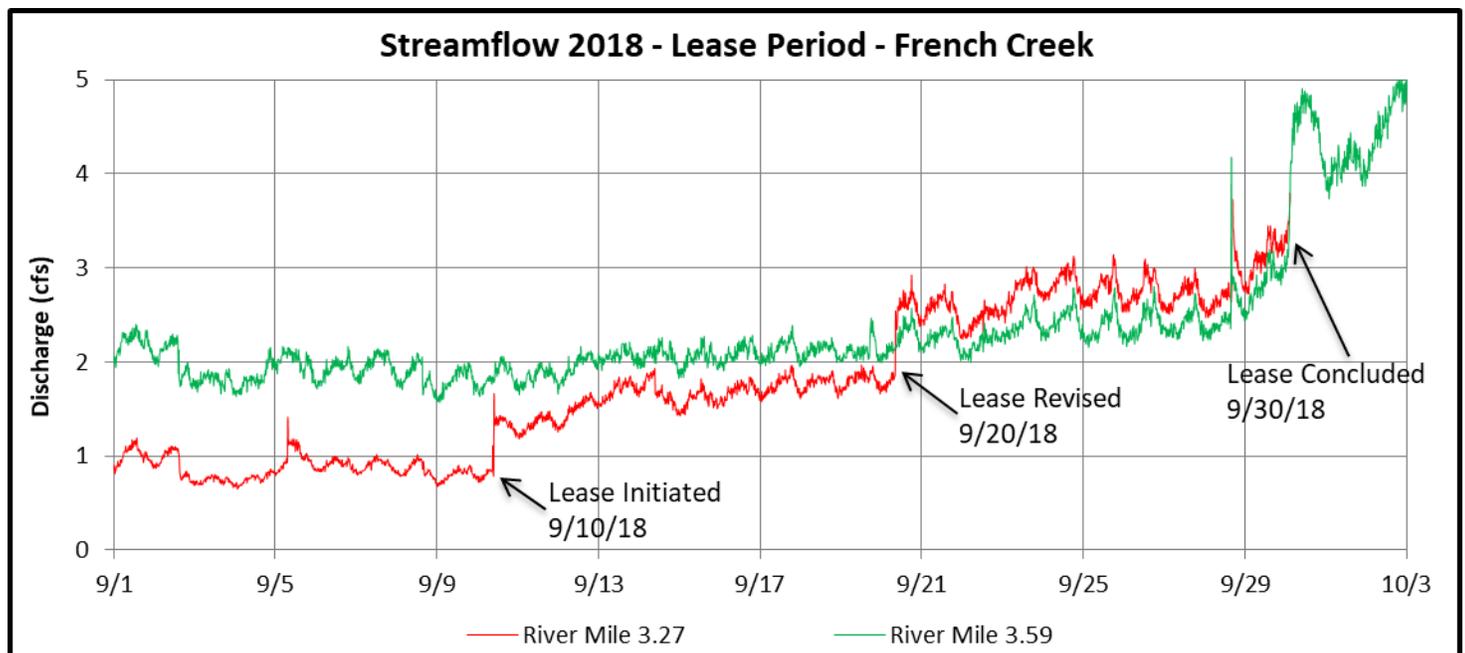


Figure 6: French Creek discharge at river mile 3.59 and 3.27 for the water lease period only.

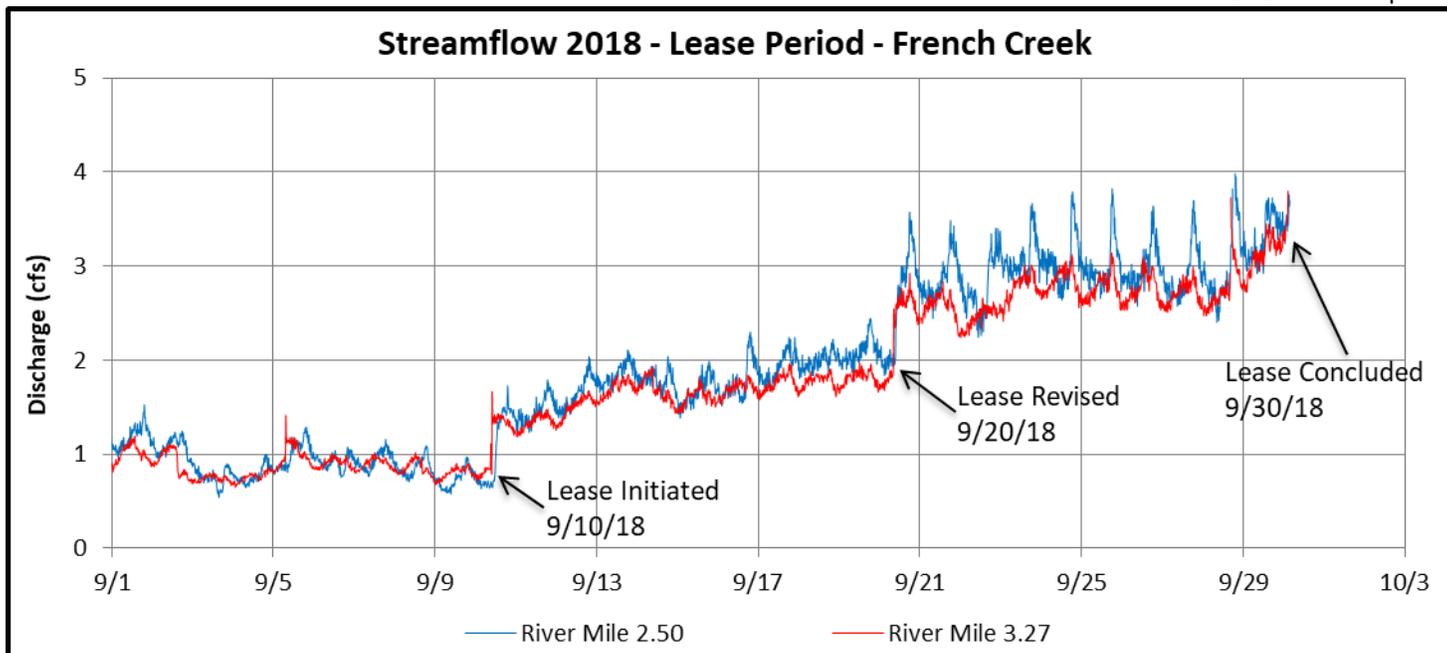


Figure 7: French Creek discharge at river mile 3.27 and 2.50 for the water lease period only.

Both the SRWT Executive Director and the SRCD visually checked conditions at the river-mile 1.91 boulder weir servicing Diversion 43 and 39 before and after the Diversion 23 lease was initiated on 9/10/18 and were able to state with confidence that the water lease produced a noticeable effect on the stream. The intake of Diversion at 43 was impeded by beaver at the time and water was not entering the ditch system. It is unknown whether the Diversion 39 pump was active at the time. Regardless this information demonstrates that a 0.5 cfs water lease from Diversion 23 impacts habitat the full 1.42 miles downstream to Diversion 43. Additional data collection was proposed for 2019 to quantify if leased water could pass the boulder weirs, especially when water was being actively diverted at Diversion 43.

The three monitoring stations and the visual observations proved to be effective in determining the downstream extent of influence of the water transaction.

Stream Temperature - 2018

French Creek water temperatures were monitored to determine whether the stream temperature regime was impacted by the transaction. Comparison of water temperature data collected from the flow stations at river mile 3.59 and at river mile 3.27 (above and below Diversion 23, respectively) demonstrates that water temperature trends are consistent although the stream warms slightly over this 0.32 mile section (Figure 8 and 9). Closer review of water temperatures through the immediate days surrounding the initiation, modification and conclusion of the transaction confirm that the lease did not impact water temperatures or daily fluctuations (Figure 9).

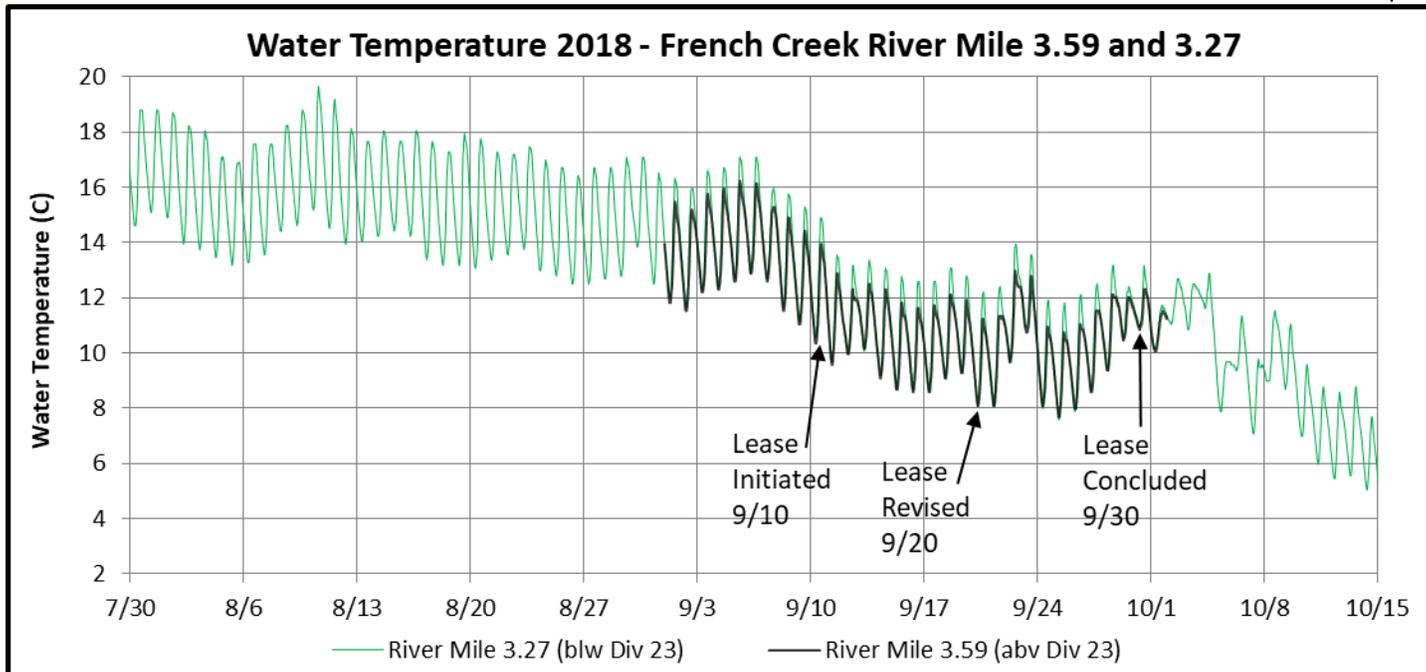


Figure 8: Water temperatures on French Creek surrounding Diversion 23 at river mile 3.59 and river mile 3.27.

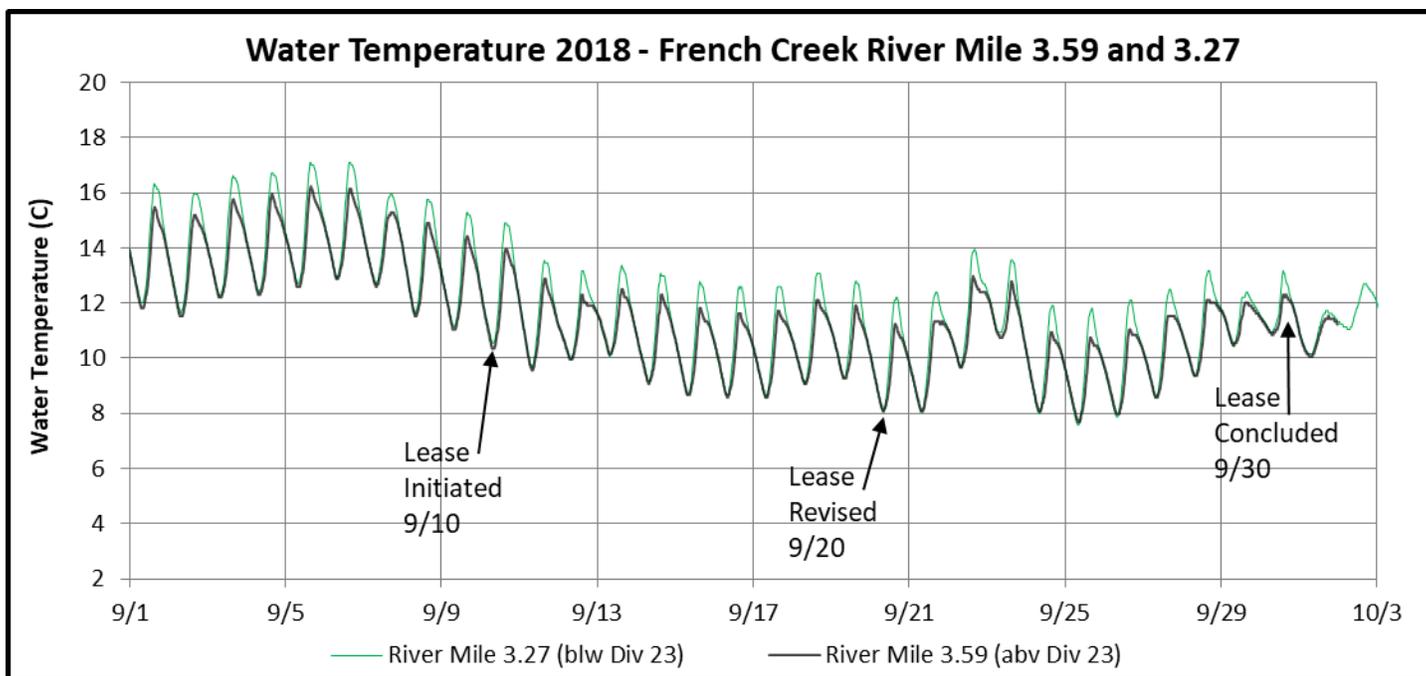
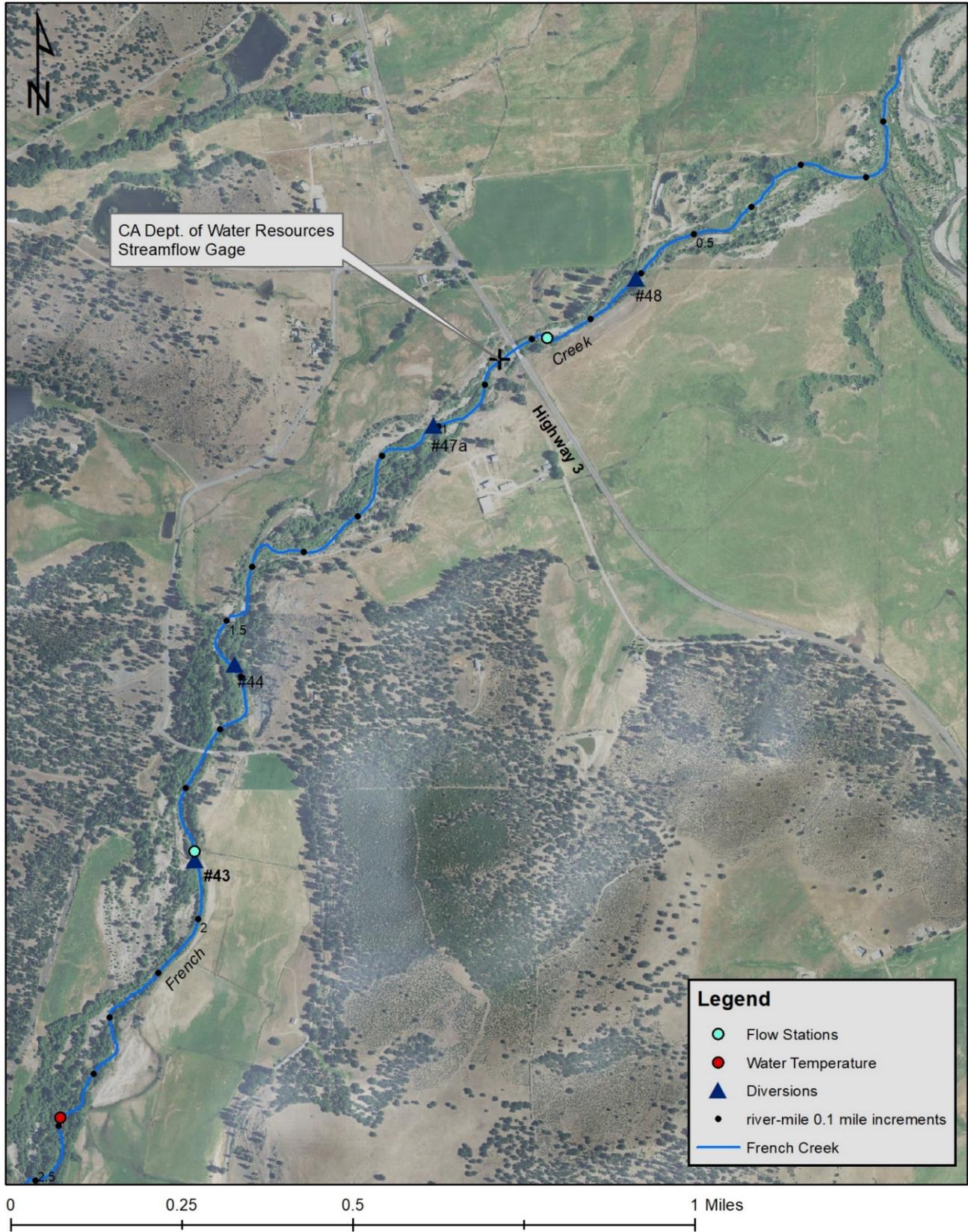


Figure 9: Water temperatures on French Creek surrounding Diversion 23 at river mile 3.59 and river mile 3.27 during the lease period.

2019 Leasing Season

The SRWT entered into two water leases on French Creek during the 2019 irrigation season. The first transaction involved the return of all available water rights from Diversion 43 at river-mile 1.91 for nearly the entire month of August (Map 3). The second transaction again involved the incremental return of water from Diversion 23 at river-mile 3.33 over the month of September.

French Creek Flow Accounting -- 2019 Data Collection



Map 3: 2019 Data Collection Sites.

French Creek Diversion 43 Transaction – 2019

Diversion Site: French Creek river-mile 1.91, French Creek Decree Diversion No. 43

Water Right: 3.85 cfs, total combined 3rd and 4th priorities

Water Right Availability:

Available flow on = 2.28 cfs

Lease Period: August 4th, 2019 – August 31st, 2019

Duration: 28 days

Leased Amount:

8/4/19 - 8/17/19 = estimated 2.28 cfs

8/18/19 - 8/31/19 = varying amounts from 2.25-1.93 cfs dependent upon streamflow and fourth priority availability

Stream Discharge before Lease was Initiated (8/2/2019): 1.26 cfs

Stream Discharge after Lease was Initiated: Withdrawn as unrepresentative
Determined

Net Instream Gain: Not

Zone of Influence: From Diversion 43 down to the next point of extraction, Diversion 44 (0.33 miles)

The water transaction at Diversion 43 involved the return of all available third and fourth priority water rights beginning in early August and continuing until the total compensation amount was reached. In this specific case, the water-users were responsible for selecting the initiation date and implementing the transaction, the SRCD was only tasked with working around their schedule to take pre- and post-lease flow measurements that confirmed compliance. The SRCD was notified mid-day on August 2nd that the water-users intended to shut-down Diversion 43 over the weekend, therefore, staff went out to the site later that afternoon to check diverted flow and measure discharge on French Creek. A flow measurement taken along a transect across the concrete flume recorded 2.28 cfs being diverted (0.25 cfs third priority + 2.03 cfs fourth priority). Next, a discharge measurement was taken on French Creek immediately below the boulder weirs that recorded streamflow to be 1.26 cfs. The following day (August 3rd), the water-users shut down water delivery into the ditch system at the fish screen and incrementally lowered the headgate over many hours until it was nearly closed but would allow remaining fish to exit through the bypass pipeline over the coming days. Late in the afternoon of August 3rd, the SRCD returned to the site and visually verified that the ditch was dry at the measuring flume. A subsequent discharge measurement along the same cross-section of French Creek recorded 4.32 cfs, however water levels were unstable over the course of the measurement thereby affecting its accuracy. The SRCD later determined that this was a result of the Diversion 43 water-users finishing their adjustments to the headgate right before the scheduled post-lease measurement, which didn't leave sufficient time for French Creek to acclimatize. Therefore, the net instream gain cannot be calculated from the pre- and post-lease measurements. Regardless, it was confirmed by the SRCD that 2.28 cfs was no longer being diverted and the ditch system was dry. The water-users returned on August 6th and completely closed the headgate after it had been confirmed that there were no longer any fish in the system. The Diversion 43 third and fourth priority water rights were returned to French Creek from August 4th through August 31st under a forbearance agreement with the SRWT. The water-users kept the diversion closed on a voluntary basis through the end of the irrigation season on September 30th.

French Creek Diversion 23 Transaction – 2019

Diversion Site: French Creek river-mile 3.33, French Creek Decree Diversion No. 23

Water Right: 1.66 cfs, 1st Priority

Water Right Availability:

4/1/2019 – 9/30/2019: 100% of 1st priority rights = 1.66 cfs

In contrast to the 2018 water year, 1st priority water rights on French Creek were never reduced in 2019

Lease Period: August 31st, 2019 – September 30th, 2019

Duration: 31 days

Leased Amount:

8/31/19 - 9/19/18 = 0.75 cfs

9/20/19 - 9/30/18 = 1.66 cfs

Stream Discharge before Lease was Initiated (8/30/2019): 1.84 cfs

Stream Discharge after Lease was Initiated: 2.98 cfs

Net Instream Gain: 1.14 cfs

Stream Discharge before Lease was revised (9/20/2019): 7.70 cfs

Stream Discharge after Lease was revised: 8.24 cfs

Net Instream Gain: 0.54 cfs

Zone of Influence: From Diversion 23 down to the next point of extraction, Diversion 43 and 39 pumping station (1.42 miles)

The water transaction at Diversion 23 was again incrementally implemented over the 2019 irrigation season. The SRWT had negotiated the lease of 0.75 cfs from August 31st to September 19th and then the lease of the full water right from September 20th to September 30th 2019. Therefore, the SRCD initiated the transaction on August 30th in preparation for compensation beginning the following day. On the morning of August 30th, a discharge measurement taken on French Creek immediately below Diversion 23 recorded 1.84 cfs, while flow through ditch was determined to be 1.64 cfs from measurements taken off the rectangular weir. The SRCD then modified rocks along the boulder weir and removed flashboards from the fish screen bypass pipe to meet the intended 0.75 cfs target. Subsequent measurement over the rectangular weir confirmed that only 0.93 cfs was still being diverted, meaning that 0.71 cfs remained in the creek. After the stream had sufficient time to acclimatize, flow along the same cross-section of French Creek was measured to be 2.98 cfs, a net gain of 1.14 cfs. Again, the fact that stream response (+1.14 cfs) was greater than the diversion reduction (-0.71 cfs) could be attributed to factors such as natural diurnal streamflow fluctuations or leaks through the measuring weir.

On September 20th, the terms of the lease changed to involve the return of the full water right to French Creek bringing the forbearance amount from 0.75 cfs to 1.66 cfs. On the morning of September 20th 2019, in preparation for this adjustment, flow on French Creek at the established transect below Diversion 23 was measured to be 7.70 cfs, while diversion through the rectangular weir was measured to be 0.62 cfs. The SRCD then reduced flow through Diversion 23 by removing flash-boards from the fish screen bypass pipeline and adding flash-boards behind the paddlewheel at the entrance to the ditch until flow was no longer passing over the rectangular weir. Streamflow on French Creek was subsequently re-measured and recorded 8.24 cfs, a net gain of 0.54 cfs. The fact that stream response (+0.54 cfs) was slightly less than the diversion reduction (-0.62 cfs) is likely attributable to the fact that French Creek was on the descending limb of a recent rain event and flow was naturally decreasing. The Diversion 23 first priority water right was returned to French Creek in its entirety from September 20th through the end of the irrigation season on September 30th.

French Creek Discharge Monitoring – 2019

In 2019, the SRCD established two stream discharge gaging stations on French Creek in order to monitor the spatial and temporal effect of the season's forbearance agreements on the hydrograph (Map 3). The SRCD intended to utilize the

same approach applied in the prior year to monitor the 2019 transaction at Diversion 43 and thereby attempt to determine the zone of influence of water released at the boulder weirs. The first flow station was installed on French Creek at river-mile 1.90, immediately below the boulder weirs to verify compliance with the agreement. It should be noted that this station would also be used to quantify the potential influence of a water lease from Diversion 23 beyond Diversion 43 (a key follow-up item from the 2018 monitoring season). Ideally, the SRCD wanted to position additional flow stations around the next downstream extraction points (Diversion 44 and possibly even Diversion 47a) in order to see whether water from Diversion 43 could extend beyond these points, however, a lack of access from private landowners precluded these activities. Therefore, the SRCD relied on the CDWR flow station at river-mile 0.86 and installed a second flow station at the next acceptable location, which ended up being below Highway 3 at river-mile 0.77. This station also served to support the wetted-perimeter analysis through lower French Creek.

Mid-French Creek River Mile 1.90

The streamflow gaging station on French Creek at river-mile 1.90 was located immediately below Diversion 43 and 39 (pumping station) (Map 3, Photo 5). The purpose of this station was to measure stream response to a transaction at Diversion 43 and track the naturally declining lease volume through the season. Additionally, the station was established to determine whether water from an upstream lease at Diversion 23 could be detected beyond Diversion 43. Monitoring equipment was deployed in a small pool between the two boulder weirs on July 3rd, 2019 and the SRCD completed five periodic discharge measurements across a range of flows exhibited by the stream from July through November 2019. Discharge measurements were taken at a cross-section established along the tail-out of a flatwater run, just downstream from lower boulder weir.



Photo 5: Streamflow gaging station on French Creek at river mile 1.90.

A stage-discharge relationship was developed with water level defined by the staff gage on the stilling well. All periodic discharge measurements completed in 2019 (along the same cross-section) were considered in the development of the rating curve, with the exception of the one taken on 8/3/19 ($Q = 4.32$ cfs) because water levels on French Creek were unstable over the course of the measurement. The SRCD later determined that this was the result of the Diversion 43 water-users having recently made adjustments at the headgate and French Creek had not yet acclimatized. The

relationship between stage (y) and discharge (x) was determined to be best defined by the following equation: $y = 1.2619x^{0.1759}$ when $y \leq 2.02$ ft $R^2 = 0.9797$. The resulting hydrograph relative to the measured values is shown in Figure 10 and 11.

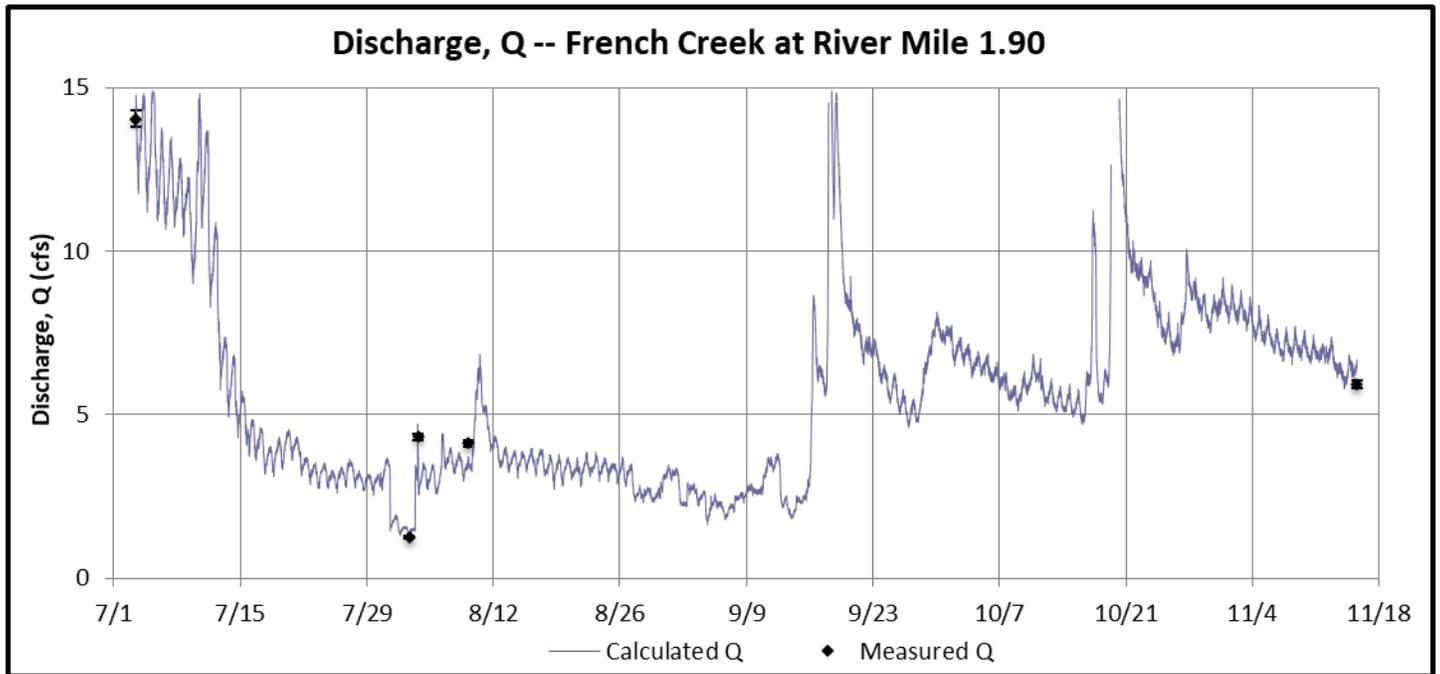


Figure 10: French Creek discharge from flow station below Diversion 43 at river mile 1.90.

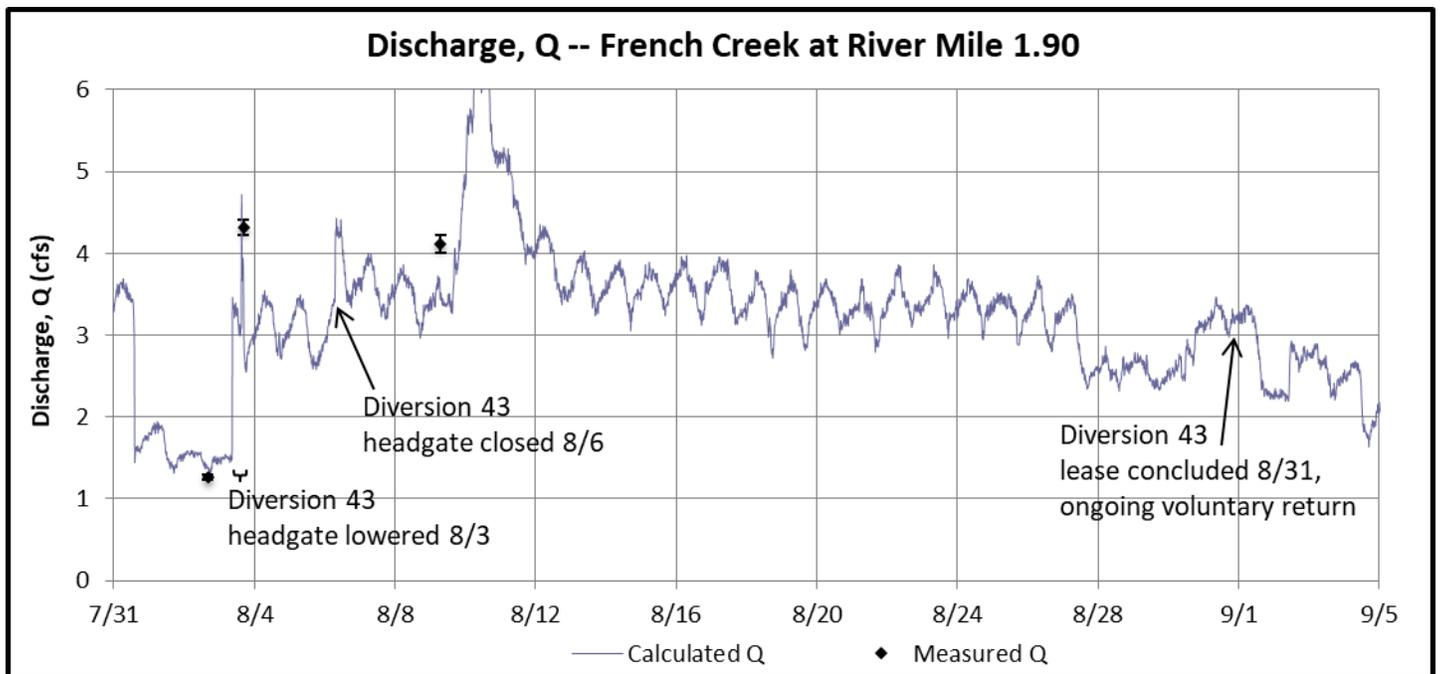


Figure 11: French Creek discharge from flow station below Diversion 43 at river mile 1.90 for the lease period only.

Lower French Creek River Mile 0.77

A second flow station was established on French Creek at river-mile 0.77 (Map 3), in order to determine whether water leased from Diversion 43 could be detected beyond Diversion 44 and 47a as well as support a wetted perimeter analysis through lower French Creek. Although this station is relatively close to the CDWR streamflow gaging station (FCC), it provides a better representation of discharge on French Creek because it is positioned below the influence of Diversion 47a, while FCC is between the extraction point and the fish screen bypass return. Additionally, over the last couple of years the low-flow channel of French Creek has moved away from FCC causing reliability issues during the base flow period. Monitoring equipment was deployed in a small pool at river-mile 0.77 approximately 100 yards below Highway 3 on June 25th, 2019 (Photo 6). Field technicians completed nine periodic discharge measurements across a range of flows exhibited by the creek from June through December 2019. Discharge measurements were taken at a cross-section established in a tail-out of a flatwater habitat unit just upstream of the gauged pool.



Photo 6: Streamflow gauging station on Lower French Creek below Highway 3 at river mile 0.77.

A stage-discharge relationship was developed with water level defined by the staff gage on the stilling well. All periodic discharge measurements completed in 2019 were considered in the development of the station's rating curve with the exception of the one taken on 7/8/19 ($Q = 7.23$ cfs). This data point was excluded because there was another measurement at a very similar water level that yielded a more accurate rating curve. The relationship between stage (y) and discharge (x) was determined to be best defined by the following equation: $y = 1.9004x^{0.0795}$ when $y \leq 2.38$ ft $R^2 =$

0.9832. The resulting hydrograph relative to the measured values is shown in Figure 11. The data has been truncated at 10/1 due to an unknown device disturbance.

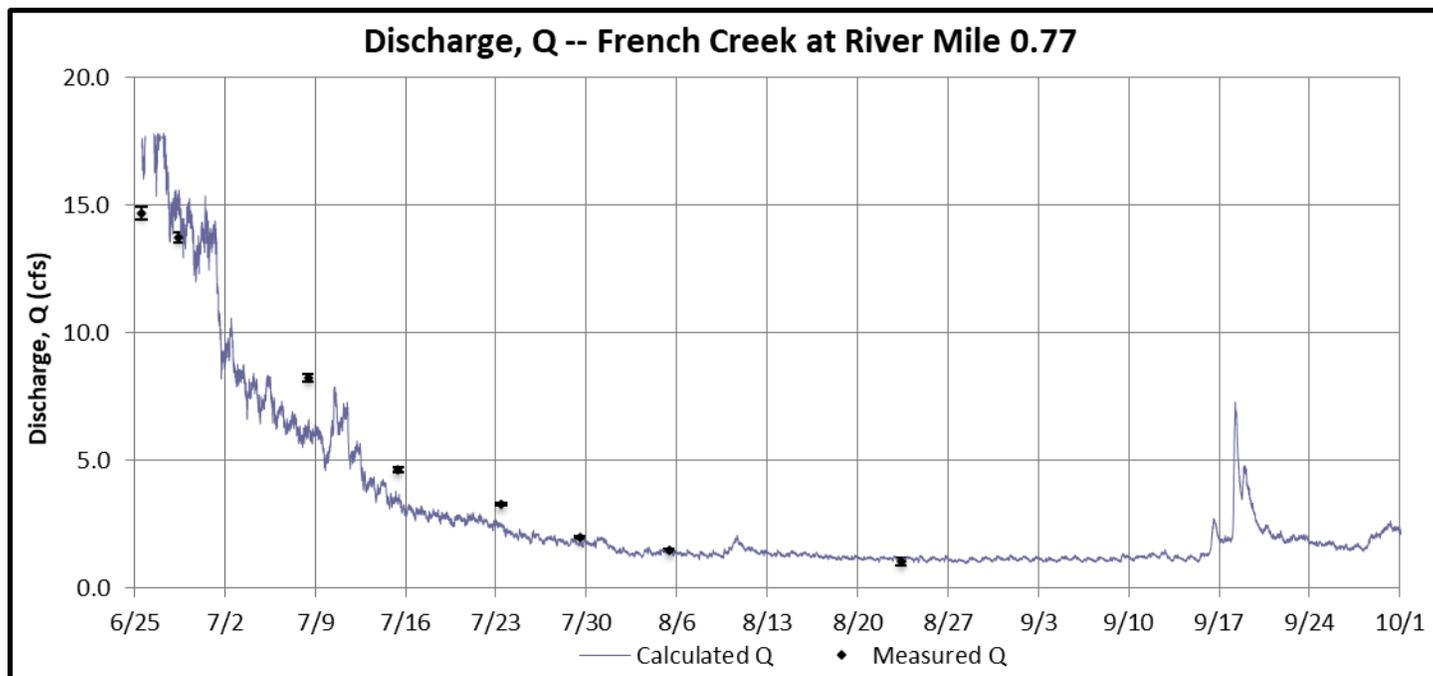


Figure 12: French Creek discharge from flow station below Highway 3 at river mile 0.77.

Hydrograph Analysis

The purpose of the flow monitoring network was to understand how French Creek responded to water transactions executed in 2019. Analysis of the hydrographs from the two stations was intended to allow the SRCD to determine the extent that the water leases at Diversions 43 and 23 affected stream flow in terms of linear length (miles), magnitude (cfs) and timing (hours or days).

The uppermost flow station managed on French Creek in 2019 was located at river-mile 1.90 below the boulder weir for Diversion 43. It should be noted that this station is positioned between the Diversion 43 intake and fish screen bypass return, therefore it does not represent discharge on French Creek when Diversion 43 is active. The station was established to monitor a transaction at Diversion 43 that was planned to involve completely closing the headgate. Due to its proximity to Diversion 43 intake, this flow station was expected to respond relatively quickly to management at the headgate. Review of the records shows the water-users incrementally adjusting the position of the headgate (both lowering and raising) on 8/3/19 from approximately 8:30 am to 15:00 (Figure 13). Unfortunately, these actions ended up occurring too near the scheduled post-lease measurement (16:00) rendering it unrepresentative and demonstrating that stream conditions can take over an hour to acclimatize. As a result, the SRCD proposes to estimate the stream response on 8/3/19 by taking the difference between average flow before and after the lease (Figure 13). These calculations suggest that approximately 1.5 cfs was released at river-mile 1.90 on 8/3/19 (3.07 cfs – 1.57 cfs). The remaining leased water was temporarily being run through the ditch system and returned through the fish screen bypass pipeline at river-mile 1.60. Once the headgate was finally closed on 8/6/19, the flow station registered a 0.87 cfs increase in discharge over a half hour period. Although the water lease was realized by the flow station over more than one day, the combined stream response between 8/3 and 8/6 adds up to 2.37 cfs (1.57 cfs + 0.87 cfs), which is consistent with the measured diversion reduction of 2.28 cfs.

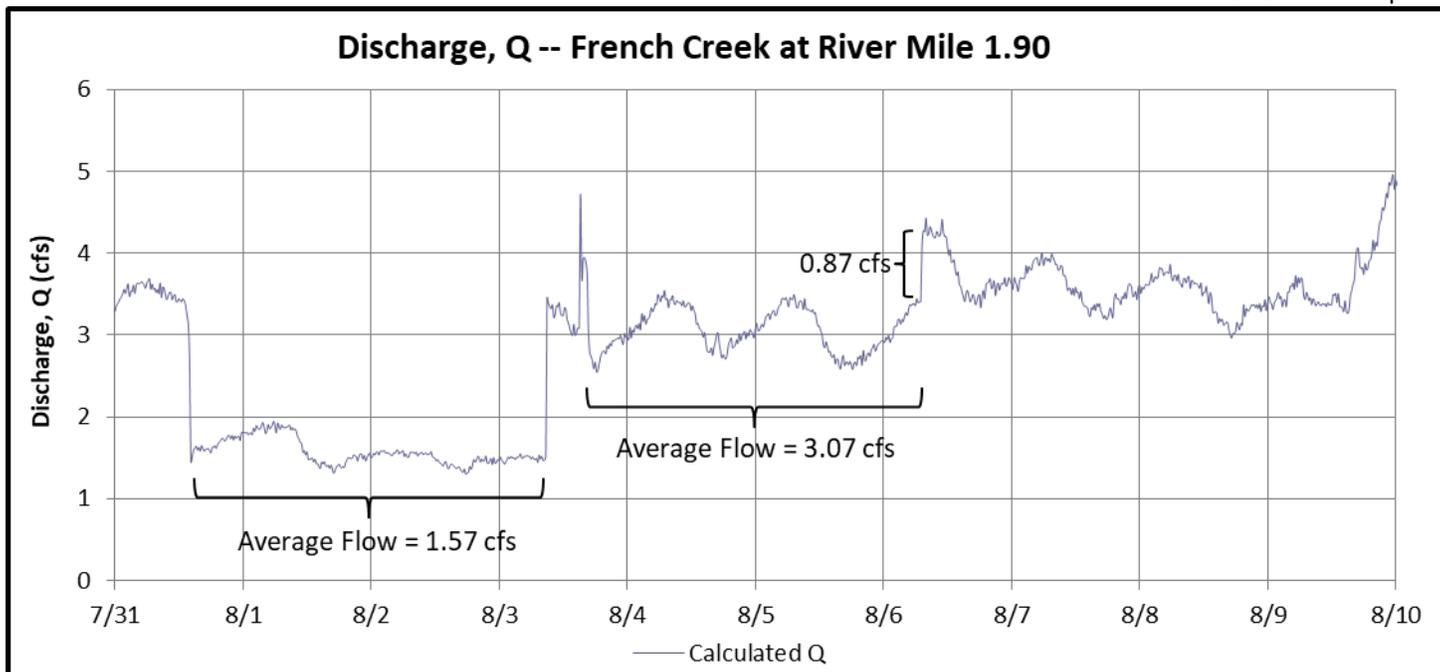


Figure 13: French Creek discharge from the flow station below Diversion 43 at river mile 1.90 for the water lease period only.

A secondary purpose of the river-mile 1.90 flow station was to determine if water released at Diversion 23 would be detectable beyond Diversion 43. Close investigation of the flow station records from 8/30 when the Diversion 23 lease was initiated and again on 9/20 when it was revised do not lead to conclusive results (Figure 14). There is a small increase (0.43 cfs) in flow on 8/30 about 1.5 – 2.5 hours after the lease was initiated but it cannot be differentiated from background noise. Then on 9/20, there is a clear increase in flow beyond ambient turbulence about 1.0 – 1.5 hours after the lease was modified, however, it cannot be specifically attributed to the lease because French Creek is on the descending limb of a recent rain event and the volume is larger than would be expected (1.04 cfs). It is unknown whether the Diversion 39 pump was active at either of these times. Unfortunately, the conditions in 2019 were such that the SRCD could not determine whether there was a quantifiable contribution of water from Diversion 23 beyond river-mile 1.90. Although this information leaves open the possibility that leased water from Diversion 23 makes a more significant impact on the hydrograph in dry water years than average water years.

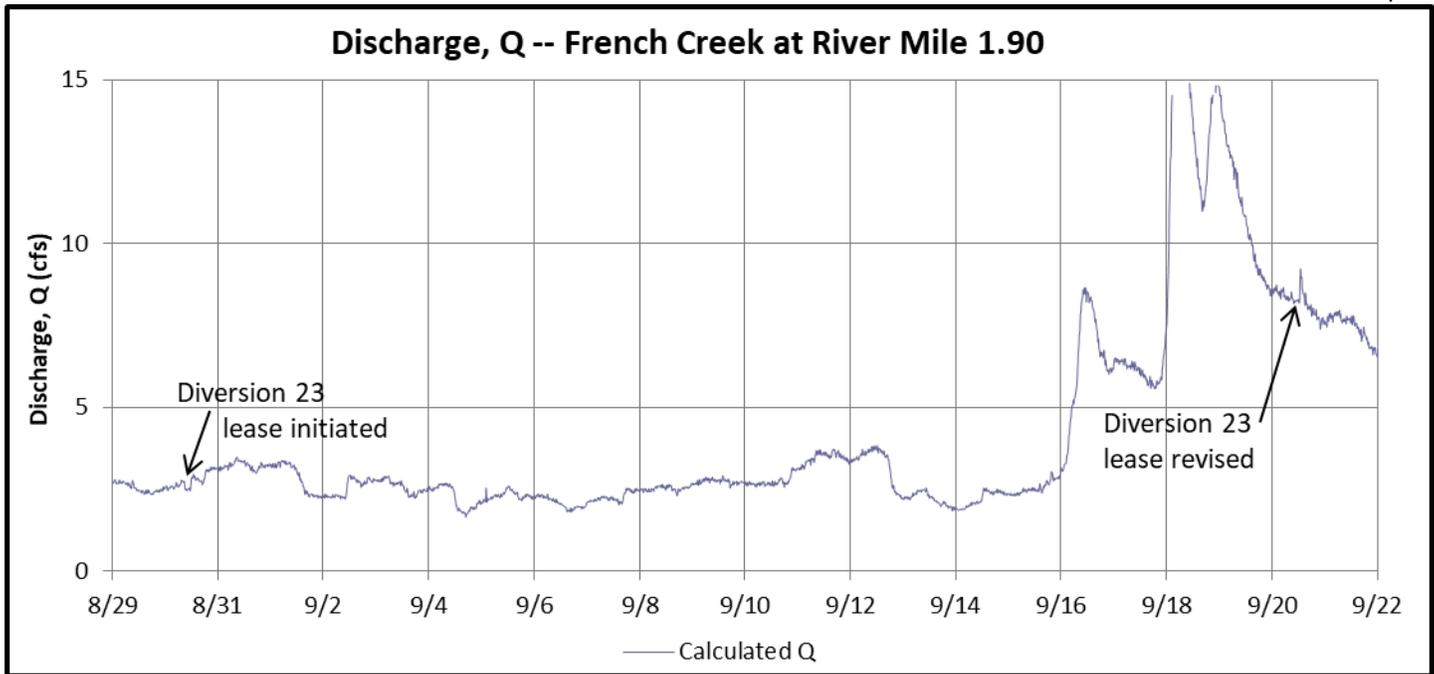


Figure 14: French Creek discharge from the flow station below Diversion 43 at river mile 1.90 for the Diversion 23 water lease period only.

Review of the records from the lowest flow station managed on French Creek at river-mile 0.77 does not illustrate a discernible response from the Diversion 43 transaction (Figure 15). Detecting the Diversion 43 lease was challenged by the fact that the water-users implemented the transaction through incremental returns over a 6 hour period on August 3rd, which effectively dilutes the stream response making it more difficult to pick out of natural flow patterns downstream. However, ultimately neither the release of 1.5 cfs on 8/3 or the release of 0.87 cfs on 8/6 resulted in any impact to the hydrograph below Highway 3 either because that water was extracted by other users or because of natural loss through the alluvial fan over this distance. In conclusion, the collective 2.28 cfs returned from Diversion 43 influenced habitats at least 0.33 miles to the next point of extraction, Diversion 44. By agreement the 0.25 cfs third priority from Diversion 43 cannot be taken to fulfill other water rights at Diversion 44, therefore this amount influenced habitat further, but the extent is unknown due to a lack of property access where intermediate flow stations could have been established.

The Diversion 23 water lease was not anticipated to be visible below Highway 3.

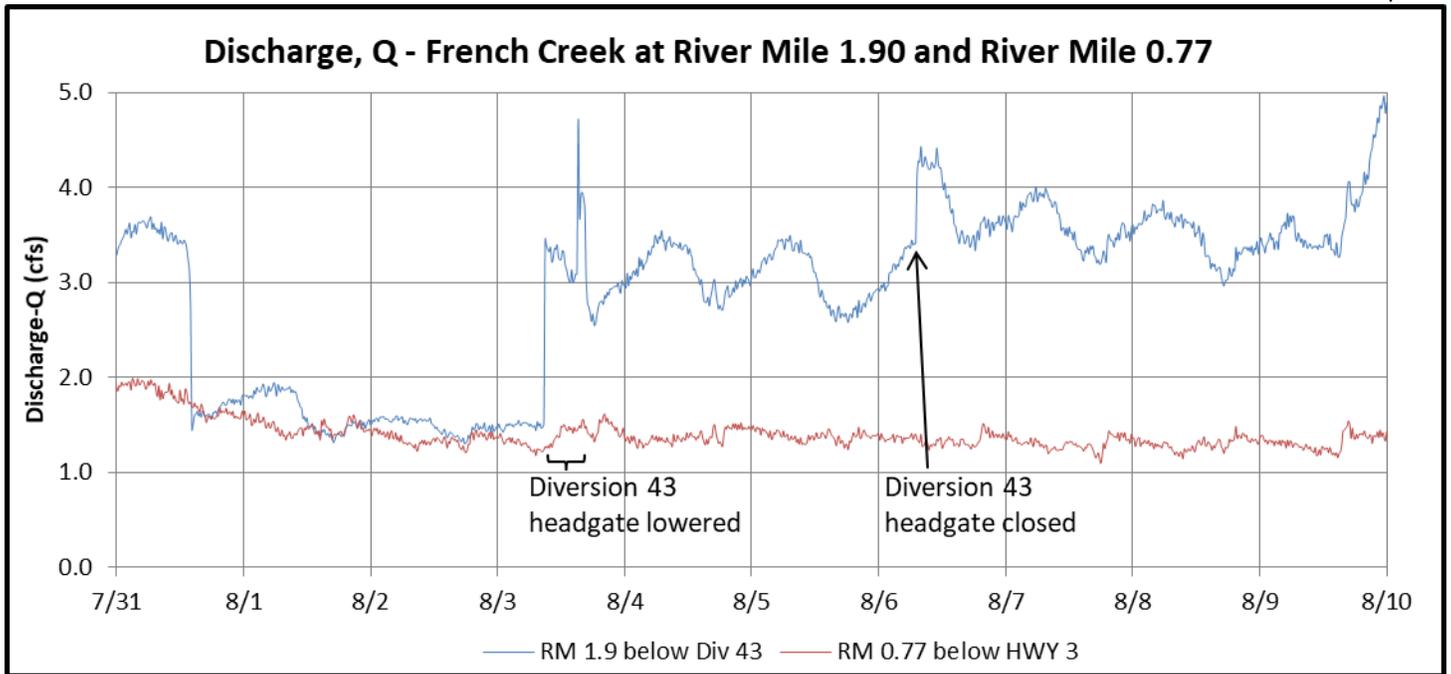


Figure 15: French Creek discharge from flow stations below Diversión 43 at river mile 1.90 and below Highway 3 at river mile 0.77 surrounding the initiation of the Diversión 43 lease.

The two monitoring stations managed in 2019 were not as effective in determining the downstream extent of influence of the water transactions at Diversión 43 and 23. Additional intermediary flow stations were necessary to interpret the data.

Stream Temperature - 2019

Water temperature monitoring was conducted surrounding the lease sites in order to confirm that the stream temperature regime was not impacted by the water transactions. Comparison of water temperature data collected from devices at river-mile 2.39 and river-mile 1.90 (above and below Diversión 43, respectively) demonstrates that water temperature trends are consistent and daily fluctuations through the immediate days surrounding initiation of the transaction remain unaffected (Figure 16). The SRCD only collected water temperature data below Diversión 23, devices were located directly below the fish screen bypass return at river-mile 3.29 and at river-mile 2.39 within the zone of influence (Figure 17). These datasets track very closely; there is a natural compression in daily fluctuations before the Diversión 23 lease was initiated and then precipitation in mid-September prior to its revision.

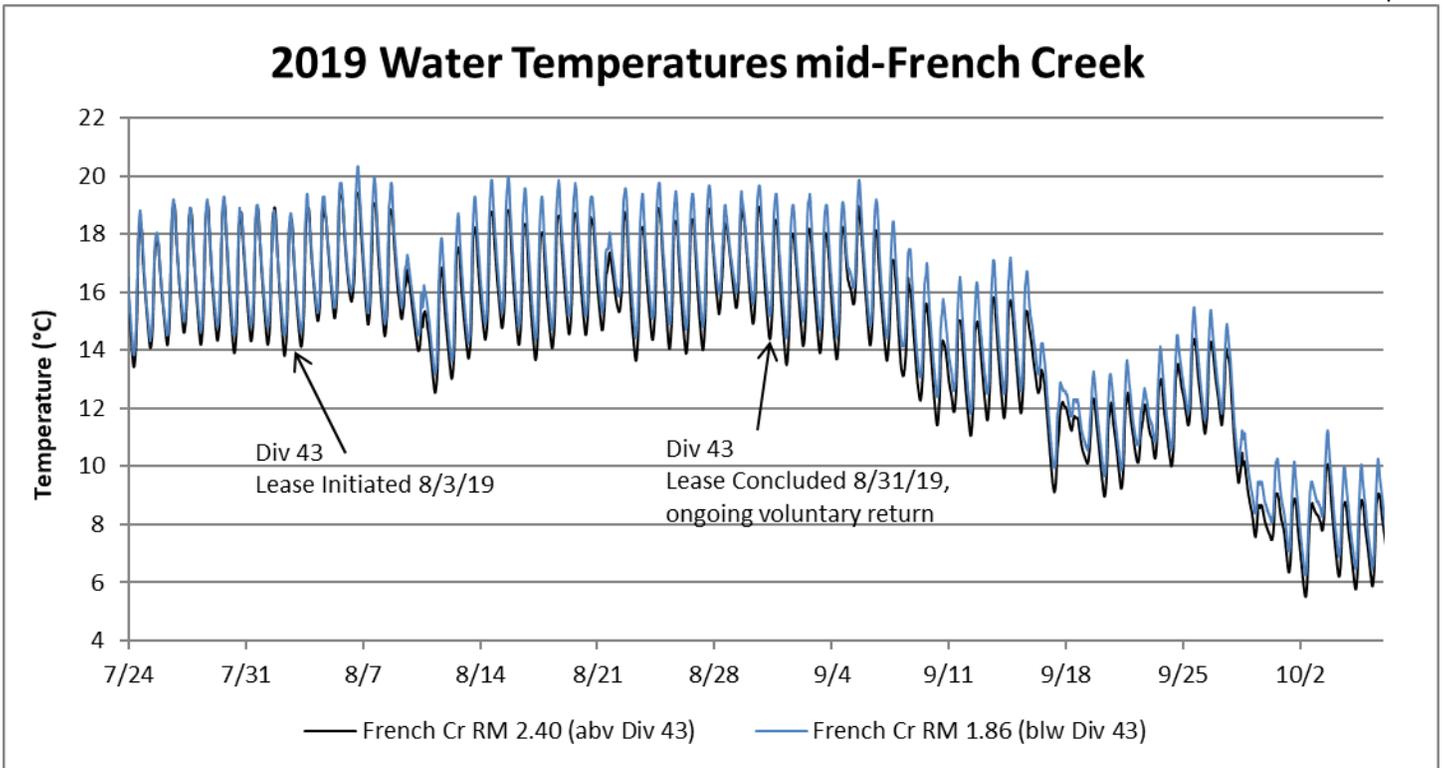


Figure 16: Mid-French Creek water temperatures during the Diversion 43 lease period.

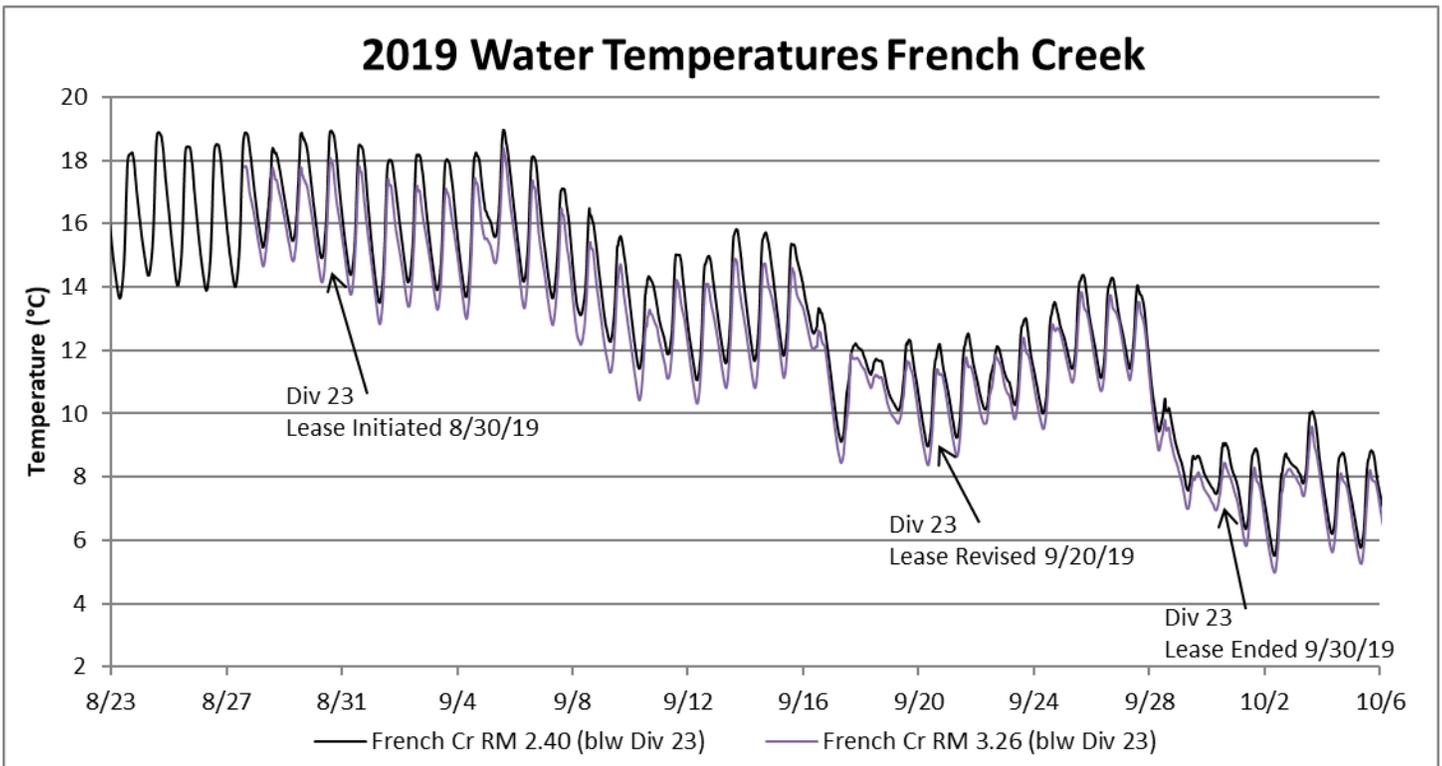


Figure 17: Mid French Creek water temperatures during the Diversion 23 lease period

Wetted Perimeter Analysis

The influence of flow augmentation on aquatic habitat condition was defined through the wetted perimeter method (WPM). The WPM characterizes the relationship between stream discharge and benthic macroinvertebrate production within riffle habitats. Due to the fact that benthic macroinvertebrates are the primary source of nourishment for salmonid species during their freshwater life stages, understanding changes in food production serves as a surrogate for understanding capacity thresholds for salmonid species. The WPM relies on the fact that riffle productivity is correlated to the wetted length of a channel cross-section as measured along the bottom of the streambed (referred to as the *wetted perimeter*). The SRCD followed the California Department of Fish and Wildlife Standard Operating Procedure for the Wetted Perimeter Method (CDFW, 2013). Cross-sections (transects) with typical rectangular channel profiles were established at 4-5 representative riffles within a reach. Transects were periodically assessed under various stream conditions and compared with discharge measurements to generate the wetted perimeter-discharge curve, an example of which can be found in Figure 18. Identification of the breakpoint and incipient asymptote allows for the determination of flow thresholds that are critically important for maintaining riffle production of benthic macroinvertebrates. The WPM assumes that the flow represented by the incipient asymptote will protect the food producing riffle habitats at a level sufficient to maintain the existing fish population at some acceptable level of sustained production (Annear et al. 2004). Application of the WPM in French Creek is intended to assist in understanding the effectiveness of flow enhancement work by the SRWT by determining the range of flows under which incremental flow augmentation would have the greatest positive impact on aquatic food chains. In 2018, five transects were established within representative riffles of middle French Creek between river-mile 2.35 and 2.70 (Map 4). In 2019, four additional transects were established within riffles of lower French Creek between river-mile 0.65 and 0.80 (Map 4).

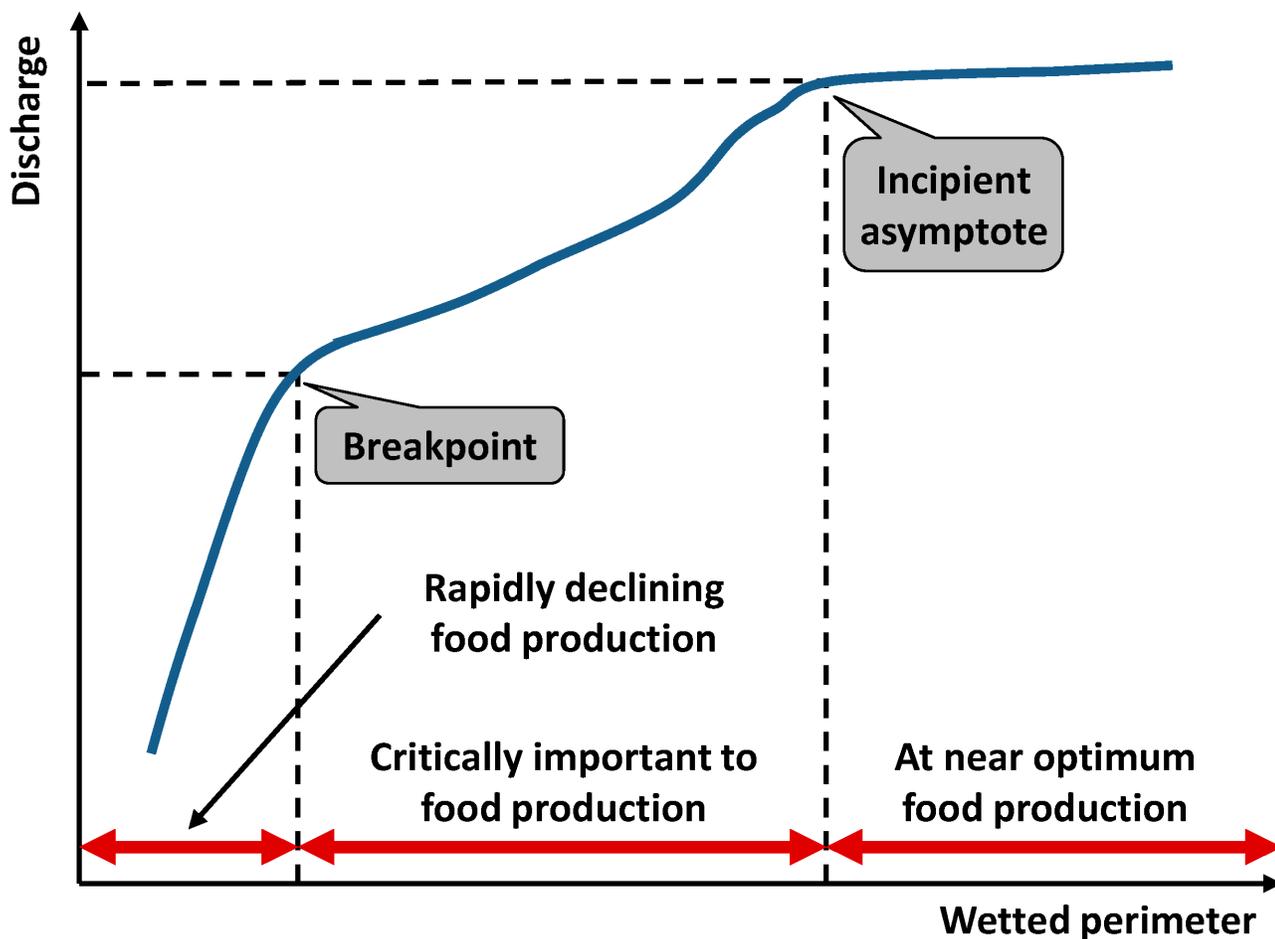
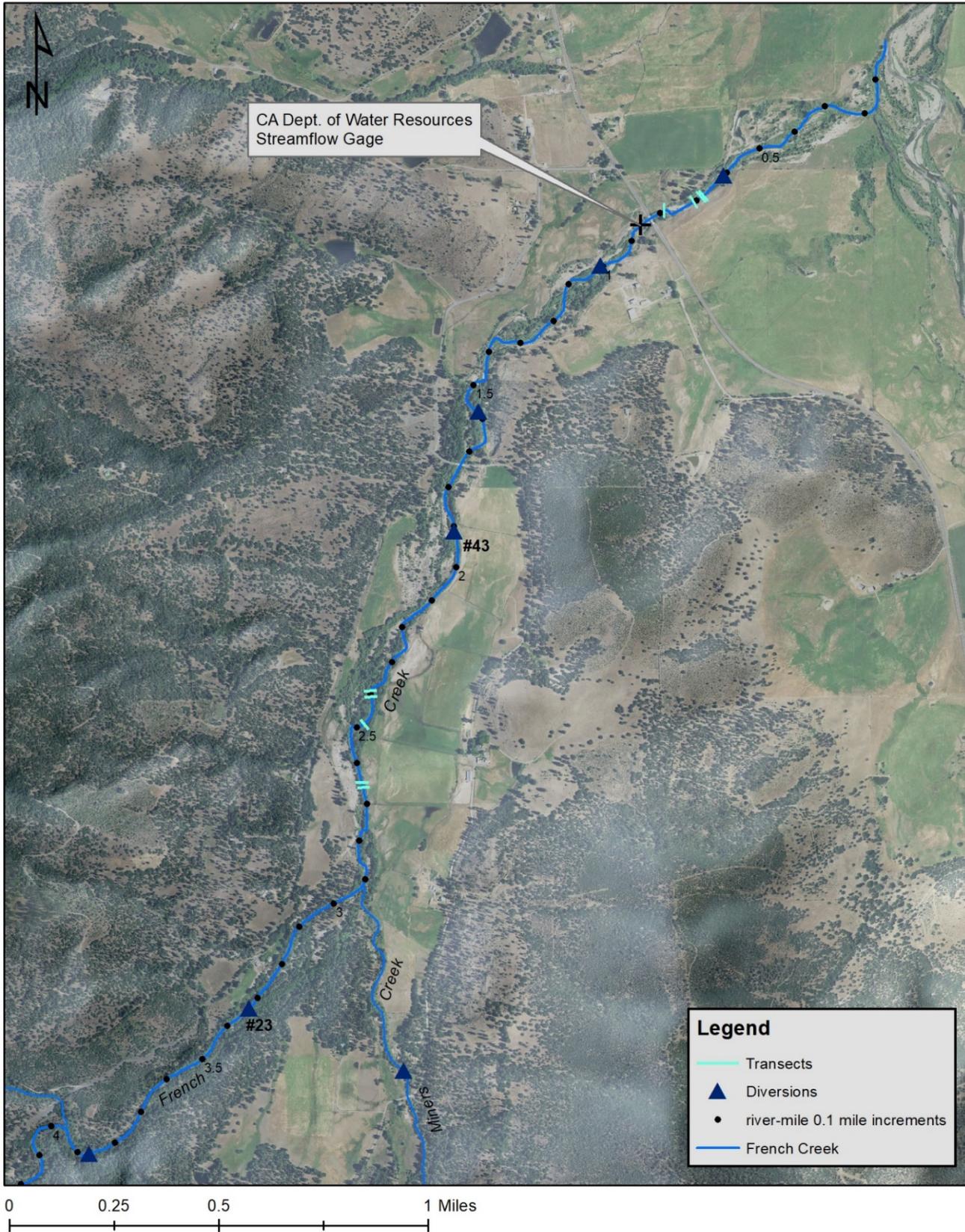


Figure 18: Example of wetted perimeter-discharge curve showing relationship between breakpoints and fish food production (Tegos et al, 2018).

Wetted Perimeter Method -- 2018 and 2019 Data Collection



Map 4: Wetted Perimeter Method transects.

From August 2018 through December 2019, the SRCD was able to collect a minimum of ten flow and transect data points for the middle French Creek riffles located between river-mile 2.35 and 2.70, which are presented in Figure 19. Cross-sections X2, X3 and X5 display a wetted perimeter-discharge curve that is roughly consistent with the example, indicating that they exhibited a sufficiently rectangular channel shape. However, X1 and X4 came out relatively flat, suggesting that they did not meet the rectangular channel criteria and are therefore unsuitable for the identification of inflection points. Analysis of X2, X3 and X5 allows for the determination of the breakpoint at 5-8 cfs and the incipient asymptote at 50-60 cfs (Table 1). Flows between the breakpoint and the incipient asymptote represent optimal conditions for riffle production of benthic macroinvertebrates. There is rapidly declining production below the breakpoint and slowly inclining production above the incipient asymptote. Based on channel conditions through French Creek the SRCD considers these results to be applicable to the reach extending from approximately river-mile 1.5 to river-mile 3.5.

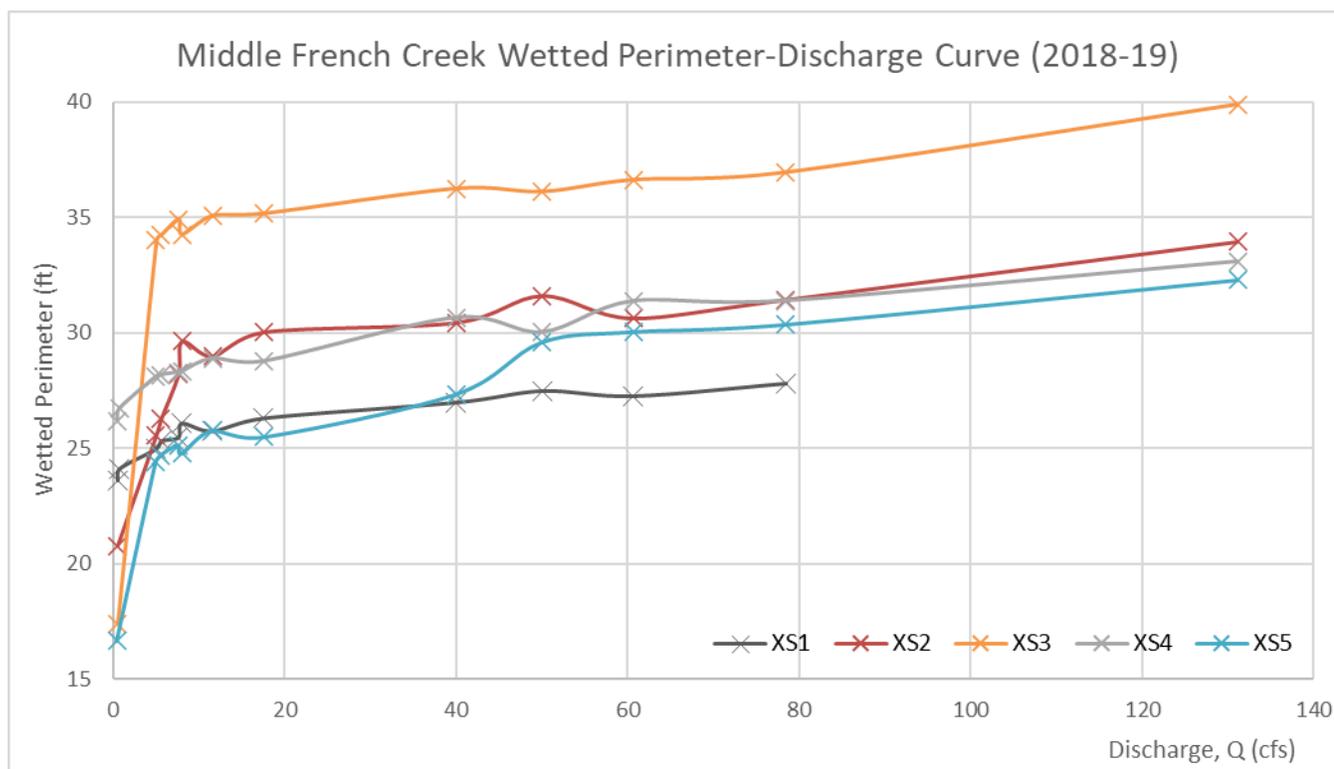


Figure 19: Mid-French Creek wetted perimeter-discharge curve for all cross sections.

Table 1: Discharge (Q) of breakpoint and incipient asymptote for selected wetted perimeter transects on Middle French Creek.

Transect	Breakpoint, Q (cfs)	Incipient Asymptote, Q (cfs)
X2	8	50
X3	6	60
X5	5	50

Based on the results from middle French Creek, the SRCD focused the lower French Creek wetted perimeter analysis on flows under 20 cfs. From June through August 2019, flow and transect data points were collected across four cross-sections established on Lower French Creek between river-mile 0.65 and 0.80 (Map 4), as presented in Figure 20. The

SRCD was unable to complete the intended 10 measurements at any of these transects because flows did not change significantly over the available study period but also because a beaver dam constructed at river-mile 1.0 (on the Diversion 48 boulder weirs) sequentially inundated X2, X3 and X4 in mid-August. However, none of these sites generated a recognizable breakpoint, which is likely due to the fact that the stream channel through this alluvial area was not sufficiently rectangular shaped allow for wetted-perimeter analysis.

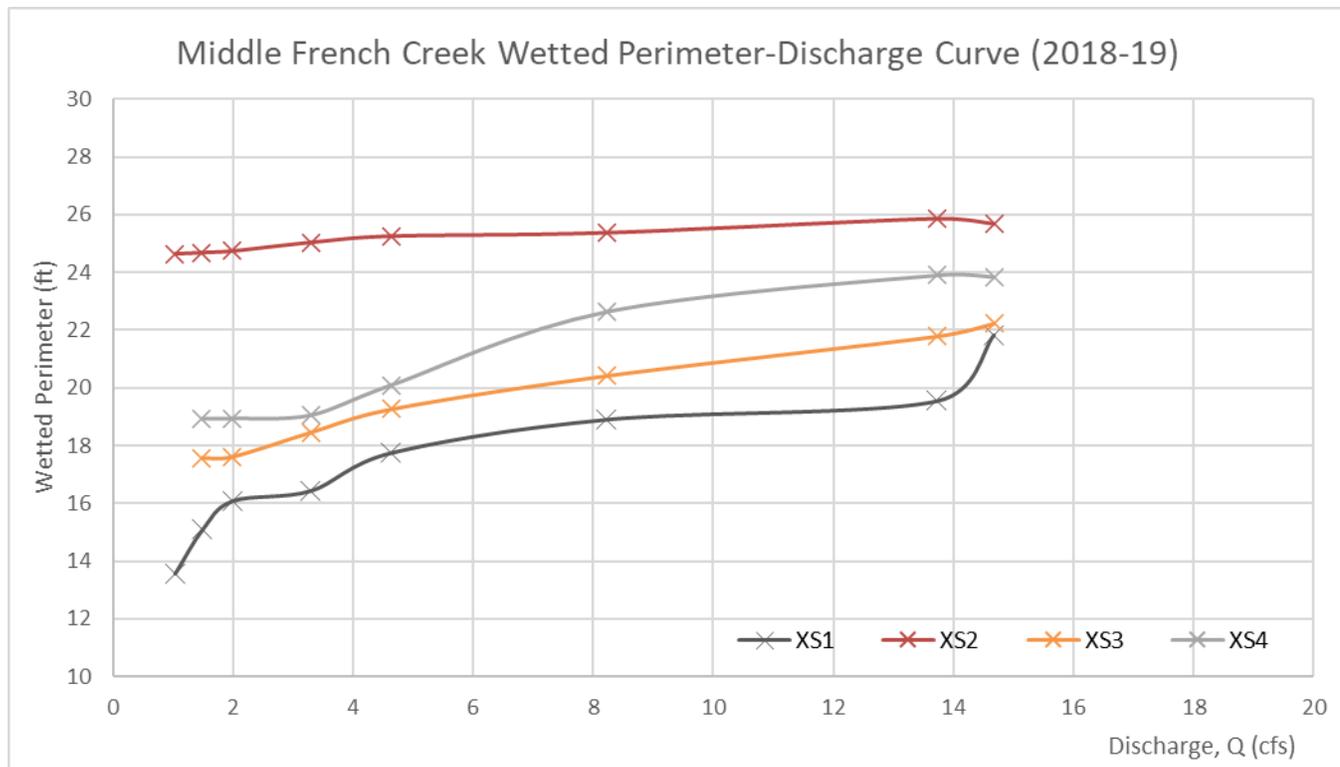


Figure 20: Lower French Creek wetted perimeter-discharge curve for all cross sections.

The results from the wetted perimeter analysis can be contextualized by viewing them in terms of the French Creek hydrograph. French Creek at the CDWR streamflow gaging station near Highway 3, generally drops below 10 cfs in the first couple of weeks of July. This is corroborated by the two flow stations managed in 2019 (normal water year), Figures 10 and 12. As such, streamflow on French Creek runs below the identified 5-8 cfs breakpoint for most of the summer months and is therefore operating at suboptimal food production through a critical salmonid rearing period. The wetted perimeter data suggests that actions by the SRWT to augment streamflow is most effective at improving food chain strength when French Creek is under 8 cfs (generally the latter half of the irrigation season). In other words, the addition of 1 cfs to mid French Creek when the stream is running under 5 cfs will produce a significantly larger increase in benthic macroinvertebrate activity than when the stream is running anywhere over 8 cfs. Therefore, when it comes to a monetary investment, the SRWT could produce the largest impact by continuing to focus on the seasonal base-flow period. Analysis of the wetted perimeter data collected under the *French Creek Flow Accounting Study* strongly supports existing flow restoration strategies being pursued in the watershed.

Biological Monitoring

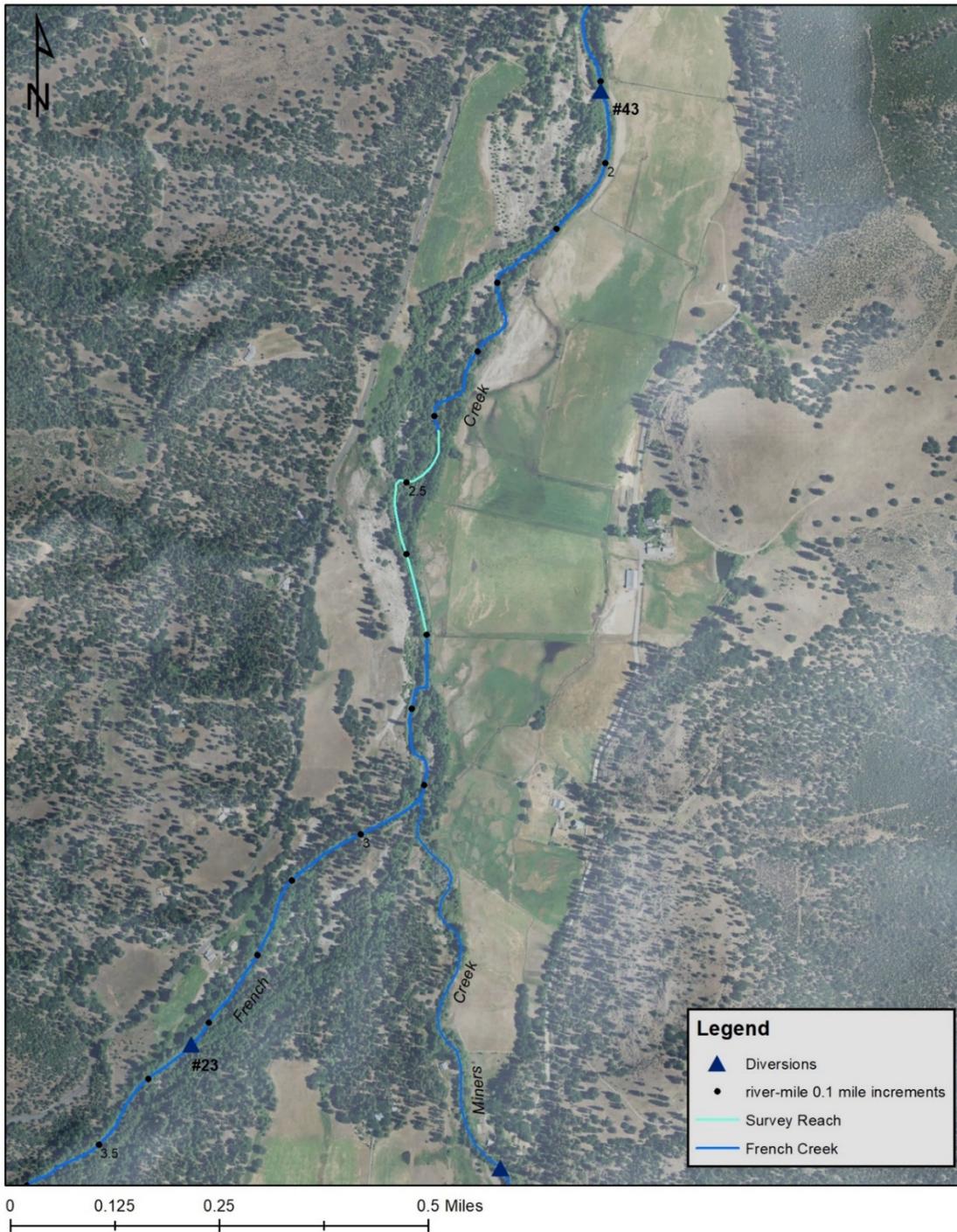
The SRCD surveyed fish populations through French Creek on several occasions to assess the relative abundance of salmonids through various stream reaches at different times during the summer rearing period. The primary purpose of these surveys was to identify fish occupancy that would benefit from a pending transaction or were already benefitting from an existing transaction. This involved a single survey in 2018 that coincided with the Diversion 23 water lease but

multiple sequential surveys in 2019 that covered habitats downstream of both the Diversion 43 and 23 leases. A summary of the findings are presented here by year.

2018

On September 4th 2018, six days before the initiation of the Diversion 23 lease, the SRCD completed a snorkel survey that covered approximately 0.28 miles of French Creek below the confluence of Miners Creek (Map 5).

French Creek Dive Survey -- 9/4/18



Map 5: Surveyed length on French Creek from snorkel on 9/4/2018 (0.28 miles).

The purpose of this survey was to assess the relative abundance of salmonids by species and age class through a section of stream that would directly benefit from a pending water transaction at Diversion 23. Note that this survey only covers a small portion of the stream that would be influenced by a water transaction at Diversion 23 as the SRWT did not secure access to any other portion of French Creek above the next take out (Diversion 43). Water clarity and visibility was excellent; the number of fish observed is reported in Figure 21.

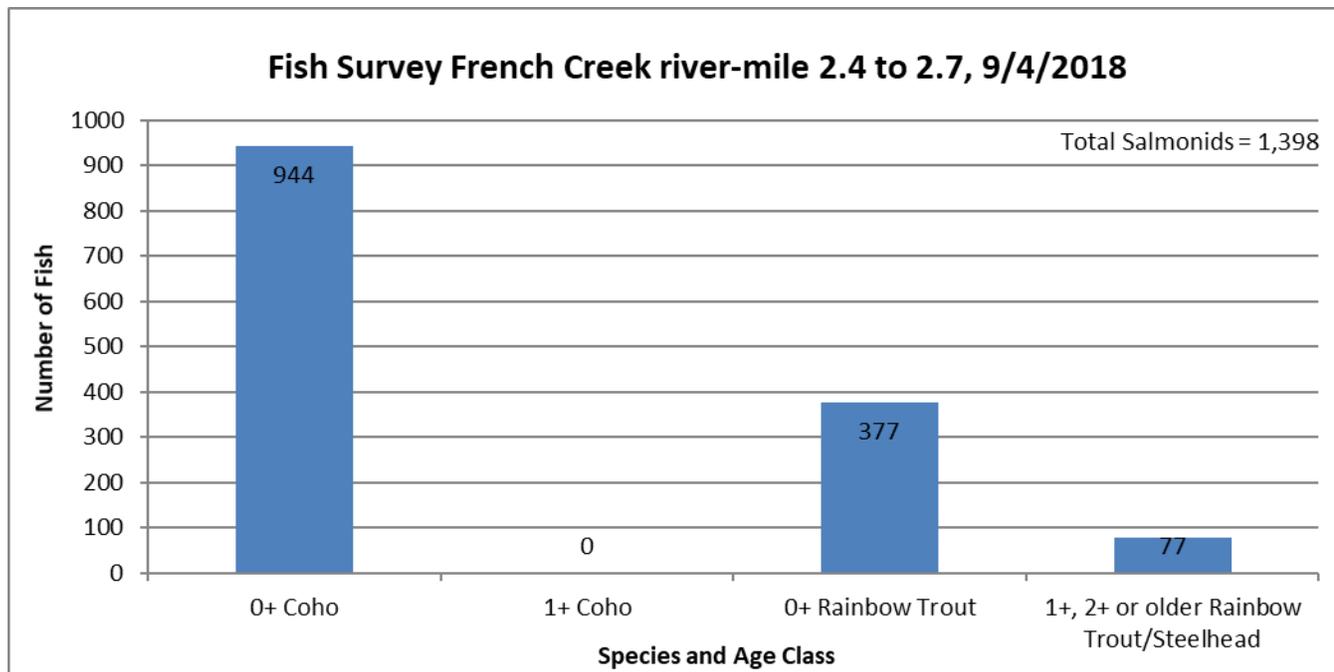


Figure 21: Survey results from French Creek river-mile 2.4 to 2.7, 9/4/2018.

Juvenile coho salmon were abundant through this section of French Creek; there were more than twice as many coho salmon as other salmonid species. Rainbow trout were found throughout the survey reach, including in the shallow margins of habitats and up against higher-velocity inflows as well as interspersed with the schools of coho salmon. Higher densities were found in habitats with complex cover elements such as undercut banks, submerged woody debris, or overhanging terrestrial vegetation. There were no other aquatic species encountered, although there was ample evidence of beaver activity including holes to dens in the bank, feeding sticks, dams, and scat.



Photo 7: Juvenile salmonids encountered in a pool representative of underwater habitat conditions on French Creek, 9/4/2018.



Photo 8: Juvenile coho salmon traversing woody debris, 9/4/2018.



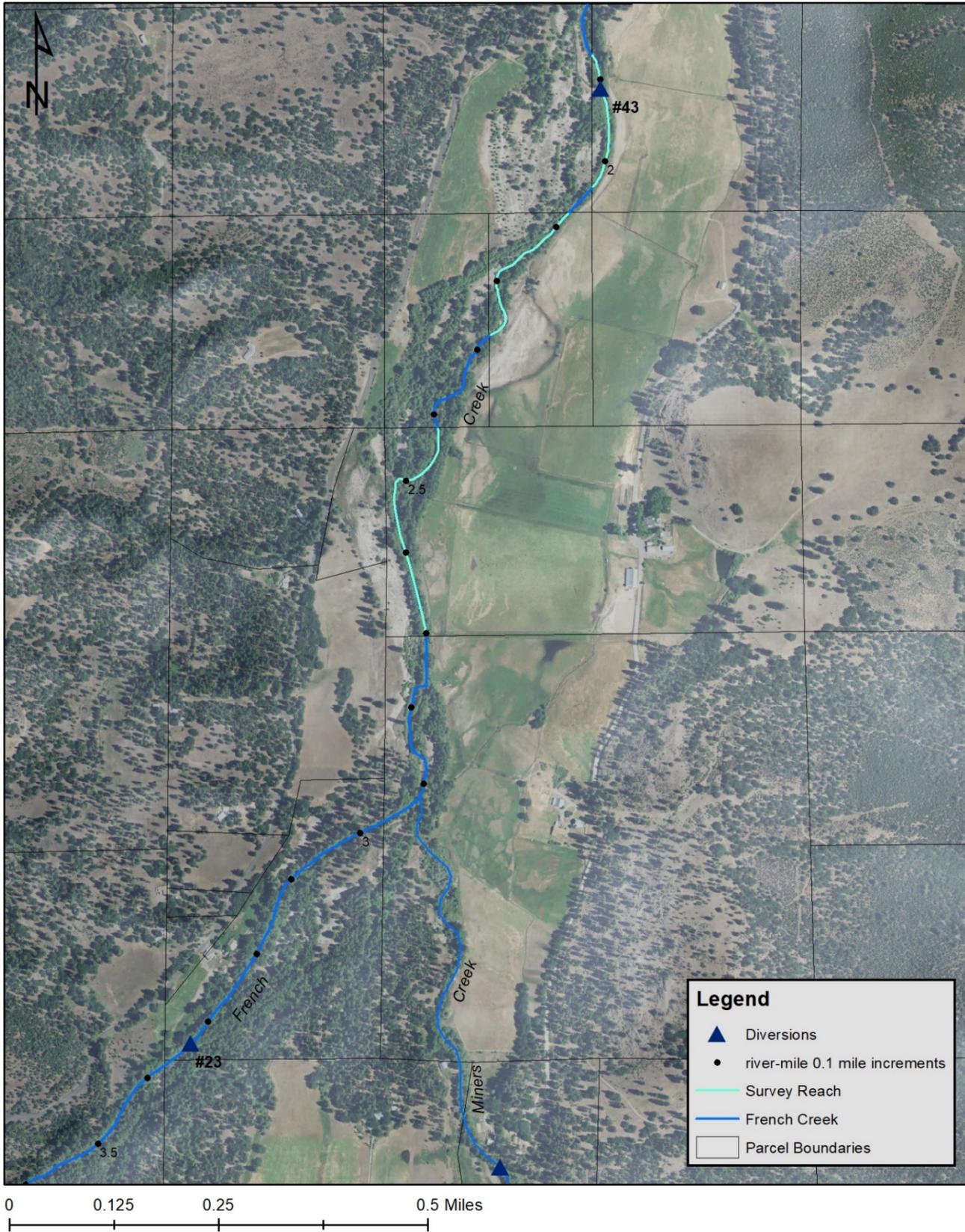
Photo 9: Rainbow/steelhead trout classified as a 3+ year old hiding under woody debris on French Creek, 9/4/2018.

2019

In 2019, SRCD field technicians completed two snorkel surveys to determine relative fish abundance by species and age class through various portions of French Creek.

On July 3rd, 2019, the SRCD completed a snorkel survey that covered approximately 0.64 miles of French Creek, between the Miners Creek Road bridge and the confluence of Miners Creek, to assess relative salmonid abundance in preparation for the seasonal leasing period (Map 6). This survey was broken into three different segments (lower, middle and upper) according to access from local landowners (Map 6). Again, this survey only covers a portion of the stream that would be influenced by pending water transactions. Fish rearing in the lower segment would be benefitted by a lease at Diversion 43, while fish rearing in the middle and upper segments would be benefitted by a lease at Diversion 23. Water clarity and visibility was excellent; the number of fish observed is reported in Figure 22.

French Creek Dive Survey -- 7/3/19



Map 6: Surveyed length on French Creek from snorkel on 7/3/2019 (0.64 miles).

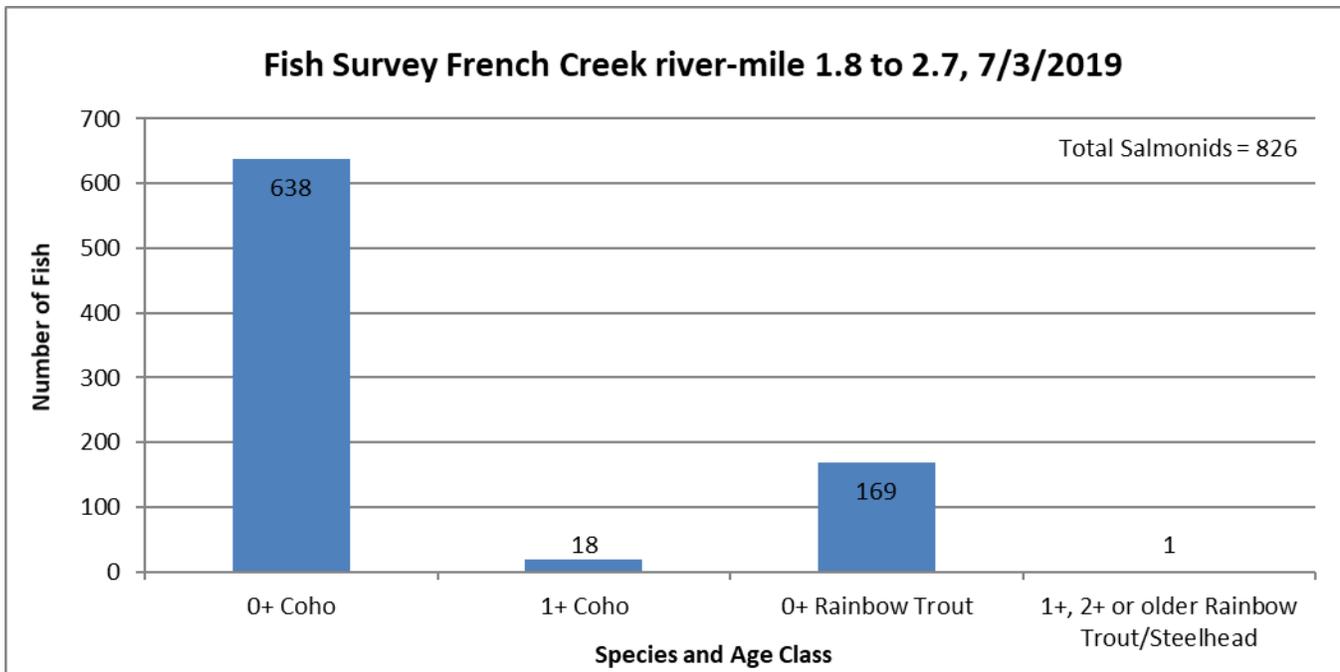


Figure 22: Survey results from French Creek river-mile 1.8 to 2.7, 7/3/2019.

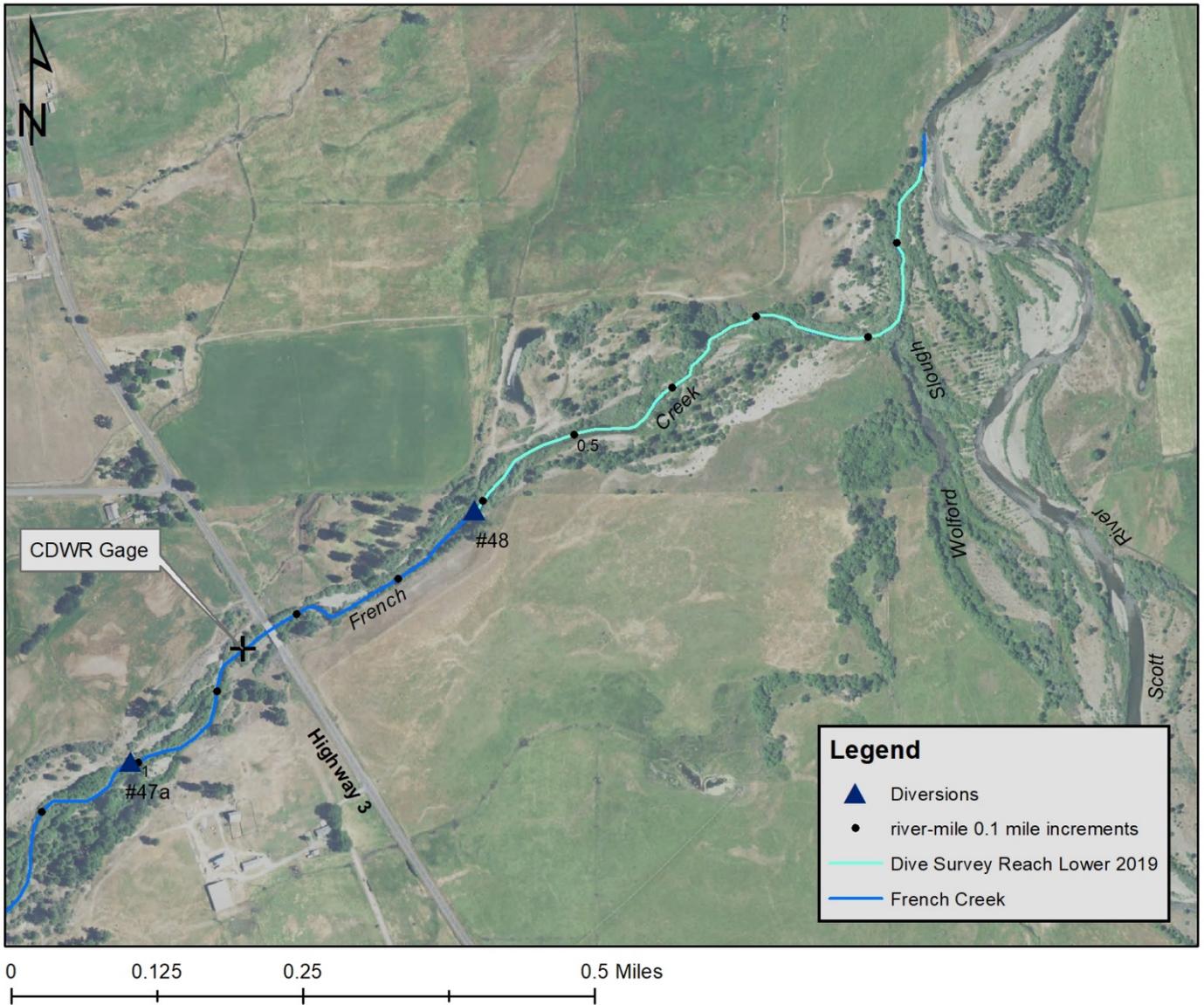
Juvenile salmonids were observed in all habitat units surveyed (Photo 10 and 11). Coho salmon were abundant through this section of French Creek; there were more than four times as many coho salmon as rainbow trout. Rainbow trout were found throughout the survey, including in the shallow margins of habitats and up against higher-velocity inflows as well as interspersed with the schools of coho salmon. There were not any other aquatic species encountered, although there was ample evidence of beaver activity including holes to dens in the bank, feeding sticks, and scat.



Photos 10 & 11: Juvenile coho salmon and rainbow trout rearing through Mid-French Creek, 7/3/2019.

Finally, on September 17th, 2019, the SRCD completed a snorkel survey from the confluence of French Creek with the Scott River upstream approximately 0.60 miles to Diversion 48 (Map 7). French Creek remained fully connected through the surveyed reach and was confirmed to be flowing into the Scott River. Water clarity and visibility was excellent; the number of fish observed is reported in Figure 23.

French Creek Dive Survey -- 9/17/19



Map 7: Surveyed length on French Creek from snorkel on 9/17/2019 (0.60 miles).

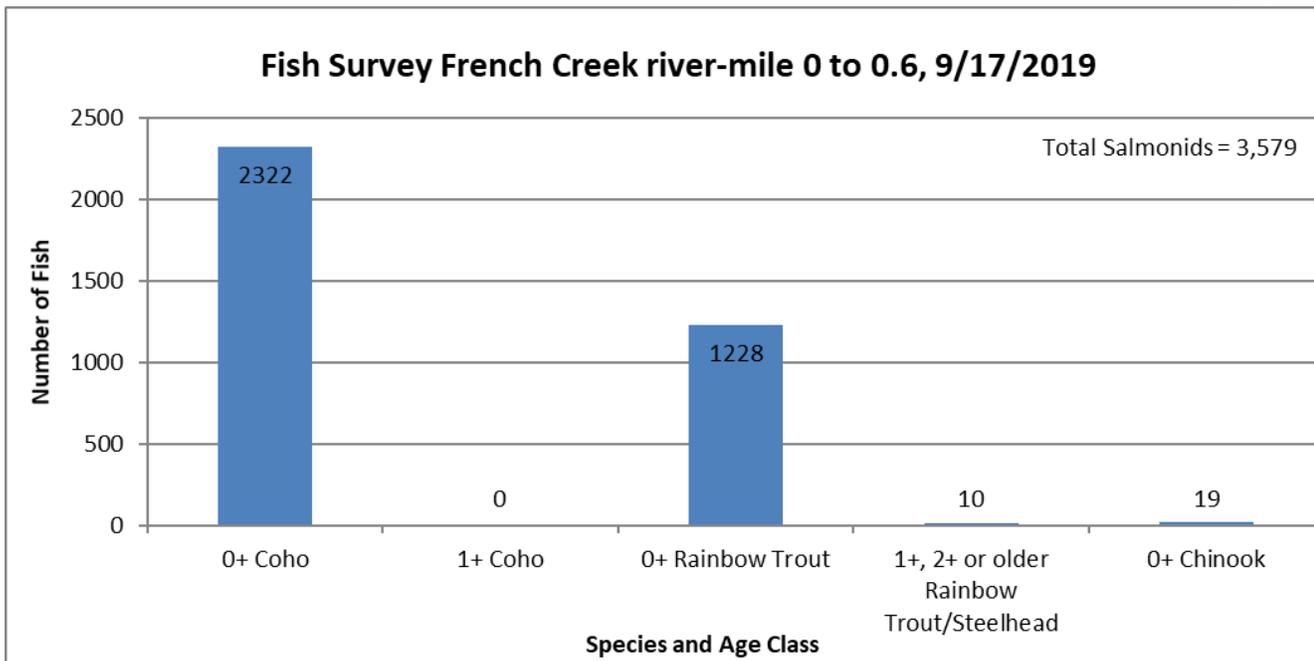


Figure 23: Survey results from French Creek river mile 0 to 0.6, 9/17/2019.

Juvenile salmonids were observed in most but not all habitat units (Photo 12 and 13). Higher densities were found in habitats with complex cover elements such as undercut banks, submerged woody debris, or overhanging terrestrial vegetation. Juvenile coho salmon were relatively uniform in size and were larger in size compared to rainbow trout of the same age class. In terms of relative abundance, there was approximately twice as many coho than rainbow trout in the surveyed reach. With regard to distribution, coho and rainbow trout were together in each habitat unit but frequently they occupied different areas of each habitat unit. Additionally, there was a higher number of coho on the upstream end of the survey reach compared to trout. Chinook were found only in the lower, more downstream habitat units closer to the mainstem Scott River. Other species observed included speckled dace and marbled sculpin. There was abundant evidence of beaver activity including beaver dams, feeding sticks and scat. Although neither of the 2019 leases at Diversion 43 and 23 were documented to have resulted in water that made it this far downstream, the survey demonstrates the abundance of salmonids that occupy the terminal reach of French Creek and the importance that it plays from a rearing habitat perspective.



Photos 12 & 13: Juvenile coho salmon and rainbow trout rearing through Lower French Creek, 9/17/2019.

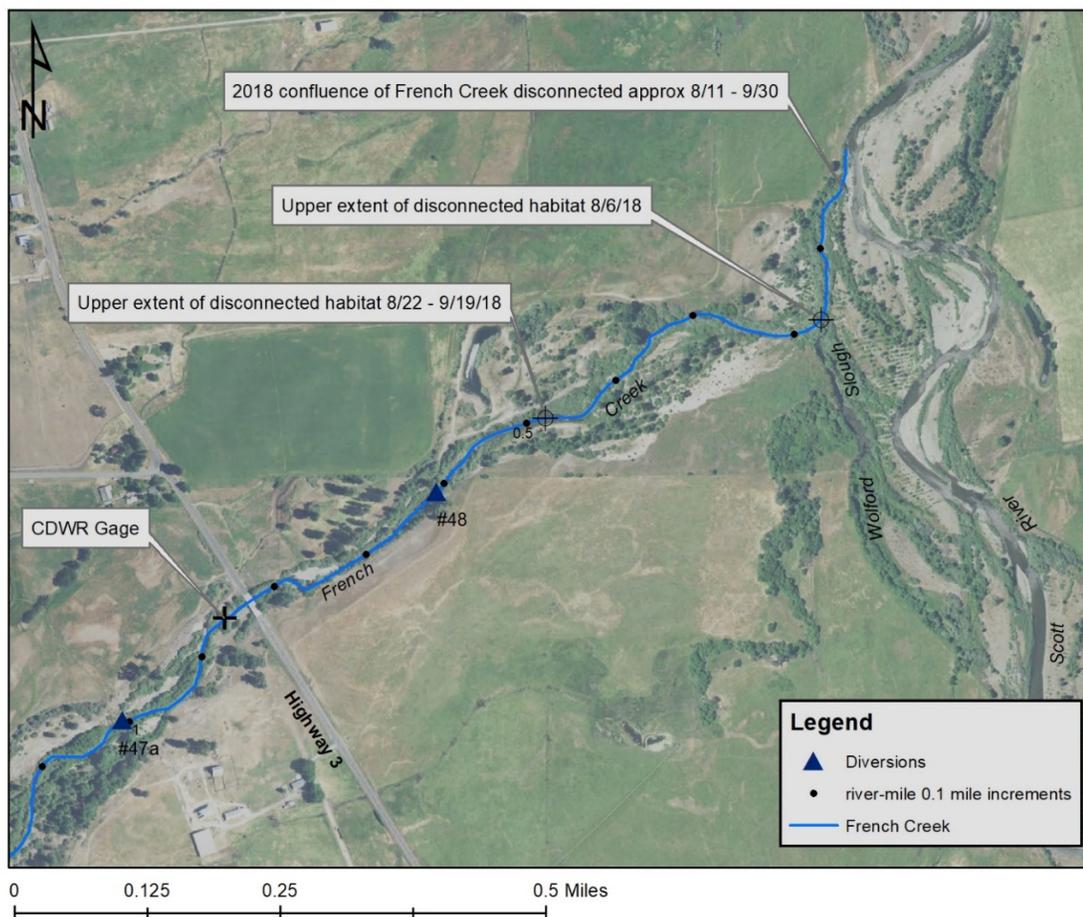
Lower French Creek Connectivity

The SRCD conducted periodic foot surveys through lower French Creek during the base-flow period of 2018 and 2019 to visually assess connectivity. The purpose of these surveys was to determine the spatial and temporal extent of disconnections through lower French Creek and particularly with the Scott River as the fragmentation of habitat through this reach has been identified as a limiting factor to rearing salmonids. The surveys involved walking French Creek from river-mile 0.60 (Diversion 48) downstream to the confluence with the Scott River. Diversion 48 was selected as the starting point because even through the critical drought from 2013-2015 the SRCD did not find surface water disconnections extend up to the boulder weirs.

Base-flow 2018

The first survey in 2018 was completed on 8/6 and at that time, the only surface water disconnection that prevented fish passage occurred near Wolford Slough at river-mile 0.17 (Map 8, Photos 14 - 15); French Creek still maintained flow into the Scott River at its confluence. Subsequent surveys completed on 8/22, 9/7 and 9/19 found that the most upstream disconnection on the main channel of French Creek extended up to river-mile 0.48 (Map 8, Photos 16 - 18) but did not involve checking the confluence. On 10/10/18 the SRWT Executive Director confirmed that French Creek had reconnected to the mainstem Scott River (personal communication). Analysis of records from the California Department of Water Resources streamflow gage on French Creek at river-mile 0.86, in combination with visual observations by SRCD and SRWT personnel, suggests that French Creek was disconnected from the Scott River from approximately 8/11 through 9/30 (Map 8, Figure 24).

Lower French Creek Connectivity -- 2018



Map 8: Surface water connectivity through lower French Creek during base-flow period of 2018.



Photos 14 & 15: French Creek disconnection at river-mile 0.17 near Wolford Slough on 8/6/2018. (A water temperature device was deployed here in 2019 to monitor this site more carefully).



Photos 16 & 17: French Creek disconnection at river mile 0.48 on 8/22/2018.



Photo 18: French Creek disconnection at river mile 0.48 on 9/19/2018.

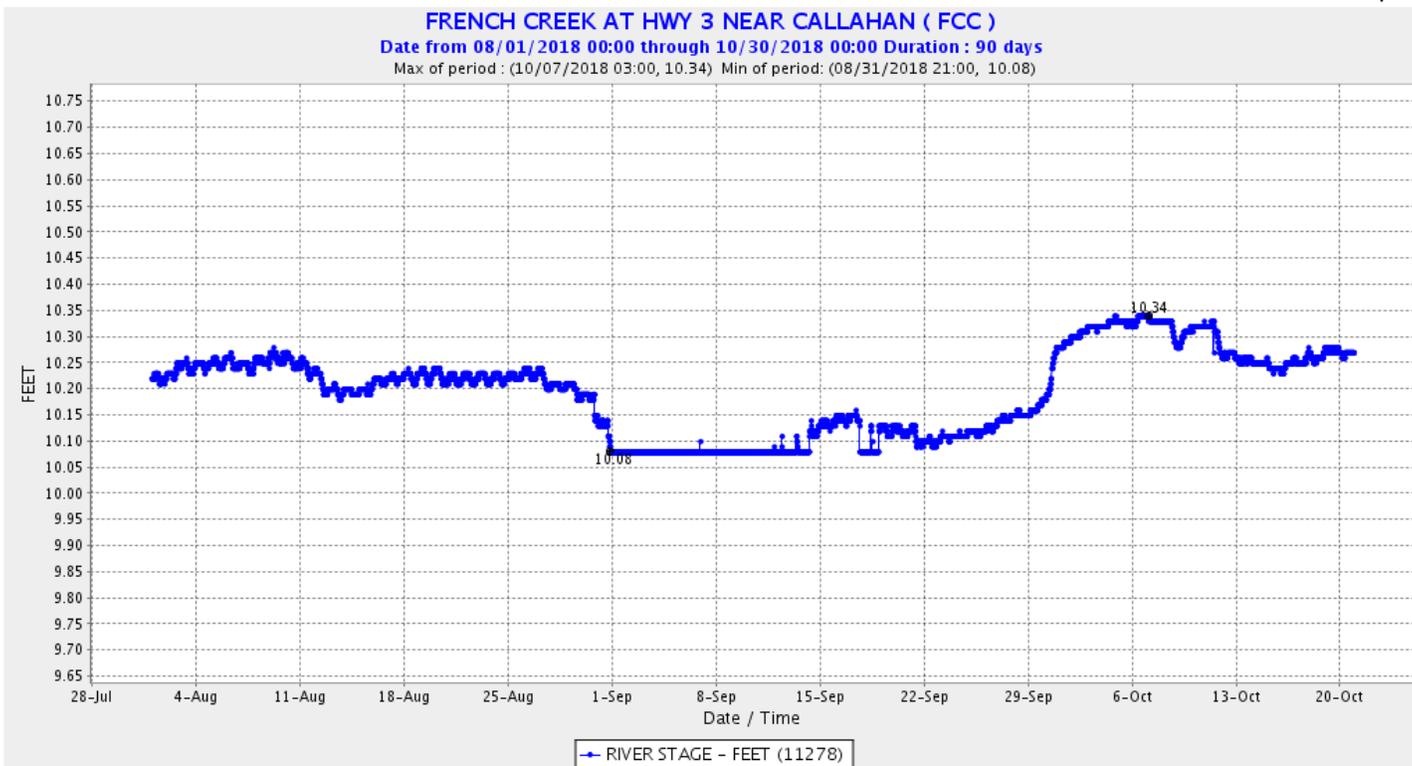
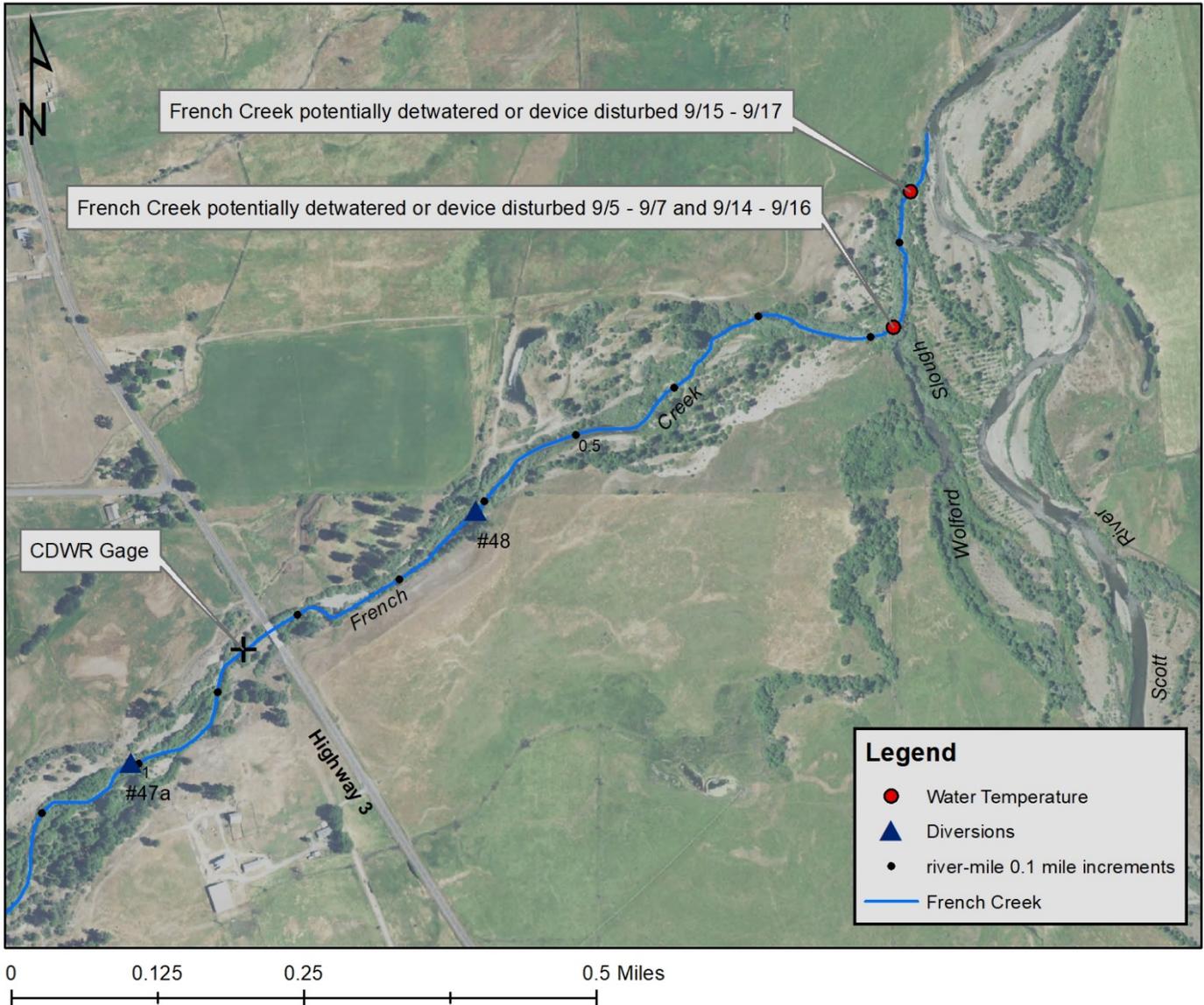


Figure 24: Stage data (water-level) from the CA Department of Water Resources streamflow gage on French Creek at river-mile 0.86 (FCC). French Creek is proposed to have been disconnected from the Scott River when water levels dropped below 10.25 feet, approximately 8/11 - 9/30/2018 (CDEC, 2018).

Base-flow 2019

Through the 2019 low-flow period, in addition to periodic foot surveys through lower French Creek the SRCD also deployed water temperature loggers at a couple of locations that were known or suspected to have gone dry in 2018 in an effort to determine a precise date for their potential dewatering in 2019 (Map 9). The temperature devices were placed directly above the confluence with the Scott River at river-mile 0.05 and directly above the confluence with Wolford Slough at river-mile 0.18 (Photos 19 - 20). Data from both of these devices show recordings in September suggesting that the creek became temporarily dewatered (Figure 25). However, neither field observations nor records from the CDWR gage support those occurrences, causing the SRCD to question their validity. It is possible that the devices were intermittently disturbed by wildlife or domestic cattle. Foot surveys completed on 7/8, 7/17, 7/22, 7/29, 8/5, 8/28 and 10/14 found that French Creek remained connected and flowing into the Scott River (Photos 21 – 22). Water levels observed on 8/28 at both water temperature sites appeared sufficient to maintain connectivity through the remainder of the base flow period. Furthermore, review of the stage data from the California Department of Water Resources streamflow gage on French Creek at river-mile 0.86 shows an increasing trend in water levels from late August through October (Figure 26). It is also possible that the precipitation event in mid-September moved the devices out of the water periodically. If French Creek did in fact become disconnected in early September, it was only temporarily. In general, 2019 was a much better water year than 2018. Additionally, extensive beaver dams around Wolford Slough and Diversion 48 contributed to the impoundment of water through lower French Creek in 2019.

Lower French Creek Connectivity -- 2019



Map 9: Surface water connectivity through lower French Creek during base-flow period of 2019.



Photo 19: Water temperature device on French Creek at river-mile 0.05 above the confluence with the Scott River on 8/5/2019. This site is suspected to have been dry around this same time in 2018.

Photo 20: Water temperature device on French Creek at river-mile 0.18 above Wolford Slough on 8/5/2019. This site was dry around this same time in 2018, see Photos 14 – 15.



Photos 21 & 22: French Creek connected at river mile 0.48 on 8/28/19. This same area was dry around this same time in 2018, see Photos 16 -17.

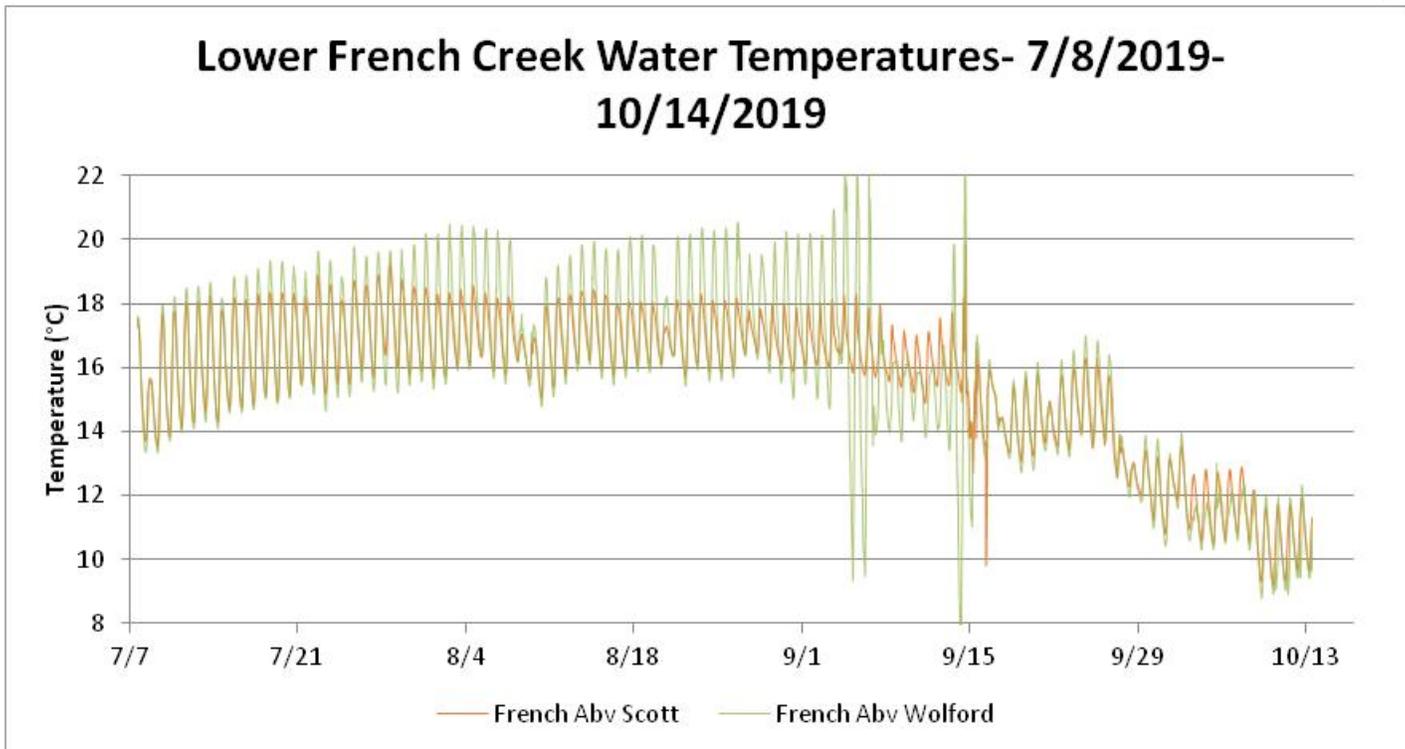


Figure 25: Water temperatures on French Creek above its confluence with the Scott River and above Wolford Slough, 7/8/19 – 10/14/19.

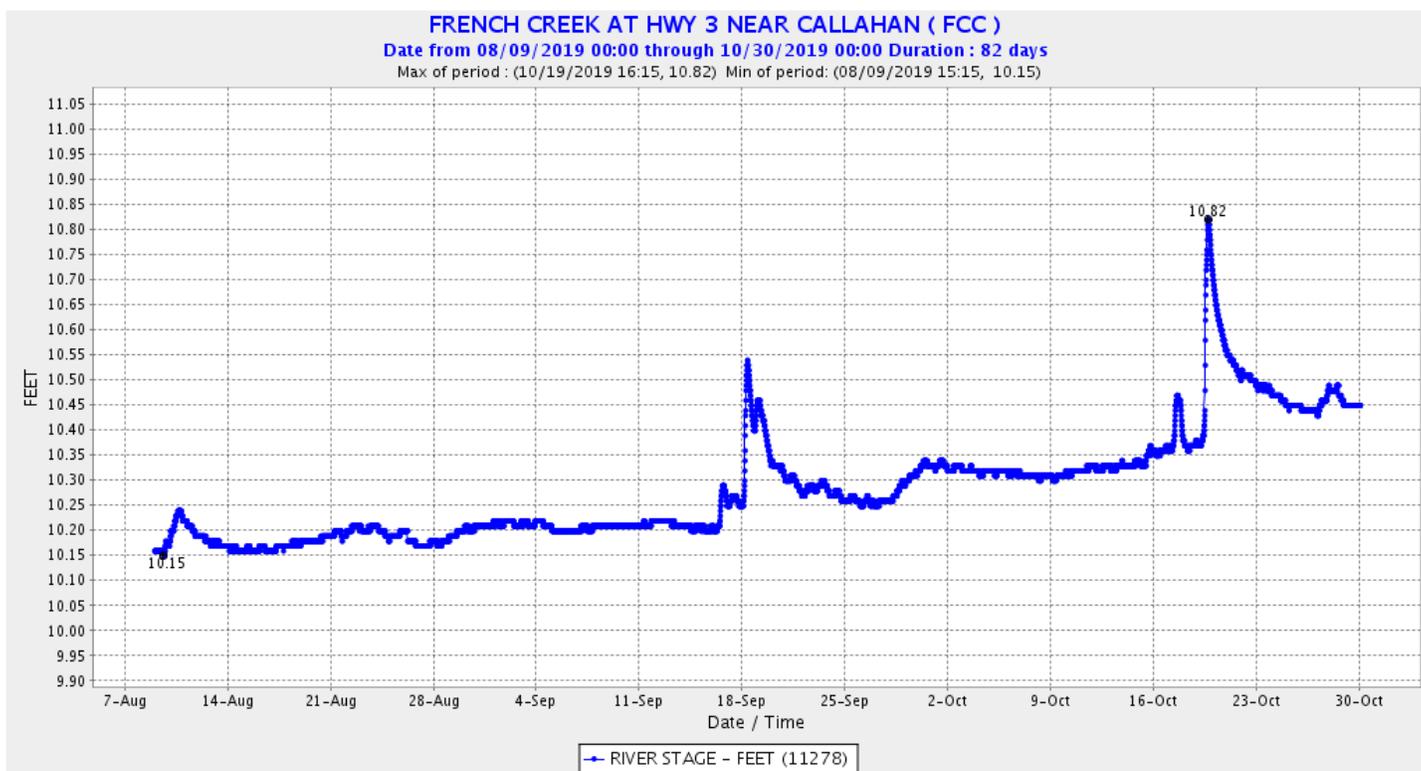


Figure 26: Stage data (water-level) from the CA Department of Water Resources streamflow gage on French Creek at river-mile 0.86 (FCC), illustrating an increasing trend in water levels from late August through October (CDEC, 2019). September is punctuated by minor precipitation from approximately 9/16 - 9/18/2019 (WRCC 2019).

Conclusions

Under the *French Creek Flow Accounting Study*, the SRCD carried out multiple effectiveness monitoring methods over the 2018-2019 field seasons to determine whether they are applicable and would be useful for the SRWT.

The SRCD found the use of flow stations in monitoring the influence of water transactions on the stream discharge to be effective when implemented as part of a comprehensive study. The combination of multiple sequential stations allowed us to determine whether dedicated flow made it past specific inputs and outputs to the stream system, in what quantity and timeframe. However, the use of flow stations is limited by the development of rating curves (necessitating 8 – 10 flow measurements), which require at least a full irrigation season to compile. Therefore, this work would be more applicable for informing multi-year transactions. Additionally, the SRCD experienced challenges in the comparison of impaired hydrographs and on a system with such a complicated water balance, not to mention underlying questions about natural gaining and losing reaches. Ultimately, the use of flow stations may provide more detail than necessary if the SRWT is seeking solely to identify the extent of influence in terms of linear distance. Stage monitoring would be a more cost-effective option for most situations.

The wetted perimeter method (WPM) involved the collection of basic stream data but over a relatively wide range of flows (base flow to bank full) which required one full year of field work. Data collection outside the irrigation season is not likely feasible in association with most seasonal transactions, therefore, the WPM would be more applicable for informing long-term or permanent dedications. It provides useful information on the relationship between streamflow and food chain productivity for salmonids, which will be extremely valuable to the SRWT for cost-benefit analysis of transactions. The SRCD found that the WPM was not effective in alluvial areas of the stream such as lower French Creek due to channel morphology, however, it was successful in the ravine and valley type areas such as middle French Creek. It seems likely that many creeks will only have one such section where the WPM is applicable, therefore it might be better to contextualize the scope of the results more on a tributary basis than on a reach basis. Where applicable, the SRCD feels that the WPM has strong utility for informing and justifying future water augmentation by the SRWT.

The SRCD found that the quality of the water year is a significant factor in connectivity through lower French Creek. Despite 2.28 cfs released from Diversion 43 and 1.66 cfs released from Diversion 23, a response was not detectable below Highway 3 yet connectivity was never impacted in 2019. It's unclear whether seasonal forbearance agreements during the base-flow period could overcome loss through the alluvial fan of French Creek. It is noted that a precipitation event on 8/9 – 8/10/2019 did produce a response below Highway 3 and it would be useful to explore this connection further. Additionally, the SRCD observed that late season beaver activity produced impoundments in some areas that were initially anticipated to disconnect. It is possible that attenuation of runoff could influence the timing of the hydrograph; this would be worth exploring further but is beyond the scope of this report.

The SRCD has the following recommendations for the SRWT:

- Installing water level monitoring stations is recommended as it is a simple and cost-effective way to determine the “zone-of-influence” of a water transaction. Processing stage readings into flow data is only necessary to quantify how much of the lease water reaches a certain point
- WPM method useful on a tributary scale. Should only be applied on other tributaries with the potential for multiple consecutive flow augmentation opportunities as it requires 12+ months of field work. Site selection should be between alluvial and ravine reaches.
- Continue to perform snorkel surveys to inform and evaluate the relative abundance of fish influenced by water transactions
- Explore the correlation between flow above the alluvial fan and response at FCC to identify volume of water necessary to influence connectivity through lower French Creek in dry years.

Finally, the SRCD would like to emphasize the value of water transactions as a tool for positively impacting stream habitat. Through the *French Creek Flow Accounting Study* we have demonstrated the ability of short-term leases to significantly improve the hydrograph and influence food-chain productivity. The natural abundance of salmonids, including coho salmon, that consistently occupy the lower 4 miles of French Creek make this area a high priority for continued restoration work including the development of long-term and permanent flow dedications. As flow on French Creek often drops to critically low levels for several months of the year, any additional water returned instream (however small) will make a meaningful impact on salmonids rearing in the tributary.

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http://cdec.water.ca.gov/jspplot/jspPlotServlet.jsp?sensor_no=11278&end=10%2F12%2F2018+14%3A41&geom=huge&interval=76&cookies=cdec01
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