Russian River Biological Opinion Status and Data Report

Year 2020 – 2021

Sonoma Water

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CHAPTER 1 Introduction

On September 24, 2008, the National Marine Fisheries Service (NMFS) issued a 15-year Biological Opinion for water supply, flood control operations, and channel maintenance conducted by the U.S. Army Corps of Engineers (USACE), Sonoma County Water Agency (Water Agency), and Mendocino County Russian River Flood Control and Water Conservation Improvement District in the Russian River watershed (NMFS 2008). The Biological Opinion authorizes incidental take of threatened and endangered Chinook salmon, coho salmon, and steelhead pending implementation of a Reasonable and Prudent Alternative (RPA) to status quo management of reservoir releases, river flow, habitat condition, and facilities in portions of the mainstem Russian River, Dry Creek, and Russian River Estuary. Mandated projects to ameliorate impacts to listed salmonids in the RPA are partitioned among USACE and the Water Agency. Each organization has its own reporting requirements to NMFS. Because coho salmon are also listed as endangered by the California Endangered Species Act (CESA), the Water Agency is party to a Consistency Determination issued by the California Department of Fish and Wildlife (CDFW) in November 2009. The Consistency Determination mandates that the Water Agency implement a subset of Biological Opinion projects that pertain to coho and the Water Agency is required to report progress on these efforts to CDFW.

Project implementation timelines in the Biological Opinion, and Consistency Determination, specify Water Agency reporting requirements to NMFS and CDFW and encourage frequent communication among the agencies. The Water Agency has engaged both NMFS and CDFW in frequent meetings and has presented project status updates on many occasions since early 2009. Although not an explicit requirement of the Biological Opinion or Consistency Determination, the Water Agency has elected to coalesce reporting requirements into one annual volume for presentation to the agencies. The following document represents the twelfth report for year 2020-2021. Previous annual reports can be accessed at http://www.sonomawater.gov.

Water Agency projects mandated by the Biological Opinion and Consistency Determination fall into six major categories:

- Biological and Habitat Monitoring;
- Habitat Enhancement;
- California Environmental Quality Act (CEQA) Compliance and Permitting;
- Planning and Adaptive Management;
- Water and Fish Facilities Improvements; and
- Public Outreach.

This report contains status updates for planning efforts, environmental compliance, and outreach but the majority of the technical information we present pertains to monitoring and habitat enhancement. The Biological Opinion requires extensive fisheries data collection in the mainstem Russian River, Dry Creek, and Estuary to detect trends and inform habitat enhancement efforts. The report presents each data collection effort independently and the primary intent of this document is to clearly communicate recent results. However, because Chinook salmon, coho salmon, and steelhead have complex life history patterns that integrate all of these environments, we also present a synthesis section to discuss the interrelated nature of the data. Some monitoring programs are extensions of ongoing Water Agency efforts that were initiated a decade or more before receipt of the Biological Opinion.

References

National Marine Fisheries Service (NMFS). 2008. Biological Opinion for Water Supply, Flood Control Operations, and Channel Maintenance conducted by the U.S. Army Corps of Engineers, the Sonoma County Water Agency, and the Mendocino County Russian River Flood Control and Water Conservation District in the Russian River Watershed. September 24, 2008.

CHAPTER 2 Public Outreach

Biological Opinion Requirements

The Biological Opinion includes minimal *explicit* public outreach requirements. The breadth and depth of the RPAs, however, *implies* that implementation of the Biological Opinion will include a robust public outreach program.

RPA 1 (Pursue Changes to D1610 Flows) mandates two outreach activities. First, it requires Sonoma Water, with the support of NMFS staff, to conduct outreach "to affected parties in the Russian River watershed" regarding permanently changing Decision 1610. Second, the RPA requires Sonoma Water to update NMFS on the progress of temporary urgency changes to flows during Section 7 progress meetings and as public notices and documents are issued.

RPA 2 (Adaptive Management of the Outlet Channel) requires that within six months of the issuance of the Biological Opinion Sonoma Water, in consultation with NMFS, "conduct public outreach and education on the need to reduce estuarine impacts by avoiding mechanical breaching to the greatest extent possible."

Finally, RPA 3 (Dry Creek Habitat Enhancements, refers to public outreach in the following mandate, "Working with local landowners, DFG[1] and NMFS, Water Agency[2] will prioritize options for implementation" of habitat enhancement.

The remaining RPAs do not mention public outreach.

Water Agency Public Outreach Activities – 2020

Meetings

Outreach activities in 2020 were significantly impacted by the global pandemic.

The Public Policy Facilitating Committee (PPFC) was slated to meet on Thursday, March 12, 2020, at the Healdsburg Community Center. The meeting was to have been combined with the Dry Creek Community Meeting and preceded by a tour of a Dry Creek Habitat Enhancement Project site and an Open House poster session, which were planned in conjunction with the Dry Creek Valley Association. The tour, poster session and meeting were advertised in the Healdsburg Tribune, a press release was issued and notices were sent out to approximately 800 individuals and agencies. The events were also promoted on Sonoma Water's website and through its social media channels.

On March 2, 2020, California Governor Newsom declared a state of emergency due to the COVID-19 pandemic. On the same day, the County of Sonoma's Public Health Officer also

[1] DFG (Department of Fish and Game) is now known as the California Department of Fish and Wildlife.
[2] Sonoma County Water Agency is now know as Sonoma Water

declared a local public health emergency. Within a few days, the county issued recommendations that all public gatherings be cancelled.

On March 10, the PPFC/Dry Creek meeting, tour and open house were cancelled. PPFC members and resource agencies were notified via email and potential attendees were notified through social media, an email and signage posted at the Healdsburg Community Center.

No community meetings, events or tours were held in 2020.

Other Outreach

Monthly BO Updates to WAC and TAC Sonoma Water provides an update on all Biological Opinion activities to the Water Advisory and Technical Advisory committees, which meet monthly and consist of the agency's water contractors. The reports are also posted to Sonoma Water's website. Sonoma Water's public information staff was diverted to the County of Sonoma's Emergency Operations Center in March and April 2020, so no Biological Opinion Update was provided at the April WAC meeting.

Dry Creek Video – Sonoma Water staff worked with contractor Inter-Fluve on a video showcasing the Dry Creek Habitat Enhancement Project.

Free Media –In 2020, press releases were issued on the community meeting regarding the Dry Creek and the Public Policy Facilitating Committee meeting and on changes in river flows due to the need to maintain water levels in Lake Mendocino.

Electronic Media – Sonoma Water updated its Biological Opinion webpage, including links on new documents and meetings. Email alerts to interested stakeholders regarding activities in the estuary were issued 27 times in 2020.

CHAPTER 3 Pursue Changes to Decision 1610 Flows

Two major reservoir projects provide water supply storage in the Russian River watershed: 1) Coyote Valley Dam/Lake Mendocino, located on the East Fork of the Russian River three miles east of Ukiah, and 2) Warm Springs Dam/Lake Sonoma, located on Dry Creek 14 miles northwest of Healdsburg. The Water Agency is the local sponsor for these two federal water supply and flood control projects, collectively referred to as the Russian River Project. Under agreements with the USACE, the Water Agency manages the water supply storage space in these reservoirs to provide a water supply and maintain summertime Russian River and Dry Creek streamflows.

The Water Agency holds water-right permits[1] issued by the State Water Resources Control Board (SWRCB) that authorize the Water Agency to divert[2] Russian River and Dry Creek flows and to re-divert[3] water stored and released from Lake Mendocino and Lake Sonoma. The Water Agency releases water from storage in these lakes for delivery to municipalities, where the water is used primarily for residential, governmental, commercial, and industrial purposes. The primary points of diversion include the Water Agency's facilities at Wohler and Mirabel Park (near Forestville). The Water Agency also releases water to satisfy the needs of other water users and to contribute to the maintenance of minimum instream flow requirements in the Russian River and Dry Creek established in 1986 by the SWRCB's Decision 1610. These minimum instream flow requirements vary depending on specific hydrologic conditions (normal, dry, and critical) that are based on cumulative inflows into Lake Pillsbury in the Eel River watershed.

NMFS concluded in the Russian River Biological Opinion that the artificially elevated summertime minimum flows in the Russian River and Dry Creek currently required by Decision 1610 result in high water velocities that reduce the quality and quantity of rearing habitat for coho salmon and steelhead. NMFS' Russian River Biological Opinion concludes that reducing Decision 1610 minimum instream flow requirements will enable alternative flow management scenarios that will increase available rearing habitat in Dry Creek and the upper Russian River, and provide a lower, closer-to-natural inflow to the estuary between late spring and early fall, thereby enhancing the potential for maintaining a seasonal freshwater lagoon that would likely support increased production of juvenile steelhead and salmon.

Changes to Decision 1610 are under the purview of the SWRCB, which retained under Decision 1610 the jurisdiction to modify minimum instream flow requirements if future fisheries studies identified a benefit. NMFS recognized that changing Decision 1610 would require a multi-year (6

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[1] SWRCB water-right permits 12947A, 12949, 12950 and 16596.
[2] Divert – refers to water diverted directly from streamflows into distribution systems for beneficial uses or into storage in reservoirs.
[3] Re-divert – refers to water that has been diverted to storage in a reservoir, then is released and diverted again at a point downstream.

to 8 years) process of petitioning the SWRCB for changes to minimum instream flow requirements, public notice of the petition, compliance with CEQA, and a SWRCB hearing process. To minimize the effects of existing minimum instream flows on listed salmonids during this process, the Russian River Biological Opinion stipulated that the Water Agency “will seek both long term and interim changes to minimum flow requirements stipulated by D1610.” The permanent and temporary changes to Decision 1610 minimum instream flow requirements specified by NMFS in the Russian River Biological Opinion are summarized in Figure 3.1.

Permanent Changes

The Russian River Biological Opinion requires the Water Agency to begin the process of changing minimum instream flows by submitting a petition to change Decision 1610 to the SWRCB within one year of the date of issuance of the final Biological Opinion. The Water Agency filed a petition with the SWRCB on September 23, 2009, to permanently change Decision 1610 minimum instream flow requirements. The requested changes are to reduce minimum instream flow requirements in the mainstem Russian River and Dry Creek between late spring and early fall during normal and dry water years and promote the goals of enhancing salmonid rearing habitat in the upper Russian River mainstem, lower river in the vicinity of the Estuary, and Dry Creek downstream of Warm Springs Dam. NMFS’ Russian River Biological Opinion concluded that, in addition to providing fishery benefits, the lower instream flow requirements “should promote water conservation and limit effects on in-stream river recreation.” NMFS’ recommended changes, based on observations during the 2001 interagency flow-habitat study and the 2007 low flow season, to achieve these goals are provided in the Russian River Biological Opinion (NMFS 2008) and are summarized in Figure 3.1.

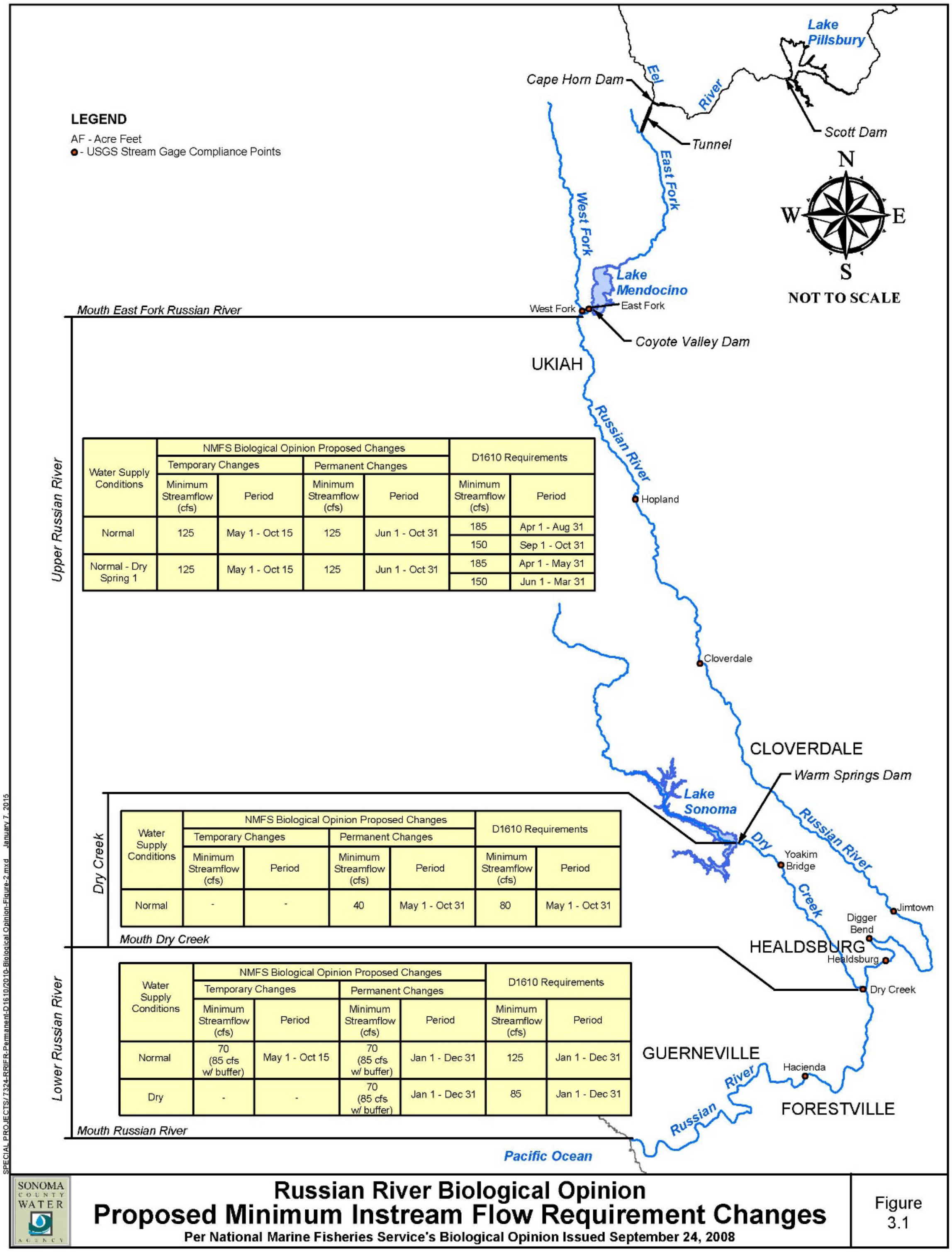
Summary Status

The SWRCB issued a second amended public notice of the Water Agency’s petition to modify Decision 1610 for public comment on March 29, 2010. Following filing of the petition to change Decision 1610, the Water Agency issued a Notice of Preparation (NOP) of an Environmental Impact Report (EIR) for the Fish Habitat Flows and Water Rights Project (Fish Flow Project).

A Draft Environmental Impact Report (EIR) was released for public review on August 19, 2016. The public comment period closed on March 10, 2017, after extending the comment period to allow additional time to review an errata released on January 26, 2017. Sonoma Water staff worked on responding to comments received on the Draft EIR in 2020.

Temporary Changes

Until the SWRCB issues an order on the petition to permanently modify Decision 1610, the minimum instream flow requirements specified in Decision 1610 (with the resulting adverse impacts to listed salmonids) will remain in effect, unless temporary changes to these requirements are made by the SWRCB. The Russian River Biological Opinion requires that the Water Agency petition the SWRCB for temporary changes to the Decision 1610 minimum instream flow requirements beginning in 2010 and for each year until the SWRCB issues an



Upper Russian River

Water Supply Conditions	NMFS Biological Opinion Proposed Changes				D1610 Requirements	
	Temporary Changes		Permanent Changes			
	Minimum Streamflow (cfs)	Period	Minimum Streamflow (cfs)	Period	Minimum Streamflow (cfs)	Period
Normal	125	May 1 - Oct 15	125	Jun 1 - Oct 31	185	Apr 1 - Aug 31
					150	Sep 1 - Oct 31
Normal - Dry Spring 1	125	May 1 - Oct 15	125	Jun 1 - Oct 31	185	Apr 1 - May 31
					150	Jun 1 - Mar 31

Dry Creek

Water Supply Conditions	NMFS Biological Opinion Proposed Changes				D1610 Requirements	
	Temporary Changes		Permanent Changes			
	Minimum Streamflow (cfs)	Period	Minimum Streamflow (cfs)	Period	Minimum Streamflow (cfs)	Period
Normal	-	-	40	May 1 - Oct 31	80	May 1 - Oct 31

Lower Russian River

Water Supply Conditions	NMFS Biological Opinion Proposed Changes				D1610 Requirements	
	Temporary Changes		Permanent Changes			
	Minimum Streamflow (cfs)	Period	Minimum Streamflow (cfs)	Period	Minimum Streamflow (cfs)	Period
Normal	70 (85 cfs w/ buffer)	May 1 - Oct 15	70 (85 cfs w/ buffer)	Jan 1 - Dec 31	125	Jan 1 - Dec 31
Dry	-	-	70 (85 cfs w/ buffer)	Jan 1 - Dec 31	85	Jan 1 - Dec 31

Figure 3.1. A summary of the permanent and temporary changes to Decision 1610 minimum instream flow requirements specified by NMFS in the Russian River Biological Opinion.

order on the Water Agency's petition for the permanent changes to these requirements. NMFS' Russian River Biological Opinion only requires that petitions for temporary changes "request that minimum bypass flows of 70 cfs be implemented at the USGS gage at the Hacienda Bridge between May 1 and October 15, with the understanding that for compliance purposes SCWA will typically maintain about 85 cfs at the Hacienda gage. For purposes of enhancing steelhead rearing habitats between the East Branch and Hopland, these petitions will request a minimum bypass flow of 125 cfs at the Healdsburg gage between May 1 and October 15."

Summary Status

The Water Agency submitted a Temporary Urgency Change Petition to the SWRCB on June 8, 2020, due to extreme drought conditions and hydrologic impacts in the Russian River watershed due to reduced inter-basin transfers from the Eel River via Pacific Gas and Electric's Potter Valley Project (Appendix 3-1). The SWRCB issued an Order approving the Water Agency's TUCP on July 28, 2020 (Appendix 3-2).

The SWRCB's Order made the following changes to the Water Agency's permits until December 27, 2020: minimum instream flow in the upper Russian River (from its confluence with the East Fork of the Russian River to its confluence with Dry Creek) remained at or above 50 cfs; and minimum instream flow in the lower Russian River (from its confluence with Dry Creek to the Pacific Ocean) remained at or above 60 cfs. If storage in Lake Mendocino dropped more than one percent below the target water supply storage level depicted in Figure 5 of the petition package (Appendix 3-1) on any day during the period of the Order, then, from that date through December 27, 2020, instream flow requirements for the Upper Russian River would be reduced from 50 cfs to 40 cfs, and instream flow requirements for the Lower Russian River would be reduced from 60 cfs to 50 cfs. Table 1 in Appendix 3-1 summarizes the calculated daily values of target water supply storage levels. The Order also stipulated that "the minimum instream flow requirement shall be implemented as a 5-day running average of average daily stream flow measurements with instantaneous minimum instream flows being no less than 40 cfs on the Upper Russian River and no less than 50 cfs on the Lower Russian River, unless storage drops more than one percent below the target water supply storage at Lake Mendocino, then the instantaneous minimum instream flow would be no less than 30 cfs on the Upper Russian River and no less than 40 cfs on the Lower Russian River." (Appendix 3-2).

The Order included several terms and conditions, including requirements for fisheries habitat monitoring and regular consultation with National Marine Fisheries Service and California Department of Fish and Wildlife regarding fisheries conditions, preparation of a water quality monitoring plan and summary data report, reporting on hydrologic conditions of the Russian River system), and reporting of activities and programs implemented by the Water Agency and its contractors to assess and reduce water loss, promote increasing water use efficiency, improve regional water supply reliability, and outreach activities conducted to encourage conservation within the Russian River watershed. The Order also include a term and condition for coordination with the Mendocino County Russian River Flood Control and Water Conservation Improvement District (District) regarding implementation of a program for real-time 3-day forecasts of hourly diversions by all of the District's irrigation and municipal customers under all bases of right and to provide an update on the outcome of the consulation and effectiveness of reporting to the Deputy Director of Water Rights, NMFS, and CDFW. The Order also included a term and condition for flow reductions when releases from Lake Mendocino were to be reduced under the Order to protect against stranding of fish.

Reports to fulfill the terms of the Order were prepared and submitted to the SWRCB and are provided in Appendix 3-3. Water quality monitoring in the Russian River Estuary is further discussed in Chapter 4.

References

National Marine Fisheries Service (NMFS). 2008. Biological Opinion for Water Supply, Flood Control Operations, and Channel Maintenance conducted by the U.S. Army Corps of Engineers, the Sonoma County Water Agency, and the Mendocino County Russian River Flood Control and Water Conservation District in the Russian River Watershed. September 24, 2008.

CHAPTER 4 Estuary Management

4.0 Introduction

The Russian River estuary (Estuary) is located approximately 97 kilometers (km; 60 miles) northwest of San Francisco in Jenner, Sonoma County, California. The Estuary extends from the mouth of the Russian River upstream approximately 10 to 11 km (6 to 7 miles) between Austin Creek and the community of Duncans Mills (Heckel 1994). When a barrier beach forms and closes the river mouth, a lagoon forms behind the beach and reaches up to Vacation Beach.

The Estuary may close throughout the year as a result of a barrier beach forming across the mouth of the Russian River. The mouth is located at Goat Rock State Beach (California Department of Parks and Recreation). Although closures may occur at any time of the year, the mouth usually closes during the spring, summer, and fall (Heckel 1994; Merritt Smith Consulting 1997, 1998, 1999, 2000; Sonoma Water and Merritt Smith Consulting 2001). Closures result in ponding of the Russian River behind the barrier beach and, as water surface levels rise in the Estuary, flooding may occur. The barrier beach has been artificially breached for decades; first by local citizens, then the County of Sonoma Public Works Department, and, since 1995, by the Sonoma Water. The Sonoma Water's artificial breaching activities are conducted in accordance with the Russian River Estuary Management Plan recommended in the Heckel (1994) study. The purpose of artificially breaching the barrier beach is to alleviate potential flooding of low-lying properties along the Estuary.

The National Marine Fisheries Service's (NMFS) Russian River Biological Opinion (NMFS 2008) found that artificially elevated inflows to the Russian River estuary during the low flow season (May through October) and historic artificial breaching practices have significant adverse effects on the Russian River's estuarine rearing habitat for steelhead, coho salmon, and Chinook salmon. The historical method of artificial sandbar breaching, which is done in response to rising water levels behind the barrier beach, adversely affects the Estuary's water quality and freshwater depths. The historical artificial breaching practices create a tidal marine environment with shallow depths and high salinity. Salinity stratification contributes to low dissolved oxygen at the bottom in some areas. The Biological Opinion (NMFS 2008) concludes that the combination of high inflows and breaching practices impact rearing habitat because they interfere with natural processes that cause a freshwater lagoon to form behind the barrier beach. Fresh or brackish water lagoons at the mouths of many streams in central and southern California often provide depths and water quality that are highly favorable to the survival of rearing salmon and steelhead.

The Biological Opinion's Reasonable and Prudent Alternative (RPA) 2, Alterations to Estuary Management (NMFS 2008) requires Sonoma Water to collaborate with NMFS and to modify Estuary water level management in order to reduce marine influence (high salinity and tidal inflow) and promote a higher water surface elevation in the Estuary (formation of a fresh or brackish lagoon) for purposes of enhancing the quality of rearing habitat for young-of-year and age 1+ juvenile (age 0+ and 1+) steelhead from May 15 to October 15 (referred to hereafter as the “lagoon management period”). A program of potential, incremental steps are prescribed to accomplish this, including adaptive management of a lagoon outlet channel on the barrier beach, study of the existing jetty and its potential influence on beach formation processes and salinity seepage through the barrier beach, and a feasibility study of alternative flood risk measures. RPA 2 also includes provisions for monitoring the response of water quality, invertebrate production, and salmonids in the Estuary to the management of water surface elevations during the lagoon management period.

Barrier Beach Management

Adaptive Management Plan

RPA 2 requires Sonoma Water, in coordination with NMFS, California Department of Fish and Wildlife (CDFW), and the U.S. Army Corps of Engineers (USACE), to annually prepare barrier beach outlet channel design plans.

Sonoma Water contracted with Environmental Science Associates (ESA) to prepare the Russian River Estuary Outlet Channel Adaptive Management Plan. The approach of the plan was to meet the objective of RPA 2 to the greatest extent feasible while staying within the constraints of existing regulatory permits and minimizing the impact to aesthetic, biological, and recreational resources of the site. Sonoma Water, in collaboration with the resource management agencies, conducted an extensive review of the plan in 2018. This update resulted in a substantial update to the 2019 plan. The measures developed in the 2019 management plan, when implemented, may not fully meet the objective established by the RPA. The concept of this approach has been developed and continues to evolve in coordination with NMFS, CDFW, and California State Parks. Estuary management for 2020 was discussed at a meeting on March 24, 2020, that included representatives from NMFS and CDFW, as well as Sonoma Water, Bodega Marine Laboratory, the U.S. Army Corps of Engineers, the North Coast Regional Water Quality Control Board, and ESA. A draft of the 2020 plan was provided to the Estuary Management Team on March 23, 2020, for review. Comments on the draft plan from these representatives informed the revision of the draft plan to create the final plan, which was finalized on May 15, 2020.

Beach Topographic Surveys

A monthly topographic survey of the beach at the mouth of the Russian River is also required under RPA 2. Topographic data was collected monthly in 2020 and provided to NMFS and CDFW. The April 2020 topographic survey was cancelled due to the presence of neonate (less than 1 week old) harbor seals at the mouth of the Russian River. The topographic maps provide documentation of changing beach widths and crest heights, which influence both flood risk and the need to respond to river mouth closures through beach management activities. A summary of beach topography changes in 2020 is provided in Attachment P, Physical Process during the 2020 Management Period in the Russian River Estuary Adaptive Management Plan 2021 (ESA, 2021).

2020 Beach and River Mouth Conditions

A barrier beach formed eight times in 2020 (Table 4.0.1). Four river mouth closures ended in self-breaches and Sonoma Water conducted water level management activities during four closures. The Russian River mouth was closed to the ocean for a total of 77 days (or 21%) in 2020.

Table 4.0.1. Summary of Russian River mouth closures in 2020. Four beach management activities were conducted in 2020.

Closure Date	Beach Management Date	No. Days Closed	Activity Time[1]	Water Elevation (ft)[2]	Beach Management Activity[3]	Excavated Volume (CY)[4]
5-Jan	7-Jan	2	8:52-10:18am	10.03	Pilot Channel	154
29-Apr	14-May	15	None	9.31	None	None
18-May	21-May	3	None	7.42	None	None
28-Sep	25-Oct	27	None	7.25	None	None
7-Nov	19-Nov	12	12:50-2:11pm	8.40	Pilot Channel	500
1-Dec	10-Dec	9	10:10-10:33am	8.10	Pilot Channel	801
21-Dec	25-Dec	4	None	5.86	None	None
25-Dec	30-Dec	5	12:47-1:47pm	8.10	Pilot Channel	362

[1] Estimated period that excavator/bulldozer equipment was on the beach.

[2] Water surface elevation recorded at the Jenner gage located at the Jenner Visitor's Center.

[3] Beach management activity consists of a pilot channel to initiate an artificial breach of the barrier beach or outlet channel to form a lagoon.

[4] Estimated volume of sand excavated with heavy equipment during artificial breach or lagoon management activity.

Lagoon Management Period Closures, Outlet Channel Implementation, and Self-Breaches

Time series of Estuary water levels, as well as the key forcing factors (waves, tides, and riverine discharge), are shown in Figure 4.0.1 for the entire 2020 lagoon management season (ESA, 2021). The lagoon water level time series (Figure 4.0.1a) summarizes the fully-tidal conditions in the Estuary throughout summer, and also shows the closure events that occurred later in the fall. During the management period, Russian River flows were significantly lower than during the wet 2019 conditions, and similar to the dry 2018 conditions. As shown in Figure 4.0.1d, flows at Hacienda dropped below 100 cubic feet per second (cfs) by mid-June and remained low until November.

As in prior years, wave heights declined in May and June and were lowest through July, August, and September (Figure 4.0.1b). Although swell events during the summer tended to have wave heights of less than 5 feet throughout the summer, there were nearly a dozen times that waves had periods above 15 seconds, and the first several days of July experienced swells with

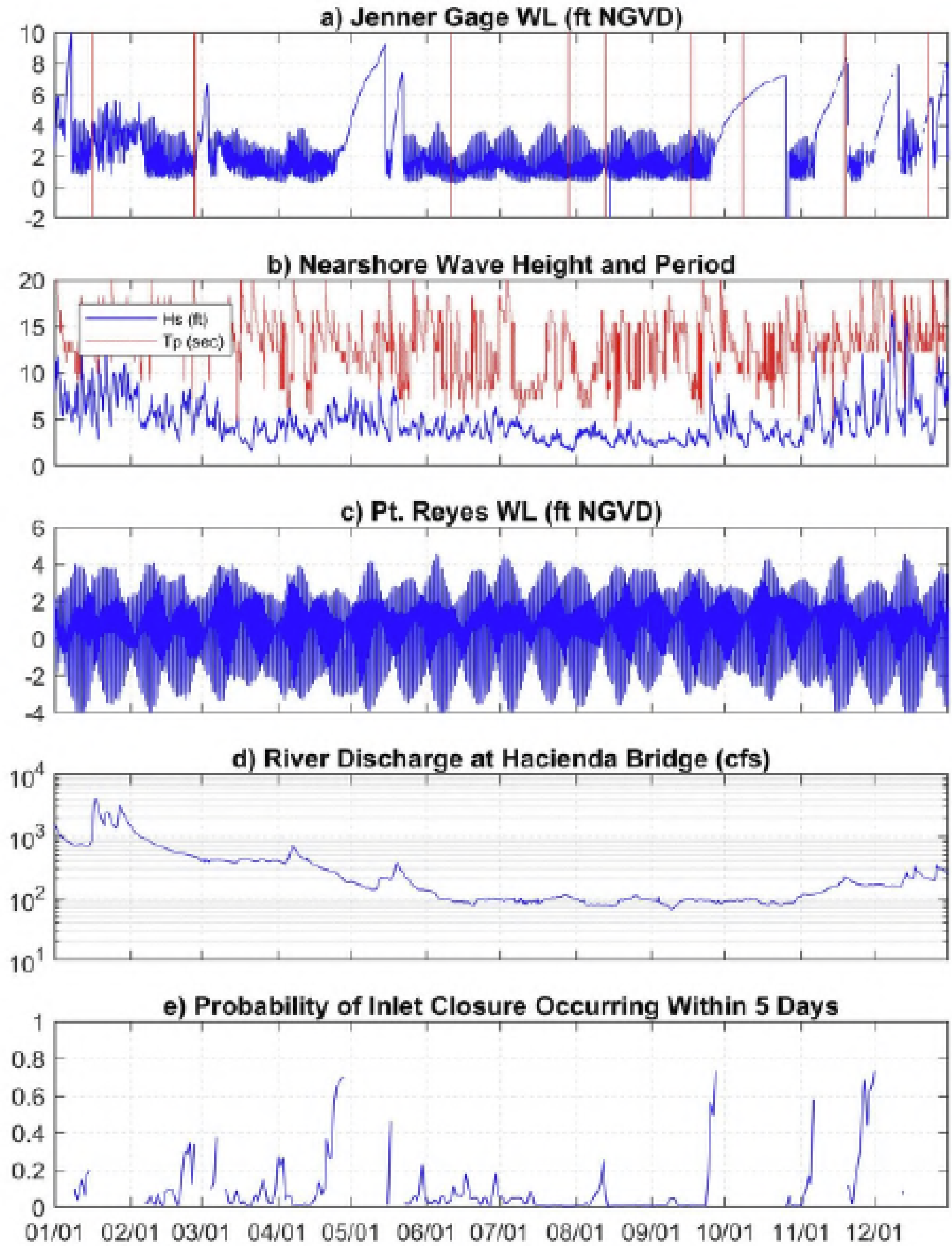


Figure 4.0.1. Estuary, Ocean, and River Conditions Compared with Closure Probability, 2020.

periods above 18 seconds. Long-period waves are relevant because they are known to be more effective at moving sand onto the beach. For instance, the long-period swells in early July were coincident with a significant shallowing of the inlet thalweg (indicated by a smaller tide range in the estuary caused by an upward shift of low tides). The location of the inlet played a role in the shape of the beach and the hydrology of the Estuary. The mouth was located next to the jetty groin for the duration of the management season (similar to 2018), which may have influenced the likelihood of closure (ESA, 2021).

During the 2020 lagoon management period, Sonoma Water staff regularly monitored current and forecasted Estuary water surface elevations, inlet state, river discharge, tides, and wave conditions to anticipate changes to the inlet's state. The winter of 2019/2020 was dry, with discharge at the USGS Hacienda Bridge station reaching a maximum of 7,390 cubic feet per second (cfs) in December 2019, and only a few other short periods that winter above 3,000 cfs. Despite the dry conditions, a short inlet closure occurred in January 2020 with water surface elevations reaching 10.03 ft at the Jenner gage. Taking a broader view of 2020, the inlet never migrated to the north end of the beach due to low discharge conditions. It remained adjacent to the jetty's groin for the entire season. The mouth closed only twice during the 2020 management season, once for three days in May and again for 27 days starting in late September and extending past the end of the management season. Four inlet closure events occurred after the end of the management season, and three were artificially breached.

Appendix P of the 2021 Russian River Estuary Adaptive Beach Management Plan (ESA, 2021) offers lessons learned based on 2020 observations of the Estuary, associated physical processes, and Sonoma Water's planning for outlet channel management. These are summarized here and may be found in ESA 2021 for fuller context:

- As observed in similarly dry years from 2012 to 2015, and 2018, peak 2020 winter flows of less than 40,000 cfs limited the inlet's northward excursion, and the inlet remained near the groin for the entire management period.
- The location of the inlet on the beach has been noted as an important factor in past reports, as northern locations are sometimes associated with muted tidal conditions, and location near Haystack Rock is associated with full exposure to wave action. In past dry years when the inlet was located adjacent to the jetty groin for extended periods of time, the groin was thought to provide some level of shielding of the inlet from southern swell waves. The groin has also been associated with a lower minimum crest elevation on the beach when the inlet location is adjacent to the groin, since the groin presumably blocks some of the wave deposition on the beach from southerly waves. However, in 2020, wave deposition was noted through the degraded region in the groin. This appears to be different than prior years when the degraded region was smaller. This could suggest that the shielding effect of the groin may be diminished as compared to prior years.

Artificial Breaching

There were eight mouth closures in 2020; two occurred during the lagoon management season. Four beach management activities were conducted by Sonoma Water in 2020, all outside the lagoon management season. More information about the wave and water level conditions during these closures are available in Appendix P of the 2021 Russian River Estuary Adaptive Beach Management Plan (ESA, 2021).

Flood Risk Management Study

The Russian River Biological Opinion, RPA 2, includes a Flood Risk Reduction step if it proves difficult to reliably achieve raised water surface elevation targets based on implementation of a lagoon outlet channel or modification of the existing jetty. Should those actions be unsuccessful in meeting estuarine water surface elevation goals, RPA 2 states that the Sonoma Water “will evaluate, in coordination with NMFS and other appropriate public agencies, the feasibility of actions to avoid or mitigate damages to structures in the town of Jenner and low-lying properties along the Estuary that are currently threatened with flooding and prolonged inundation when the barrier beach closes and the Estuary’s water surface elevation rises above 9 feet. Such actions may include, but are not limited to, elevating structures to avoid flooding or inundation.”

As described in earlier annual reports, the first effort to address flood risk management feasibility was compilation of a preliminary list of structures, properties, and infrastructure that would be subject to flooding/inundation as the result of sandbar formation and if the Estuary were allowed to naturally breach. As required by RPA 2, the Sonoma Water submitted a preliminary list of properties, structures, and infrastructure that may be subject to inundation if the barrier beach at the mouth of the Russian River was allowed to naturally breach. This preliminary list was updated for the California Coastal Commission Coastal Development Permit application process. Allowing Estuary water surface elevations to rise to between 10 and 12 feet NGVD (the estimated water surface elevation if the barrier beach was allowed to naturally breach per consultation with NMFS) may potentially inundate portions of properties.

As described in previous reports, the Sonoma Water was awarded federal funding from the National Oceanic and Atmospheric Administration (NOAA) under its Habitat Blueprint framework to provide funds to the United States Geological Survey (USGS) expansion of its sea level rise model (the Coast Storm Modeling System or CoSMoS) from Bodega Bay north along the Sonoma Coast to Point Area, including the Russian River Estuary up to Duncans Mills, to be used to inform adaptation planning and Estuary management efforts (model included both open and closed river mouth conditions). These model scenarios were incorporated into the Our Coast, Our Future (OCOF) web platform by Point Blue Conservation Science (https://ourcoastourfuture.org/case-studies/). Sonoma Water hopes to use the CoSMoS and OCOF information to inform future flood risk feasibility studies of sea level rise and climate change effects on estuary flood risk and habitat management. In 2018, Sonoma Water began identifying next steps for the flood risk scope of work and plan to meet with resource agencies in 2021 and 2022 to more fully develop the work to be completed.

Conclusions and Recommendations

A barrier beach formed eight times in 2020. Four river mouth closures ended in self-breaches and Sonoma Water conducted four water level management activities outside the lagoon management season (Table 4.0.1). The Russian River mouth was closed to the ocean for a total of 77 days (or 21%) in 2020.

4.1 Water Quality Monitoring

Water quality monitoring was conducted in the lower, middle, and upper reaches of the Russian River Estuary, including two tributaries and the Maximum Backwater Area (MBA), between the mouth of the river at Jenner and Vacation Beach near Guerneville. Sonoma Water staff continued to collect data to establish baseline information on water quality in the Estuary, gain a better understanding of the longitudinal and vertical water quality profile during the ebb and flow of the tide, and track changes to the water quality profile that may occur during periods of barrier beach closure, partial or full lagoon formation, lagoon outlet channel implementation, and barrier beach breach.

Saline water is denser than freshwater and a salinity “wedge” (halocline) forms in the Estuary as freshwater outflow passes over the denser tidal inflow. During the Lagoon Management Period, the lower and middle reaches of the Estuary up to Sheephouse Creek are predominantly saline environments with a thin freshwater layer that flows over the denser saltwater. The upper reach of the Estuary transitions to a predominantly freshwater environment, which is periodically underlain by a denser, saltwater layer that migrates upstream to Duncans Mills during summer low flow conditions and barrier beach closure. Additionally, river flows, tides, topography, and wind action affect the amount of mixing of the water column at various longitudinal and vertical positions within the reaches of the Estuary. The Maximum Backwater Area encompasses the area of the river between Duncans Mills and Vacation Beach that is generally outside the influence of saline water, but within the upper extent of inundation and backwatering that can occur during tidal cycles and lagoon formation.

Methods

Continuous Multi-Parameter Monitoring

Water quality was monitored using YSI Series 6600 multi-parameter datasondes. Hourly salinity (parts per thousand), water temperature (degrees Celsius), dissolved oxygen (percent saturation), dissolved oxygen (milligrams per liter), and pH (hydrogen ion) data were collected. Datasondes were cleaned and recalibrated periodically following the YSI User Manual procedures, and data was downloaded during each calibration event.

Five (5) stations were established for continuous water quality monitoring, including two stations in the mainstem Estuary, two tributary stations, and one station in the MBA near Villa Grande (Figure 4.1.1). One mainstem Estuary station was located in the middle reach at Patty’s Rock upstream of Penny Island (Patty’s Rock Station). One tributary station was located in the mouth of Willow Creek, which flows into the middle reach of the Estuary (Willow Creek Station). One mainstem Estuary station was located in the upper reach downstream of Austin Creek in Brown’s Pool (Brown’s Pool Station). The other tributary station was located downstream of the first steel bridge in lower Austin Creek, which flows into the mainstem Russian River above Brown’s Pool Station. One mainstem station was located in the MBA in a pool across from Patterson Point in Villa Grande (Patterson Point Station).

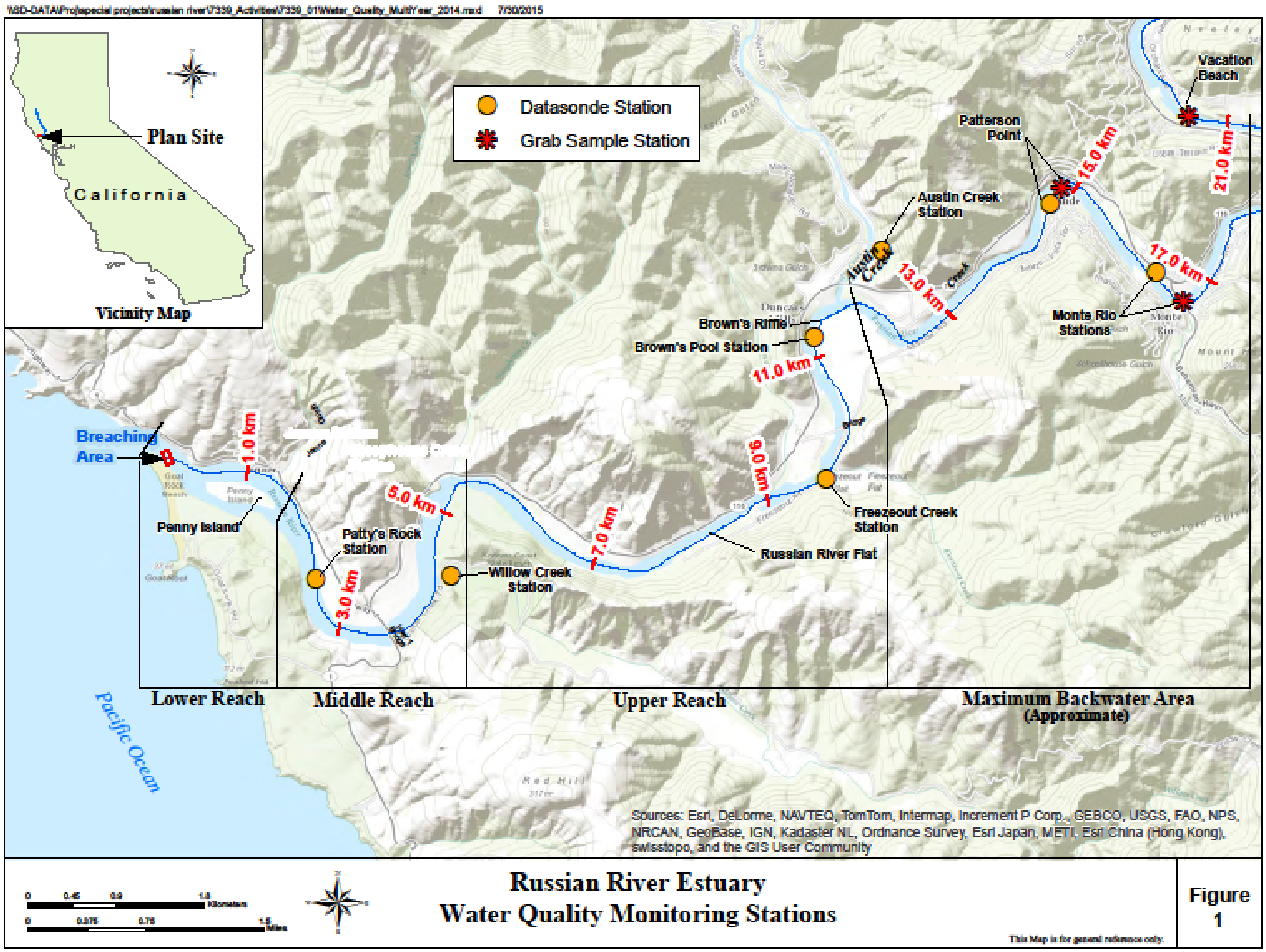


Figure 4.1.1. 2020 Russian River Estuary water quality monitoring stations.

The rationale for choosing mainstem Estuary sites, including the Brown's Pool Station, was to locate the deepest holes at various points throughout the Estuary to obtain the fullest vertical profiles possible and to monitor salinity circulation and stratification, hypoxic and/or anoxic events, and temperature stratification. Sondes were located near the mouths of Willow and Austin Creeks to collect baseline water quality conditions and monitor potential changes to water quality (e.g salinity intrusion) resulting from tidal cycling or inundation during partial or full lagoon formation. The Patterson Point station was established to monitor potential changes to water quality conditions (including potential salinity migration) in the MBA while inundated during lagoon formation (Figure 4.1.1). Mainstem Estuary and MBA monitoring stations up to Patterson Point were comprised of a concrete anchor attached to a steel cable suspended from the surface by a large buoy (Figure 4.1.2).

The Patty's Rock, Brown's Pool, and Patterson Point stations had a vertical array of two datasondes to collect water quality profiles. The Patty's Rock station, located in the middle reach of the Estuary, is predominantly saline and had sondes placed near the surface at approximately 1 meter depth (~1m), and at the mid-depth (~4-5m) portion of the water column. The Brown's Pool station in the upper reach of the Estuary, where the halocline is deeper and the water is predominantly fresh to brackish, had sondes placed at the bottom (~8-10m) and mid-depth (~4-7m) portions of the water column. The Patterson Point monitoring station, located in the MBA, also had datasondes placed at the bottom (~10-13m) and mid-depth (~6-7m) portions of the water column (Figure 4.1.2).

Sondes were located in this manner to track vertical and longitudinal changes in water quality characteristics during periods of tidal circulation, barrier beach closure, lagoon formation, lagoon outlet channel implementation, and sandbar breach.

The monitoring stations in Austin Creek and Willow Creek consisted of one datasonde suspended at approximately mid-depth (~1-2m during open conditions) in the thalweg at each respective site.

The Patty's Rock and Patterson Point stations were deployed from May to November. The Brown's Pool station was deployed in May; however it was removed from the site by unknown persons sometime during the season before Sonoma Water staff could access the site to retrieve the equipment. The Austin Creek sonde was deployed from May to August when a lack of water required equipment removal for the remainder of the season. The Willow Creek sonde was deployed year-round.

Grab Sample Collection

In 2020, Sonoma Water staff continued to conduct nutrient and indicator bacteria grab sampling at three stations in the freshwater segment of the Russian River Estuary referred to as the MBA, including one station established in 2010 just downstream of the Monte Rio Bridge (Monte Rio Station). The 2020 grab sampling effort represented the seventh year of collecting samples at Patterson Point in Villa Grande (Patterson Point Station) and downstream of the Vacation Beach summer dam (Vacation Beach station). Refer to Figure 4.1.1 for grab sampling locations.

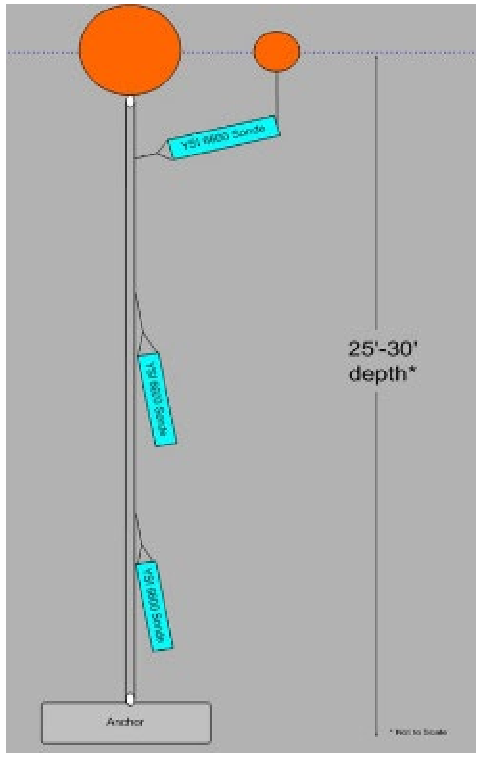


Figure 4.1.2. Typical Russian River Estuary monitoring station datasonde array.

Sonoma Water staff collected grab samples weekly from 14 May to 15 October. Additional focused sampling (collecting three samples over a ten day period) was conducted following or during specific river management and operational events including removal of summer recreational dams.

Nutrient sampling was conducted for total organic nitrogen, ammonia, unionized ammonia, nitrate, nitrite, total Kjeldahl nitrogen, total nitrogen, total phosphorus, total orthophosphate, dissolved and total organic carbon, total dissolved solids, and turbidity, as well as for *Chlorophyll a*, which is a measurable parameter of algal growth that can be tied to excessive nutrient concentrations and reflect a biostimulatory response. Grab samples were also collected for the presence of indicator bacteria including total coliforms, *Escherichia coli* (*E. coli*) and Enterococcus. These bacteria are considered indicators of water quality conditions that may be a concern for water contact recreation and public health.

Nutrients, organic carbon, total dissolved solids, turbidity, and *chlorophyll a* grab samples were analyzed at Alpha Analytical Labs in Ukiah, and bacterial grab samples were analyzed at the Sonoma County Department of Health Services (DHS) lab in Santa Rosa.

The sampling results for total nitrogen, total phosphorus, turbidity, *chlorophyll a*, and bacterial indicators are analyzed and discussed below. Sampling results for other nutrient components, dissolved and total organic carbon, and total dissolved solids are included; however, an analysis and discussion of these constituents is not included in this report.

Results

As mentioned briefly in the methods section, there were several issues that arose during the season that significantly affected the amount of continuous sonde data collected. In addition to delays and limitations to conducting field work due to the COVID-19 pandemic, there were access issues to monitoring stations due to increased sedimentation in the lower river, and there were several equipment failures as well as the theft of an entire monitoring station.

The Austin Creek and Willow Creek sondes malfunctioned and did not record data while deployed during the 2020 monitoring season and the Brown's Pool station was removed from the water and taken from the site by unknown persons before Sonoma Water staff could access the site to retrieve the equipment and download data.

As a result, the 2020 dataset only includes continuous sonde data for the Patty's Rock station in the middle reach of the Estuary, and the Patterson Point station in the MBA. However, the data that was collected showed similar water quality conditions and trends seen during past years' monitoring efforts conducted between 2004 and 2019.

The lower and middle reaches are predominantly saline environments with a thin freshwater layer that flows over the denser saltwater layer. The upper reach transitions to a predominantly freshwater environment, which is periodically underlain by a denser, saltwater layer that migrates up and downstream and appears to be affected in part by freshwater inflow rates, tidal inundation, barrier beach closure, and subsequent tidal cycles following reopening of the barrier beach. The river upstream of Brown's Pool is considered predominantly freshwater habitat. The lower and middle reaches of the Estuary are subject to tidally-influenced fluctuations in water depth during open conditions and inundation during barrier beach closure, as is the upper reach and the MBA to a lesser degree.

Table 4.1.1 presents a summary of minimum, mean, and maximum values for temperature, depth, dissolved oxygen, pH, and salinity recorded at the various datasonde monitoring stations. Data associated with malfunctioning datasonde equipment has been removed from the data sets, resulting in the data gaps observed in the figures presented below. These data gaps may affect minimum, mean, and maximum values of the various constituents monitored in 2020, including dissolved oxygen at the Patty's Rock mid-depth sonde from mid-October to the end of November.

Although gaps exist in the 2020 data that affect sample statistics, Sonoma Water staff have collected long time-series data on an hourly frequency for several years at most of these stations, and it is unlikely that the missing data appreciably affected the broader understanding of water quality conditions within the Estuary. The following sections provide a brief discussion of the results observed for each parameter monitored.

Salinity

Full strength seawater has a salinity of approximately 35 parts per thousand (ppt), with salinity decreasing from the ocean to the upstream limit of the Estuary, which is considered freshwater at approximately 0.5 ppt (Horne, 1994). The Patty's Rock mid-depth sonde in the middle reach

Table 4.1.1. Russian River Estuary 2020 Water Quality Monitoring Results. Minimum, mean, and maximum values for temperature (degrees Celsius), depth (meters), dissolved oxygen concentration (milligrams per Liter), dissolved oxygen (percent) saturation, hydrogen ion (pH units), and salinity (parts per thousand).

Monitoring Station ***Sonde***	**Temperature** (°C)	**Depth** (m)	**Dissolved Oxygen** (mg/L)	**Dissolved Oxygen** (%) saturation	**Hydrogen Ion** (pH)	**Salinity** (ppt)
Patty's Rock						
Surface May 7, 2020 - November 24, 2020						
Min	11.2	1.5	0.2	2.4	7.0	0.5
Mean	15.0	2.2	8.6	99.1	7.9	24.5
Max	**21.2**	**4.1**	**19.5**	**219.5**	**8.6**	**32.1**
Mid-Depth May 7, 2020 - November 24, 2020						
Min	10.6	4.6	0.2	2.3	7.1	11.1
Mean	13.5	5.4	7.6	87.6	7.9	29.5
Max	**17.5**	**7.3**	**15.1**	**173.9**	**8.6**	**34.7**
Patterson Point						
Mid-Depth May 7, 2020 - November 12, 2020						
Min	9.8	6.2	0.9	10.3	7.3	0.1
Mean	19.7	6.4	7.0	75.8	7.7	0.1
Max	**23.2**	**7.1**	**12.0**	**111.9**	**8.2**	**0.2**
Bottom May 7, 2020 - November 12, 2020						
Min	10.4	10.1	0.2	1.6	6.6	0.1
Mean	18.7	10.7	2.3	24.0	7.1	0.2
Max	**21.9**	**12.3**	**10.2**	**92.9**	**7.8**	**0.3**

was located in a predominantly saline environment, whereas the surface sonde was located at the saltwater-freshwater interface (halocline or salt wedge) and recorded both freshwater and saltwater conditions. In the lower and middle reaches of the Estuary, salinities can range as high as 30 ppt in the saltwater layer, with brackish conditions prevailing at the upper end of the salt wedge, to less than 1 ppt in the freshwater layer on the surface.

In the upper reach, the Estuary typically transitions from predominantly saline conditions to brackish and freshwater conditions in the Heron Rookery area, located downstream from the town of Duncans Mills. Further upstream, the Freezeout Creek area is located in a predominantly freshwater environment; however, brackish conditions can occur during open Estuary conditions with lower in-stream flows, as well as during barrier beach closure or perched conditions. The upper extent of the upper reach of the Estuary is located in the Brown's Pool area where conditions are predominantly freshwater habitat with periodic salinity migration creating brackish conditions at depth. This area is located next to Casini Ranch just downstream of the confluence with Austin Creek and what is considered the beginning of the MBA.

The Patterson Point station is located in the MBA in freshwater habitat that can become inundated during high tides, barrier beach closures, perched conditions, and lagoon formation. Elevated salinity levels were not observed at Patterson Point during either open or closed barrier beach conditions in 2020.

Lower and Middle Reach Salinity

The Patty's Rock station is located at river kilometer 2.5 (rkm 2.5), which is approximately 2.5 km upstream from the river mouth. The surface sonde at the Patty's Rock station was suspended at a depth of approximately 1.5 to 4 meters, and experienced frequent hourly fluctuations in salinity during open conditions. These fluctuations are influenced by freshwater inflows, tidal movement and expansion and contraction of the salt wedge. The freshwater layer was observed to deepen and become more persistent at the surface sonde during closed barrier beach conditions (Figure 4.1.3). Concentrations ranged from 0.5 to 32.1 ppt at the Patty's Rock surface sonde with a mean salinity value of 24.5 ppt (Table 4.1.1).

The mid-depth sonde at the Patty's Rock station was suspended at a depth of approximately 5 to 7 meters, and also experienced frequent fluctuations in salinity concentrations, though to a lesser degree than the surface sonde. Concentrations ranged from 11.1 to 34.7 ppt at the Patty's Rock mid-depth sonde with a mean salinity value of 29.5 ppt (Table 4.1.1).

The Estuary experienced two closures following the 2020 management period, including one closure that lasted 27 days between 28 September and 25 October (Figure 4.1.3). Declines in salinity during barrier beach closure and lagoon formation were due to a combination of freshwater inflows increasing the depth of the freshwater layer over the salt layer, a reduction in tidal inflow, the compression and leveling out of the salt layer, and seepage of saline water through the barrier beach. Salinity returned to pre-closure levels within a few hours after the barrier beach reopened, although the time required to return to pre-closure conditions can vary between closure events. This variability is related to the strength of subsequent tidal cycles, freshwater inflow rates, topography, relative location within the Estuary, and to a lesser degree, wind mixing.

Maximum Backwater Area Salinity

One station was located in the MBA at Patterson Point (rkm 14.9) (Figure 4.1.1). Patterson Point was not observed to have salinity levels above normal background conditions expected in freshwater habitats, during both open and closed barrier beach conditions (Figure 4.1.4).

The Patterson Point bottom sonde had a mean salinity concentration of 0.2 ppt, a minimum concentration of 0.1 ppt, and a maximum concentration of 0.3 ppt. The Patterson Point mid-depth sonde had a mean salinity concentration of 0.1 ppt, a minimum concentration of 0.1 ppt, and a maximum concentration of 0.2 ppt.

Temperature

During open Estuary conditions, mainstem water temperatures were reflective of the halocline, with lower mean and maximum temperatures typically being observed in the saline layer at the bottom and mid-depth sondes compared to temperatures recorded in the freshwater layer at the mid-depth and surface sondes (Figures 4.1.5 and 4.1.6). The differences in temperatures

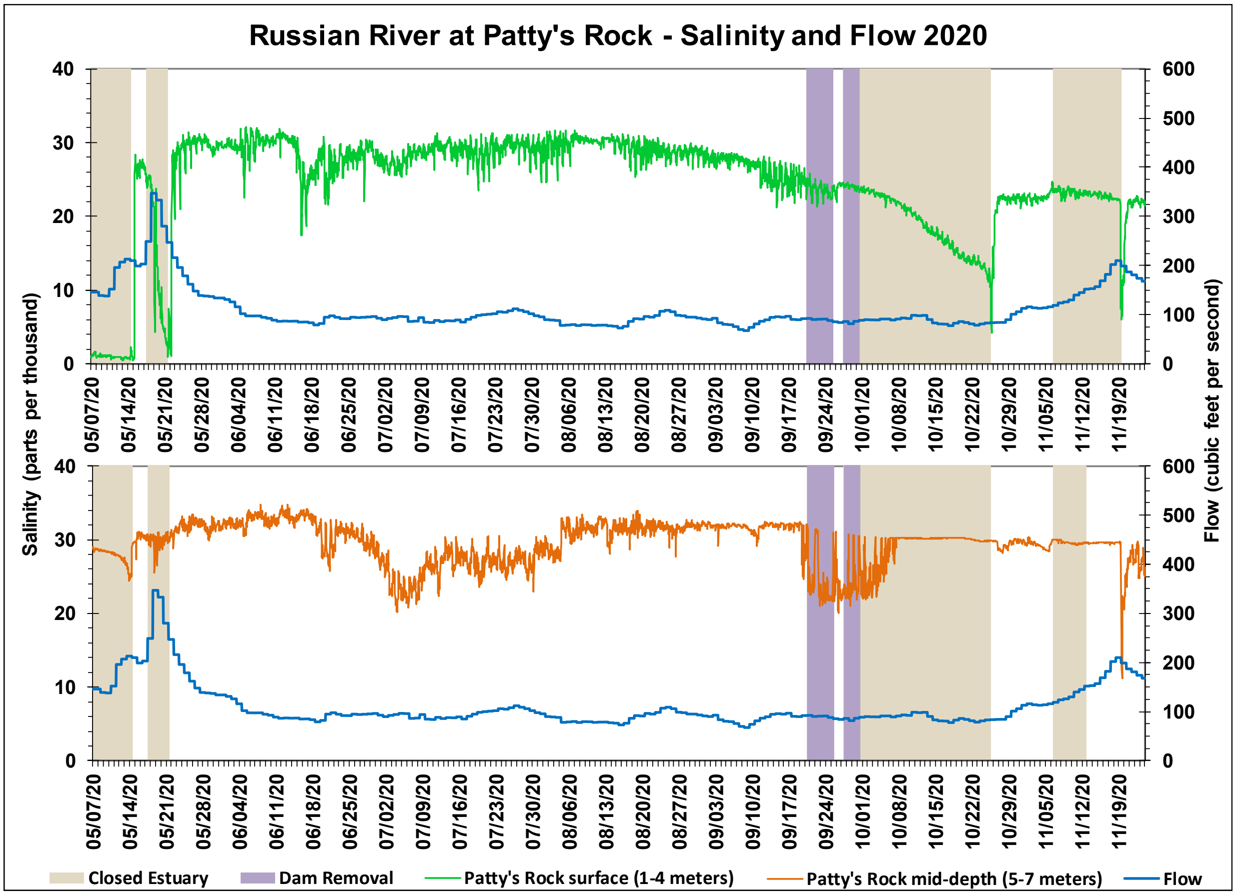


Figure 4.1.3. 2020 Russian River at Patty's Rock Salinity and Flow Graph

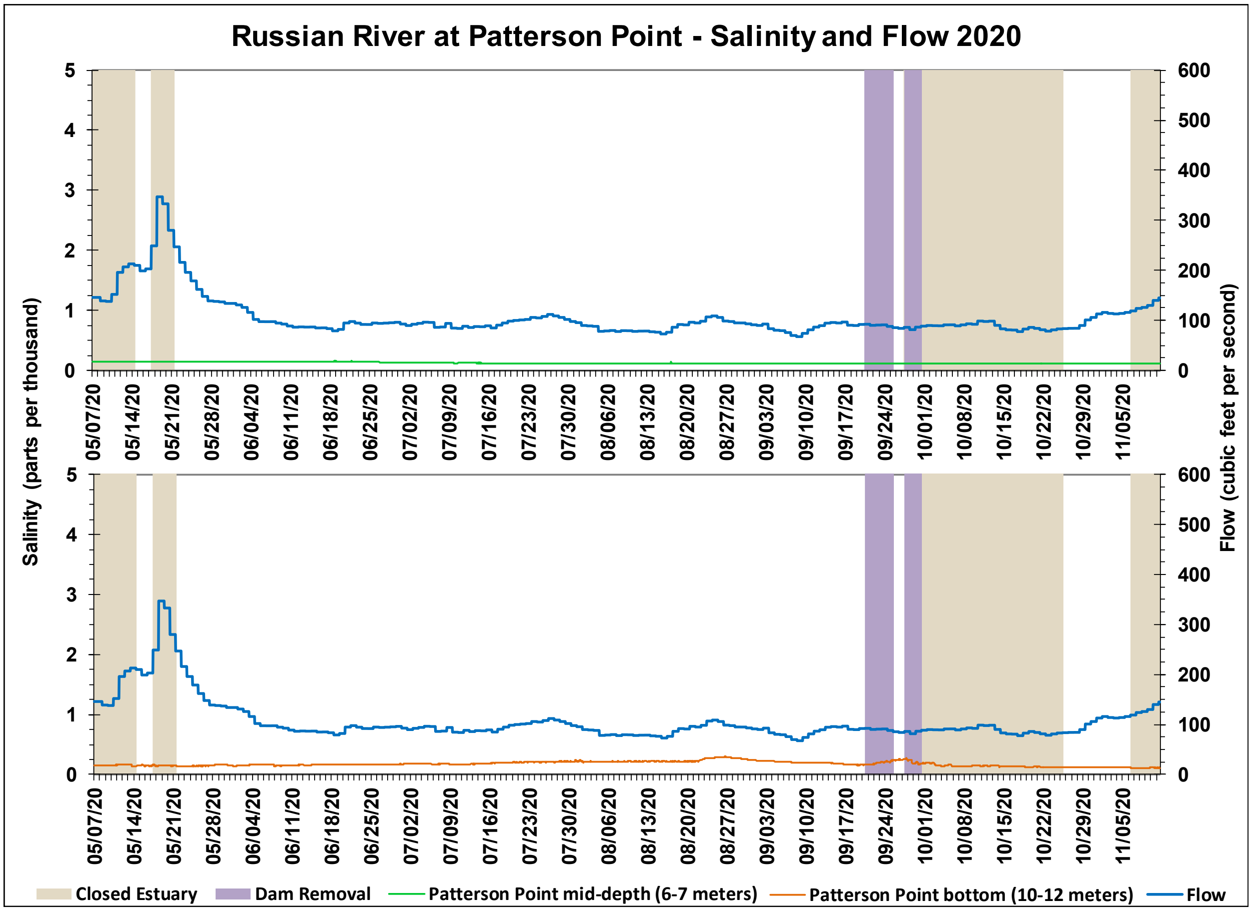


Figure 4.1.4. 2020 Russian River at Patterson Point Salinity and Flow Graph

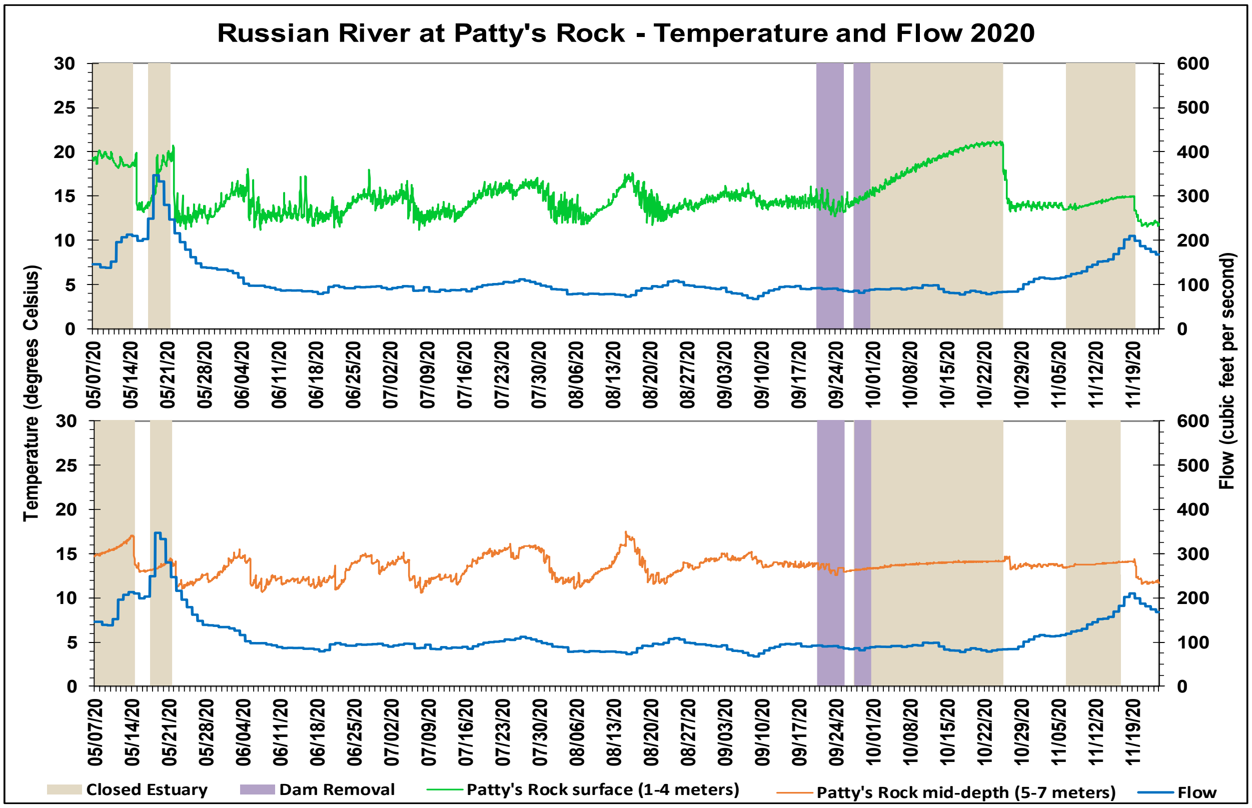


Figure 4.1.5. 2020 Russian River at Patty's Rock Temperature and Flow Graph

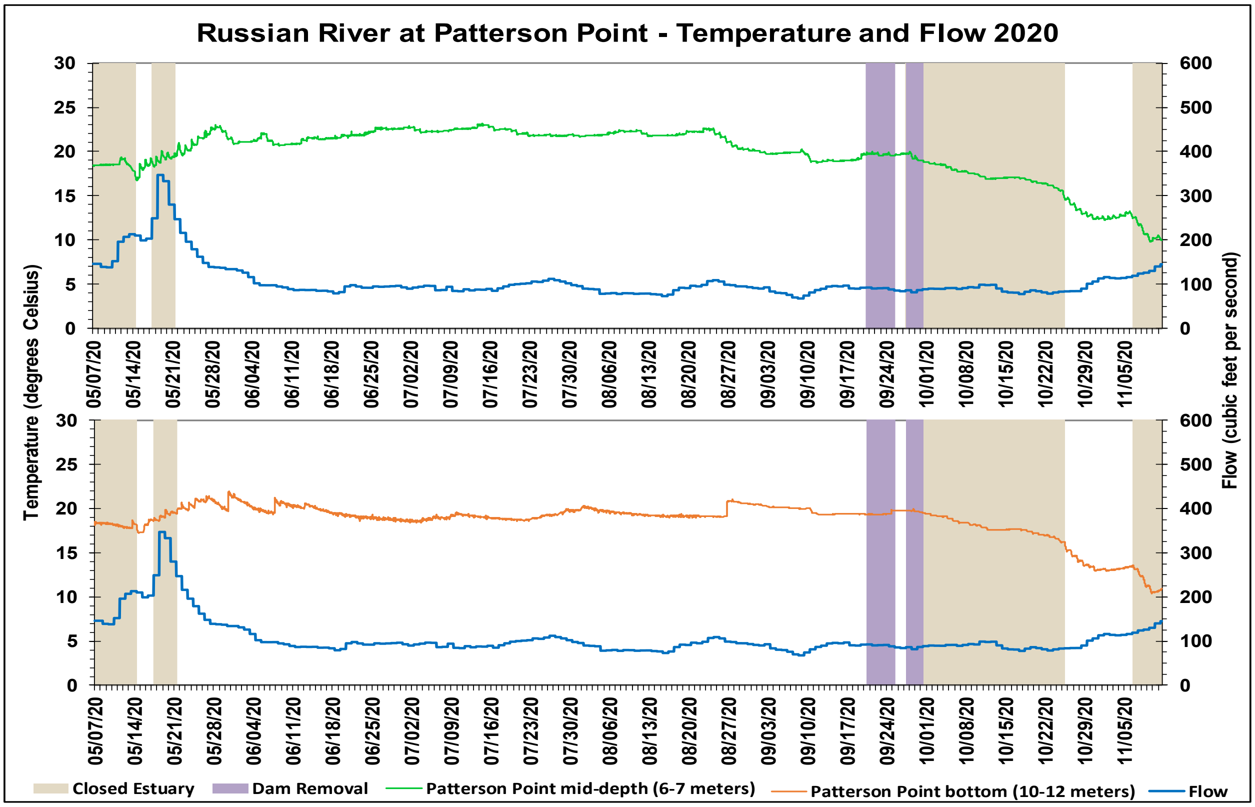


Figure 4.1.6. 2020 Russian River at Patterson Point Temperature and Flow Graph

between the underlying saline layer and the overlying freshwater layer can be attributed in part to the source of saline and fresh water. During open Estuary conditions, the Pacific Ocean, where temperatures are typically around 10 degrees Celsius (°C), is the source of saltwater in the Estuary. Whereas, the mainstem Russian River, with water temperatures reaching as high as 27 °C in the interior valleys, is the primary source of freshwater in the Estuary.

During closed Estuary conditions, increasing temperatures associated with fresh/saltwater stratification were observed to occur at the Patty's Rock station (Figure 4.1.5). Density and temperature gradients between freshwater and saltwater play a role in stratification and serve to prevent/minimize mixing of the freshwater and saline layers. During the warmer dry months of summer and fall, when the Estuary is closed or the river mouth is perched and the supply of cool tidal inflow is reduced, solar radiation heats the overlying freshwater surface layer and underlying saline layer. The overlying freshwater surface layer restricts the release of this heat from the underlying saline layer, which can result in higher water temperatures in the underlying saline layer than in the overlying freshwater layer. Stratification-based heating has also been observed to result in higher temperatures in the mid-depth saline layer compared to the bottom layer in deep pools, forming a three-layered water column. This stratification-based heating can also contribute to higher seasonal mean temperatures in the saline layer than would be expected to occur under open conditions.

Lower and Middle Reach Temperature

The Patty's Rock surface sonde was located at the freshwater/saltwater interface and was observed to have a maximum temperature of 21.2 °C (Table 4.1.1). Whereas, the mid-depth sonde was located primarily in saltwater and had a maximum temperature of 17.5 °C. Maximum temperatures at the surface sonde were observed in brackish water during conditions that were transitioning from closed to open in late May, and during closed barrier beach conditions in October when the sonde was in the saline layer of the water column. Maximum temperatures at the mid-depth sonde were observed in saline water during closed barrier beach conditions in May and open conditions in August (Figures 4.1.5 and 4.1.3). The Patty's Rock surface sonde had a mean temperature of 15.0 °C and a minimum temperature of 11.2 °C. The mid-depth sonde had a mean temperature of 13.5 °C and a minimum temperature of 10.6 °C.

Maximum Backwater Area Temperature

The Patterson Point mid-depth sonde had a maximum temperature of 23.2 °C, a mean temperature of 19.7 °C, and a minimum temperature of 9.8 °C. The Patterson Point bottom sonde had a maximum temperature of 21.9°C, a mean temperature of 18.7 °C, and a minimum temperature of 10.4 °C (Table 4.1.1). Under open and closed conditions, temperatures were often lower at the bottom sonde compared to the mid-depth, which suggests that thermal stratification may be occurring (Figure 4.1.6). It is also possible that a groundwater source could be contributing colder water at depth, or it could a combination of effects occurring in tandem. Temperatures continued to decline with atmospheric temperatures through the end of the season (Figure 4.1.6).

Dissolved Oxygen

Dissolved oxygen (DO) levels in the Estuary, including the MBA, depend upon factors such as the extent of diffusion from surrounding air and water movement, including freshwater inflow. DO is affected by salinity and temperature stratification, tidal and wind mixing, abundance of aquatic plants, and presence of decomposing organic matter. DO affects fish growth rates, embryonic development, metabolic activity, and under severe conditions, stress and mortality. Cold water has a higher saturation point than warmer water; therefore cold water is capable of carrying higher levels of oxygen.

DO levels are also a function of nutrients, which can accumulate in water and promote plant and algal growth that both produce and consume DO during photosynthesis and respiration. Estuaries tend to be naturally eutrophic because land-derived nutrients are concentrated where runoff enters the marine environment in a confined channel[1]. Upwelling in coastal systems also promotes increased productivity by conveying deep, nutrient-rich waters to the surface, where the nutrients can be assimilated by algae. Excessive nutrient concentrations and plant, algal, and bacterial growth can overwhelm eutrophic systems and lead to a reduction in DO levels that can affect the overall ecological health of the system.

Lower and Middle Reach Dissolved Oxygen

Mean dissolved oxygen concentrations at Patty's Rock were generally higher at the surface sonde compared to the mid-depth sonde. Whereas the Patty's Rock surface sonde had a mean DO concentration of 8.6 mg/L, the mid-depth sonde had a mean DO concentration of 7.6 mg/L (Table 4.1.1). The mid-depth and surface sondes were both observed to experience supersaturation conditions, and occasional hypoxic conditions. These supersaturation and hypoxic events were observed during open and closed conditions (Figure 4.1.7).

The effect of closed conditions at the surface sonde was variable as DO concentrations were observed to remain relatively unchanged during closures in May but declined to hypoxic and anoxic conditions during the October closure (Figure 4.1.7). The Patty's Rock surface sonde had a minimum DO concentration of 0.2 mg/L (Table 4.1.1). Minimum concentrations were observed to occur in brackish to saline water during closed conditions (Figures 4.1.7 and 4.1.3).

DO concentrations were observed to become hypoxic at the Patty's Rock mid-depth sonde during closed conditions (Figure 4.1.7). The minimum DO concentration at the mid-depth sonde was 0.2 mg/L, which occurred before and during and briefly following the early May closure event (Table 4.1.1).

The Patty's Rock surface sonde, and mid-depth sonde to a lesser degree, experienced hourly fluctuating supersaturation events. Supersaturation events were observed at the surface sonde primarily during open Estuary conditions (Figure 4.1.7). Supersaturation events typically occurred during open conditions at the mid-depth sonde. At times when oxygen production

[1] National Estuarine Eutrophication Assessment by NOAA National Centers for Coastal Ocean Science (NCCOS) and the Integration and Application Network (IAN), 1999.

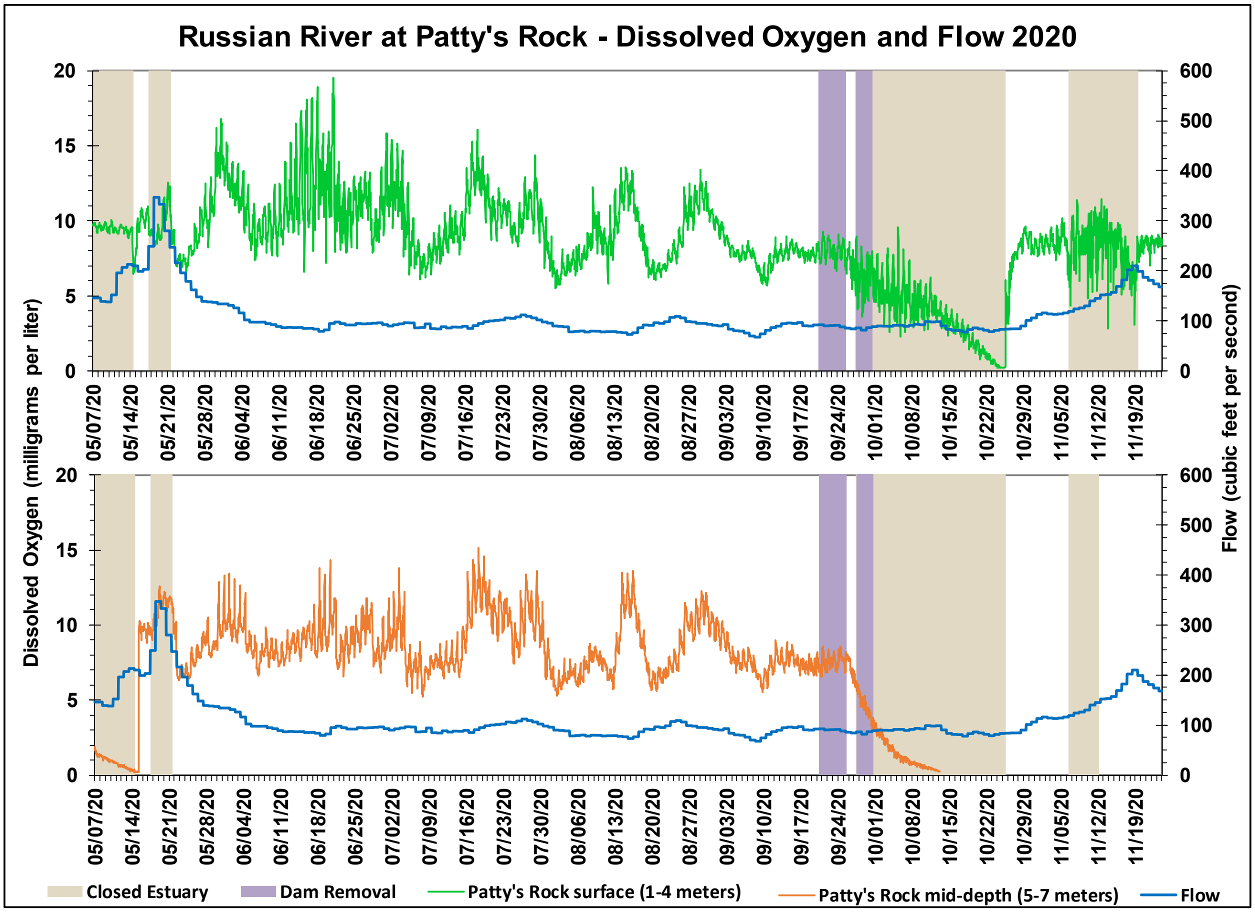


Figure 4.1.7. 2020 Russian River at Patty's Rock Dissolved Oxygen and Flow Graph

exceeds the diffusion of oxygen out of the system, supersaturation may occur (Horne, 1994). DO concentrations exceeding 100% saturation in the water column are considered supersaturated conditions. Because the ability of water to hold oxygen changes with temperature, there are a range of concentration values that correspond to 100% saturation. For instance, at sea level, 100% saturation is equivalent to approximately 11 mg/L at 10 °C, but only 8.2 mg/L at 24 °C. Consequently, these two temperature values roughly represent the range of temperatures typically observed in the Estuary.

The Patty's Rock surface sonde had a maximum DO concentration of 19.5 mg/L, which corresponded to 220% saturation (Table 4.1.1). The maximum DO concentration at the mid-depth sonde was 15.1 mg/L, which corresponded to 174% saturation (Table 4.1.1).

Maximum Backwater Area Dissolved Oxygen

The Patterson Point bottom sonde had a minimum DO concentration of 0.2 mg/L, a mean concentration of 2.3 mg/L, and a maximum concentration of 10.2 mg/L (93%). The bottom sonde was predominantly hypoxic to anoxic from June through September under open and closed conditions, and remained depressed through October (Figure 4.1.8).

The Patterson Point mid-depth sonde had minimum, mean, and maximum DO concentrations of 0.9, 7.0, and 12.0 mg/L (112%), respectively (Table 4.1.1 The mid-depth sonde was observed to experience several episodes of depressed concentrations as low as 0.9 mg/L from June through August during open conditions (Figure 4.1.8). DO concentations recovered by September and generally remained above 7.0 mg/L into November, including during summer dam removal and barrier beach closure in October (Figure 4.1.8).

Hydrogen Ion (pH)

The acidity or alkalinity of water is measured in units called pH, an exponential scale of 1 to 14 (Horne, 1994). Acidity is controlled by the hydrogen ion H+, and pH is defined as the negative log of the hydrogen ion concentration. A pH value of 7 is considered neutral, freshwater streams generally remain at a pH between 6 and 9, and ocean derived salt water is usually at a pH between 8 and 9. When the pH falls below 6 over the long term, there may be a noticeable reduction in the abundance of many species, including snails, amphibians, crustacean zooplankton, and fish such as salmon and some trout species (Horne, 1994).

Lower and Middle Reach pH

The Patty's Rock surface sonde had a minimum pH value of 7.0, a mean pH value of 7.9, and a maximum pH value of 8.6 pH (Table 4.1.1). The Patty's Rock mid-depth sonde had a minimum pH value of 7.1, a mean pH value of 7.9, and a maximum pH value of 8.6 pH (Figure 4.1.9).

Patty's Rock pH values were observed to vary with increases and decreases of DO concentrations, with higher values generally observed during supersaturation conditions and lower values during hypoxic conditions (Figures 4.1.9 and 4.1.7). Overall, pH values did not appear to be significantly affected by summer flows or closed conditions and remained fairly stable through the monitoring period.

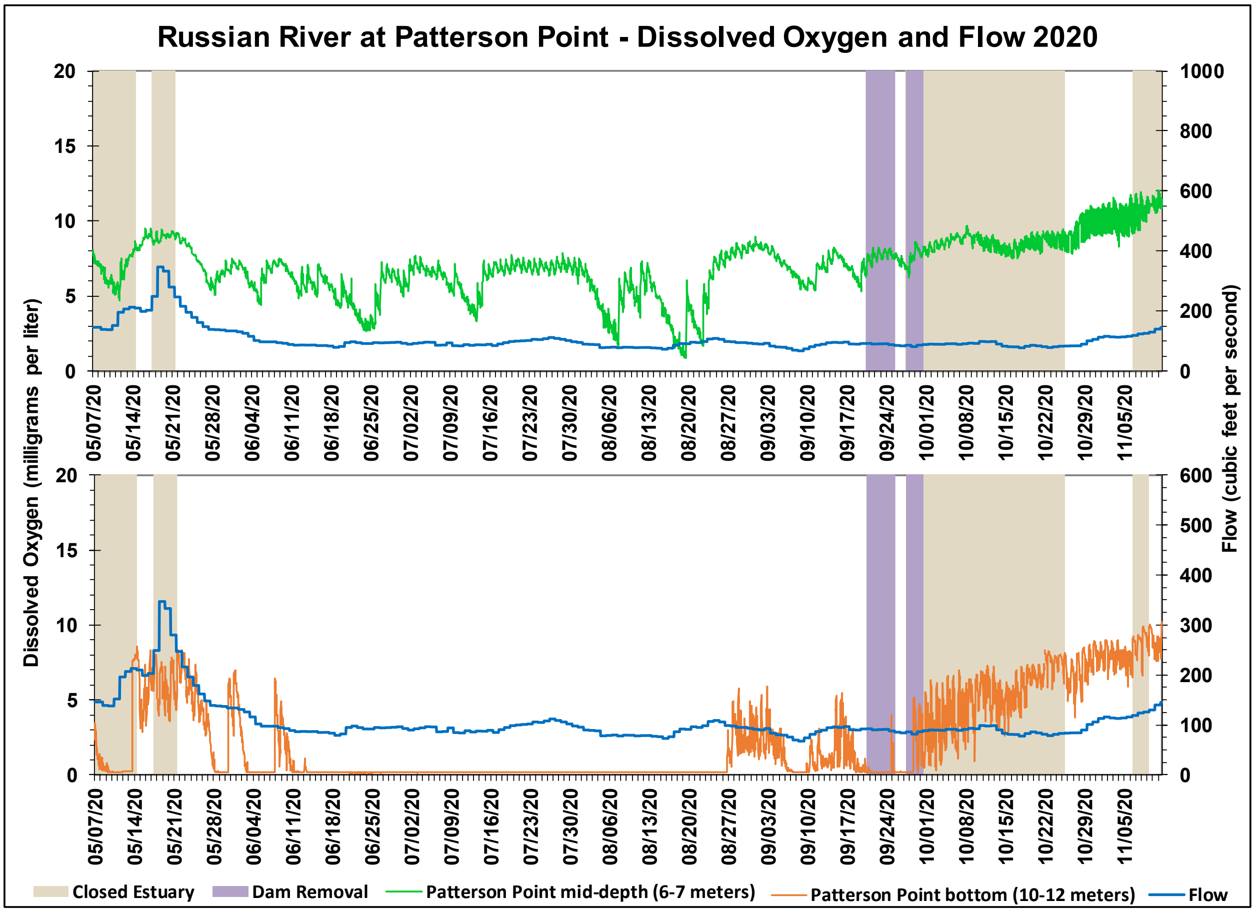


Figure 4.1.8. 2020 Russian River at Patterson Point Dissolved Oxygen and Flow Graph

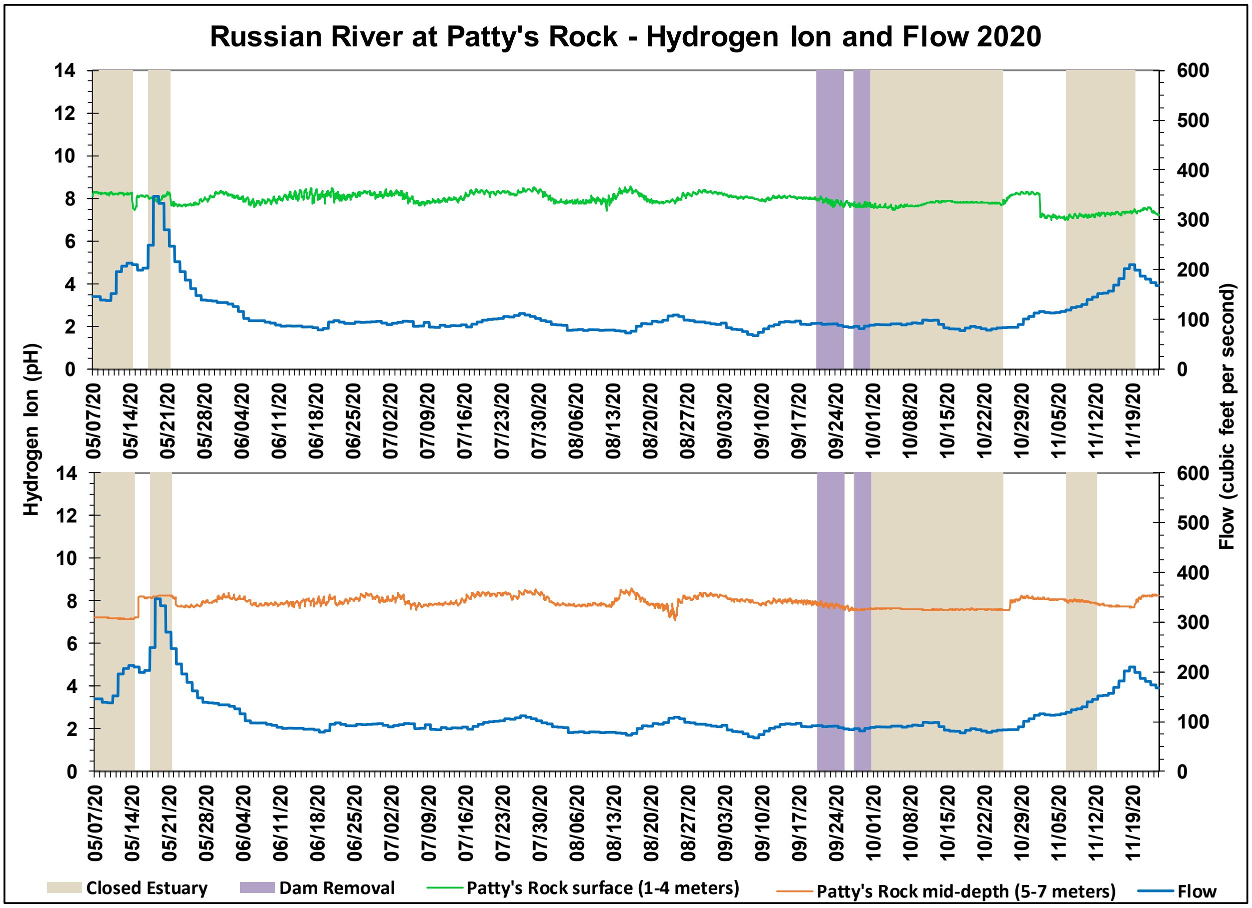


Figure 4.1.9. 2020 Russian River at Patty's Rock Hydrogen Ion and Flow Graph

Maximum Backwater Area pH

The Patterson Point mid-depth sonde had a minimum pH value of 7.3, a mean pH value of 7.7, and a maximum pH value of 8.2 (Table 4.1.1).The Patterson Point bottom sonde had a minimum pH value of 6.8, a mean pH value of 7.1, and a maximum pH value of 7.8 (Table 4.1.1). The Patterson Point sondes also had pH values that were generally observed to vary with increases and decreases of DO concentrations, although values did not appear to be significantly affected by summer flows or closed conditions and remained fairly stable through the monitoring period (Figures 4.1.10 and 4.1.8).

Grab Sampling

Sonoma Water staff conducted weekly grab sampling from 19 May to 15 October at three freshwater stations in the MBA, including Patterson Point, Monte Rio, and Vacation Beach (Figure 4.1.1). Additional focused sampling was conducted during and after summer dam removal in late September, where Sonoma Water staff would collect three samples over a ten day period (Tables 4.1.2 through 4.1.7). Samples collected and analyzed for nutrients, turbidity, *chlorophyll a*, and indicator bacteria are discussed below. Other sample results including total and dissolved organic carbon, and dissolved solids are not discussed, but are included (Tables 4.1.2 through 4.1.4).

Nutrients

The United States Environmental Protection Agency (USEPA) has established section 304(a) nutrient criteria across 14 major ecoregions of the United States. The Russian River was designated in Aggregate Ecoregion III (USEPA, 2013a). USEPA's section 304(a) criteria are intended to provide for the protection of aquatic life and human health (USEPA, 2013b). The following discussion of nutrients compares sampling results to these USEPA criteria. However, it is important to note that these criteria are established for freshwater systems, and as such, are only applicable to the freshwater portions of the Estuary. Currently, there are no numeric nutrient criteria established specifically for estuaries.

Total Nitrogen

The USEPA desired goal for total nitrogen in Aggregate Ecoregion III is 0.38 mg/L for rivers and streams not discharging into lakes or reservoirs (USEPA, 2000). Calculating total nitrogen values requires the summation of the different components of total nitrogen; organic and ammoniacal nitrogen (together referred to as Total Kjeldahl Nitrogen or TKN), and nitrate/nitrite nitrogen.

The EPA criteria for Total Nitrogen was not exceeded (0 of 72 or 0%) at any of the three monitoring stations during the 2020 monitoring period with Hacienda flows ranging from approximately 69.9 cfs to 347 cfs (Tables 4.1.2 through 4.1.4 and Figure 4.1.11). However, there were a few elevated concentrations of total nitrogen that occurred in the spring and early summer, as well as during summer dam removal in late September (Figure 4.1.11).

The maximum total nitrogen concentration observed at Patterson Point was 0.063 mg/L on 16 June during open conditions with a flow of approximately 85 cfs (Table 4.1.2). Observed total nitrogen values at Patterson Point were comprised solely by detectable concentrations of Nitrate

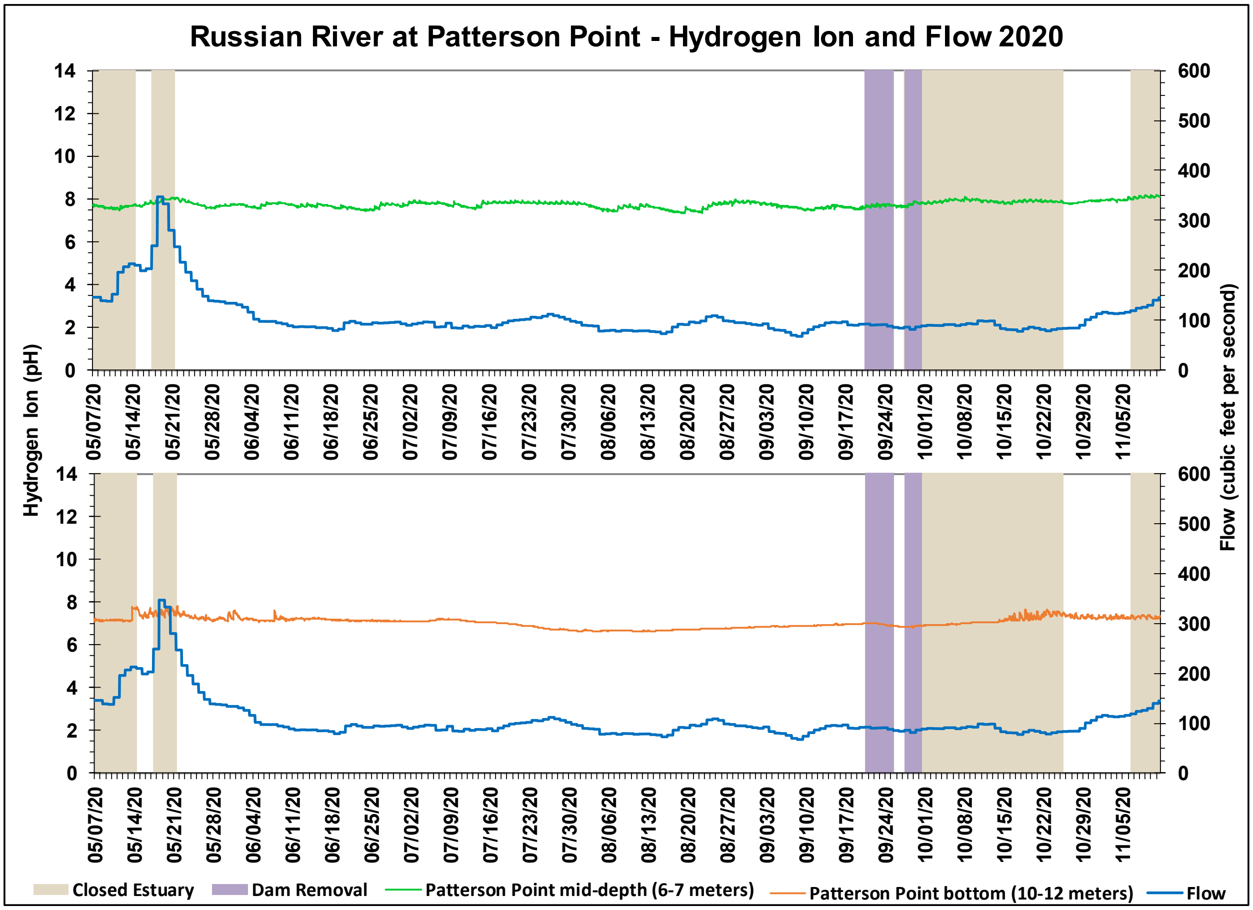


Figure 4.1.10. 2020 Russian River at Patterson Point Hydrogen Ion and Flow Graph

Table 4.1.2. 2020 Russian River at Patterson Point Station Grab Sample Results

Patterson Point	Temperature	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen**	Phosphorus, Total	Total Orthophosphate	Dissolved Organic Carbon	Total Organic Carbon	Total Dissolved Solids	Turbidity	Chlorophyll-a	USGS 11467000 RR near Guerneville (Hacienda)***	Estuary Condition	Jenner Gauge
MDL*		0.20	0.10	0.00010	0.040	0.050	0.20	0.50	0.010	0.030	0.600	0.300	10	0.10	0.0010	Flow Rate****		
Date	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	(cfs)		(ft)
5/19/2020	19.4	ND	ND	ND	0.042	ND	ND	0.042	**0.053**	0.12	1.49	1.88	160	1.7	ND	347	Closed	4.93
5/26/2020	22.6	ND	ND	ND	ND	ND	ND	ND	**0.070**	0.16	1.56	2.19	150	**2.7**	0.001	162	Open	0.46
6/2/2020	22.3	ND	ND	ND	ND	ND	ND	ND	**0.071**	0.17	1.39	1.90	140	1.6	0.0011	131	Open	1.81
6/9/2020	22.3	ND	ND	ND	0.058	ND	ND	0.058	**0.069**	0.16	1.41	1.73	150	1.3	ND	94.7	Open	0.42
6/16/2020	22.9	ND	ND	ND	0.063	ND	ND	0.063	**0.086**	0.16	1.26	1.76	150	1.1	ND	85	Open	1.05
6/23/2020	23.7	ND	ND	ND	ND	ND	ND	ND	**0.070**	0.15	1.01	1.70	170	0.94	**0.002**	94.7	Open	0.55
6/30/2020	23.6	ND	ND	ND	ND	ND	ND	ND	**0.069**	0.16	1.31	1.88	150	1.2	**0.002**	96.3	Open	1.85
7/7/2020	23.2	ND	ND	ND	ND	ND	ND	ND	**0.059**	0.13	1.39	1.75	160	0.85	0.001	86.2	Open	0.46
7/14/2020	24.5	ND	ND	ND	ND	ND	ND	ND	**0.056**	0.12	1.34	1.74	150	0.82	ND	87.8	Open	0.93
7/21/2020	23.0	ND	ND	ND	ND	ND	ND	ND	**0.051**	0.093	1.38	1.72	140	1.1	ND	100	Open	0.5
7/28/2020	22.6	ND	ND	ND	ND	ND	ND	ND	**0.041**	0.068	1.33	1.67	140	0.83	ND	109	Open	0.8
8/4/2020	23.7	ND	ND	ND	ND	ND	ND	ND	**0.041**	0.067	1.39	1.84	130	1.0	ND	88.2	Open	0.38
8/11/2020	23.4	ND	ND	ND	ND	ND	ND	ND	**0.041**	0.065	1.40	1.72	140	1.2	0.0010	78.1	Open	1.22
8/18/2020	23.4	ND	ND	ND	ND	ND	ND	ND	**0.045**	0.081	1.31	1.57	140	0.71	ND	86.4	Open	0.46
9/1/2020	20.9	ND	ND	ND	ND	ND	ND	ND	**0.033**	0.036	1.26	1.51	170	0.51	ND	91.3	Open	0.76
9/8/2020	22.6	ND	ND	ND	ND	ND	ND	ND	**0.029**	0.038	1.23	1.72	140	1.2	ND	69.9	Open	0.88
9/15/2020	19.8	ND	ND	ND	ND	ND	ND	ND	**0.027**	0.043	1.12	1.44	150	1.1	0.001	95.9	Open	1.05
9/22/2020	20.7	ND	ND	ND	ND	ND	ND	ND	0.021	0.032	1.18	1.50	120	0.70	0.002	90.2	Open	0.67
9/25/2020	21.2	ND	ND	ND	ND	ND	ND	ND	**0.024**	0.037	1.26	1.51	150	1.0	0.001	88.1	Open	2.44
9/29/2020	20.1	ND	ND	ND	ND	ND	ND	ND	**0.028**	0.047	1.20	1.52	130	0.39	ND	81.6	Closed	3.5
10/6/2020	18.8	ND	ND	ND	0.053	ND	ND	0.053	**0.034**	0.066	1.26	1.57	140	0.95	ND	91.3	Closed	5.31
10/8/2020	18.7	ND	ND	ND	ND	ND	ND	ND	**0.035**	0.056	1.16	1.54	140	1.0	0.0016	91.2	Closed	5.6
10/13/2020	17.9	ND	ND	ND	0.061	ND	ND	0.061	**0.028**	0.051	1.25	1.47	140	0.49	ND	98.6	Closed	6.32
10/15/2020	18.4	ND	ND	ND	0.059	ND	ND	0.059	**0.032**	0.046	1.28	1.45	140	0.41	ND	83.2	Closed	6.53

* Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors, all results are preliminary and subject to final revision.

** Total nitrogen is calculated through the summation of the different components of total nitrogen: organic and ammoniacal nitrogen (together referred to as Total Kjeldahl Nitrogen or TKN) and nitrate/nitrite nitrogen.

*** United States Geological Survey (USGS) Continuous-Record Gaging Station

**** Flow rates are preliminary and subject to final revision by USGS.

Recommended EPA Criteria based on Aggregate Ecoregion III

Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L

Total Nitrogen: 0.38 mg/L

Chlorophyll *a*: 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L

Turbidity: 2.34 FTU/NTU

Table 4.1.3. 2020 Russian River at Monte Rio Station Grab Sample Results

Monte Rio	Temperature	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen**	Phosphorus, Total	Total Orthophosphate	Dissolved Organic Carbon	Total Organic Carbon	Total Dissolved Solids	Turbidity	Chlorophyll-a	USGS 11467000 RR near Guerneville (Hacienda)***	Estuary Condition	Jenner Gauge
MDL*		0.20	0.10	0.00010	0.040	0.050	0.20	0.50	0.010	0.030	0.600	0.300	10	0.10	0.0010	Flow Rate****		
Date	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	(cfs)		(ft)
5/19/2020	19.4	ND	ND	ND	ND	ND	ND	ND	**0.066**	0.14	1.47	2.07	160	**3.5**	0.0014	347	Closed	4.97
5/26/2020	23.0	0.26	ND	ND	ND	ND	0.26	0.26	**0.076**	0.15	1.58	2.14	160	**4.3**	0.001	162	Open	0.42
6/2/2020	22.5	ND	ND	ND	ND	ND	ND	ND	**0.070**	0.15	1.77	1.81	150	**2.9**	ND	131	Open	1.73
6/9/2020	22.3	ND	ND	ND	0.057	ND	ND	0.057	**0.066**	0.15	1.40	1.75	160	0.79	ND	94.7	Open	0.38
6/16/2020	22.6	ND	ND	ND	ND	ND	ND	ND	**0.065**	0.14	1.27	1.81	150	0.77	ND	85	Open	0.93
6/23/2020	24.1	ND	ND	ND	ND	ND	ND	ND	**0.064**	0.13	1.44	1.72	160	0.89	0.002	94.7	Open	0.5
6/30/2020	24.1	ND	ND	ND	ND	ND	ND	ND	**0.067**	0.15	1.32	1.90	170	0.91	0.002	96.3	Open	1.77
7/7/2020	23.5	ND	ND	ND	ND	ND	ND	ND	**0.053**	0.12	1.69	1.72	160	0.88	0.0013	86.2	Open	0.46
7/14/2020	24.7	ND	ND	ND	ND	ND	ND	ND	**0.052**	0.11	1.35	1.72	150	1.0	0.001	87.8	Open	0.88
7/21/2020	23.1	ND	ND	ND	ND	ND	ND	ND	**0.043**	0.076	1.35	1.71	140	1.6	0.001	100	Open	0.55
7/28/2020	23.1	ND	ND	ND	ND	ND	ND	ND	**0.038**	0.056	1.34	1.76	140	1.1	**0.0018**	109	Open	0.71
8/4/2020	23.9	ND	ND	ND	ND	ND	ND	ND	**0.037**	0.052	1.43	1.66	130	0.90	0.0010	88.2	Open	0.38
8/11/2020	23.3	ND	ND	ND	ND	ND	ND	ND	**0.047**	0.053	1.40	1.72	140	1.2	0.0012	78.1	Open	1.14
8/18/2020	23.7	ND	ND	ND	ND	ND	ND	ND	**0.040**	0.069	1.30	1.52	140	0.83	ND	86.4	Open	0.59
9/1/2020	20.9	ND	ND	ND	ND	ND	ND	ND	**0.029**	0.036	1.26	1.51	150	0.78	0.001	91.3	Open	1.22
9/8/2020	22.7	ND	ND	ND	ND	ND	ND	ND	**0.027**	0.038	1.25	1.61	150	0.96	ND	69.9	Open	0.84
9/15/2020	19.7	ND	ND	ND	ND	ND	ND	ND	**0.025**	0.035	1.12	1.45	150	1.9	0.002	95.9	Open	1.6
9/22/2020	20.8	ND	ND	ND	ND	ND	ND	ND	**0.024**	ND	1.20	1.47	130	0.74	**0.002**	90.2	Open	0.67
9/25/2020	20.7	0.21	ND	ND	ND	ND	0.21	0.21	**0.023**	0.033	1.21	1.52	95	1.2	0.001	88.1	Open	2.44
9/29/2020	19.9	ND	ND	ND	ND	ND	ND	ND	**0.027**	0.039	1.16	1.49	140	0.62	ND	81.6	Closed	3.5
10/6/2020	18.5	ND	ND	ND	0.055	ND	ND	0.055	**0.038**	0.066	1.17	1.53	140	1.6	ND	91.3	Closed	5.31
10/8/2020	18.9	ND	ND	ND	ND	ND	ND	ND	**0.034**	0.061	1.35	1.45	130	1.0	0.001	91.2	Closed	5.65
10/13/2020	17.6	ND	ND	ND	0.053	ND	ND	0.053	**0.028**	0.051	1.22	1.41	130	0.90	ND	98.6	Closed	6.32
10/15/2020	18.4	ND	ND	ND	0.056	ND	ND	0.056	**0.030**	0.050	1.23	1.36	130	0.54	ND	83.2	Closed	6.57

* Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors, all results are preliminary and subject to final revision.

** Total nitrogen is calculated through the summation of the different components of total nitrogen: organic and ammoniacal nitrogen (together referred to as Total Kjeldahl Nitrogen or TKN) and nitrate/nitrite nitrogen.

*** United States Geological Survey (USGS) Continuous-Record Gaging Station

**** Flow rates are preliminary and subject to final revision by USGS.

Recommended EPA Criteria based on Aggregate Ecoregion III

Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L

Total Nitrogen: 0.38 mg/L

Chlorophyll *a*: 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L

Turbidity: 2.34 FTU/NTU

Table 4.1.4. 2020 Russian River at Vacation Beach Station Grab Sample Results

Vacation Beach	Temperature	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen**	Phosphorus, Total	Total Orthophosphate	Dissolved Organic Carbon	Total Organic Carbon	Total Dissolved Solids	Turbidity	Chlorophyll-a	USGS 11467000 RR near Guerneville (Hacienda)***	Estuary Condition	Jenner Gauge
MDL*		0.20	0.10	0.00010	0.040	0.050	0.20	0.50	0.010	0.030	0.600	0.300	10	0.10	0.0010	Flow Rate****		
Date	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	(cfs)		(ft)
5/19/2020	19.6	0.21	ND	ND	ND	ND	0.21	0.21	**0.068**	0.14	1.66	2.11	180	**2.4**	**0.003**	347	Closed	4.93
5/26/2020	22.9	ND	ND	ND	ND	ND	ND	ND	**0.066**	0.14	1.52	2.10	160	2.2	**0.002**	162	Open	0.42
6/2/2020	22.5	ND	ND	ND	ND	ND	ND	ND	**0.062**	0.12	1.47	1.79	140	1.9	**0.0021**	131	Open	1.64
6/9/2020	22.6	ND	ND	ND	ND	ND	ND	ND	**0.058**	0.12	1.37	1.73	160	1.7	**0.0023**	94.7	Open	0.34
6/16/2020	23.5	ND	ND	ND	ND	ND	ND	ND	**0.059**	0.12	1.24	1.78	140	1.7	0.0013	85	Open	0.88
6/23/2020	24.8	ND	ND	ND	ND	ND	ND	ND	**0.057**	0.10	1.39	1.91	160	1.6	**0.0030**	94.7	Open	0.5
6/30/2020	24.6	0.35	ND	ND	ND	ND	0.35	0.35	**0.059**	0.12	1.34	1.91	140	1.4	**0.0019**	96.3	Open	1.73
7/7/2020	24.1	ND	ND	ND	ND	ND	ND	ND	**0.043**	0.090	1.35	1.69	150	1.2	0.0016	86.2	Open	0.46
7/14/2020	25.4	ND	ND	ND	ND	ND	ND	ND	**0.045**	0.084	1.37	1.77	150	1.6	**0.0022**	87.8	Open	0.8
7/21/2020	23.4	ND	ND	ND	ND	ND	ND	ND	**0.037**	0.060	1.37	1.65	140	2.2	**0.0022**	100	Open	0.59
7/28/2020	23.1	ND	ND	ND	0.083	ND	ND	0.083	**0.032**	0.043	1.28	1.71	140	0.93	**0.0021**	109	Open	0.63
8/4/2020	24.1	ND	ND	ND	ND	ND	ND	ND	**0.031**	0.040	1.33	1.60	130	1.4	0.0017	88.2	Open	0.42
8/11/2020	23.8	ND	ND	ND	ND	ND	ND	ND	**0.031**	0.041	1.34	1.67	140	1.7	ND	78.1	Open	1.14
8/18/2020	24.3	ND	ND	ND	ND	ND	ND	ND	**0.031**	0.052	1.30	1.47	150	1.1	0.0017	86.4	Open	1.05
9/1/2020	21.0	ND	ND	ND	ND	ND	ND	ND	**0.028**	ND	1.20	1.42	130	1.2	0.0011	91.3	Open	1.68
9/8/2020	23.2	ND	ND	ND	ND	ND	ND	ND	**0.022**	ND	1.17	1.53	140	1.1	ND	69.9	Open	0.97
9/15/2020	19.5	ND	ND	ND	ND	ND	ND	ND	**0.024**	0.031	1.12	1.37	140	2.3	ND	95.9	Open	1.94
9/22/2020	21.0	ND	ND	ND	ND	ND	ND	ND	**0.024**	0.032	1.20	1.47	120	1.1	0.0013	90.2	Open	0.76
9/25/2020	20.7	ND	ND	ND	ND	ND	ND	ND	**0.054**	0.045	1.15	1.49	140	**3.9**	**0.0042**	88.1	Open	2.44
9/29/2020	19.8	ND	ND	ND	ND	ND	ND	ND	**0.028**	0.035	1.16	1.46	120	1.2	0.0017	81.6	Closed	3.54
10/6/2020	18.7	ND	ND	ND	0.052	ND	ND	0.052	**0.023**	ND	ND	0.453	130	2.2	0.003	91.3	Closed	5.35
10/8/2020	18.6	ND	ND	ND	ND	ND	ND	ND	**0.025**	0.032	1.10	1.37	140	1.0	0.0012	91.2	Closed	5.6
10/13/2020	17.8	ND	ND	ND	0.051	ND	ND	0.051	**0.023**	ND	1.13	1.33	120	1.7	ND	98.6	Closed	6.32
10/15/2020	18.8	ND	ND	ND	0.051	ND	ND	0.051	**0.023**	0.033	1.16	1.36	130	0.61	ND	83.2	Closed	6.57

* Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors, all results are preliminary and subject to final revision.

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*** United States Geological Survey (USGS) Continuous-Record Gaging Station

**** Flow rates are preliminary and subject to final revision by USGS.

Recommended EPA Criteria based on Aggregate Ecoregion III

Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L

Total Nitrogen: 0.38 mg/L

Chlorophyll *a*: 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L

Turbidity: 2.34 FTU/NTU

Table 4.1.5. 2020 Russian River at Patterson Point Station Indicator Bacteria Grab Sample Results

Patterson Point	Temperature	Total Coliforms (Colilert)	Total Coliforms Diluted 1:10 (Colilert)	E. coli (Colilert)	E. coli Diluted 1:10 (Colilert)	Enterococcus (Enterolert)	USGS 11467000 RR near Guerneville (Hacienda)***	Estuary Condition	Jenner Gauge
MDL*		<1	<10	<1	<10	<1	Flow Rate****		
Date	°C	MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL	(cfs)		(ft)
5/19/2020	19.4	613.1	906	10.8	<10	7.4	347	Closed	4.93
5/26/2020	22.6	980.4	1500	50.5	10	9.3	162	Open	0.46
6/2/2020	22.3	1203.3	2359	14.5	20	1.0	131	Open	1.81
6/9/2020	22.3	1203.3	1043	63	20	3.0	94.7	Open	0.42
6/16/2020	22.9	1553.1	1014	11	41	7.4	85	Open	1.05
6/23/2020	23.7	1732.9	2755	41.4	31	22.6	94.7	Open	0.55
6/30/2020	23.6	1986.3	1178	21.6	10	17.1	96.3	Open	1.85
7/7/2020	23.2	1046.2	1223	4.1	<10	9.8	86.2	Open	0.46
7/14/2020	24.5	1046.2	1250.0	6.3	<10	7.3	87.8	Open	0.93
7/21/2020	23.0	1203.3	1169	10.9	10	17.0	100	Open	0.5
7/28/2020	22.6	1119.9	862	7.5	<10	14.6	109	Open	0.8
8/4/2020	23.7	1553.1	1050	6.3	<10	3.0	88.2	Open	0.38
8/11/2020	23.4	>2419.6	3998	6.3	10	11.8	78.1	Open	1.22
8/18/2020	23.4	>2419.6	1483	9.8	<10	14.8	86.4	Open	0.46
9/1/2020	20.9	1732.9	1553	14.5	<10	<10	91.3	Open	0.76
9/8/2020	22.6	1732.9	1333	13.2	41	13.2	69.9	Open	0.88
9/15/2020	19.8	1732.9	1450	9.8	10	14.5	95.9	Open	1.05
9/22/2020	20.7	1986.3	1222	21.6	10	35.9	90.2	Open	0.67
9/25/2020	21.2	1046.2	934	22.8	30	30.5	88.1	Open	2.44
9/29/2020	20.1	2419.6	1565	24	72	26.5	81.6	Closed	3.5
10/6/2020	18.8	2419.6	1725	88.6	109	**111.9**	91.3	Closed	5.31
10/8/2020	18.7	2419.6	3255	78.0	72	**85.5**	91.2	Closed	5.6
10/13/2020	17.9	2419.6	2909	142.1	146	**135.4**	98.6	Closed	6.32
10/15/2020	18.4	>2419.6	3433	88.6	158	**145.0**	83.2	Closed	6.53

* Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors, all results are preliminary and subject to final revision.

** United States Geological Survey (USGS) Continuous-Record Gaging Station

*** Flow rates are preliminary and subject to final revision by USGS.

Recommended California Department of Public Health (CDPH) Draft Guidance - Single Sample Maximum (SSM):

Total Coliform (SSM): 10,000 per 100ml

Environmental Protection Agency (EPA) Recreational Water Quality Criteria - Beach Action Value (BAV):

E. coli (BAV): 235 per 100 ml *Enterococcus*(BAV): 61 per 100 ml

(Beach notification is recommended when indicator organisms exceed the SSM for Total Coliform or the BAV for *E. coli*) - Indicated by red text

Table 4.1.6. 2020 Russian River at Monte Rio Station Indicator Bacteria Grab Sample Results

Monte Rio	Temperature	Total Coliforms (Collert)	Total Coliforms Diluted 1:10 (Colilert)	E. coli (Colilert)	E. coli Diluted 1:10 (Colilert)	Enterococcus (Enterolert)	USGS 11467000 RR near Guerneville (Hacienda)***	Estuary Conditions	Jenner Gauge
MDL*		20		20		2	Flow Rate****		
Date	°C	MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL	(cfs)		(ft)
5/19/2020	19.4	1299.7	1658	35	52	10.9	347	Closed	4.93
5/26/2020	23.0	1732.9	2014	96	31	2.0	162	Open	0.46
6/2/2020	22.5	1119.9	1483	13.5	20	5.1	131	Open	1.81
6/9/2020	22.3	1203.3	833	16.1	20	14.8	94.7	Open	0.42
6/16/2020	22.6	1413.6	1616	31.3	63	36.8	85	Open	1.05
6/23/2020	24.1	2419.6	2382	45.7	52	60.5	94.7	Open	0.55
6/30/2020	24.1	1732.9	1396	48.0	31	42.0	96.3	Open	1.85
7/7/2020	23.5	1553.1	1017	7.5	31	26.6	86.2	Open	0.46
7/14/2020	24.7	1203.3	1396.0	31.5	86.0	5.1	87.8	Open	0.93
7/21/2020	23.1	980.4	683	6.1	10	10.9	100	Open	0.5
7/28/2020	23.1	1553.1	1723	43.5	85	25.9	109	Open	0.8
8/4/2020	23.9	1203.3	1211	19.7	10	4.1	88.2	Open	0.38
8/11/2020	23.3	1413.6	1467	17.3	30	3.0	78.1	Open	1.22
8/18/2020	23.7	1986.3	2014	15.5	40	6.3	86.4	Open	0.46
9/1/2020	20.9	1299.7	**12997**	4.1	10	<10	91.3	Open	0.76
9/8/2020	22.7	2419.6	1616	15.8	31	8.5	69.9	Open	0.88
9/15/2020	19.7	1986.3	1785	13.5	<10	9.8	95.9	Open	1.05
9/22/2020	20.8	1986.3	1515	37.3	53	12.1	90.2	Open	0.67
9/25/2020	20.7	1553.1	1421	14.5	20	16.1	88.1	Open	2.44
9/29/2020	19.9	1553.1	1396	13.2	41	27.5	81.6	Closed	3.5
10/6/2020	18.5	1732.9	1664	58.1	52	**85.7**	91.3	Closed	5.31
10/8/2020	18.9	2419.6	2098	78.0	189	**107.0**	91.2	Closed	5.6
10/13/2020	17.6	1986.3	918	129.6	110	**104.3**	98.6	Closed	6.32
10/15/2020	18.4	2419.6	2282	96.0	132	**88.0**	83.2	Closed	6.53

* Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors, all results are preliminary and subject to final revision.

** United States Geological Survey (USGS) Continuous-Record Gaging Station

*** Flow rates are preliminary and subject to final revision by USGS.

Recommended California Department of Public Health (CDPH) Draft Guidance - Single Sample Maximum (SSM):
Total Coliform (SSM): 10,000 per 100ml

Environmental Protection Agency (EPA) Recreational Water Quality Criteria - Beach Action Value (BAV):
E. coli (BAV): 235 per 100 ml *Enterococcus*(BAV): 61 per 100 ml
(Beach notification is recommended when indicator organisms exceed the SSM for Total Coliform or the BAV for *E. coli*) - Indicated by red text

Table 4.1.7. 2020 Russian River at Vacation Beach Station Indicator Bacteria Grab Sample Results

Vacation Beach	Temperature	Total Coliforms (Collilert)	Total Coliforms Diluted 1:10 (Collilert)	E. coli (Collilert)	E. coli Diluted 1:10 (Collilert)	Enterococcus (Enterolert)	USGS 11467000 RR near Guerneville (Hacienda)***	Estuary Condition	Jenner Gauge
MDL*		20		20		2	Flow Rate****		
Date	°C	MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL	(cfs)		(ft)
5/19/2020	19.6	920.8	1450	35.5	41	14.6	347	Closed	4.93
5/26/2020	22.9	1046.2	2143	96	20	4.1	162	Open	0.46
6/2/2020	22.5	1203.3	2046	13.4	31	4.1	131	Open	1.81
6/9/2020	22.6	1732.9	1470	7.3	10	7.4	94.7	Open	0.42
6/16/2020	23.5	>2419.6	2909	30.1	20	14.8	85	Open	1.05
6/23/2020	24.8	>2419.6	**>24196**	35.4	52	57.1	94.7	Open	0.55
6/30/2020	24.6	1732.9	1211	10.5	<10	29.8	96.3	Open	1.85
7/7/2020	24.1	1299.7	1354	10.9	<10	6.3	86.2	Open	0.46
7/14/2020	25.4	2419.6	2359	5.2	10	6.3	87.8	Open	0.93
7/21/2020	23.4	1413.6	1198	5.2	10	5.2	100	Open	0.5
7/28/2020	23.1	>2419.6	2909	4.1	<10	4.0	109	Open	0.8
8/4/2020	24.1	2419.6	1616	9.7	10	3.1	88.2	Open	0.38
8/11/2020	23.8	>2419.6	2495	4.1	<10	3.0	78.1	Open	1.22
8/18/2020	24.3	2419.6	1483	15.5	10	3.1	86.4	Open	0.46
9/1/2020	21.0	1203.3	986	4.1	20	<10	91.3	Open	0.76
9/8/2020	23.2	2419.6	1725	23.3	20	8.6	69.9	Open	0.88
9/15/2020	19.5	1413.6	1500	20.4	20	5.2	95.9	Open	1.05
9/22/2020	21.0	1299.7	1187	21.1	10	5.2	90.2	Open	0.67
9/25/2020	20.7	1986.3	1860	13.1	31	6.3	88.1	Open	2.44
9/29/2020	19.8	248.1	**17329**	13.2	**288**	34.5	81.6	Closed	3.5
10/6/2020	18.7	920.8	1019	15.1	20	30.1	91.3	Closed	5.31
10/8/2020	18.6	1119.9	933	21.8	31	9.7	91.2	Closed	5.6
10/13/2020	17.8	866.4	298	24.1	<10	22.8	98.6	Closed	6.32
10/15/2020	18.8	920.8	677	27.5	52	16.1	83.2	Closed	6.53

* Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors, all results are preliminary and subject to final revision.

** United States Geological Survey (USGS) Continuous-Record Gaging Station

*** Flow rates are preliminary and subject to final revision by USGS.

Recommended California Department of Public Health (CDPH) Draft Guidance - Single Sample Maximum (SSM):

Total Coliform (SSM): 10,000 per 100ml

Environmental Protection Agency (EPA) Recreational Water Quality Criteria - Beach Action Value (BAV):

E. coli (BAV): 235 per 100 ml — *Enterococcus*(BAV): 61 per 100 ml

(Beach notification is recommended when indicator organisms exceed the SSM for Total Coliform or the BAV for *E. coli*) - Indicated by red text

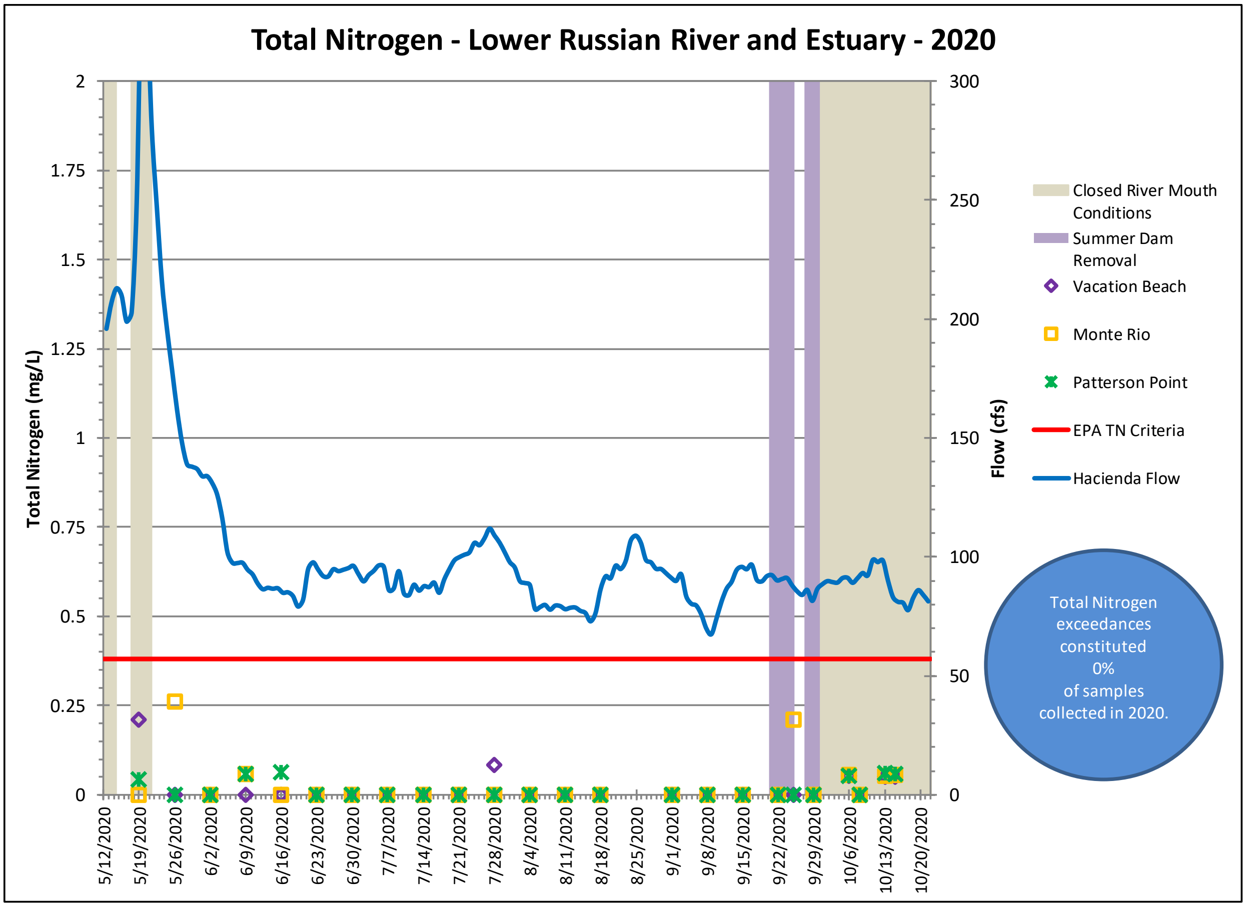


Figure 4.1.11. 2020 Russian River Grab Sampling Results for Total Nitrogen

as N (Table 4.1.2). The minimum concentration at Patterson Point was non-detect (ND), which occurred eighteen (18) times during open and closed conditions with flows ranging from approximately 69.9 cfs to 162 cfs (Table 4.1.2).

The maximum total nitrogen concentration observed at Monte Rio was 0.26 mg/L on 26 May during open conditions with a flow of approximately 162 cfs (Table 4.1.3). The minimum concentration at Monte Rio was non-detect (ND), which occurred eighteen (18) times during open and closed conditions and flows that ranged from approximately 69.9 to 347 cfs (Table 4.1.3).

The maximum total nitrogen concentration observed at Vacation Beach was 0.35 mg/L which occurred on 30 June during open conditions and a flow of approximately 96.3 cfs (Table 4.1.4). The minimum concentration at Vacation Beach was 0.035 mg/L, which occurred eighteen (18) times during open and closed river mouth/Estuary conditions and flows that ranged from approximately 69.9 to 162 cfs (Table 4.1.4). The maximum total nitrogen concentration observed at Vacation Beach was 0.35 mg/L which occurred on 30 June during open conditions and a flow of approximately 96.3 cfs (Table 4.1.4). The minimum concentration at Vacation Beach was 0.035 mg/L, which occurred eighteen (18) times during open and closed river mouth/Estuary conditions and flows that ranged from approximately 69.9 to 162 cfs (Table 4.1.4).

Total Phosphorus

The USEPA's desired goal for total phosphates as phosphorus in Aggregate Ecoregion III has been established as 21.88 micrograms per liter (µg/L), or approximately 0.022 mg/L, for rivers and streams not discharging into lakes or reservoirs (USEPA, 2000). All three lower river stations predominantly exceeded the EPA criteria for total phosphorous (71 of 72 or 98.6%) in 2020 with flows that ranged from 69.9 cfs to 347 cfs, continuing a trend of consistent exceedances observed in previous years (Tables 4.1.2 through 4.1.4 and Figure 4.1.12). Patterson Point was the only station that did not exceed the total phosphorus criteria during every sampling event in 2020 (Table 4.1.2).

Exceedances occurred during open and closed Estuary conditions, , and concentrations were observed to generally be higher in the spring and early summer, including during elevated storm flows in May, and trending downward through the rest of the season (Figure 4.1.12). The maximum total phosphorus concentration observed at Patterson Point was 0.086 mg/L on 16 June during open conditions with a flow of approximately 85 cfs (Table 4.1.2 and Figure 4.1.12). The minimum concentration at Patterson Point was was 0.021 mg/L, which occurred on 22 September during open conditions and summer dam removal with a flow of approximately 90.2 cfs (Table 4.1.2). The lowest flow recorded during the sampling events was approximately 69.9 cfs, which occurred on 8 September, with a concentration of 0.029 mg/L (Table 4.1.2).

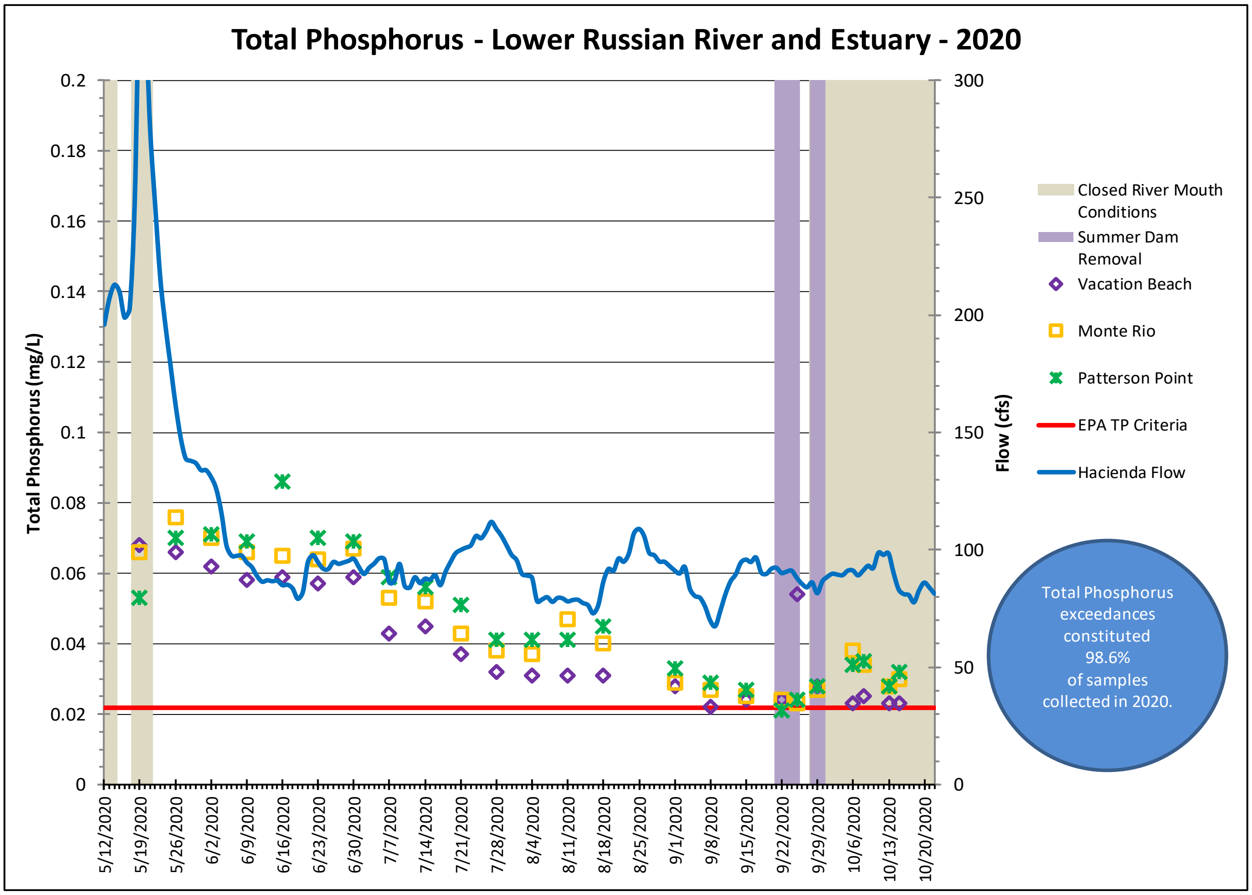


Figure 4.1.12. 2020 Russian River Grab Sampling Results for Total Phosphorus

The maximum total phosphorus concentration observed at Monte Rio was 0.076 mg/L on 26 May during open conditions with a flow of approximately 162 cfs (Table 4.1.3 and Figure 4.1.12). The minimum concentration at Monte Rio was 0.023 mg/L, which occurred on 25 September during open conditions and summer dam removal, with a flow of approximately 88.1 cfs (Table 4.1.3). The lowest flow recorded during the sampling events was approximately 69.9 cfs, which occurred on 8 September, with a concentration of 0.027 mg/L (Table 4.1.3).

The maximum total phosphorus concentration observed at Vacation Beach was 0.068 mg/L on 19 May during closed conditions and a Hacienda flow of approximately 347 cfs (Table 4.1.4 and Figure 4.1.12). The mean concentration at Vacation Beach was 0.041 mg/L. The minimum concentration at Vacation Beach was 0.022 mg/L, which occurred on 8 September during open conditions and a flow of approximately 69.9 cfs (Table 4.1.4).

Turbidity

The EPA recommended criteria of 2.34 nephelometric turbidity units (NTU) for turbidity was exceeded one (1) time at Patterson Point, three (3) times at Monte Rio, and two (2) times at Vacation Beach (6 of 72 or 8.3%) during the 2020 monitoring season (Tables 4.1.2 through 4.1.4). Exceedances were observed to primarily occur during the first half of the season with open and closed conditions and flows ranging from 131 cfs to 347 cfs (Figure 4.1.13). One of the exceedances at Vacation Beach occurred during summer dam removal. Turbidity values were generally higher at Vacation Beach than at the other stations, and appear to be a result of increased turbulence from streamflow over the Vacation Beach summer dam and through the fish ladder just upstream of the monitoring location.

The maximum turbidity value observed at Patterson Point was 2.7 NTU on 26 May during open conditions and a flow of approximately 162 cfs at the Hacienda USGS gage (Table 4.1.2 and Figure 4.1.13). The mean value at Patterson Point was 4.6 NTU. The minimum value at Patterson Point was 0.39 NTU, which occurred on 29 September during closed conditions and summer dam removal, with a flow of approximately 81.6 cfs (Table 4.1.2). The lowest flow recorded during sampling was approximately 69.9 cfs, which occurred on 8 September, with a value of 1.2 NTU (Table 4.1.2).

The maximum turbidity value observed at Monte Rio was 4.3 NTU on 26 May during open conditions and a flow of approximately 162 cfs (Table 4.1.3 and Figure 4.1.13). The minimum value at Monte Rio was 0.54 NTU, which occurred on 15 October during closed conditions and a flow of approximately 83.2 cfs (Table 4.1.3). The lowest flow recorded during sampling was approximately 69.9 cfs, which occurred on 8 September, with a value of 0.96 NTU (Table 4.1.3).

The maximum turbidity value observed at Vacation Beach was 3.9 NTU on 25 September during open conditions and summer dam removal, with a flow of approximately 88.1 cfs (Table 4.1.4 and Figure 4.1.13). The minimum value at Vacation Beach was 0.61 NTU, which occurred on 15 October during closed conditions and a flow of approximately 83.2 cfs (Table 4.1.4). The lowest flow recorded during sampling was approximately 69.9 cfs, which occurred on 8 September, with a value of 1.1 NTU (Table 4.1.4).

Chlorophyll a

In the process of photosynthesis, *chlorophyll a* - a green pigment in plants, absorbs sunlight and combines carbon dioxide and water to produce sugar and oxygen. *Chlorophyll a* can therefore serve as a measureable parameter of algal growth. Qualitative assessment of primary production on water quality can be based on *chlorophyll a* concentrations. A U.C. Davis report on the Klamath River (1999) assessing potential water quality and quantity regulations for restoration and protection of anadromous fish in the Klamath River includes a discussion of *chlorophyll a* and how it can affect water quality. The report characterizes the effects of *chlorophyll a* in terms of different levels of discoloration (e.g., no discoloration to some, deep, or very deep discoloration). The report indicated that less than 10 µg/L (or 0.01 mg/L) of *chlorophyll a* exhibits no discoloration (Deas and Orlob, 1999). Additionally, the USEPA criterion for *chlorophyll a* in Aggregate Ecoregion III is 1.78 µg/L, or approximately 0.0018 mg/L for rivers and streams not discharging into lakes or reservoirs (USEPA, 2000). However, it is important to

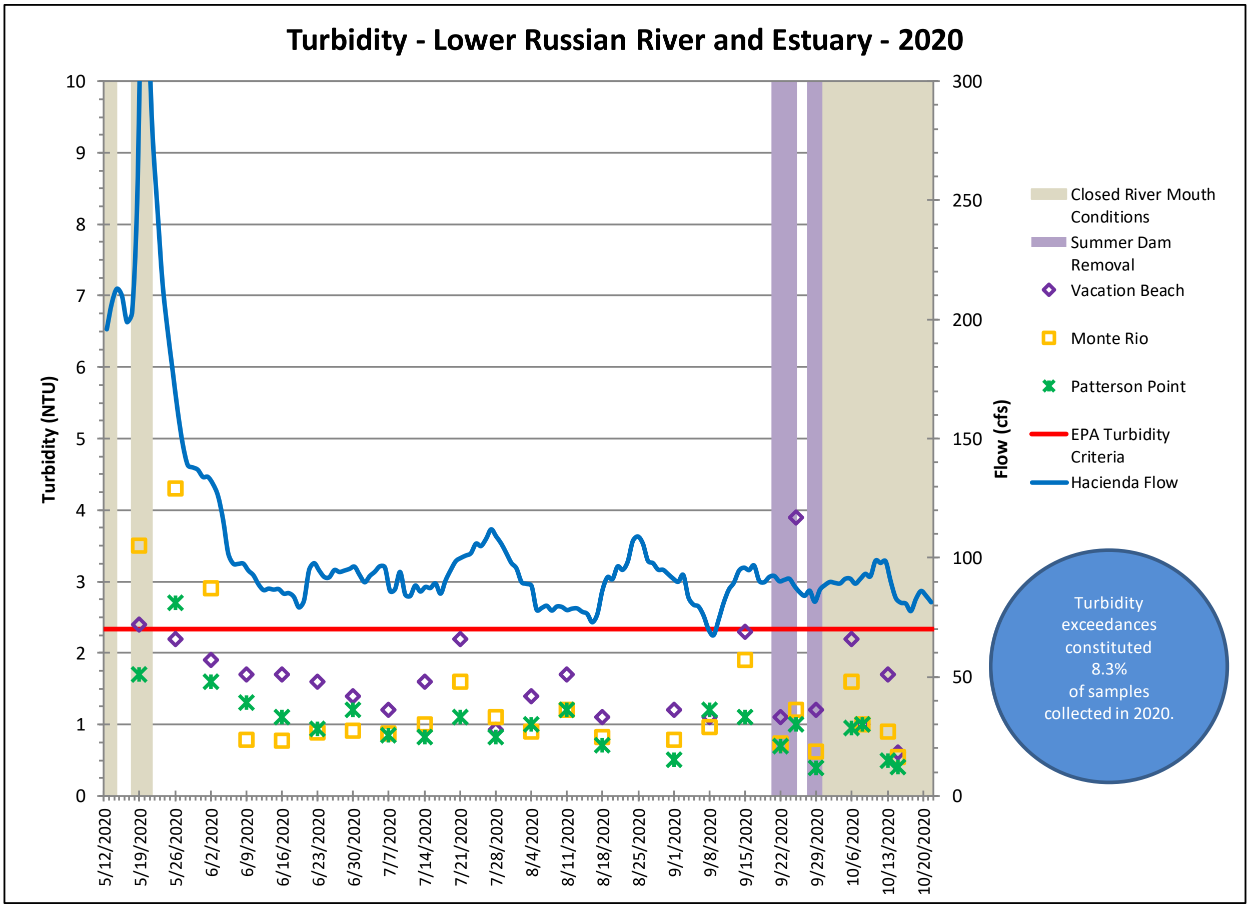


Figure 4.1.13. 2020 Russian River Grab Sampling Results for Turbidity

note that the EPA criterion is established for freshwater systems, and as such, is only applicable to the freshwater portions of the Estuary. Currently, there are no numeric *chlorophyll a* criteria established specifically for estuaries.

Chlorophyll a concentrations exceeded the EPA criteria ten times at Vacation Beach and twice each at Monte Rio and Patterson Point (14 of 72 or 19.4%) under open and closed conditions and flows that ranged from 88.1 cfs to 347 cfs (Tables 4.1.2 through 4.1.4 and Figure 4.1.14). *Chlorophyll a* values varied through the season with several ND values occurring at all three stations, including during summer dam removal in September and barrier beach closure in October (Figure 4.1.14).

The maximum *chlorophyll a* concentration observed at Patterson Point was 0.0021 mg/L on 23 June during open conditions with a flow of approximately 94.7 cfs (Table 4.1.2 and Figure 4.1.14). The minimum value at Patterson Point was ND, which occurred fifteen (15) times periodically through the season, during open and closed conditions and summer dam removal and flows that ranged from 69.9 to 347 cfs (Table 4.1.2).

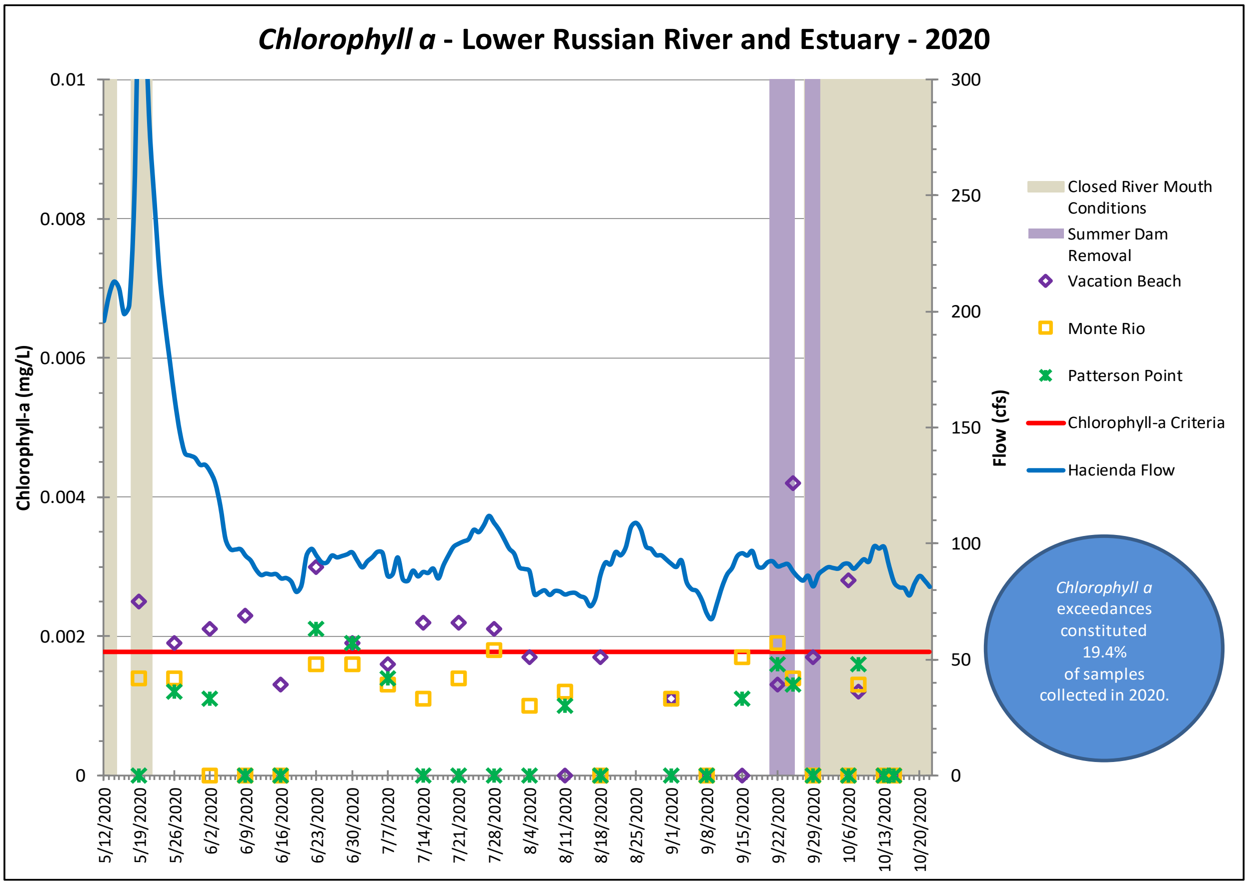


Figure 4.1.14. 2020 Russian River Grab Sampling Results for *Chlorophyll a*

The maximum *chlorophyll a* concentration observed at Monte Rio was 0.0019 mg/L on 22 September during open conditions and summer dam removal and a flow of approximately 90.2 cfs (Table 4.1.3). The minimum value at Monte Rio was ND, which occurred ten (10) times through the season during open and closed conditions and summer dam removal with flows that ranged from 69.9 to 164 cfs (Table 4.1.3).

The maximum *chlorophyll a* concentration observed at Vacation Beach 0.0042 mg/L on 25 September during open conditions and summer dam removal and a flow of approximately 88.1 cfs (Table 4.1.4 and Figure 4.1.14). The minimum value at Vacation Beach was ND, which occurred six (6) times in the latter half of the season during open and closed conditions and flows that ranged from 69.9 to 164 cfs. *Chlorophyll a* values at Vacation Beach were generally higher in the spring and early summer, and trending downward through the season before increasing during summer dam removal and barrier beach closure (Figure 4.1.14).

Indicator Bacteria

The California Department of Public Health (CDPH) developed the "Draft Guidance for Fresh Water Beaches," which describes bacteria levels that, if exceeded, may require posted warning signs in order to protect public health (CDPH, 2011). The CDPH draft guideline for single sample maximum concentrations is: 10,000 most probable numbers (MPN) per 100 milliliters (ml) for total coliform, 235 MPN per 100 ml for E. coli, and 61 MPN per 100 ml for Enterococcus.

In 2012, the United States Environmental Protection Agency (EPA) issued Clean Water Act (CWA) §304(a) Recreational Water Quality Criteria (RWQC) for States (EPA, 2012). The RWQC recommends using two criteria for assessing water quality relating to fecal indicator bacteria: the geometric mean (GM) of the dataset, and changing the single sample maximum (SSM) to a Statistical Threshold Value (STV) representing the 75th percentile of an acceptable water-quality distribution. However, the EPA recommends using STV values as SSM values for potential recreational beach posting and those values are provided in this report for comparative purposes. It must be emphasized that these are draft guidelines and criteria, not adopted standards, and are therefore both subject to change (if it is determined that the guidelines and/or criteria are not accurate indicators).

Samples were collected during the monitoring season for diluted and undiluted analysis of *E. coli* and total coliform for comparative purposes and the results are included in Tables 4.1.5 through 4.1.7 and Figures 4.1.15 and 4.1.16. Samples collected for Enterococcus were undiluted only and results are included in Tables 4.1.5 through 4.1.7 and Figure 4.1.17. Sonoma Water submitted samples to the Sonoma County DHS Public Health Division Lab in Santa Rosa for bacteria analysis. *E. coli* and total coliform were analyzed using the Colilert method and Enterococcus was analyzed using the Enterolert method. Samples for all other constituents were submitted to Alpha Labs in Ukiah for analysis. Total Coliform and *E. coli* data presented in Figures 4.1.15 and 4.1.16 utilize undiluted sample results unless the reporting limit has been exceeded, at which point the diluted results are utilized.

Beginning in 2014, staff at the NCRWQCB indicated that Enterococcus was not being utilized as a fecal indicator bacteria in freshwater environments due to evidence that Enterococcus colonies can be persistent in the water column and therefore its presence at a given freshwater site may not always be associated with a fecal source. Sonoma Water staff will continue to collect Enterococcus samples and record and report the data however, Enterococcus results will not be relied upon when coordinating with the NCRWQCB and Sonoma County DHS about potentially posting warning signs at freshwater beach sites or to discuss potential adaptive management actions including mechanical breaching of the barrier beach to address potential threats to public health.

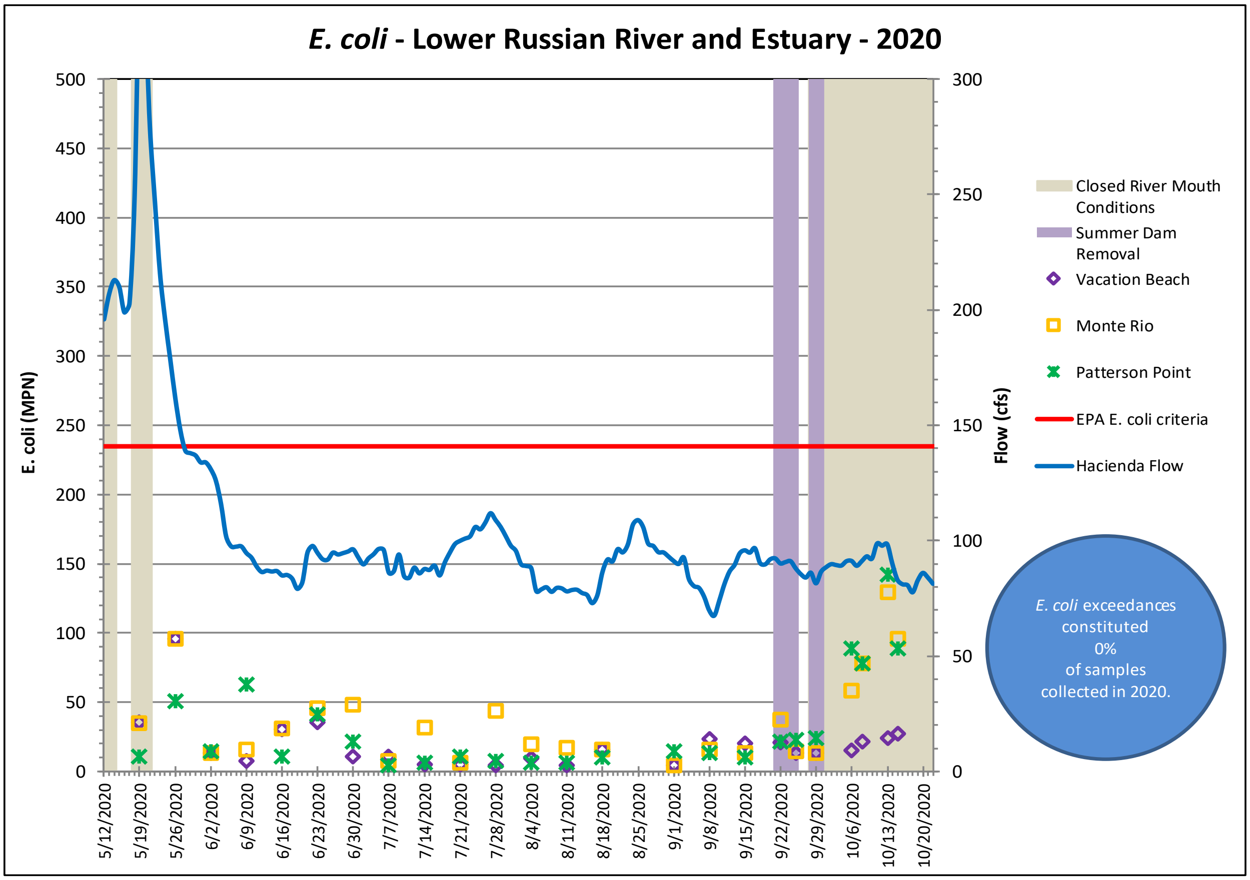


Figure 4.1.15. 2020 Russian River Grab Sampling Results for E. coli

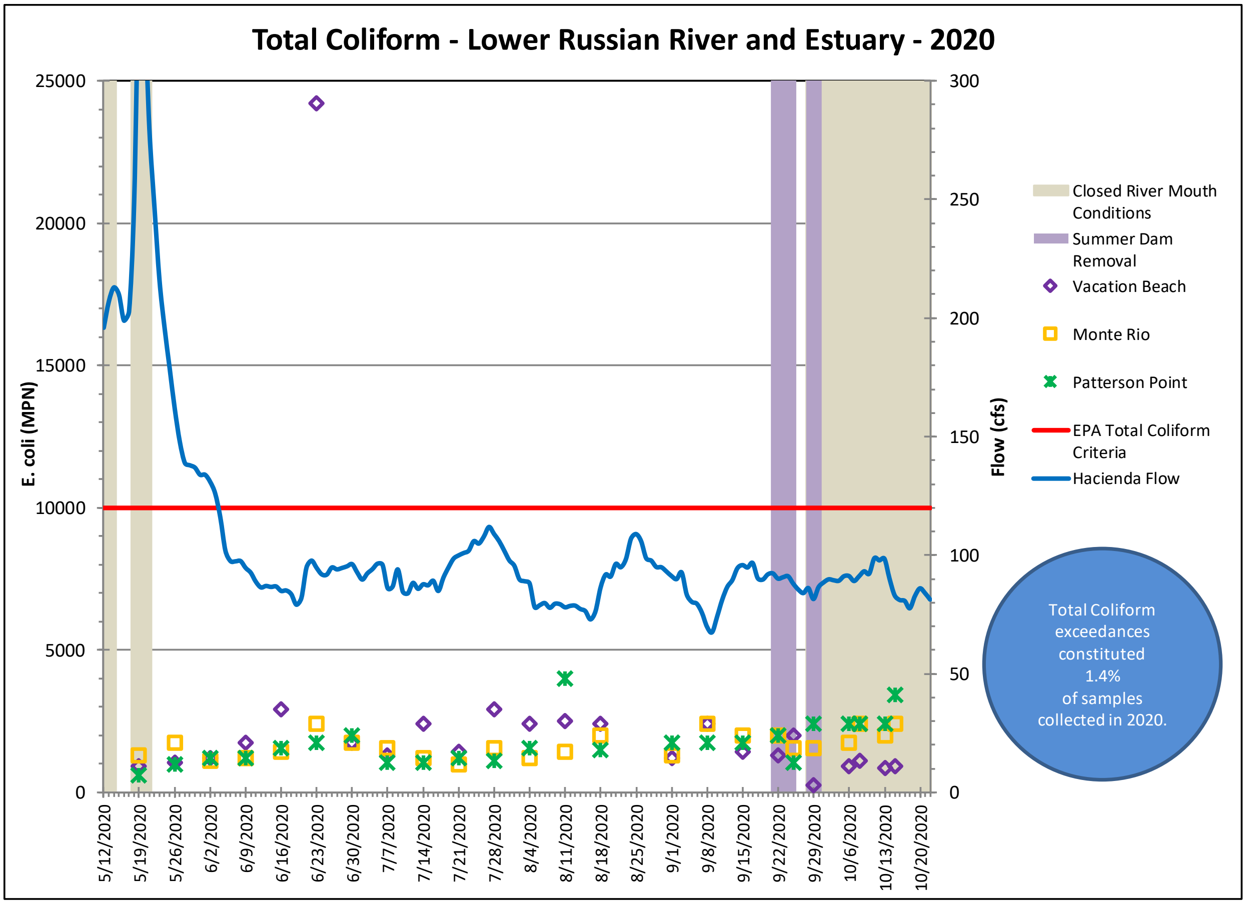


Figure 4.1.16. 2020 Russian River Grab Sampling Results for Total Coliform

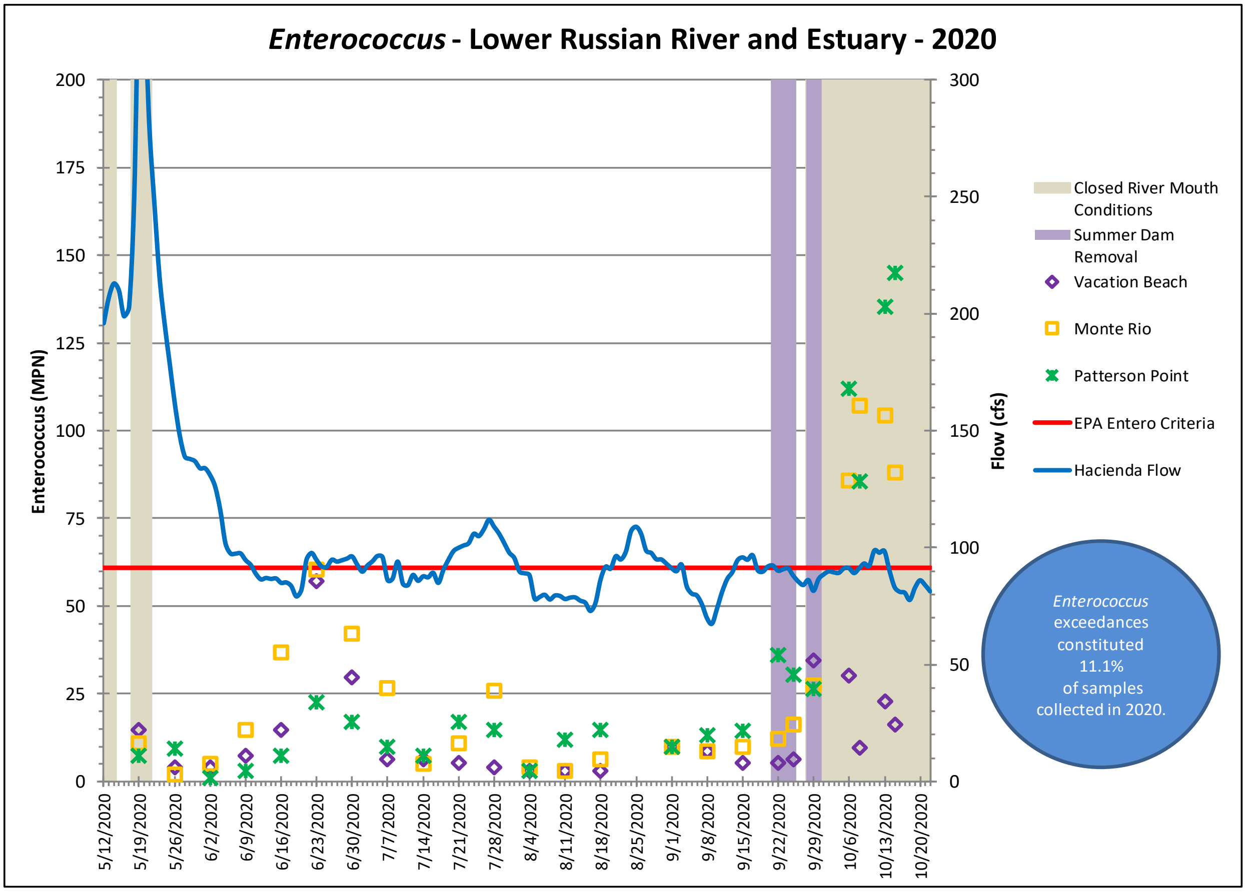


Figure 4.1.17. 2020 Russian River Grab Sampling Results for Enterococcus

E. coli

There were no exceedances (0 of 72 or 0%) of the EPA criteria for *E. coli* during the 2020 monitoring season at the lower river stations (Tables 4.1.5 through 4.1.7 and Figure 4.1.15).

The maximum *E. coli* concentration observed at Patterson Point was 142.1 MPN/100mL, which occurred on 13 October during closed conditions and a flow of approximately 98.6 cfs (Table 4.1.5 and Figure 4.1.15).

The maximum *E. coli* concentration observed at Monte Rio was 129.6 MPN/100mL, which occurred on 13 October during closed conditions and a flow of approximately 98.6 cfs (Table 4.1.6 and Figure 4.1.15).

The maximum *E. coli* concentration observed at Vacation Beach was 96 MPN/100mL, which occurred on 26 May during open conditions and a flow of approximately 162 cfs (Table 4.1.7 and Figure 4.1.15). There was a diluted sample that had a concentration of 288 MPN/100mL on 29 September (Table 4.1.7). However the undiluted sample result of 13.2 MPN/100mL collected during the same sampling event was utilized for reporting purposes, as the maximum reporting limit had not been exceeded (Table 4.1.7).

Summer dam removal and barrier beach closure may have had an effect on *E. coli* concentrations, as values were observed to slightly increase at Monte Rio, Patterson Point, and Vacation Beach to a lesser degree in October (Figure 4.1.15).

Total Coliform

There was one exceedance (1 of 72 or 1.4%) of the CDPH guideline for Total Coliform during the 2020 monitoring season (Tables 4.1.5 through 4.1.7 and Figure 4.1.16). Aside from the one exceedance, Total Coliform concentrations remained low at all three stations during the monitoring season (Figure 4.1.16).

The maximum Total Coliform concentration observed at Patterson Point was 3,998 MPN/100mL, which occurred during open Estuary conditions and a flow of approximately 78.1 cfs (Table 4.1.5 and Figure 4.1.16).

The maximum Total Coliform concentration observed at Monte Rio was 2,419.6 MPN/100mL, which occurred four times during open and closed conditions and flows that ranged from 69.9 to 94.7 cfs (Table 4.1.6 and Figure 4.1.16). There was a diluted sample that measured 12,997 MPN/100mL on 1 September. However, the undiluted sample result of 1,299.7 MPN/100mL collected during the same sampling event was utilized for reporting purposes, as the maximum reporting limit had not been exceeded (Table 4.1.6).

The one exceedance of the Total Coliform guideline was the maximum concentration observed at the Vacation Beach station, which occurred on 23 June with a value of >24,196 MPN/100mL during open conditions and a flow of approximately 94.7 cfs (Table 4.1.5 and Figure 4.1.16).

Enterococcus

Following barrier beach closure in late September, the Monte Rio and Patterson Point stations were observed to have four exceedances each (8 of 72 or 11.1%) of the EPA criteria for Enterococcus with flows that ranged from 83.2 to 98.6 cfs (Tables 4.1.5 and 4.1.6 and Figure 4.1.17).

The Patterson Point station had a maximum Enterococcus concentration of 145.0 MPN/100mL on 15 October during closed conditions with a flow of approximately 83.2 cfs (Table 4.1.5 and Figure 4.1.17).

The Monte Rio station had a maximum Enterococcus concentration of 107.0 MPN/100mL that occurred on 8 October during closed conditions with a flow of approximately 91.2 cfs (Table 4.1.6 and Figure 4.1.17).

The Vacation Beach station did not have any exceedances of the EPA criteria for Enterococcus, with a maximum concentration of 57.1 MPN/100mL that occurred on 23 June during open conditions and a flow of approximately 94.7 cfs (Table 4.1.7 and Figure 4.1.17).

All three stations were observed to have an increase in Enterococcus concentrations during the month of June, however, none of the stations exceeded the criteria. External factors including contact recreation, barrier beach closure, and the late-September removal of summer dams in lower river likely had an effect on elevated Enterococcus concentrations observed in the Monte Rio and Patterson Point areas during the 2020 monitoring season (Figure 4.1.17).

Conclusions and Recommendations

Continuous Water Quality Monitoring Conclusions

Water quality conditions observed during the 2020 monitoring season were similar to conditions observed during previous monitoring seasons, and similar to the dynamic conditions associated with an estuarine river system. The differing physical properties associated with freshwater versus those of saltwater play a pivotal role in the stratification that is common in the Estuary. Since the saltwater is denser than the freshwater inflow, the saltwater layer is observed below the freshwater layer, and the slope of the temperature and density gradients is typically steepest at the halocline. While this relationship is a key player in what shapes the water quality conditions in the Estuary, there are other influences at work in the Estuary as well, including wind mixing, river inflow, tidal influence, shape and size of the river mouth, air temperatures, and others.

There were no beach management actions taken during the lagoon management period in 2020 since the mouth of the Estuary self-breached naturally after each closure. Consequently, there was no opportunity for Sonoma Water staff to assess the availability of suitable aquatic habitat for rearing salmonids in comparison to closed and open Estuary conditions. Although Sonoma Water staff were not able to assess the merits of a lagoon outlet channel, staff were still able to collect data that provides a fuller understanding of salinity migration in the Upper Reach of the Estuary.

As freshwater flows in the Russian River decrease through spring, the salt layer typically migrates upstream. However, the degree of salinity migration can be highly variable depending on the orientation and aspect of the river mouth in relation to the barrier beach and jetty. The jetty can serve to mute the strength of the tidal cycle if the river mouth is oriented against the jetty.

Salinity migration patterns in the upper reach of the Estuary were not collected in 2020 due to the theft of monitoring equipment at the Brown’s Pool (rkm 11.3) station. However, based on data collected during past monitoring seasons, it is not unreasonable to expect salinity migration to periodically occur in this area (Martini-Lamb and Manning, 2020).

Whereas, monitoring conducted in 2020 in the MBA at the Patterson Point station continued to show freshwater conditions with a maximum salinity value of approximately 0.3 ppt (Table 4.1.2). Water is considered fresh at approximately 0.5 ppt. These results correspond with the data collected in the Upper Reach of the Estuary and the MBA since 2010 and further supports the theory that Brown’s Riffle (rkm 11.4) and the confluence of Austin Creek (rkm 11.65) provide a significant hydrologic barrier to salinity migration in the mainstem Russian River.

Temperature, pH, and dissolved oxygen patterns during the 2020 monitoring season were also similar to those observed in previous monitoring years. While the Russian River Estuary is a dynamic estuarine system, the seasonal changes during the monitoring seasons have largely followed similar patterns each year since the implementation of the Biological Opinion in 2009.

To further illustrate the extent of salinity migration, a graphical representation of the maximum salinity levels recorded at various stations in the Russian River Estuary between 2009 and 2019 is being presented (Figure 4.1.18). The sondes chosen for this graph were situated in the lower portion of the water column at each station, where saline water would be expected to occur. This generally corresponds to approximately three to four meter depths for the Mouth, Patty's Rock, and Sheephouse Creek stations, six to nine meter depths at the Heron Rookery station, six to seven meter depths at the Freezeout Creek station, eight to eleven meter depths at the Brown's Pool station, six to eight meter depths at Villa Grande, nine to eleven meters depth at Patterson Point, and one to two meters at the Monte Rio station. In the upper reaches of the Estuary and MBA, the sondes are located on the bottom of the river because the salt layer is typically thin when it occurs at these river locations. Excluding the depth variations, the graph depicts the decrease in salinity the further upstream in the Estuary and MBA the monitoring station is located.

The graph also illustrates the variable nature of salinity levels in the Upper Reach of the Estuary. For instance, in 2014 and 2016, the maximum salinity concentrations observed at Brown's Pool were nearly identical at approximately 11 ppt, whereas in 2017, 2018, and 2019 the maximum salinity concentration was 0.2 ppt.

Note that there are no elevated salinity levels recorded in the Maximum Backwater Area for any monitoring seasons. As was mentioned above, it is possible that saline water does not migrate past the riffle between Brown's Pool and the confluence of Austin Creek due to hydrologic and/or geologic conditions that serve to define a transition from the Estuary and the beginning of the Maximum Backwater Area.

Water Quality Grab Sampling Conclusions

The 2020 grab sampling effort in the Estuary continued to collect a robust set of data similar in effort to the 2012 through 2019 monitoring seasons. Additional focused sampling was conducted during summer dam removal in late September and barrier beach closure in October. Table 4.1.8 shows the total yearly number of sampling trips and the total number of samples collected within the freshwater portions of the Estuary and Maximum Backwater Area during each monitoring season since the implementation of the Biological Opinion in 2009.

The mainstem Russian River, as measured at the USGS Hacienda gage, experienced lower flows in 2020 compared to past years including 2019 (Figure 4.1.19). For example, a late season storm in 2019 significantly elevated flows from approximately 600 cfs to over 3,000 cfs at Hacienda in mid-May. Flows remained above 500 cfs into early June, resulting in mainstem flows decreasing to base summertime flows later in the dry season compared to previous years, including 2020 (Figure 4.1.19).

By comparison a much smaller late-season storm in 2020 only increased Hacienda flows from about 200 cfs to approximately 350 cfs in mid-May before dropping to 100 cfs by early June,

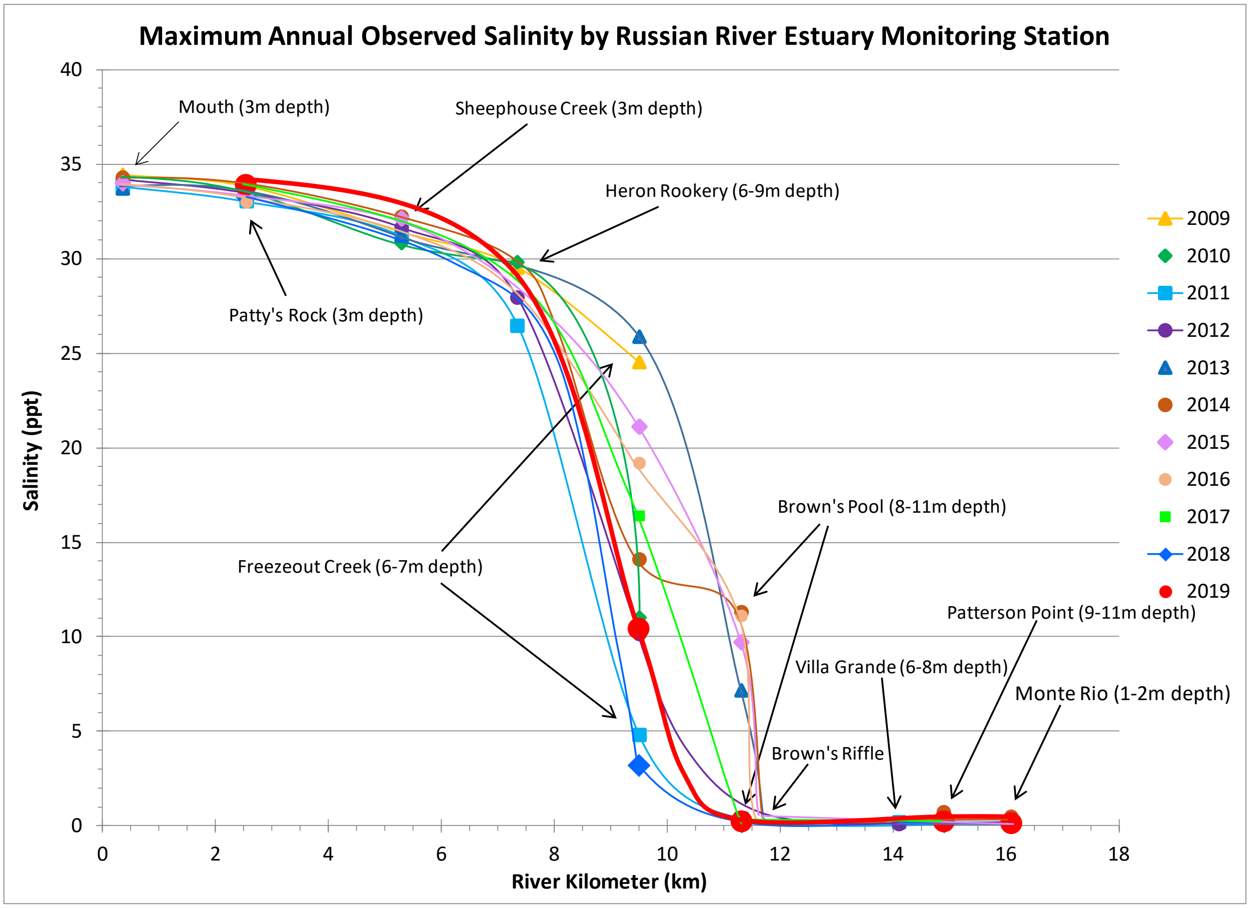


Figure 4.1.18. The maximum salinities at monitoring stations throughout the Russian River Estuary and Maximum Backwater Area between the years of 2009 and 2019.

Table 4.1.8. The total number of grab sampling trips per monitoring season and the total number of samples taken in the freshwater portion of the Russian River Estuary and Maximum Backwater Area per monitoring season. Note: duplicate and triplicate samples were counted as separate samples during the same sampling trip.

Estuary Monitoring Season	Total Number of Sampling Trips	Total Number of Samples
2009	7	7
2010	13	39
2011	13	52
2012	18	72-90
2013	33	98
2014	26-31	104-111
2015	26-27	104-106
2016	29-30	87-90
2017	26	75
2018	25	75
2019	25	75
2020	24	72

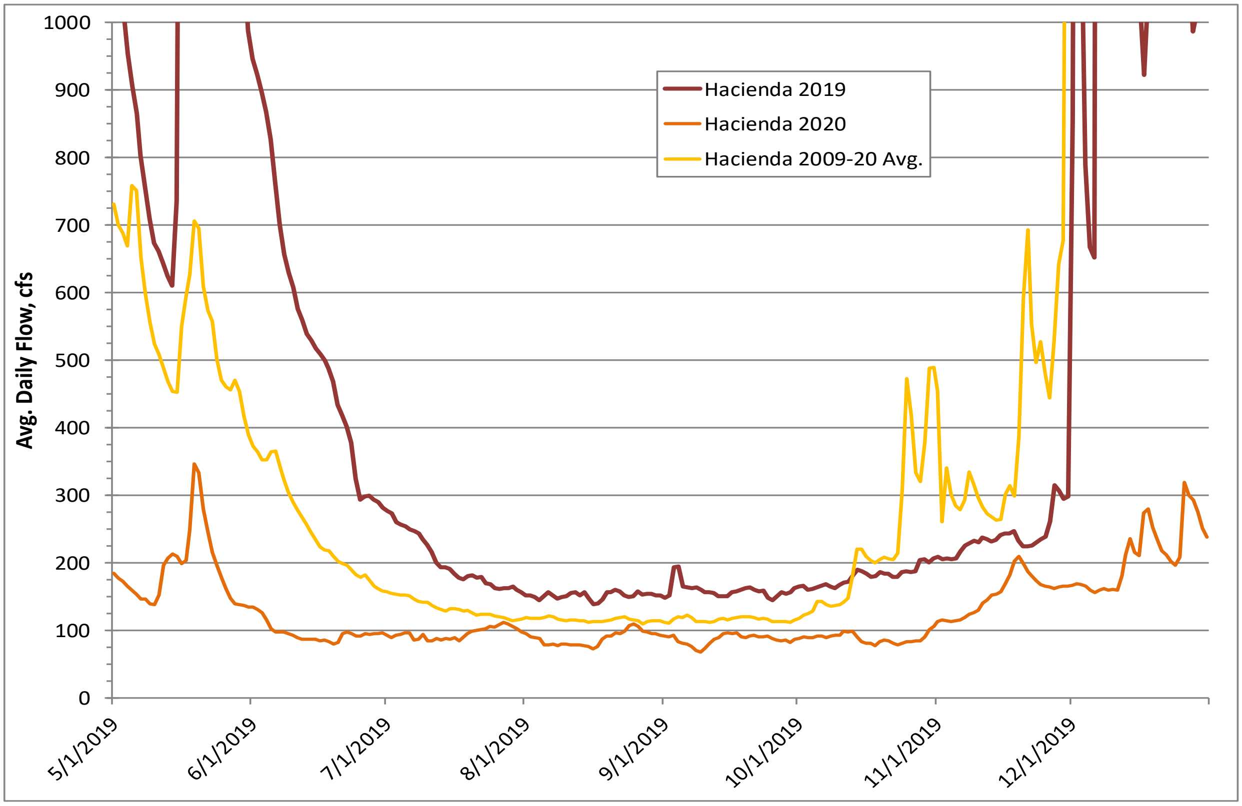


Figure 4.1.19. Comparison of 2019, 2020 and 2009-2020 average daily flows in the Lower Russian River as measured at USGS Hacienda gage in cubic feet per second. Flow rates are preliminary and subject to final revision by USGS.

resulting in flows decreasing earlier in the season compared to previous years (Figure 4.1.19). Finally, while summertime base flows at Hacienda remained above 150 cfs in 2019, summertime base flows in 2020 were generally below 100cfs and frequently below 85 cfs (Figure 4.1.19).

The 2020 grab sampling effort observed Total Phosphorus exceedances in 98.6% of all samples collected (Table 4.1.9). This is not uncommon in the lower Russian River, and similar percentages of the samples analyzed for Total Phosphorus were in exceedance during previous monitoring seasons. Table 4.1.9 shows the percentage of samples that were in exceedance each season since 2009.

The Total Nitrogen, *chlorophyll a*, and turbidity exceedances in 2020 were all on the lower end of percentages observed in previous monitoring years, including zero (0%) Total Nitrogen exceedances in 2020 (Table 4.1.9).

Year to year variability in the percentage of exceedances, and concentrations and values, for the constituents discussed above can be attributed in large part to: the frequency, timing, and severity of storm events, fluctuating stream flow rates, atmospheric conditions; contact recreation; the frequency and timing of barrier beach closures, the strength of tidal cycles, summer dam removal, topography, relative location within the Estuary, and wind mixing.

Table 4.1.9. The percentages of freshwater samples taken that were in exceedance of U.S. EPA water quality criteria for Total Phosphorus, Total Nitrogen, and Chlorophyll a. Note; Chlorophyll a was not quantified below 0.01 mg/L in 2009, and as such, cannot be verified against the U.S. EPA criteria of 0.00178 mg/L. Also, the Total Nitrogen values in 2009 were not quantified sufficiently against the criteria to make comparisons. The U.S. EPA criteria for Total Nitrogen is 0.38 mg/L, and the criteria for Total Phosphorus is 0.02188 mg/L. Finally, samples were not analyzed for Turbidity in 2009.

Estuary Monitoring Season	Percentage of Total Phosphorus Samples in Exceedance	Percentage of Total Nitrogen Samples in Exceedance	Percentage of Total *Chlorophyll a* Samples in Exceedance	Percentage of Turbidity Samples in Exceedance
2009	100	N/A	N/A	N/A
2010	84.6	15.4	18.0	23.1
2011	92.3	30.8	23.7	25.0
2012	61.5	6.9	11.5	2.8
2013	99.0	15.3	44.9	13.3
2014	100	14.4	23.1	22.0
2015	86.5	1.9	26.0	3.9
2016	83.9	8.1	39.1	19.5
2017	97.3	9.3	54.7	38.7
2018	93.3	5.3	36.6	9.3
2019	85.3	9.5	48.0	53.3
2020	98.6	0	19.4	8.3

The percentage of *E. coli* exceedances from 2009 until 2020 can be seen in Table 4.1.10. The percentage of exceedances for Total coliform and *E. coli* have been observed to remain relatively low over the years of sampling.

E. coli was not sampled for in 2010, with sampling being conducted for fecal coliforms instead. Samples collected in 2009 were analyzed using the multiple tube fermentation technique, whereas samples collected from 2011 through 2020 were analyzed using the Colilert Quanti-Tray method. Percentages for total coliform samples are not included prior to 2015, since values were not quantified above 1,600 MPN for 2010 and a portion of 2011, or above >2,419.6 MPN for 2012, 2013 and a portion of the 2014 season. Both levels are below CDPH Guidelines, therefore it is impossible to establish percent criteria exceedances for those monitoring seasons.

Table 4.1.10. The percentages of freshwater samples taken that were in exceedance of CDPH Guidelines for *E. coli* and Total Coliform for the sampling years 2009 through 2020. Note that for 2009, the analyzing method was multiple tube fermentation, and for 2011-2020 the method was Colilert Quanti-Tray.

Estuary Monitoring Season	Percentage of Total *E. coli* Samples in Exceedance	Percentage of Total Coliform Samples in Exceedance
2009	0	N/A
2010	N/A	N/A
2011	0	N/A
2012	0	N/A
2013	1.0	N/A
2014	6.3	N/A
2015	1.9	3.8
2016	2.2	0
2017	1.3	4.0
2018	1.3	0
2019	4.0	2.7
2020	0	1.4

Overall, data collected through the grab sampling effort in 2020 appear consistent with data collected between 2009 and 2019.

Additionally, based on the assemblage of data collected by Sonoma Water, it does not appear that lower flows observed in 2020 negatively affected water quality or the availability of aquatic habitat, or provided a significant contribution to biostimulatory conditions when compared to data collected during years with normal water year flow rates, such as 2019.

Time series trend analyses of the grab sampling data collected could prove useful in the future. Further analysis could elucidate any trends that may exist temporally or longitudinally through the Estuary and guide water quality monitoring efforts in the future.

Trend analyses could determine if there have been changes over time for any of the constituents collected under this project. Certain trend tests are used for non-parametric data analysis such as water quality data, including the Sen Slope test, the Kendall-Theil test, the Seasonal Kendall test, or a variety of other suitable statistical tests. Analyses of this nature require both time and expert knowledge of environmental statistical analysis. As such, they are difficult to run and outside the scope of this project at this time. In the future, allocating resources to analyses of this nature, on these data, would likely give a better understanding of the existence, or absence, of trends in the data.

4.2 Algae Sampling

Monitoring of periphytic and planktonic algae was conducted to document the algal response following Estuary closure; and establish baseline ecological data for algal populations representative of habitats available in the Russian River at Patterson Point. Monitoring for both was conducted as soon as river flows allowed a systematic investigation of abundance, cover, and successional processes. Data collected in 2020 is currently being analyzed and will be provided in a supplemental report.

4.3 Invertebrate Prey Monitoring, Salmonid Diet Analysis and Juvenile Steelhead Behavior

The 2008 Biological Opinion stated that “densities of steelhead appear to be low in the Russian River Estuary, a condition that is likely due to reduced water quality (e.g., elevated salinity and other water quality dynamics) as well as diminished production of invertebrates that are typically the forage base of juvenile salmonids. The Russian River Biological Opinion requires the Sonoma Water to “monitor the effects of alternative water level management scenarios and resulting changes in depths and water quality (primarily salinity, dissolved oxygen concentration, temperature, and pH) on the productivity of invertebrates that would likely serve as the principal forage base of juvenile salmonids in the Estuary (NMFS, 2008). Specifically, the Sonoma Water is determining the temporal and spatial distribution, composition (species richness and diversity), and relative abundance of potential prey items for juvenile salmonids in the Estuary, and evaluating invertebrate community response to changes in sandbar management strategies, inflow, estuarine water circulation patterns (stratification), and water quality; and to provide a qualitative description of salmonid diet in the Estuary.

The monitoring of invertebrate productivity in the Estuary focuses primarily on epibenthic and benthic marine and aquatic arthropods within the classes Crustacea and Insecta, the primary invertebrate taxa that serve as prey for juvenile salmonids, especially steelhead (*Oncorhynhus mykiss*) that may be particularly characteristic of conditions unique to estuarine lagoons for which steelhead may be adapted in intermittent estuaries near the southern region of their distribution (Hayes and Kocik 2014). The monitoring effort will involve systematic sampling and analysis of zooplankton, epibenthic, and benthic invertebrate species” (NMFS, 2008, page 254).

Commensurate with assessment of potential responses to Estuary conditions by the macroinvertebrate prey of juvenile salmonids, the Sonoma Water is also monitoring juvenile salmonid diet composition and behavior. Based on the hypothesis that both diet and behavior of juvenile salmonids will vary as a function of increased water level and rearing space when the mouth of the Estuary is closed, the potentially differential effects of density-dependent interactions on diet composition and consumption rate are being compared between open and closed Estuary conditions. To facilitate the synthesis of this information with more precise information on juvenile salmonid exposure to variability in Estuary salinity and thermal regime, the Sonoma Water is supporting hydroacoustic telemetry of their position, behavior and residence as a function of Estuary conditions. The purpose of this effort is to determine for juvenile steelhead in the Estuary the variation under different Estuary open-closure conditions in: (1) the Estuary's water quality environment and the specific water quality conditions experienced by the juvenile steelhead; (2) their behavior in terms of estuarine habitat, reach occupancy and intra-estuarine movement patterns; (3) diet composition; (4) potential (modeled) and empirical growth. These will be used to refine parameters used in the Seghesio (2011) bioenergetics model to generate more empirically-based potential growth estimates during juvenile steelhead response to changing conditions in this intermittent Estuary.

Sonoma Water entered into an agreement with Dr. Charles "Si" Simenstad and his colleagues at the University of Washington, School of Aquatic and Fishery Sciences' Wetland Ecosystem Team (UW-WET) to conduct studies of the ecological response of the Estuary to natural and alternative management actions associated with the opening and closure of the Estuary mouth. Dr. Simenstad is a researcher with expertise in estuarine/early marine ecology of juvenile Pacific salmon, feeding ecology of fishes, estuarine food webs, tidal wetland landscape ecology, restoring estuarine wetlands, and the ecological effects of anthropogenic alterations to coastal ecosystems. This component of the study is designed to evaluate how different natural and managed barrier beach conditions in the Estuary affect juvenile salmon foraging and their potential prey resources over different temporal and spatial scales. Systematic sampling is intended to capture the natural ecological responses (prey composition and consumption rate) of juvenile salmon and availability of their prey resources (insect, benthic and epibenthic macroinvertebrates, zooplankton) under naturally variable, seasonal changes in water level, salinity, temperature and dissolved oxygen conditions. A second approach, event sampling, was originally proposed in 2009 to contrast juvenile salmonid foraging and prey availability changes over Estuary closure and re-opening events. The hydroacoustic telemetry component was particularly adaptable and targeted for the event sampling.

Based on prior data on the foraging of juvenile salmonids in the region's estuaries, the dominant prey of juvenile steelhead can be generally classified as invertebrate organisms that are epibenthic and benthic infauna. All of these prey sources are vulnerable to the variable conditions imposed by river mouth conditions, but taxa composition, relative abundance and production may vary as a function of both longitudinal axis (reach) of the Estuary and cross-channel distribution. Another potential invertebrate component, pelagic zooplankton, has not appeared in juvenile salmon diets in either open or closed Estuary conditions. Epibenthic, benthic, and zooplankton invertebrate sampling has been conducted monthly from May to October since 2009. Most of these sampling events were completed during open river mouth, tidal conditions in the Estuary providing a robust baseline dataset. The composition and abundance of invertebrates was consistent among monthly sampling and among years indicating that the current dataset is adequate to characterize the invertebrate fauna of the Estuary. The main gap in data is sampling during prolonged lagoon conditions in the Estuary, which is the continuing focus of the on-going research. The methods and results presented in the following sections focus on the overall lessons of monitoring invertebrates in the Estuary through 2019.

Due to the COVID-19 global pandemic and public health safety precautions, some monitoring activities were delayed, modified, or suspended in 2020, including invertebrate monitoring.

Sonoma Water implemented ten years of extensive aquatic invertebrate research for the Estuary Management Project. Monitoring reports were completed annually, including a summary and synthesis report of the decadal dataset and findings (Accola et al., 2021). This report provides a long-term analysis and summary of several independent studies related to salmonid diet, prey availability, juvenile steelhead distribution and behavior, and comparison of invertebrate composition and steelhead performance in other Pacific coast estuaries. In addition, these Estuary studies evaluated the response of invertebrates and steelhead to changing river mouth conditions. The scope of many of these studies are beyond the requirements stated in the Biological Opinion. Scientific journal articles and graduate theses/dissertation produced from Estuary invertebrate research are listed below.

- Fuller, J. A. 2011. Extended residency and movement behavior of juvenile steelhead (*Oncorhynchus mykiss*) in the Russian River Estuary, California. Master's thesis. Humboldt State University.
- Seghesio, E. E. 2011. The influence of an intermittently closed, Northern California estuary on the feeding ecology of juvenile steelhead (*Oncorhynchus mykiss*) and Chinook salmon (*Oncorhynchus tshawytscha*). Master's thesis. University of Washington, School of Aquatic and Fishery Sciences.
- Matsubu, W. C., C. A. Simenstad, and G. E. Horton. 2017. Juvenile steelhead locate coldwater refugia in an intermittently closed estuary. Transactions of the American Fisheries Society 146:680–695.
- Matsubu, W. C. 2019. Tradeoffs of juvenile steelhead (*Oncorhynchus mykiss*) rearing in an intermittently closed estuary, northern California USA. PhD dissertation. University of Washington, School of Aquatic and Fishery Sciences.

Summary of Methods

Field sampling and laboratory process methods implemented by Sonoma Water and UW-WET are described in previous reports. Following is a summary of the field and laboratory efforts conducted over the entire monitoring effort.

Invertebrate surveys were conducted from 2010 to 2019 in the Estuary. Surveys were completed monthly and at 7 and 14 days after a river mouth closure to monitor conditions during the transition from tidal Estuary to lagoon. Sampling for fish diet and prey availability was designed to coincide with established Sonoma Water and other related sampling sites distributed in the lower, middle, and upper reaches of the Estuary during the Lagoon Management Period (May 15 to October 15). Each survey event consisted of sampling at four sites distributed through the three estuarine reaches (Figure 4.3.1): Lower Reach—River Mouth and Penny Point; Middle Reach—Willow Creek; and Upper Reach—Freezeout Bar. Each of the sites included three, lateral transects across the Estuary over which four sampling methods were deployed to sample availability of juvenile steelhead prey (Figures 4.3.2 – 4.3.7 for more specific locations by different sampling methods). Collections at each station consisted of 12 benthic, 14 epibenthic, and 3 zooplankton for a total of 29 samples/station and combined total of

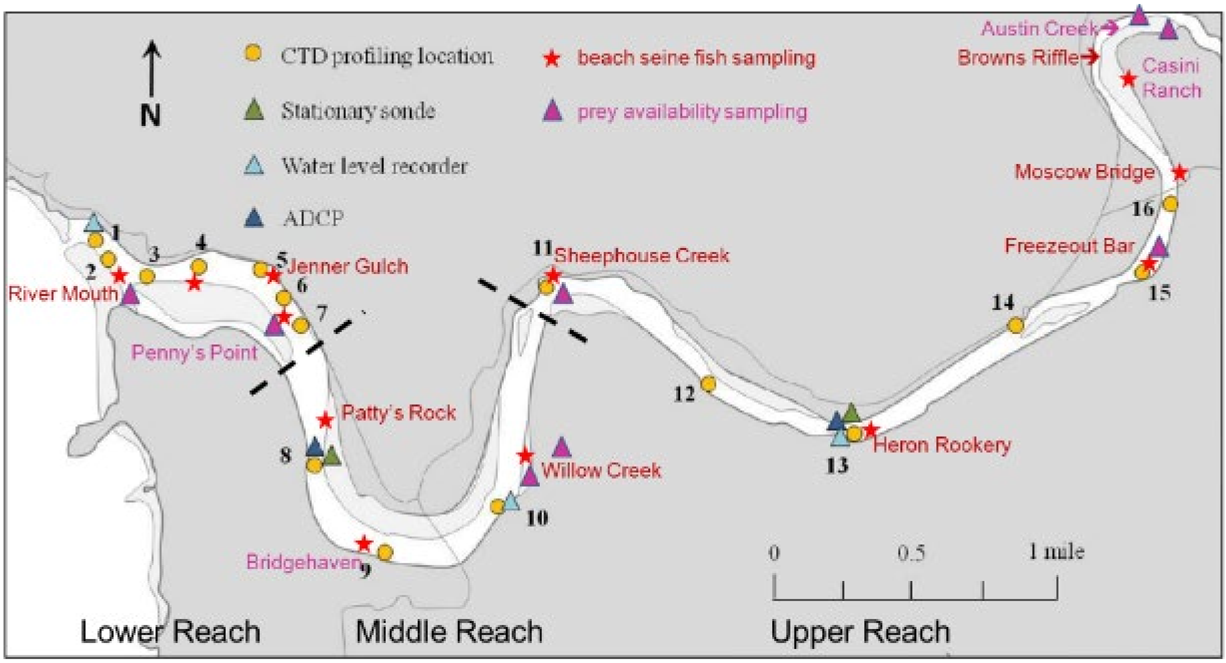


Figure 4.3.1. Locations of sampling stations for juvenile salmon diet (seining location) and prey resource availability (benthic infauna, epibenthos, zooplankton) in three reaches of the Russian River Estuary.

Figure 4.3.2 . Distribution of juvenile salmonid prey resource availability in three reaches of the Russian River Estuary.

Figure 4.3.3. Distribution of juvenile salmonid prey availability sampling transects and techniques at the River Mouth site in the Russian River Estuary.

Figure 4.3.4. Distribution of juvenile salmonid prey availability sampling transects and techniques at the Penny Point site in the Russian River Estuary.

Figure 4.3.5. Distribution of juvenile salmonid prey availability sampling transects and techniques at the Willow Creek site in the Russian River Estuary.

Figure 4.3.6. Distribution of juvenile salmonid prey availability sampling transects and techniques at the Freezeout Bar site in the Russian River Estuary.

Figure 4.3.7. Modification of sampling techniques during closed conditions for distribution of juvenile salmonid prey availability sampling transects and techniques at Willow Creek site in the Russian River Estuary. The grey area is the inundation of area during closed conditions.

116 samples/survey event. During mouth closures an additional three benthic and three epibenthic samples were collected along the inundated shoreline. These samples were placed in jars, preserved, and sent to UW-WET for taxonomic identification, enumeration, and analysis. Over the course of study, 48 survey events were completed (32 open mouth, 16 closed mouth) for a total collection of 5,585 invertebrate samples.

In addition, gastric-lavaged stomach samples were collected from 338 juvenile steelhead and 662 Chinook salmon smolts, and processed by UW-WET. Overall, there were 6,585 diet and prey availability samples collected, processed, and analyzed since 2010. UW-WET processed a subset of samples in the latter years of the study and targeted samples collected in association with river mouth closure events.

Salmonid diet samples have been coincident with beach seining at 11 sites (Figure 4.3.1; modified from Largier and Behrens 2010) sampled for juvenile salmon by the Sonoma Water – (1) Lower Reach: River Mouth, Penny's Point and Jenner Gulch; (2) Middle Reach: Patty’s Rock, Bridgehaven and Willow Creek; and, (3) Upper Reach: Sheephouse Creek, Heron Rookery, Freezeout Bar, Moscow Bridge and Casini Ranch. These locations also overlap with sites established by water quality measurements for dissolved oxygen, temperature and salinity.

Summary of Results

Accola et al. (2021) compiled and reviewed all of the Estuary invertebrate studies into a summary and synthesis report of the decadal dataset and findings. Below is a summary of the important research findings that comply with the Biological Opinion invertebrate monitoring requirements.

Spatial Distribution, Composition, and Relative Abundance of Invertebrates

Invertebrate composition showed differences between and among the three reaches of the Estuary that appeared to follow longitudinal water conditions transitioning from seawater in the lower reach to freshwater in the upper reach. However, the invertebrates that are important prey for juvenile steelhead were relatively consistent during a decade of study, see below for more details. Epibenthic sampling indicated a somewhat distinct invertebrate prey community composition between the River Mouth and the Penny Point sampling sites in the lower reach, but often distinct prey assemblages between the upper reach at Freezeout Bar site versus the lower reach and assemblages at the Willow Creek site in the middle reach. Presumably, salinity distribution is a likely determinant of these distinctions but cannot preclude the other influences of tidal exchange, substrate or other factors.

Salmonid Diet and Invertebrate Response to River Mouth Condition

Prey composition and densities in the Estuary were relatively comparable over the ten years of study, implying a relatively consistent estuarine prey community available for juvenile steelhead despite some variability in the occurrence and duration of freshwater outflow and Estuary closure events. The supplemental epibenthic sled sampling along the inundated shoreline during continued Estuary closures suggested no recognizable gradient or differentiation in the composition and relative density distribution of preferred prey. This would suggest that within the three Estuary reaches (lower, middle, upper) there was uniform or a relatively minor gradient of prey density distribution from their deeper channel to their shallower, marginal habitats due to Estuary closure.

In comparing juvenile steelhead diets between open and closed Estuary mouth conditions, there was no detection of any significant changes in diet composition. Juvenile steelhead consistently fed on common prey taxa over an inter-annual timespan. Spatial variation among Estuary reaches accounted for prey differences more than temporal variation or even variation due to open or closed mouth condition. Prey distributions are consistently organized along a salinity gradient (primarily distinguishing the upper reach of the Estuary dominated by freshwater river flows); however, prey composition was consistent within the three Estuary reaches (lower, middle, and upper) regardless of mouth condition.

A bioenergetics model investigating the relationship of diet composition and water temperature determined that growth rates of juvenile steelhead in the Estuary rival the highest in literature both in natural environments and under laboratory conditions. Therefore, growth of juvenile steelhead in the Estuary is likely not a limiting factor in the recovery of threatened steelhead in the Russian River watershed.

Diet composition of both juvenile steelhead and Chinook salmon in the Estuary indicated that these fish feed on relatively few taxa of aquatic invertebrates, consisting of epibenthic crustaceans and aquatic insects, that are common in the Estuary. In addition, there was a persistent uniformity in juvenile steelhead foraging on epibenthic prey. Accola et al. (2021) concluded that “our results and related accounts from other intermittent estuaries in the region indicates that juvenile salmonid feeding ecology in the Estuary is of relatively modest diversity and remarkably consistent. Thus, their feeding should be predictable as long as the spectrum of available prey is not dramatically altered…and…these prey taxa are reported to be common components in juvenile steelhead (and Chinook salmon, in a few cases) diets in other intermittent systems estuaries along the California coast.”

Conclusions

The invertebrate studies in the Estuary were able to quantify and determine several characteristics of the invertebrate community and their importance as prey for rearing juvenile steelhead, which are listed below.

- The annual composition and abundance of invertebrates in the Estuary were similar across the ten years of study, implying a relatively consistent prey base for juvenile steelhead.
- Invertebrate distributions were consistently organized along a salinity gradient from seawater at the river mouth to freshwater at the upstream end of the Estuary.
- Invertebrate composition was consistent within the three reaches of the Estuary regardless of mouth condition.
- During river mouth closures that inundated the shoreline, the density and distribution of invertebrates in the newly created marginal habitat was similar to the adjacent deeper channel.
- Juvenile steelhead consistently fed on relatively few taxa of common aquatic invertebrates consisting of epibenthic crustaceans and aquatic insects.
- The diet of juvenile steelhead did not appear to change under open or closed mouth conditions.
- The development of juvenile steelhead was exceptionally high in the Estuary, indicating that growth rate is likely not a limiting factor in the recovery of steelhead in the Russian River watershed.
- The high growth rates of juvenile steelhead suggest that prey abundance is not a limiting factor for rearing steelhead survival.

4.4 Fish Sampling – Beach Seining

Sonoma Water has been fish sampling the Russian River Estuary since 2004 - prior to issuance of the Biological Opinion. An Estuary fish survey methods study was completed in 2003 (Cook 2004). Due to the COVID-19 global pandemic and public health safety precautions, some monitoring activities were delayed, modified, or suspended in 2020, including beach seining. Beach seining methods in the Estuary requires a large number of staff working nearly shoulder to shoulder to pull in the seine and handle fish captured. A protocol could not be developed to protect the safety of staff in 2020.

4.5 Downstream Migrant Trapping

The RPA in the Russian River Biological Opinion requires Sonoma Water to provide information about the timing of downstream movements of juvenile steelhead into the Russian River Estuary, their relative abundance and the size/age structure of the population as related to the implementation of an adaptive management approach to promote formation of a perched freshwater lagoon. The sampling design implemented by Sonoma Water and described in this section specifically targets the detection and capture of anadromous salmonid young-of-the-year (YOY, age-0) and parr (≥age-1) (collectively referred to as juveniles) as well as smolts. In order to help accomplish the objectives listed above, Sonoma Water undertook fish capture and PIT-tagging activities at selected trapping sites upstream of the Estuary (Figure 4.5.1):

- Mainstem Russian River at Mirabel
- Mark West Creek
- Dutch Bill Creek
- Austin Creek
- Dry Creek (capture only, included for broader sampling context)

Stationary PIT antenna arrays were operated in the following locations:

- Upstream end of the Estuary in Duncans Mills (rkm 10.46)
- Near the mouth of Austin Creek (rkm 0.5)

Implementation of the monitoring activities described here are the result of a continually-evolving process of evaluating and improving on past monitoring approaches. Descriptions and data from other monitoring activities conducted in the Estuary (e.g., water quality monitoring, beach seining) as well as fish trapping operations in Dry Creek and the Mirabel downstream migrant traps on the mainstem Russian River are presented Russian River Biological Opinion Status and Data Report Year 2020-2021.

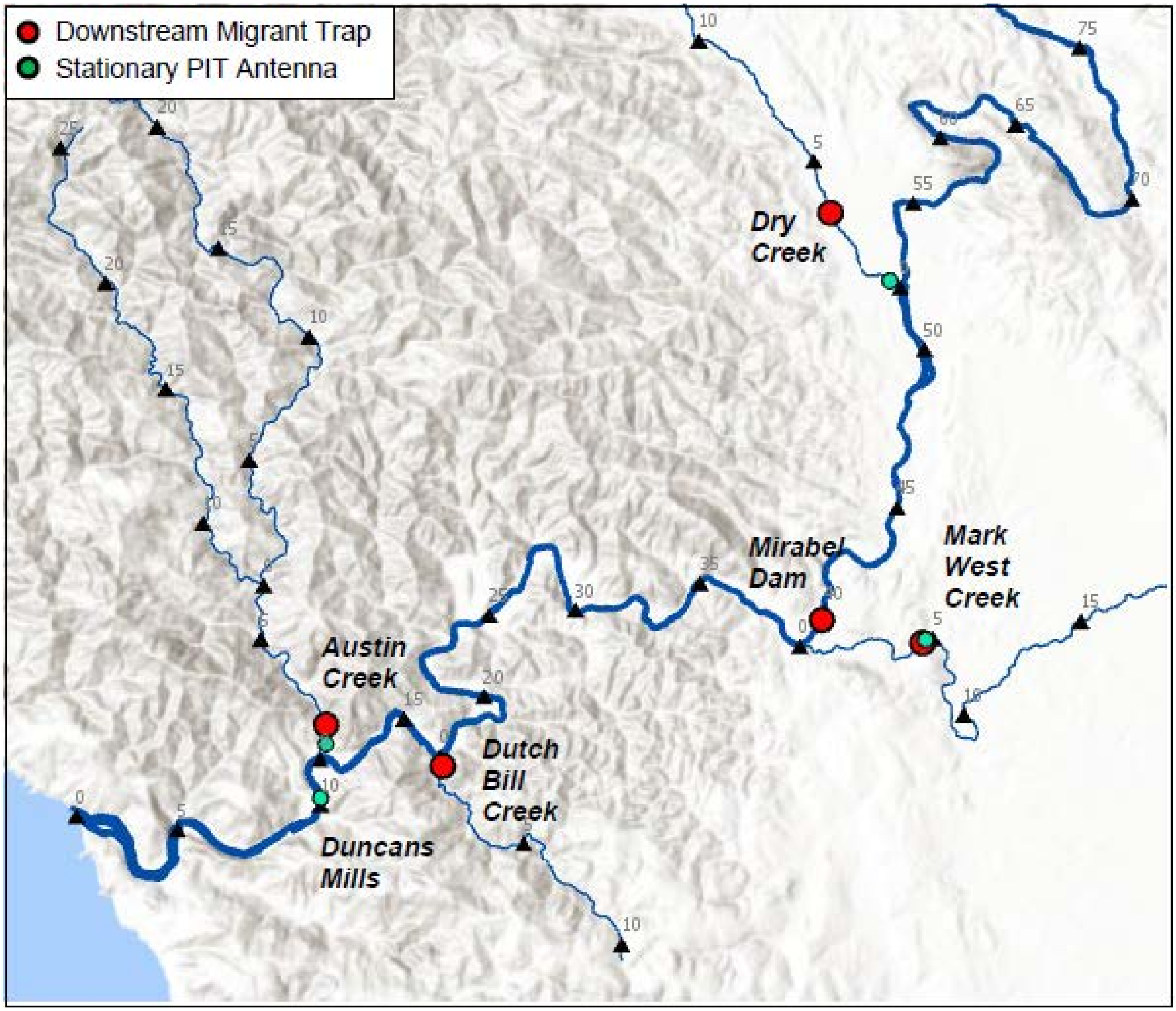


Figure 4.5.1. Map of downstream migrant detection sites in the lower Russian River, 2020. Numbered symbols along stream courses represent distance (km) from the mouth of each stream.

Methods

In 2020 Sonoma Water again relied on downstream migrant traps and stationary PIT antenna arrays at lower-basin trap sites to address the objectives in the RPA. Similar to 2010 through 2019, fish were physically captured at downstream migrant traps (rotary screw trap, funnel trap or pipe trap depending on the site), sampled for biological data and released. PIT tags were applied to a subset of age-0 steelhead captured at trap sites and fish were subject to detection at downstream PIT antenna arrays if they moved downstream into the Estuary. The following sections describe the sampling methods and analyses conducted for data collected at each site.

Estuary/Lagoon PIT antenna systems

Typically two antenna arrays with multiple flat plate antennas (antennas designed to lay flat on the stream bottom) are installed in the upper Estuary near the town of Duncans Mills (rkm 10.44 and 10.46) to detect PIT-tagged fish entering the Estuary (Figure 4.5.2).

Figure 4.5.2. Flat plate antenna arrays at Duncans Mills (river km 10.44 and 10.46). Rectangles represent individual flat plate antennas.

Generally, 12 antennas were operated continuously throughout the year. The orientation of the antennas consisted of 2 rows of antennas with one row slightly upstream of the other. Each row contained 6 antennas placed side by starting at the west river bank and extending out into the channel.

Lower Russian River Fish Trapping and PIT tagging

Following consultation with NMFS and CDFW, Sonoma Water identified three lower Russian River tributaries (Mark West Creek, Dutch Bill Creek and Austin Creek, Figure 4.5.1) in which to operate fish traps as a way to supplement data collected from the Duncans Mills PIT antenna array and during sampling by beach seining throughout the Estuary (Figure 4.5.1). Downstream migrant traps are also operated at the Mirabel inflatable dam. Sonoma Water operated three types of downstream migrant traps in 2020: rotary screw trap, funnel trap and pipe trap depending on the stream, water depth, and velocity (Figure 4.5.3). Fish traps were checked daily by Sonoma Water staff during the trapping season (March through July). Captured fish were enumerated and identified to species and life stage at all traps. All PIT-tagged fish were measured for fork length (±1 mm) and weighed (±0.1 g). Additionally, a subset of all non-PIT-tagged individuals were measured and weighed each day. PIT tags were implanted in a portion of the total number of steelhead YOY and parr captured that were ≥60 mm in fork length.

Mainstem Russian River at Mirabel and Dry Creek at Westside Road

Typically two rotary screw traps (one 5 foot and one 8 foot) adjacent to one another are operated on the mainstem Russian River immediately downstream of the Sonoma Water's inflatable dam site at Mirabel (approximately 38.7 km upstream of the river mouth in Jenner) (Table 4.5.1). Sonoma Water also operates a rotary screw trap at Dry Creek. The purpose of these trapping efforts was to fulfill a broader set of objectives in the Russian River Biological Opinion than what is described in the current section of this report.

Mark West Creek

A pipe trap was installed on Mark West Creek approximately 4.8 km upstream of the mouth on April 28. The pipe trap was removed and all trapping operations were suspended on June 17 when fish captures declined rapidly (Table 4.5.1).

Mark West Creek: Pipe trap (fished 4/27-6/17).

Dutch Bill Creek: Funnel net (3/9-3/16).

Austin Creek: Funnel trap (fished 4/21-4/24, 5/20-6/4), pipe trap (fished 4/25-5/19, 6/5-6/12).

Figure 4.5.3. Photographs of downstream migrant traps operated by the Sonoma Water (Mark West, Dutch Bill and Austin creeks). See the Russian River Biological Opinion Status and Data Report year 2020-2021 for details regarding operation of the Mirabel and Dry Creek traps.

Table 4.5.1. Installation and removal dates, and total number of days fished for lower Russian River monitoring sites operated by Sonoma Water in 2020.

Monitoring site (gear type)	Installation date	Removal date	Number of days fished
Dry Creek (DSMT)	4/24	7/28	87
Mirabel (DSMT)	4/21	6/15	56
Mark West Creek (DSMT)	4/28	6/17	44
Dutch Bill Creek (DSMT)	3/9	6/6	64
Austin Creek (DSMT)	4/21	6/12	52
Duncans Mills (PIT antenna array)[1]	Continuous	Continuous	Continuous

[1]See text for details on changes to PIT antenna array throughout the season.

Dutch Bill Creek

A funnel net pipe was installed on Dutch Bill Creek adjacent to the park in downtown Monte Rio (approximately 0.3 km upstream of the creek mouth) on March 9. The funnel net was removed and replaced with a pipe trap on March 16 because of low water velocity. The trap was removed from the creek on March 17 due to uncertainties with staffing related to the COVID-19 pandemic. The pipe trap was reinstalled on April 13, fished until the completion of trapping operations on June 6, when stream flow in lower Dutch Bill Creek became disconnected (Table 4.5.1).

Austin Creek

A funnel net was installed in Austin Creek on April 21. Due to low water velocity this trap was changed to a pipe trap on April 25. On May 20 the trap was changed back to a funnel net because the weir associated with the pipe trap was collapsing. On June 5 the funnel net was again changed to a pipe trap due to low water velocities. Trapping continued until June 12 when surface flow in lower Austin Creek was no longer contiguous and daily catches of steelhead dropped to zero (Table 4.5.1).

Steelhead parr were marked with PIT tags and released upstream of the trap in order to measure trap efficiency and estimate population size of fish passing the trap site (Figure 4.5.4). Sonoma Water operated a dual PIT antenna array approximately 0.2 km downstream of the funnel trap and approximately 0.5 km upstream from the mouth of Austin Creek in order to detect PIT-tagged steelhead moving out of Austin Creek. The PIT antenna array was located at the upstream extent of the area that can be inundated by the Russian River during closure of the barrier beach; therefore, it is likely that once fish passed the antenna array they had effectively entered the Estuary/lagoon. A second PIT tag antenna array located in the Estuary at Duncans Mills (approximately 1.5 km downstream) is typically used to calculate antenna efficiency for the PIT antenna array located in Austin Creek.

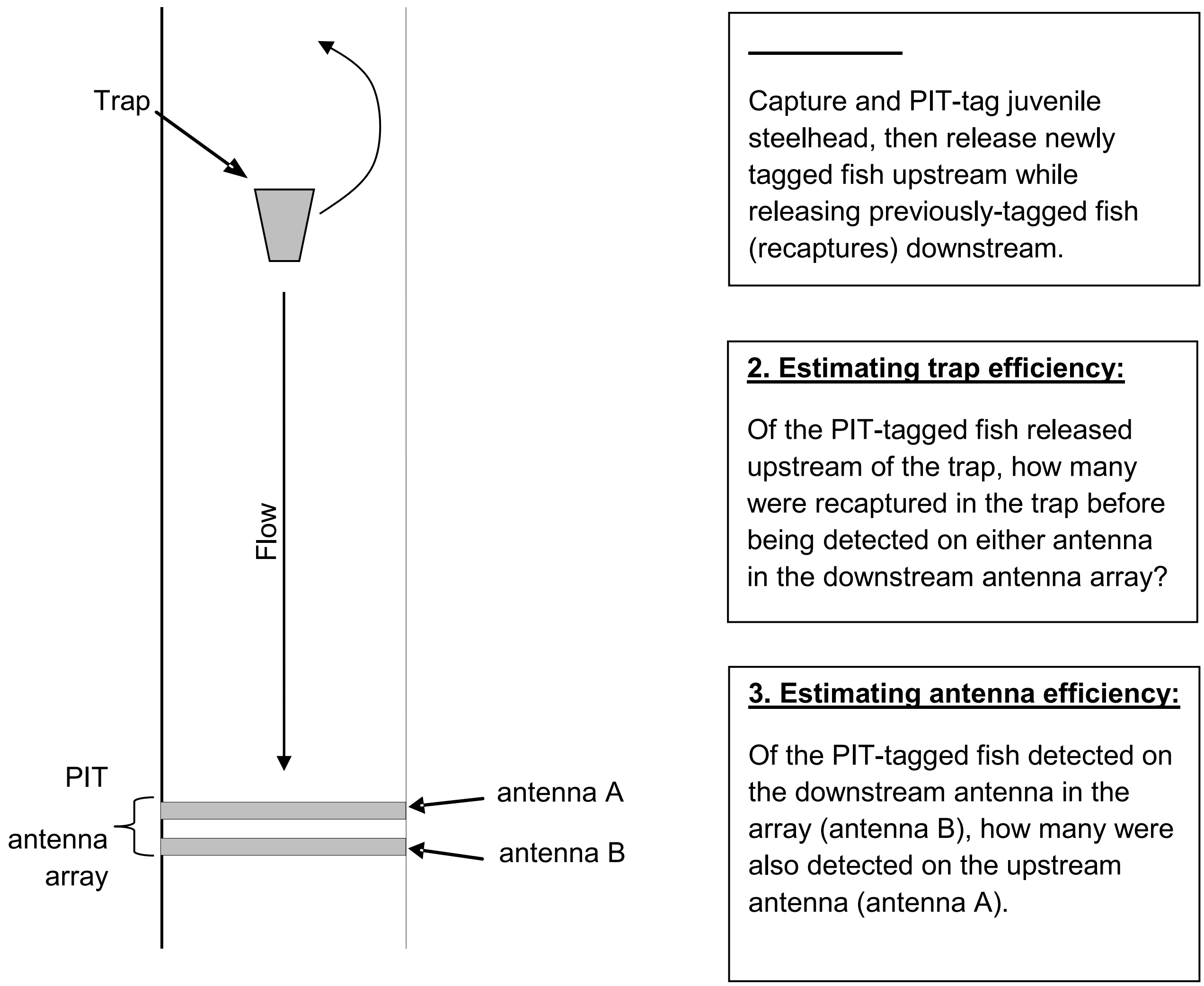


Figure 4.5.4. Diagram illustrating the relative location of the downstream migrant trap and PIT antenna array operated on Austin Creek and outline of how antenna efficiency was estimated.

Results

Stream flow largely dictates when downstream migrant traps can be installed (Figure 4.5.5). The sampling period most likely encompassed a high portion of the juvenile steelhead movement period but a substantial portion of the steelhead smolt migration period was likely missed due to the early run timing of steelhead smolts.

Steelhead

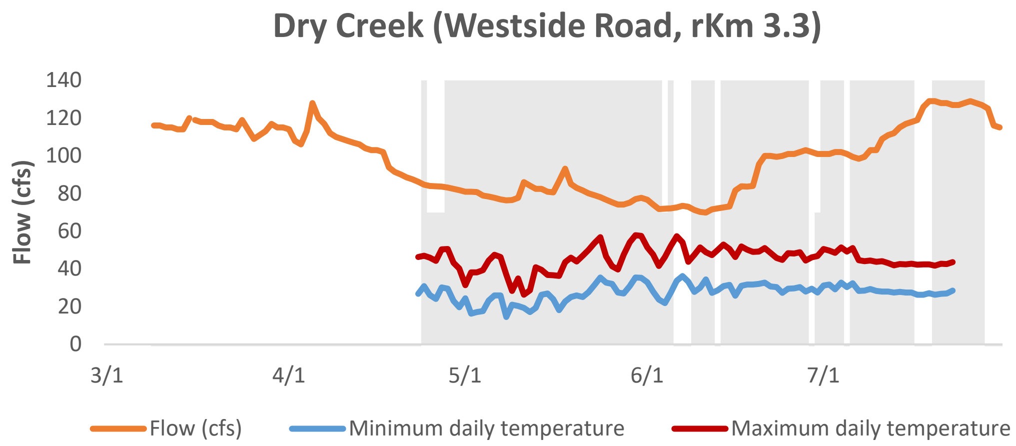
Steelhead were most frequently encountered at the Dry Creek trap compared to other downstream migrant traps (Figure 4.5.6). In total 3,370 YOY and parr, and 49 smolts were captured at the Dry Creek trap. In Austin Creek 1,387 YOY and parr and 1 smolt were captured. At Dutch Bill Creek 2,304 YOY and parr and 11 smolts were captured. At Mark West Creek 16 YOY and parr, and 15 smolts were captured. At the Mainstem Russian River trap 111 YOY and parr and 94 smolts were captured.

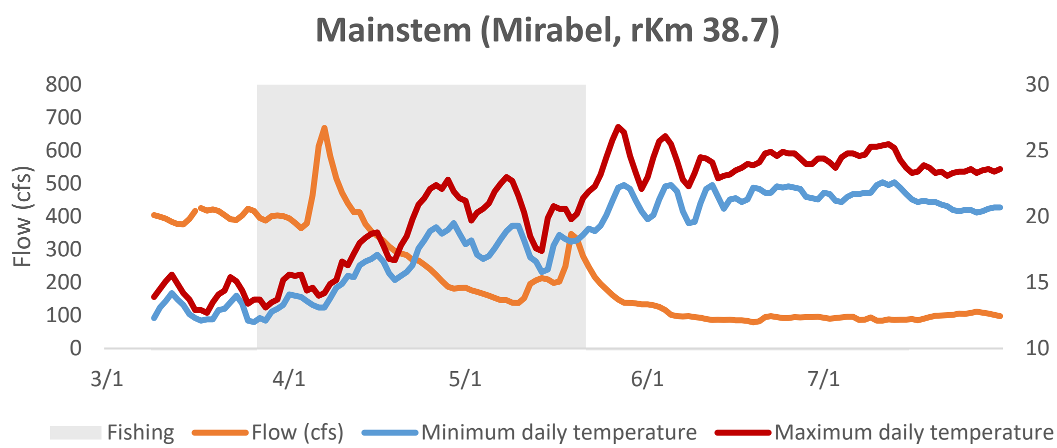
In 2020 Sonoma Water relied on the Duncans Mills PIT tag antennas for estimating the number of steelhead YOY and parr that entered the Estuary. Of the 383 juvenile steelhead that were PIT-tagged in the Austin Creek downstream migrant trap, 37 (9.7 %) were detected on the PIT antenna array at Duncans Mills (Tables 4.5.2 and 4.5.3). Reasons for non-detection include an unknown number of fish that simply did not move into the Estuary as well as fish that moved into the tidal portion of the Estuary but were not detected due to imperfect PIT antenna array detection efficiency at Duncans Mills.

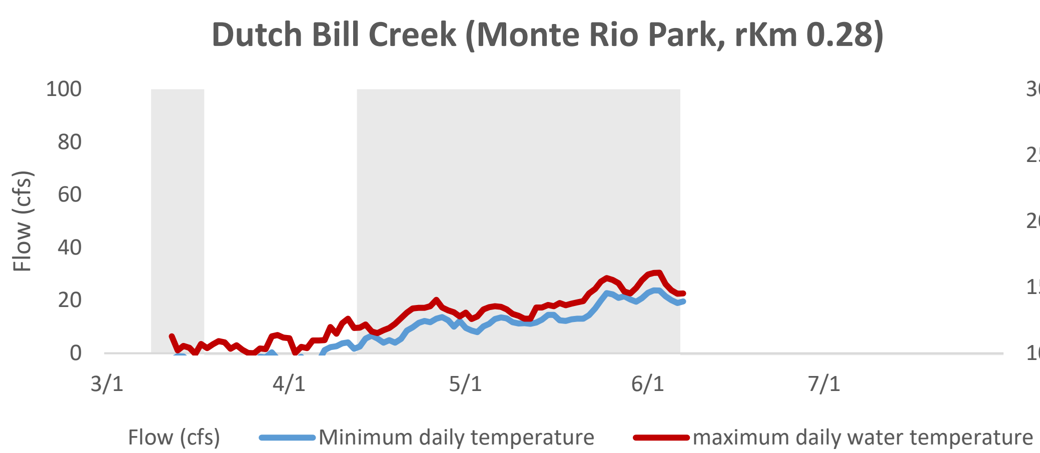
Over the course of the season, 1,387 steelhead were captured at Austin Creek of which 603 were YOY (344 of the 603 YOY were ≥60 mm, Figure 4.5.7). Although Sonoma Water applied PIT tags to 383 total individuals (YOY+parr), based on their size, 371 of these PIT-tagged fish were estimated to be YOY. In total, 273 PIT-tagged steelhead YOY were released upstream of the trap and 98 were released downstream of the trap (Table 4.5.4). Because 189 of the 371 PIT-tagged YOY were detected on the Austin Creek PIT antenna array downstream of the trap, at least 50% (189/371) moved downstream into the Estuary/lagoon. Because of imperfect antenna detection efficiency, those minimum counts that were based only on PIT-tagged YOY were expanded to the entire population of YOY in the vicinity of the Austin Creek trap (both tagged and untagged) as follows.

Of the 37 PIT tagged individuals (YOY+parr) detected on the downstream antenna in the array (Duncans Mills), 31 were also detected on the upstream antenna array (Austin Creek) resulting in an estimated antenna efficiency of 84% (31/37). In order to estimate the number of YOY out of the original 189 that actually moved downstream of the Austin Creek antenna array, this proportion was used to expand the detections to 225.

In total 127 YOY that were detected on either of the downstream PIT antenna arrays were also released upstream of the trap, however only 5 were recaptured in the trap. Because so few steelhead were recaptured in the trap a population estimate were not calculated. When compared to Austin and Dry Creeks fewer numbers of juvenile steelhead were captured at the mainstem Russian River and Mark West Creek (Figure 4.5.6) resulting in fewer numbers of juvenile steelhead were PIT-tagged at these locations (Table 4.5.3). Fork lengths of


Dry Creek (Westside Road, rKm 3.3)
Flow (cfs)
Temperature (°C)
140
120
100
80
60
40
20
0
30
25
20
15
10
3/1
4/1
5/1
6/1
7/1
Flow (cfs)
Minimum daily temperature
Maximum daily temperature


Mainstem (Mirabel, rKm 38.7)
Flow (cfs)
Temperature (°C)
800
700
600
500
400
300
200
100
0
30
25
20
15
10
3/1
4/1
5/1
6/1
7/1
Fishing
Flow (cfs)
Minimum daily temperature
Maximum daily temperature


Dutch Bill Creek (Monte Rio Park, rKm 0.28)
Flow (cfs)
Temperature (°C)
100
80
60
40
20
0
30
25
20
15
10
3/1
4/1
5/1
6/1
7/1
Flow (cfs)
Minimum daily temperature
maximum daily water temperature

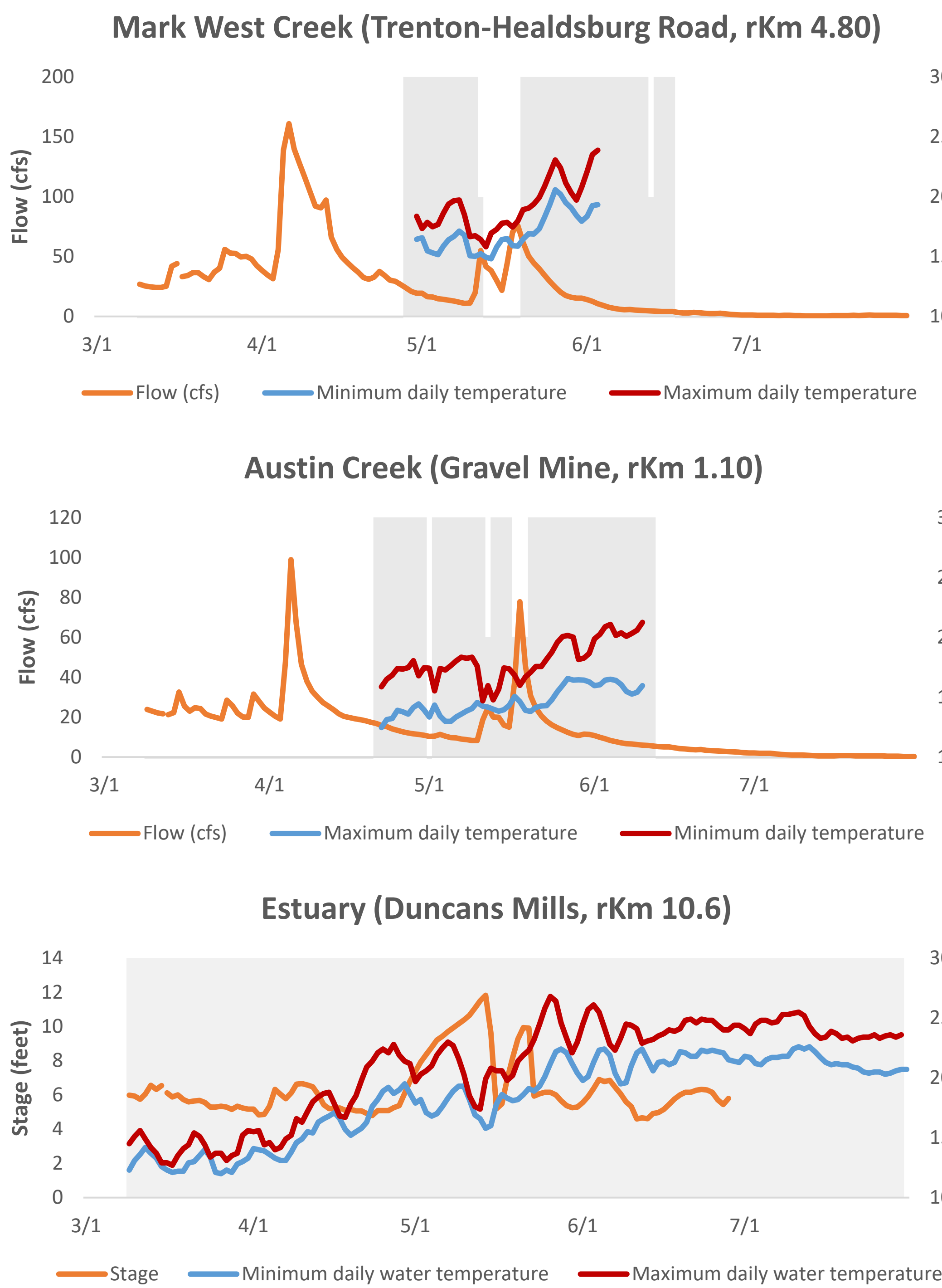
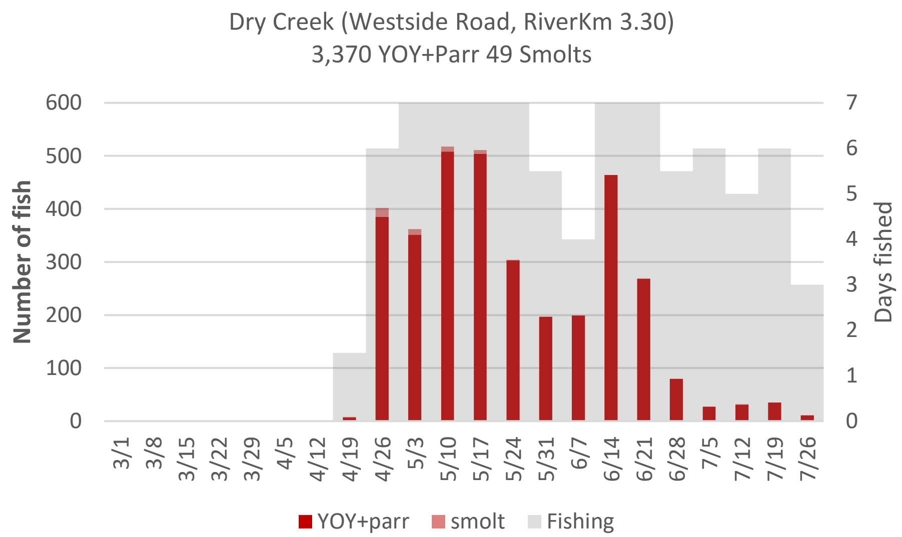
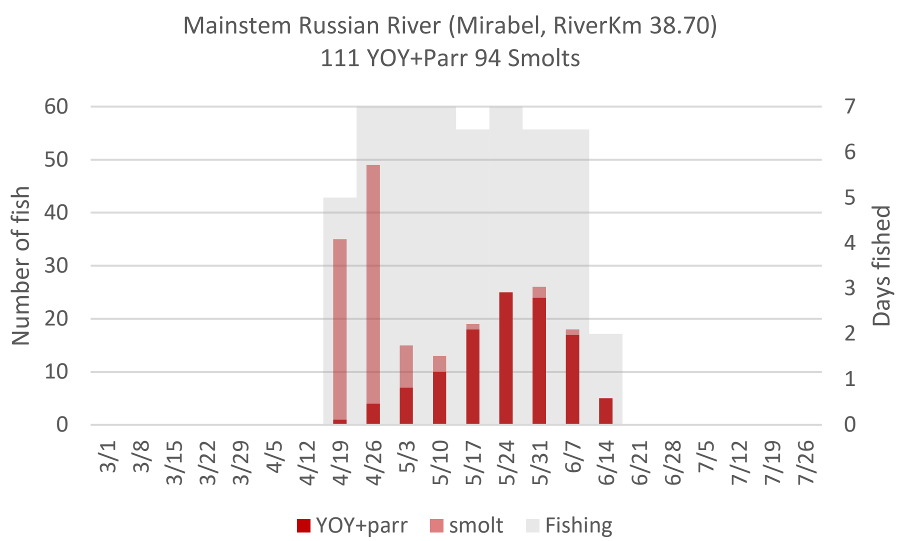
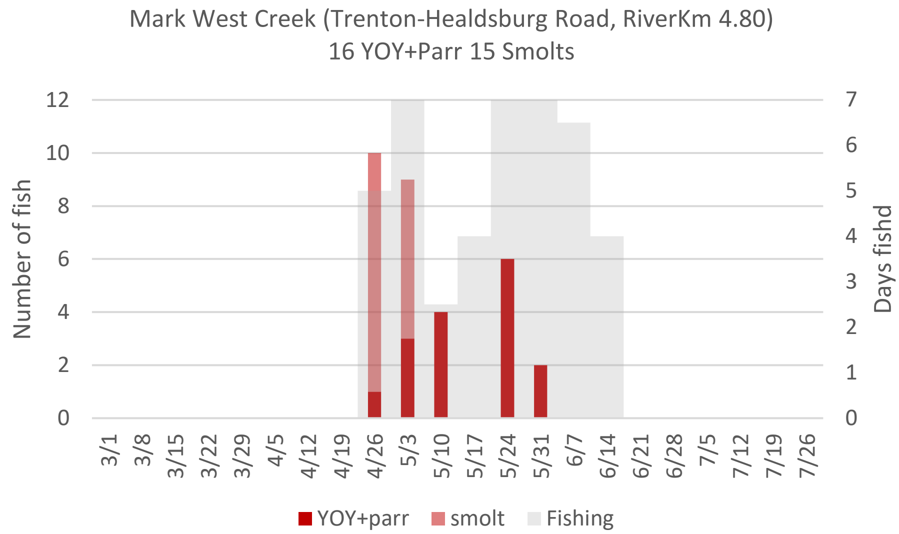
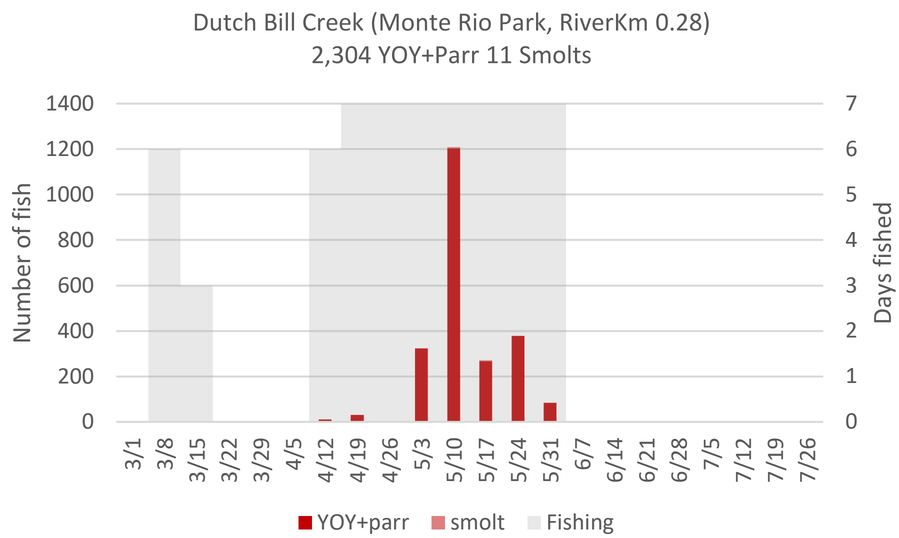


Figure 4.5.5. Environmental conditions at downstream migrant detection sites from March 1 to July 31, 2020. Gray shading indicates the proportion of each day that each facility was operated. Discharge data are from the USGS gage at Healdsburg (mainstem Russian, 11464000), the USGS gage at Trenton-Healdsburg Road (Mark West Creek, 11466800), a gage operated by CMAR on Dutch Bill Creek (data unavailable in 2020) and the USGS gauge at Cazadero (Austin Creek, 11467200). Stage (max daily) data for the Estuary are from the USGS gage near Highway 1 (11467270). Estuary and Mainstem water temperature data are from the USGS Hacienda gage (11467000) approximately 20 river Km upstream of the Estuary. At all other sites temperature data are from the data loggers operated by Sonoma Water at each monitoring site.


Dry Creek (Westside Road, RiverKm 3.30)
3,370 YOY+Parr 49 Smolts
Number of fish
Days fished
600
500
400
300
200
100
0
7
6
5
4
3
2
1
0
3/1
3/8
3/15
3/22
3/29
4/5
4/12
4/19
4/26
5/3
5/10
5/17
5/24
5/31
6/7
6/14
6/21
6/28
7/5
7/12
7/19
7/26
YOY+parr
smolt
Fishing


Mainstem Russian River (Mirabel, RiverKm 38.70)
111 YOY+Parr 94 Smolts
Number of fish
Days fished
60
50
40
30
20
10
0
7
6
5
4
3
2
1
0
3/1
3/8
3/15
3/22
3/29
4/5
4/12
4/19
4/26
5/3
5/10
5/17
5/24
5/31
6/7
6/14
6/21
6/28
7/5
7/12
7/19
7/26
YOY+parr
smolt
Fishing


Mark West Creek (Trenton-Healdsburg Road, RiverKm 4.80)
16 YOY+Parr 15 Smolts
Number of fish
Days fishd
0
2
4
6
8
10
12
0
1
2
3
4
5
6
7
3/1
3/8
3/15
3/22
3/29
4/5
4/12
4/19
4/26
5/3
5/10
5/17
5/24
5/31
6/7
6/14
6/21
6/28
7/5
7/12
7/19
7/26
YOY+parr
smolt
Fishing


Dutch Bill Creek (Monte Rio Park, RiverKm 0.28)
2,304 YOY+Parr 11 Smolts
Number of fish
Days fished
0
200
400
600
800
1000
1200
1400
0
1
2
3
4
5
6
7
3/1
3/8
3/15
3/22
3/29
4/5
4/12
4/19
4/26
5/3
5/10
5/17
5/24
5/31
6/7
6/14
6/21
6/28
7/5
7/12
7/19
7/26
YOY+parr
smolt
Fishing

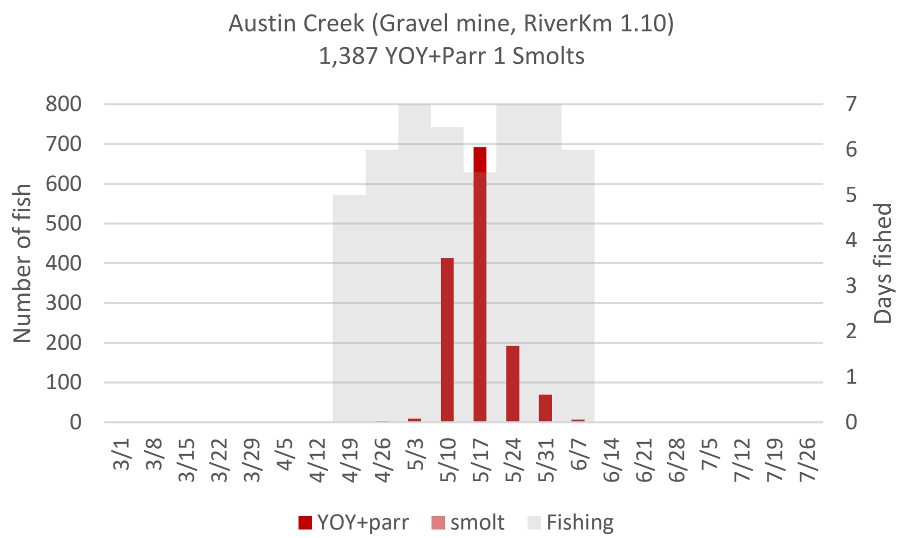


Figure 4.5.6. Weekly capture of steelhead by life stage at lower Russian River downstream migrant trapping sites, 2020. Gray shading indicates the number of days per week that the trap was fishing. Note the different vertical scale among plots for each site.

Table 4.5.2. Number of steelhead juveniles PIT-tagged at downstream migrant traps, 2009-2020 (N.T. indicates that tagging steelhead was not part of the protocol for that year, a dash indicates the trap was not operated).

Site	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Dry Creek	N.T.	N.T.	N.T.	N.T.	2,703	1,348	N.T.	N.T.	N.T.	N.T.	N.T.	N.T
Mainstem	5	96	99	315	100	101	-	-	1	63	40	46
Mark West Creek	-	-	-	43	135	18	19	546	49	62	125	14
Dutch Bill Creek	-	46	22	6	12	21	7	46	377	12	74	176
Austin Creek	-	996	500	1,636	1,749	590	107	1,205	359	780	172	383
Total	**5**	**1,138**	**621**	**2,000**	**4,699**	**2,078**	**133**	**1,797**	**791**	**917**	**411**	**618**

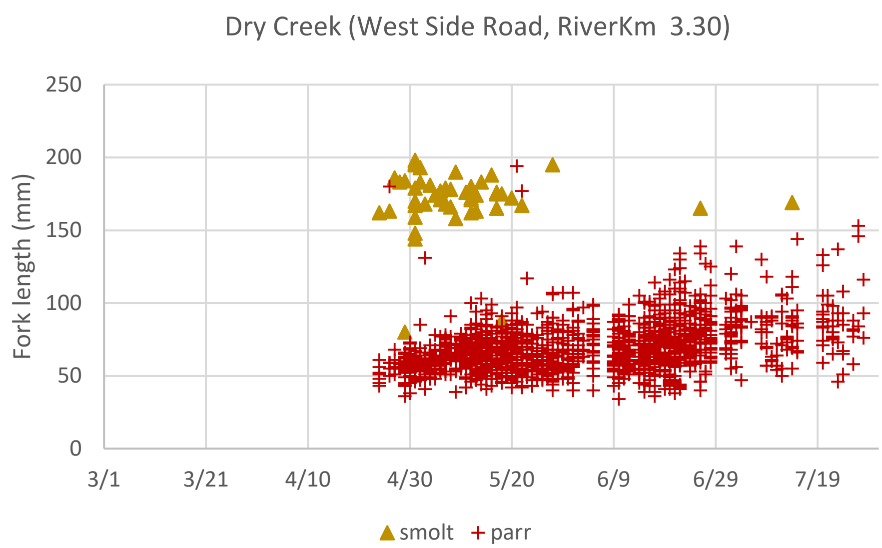
Table 4.5.3. The number of steelhead captured at downstream migrant traps, the number PIT tagged and the number detected on the Duncans Mills PIT tag detection systems before October 15, 2020.

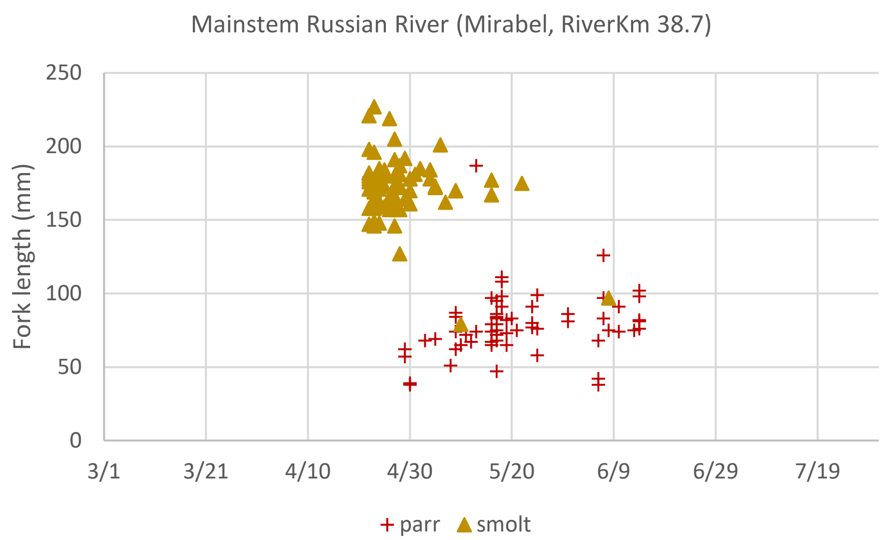
Site	Number Captured	Number PIT-Tagged	Number (proportion) Detected at Duncans Mills
Mainstem	204	46	0 (0)
Mark West Creek	31	14	0 (0)
Dutch Bill Creek	2,281	176	9 (0.05)
Austin Creek	1,377	382	37 (0.10)
Total	3,893	618	45 (0.07)

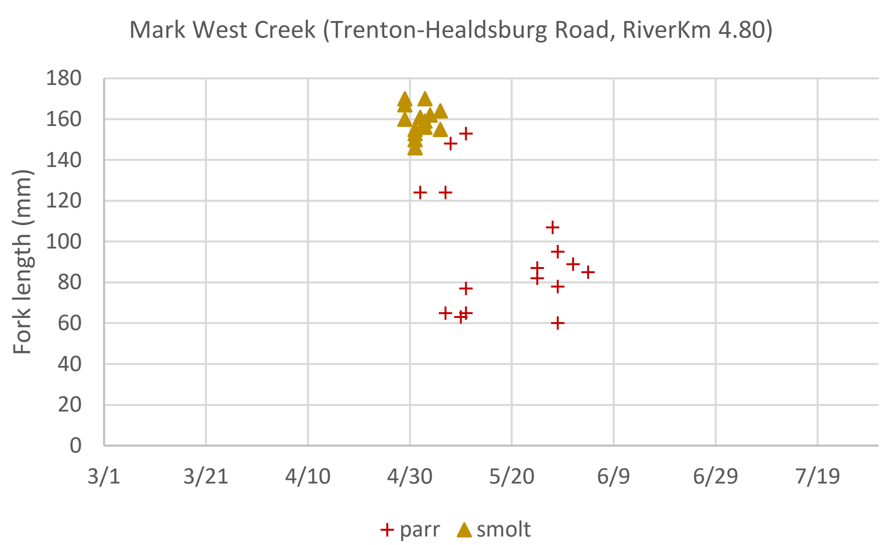
Table 4.5.4. PIT tag and trap capture metrics and values for young-of-year (YOY) steelhead in Austin Creek. Note that 2010 numbers differ from Martini-Lamb and Manning (2011) because they have been adjusted to only include YOY.

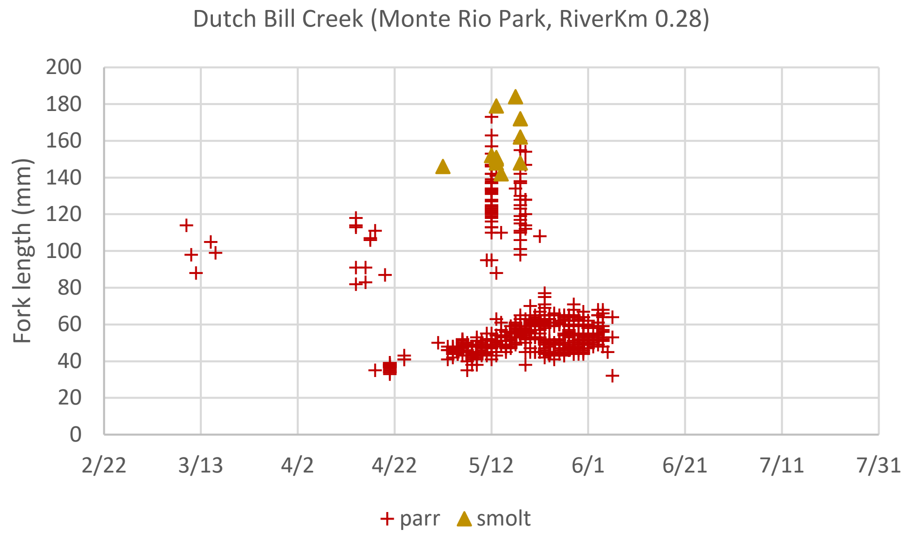
Metric	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Number pit-tagged YOY released upstream of trap	765	324	1,356	0	214	101	1,132	244	713	128	273
Number pit-tagged YOY released downstream of trap	195	2	162	1,746	269	6	73	2	6	7	98
Number pit-tagged YOY detected on antenna array that were tagged in Austin creek	547	131	574	1,335	275	13	193	80	291	53	189
Number pit-tagged YOY released upstream & detected on antenna array	389	131	486	0	57	13	151	80	291	49	127
Number released upstream & recaptured in trap & detected on antenna	47	8	196	0	2	0	60	0	61	3	5
Estimated trap efficiency	**12.1%**	**6.1%**	**40.3%**	**N/A**	**N/A**	**N/A**	**39.7%**	**N/A**	**21.0%**	**5.7%**	**N/A**
Number YOY+parr detected on both antennas in array	241	93	85	399	129	34	76	52	60	64	31
Number YOY+parr detected on downstream antenna only	288	178	129	463	162	35	205	55	75	71	37
Estimated antenna efficiency	**83.6%**	**52.2%**	**65.9%**[1]	**86.2%**[1]	**79.6%**[1]	**97.1%**	**37.1%**[1]	**94.5%**	**80%**[1]	**90.1%**	**83.7%**
Number YOY captured and pit-tagged	960	324	1,518	1,746	483	42	993	319	719	168	371
Total number of YOY captured (≥60 mm only)	2,617	453	2,341	4,216	541	42	2,427	319	2,056	368	344
Estimated number of pit-tagged YOY emigrants (≥60 mm only)	**632**	**251**	**759**	**1,549**	**325**	**32**	**520**	**55**	**93**	**138**	**225**
Estimated proportion of pit-tagged YOY that emigrated (≥60 mm only)	**65.8%**	**77.5%**	**50%**	**88.5%**	**67.3%**	**76.2%**	**46.0%**	**17.2%**	**40.5%**	**38%**	**50%**
Estimated population size of YOY at trap	**21,628**	**7,426**	**5,804**	**N/A**	**N/A**	**N/A**	**6,113**	**N/A**	**9,791**	**6,456**	**N/A**
Estimated number of YOY in population that emigrated	**14,231**	**5,755**	**2,901**	**N/A**	**N/A**	**N/A**	**2,812**	**N/A**	**3,965**	**2,453**	**N/A**

[1]Efficiency is based on detections of PIT-tagged fish at Duncans Mills.


Dry Creek (West Side Road, RiverKm 3.30)
Fork length (mm)
250
200
150
100
50
0
3/1
3/21
4/10
4/30
5/20
6/9
6/29
7/19
smolt
parr


Mainstem Russian River (Mirabel, RiverKm 38.7)
Fork length (mm)
250
200
150
100
50
0
3/1
3/21
4/10
4/30
5/20
6/9
6/29
7/19
parr
smolt


Mark West Creek (Trenton-Healdsburg Road, RiverKm 4.80)
Fork length (mm)
180
160
140
120
100
80
60
40
20
0
3/1
3/21
4/10
4/30
5/20
6/9
6/29
7/19
parr
smolt



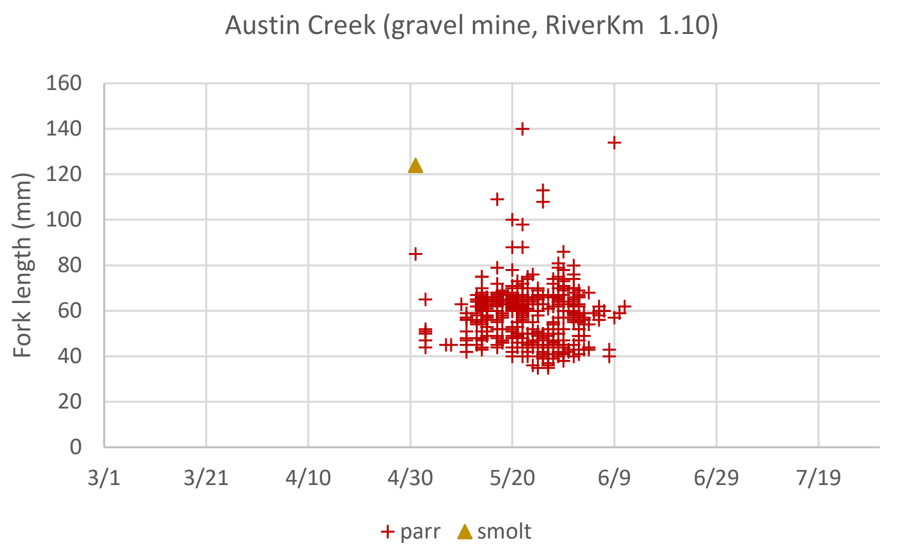


Figure 4.5.7. Weekly fork lengths of steelhead captured at lower Russian River downstream migrant trap sites, 2020.

fish caught at these traps show at least 3 year classes with steelhead YOY present at each of the trapping locations (Figure 4.5.7). As in other years, the low number of steelhead smolts captured at the trap sites was likely due to a large portion of the smolt outmigration occurring before trap installation and the generally low trap efficiencies for steelhead smolts that is well-documented in the Russian River and elsewhere.

Coho Salmon

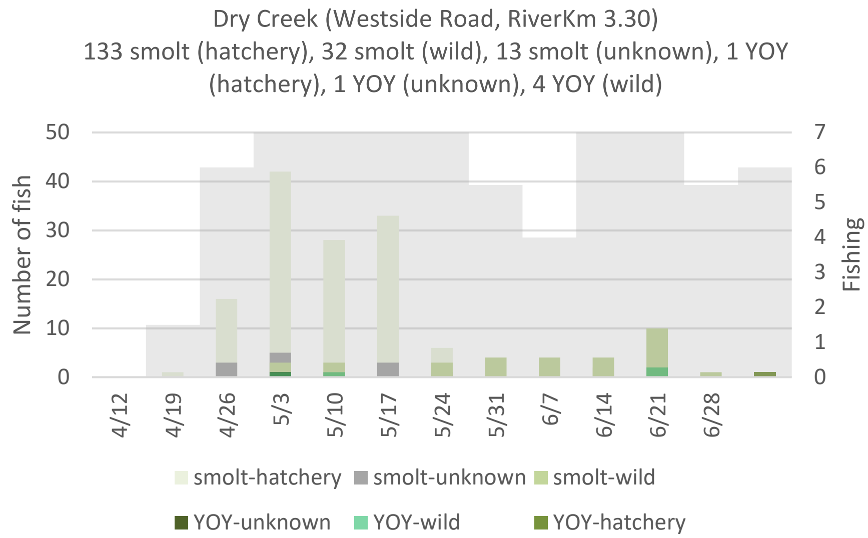
The capture of coho salmon varied at the five downstream migrant traps along the Russian River and tributaries in 2020 (Figure 4.5.8). At Dry Creek 133 hatchery smolts, 32 wild smolts, 1 hatchery YOY, 1 YOY of unknown origin, and 4 wild YOY were detected at the trap. On the mainstem Russian River 599 hatchery smolts, 16 wild smolts, 24 wild YOY, and 73 smolts of unknown origin were detected at the trap. At Mark West Creek, 465 hatchery smolts, 14 wild smolts, and 65 smolts of unknown origin were captured. A total of 1,835 hatchery smolts, 487 smolt of unknown origin, 224 wild smolts, 2 wild YOY and 2 YOY of unknown origin were captured at the Dutch Bill Creek trap. At Austin Creek, 59 hatchery smolts, 10 wild smolts, 1 YOY of unknown origin, and 31 wild YOY were captured. Based on length data collected at the lower Russian River traps, there were at least two age groups (YOY: age-0 and parr/smolt: ≥age-1) of coho captured (Figure 4.5.9). For a more detailed analysis of downstream migrant trapping catches of coho salmon from other Russian River streams see UCCE Coho Salmon Monitoring Program results for 2020.

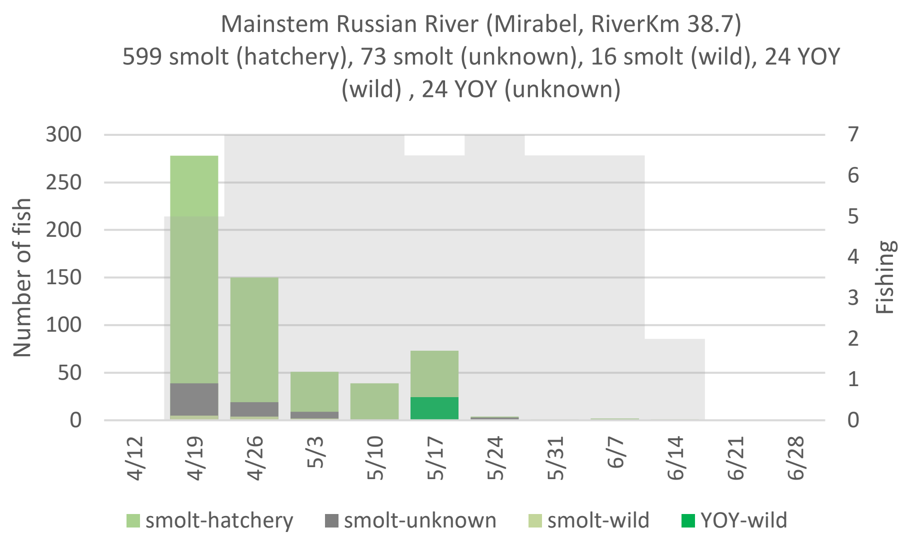
Chinook Salmon

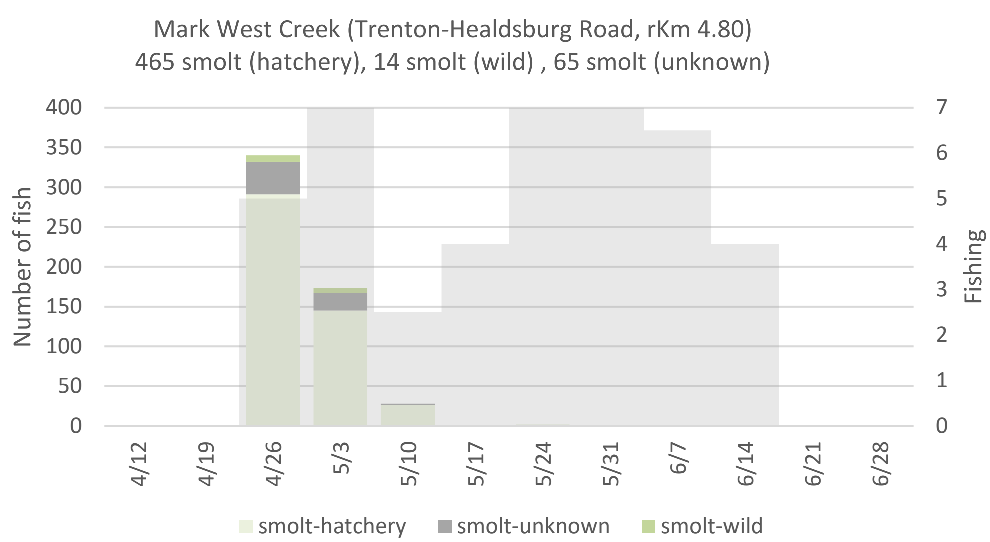
In 2020 relatively few Chinook smolts were captured in Austin Creek, Dutch Bill Creek, and Mark West Creek (0, 0, and 2 respectively). In the mainstem Russian River 3,837 Chinook smolts were captured (Figure 4.5.10). Fork lengths of Chinook increased over the course of the trapping season (Figure 4.5.11). A total of 1,407 Chinook salmon smolts were marked with fin clips and released upstream of the trap. Of these, 24 (1.7 percent) were recaptured. Because so few fish were recaptured we chose not to construct a population estimate Chinook smolts at the mainstem trap. For more details on characteristics of Chinook smolts captured at Dry Creek see the Russian River Biological Opinion Status and Data Report year 2020-2021.

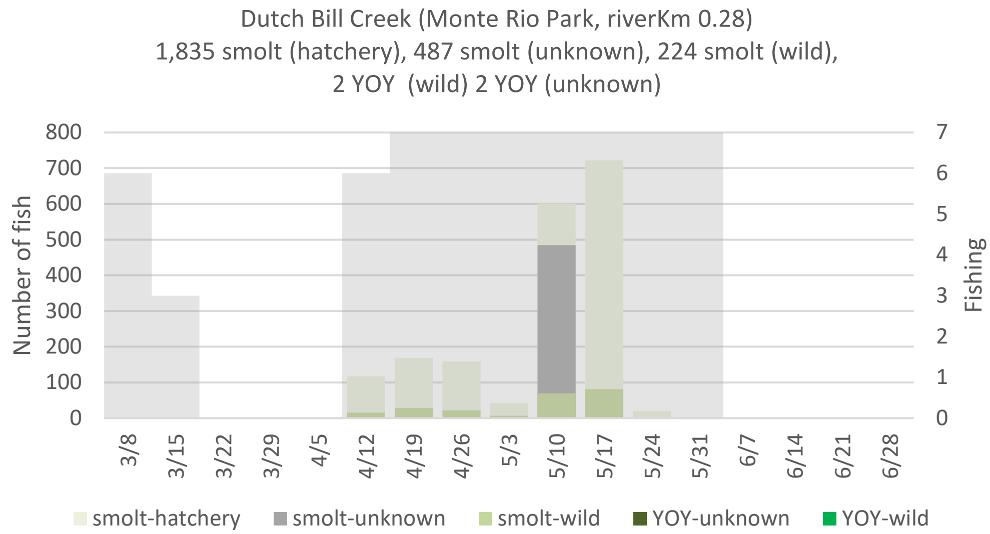
Conclusions and Recommendations

Russian River Biological Opinion objectives regarding the timing of Estuary entry are partially met by using PIT tag detections from the paired antenna array in lower Austin Creek where antenna efficiency estimates are possible and where fish moving past that array have effectively entered the Estuary. In 2020, as in past years, many steelhead YOY were detected leaving Austin Creek and entering the Estuary. This same pattern was not seen at the other tributary monitoring sites. Austin Creek has a large amount of spawning habitat in the lower portions of the creek, but this section of creek often becomes dry in the summer. More steelhead YOY may


Dry Creek (Westside Road, RiverKm 3.30)
133 smolt (hatchery), 32 smolt (wild), 13 smolt (unknown), 1 YOY (hatchery), 1 YOY (unknown), 4 YOY (wild)
Number of fish
Fishing
50
40
30
20
10
0
7
6
5
4
3
2
1
0
4/12
4/19
4/26
5/3
5/10
5/17
5/24
5/31
6/7
6/14
6/21
6/28
smolt-hatchery
smolt-unknown
smolt-wild
YOY-unknown
YOY-wild
YOY-hatchery


Mainstem Russian River (Mirabel, RiverKm 38.7)
599 smolt (hatchery), 73 smolt (unknown), 16 smolt (wild), 24 YOY (wild) , 24 YOY (unknown)
Number of fish
Fishing
300
250
200
150
100
50
0
7
6
5
4
3
2
1
0
4/12
4/19
4/26
5/3
5/10
5/17
5/24
5/31
6/7
6/14
6/21
6/28
smolt-hatchery
smolt-unknown
smolt-wild
YOY-wild


Mark West Creek (Trenton-Healdsburg Road, rKm 4.80)
465 smolt (hatchery), 14 smolt (wild) , 65 smolt (unknown)
Number of fish
Fishing
400
350
300
250
200
150
100
50
0
7
6
5
4
3
2
1
0
4/12
4/19
4/26
5/3
5/10
5/17
5/24
5/31
6/7
6/14
6/21
6/28
smolt-hatchery
smolt-unknown
smolt-wild



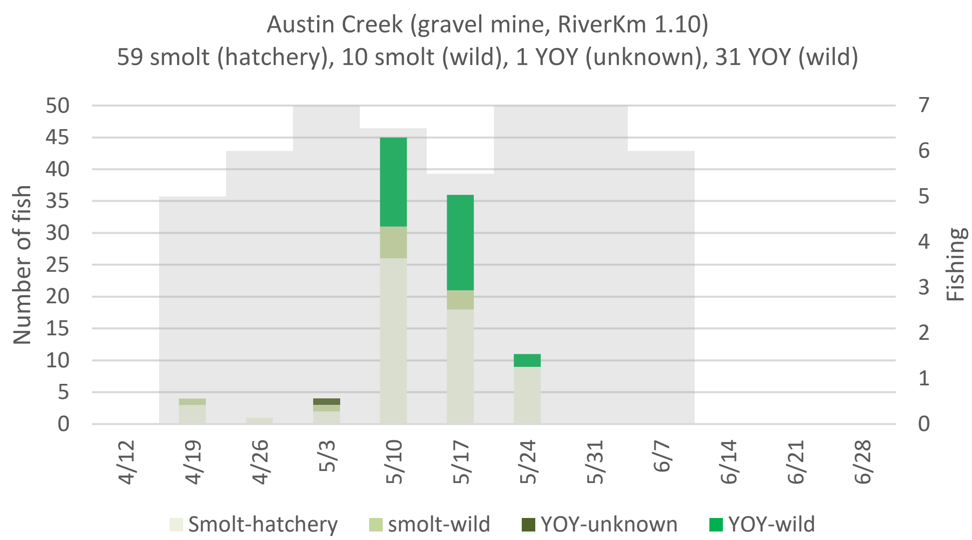
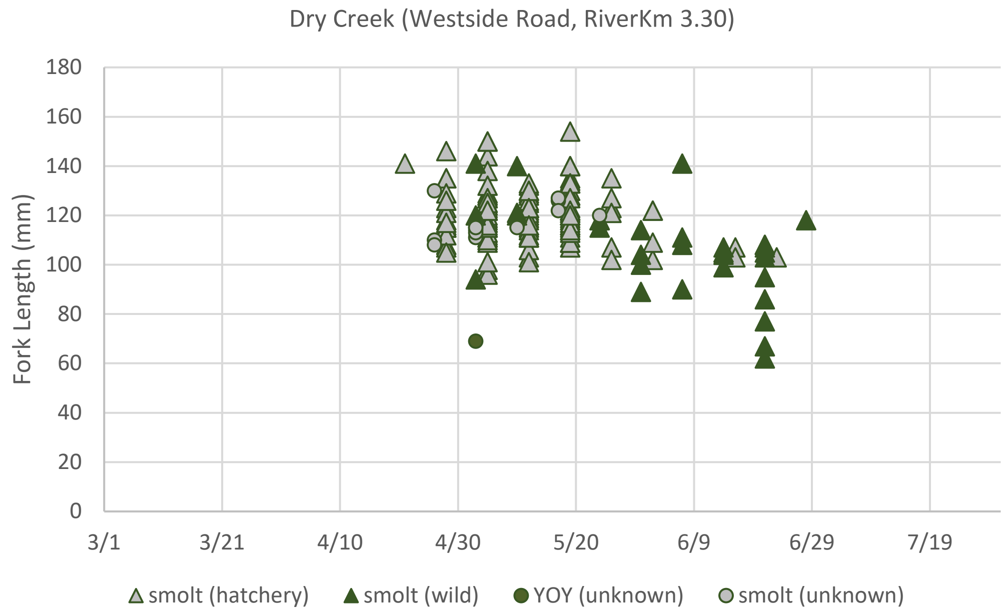
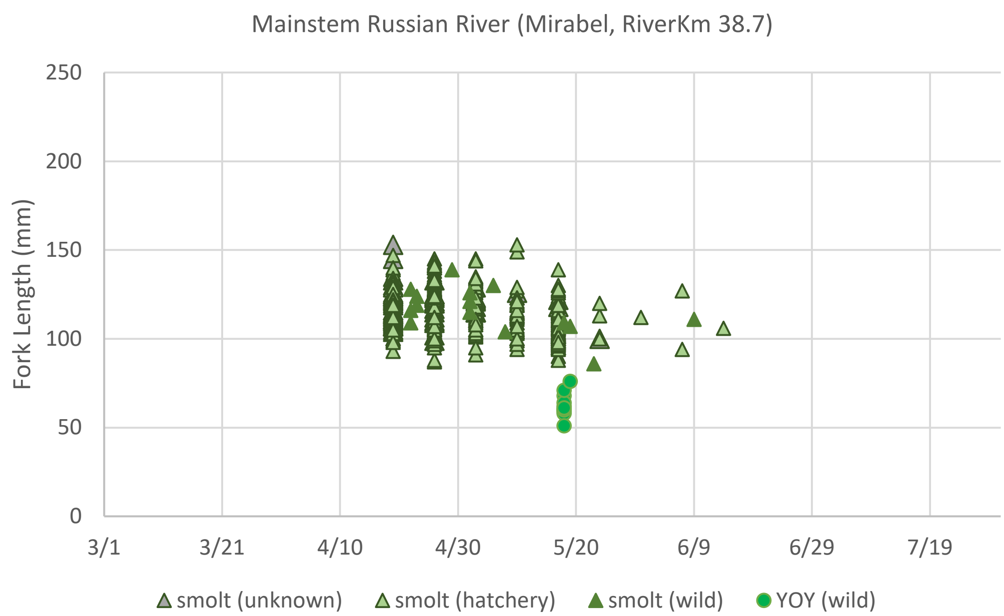
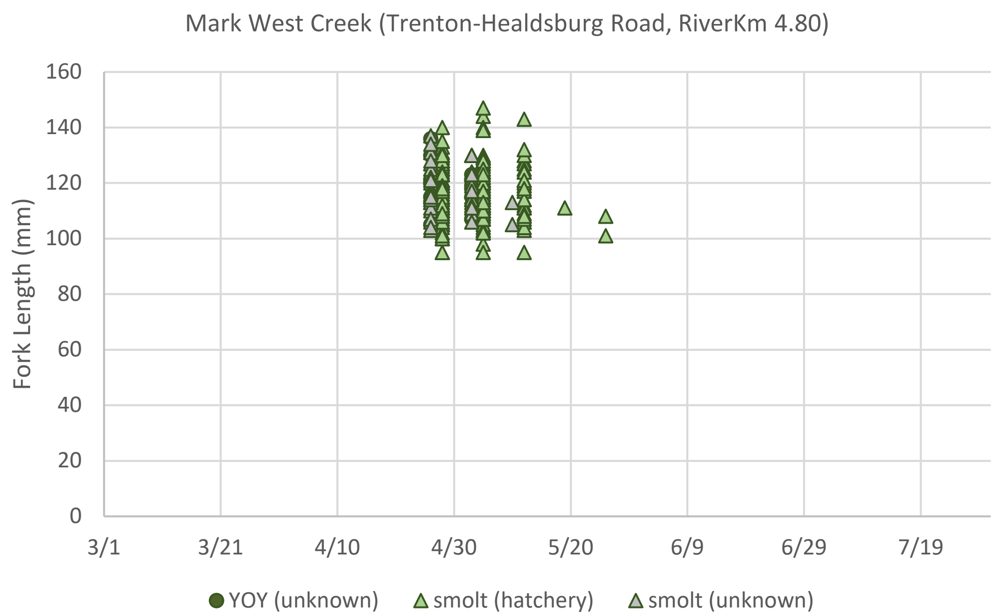
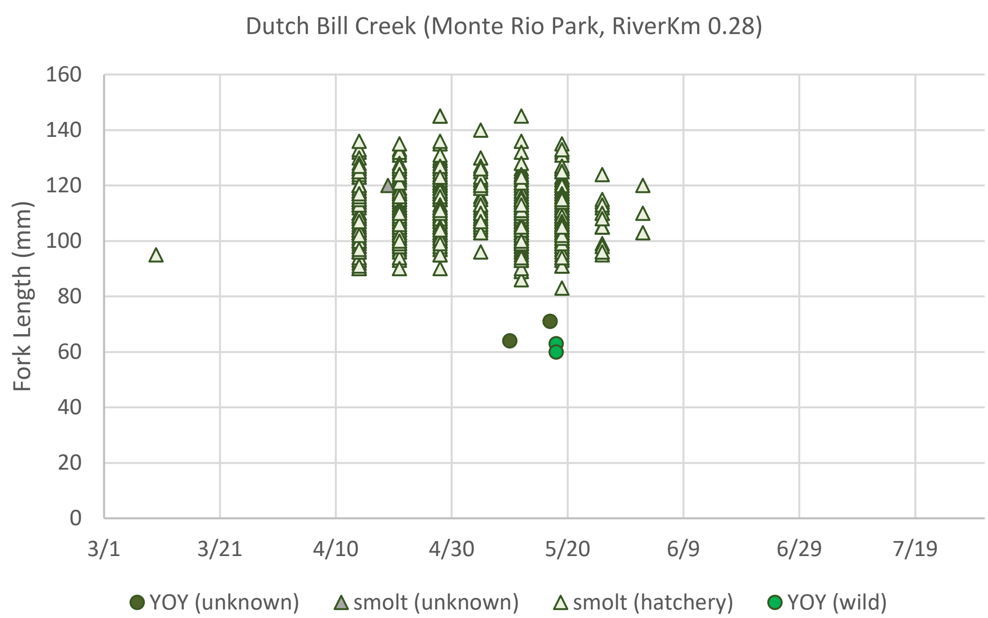


Figure 4.5.8. Weekly capture of coho salmon by life stage at lower Russian River downstream migrant trapping sites, 2020. Gray shading indicates the number of days per week that the trap was fishing. Note the different vertical scale among plots for each site.


Dry Creek (Westside Road, RiverKm 3.30)
Fork Length (mm)
180
160
140
120
100
80
60
40
20
0
3/1
3/21
4/10
4/30
5/20
6/9
6/29
7/19
smolt (hatchery)
smolt (wild)
YOY (unknown)
smolt (unknown)


Mainstem Russian River (Mirabel, RiverKm 38.7)
Fork Length (mm)
250
200
150
100
50
0
3/1
3/21
4/10
4/30
5/20
6/9
6/29
7/19
smolt (unknown)
smolt (hatchery)
smolt (wild)
YOY (wild)


Mark West Creek (Trenton-Healdsburg Road, RiverKm 4.80)
Fork Length (mm)
0
20
40
60
80
100
120
140
160
3/1
3/21
4/10
4/30
5/20
6/9
6/29
7/19
YOY (unknown)
smolt (hatchery)
smolt (unknown)


Dutch Bill Creek (Monte Rio Park, RiverKm 0.28)
Fork Length (mm)
0
20
40
60
80
100
120
140
160
3/1
3/21
4/10
4/30
5/20
6/9
6/29
7/19
YOY (unknown)
smolt (unknown)
smolt (hatchery)
YOY (wild)

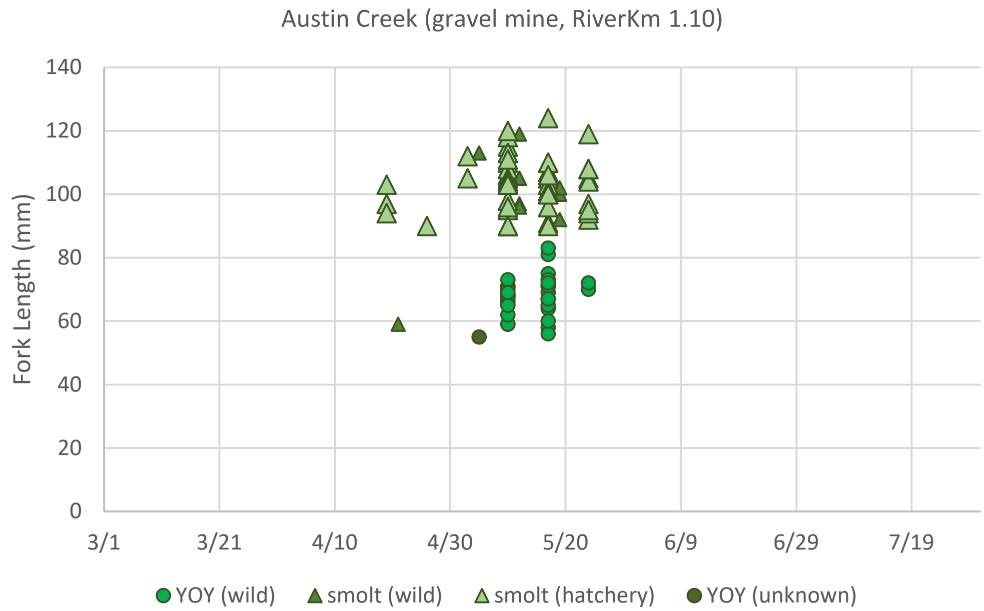


Figure 4.5.9. Weekly fork lengths of coho salmon captured at lower Russian River downstream migrant trap sites, 2020.

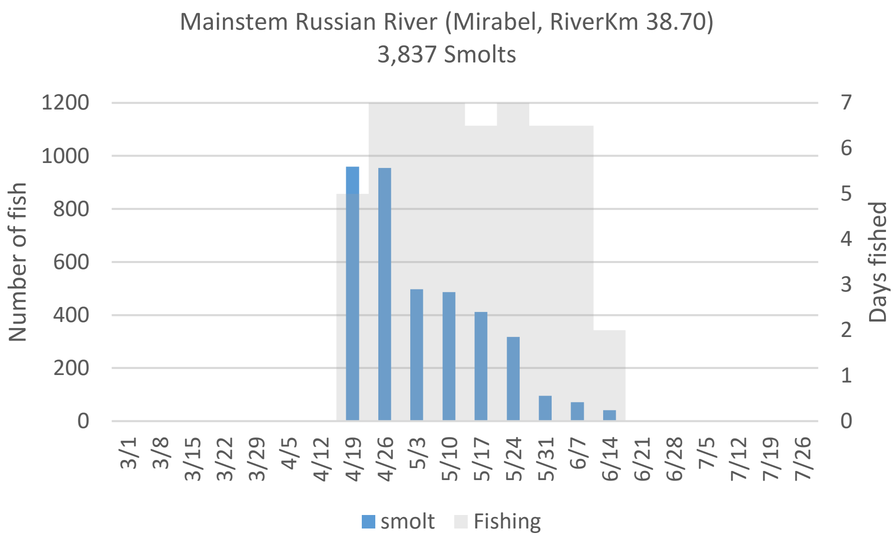


Figure 4.5.10. Weekly capture of Chinook salmon smolts at the Mirabel fish ladder on the mainstem Russian River, 2020. Gray shading indicates portion of each week trap was fishing. Note the different vertical scale among plots for each site.

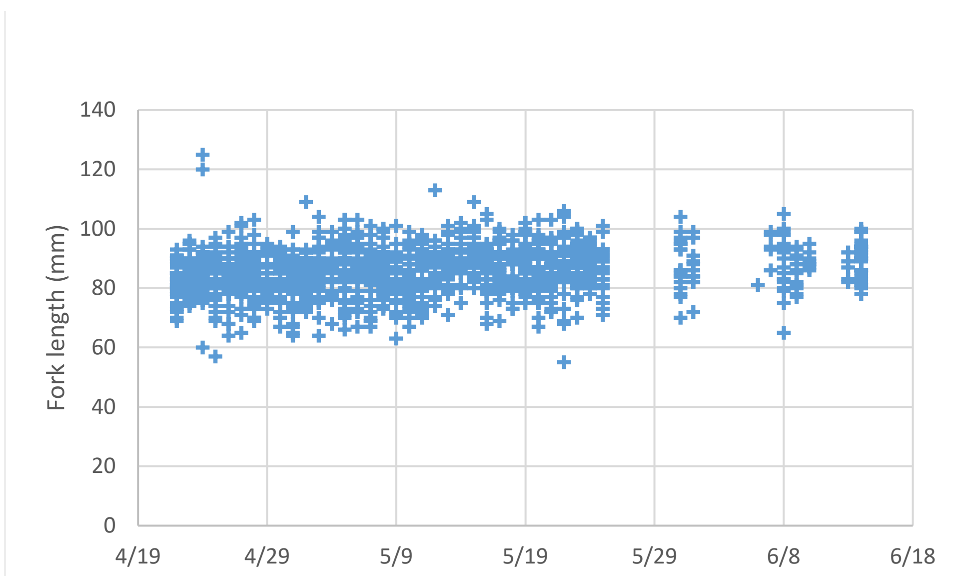


Figure 4.5.11. Weekly fork lengths of Chinook salmon captured at the Wohler Mirabel trap site on the mainstream Russian River downstream migrant trap sites, 2020.

emigrate from Austin Creek when compared to our other sample sites because more steelhead YOY may be produced in Austin Creek and opportunities to over summer in lower Austin Creek are limited.

In 2020, PIT tag detection at Austin Creek and at Duncans Mills were relied upon to estimate the number of YOY that entered the Estuary. Detections of PIT tagged fish were not guaranteed because fish orientation (PIT tags must be perpendicular to the antenna for reliable detection), and multiple PIT-tagged fish in the detection field of the same antenna at the same time can effect detection probability. While these limitations result in decreased antenna efficiency they are not of concern as long as detection efficiency can be estimated for use in expanding the number of fish detected. PIT-tagging steelhead YOY at upstream locations and detecting those individuals if and when they move into the Estuary (along with beach seining in the Estuary itself) remains the best option for addressing the fish monitoring objectives in the Russian River Biological Opinion at this time. Attempts continue to measure antenna efficiency at Duncans Mills so that expanded counts of PIT tagged individuals passing the antenna array can be constructed in future years.

In 2020 the number of steelhead captured at Dutch Bill Creek was significantly higher than in previous years. This is likely because many adult steelhead constructed redds immediately upstream of the trap site in 2020. As steelhead YOY emerged from these redds they were susceptible to capture by the Dutch Bill Creek trap. In 2020 hatchery adult steelhead were transported from the Warm Springs Hatchery and released into the lower Russian River in order to give anglers additional opportunities to capture these fish. These hatchery adult steelhead that were released in the lower Russian River may be partially responsible for the increase in the number of steelhead redds constructed immediately upstream of the Dutch Bill Creek trap.

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Chapter 5 Dry Creek Habitat Enhancement, Planning, and Monitoring

Introduction

The Biological Opinion contains a timeline that prescribes a series of projects to improve summer and winter rearing habitat for juvenile coho salmon and steelhead in Dry Creek (Figure 5.1). During the initial three years of implementation, 2008 to 2011, the Water Agency was charged with improving fish passage and habitat in selected tributaries to Dry Creek and the lower Russian River. The status of those efforts is described in previous reports (Martini-Lamb and Manning 2020). For the mainstem of Dry Creek, during this initial period, Sonoma Water was directed to perform fisheries monitoring, develop a detailed adaptive management plan, and conduct feasibility studies for large-scale habitat enhancement and a potential water supply bypass pipeline. The pipeline feasibility study was completed in 2011 and is reported in Martini-Lamb and Manning 2011.

In 2012, Sonoma Water began construction of the first phase of the Dry Creek Habitat Enhancement Demonstration Project. A second phase of the Dry Creek Habitat Enhancement Demonstration Project was constructed in 2013 with a third and final phase of the Demonstration Project constructed in 2014. The Dry Creek Habitat Enhancement Demonstration Project consists of a variety of habitat enhancement projects along a section of Dry Creek a little over one mile in length in the area centered around Lambert Bridge. Concurrently, the U.S. Army Corps of Engineers completed construction in 2013 of a habitat enhancement project on U.S. Army Corps of Engineers owned property just below Warm Springs Dam (Reach 15 area). In 2016, Sonoma Water began construction on the Dry Creek Habitat Enhancement Phase 2, Part 1 Project (centered approximately a mile upstream of the Demonstration Project) and the Dry Creek Habitat Enhancement Phase 3, Part 1 Project (centered in a lower reach area of Dry Creek just below the Westside Road Bridge crossing of Dry Creek). Construction activities for both the Phase 2, Part 1 and Phase 3, Part 1 projects were completed during the 2017 construction season. In 2018, Sonoma Water began construction of two sites (Corps of Engineers/Weinstock property site and Vala property site) of the Phase 2, Part 2 (Reach 14) habitat work. Also in 2018, the U.S. Army Corps of Engineers completed the Phase 3, Part 2 habitat work in Reach 4A. In 2019, Sonoma Water completed the remaining site (Gallo property) of the Phase 2, Part 2 habitat work in Reach 14. In 2020, Sonoma Water started construction of the Phase 3, Part 3 (Reach 5A) habitat work. Also in 2020, Sonoma Water conducted maintenance work at several of the existing habitat sites in Reaches 4A, 7, and 8 to maintain or restore habitat function. Additional sites in reaches 1, 2, 4, 5, 10, and 13 are in design for tentative construction at a future date. Figure 5.2provides an overview of the habitat sites that are completed, under construction as of 2020, tentative future sites still in design, and reach locations where maintenance occurred in 2020.

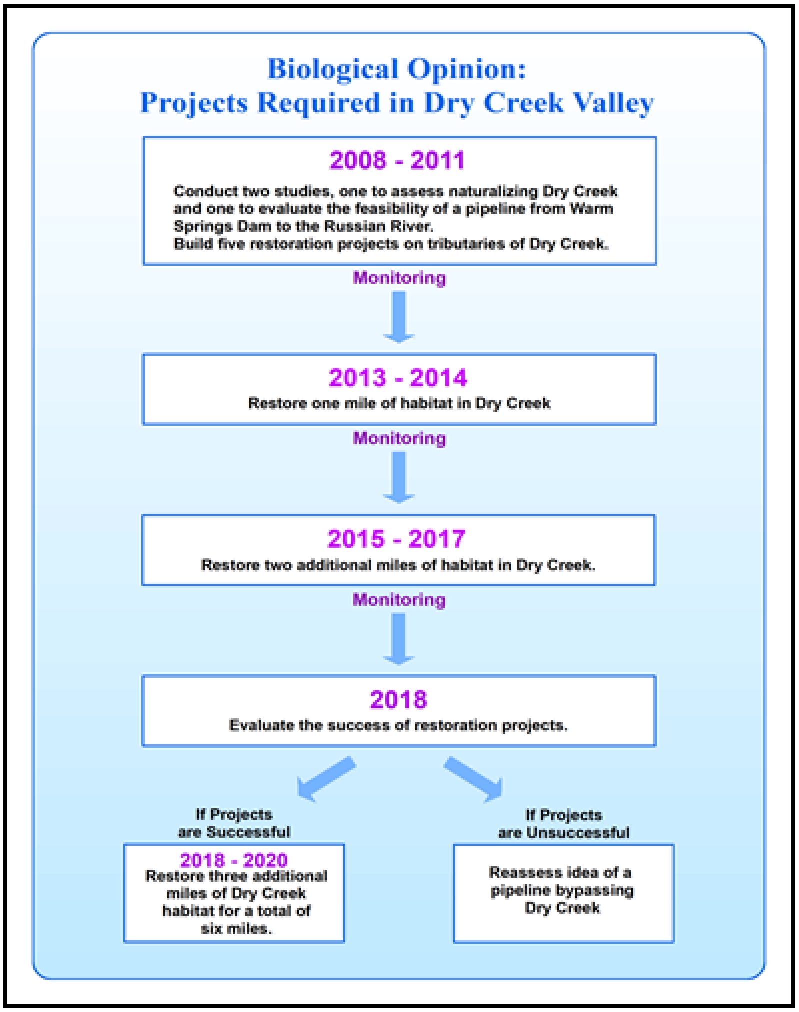


Figure 5.1. Timeline for implementation of Biological Opinion projects on Dry Creek.

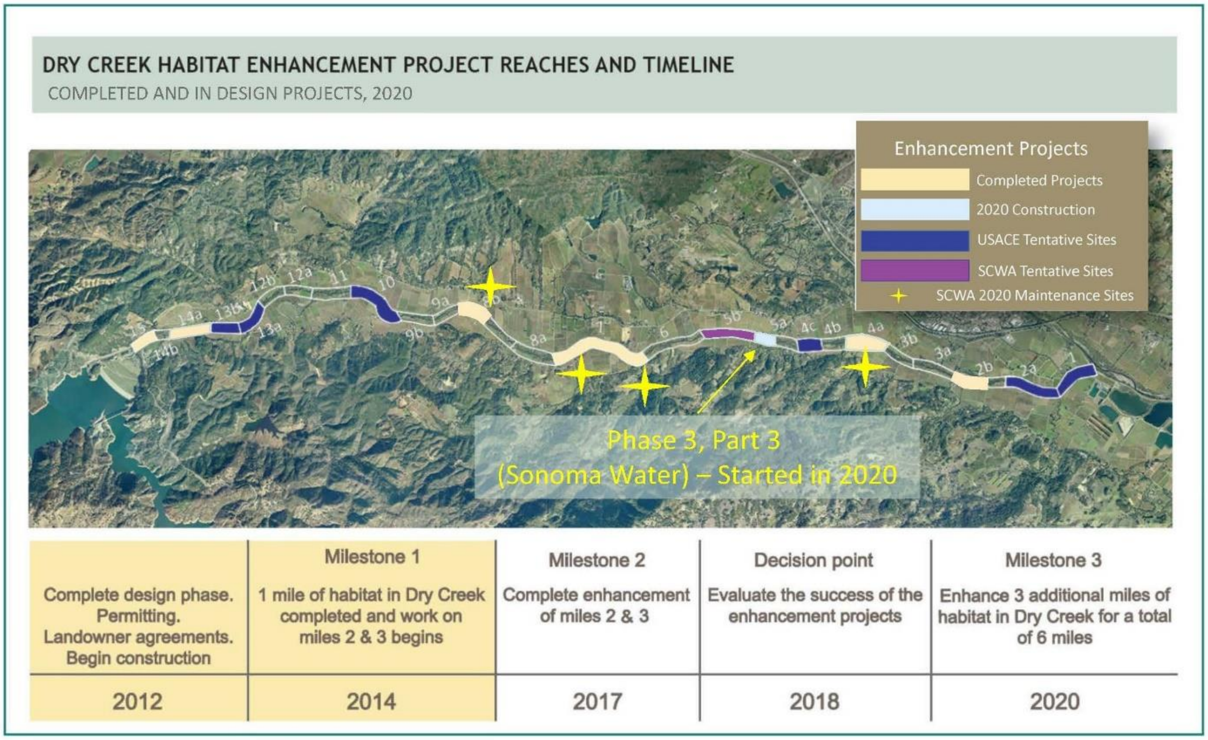


Figure 5.2. Dry Creek habitat projects constructed in 2020, tentatively planned for future construction, and existing sites maintained in 2020.

2020 Habitat Enhancement Overview

In 2020 construction was started in Reach 5A (Boaz property), which was the first part of the Phase 3 Part 3 construction. The 2020 season also saw some maintenance activities at existing habitat enhancement sites in Reach 4, Reach 7, and Reach 8. Maintenance work consisted of removal of nuisance sedimentation, repair of minor erosion within one of the sites, and vegetation planting/management. In the 2020 season, Sonoma Water staff conducted post-effective flow monitoring in previously completed reaches (Weinstock, Gallo, Truett-Hurst, Van Alyea, Farrow-Wallace, Ferrari-Carano-Olson, and City of Healdsburg-Geyser Peak) (Figure 5.3).

Of the seven habitat enhancement reaches surveyed in 2020, monitoring data resulted in 5 of those reaches rated good-excellent and 2 were rated fair (Table 5.1). One reach previously rated fair was upgraded to good (Farrow Wallace) while two reaches were downgraded from good to fair (Truett Hurst) and good to poor (City of Healdsburg) ratings after subsequent monitoring in 2019.

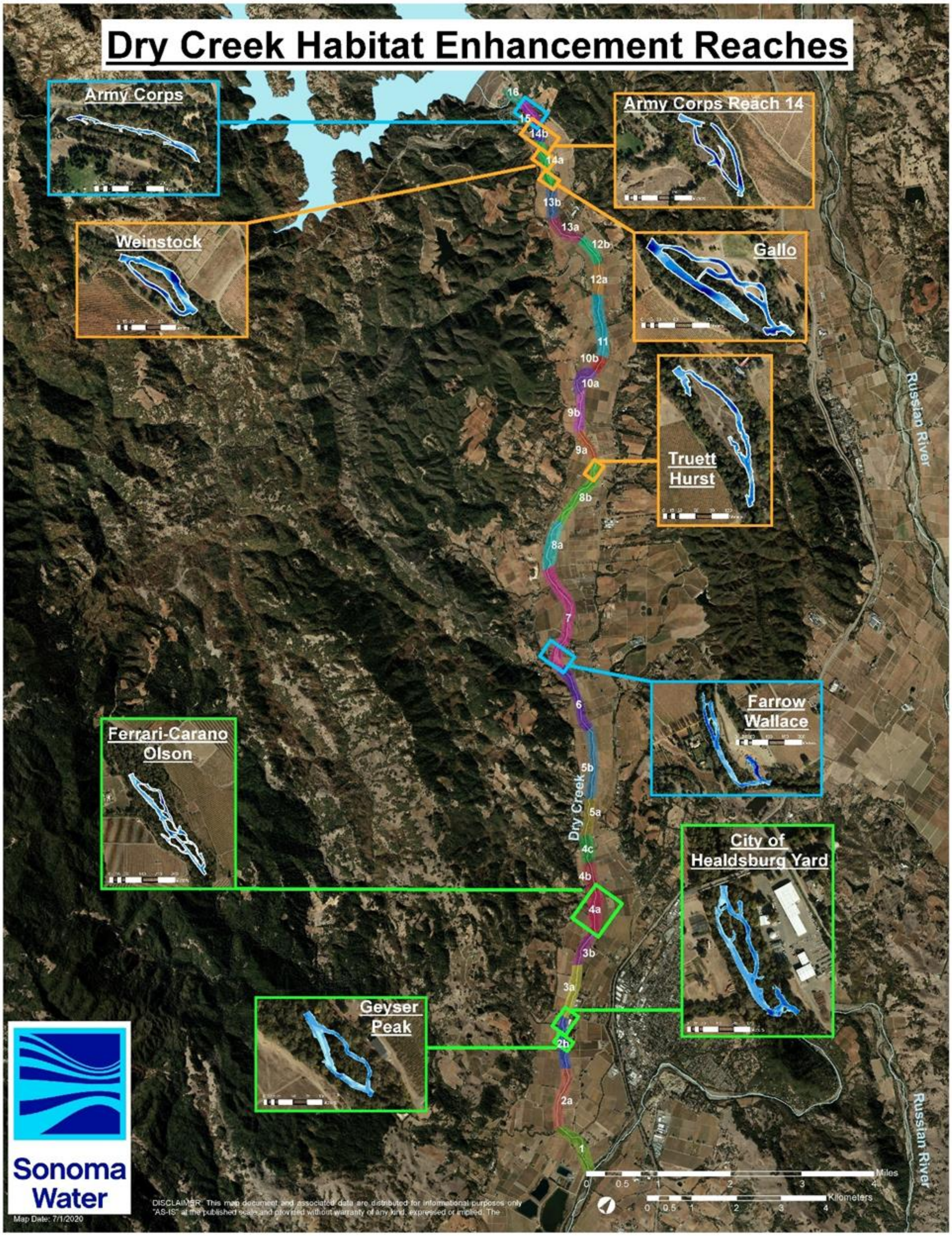


Figure 5.3. Location of Dry Creek habitat enhancement reaches monitored for effectiveness in 2019.

Table 5.1. Post-enhancement ratings for Dry Creek enhancement reaches surveyed in 2020.

Enhancement Reach	Post-effective Flow Rating
Weinstock	Good
Gallo	Good
Truett Hurst	Good
Van Alyea	Excellent
Farrow, Wallace	Good
Ferrari-Carano, Olson	Fair
Geyser Peak	Fair

Dry Creek Adaptive Management Plan

In 2014, an Adaptive Management Plan (AMP) to guide the process for evaluating habitat enhancement projects in Dry Creek was completed (Porter et al. 2014). Development of the Dry Creek AMP was facilitated by ESSA Technologies Ltd. (an independent consulting firm from Vancouver Canada) and it represented the culmination of a 3-year process including NMFS, CDFW, Sonoma Water, USACE, and Inter-Fluve (the design contractor for the initial phase of habitat enhancement). Enhancement projects were designed and implemented with the objective of addressing the lack of low water velocity areas with adequate cover and appropriate water depth that limit habitat suitability for juvenile salmonids in general and juvenile Coho Salmon in particular (NMFS 2008).

The Dry Creek AMP is based on the concept of adaptive management which involves synthesizing existing knowledge, exploring alternative actions, making explicit predictions of their outcomes, selecting one or more actions to implement, monitoring to see if the actual outcomes match those predicted, and then using these results to learn and adjust future management plans and policy (see Porter et al. 2014 and references therein). Sonoma Water's and USACE's level of compliance with the RPA for Dry Creek will involve examination of data from implementation, effectiveness and, to a lesser extent, validation monitoring. The process of Timer#31combining monitoring data stems from first selecting a stream reach for enhancement then developing enhancement designs given geomorphic and landowner constraints. Once these designs are agreed to by parties to NMFS' Russian River Biological Opinion and enhancement projects are implemented, monitoring begins (Figure 5.4).

Prior to construction of a given enhancement project, but following reach selection and approval of construction design, pre-enhancement effectiveness monitoring is conducted. The objective of pre-enhancement monitoring is to rate existing habitat local to the intended enhancement project. Once construction of the project is complete, implementation monitoring is conducted to determine if the habitat enhancement was implemented according to the approved design. If it was, post-enhancement effectiveness monitoring is conducted following a geomorphically effective flow or within three years (whichever comes first). Validation monitoring aimed at assessing whether the habitat enhancement is achieving intended biological objectives is conducted after project implementation and can occur before, during or after post-enhancement effectiveness monitoring.

Enhancement project success is primarily based on the results of effectiveness monitoring and, in particular, post-enhancement effectiveness data. Importantly, however, implementation monitoring not only triggers post-enhancement effectiveness monitoring by addressing the question of whether the habitat enhancement was implemented according to the approved design, but it also builds a template for conducting that monitoring. Though less important for evaluating overall project success, validation monitoring can be key in tipping the overall project rating but only in a positive direction (Figure 5.4).

The specific quantitative data collected for effectiveness monitoring vary depending on aspects of the habitat being evaluated. Regardless, however, the aim is to evaluate habitat in light of those factors deemed in the RPA as most significantly impacting juvenile salmonid rearing habitat in Dry Creek (current velocity, depth, cover, habitat complexity). The RPA recognizes validation monitoring as being important given the complexity of major habitat enhancements and influences of uncontrollable factors such as major flood events. For both types of monitoring, the AMP lists “primary metrics” and outlines how data collection to evaluate against these metrics will occur (see Effectiveness Monitoring and Validation Monitoring sections). In some cases, data on “secondary metrics” which may inform habitat-related questions in Dry Creek as well as (potentially) beyond Dry Creek.

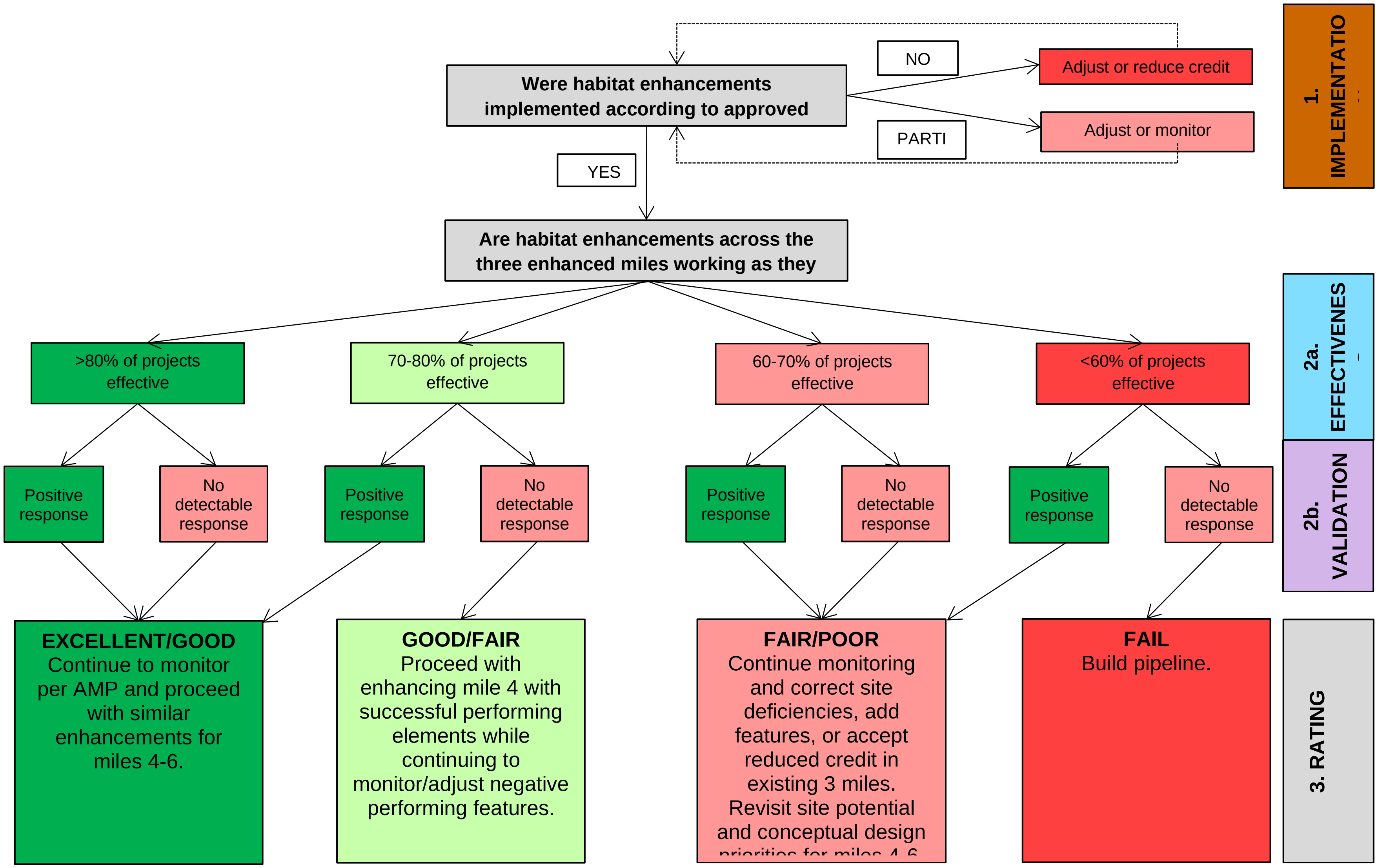


Figure 5.4. Process for determining course of action after the first three miles of Dry Creek have been enhanced. Ratings will be based on an objective evaluation in a step-wise phased monitoring approach which includes physical and biological quantitative measurements which lead to qualitative ratings (Porter et al. 2014).

Data Roll-up

Implementation monitoring is based solely on qualitative data at the habitat feature scale (i.e., was the feature installed in the approved location in the approved manner?) while effectiveness and validation monitoring are based on collecting quantitative data at one scale (i.e., the feature, site, enhancement reach scale) then qualitatively "rolling-up" those results to the next broader spatial scale (Figure 5.5).

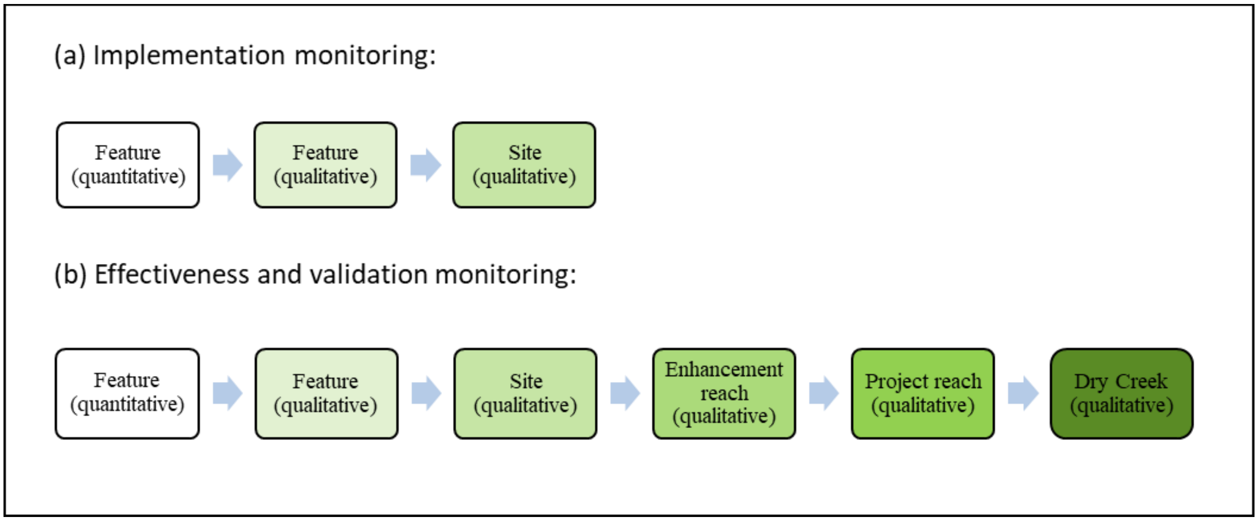


Figure 5.5. Illustration of the rollup concept for (a) implementation and (b) effectiveness and validation monitoring (from Porter et al. 2014).

In the sections that follow, definition of the following terms is necessary (from Porter et al. 2014):

- **Features:** Individually engineered elements (e.g., large woody debris accumulation, riffle, pool, side channel, alcove, boulder cluster, etc.) that will individually or in composite make up a habitat enhancement site (see definition for Site below). Features can in some cases represent complete habitat units (see definition for Habitat Unit below), while in other cases they represent only structural components within a habitat unit (e.g., large wood placement).
- **Site:** One or more engineered habitat features (see definition for Features above) that have been designed to work in combination to enhance a stream reach.
- **Enhancement reach:** A specified collection of enhancement sites (see definition for site above) that are implemented in close proximity to one another.
- **Project reach:** A specified collection of enhancement reaches (see definition for Enhancement Reach above).

The qualitative rating derived for a given group of features within a site, sites within an enhancement reach or enhancement reaches within a project reach represent the basis for overall rating of habitat enhancements. These overall ratings will influence crediting toward the total length of habitat enhanced in Dry Creek (Figure 5.4Figure 5.4).

- Excellent-Good: >80% rated Good or Excellent
- Fair-Poor: 60-80% rated Good or Excellent
- Fail: <60% rated Good or Excellent

5.1 Dry Creek Habitat Enhancement Implementation

Phase 3, Part 3

The 2020 construction season saw the start of construction for the Phase 3, Part 3 (Reach 5A) habitat work. The construction management for Phase 3, Part 3 was overseen by Sonoma Water. See Figure 5.3 above for the general project location and Figure 5.1.1 below for the project work area layout at the site.

The Phase 3, Part 3 project area is along approximately 800 feet of Dry Creek in the Reach 5A area of Dry Creek, approximately 2 miles downstream of Lambert Bridge. This site consists of large bank stabilization component and two constructed side-channel components. The bank stabilization component was the bulk of the work accomplished in 2020. The bank stabilization consisted of rock slope protection on the lower portion of the bank and vegetated soil lifts on the upper portion of the slope. Because of the instability of the existing slope here, and because of the proximity of an existing home close to this unstable bank, the slope stabilization effort was the initial focus of the construction work. Once the bank was stable, then the modifications to add the additional habitat features could begin. Please refer to Photo 5.1.1, Photo 5.1 2, Photo 5.1.3, Photo 5.1.4, Photo 5.1.5, Photo 5.1.6, and Photo 5.1.7.

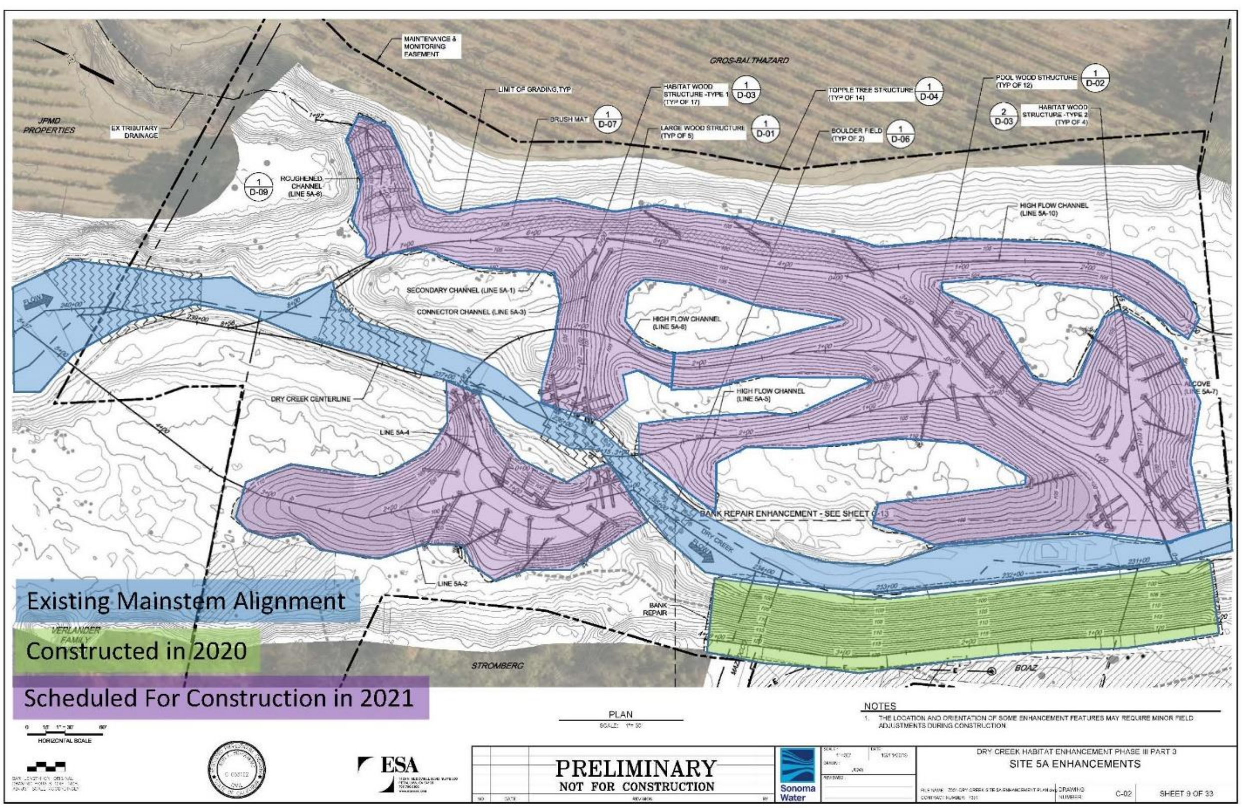


Figure 5.1.1. This figure shows the work area for the Dry Creek Habitat Enhancement Project, Phase 3, Part 3. The bank stabilization component of this work was constructed first during the 2020 construction season. The majority of the work for the habitat enhancement areas is scheduled to be constructed in 2021.

Photo 5.1.1. Phase 3, Part 3. Upper end of bank stabilization work area, looking downstream pre-project condition. July 30, 2020.

Photo 5.1 2. Phase 3, Part 3. Upper end of bank stabilization work area, looking downstream pre-project condition. July 30, 2020.

Photo 5.1.3. Phase 3, Part 3. Lower end of bank stabilization work area, looking upstream. Initial clearing and access road underway. July 30, 2020.

Photo 5.1.4. Phase 3, Part 3. Rock slope protection construction in progress. Note sheet-pile isolating work area from active flow of Dry Creek. September 10, 2020.

Photo 5.1.5. Phase 3, Part 3. Initial clearing of habitat site work area and being used as a dewatering basin for the bank stabilization work. September 10, 2020.

Photo 5.1.6. Phase 3, Part 3. Sonoma Water's biologists conducting fish rescue within the isolated work area. September 15, 2020.

Photo 5.1.7. Phase 3, Part 3. Bank stabilization section work is complete. November 3, 2020.

2020 Dry Creek Habitat Maintenance Work

The 2020 construction season also saw some maintenance work conducted at several existing habitat sites in different reaches of Dry Creek. The maintenance work primarily consisted of either removing gravel deposits or repairing erosion that occurred as a result of high flows in Dry Creek. The work was undertaken to restore habitat function or to limit the potential for a future reduction in habitat function. Maintenance work was conducted in Reach 4A, Reach 7, and in Reach 8.

Reach 4A (U.S. Army Corps of Engineers CAP 1135 Site)

Portions of the Corps of Engineers Dry Creek Ecosystem Restoration CAP 1135 Site (Ferrari-Carano and Olson properties, Figure 5.1.2), which was constructed in 2018 by the Corps of Engineers sustained localized aggradation during the high flow events of 2019, resulting in changes from the original design configuration. Sonoma Water staff consulted with the original project design team from Environmental Science Associates for the project to establish a cost-effective maintenance plan that would restore the majority of the original designed habitat functions while also trying to limit the potential for future high-flow events to impact the project. Maintenance work was conducted by Sonoma Water in September of 2020 to re-establish connectivity primarily to the river-left side channel and the lower end of the original main channel in the project area. Maintenance work involved bringing equipment in from the river left side of the channel, which required installing a temporary crossing point over the current main flow of Dry Creek in the work area. The equipment was then used to excavate out the channel area that aggraded during the 2019 high flow season and reopen or add connections between the mainstem and the side-channel. New plantings were also installed both to provide riparian canopy function, but to also provide additional bank stability. Willow baffles (densely planted walls of willows) were also planted in two locations to discourage future sediment flows from entering the habitat features. Please refer to Photo 5.1.8, Photo 5.1.9, Photo 5.1.10, Photo 5.1.11, Photo 5.1.12, Photo 5.1.13, Photo 5.1.14, Photo 5.1.15, Photo 5.1.16, Photo 5.1.17, Photo 5.1.18, and Photo 5.1.19.

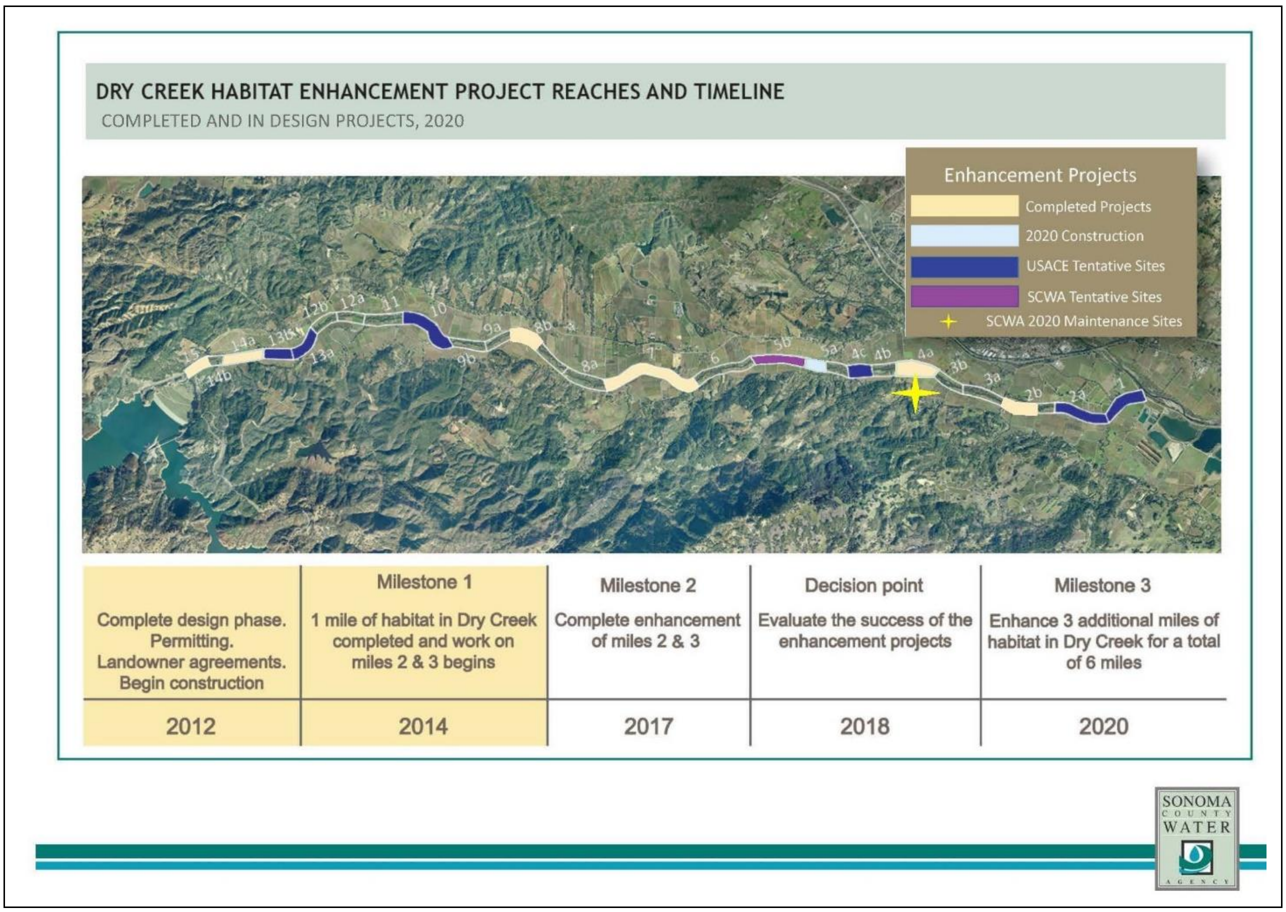


Figure 5.1.2. Showing the general location of the 2020 Reach 4A habitat maintenance work.

Photo 5.1.8. Reach 4A Site Post-Construction on November 19, 2018.

Photo 5.1.9. Reach 4A Site high flows (approximately 3,000 cubic feet per second) on February 21, 2019.

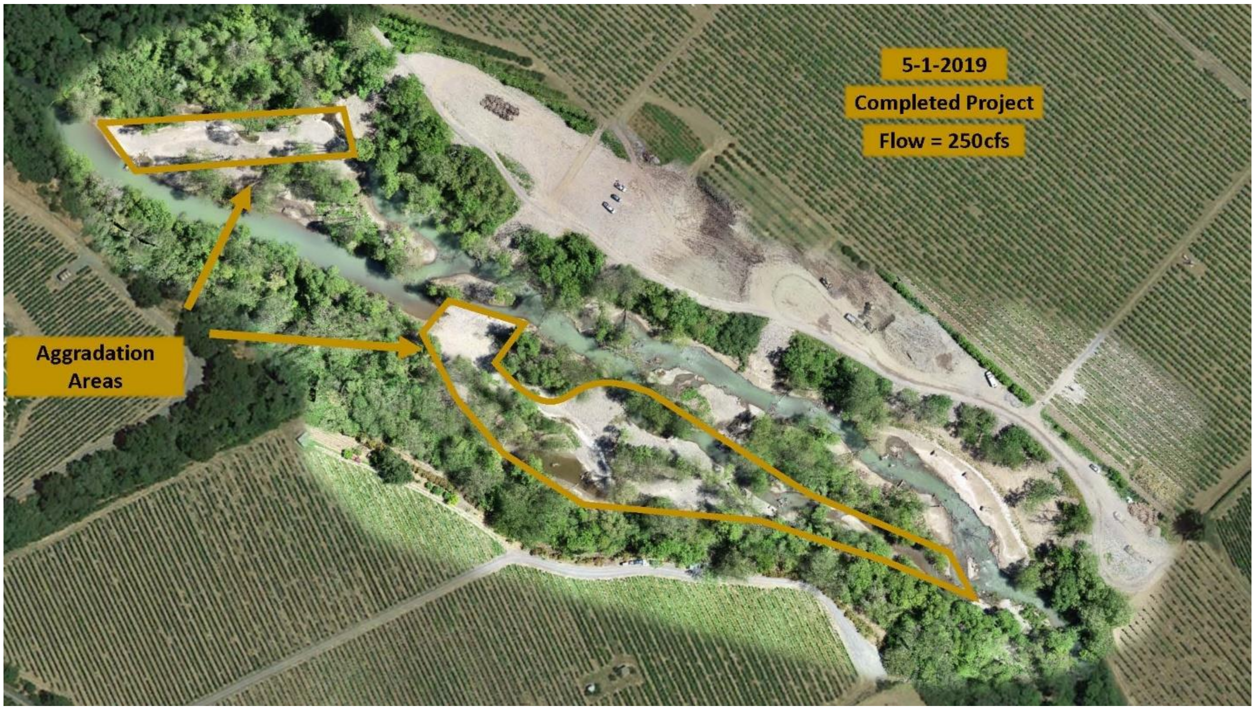


Photo 5.1.10. Reach 4A post 2019 high flows. Site showing areas of significant aggradation as a result of the 2019 high flow event. Photo taken at 250cfs flows in May of 2019.

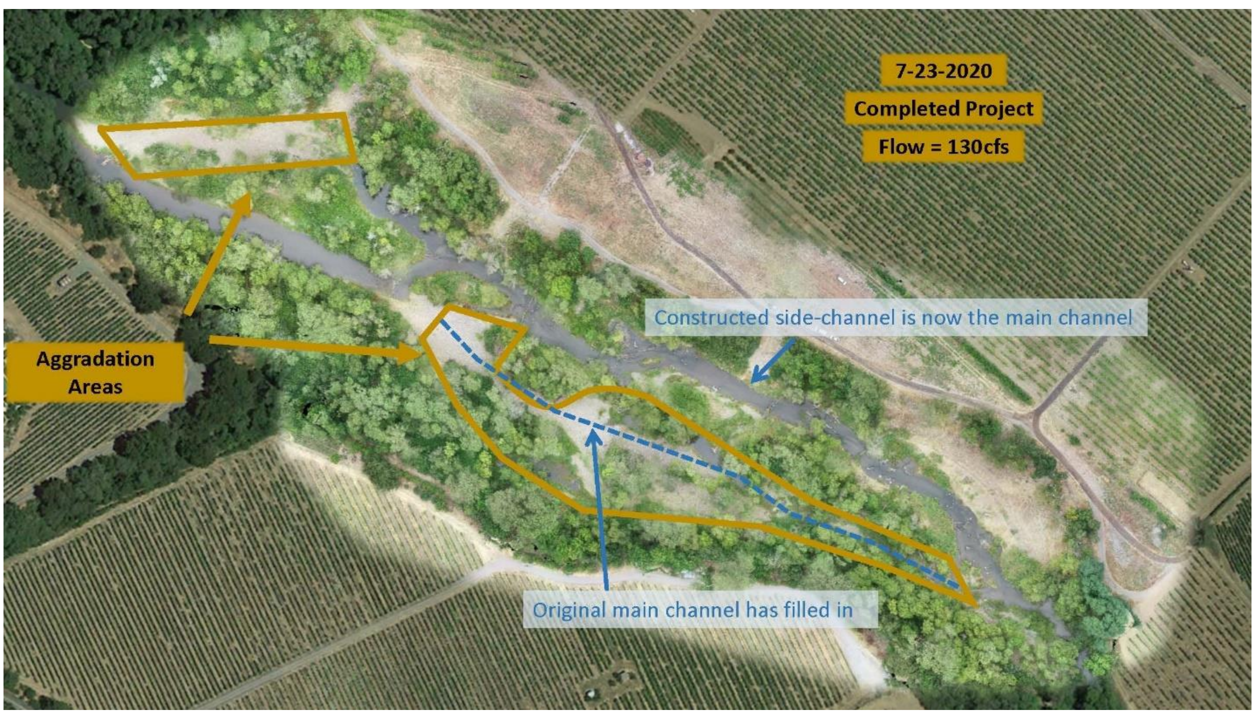


Photo 5.1.11. Reach 4 Site with same areas of significant aggradation shown, but with flows now closer to baseline. Photo taken at 130cfs flows in July of 2020.

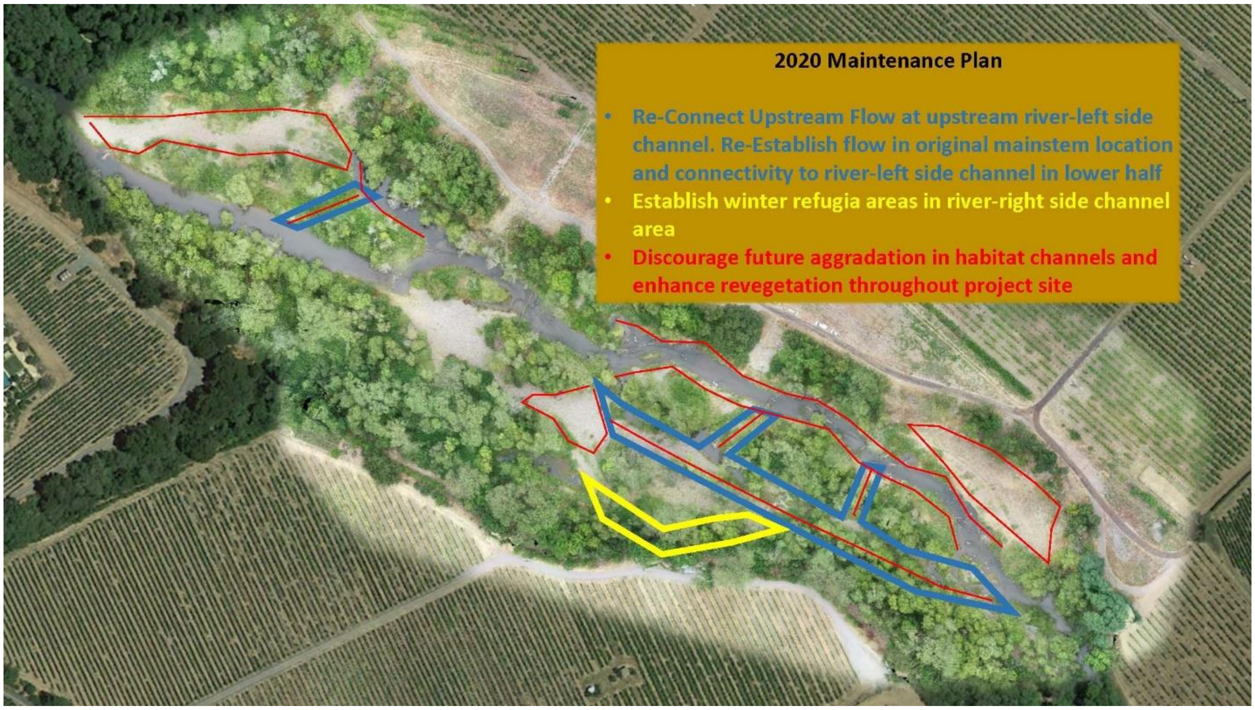


Photo 5.1.12. Reach 4A showing the 2020 Maintenance Plan to re-establish flow connectivity to the river-left side channel and mainstem channel locations. The maintenance plan also included removal of deposited material from the river-right channel to establish winter high-flow refugia. Willow cuttings and alder plantings installed throughout to discourage future aggradation and to help stabilize areas within the site.

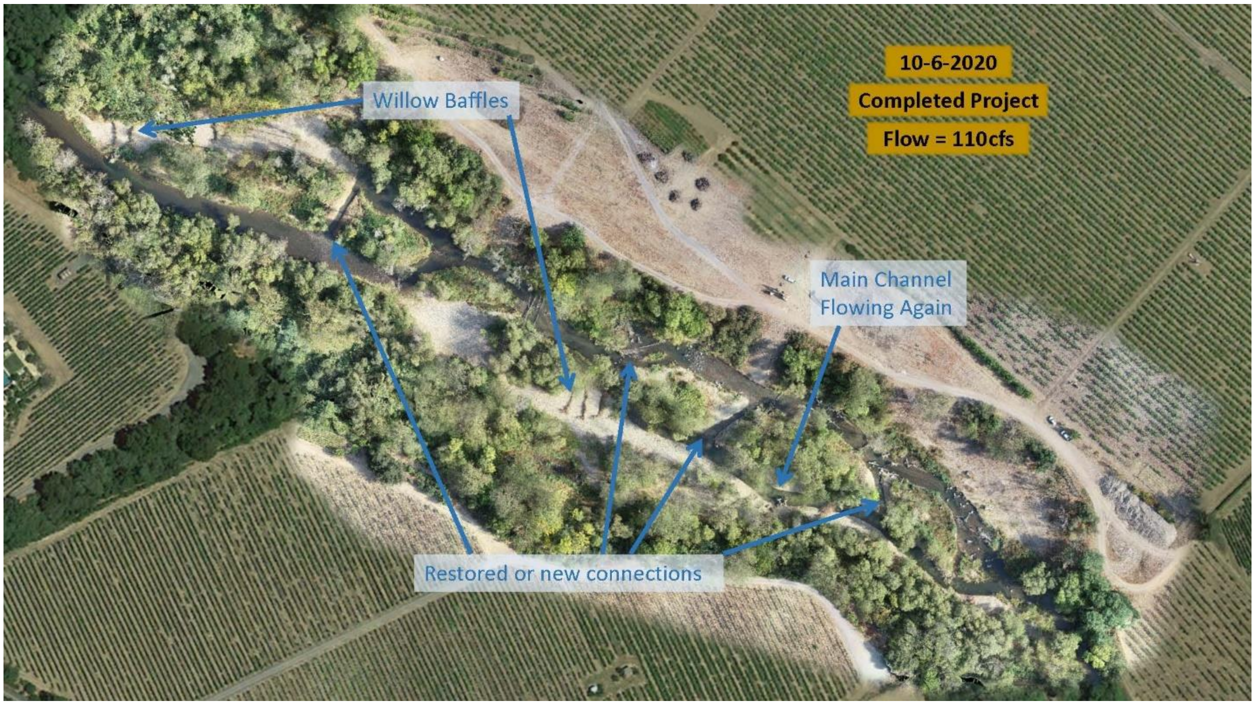


Photo 5.1.13. Reach 4A after 2020 maintenance work complete. October 6, 2020.

Photo 5.1.14. Reach 4A. Bridge crossing installation. September 2, 2020.

Photo 5.1.15. Reach 4A. Turbidity curtain and fish screening installed at downstream end of habitat work. September 3, 2020.

Photo 5.1.16. Reach 4A. Existing aggraded area in Reach 4. Existing habitat structure visible. Low flow no longer exists in this area due to aggradation that occurred in high flow events. September 3, 2020.

Photo 5.1.17. Reach 4A. Same view as in photo 5.1.10 above. Low flow channel re-established and existing habitat structure exposed again. September 21, 2020.

Photo 5.1.18. Reach 4A. Low flow channel re-established at lower end of Reach 4. September 21, 2020.

Photo 5.1.19. Reach 4A. New willow baffles installed to discourage paths for future aggradation within the habitat site. September 21, 2020.

Reach 7 (Demonstration Reach, Farrow Property)

A minor amount of erosion had occurred around an engineered log jam at the outlet to a constructed backwater pond on the Farrow property (located downstream of Lambert Bridge in Reach 7, Figure 5.1.3). High flows over the structure have resulted in finer gravel materials being winnowed out from between the logs (the entire structure is currently exposed, where the original design just had the creek facing portion of the log structure exposed). The landowners have expressed concern that the structure in its current state could present a hazard for their customers and asked Sonoma Water to restore the area back to its original design look. The repair work would require bringing in small rock to fill the voids between the logs and then cover the top again with gravel material (the gravel material would be sourced from the gravel being removed at the nearby Van Alyea site, see below). The larger rock material will help stabilize the site against erosion of material from between the logs during future high flow events. New willow cuttings would also be installed around the structure to further guard against future erosion potential. Please refer to Photo 5.1.20, Photo 5.1.21, Photo 5.1.22, Photo 5.1.23, Photo 5.1.24, and Photo 5.1.25.

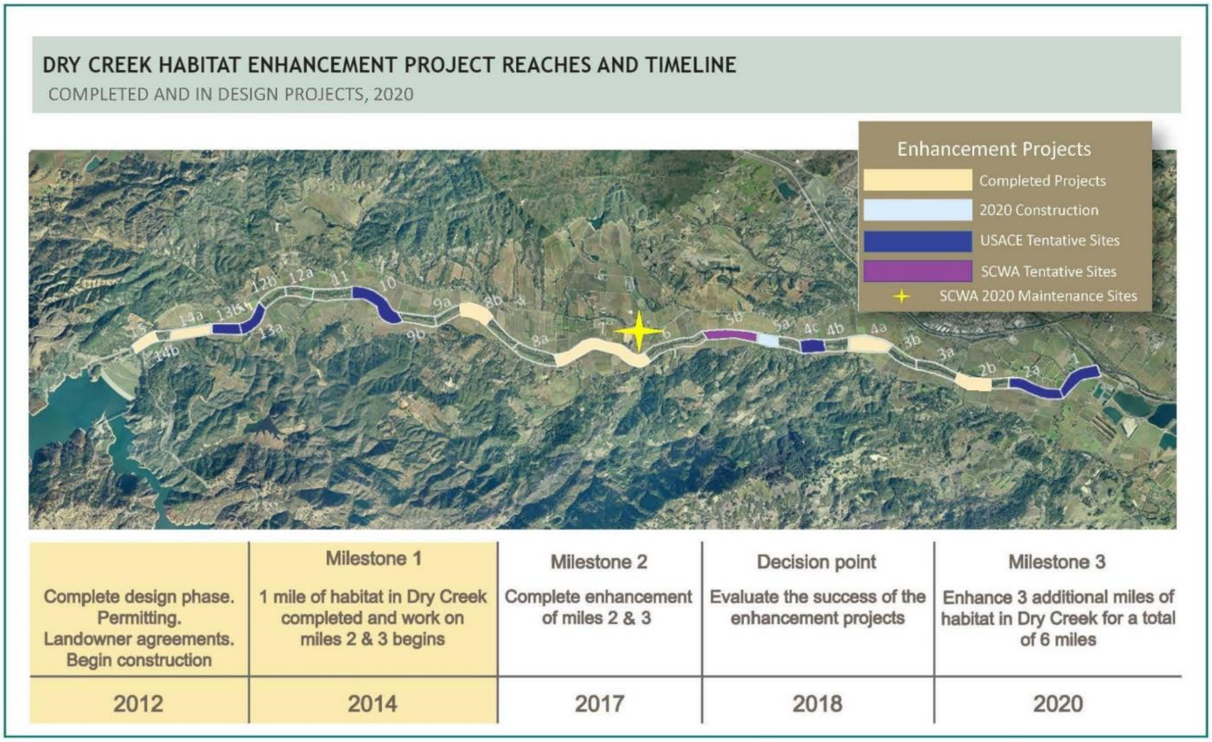


Figure 5.1.3. Showing the general location of the 2020 Reach 7 (Farrow Property Site) habitat maintenance work.

Photo 5.1.20. Reach 7 - Farrow site. Exposed engineered log structure work area shown in green.

Photo 5.1.21. Reach 7 - Farrow site. Photo shows eroded area exposing back portion of engineered logjam at outlet of backwater pond. September 13, 2018.

Photo 5.1.22. Reach 7 - Farrow site. Start of erosion repair work. July 30, 2020.

Photo 5.1.23. Reach 7 - Farrow site. New willow cuttings installed in engineered logjam. August 4, 2020.

Photo 5.1.24. Reach 7 - Farrow site. New growth on willow cuttings at engineered logjam. September 17, 2020.

Photo 5.1.25. Reach 7 - Farrow site. Completed erosion repair at engineered logjam. September 17, 2020.

Reach 7 (Demonstration Reach, Van Alyea)

A moderate amount of aggradation during high flow events occurred at the upstream end of a constructed backwater pond located on the Van Alyea Property within Reach 7 of Dry Creek (Figure 5.1.4). The amount of aggradation that has occurred compared to the size of the habitat pond is relatively small, but the aggradation that occurred ended up on top of the outlet of a conduit that brings freshwater into the pond from the mainstem of Dry Creek. Without the conduit functioning, the blocked conduit results in water quality concerns (low dissolved oxygen levels in the pond) during certain times of the year that is reducing the habitat potential for the targeted steelhead and coho salmon species. Maintenance work at this site consisted of removing the deposited gravel material, installing a short extension on the conduit outlet pipe to reduce potential for future events to cover the pipe, and installation of new willow baffles upstream of the pond to discourage flow paths that could be pathways for gravel coming into the pond during high flow events. Please refer to Photo 5.1.26, Photo 5.1.27, Photo 5.1.28, Photo 5.1.29, Photo 5.1.30, Photo 5.1.31, Photo 5.1.32, and Photo 5.1.33.

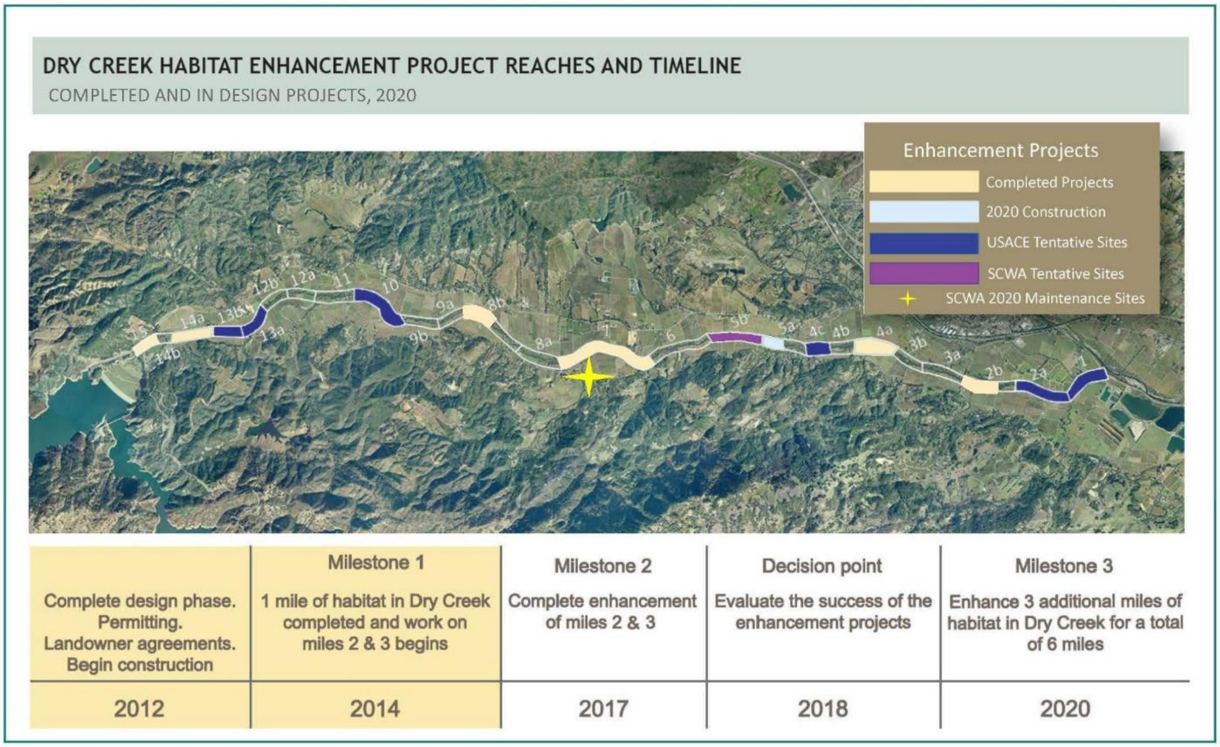


Figure 5.1.4. Showing the general location of the 2020 Reach 7 (Van Alyea Property Site) habitat maintenance work.

Photo 5.1.26. Reach 7 - Van Alyea Site. This figure shows the gravel removal area shown in green and the access route down to the work area in blue.

Photo 5.1.27. Reach 7 - Van Alyea Site. Photo shows recent gravel deposit after high flow events in 2019. May 7, 2019.

Photo 5.1.28. Reach 7 - Van Alyea Site. Gravel deposited in upper end of backwater pond, covering outlet of freshwater conduit from Dry Creek. Photo shows turbidity curtain installed around work site prior to removing gravel. July 29, 2020.

Photo 5.1.29. Reach 7 - Van Alyea Site. Removal of gravel material and locating freshwater conduit outlet in process. July 30, 2020.

Photo 5.1.30. Reach 7 - Van Alyea Site. View of gravel removal work looking from lower end of backwater pond on the Van Alyea property. July 30, 2020.

Photo 5.1.31. Reach 7 - Van Alyea Site. New willow baffle upstream of backwater pond to discourage future gravel deposition into the pond. August 4, 2020.

Photo 5.1.32. Reach 7 - Van Alyea Site. Gravel removal work complete. September 17, 2020.

Photo 5.1.33. Reach 7 - Van Alyea Site. Gravel removal work complete and view of the backwater pond. September 17, 2020.

Reach 8 (Carlson Site)

One of the constructed alcoves within the Reach 8 area of Dry Creek (Carlson site, Figure 5.1 5) has had some gravel deposition in the inlet channel at the upper end of the alcove. This gravel deposition is blocking the inflow of freshwater into the upper end of the alcove. A piece of equipment will be brought in to remove the gravel blocking the inlet. Please refer to Photo 5.1.34, Photo 5.1.35, Photo 5.1.36, and Photo 5.1.37.

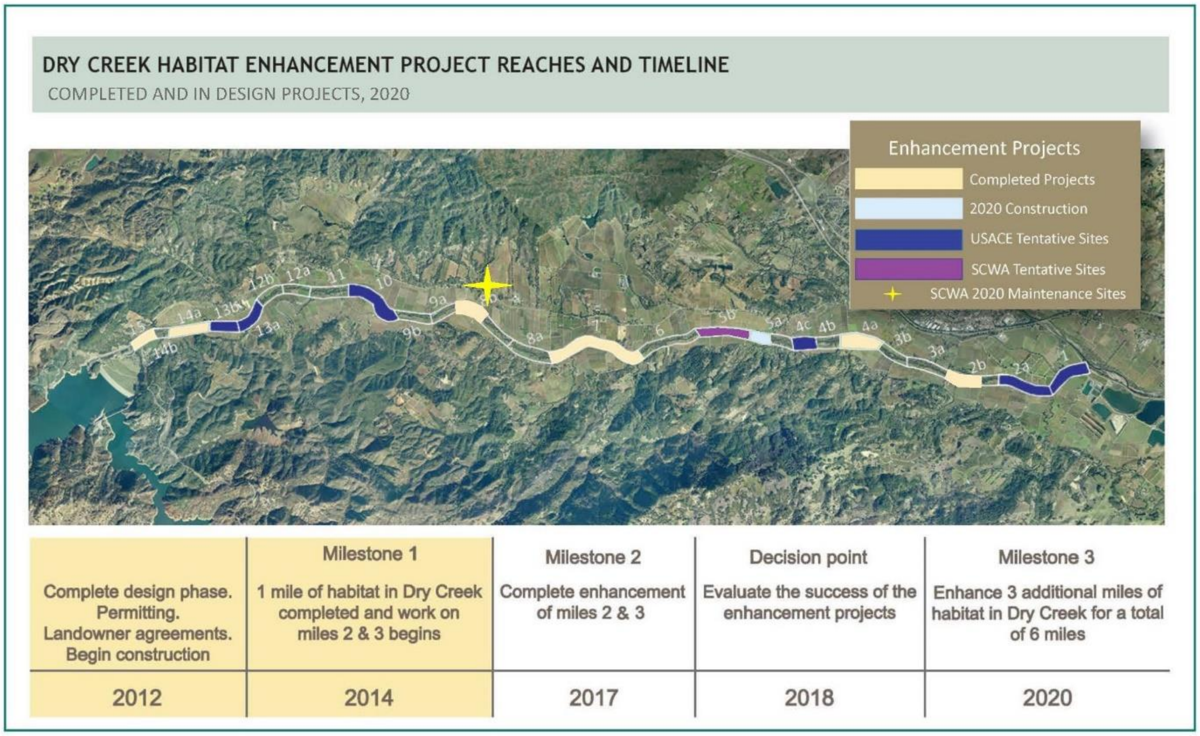


Figure 5.1 5. Showing the general location of the 2020 Reach 8 (Carlson Site) habitat maintenance work.

Photo 5.1.34. Showing the location of the 2020 Reach 8 (Carlson Site) habitat maintenance work. The work area to clear gravel from the side channel inlet is shown in green. The blue area indicates where gravel was left onsite per the request of the landowner.

Photo 5.1.35. Reach 8 - Carlson Site. Photo showing inlet to the side-channel cleared of sediment blocking flow. August 18, 2020.

Photo 5.1.36. Reach 8 - Carlson Site. View down the alcove after inlet to alcove cleared. August 18, 2020.

Photo 5.1.37. Reach 8 - Carlson Site. New willow cuttings sprouting along inlet area that was cleared. September 10, 2020.

5.2 Effectiveness monitoring

Performance Measures

Effectiveness monitoring focuses on the physical response of Dry Creek to habitat enhancements and determines "whether habitat enhancement is having the intended effect on physical habitat quality" in Dry Creek (NMFS 2008, pg. 266). NMFS (2008) concluded that sub-optimal water velocity, depth, and instream cover limit juvenile coho salmon and steelhead and suggested optimal values for water velocity depth, and cover as part of the Reasonable and Prudent Alternative (NMFS 2008). The Joint Monitoring Team, consisting of representatives from NMFS, CDFW, USACE, and the Water Agency, refined these values within the Dry Creek Adaptive Management Plan (AMP) (Porter et al. 2014) and developed primary performance metrics linked to the optimal values of water velocity, depth, and cover by which to evaluate the effectiveness of habitat features, sites, and reaches Table 5.2.1). The Joint Monitoring Team also identified secondary performance metrics that help determine the effectiveness of habitat enhancements to influence non-target, ancillary conditions (e.g., water temperature, dissolved oxygen concentration). The AMP also suggested target flows to represent seasonal variation critical to each life stage (Porter et al. 2014).

Table 5.2.1. Primary and secondary performance measures from the Dry Creek Adaptive Management Plan.

Type of Performance Measure	Performance Measure	Life Stage	Spring Flow[1]	Summer Flow[2]	Winter Flow[3]
Primary	Velocity (ft/sec)	fry	0-0.5 ft/s	n/a	n/a
Primary	Depth (ft)	fry	0.5-2.0 ft	n/a	n/a
Primary	Velocity (ft/sec)	Summer/winter parr	0-0.5 ft/s	0-0.5 ft/s	0-0.5ft/s
Primary	Depth (ft)	Summer/winter parr	2-4 ft	2-4 ft	2-4 ft
Primary	Shelter value	Juvenile	≥80	≥80	≥80
Primary	Pool: Riffle ratio	Juvenile	n/a	1:2 to 2:1	n/a
Secondary	Temperature (°C)	Juvenile	n/a	8-16° C	n/a
Secondary	Dissolved oxygen (mg/l)	Juvenile	n/a	6-10 mg/l	n/a
Secondary	Canopy (%)	Juvenile	80 %	80 %	80 %
Secondary	Quiet water (< 0.5 ft/s) (%)	Juvenile	n/a	n/a	≥ 25%
Secondary	Off-channel access (off-ramps) (ft/sec)	Juvenile	0.05 – 0.06 f/s (Ucrit); 3.3 ft/s (burst speed)	0.05 – 0.06 f/s (Ucrit); 3.3 ft/s (burst speed)	0.05 – 0.06 f/s (Ucrit); 3.3 ft/s (burst speed)
Secondary	Connectivity	Juvenile	Undefined	Undefined	Undefined
Secondary	Substrate particle size (in.)	Adult	n/a	n/a	0.25-2.5 in.
Secondary	Depth (ft)	Adult	n/a	n/a	0.5-1.6 ft

[1] Target coho life stage during spring is newly emerged feeding fry which use shallower depths than would be preferred later in the summer and winter when fish would be larger. Target spring flow (discharge within the enhancement reach) is 200 cfs (approximately double the summer "base" flow).
[2] Target summer flow is 105 cfs
[3] Target winter flow is 1000 cfs

Spatial Scales

Data collection to evaluate the effectiveness of the Dry Creek Habitat Enhancement Project occurred across several increasingly broad spatial scales that nest within each other as they increase in size:

- Feature: Individually engineered elements (e.g., large woody debris accumulation, riffle, pool, side channel, alcove, boulder cluster).

- Habitat unit: A designation within a habitat classification system (e.g., Flosi et al. 2010) that allows stratification (based on natural patterns of variation) when attempting to quantify physical attributes of a stream.

- Site: An engineered portion of stream channel (e.g., side channel or alcove) constructed within an enhancement reach (see definition below), or a portion of stream channel adjacent to engineered portions of stream channel (e.g., a mainstem portion of channel adjacent to a constructed side channel). Sites typically contain several features and habitat units, but in some cases may contain no features and a single habitat unit (e.g., a mainstem portion of channel with no features adjacent to constructed side channel). Sites may also contain several features, but no habitat unit, such as floodplain sites that are dry during the summer.

- Enhancement reach: A collection of sites implemented in close proximity to one another.

- Project reach: A collection of enhancement reaches implemented during the same project phase

Quantitative and qualitative data collected at the feature and habitat unit-scale provide the basis to inform evaluation of progressively larger sites, enhancement reaches, and project reaches. This integration, or spatial rollup, allows a robust evaluation of individual project elements across multiple spatial scales.

Effectiveness Ratings

Within the AMP, the Joint Monitoring Team developed checklists to evaluate and rate the physical effectiveness of the Dry Creek Habitat Enhancement Project (See Porter et al [2014], pp. 40-45). The Joint Monitoring Team expanded existing checklists developed by Harris (2004) by incorporating additional quantitative metrics outlined in the RPA. The checklists integrate hydraulic (water depth and velocity) and shelter (shelter value, percent cover, shelter score) data to evaluate project performance relative to primary metrics (Table 5.2.1) and qualitative observations of features. The ratings of features and habitat units inform ratings of sites, enhancement reaches, and project reaches, which occur at increasingly broader spatial scales. Quantitative data collected to evaluate project performance support qualitative ratings that provide the basis for evaluating the overall effectiveness of habitat enhancement measures (see Methods, below). The qualitative ratings determine relative success of habitat enhancement measures within sites and habitat enhancement reaches, and determine potential future outcomes (management actions) (Table 5.2.2).

Table 5.2.2. Potential enhancement reach ratings, criteria, and future outcomes (actions). From Porter et al. 2014.

Rating	Objectives	Criteria	Unintended Effects	Future Outcome
Excellent-Good	Achieved all or most stated reach design objectives.	All or most sites/ enhancement reaches meet or exceed targeted values.(>80% of sites rated Good or Excellent)	None or minimal negative unintended effects. Unintended positive effects may outweigh failure to achieve a targeted value.	Continue to monitor according to adaptive management plan.
Fair-Poor	Partially achieved most reach design objectives, or objectives not achieved were beyond reach capacity	Some sites / enhancement reaches did not meet targeted values (60-80% of sites/ enhancement reaches rated Good or Excellent)	May have minor or major unintended negative effects that partially offset objectives or negates a targeted gain.	Develop and implement plans to correct site or metric deficiencies, add sites/features or reduce total project habitat credit. Step up monitoring on sites and features exhibiting negative performance.
Fail	Many sites achieved no goals; objectives not achieved were the fault of the feature; sites/feature may be completely gone.	Many sites/ enhancement reaches did not meet targeted values (<60% of sites/ enhancement reaches rated Good or Excellent).	Few positive effects and/or unintended negative effects may be degrading the habitat and outweigh achieved objectives.	Reduce total project habitat credit, and abandon use of failed features. Revisit site potential and conceptual design priorities

Methods

Performance Measures

Performance measure data collection focuses on data to assess the Dry Creek Habitat Enhancement Project against the primary performance measures of water depth (0.5-2 or 2-4 ft) and velocity (<0.5 ft/s), pool to riffle ratio, and amount of instream cover (shelter score) from the AMP (Porter et al. 2014) (Table 5.2.1). Depth, velocity, pool to riffle ratio, and shelter score also provide a means to directly assess against optimal habitat values suggested as part of the RPA in the BO (NMFS 2008). We collected data from April to September during summer baseflow conditions. Daily average discharge ranged from 95 to 135 cfs over the monitoring period (as measured at the Dry Creek below Lambert Bridge near Geyserville USGS gage [gage #11465240]), and monitoring did not occur at discharges above 135 cfs to ensure accuracy and consistency when measuring depth and velocity, determining habitat types and evaluating cover.

Depth and velocity

The AMP suggested collecting water depth and velocity at points along transects placed within constructed backwaters and main channel portions of Dry Creek, and “habitat feature mapping” near selected habitat enhancements (logjams, boulder fields). Habitat feature mapping would result in two-dimensional depictions of depth and velocity around habitat features and allow quantification of optimal habitat area adjacent to features. Upon consultation with NMFS, and through field experimentation with several mapping and survey tools (auto-level, differential global positioning system, total station), Sonoma Water developed a robust habitat feature mapping method to characterize all portions of the Dry Creek channel, not just adjacent to enhancement features, obviating the need to collect cross-sectional data.

Field crews collected water depth and velocity at points across the streambed using handheld flow meters and a total station. At each point, we collected geographic location (latitude, longitude, elevation), and water depth and velocity by aiming the total station at a USGS topset rod fit with a survey prism and a flow meter (Figure 5.2.1). The technique allowed simultaneous collection of spatially accurate topographic and hydraulic data (water depth and velocity) that enabled comparison to future conditions. Field crews focused point collection on breaks in slope and breaks in water velocity, and at a minimum collected points at the top of each bank, water surface elevation, toe of bank, thalweg, and at least two points between toe of bank and thalweg.

We processed the data within a Geographic Information System (GIS) to create detailed maps of hydraulic conditions (water depth and velocity) to spatially characterize habitat conditions and quantify optimal fry and juvenile habitat. We processed spatial data to create raster (grid) based digital elevation models (DEMs) that classified hydraulic habitat conditions according to the primary metrics from the AMP (depth [0.5-2 ft or 2-4 ft], depending on life stage and velocity [<0.5 ft/s]) to identify the location of habitat falling within optimal depth, velocity, and depth and velocity ranges as polygons (Figure 5.2.2). Generating polygons within a GIS also allowed us to quantify the areas of optimal habitat.

Figure 5.2.1. Dry Creek effectiveness monitoring. At each data point, we collected geographic location (latitude, longitude, elevation), and water depth and velocity by aiming the total station at a USGS topset rod fit with a survey prism and a flow meter.

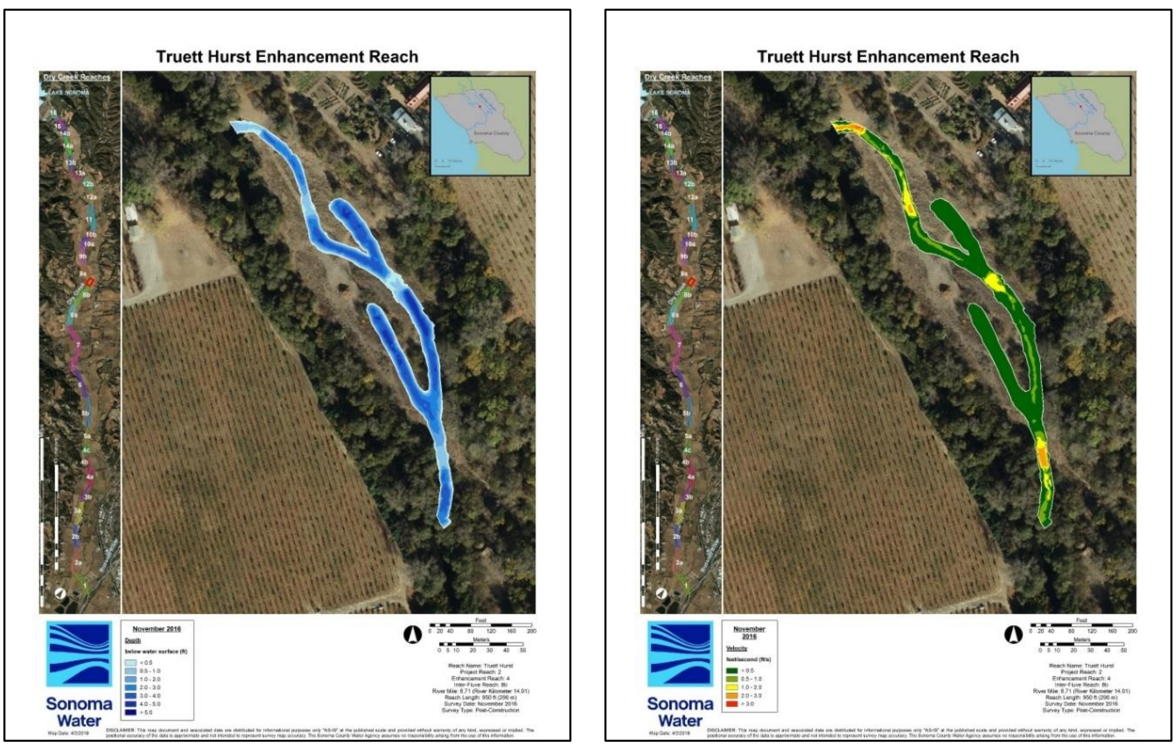


Figure 5.2.2. Digital elevation models (DEMs) created from spatially referenced depth and velocity points.

Habitat Types, Pool to Riffle Ratio, and Shelter Scores

We inventoried instream habitat units using descriptions from the California Salmonid Habitat Restoration Manual (Flosi et al. 2010). Differences in local channel gradient, water velocity, depth, and substrate size distinguish habitat types. Flosi et al. (2010) use four hierarchical levels to describe physical fish habitat, with each successive level providing greater detail. The most elementary descriptions (Levels 1 and 2) break stream channels into pool, riffle, or flatwater habitat types Successive levels differentiate habitat types by location within the stream channel (e.g., mid-channel pools, Level 3) or by cause or agent of formation (e.g., lateral-scour, log-formed pools, Level 4). In this survey, we inventoried habitat types to Level 2 and delineated upstream and downstream boundaries with nail spikes on the right and left bank. We surveyed the location of the nail spikes with a total station and processed the data within a GIS to create polygons of habitat types (Figure 5.2.3). After the inventory, we determined pool: riffle ratio to compare against the performance metric of 1:2 (0.5) to 2:1 (2.0) (Figure 5.2.3) (Porter et al. 2014).

Field crews determined the shelter value of individual habitat units within each enhancement site. Flosi et al. (2010) rates instream shelter by multiplying the complexity of available cover (0 = no shelter, 3 = highly complex shelter) by the overhead area occupied by that cover (0 = 0% of overhead area covered, 100 = 100% of overhead area covered) The maximum shelter value is 300 (3 [complexity of available cover within a habitat unit] * 100 [area of habitat unit covered]), with a score of ≥80 considered optimal within the AMP (Porter et al. 2014) (Figure 5.2.3).

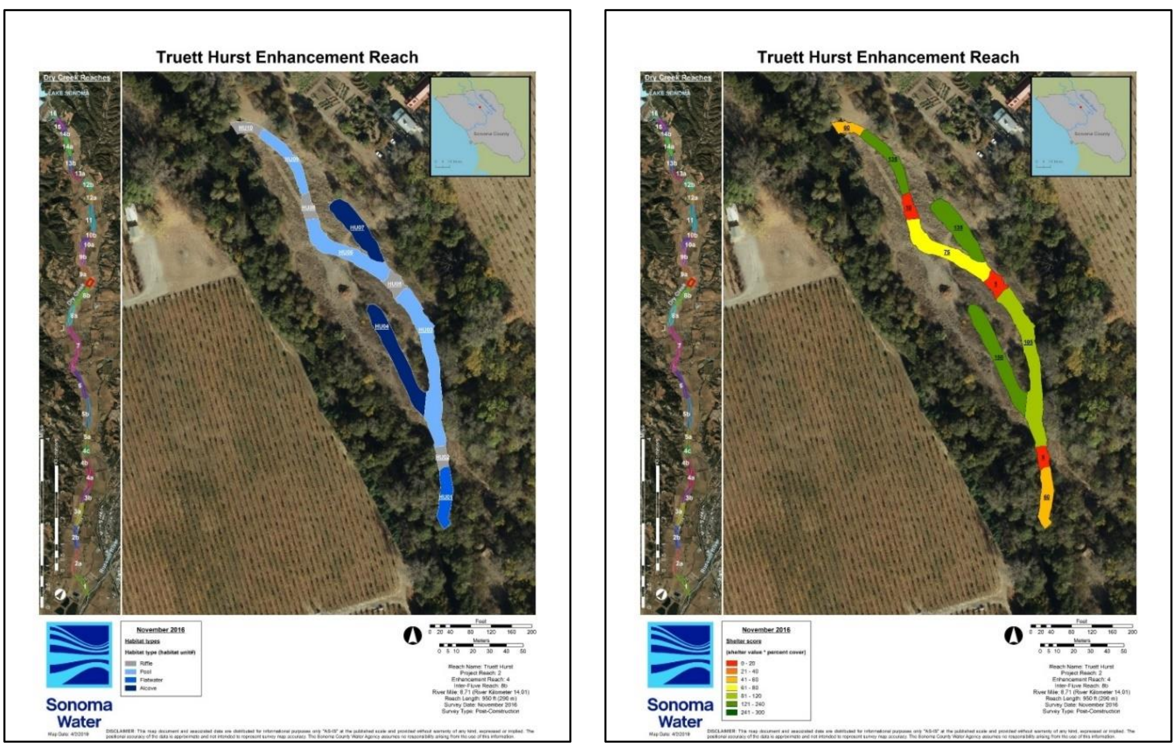


Figure 5.2.3. Example of inventoried habitat types and estimated shelter values within a Dry Creek habitat enhancement reach.

Effectiveness Ratings

We used modified monitoring checklists from the AMP to quantitatively and qualitatively evaluate enhancement features, habitat units, sites, and reaches. As noted above, the Joint Monitoring Team expanded checklists from Harris (2004) by incorporating quantitative metrics outlined in the RPA and to allow spatial rollup of the evaluation of project performance. The AMP included pre- and post-enhancement checklists for off-channel, in-channel, and areas along the bank for a total of six individual checklists (See Porter et al [2014], pp. 40-45). We modified off-channel and in-channel checklists to include bank areas, obviating the need for a bank stabilization checklist, and used the same checklists for pre-and post-enhancement, for a total of two individual checklists Table 5.2.3 and Table 5.2.4). We standardized each checklist to ask the same number of questions, albeit with slightly different questions for off- and in-channel areas).

We retained the general order of the AMP checklist, but reclassified questions into spatially explicit data categories. The original AMP checklists ordered and grouped questions into several data categories (feature, depth/habitat, shelter, channel, velocity, and other) that included observations at multiple spatial scales (Table 5.2.3 and Table 5.2.4; see question 7: Current level II habitat type? [habitat unit scale]) and question 8: If an objective, did the feature create the targeted instream habitat type? [feature-scale]) are both in the depth/habitat category). We reclassified questions into data categories that evaluated enhancement features (feature data) or habitat units through hydraulic data and shelter data (habitat unit data) (Table 5.2.3 and Table 5.2.4). Grouping the questions facilitated the rollup from feature and habitat unit data into site and reach ratings.

Table 5.2.3. Off-channel effectiveness monitoring checklist showing original data category from the AMP (left column) and modified data category (right column).

ORIGINAL DATA CATEGORY	#	QUESTION	MODIFIED DATA CATEGORY
FEATURE	1.	LENGTH OF TARGETED TREATMENT (FT)	FEATURE DATA
	2.	WIDTH OF TARGETED TREATMENT: (FT)	FEATURE DATA
	3.	ESTIMATE AREA OF THE TARGETED FEATURE: (FT²)	FEATURE DATA
	4.	STRUCTURAL CONDITION OF FEATURE: EXCL, GOOD, FAIR, POOR, FAIL	FEATURE DATA
	5a	ARE PROBLEMS WITH THE FEATURE VISIBLE?	FEATURE DATA
	5b	TYPES: ANC, BBB, CRF, MAT, SHF, STR, SWA, UND, UNS, WSH, OTH	FEATURE DATA
	6a	IS THE FEATURE STILL IN ITS ORIGINAL LOCATION?	FEATURE DATA
	6b	IS THE FEATURE STILL IN ITS ORIGINAL POSITION?	FEATURE DATA
	6c	IF YES: LBK, MDC, RBK, SPN, OTH	FEATURE DATA
	6d	IS THE FEATURE STILL IN ITS ORIGINAL ORIENTATON?	FEATURE DATA
	6e	IF YES: DNS, MUL, PRL, PRP, UPS, OTH	FEATURE DATA
DEPTH/HABITAT	7.	CURRENT LEVEL II HABITAT UNIT TYPE: FLT, POO, RIF, DRY, ALC, OTH	HABITAT UNIT (SHELTER) DATA
	8.	IF AN OBJECTIVE, DID THE FEATURE CREATE THE TARGETED INSTREAM HABITAT TYPE?	FEATURE DATA
	9.	WERE THERE ANY UNINTENDED EFFECTS BY THE FEATURE ON THE HABITAT TYPE? IF Y, COMMENT.	FEATURE DATA
	10.	MEAN WATER DEPTH IN HABITAT UNIT: FT	HABITAT UNIT (HYDRAULIC) DATA
	11a	MAXIMUM WATER DEPTH IN HABITAT UNIT: FT	HABITAT UNIT (HYDRAULIC) DATA
	11b	AREA OF HABITAT UNIT WITHIN 0.5 -2.0 FT DEPTH: (FT2)	HABITAT UNIT (HYDRAULIC) DATA
	11c	AREA OF HABITAT UNIT WITHIN 2.0 -4.0 FT DEPTH: (FT2)	HABITAT UNIT (HYDRAULIC) DATA
	11d	AREA OF HABITAT UNIT WITHIN 0.5-4.0 FT DEPTH: (FT2)	HABITAT UNIT (HYDRAULIC) DATA
	11e	% AREA OF HABITAT UNIT WITHIN 0.5 -2.0 FT DEPTH	HABITAT UNIT (HYDRAULIC) DATA
	11f	% AREA OF HABITAT UNIT WITHIN 2.0 -4.0 FT DEPTH	HABITAT UNIT (HYDRAULIC) DATA
	11g	% AREA OF HABITAT UNIT WITHIN 0.5-4.0 FT DEPTH	HABITAT UNIT (HYDRAULIC) DATA
	11h	IF AN OBJECTIVE, DID THE FEATURE INCREASE/DECREASE WATER DEPTH IN THE TREATMENT AREA?	FEATURE DATA
SHELTER	12a	TARGETED DEPTH OR RANGE (FT) IN HABITAT UNIT	HABITAT UNIT (SHELTER) DATA
	12b	ESTIMATE AREA OF FEATURE WITHIN TARGETED DEPTH OR RANGE FT²:	FEATURE DATA
	13.	WERE THERE ANY UNINTENDED EFFECTS OF THE FEATURE ON THE WATER DEPTH? IF Y, COMMENT.	FEATURE DATA
	14.	INSTREAM SHELTER VALUE IN THE HABITAT UNIT: 0, 1, 2, 3	HABITAT UNIT (SHELTER) DATA
	15.	PERCENT OF HABITAT UNIT COVERED BY SHELTER: %	HABITAT UNIT (SHELTER) DATA
	16a	1ST DOMINANT COVER IN HABITAT UNIT: BED, BOL, BUB, LWD, RTW, SWD, UCB, VEG, OTH	HABITAT UNIT (SHELTER) DATA
	16b	2ND DOMINANT IN HABITAT UNIT: BED, BOL, BUB, LWD, RTW, SWD, UCB, VEG, OTH	HABITAT UNIT (SHELTER) DATA
	17a	IF AN OBJECTIVE, DID THE FEATURE INCREASE INSTREAM SHELTER RATING?	FEATURE DATA
	17b	A. CALCULATE THE SHELTER RATING FOR THE HABITAT UNIT: 0-300	HABITAT UNIT (SHELTER) DATA
	18a	LARGE WOODY DEBRIS COUNT IN HABITAT UNIT: D >1', L 6-20'	HABITAT UNIT (SHELTER) DATA
	18b	LARGE WOODY DEBRIS COUNT IN HABITAT UNIT: D >1', L >20'	HABITAT UNIT (SHELTER) DATA
	19a	IF AN OBJECTIVE, DID THE FEATURE INCREASE LWD COUNT IN THE HABITAT UNIT?	FEATURE DATA
	19b	LWD RECRUITMENT MECHANISMS IN HABITAT UNIT: ANC, EXC, EXH, INT, RPR, UNA, OTH	HABITAT UNIT (SHELTER) DATA
CHANNEL	20.	CURRENT STREAM CHANNEL PROBLEMS IN THE HABITAT UNIT: AGG, BRD, FLO, GRC, HDC, INC, NAR, SCU, STT, WID, NON, OTH	HABITAT UNIT (SHELTER) DATA
	21a	IF AN OBJECTIVE, DID THE FEATURE LEAD TO THE TARGETED CHANNEL CONDITIONS?	FEATURE DATA
	21b	OVERALL OFFCHANNEL CONDITION (SITE): AGG, FPD, GRC, INC, NAR, SIN, STB, TOG, WID, OTH	FEATURE DATA
	21c	OUTLET CONDITIONS (SITE): AGG, FPD, GRC, INC, NAR, SIN, STB, TOG, WID, OTH	FEATURE DATA
	21d	INLET CONDITIONS (SITE): AGG, FPD, GRC, INC, NAR, SIN, STB, TOG, WID, OTH	FEATURE DATA
	22.	WERE THERE ANY UNINTENDED EFFECTS ON THE STREAM CHANNEL AT THE FEATURE? IF Y, COMMENT.	FEATURE DATA
VELOCITY	23.	IF AN OBJECTIVE, DID THE FEATURE DECREASE/INCREASE VELOCITY IN THE TREATMENT AREA?	FEATURE DATA
	24.	TARGETED VELOCITY/RANGE IN THE HABITAT UNIT: (FT/SEC)	HABITAT UNIT (SHELTER) DATA
	25.	DID THE FEATURE ACHIEVE THE TARGETED VELOCITY?	FEATURE DATA
	26a	MEASURED MINIMUM VELOCITY (FT/SEC) IN HABITAT UNIT	HABITAT UNIT (HYDRAULIC) DATA
	26b	MEASURED MAX VELOCITY (FT/SEC) IN HABITAT UNIT	HABITAT UNIT (HYDRAULIC) DATA
	26c	MEASURED MEAN VELOCITY (FT/SEC) IN HABITAT UNIT	HABITAT UNIT (HYDRAULIC) DATA
	27.	AREA OF HABITAT UNIT WITHIN TARGETED VELOCITY: (FT²)	HABITAT UNIT (HYDRAULIC) DATA
	28.	PERCENT OF HABITAT UNIT WITHIN TARGETED VELOCITY (SEE ABOVE): (%)	HABITAT UNIT (HYDRAULIC) DATA
	29.	WERE THERE ANY UNINTENDED EFFECTS OF FEATURE ON VELOCITY IF Y, COMMENT.	FEATURE DATA
OTHER	30a	1ST/2ND DOMINANT SUBSTRATE IN HABITAT UNIT: BED, BOL, COB, GRV, SND, SLC, OTH	HABITAT UNIT (SHELTER) DATA
	30b	2ND DOMINANT SUBSTRATE IN HABITAT UNIT: BED, BOL, COB, GRV, SND, SLC, OTH	HABITAT UNIT (SHELTER) DATA
	31.	IF AN OBJECTIVE, DID THE FEATURE ACHIEVE THE TARGETED SUBSTRATE COMPOSITION?	FEATURE DATA
	32.	% CANOPY MEASUREMENT:	HABITAT UNIT (SHELTER) DATA
	33.	PHOTOPOINT DATA COLLECTED: YES /NO	HABITAT UNIT (SHELTER) DATA
	34.	TEMPERATURE PROFILE: YES /NO	HABITAT UNIT (SHELTER) DATA
	35.	DISSOLVED OXYGEN PROFILE: YES/NO	HABITAT UNIT (SHELTER) DATA
RATING	36a	TOTAL HABITAT UNIT AREA WHERE TARGETED DEPTH, VELOCITY AND SHELTER CRITERIA OVERLAP	HABITAT UNIT (HYDRAULIC) DATA
	36b	TOTAL HABITAT UNIT AREA WHERE < 0.5 F/S; 0.5 TO 2 FT AND SHELTER CRITERIA OVERLAP	HABITAT UNIT (HYDRAULIC) DATA
	36c	TOTAL HABITAT UNIT AREA WHERE < 0.5 F/S; 2 TO 4 FT AND SHELTER CRITERIA OVERLAP	HABITAT UNIT (HYDRAULIC) DATA
	36d	% HABITAT UNIT AREA WHERE TARGETED DEPTH, VELOCITY AND SHELTER CRITERIA OVERLAP	HABITAT UNIT (HYDRAULIC) DATA
	36e	% HABITAT UNIT AREA WHERE < 0.5 F/S; 0.5 TO 2 FT AND SHELTER CRITERIA OVERLAP	HABITAT UNIT (HYDRAULIC) DATA
	36f	% HABITAT UNIT AREA WHERE < 0.5 F/S; 2 TO 4 FT AND SHELTER CRITERIA OVERLAP	HABITAT UNIT (HYDRAULIC) DATA
	37.	DOES THIS FEATURE NEED: DEC, ENH, MNT, REP, NON, OTH	FEATURE DATA
	38.	ARE ADDITIONAL RESTORATION TREATMENTS RECOMMENDED AT THIS LOCATION?	FEATURE DATA

Table 5.2.4. In-channel effectiveness monitoring checklist showing original data category from the AMP (left column) and modified data category (right column).

ORIGINAL DATA CATEGORY	#	QUESTION	MODIFIED DATA CATEGORY
FEATURE	1.	LENGTH OF TARGETED TREATMENT (FT)	FEATURE DATA
	2.	WIDTH OF TARGETED TREATMENT: (FT)	FEATURE DATA
	3.	ESTIMATE AREA OF THE TARGETED **FEATURE**: (FT^2)	FEATURE DATA
	4.	STRUCTURAL CONDITION OF **FEATURE**: EXCL, GOOD, FAIR, POOR, FAIL	FEATURE DATA
	5a	ARE PROBLEMS WITH THE **FEATURE** VISIBLE?	FEATURE DATA
	5b	TYPES: ANC, BBB, CRF, MAT, SHF, STR, SWA, UND, UNS, WSH, OTH	FEATURE DATA
	6a	IS THE **FEATURE** STILL IN ITS ORIGINAL LOCATION?	FEATURE DATA
	6b	IS THE **FEATURE** STILL IN ITS ORIGINAL POSITION?	FEATURE DATA
	6c	IF YES: LBK, MDC, RBK, SPN, OTH	FEATURE DATA
	6d	IS THE **FEATURE** STILL IN ITS ORIGINAL ORIENTATON?	FEATURE DATA
	6e	IF YES: DNS, MUL, PRL, PRP, UPS, OTH	FEATURE DATA
DEPTH/HABITAT	7.	CURRENT LEVEL II HABITAT TYPE: FLT, POO, RIF, DRY, ALC, OTH	HABITAT UNIT (SHELTER) DATA
	8.	IF AN OBJECTIVE, DID THE **FEATURE** CREATE THE TARGETED INSTREAM HABITAT TYPE?	FEATURE DATA
	9.	WERE THERE ANY UNINTENDED EFFECTS BY THE **FEATURE** ON THE HABITAT TYPE? IF Y, COMMENT.	FEATURE DATA
	10.	MEAN WATER DEPTH IN **HABITAT UNIT**: FT	HABITAT UNIT (HYDRAULIC) DATA
	11a	MAXIMUM WATER DEPTH IN **HABITAT UNIT**: FT	HABITAT UNIT (HYDRAULIC) DATA
	11b	AREA OF **HABITAT UNIT** WITHIN 0.5 -2.0 FT DEPTH: (FT2)	HABITAT UNIT (HYDRAULIC) DATA
	11c	AREA OF **HABITAT UNIT** WITHIN 2.0 -4.0 FT DEPTH: (FT2)	HABITAT UNIT (HYDRAULIC) DATA
	11d	AREA OF **HABITAT UNIT** WITHIN 0.5-4.0 FT DEPTH: (FT2)	HABITAT UNIT (HYDRAULIC) DATA
	11e	% AREA OF **HABITAT UNIT** WITHIN 0.5 -2.0 FT DEPTH	HABITAT UNIT (HYDRAULIC) DATA
	11f	% AREA OF **HABITAT UNIT** WITHIN 2.0 -4.0 FT DEPTH	HABITAT UNIT (HYDRAULIC) DATA
	11g	% AREA OF **HABITAT** UNIT WITHIN 0.5-4.0 FT DEPTH	HABITAT UNIT (HYDRAULIC) DATA
	11h	IF AN OBJECTIVE, DID THE **FEATURE** INCREASE/DECREASE WATER DEPTH IN THE TREATMENT AREA?	FEATURE DATA
SHELTER	12a	TARGETED DEPTH OR RANGE (FT) IN **HABITAT UNIT**	HABITAT UNIT (SHELTER) DATA
	12b	ESTIMATE AREA OF **FEATURE** WITHIN TARGETED DEPTH OR RANGE FT^2:	FEATURE DATA
	13.	WERE THERE ANY UNINTENDED EFFECTS OF THE **FEATURE** ON THE WATER DEPTH? IF Y, COMMENT.	FEATURE DATA
	14.	INSTREAM SHELTER VALUE IN THE **HABITAT UNIT**: 0, 1, 2, 3	HABITAT UNIT (SHELTER) DATA
	15.	PERCENT OF **HABITAT UNIT** COVERED BY SHELTER: %	HABITAT UNIT (SHELTER) DATA
	16a	1ST DOMINANT COVER IN **HABITAT UNI**T: BED, BOL, BUB, LWD, RTW, SWD, UCB, VEG, OTH	HABITAT UNIT (SHELTER) DATA
	16b	2ND DOMINANT IN **HABITAT UNIT**: BED, BOL, BUB, LWD, RTW, SWD, UCB, VEG, OTH	HABITAT UNIT (SHELTER) DATA
	17a	IF AN OBJECTIVE, DID THE **FEATURE** INCREASE INSTREAM SHELTER RATING?	FEATURE DATA
	17b	A. CALCULATE THE SHELTER RATING FOR THE **HABITAT UNIT**: 0-300	HABITAT UNIT (SHELTER) DATA
	18a	LARGE WOODY DEBRIS COUNT IN **HABITAT UNIT**: D >1', L 6-20'	HABITAT UNIT (SHELTER) DATA
	18b	LARGE WOODY DEBRIS COUNT IN **HABITAT UNIT**: D >1', L >20'	HABITAT UNIT (SHELTER) DATA
	19a	IF AN OBJECTIVE, DID THE **FEATURE** INCREASE LWD COUNT IN THE **HABITAT UNIT**?	FEATURE DATA
	19b	LWD RECRUITMENT MECHANISMS IN **HABITAT UNIT**: ANC, EXC, EXH, INT, RPR, UNA, OTH	HABITAT UNIT (SHELTER) DATA
CHANNEL	20.	CURRENT STREAM CHANNEL PROBLEMS IN THE **HABITAT UNIT**: AGG, BRD, FLO, GRC, HDC, INC, NAR, SCU, STT, WID, NON, OTH	HABITAT UNIT (SHELTER) DATA
	21a	IF AN OBJECTIVE, DID THE **FEATURE** LEAD TO THE TARGETED CHANNEL CONDITIONS?	FEATURE DATA
	21b	CONDITIONS AT THE **FEATURE**: AGG, FPD, GRC, INC, NAR, SIN, STB, TOG, WID, OTH	FEATURE DATA
	22.	WERE THERE ANY UNINTENDED EFFECTS ON THE STREAM CHANNEL AT THE **FEATURE**? IF Y, COMMENT.	FEATURE DATA
VELOCITY	23.	IF AN OBJECTIVE, DID THE **FEATURE** DECREASE/INCREASE VELOCITY IN THE TREATMENT AREA?	FEATURE DATA
	24.	TARGETED VELOCITY/RANGE IN THE **HABITAT UNIT**: (FT/SEC)	HABITAT UNIT (SHELTER) DATA
	25.	DID THE **FEATURE** ACHIEVE THE TARGETED VELOCITY?	FEATURE DATA
	26a	MEASURED MINIMUM VELOCITY (FT/SEC) IN **HABITAT UNIT**	HABITAT UNIT (HYDRAULIC) DATA
	26b	MEASURED MAX VELOCITY (FT/SEC) IN **HABITAT UNIT**	HABITAT UNIT (HYDRAULIC) DATA
	26c	MEASURED MEAN VELOCITY (FT/SEC) IN **HABITAT UNIT**	HABITAT UNIT (HYDRAULIC) DATA
	27.	AREA OF **HABITAT UNIT** WITHIN TARGETED VELOCITY: (FT^2)	HABITAT UNIT (HYDRAULIC) DATA
	28.	PERCENT OF **HABITAT UNIT** WITHIN TARGETED VELOCITY (SEE ABOVE): (%)	HABITAT UNIT (HYDRAULIC) DATA
	29.	WERE THERE ANY UNINTENDED EFFECTS OF **FEATURE** ON VELOCITY IF Y, COMMENT.	FEATURE DATA
OTHER	30a	1ST/2ND DOMINANT SUBSTRATE IN **HABITAT UNIT**: BED, BOL, COB, GRV, SND, SLC, OTH	HABITAT UNIT (SHELTER) DATA
	30b	2ND DOMINANT SUBSTRATE IN **HABITAT UNIT**: BED, BOL, COB, GRV, SND, SLC, OTH	HABITAT UNIT (SHELTER) DATA
	31.	IF AN OBJECTIVE, DID THE **FEATURE** ACHIEVE THE TARGETED SUBSTRATE COMPOSITION?	FEATURE DATA
	32.	% CANOPY MEASUREMENT:	HABITAT UNIT (SHELTER) DATA
	33.	PHOTOPOINT DATA COLLECTED: YES /NO	HABITAT UNIT (SHELTER) DATA
	34.	TEMPERATURE PROFILE: YES /NO	HABITAT UNIT (SHELTER) DATA
	35.	DISSOLVED OXYGEN PROFILE: YES/NO	HABITAT UNIT (SHELTER) DATA
RATING	36a	TOTAL **HABITAT UNIT** AREA WHERE TARGETED DEPTH, VELOCITY AND SHELTER CRITERIA OVERLAP	HABITAT UNIT (HYDRAULIC) DATA
	36b	TOTAL **HABITAT UNIT** AREA WHERE < 0.5 F/S; 0.5 TO 2 FT AND SHELTER CRITERIA OVERLAP	HABITAT UNIT (HYDRAULIC) DATA
	36c	TOTAL **HABITAT UNIT** AREA WHERE < 0.5 F/S; 2 TO 4 FT AND SHELTER CRITERIA OVERLAP	HABITAT UNIT (HYDRAULIC) DATA
	36d	% **HABITAT UNIT** AREA WHERE TARGETED DEPTH, VELOCITY AND SHELTER CRITERIA OVERLAP	HABITAT UNIT (HYDRAULIC) DATA
	36e	% **HABITAT UNIT** AREA WHERE < 0.5 F/S; 0.5 TO 2 FT AND SHELTER CRITERIA OVERLAP	HABITAT UNIT (HYDRAULIC) DATA
	36f	% **HABITAT UNIT** AREA WHERE < 0.5 F/S; 2 TO 4 FT AND SHELTER CRITERIA OVERLAP	HABITAT UNIT (HYDRAULIC) DATA
	37.	DOES THIS **FEATURE** NEED: DEC, ENH, MNT, REP, NON, OTH	FEATURE DATA
	38.	ARE ADDITIONAL RESTORATION TREATMENTS RECOMMENDED AT THIS LOCATION?	FEATURE DATA

Feature Ratings

From the modified checklists, we reduced the number of questions used to rate each enhancement feature to focus on feature condition, function, and apparent effect on habitat. The modified checklists for off- and in-channel areas contain up to 30 questions in the feature data category, including questions with multiple parts (e.g., Question 21; Table 5.2.3 and Table 5.2.4). We reduced the list to 11 questions with each response assigned a numeric score (Table 5.2.5). The sum of the numeric scores for each feature (up to 15 points) corresponds to a qualitative rating ranging from excellent to fail. We used the reduced list to score and rate each feature, but still answered the full list of questions for each feature (see completed checklists in Appendices). The full list provides ancillary qualitative information beyond the reduced list, but the reduced list directly evaluates feature condition, function, and effect on habitat, and is more efficient given the number of features in the Dry Creek Habitat Enhancement Project (>600 as of November 2020) and the number of feature data questions in the original and modified AMP checklists.

Habitat Unit Ratings

We also reduced the number of questions used to rate habitat units to focus on area of hydraulic habitat and shelter data, and to directly evaluate performance relative to primary performance measures (Table 5.2.6). The modified checklists for off- and in-channel areas each contain 40 habitat unit data questions, including questions with multiple parts (e.g., Question 16; Table 5.2.3 and Table 5.2.4). The reduced list of habitat unit data questions includes shelter value, percent overhead cover, and the calculated shelter score, with each response assigned a numeric score (Table 5.2.6). The reduced list of habitat unit data questions also includes the percent area of a habitat unit within optimal depth (0.5–2.0 ft; 2.0–4.0 ft) and velocity (≤0.5 ft/s) ranges, both singly and in combination, as specified in the BO and AMP, each assigned a numeric score (Table 5.2.6). The sum of the numeric scores for habitat units (up to 35 points) determines a qualitative rating ranging from excellent to fail. As with feature data, we still answered the full list of questions for each habitat unit (see completed checklists in Appendix 5.2). But, the reduced list directly evaluates habitat unit shelter and hydraulic habitat, which are primary performance measures in the AMP, and is more efficient given the number of habitat units evaluated for the Dry Creek Habitat Enhancement Project (>700 as of November 2020) and the number of habitat unit data questions in the original and modified AMP checklists.

Table 5.2.5. Feature data questions used to rate each enhancement feature, the highest numerical score assigned to each response, and the qualitative rating assigned to the range of quantitative ratings.

Question #	Question	Highest possible score
4.	Structural condition of feature[a]	5
5a	Are problems with the feature visible?[b]	1
6a	Is the feature still in its original location?[c]	1
6b	Is the feature still in its original position?[c]	1
6d	Is the feature still in its original orientation?[c]	1
8.	Did the feature create the targeted instream habitat type?[c]	1
9.	Were there any unintended effects by the feature on the habitat type?[b]	1
17a	Did the feature increase instream shelter rating?[c]	1
19a	Did the feature increase LWD count in the habitat unit?[c]	1
21a	Did the feature lead to the targeted channel conditions?[c]	1
25.	Did the feature achieve the targeted velocity?[c]	1
Feature quantitative rating	**(sum of above)**	**15**
Feature qualitative rating[a]		**Excellent**

[a]Excellent = 5 points; Good = 4 point; Fair = 3 points; Poor = 2 points; Fail = 1 point
[b]Yes = 0 points; No = 1 point
[c]Yes = 1 point; No = 0 points

Table 5.2.6. Habitat unit data questions used to rate each habitat unit, the highest numerical score assigned to each response, and the qualitative rating assigned to the range of quantitative ratings.

Question #	Question	Highest possible score
11e	% Area of **habitat unit** within 0.5 -2.0 ft depth[a]	4
11f	% Area of **habitat unit** within 2.0 -4.0 ft depth[a]	4
14.	Instream shelter value in the **habitat unit**: 0, 1, 2, 3[b]	5
15.	Percent of **habitat unit** covered by shelter: %[c]	5
17b	Calculate the shelter rating for the **habitat unit**: 0-300[d]	5
28.	Percent of **habitat unit** within targeted velocity: (%)[a]	4
36e	% **habitat unit** area where < 0.5 f/s; 0.5 to 2 ft and shelter criteria overlap[a]	4
36f	% **habitat unit** area where < 0.5 f/s; 2 to 4 ft and shelter criteria overlap[a]	4
Habitat quantitative rating	**(sum of above)**	**35**
Habitat qualitative rating[a]		**Excellent**

[a]≥40% = 4 points; ≥30% = 3 points; ≥20% = 2 points; ≥10% = 1 point, ; ≥5% = 0 points
[b]3 = 5 points; 2 = 4 points, 1 = 3 points, 0 = 0 points
[c]≥80% = 5 points; ≥60% = 4 points; ≥40% = 3 points; ≥20% = 2 points; ≥10% = 1 point; <10% = 0 points
[d]≥140 = 5 points; ≥100 = 4 points; ≥80 = 3 points; ≥60 = 2 points; ≥40 = 1 point; <40 = 0 points

Site and Enhancement Reach Ratings

Data collected at the feature and habitat unit scale provide the basis to evaluate and rate sites and enhancement reaches (Table 5.2.7). We calculated an average feature rating and an average habitat unit rating for each site. The sum of the site average feature rating and site average habitat unit ratings equaled the overall site quantitative rating (up to 50 points), which we converted to a site qualitative rating, ranging from excellent to fail, similar to ratings for features and habitat units. Following the upward progression of spatial scales from habitat unit to site, the average of all sites within an enhancement reach determined the enhancement reach quantitative and qualitative ratings (Table 5.2.7).

Table 5.2.7. Spatial roll-up of site average feature and habitat unit ratings into site and enhancement reach rating using an enhancement reach with three sites as an example. The sum of the site average feature and habitat unit ratings determine the site quantitative and qualitative rating. The average of site ratings determines the enhancement reach quantitative and qualitative rating.

Site number	**1**	**2**	**3**
Site average **feature** quantitative rating[a]	15	15	15
Site average **feature** qualitative rating[a]	Excellent	Excellent	Excellent
Site average **habitat unit** quantitative rating[b]	35	35	35
Site average **habitat unit** qualitative rating[b]	Excellent	Excellent	Excellent
Site quantitative rating (sum of site average feature and habitat unit rating)[c]	50	50	50
Site qualitative rating[c]:	Excellent	Excellent	Excellent
Enhancement reach quantitative rating (average of site rating)[c]	50		
Enhancement reach qualitative rating[c]:	Excellent		

[a]out of 15; Excellent (>=12), Good (>=9), Fair (>=6), Poor (>=3), Fail (<3)
[b]out of 35; Excellent (>=28), Good (>=21), Fair (>=14), Poor (>=7), Fail (<7)
[c]out of 50; Excellent (>=40), Good (>=30), Fair (>=20), Poor (>=10), Fail (<10)

Monitoring Frequency

The AMP recommended monitoring sites at three different time periods: prior to enhancement (pre-enhancement), just after enhancement (post-enhancement), and following a geomorphically effective flow (post-effective flow) (Porter et al. 2014). Pre-enhancement surveys include depth, velocity, habitat type and shelter value, but do not include feature data, as feature installation occurs during construction of enhancement sites. Accordingly, pre-enhancement site and enhancement reach ratings do not include feature ratings. Post-enhancement surveys occur after construction and include quantitative ratings and qualitative ratings of all spatial scales (feature, habitat unit, site, and enhancement reach). The AMP also recommends collecting data after a geomorphically effective flow (the flow [discharge] responsible for transporting the largest volume of sediment in a river or stream over the long-term). In the absence of a geomorphically effective discharge, the AMP recommends collecting data within three years after construction (Porter et al. 2014). Inter-Fluve (2013) found that the geomorphically effective flow in Dry Creek occurred at a return period of less than one year (i.e., annually or sub-annually). Following this, post-effective flow surveys typically occurred the following spring or summer after construction. After the initial post-effective flow survey, Sonoma Water surveys each site every three years.

We also added a post-repair monitoring time-period. The AMP recommends future outcomes (actions) for enhancement reaches receiving low ratings (fair to fail) that range from corrective action (repair or modification) to a reduction in potential habitat credit, to abandonment of features, sites, or enhancement reaches (Table 5.2.2). If Sonoma Water repaired or modified a site, we conducted post-repair effectiveness monitoring shortly after repairs or modifications. We added post-repair to the monitoring time periods to differentiate from post-enhancement monitoring that occurs after a site is newly constructed. We will include a post-repair monitoring time period as necessary in future monitoring reports.

Results

During the summer and fall 2020, Sonoma Water effectiveness monitored nine enhancement reaches totaling nearly 650,000 ft^2 on mainstem Dry Creek, side channels, and alcoves (Table 5.2.8, Figure 5.2.4). Fields crews collected over 28,000 depth and velocity points, evaluated 521 features for their condition, and evaluated 197 habitat units for their hydraulic (depth and velocity) and shelter characteristics. The monitored enhancement reaches stretch from Reach 2b (as defined by Inter-Fluve 2012, River Mile [RM] 1.67) to Reach 14 (RM 12.75) (Figure 5.2.4). We monitored and rated the pre-enhancement condition of one reach to be fully constructed in 2021 (Boaz Gros-Balthazard; see Pre-enhancement results below), eight enhancement reaches post-effective flow (Weinstock, Gallo, Truett Hurst, Van Alyea, Farrow Wallace, Ferrari-Carano, Olson, and Geyser Peak; see Post-effective flow results below), and one reach repaired during the fall of 2020 (Ferrari-Carano, Olson; see Post-repair results below). Sonoma Water constructed the Gallo enhancement reach in 2019 and this is the first post-effective flow effectiveness monitoring survey for the reach. The results below summarize effectiveness monitoring results for pre-enhancement, post-effective flow, and post-repair time periods by enhancement reach. We did not conduct any post-enhancement monitoring as only partial construction of Boaz Gros-Balthazard occurred in 2020 (post-enhancement monitoring will occur in 2021 after complete construction). Each summary describes the amount of habitat monitored within each main and side channel area, the area and percent of the enhancement reach meeting depth and velocity criteria, habitat types, shelter scores, and pool to riffle ratio. We also summarize the feature and habitat unit ratings that inform the site ratings, and the roll-up of site ratings into the enhancement reach rating.

Table 5.2.8. Dry Creek enhancement reaches monitored in 2020, type of monitoring conducted, and area of aquatic habitat monitored. Reaches listed from upstream (closest to Warm Springs Dam) to downstream (closest to confluence with Russian River) (-- indicates monitoring not conducted).

Enhancement Reach	Pre-enhancement (ft^2)	Post-enhancement (ft^2)	Post-effective Flow (ft^2)	Post-repair (ft^2)
Weinstock	--	--	46,369	--
Gallo	--	--	83,576	--
Truett Hurst	--	--	65,887	--
Van Alyea	--	--	73,138	--
Farrow, Wallace	--	--	80,913	--
Boaz, Gros Balthazard	37,946	--	--	--
Ferrari-Carano Olson	--	--	111,237	104,768
Geyser Peak	--	--	39,452	--
TOTAL (ft^2)	**37,946**	**--**	**500,572**	**104,768**
GRAND TOTAL (ft^2)	**643,287**			

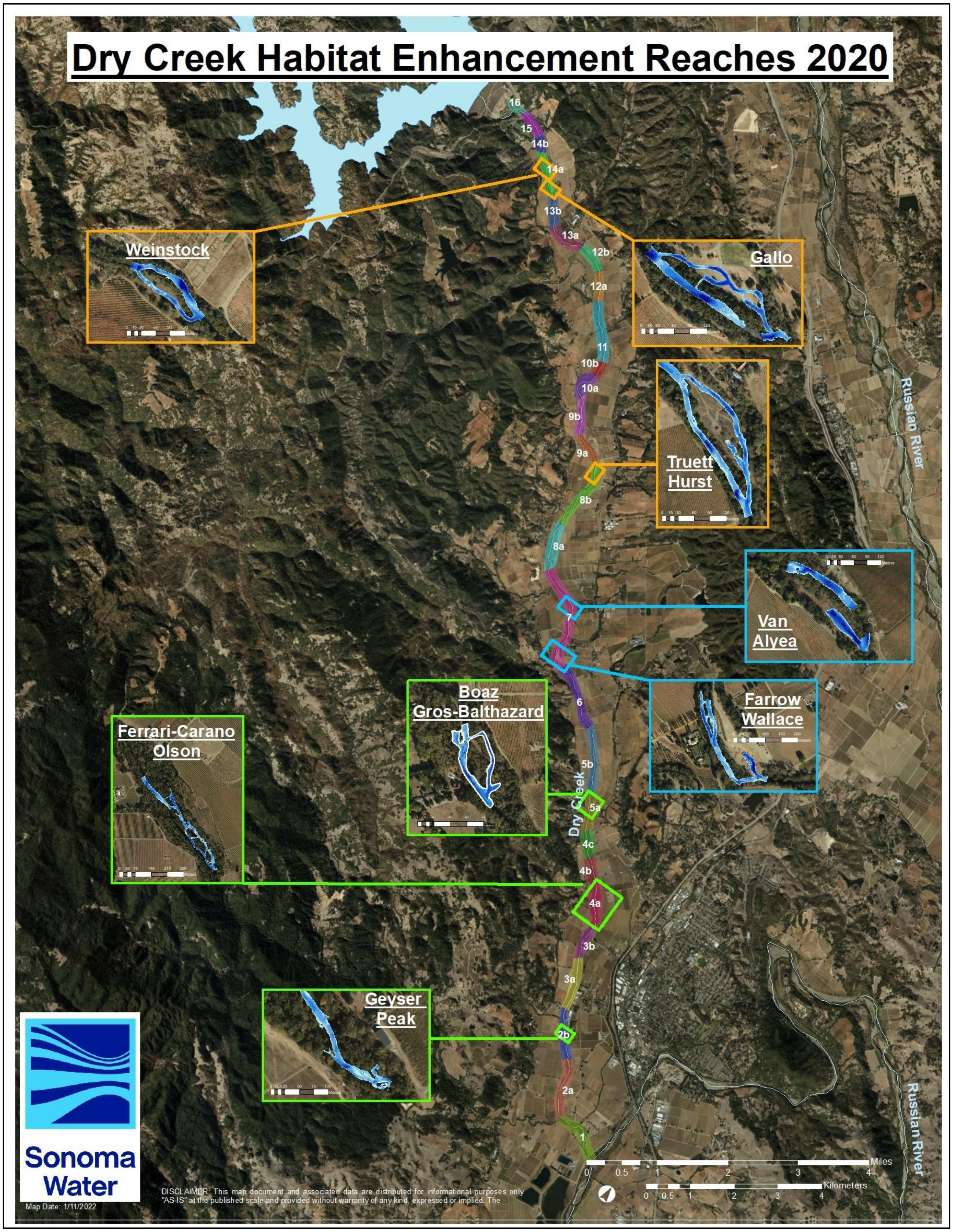


Figure 5.2.4. Location of Dry Creek habitat enhancement reaches monitored in 2020.

Pre-enhancement

Boaz Gros-Balthazard Enhancement Reach

Sonoma Water monitored the pre-enhancement condition of the Boaz Gros-Balthazard enhancement reach in May 2020. The reach covered 37,946 ft^2 within the main channel of Dry Creek, with 20% meeting optimal depth and velocity criteria, mostly along the channel margins (Table 5.2.9, Figure 5.2.5). Seven habitat units made up the enhancement reach, with a pool to riffle ratio of 1:2 (0.50) and an average shelter score of 120 (Table 5.2.10, Figure 5.2.6, Figure 5.2.7). Five habitat units met or exceeded the optimal shelter value of 80. The reach comprised one mainstem enhancement site with fair habitat unit ratings and fair overall reach rating (Table 5.2.11, Figure 5.2.8, Figure 5.2.9; see Appendix 5.2 for all measured values, scores, and ratings).

Depth and velocity

Table 5.2.9. Areas and percentages of: wetted area, optimal depth and velocity, and optimal hydraulic habitat within the Boaz Gros-Balthazard enhancement reach, May 2020.

Boaz Gros-Balthazard Pre-enhancement May 2020	Wetted area (ft^2)	0.5 – 2.0 ft (ft^2)	2.0 – 4.0 ft (ft^2)	Total (ft^2)	< 0.5 ft/s (ft^2)	0.5 – 2.0 ft < 0.5 ft/s (ft^2)	2.0 – 4.0 ft < 0.5 ft/s (ft^2)	Total (ft^2)
Main channel area	37,946	26,098	7,339	33,437	10,356	5,701	1,799	7,500
Main channel % of wetted area	100%	69%	19%	88%	27%	15%	5%	20%

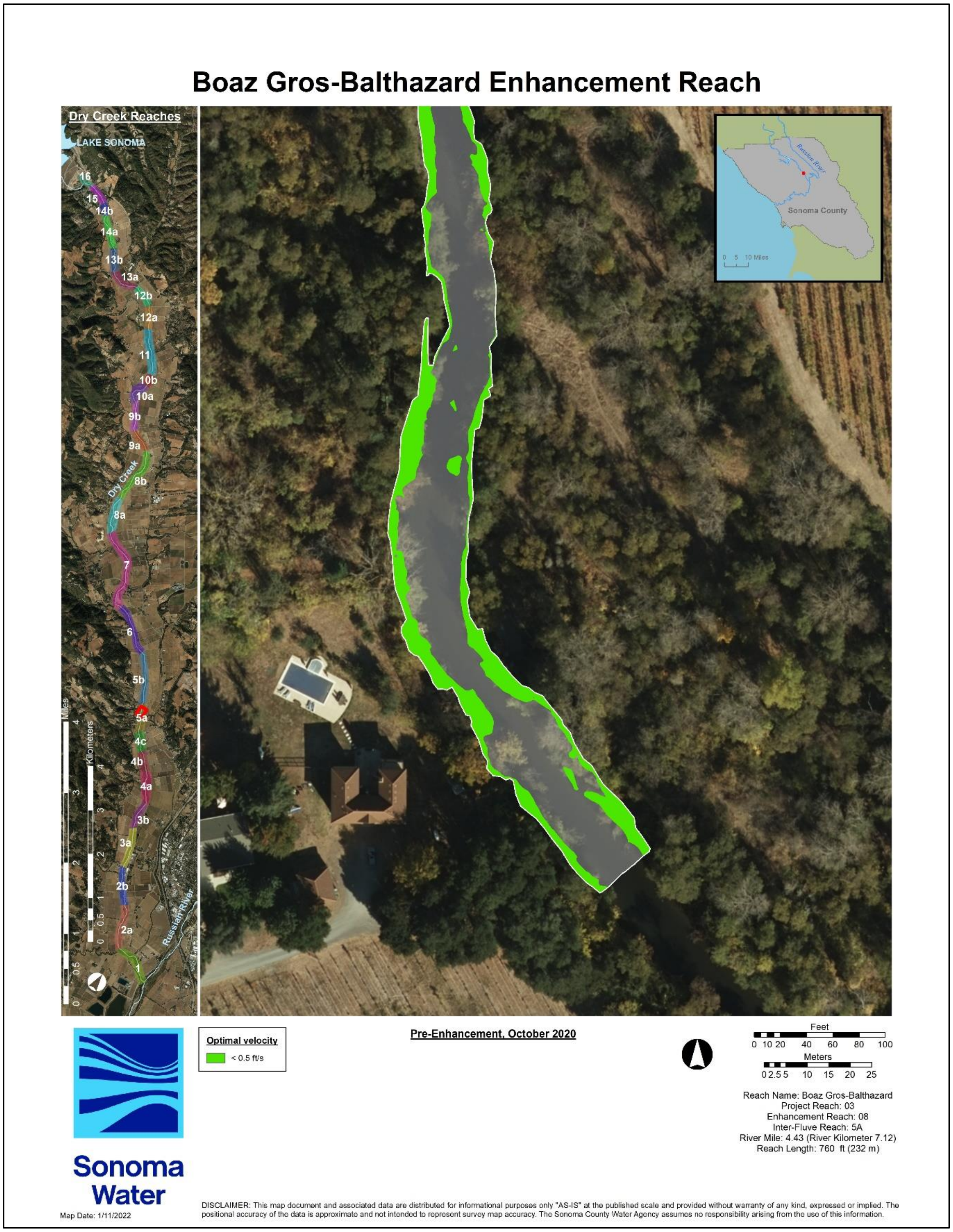


Figure 5.2.5. Optimal hydraulic habitat for fry (<0.5 ft/s, 0.5-2.0 ft) and parr (<0.5 ft/s, 2.0-4.0 ft) within the Boaz Gros-Balthazard enhancement reach, May 2020.

Habitat types, pool to riffle ratio, and shelter scores

Table 5.2.10. Habitat, types, shelter score, percent cover, and shelter value for main channel habitat units within the Boaz Gros-Balthazard enhancement reach, May 2020.

Habitat Unit #	Habitat Type	Shelter Value	Percent Cover	Shelter Score
HU01	Flatwater	2	30	60
HU02	Pool	3	45	135
HU03	Flatwater	3	45	135
HU04	Flatwater	3	70	210
HU05	Riffle	3	45	135
HU06	Flatwater	3	30	90
HU07	Riffle	3	25	75
Pool: riffle	**1: 2 (0.50)**			**Avg = 120**

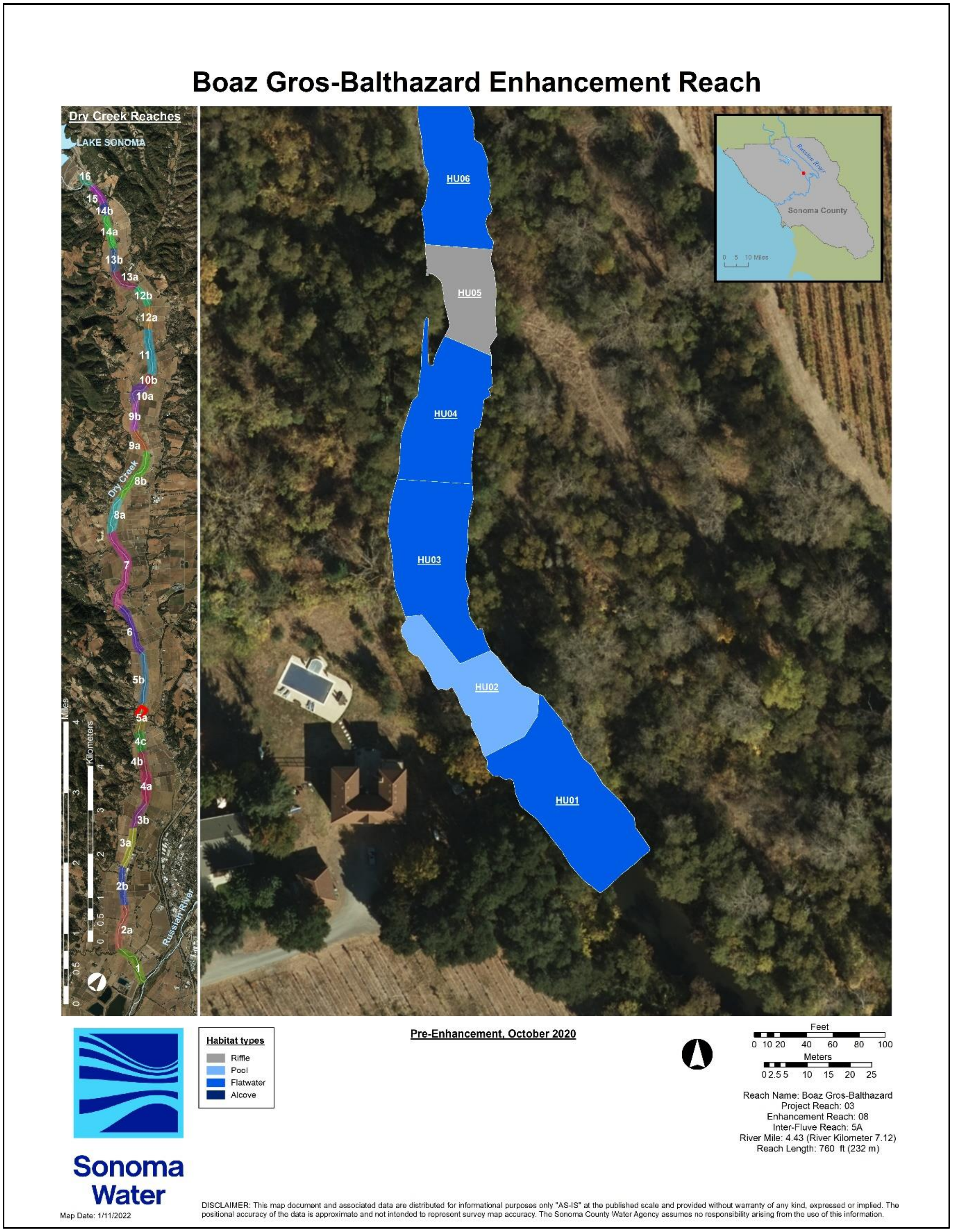


Figure 5.2.6. Habitat unit number and type within the Boaz Gros-Balthazard enhancement reach, May 2020.

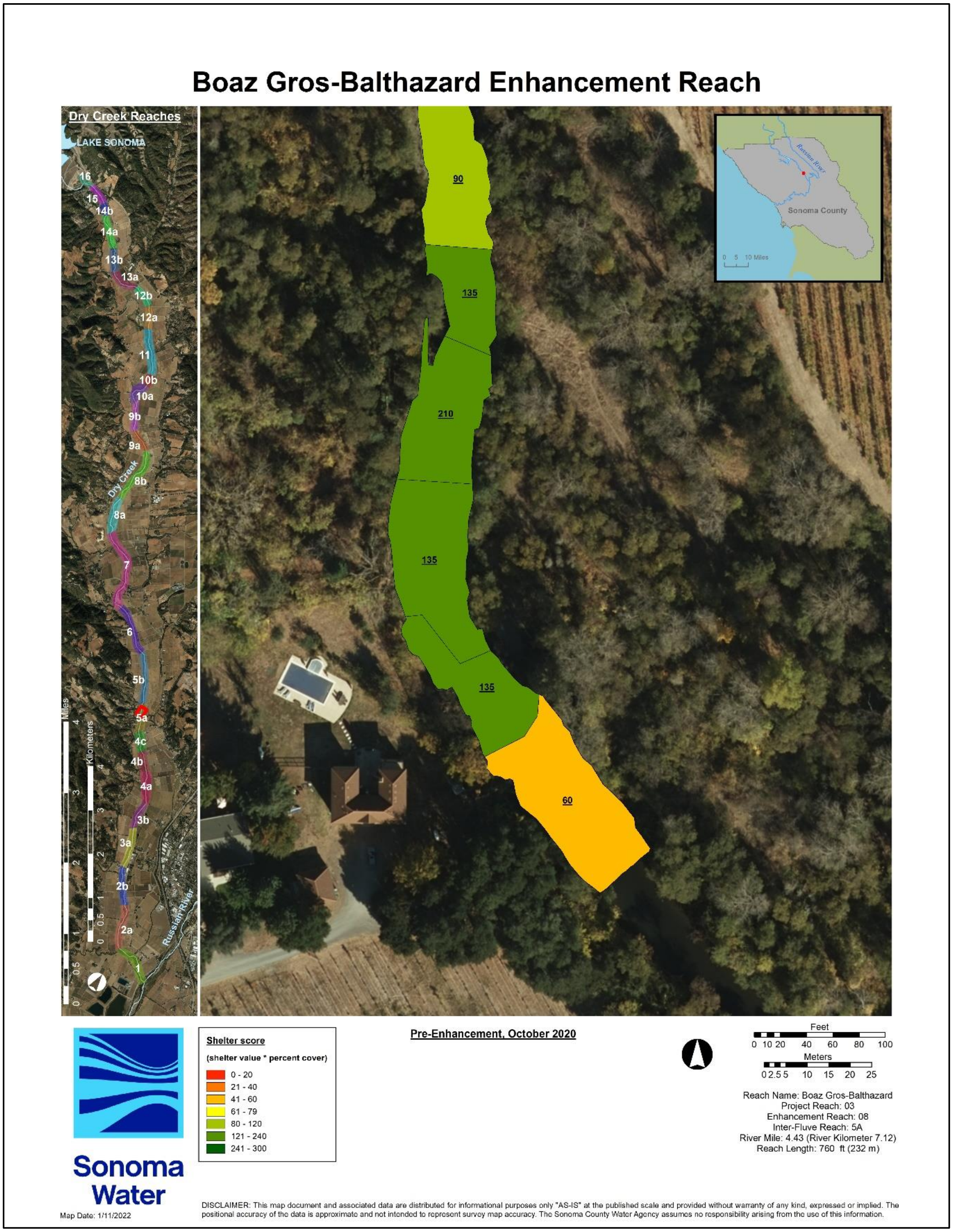


Figure 5.2.7. Habitat unit shelter values within the Boaz Gros-Balthazard enhancement reach, May 2020.

Habitat unit, site, and reach ratings

Table 5.2.11. Pre-enhancement average feature, habitat unit, site, and reach ratings (rounded to the nearest whole number) for the for the Boaz Gros-Balthazard enhancement reach, May 2020.

Site number	**1**			
Site type	**Main channel**			
Site average feature quantitative rating[a]	0			
Site average feature qualitative rating[a]	Not rated			
Site average habitat unit quantitative rating[b]	20			
Site average qualitative rating[b]	Fair			
Site quantitative rating (sum of site average feature and habitat unit rating)[c]	20			
Site qualitative rating[c]	Fair			
Enhancement reach quantitative rating (average of site rating)[c]	20			
Enhancement reach qualitative rating[c]:	Fair			

[a]not included in rating
[b]out of 35; Excellent (>=28), Good (>=21), Fair(>=14), Poor (>=7), Fail (<7)
[c]out of 35; Excellent (>=28), Good (>=21), Fair(>=14), Poor (>=7), Fail (<7)

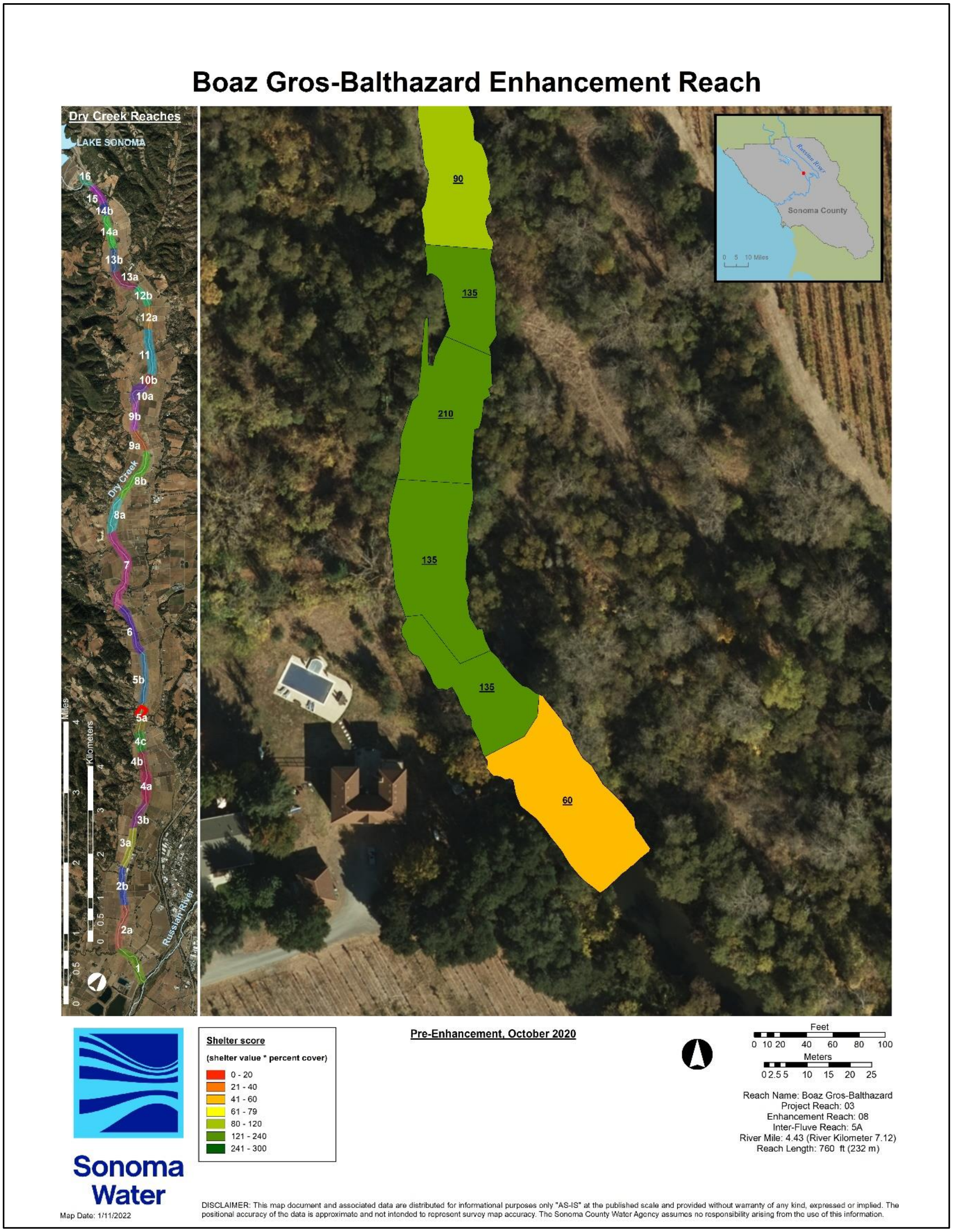


Figure 5.2.8. Habitat unit ratings for the Boaz Gros-Balthazard enhancement reach, May 2020.

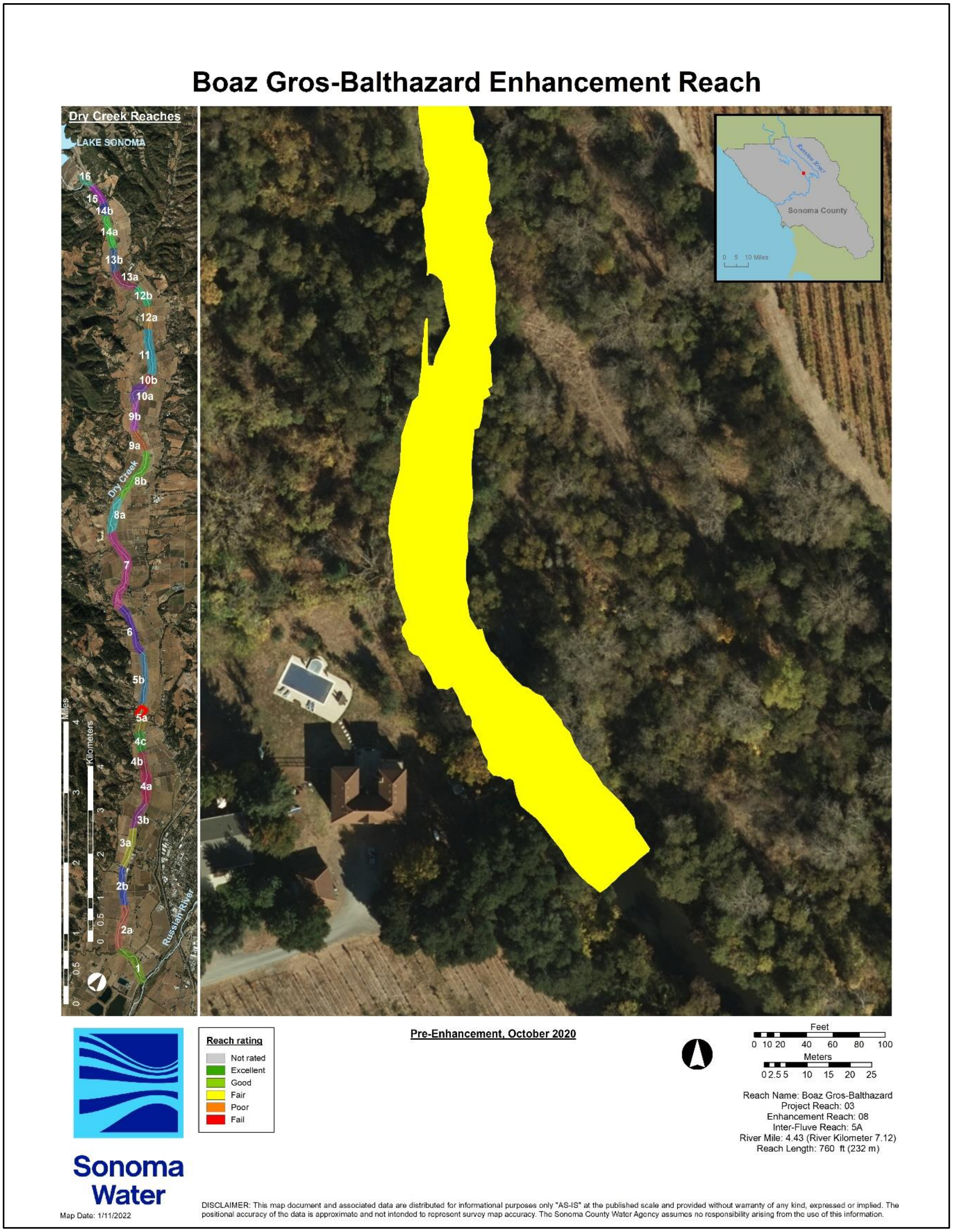


Figure 5.2.9. Pre-enhancement site and reach rating for the Boaz Gros-Balthazard enhancement reach, May 2020.

Post-effective Flow

Summary

Sonoma Water monitored the post-effective flow conditions of the, Weinstock, Gallo, Truett Hurst, Van Alyea, Farrow Wallace, Ferrari-Carano-Olson, and Geyser Peak enhancement reaches in 2020 (Table 5.2.8, Figure 5.2.4). Overall, the enhancement reaches encompassed 500,572 ft^2 within main- and off-channel areas, with 30% of the total area meeting optimal depth and velocity criteria (Table 5.2.12). Monitoring examined 148,979 ft^2 of off-channel area, of which 39% met optimal depth and criteria, compared with 351,593 ft^2 and 27% in the main channel. Crews observed 154 habitat units across all enhancement reaches with a total pool to riffle ratio of 57:55 (1.05) and a total average shelter score of 97 (Table 5.2.13). Average alcove shelter score (224, n = 15) and average pool shelter score (110, n = 57) exceeded the optimum shelter score of 80, followed by flatwaters (74, n = 27), and riffles (59, n = 55). Post-effective flow, Weinstock, Gallo, Truett Hurst, and Farrow Wallace enhancement reaches rated good, Van Alyea rated excellent, and Ferrari-Carano, Olson and Geyser Peak rated fair. (Table 5.2.14; see below for individual enhancement reach summaries and Appendix 5.2 for all measured values, scores, and ratings).

Depth and velocity

Table 5.2.12. Post-effective flow areas and percentages of: wetted area, optimal depth and velocity, and optimal hydraulic habitat within Dry Creek enhancement surveyed in 2020.

Dry Creek Post-effective Flow 2020	Wetted area (ft^2)	0.5 – 2.0 ft (ft^2)	2.0 – 4.0 ft (ft^2)	Total (ft^2)	< 0.5 ft/s (ft^2)	0.5 – 2.0 ft < 0.5 ft/s (ft^2)	2.0 – 4.0 ft < 0.5 ft/s (ft^2)	Total (ft^2)
Main channel area	351,593	157,453	113,675	271,129	147,901	51,817	42,941	94,758
Off channel area	148,979	69,635	40,340	109,975	89,155	35,636	22,065	57,701
Total area	**500,572**	**227,088**	**154,016**	**381,104**	**237,056**	**87,453**	**65,006**	**152,459**
Main channel % of wetted area	70%	44%	32%	77%	43%	15%	12%	27%
Off channel % of wetted area	30%	47%	27%	74%	60%	24%	15%	39%
Total % of wetted area	**100%**	**45%**	**31%**	**76%**	**47%**	**17%**	**13%**	**30%**

Habitat types, pool to riffle ratio, and shelter scores

Table 5.2.13. Post-enhancement habitat types, pool: riffle ratio and average shelter score within Dry Creek enhancement reaches surveyed in 2020.

Habitat Type	# of Habitat Units	Shelter Score
Riffle	55	59
Pool	57	110
Flatwater	27	74
Alcove	15	224
Pool: riffle	**57:55 (1.04)**	**Avg: 97**

Reach ratings

Table 5.2.14. Post-enhancement ratings for Dry Creek enhancement reaches surveyed in 2020.

Enhancement Reach	Post-effective Flow Rating
Weinstock	Good
Gallo	Good
Truett Hurst	Good
Van Alyea	Excellent
Farrow, Wallace	Good
Ferrari-Carano, Olson	Fair
Geyser Peak	Fair

Weinstock Enhancement Reach

Sonoma Water monitored the post-effective flow condition of the Weinstock enhancement reach in November 2020. Previous effectiveness monitoring surveys occurred in July 2018 (pre-enhancement), October 2018 (post-enhancement), and September 2019 (post-effective flow) receiving fair, good, and good ratings, respectively. The enhanced reach encompassed 46,369 ft^2 within main- and off-channel areas of Dry Creek with 27% of the total area meeting optimal depth and velocity criteria (Table 5.2.15, Figure 5.2.10). The monitoring characterized 34,250 ft^2 of main channel area, and 12,119 ft^2 of side channel area, of which 26% and 29% met optimal depth and velocity criteria, respectively. Seventeen habitat units composed the enhancement reach, with a pool to riffle ratio of 11:4 (2.75) and average shelter score of 71 (Table 5.2.16, Figure 5.2.11, Figure 5.2.12). Seven habitat units met or exceeded the optimum shelter score of 80. The enhancement reach comprised two enhancement sites (one main-channel, one side channels; Table 5.2.17, Figure 5.2.13), with excellent site average feature ratings, and fair site average habitat unit ratings (Table 5.2.17, Figure 5.2.14, Figure 5.2.15). Enhancement sites received good ratings (Table 5.2.17, Figure 5.2.16). Overall, the Weinstock enhancement reach received a good effectiveness monitoring rating (Table 5.2.17, Figure 5.2.17; see Appendix 5.2 for all measured values, scores, and ratings).

Depth and velocity

Table 5.2.15. Areas and percentages of: wetted area, optimal depth and velocity, and optimal hydraulic habitat within the Weinstock enhancement reach, November 2020.

Weinstock Post-effective flow November 2020	**Wetted area (ft^2)**	**0.5 – 2.0 ft**	**2.0 – 4.0 ft**	**Total**	**< 0.5 ft/s**	**0.5 – 2.0 ft < 0.5 ft/s**	**2.0 – 4.0 ft < 0.5 ft/s**	**Total**
Main channel area	34,250	12,709	12,130	24,839	15,025	5,331	3,692	9,022
Side channel area	12,119	6,581	4,385	10,966	4,580	2,391	1,091	3,482
Total area	**46,369**	**19,290**	**16,516**	**35,805**	**19,605**	**7,722**	**4,782**	**12,505**
Main channel % of wetted area	74%	37%	35%	73%	44%	16%	11%	26%
Side channel % of wetted area	26%	54%	36%	90%	38%	20%	9%	29%
Total % of wetted area	**100%**	**42%**	**36%**	**77%**	**42%**	**17%**	**10%**	**27%**

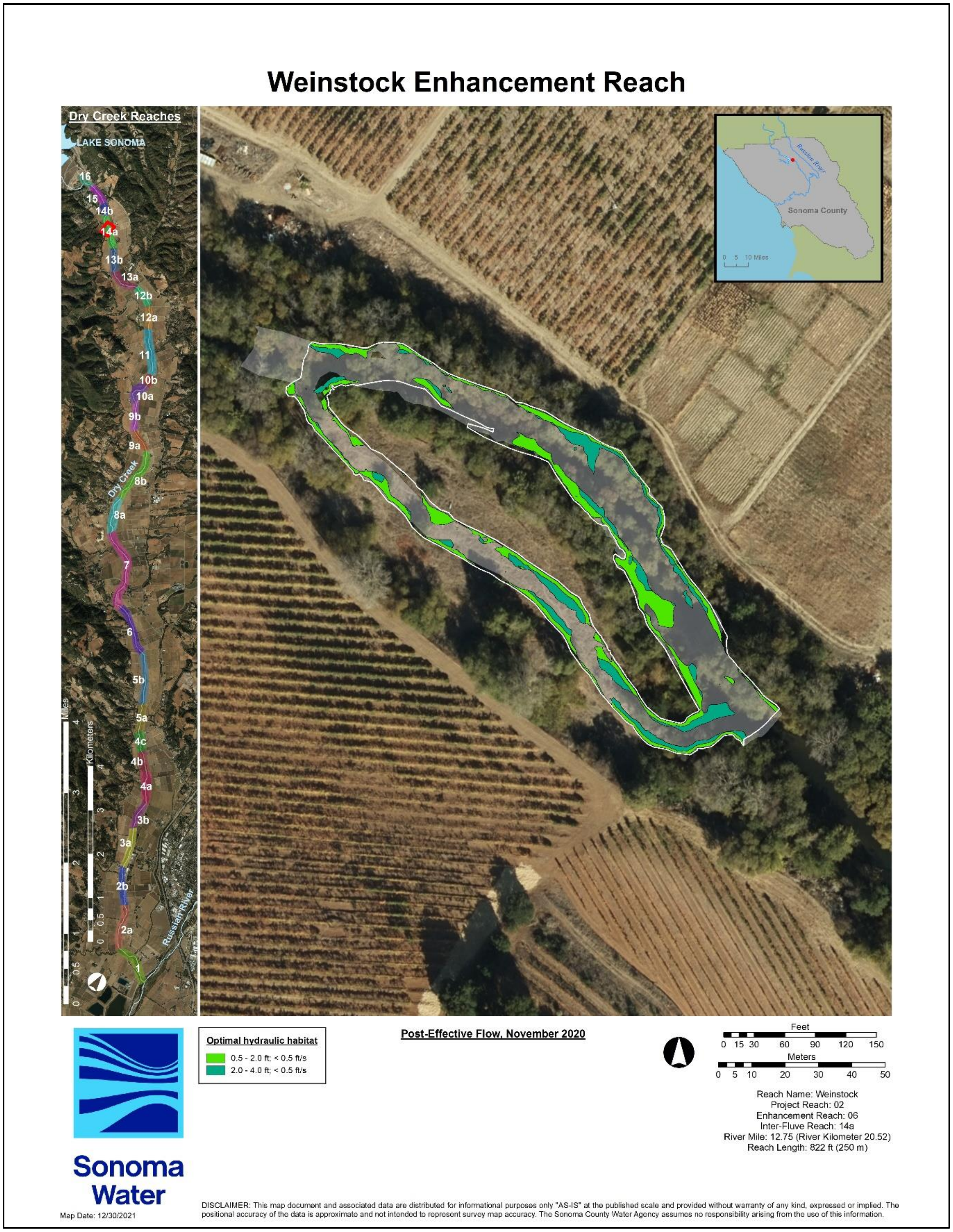


Figure 5.2.10. Optimal hydraulic habitat for fry (<0.5 ft/s, 0.5-2.0 ft) and parr (<0.5 ft/s, 2.0-4.0 ft) within the Weinstock enhancement reach, November 2020.

Habitat types, pool to riffle ratio, and shelter scores

Table 5.2.16. Habitat, types, shelter value, percent cover, and shelter score for habitat units within the Weinstock enhancement reach, November 2020.

Habitat Unit #	Habitat Type	Shelter Value	Percent Cover	Shelter Score
HU01	Pool	3	50	150
HU02	Riffle	3	20	60
HU03	Pool	3	35	105
HU04	Pool	3	15	45
HU05	Flatwater	2	10	20
HU06	Pool	3	15	45
HU07	Riffle	3	20	60
HU08	Pool	3	40	120
HU09	Riffle	1	10	10
HU10	Pool	2	10	20
HU11	Flatwater	3	40	120
HU12	Flatwater	2	45	90
HU13	Pool	3	25	75
HU14	Flatwater	1	10	10
HU15	Pool	1	15	15
HU16	Riffle	3	40	120
HU17	Pool	3	45	135
Pool: riffle	**11:4 (2.75)**			**Avg = 71**

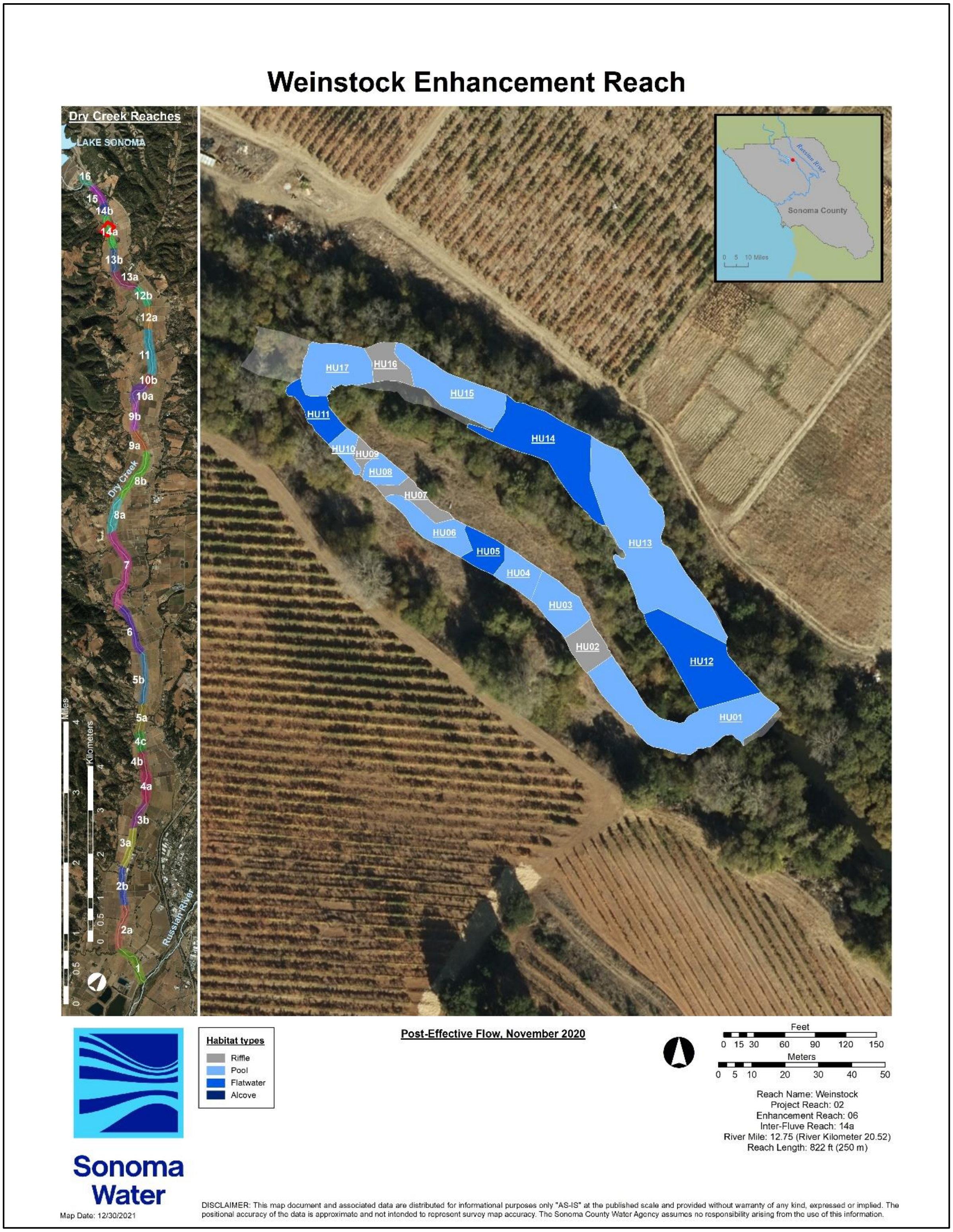


Figure 5.2.11. Habitat unit number and type within the Weinstock enhancement reach, November 2020.

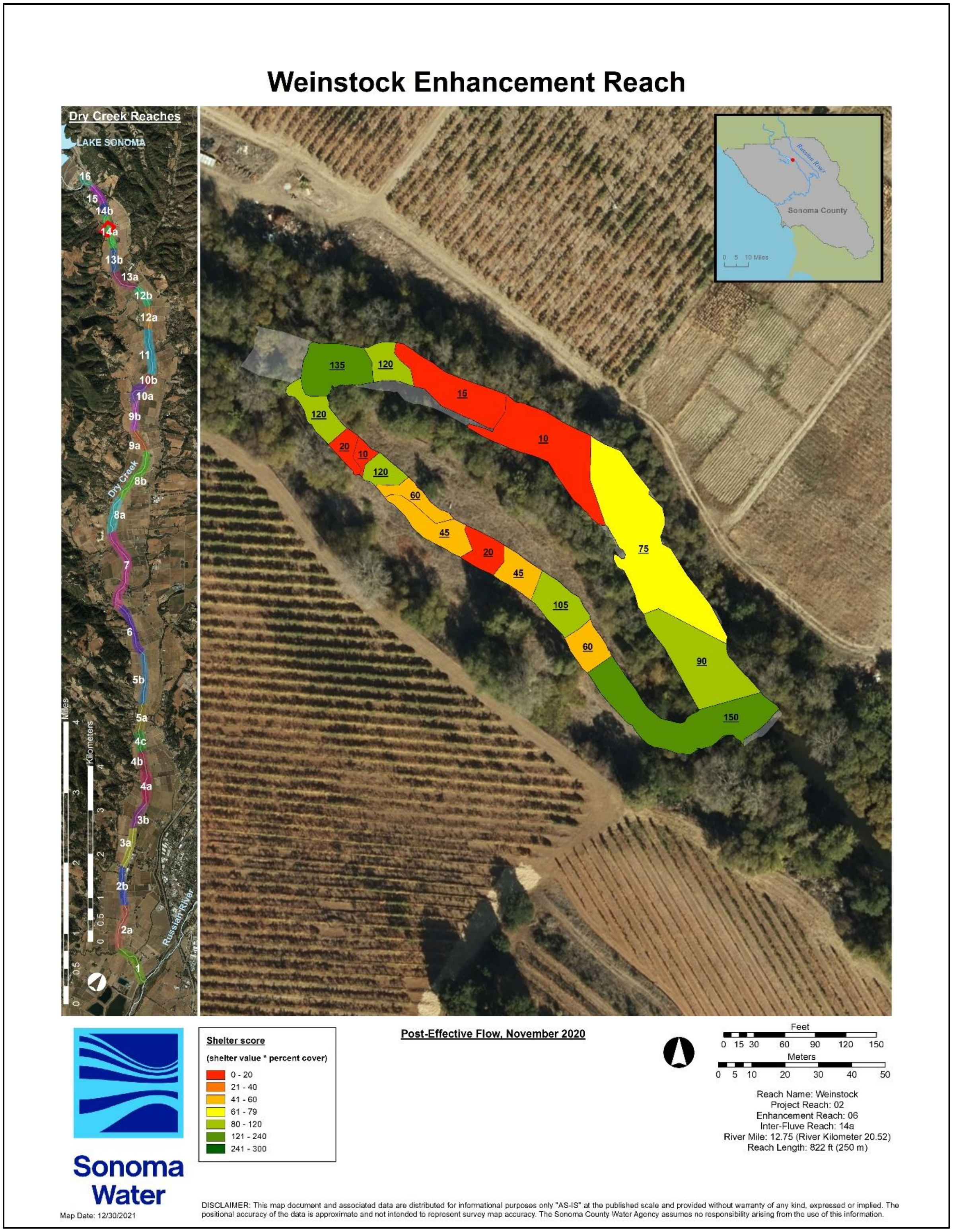


Figure 5.2.12. Habitat unit shelter scores within the Weinstock enhancement reach, November 2020.

Feature, habitat unit, site, and reach ratings

Table 5.2.17. Post-effective flow average feature, average habitat unit, site, and reach ratings (rounded to the nearest whole number) for the Weinstock enhancement reach, November 2020.

Site number	**1**	**2**		
Site type	**Main channel**	**Side channel**		
Site average feature quantitative rating[a]	13	13		
Site average feature qualitative rating[a]	Excellent	Excellent		
Site average habitat unit quantitative rating[b]	20	20		
Site average qualitative rating[b]	Fair	Fair		
Site quantitative rating (sum of site average feature and habitat unit rating) [c]	33	33		
Site qualitative rating[c]	Good	Good		
Enhancement reach quantitative rating (average of site rating) [c]	33			
Enhancement reach qualitative rating[c]:	Good			

[a]out of 15; Excellent (>=12), Good (>=9), Fair (>=6), Poor (>=3), Fail (<3)
[b]out of 35; Excellent (>=28), Good (>=21), Fair(>=14), Poor (>=7), Fail (<7)
[c]out of 50; Excellent (>=40), Good (>=30), Fair (>=20), Poor (>=10), Fail (<10)

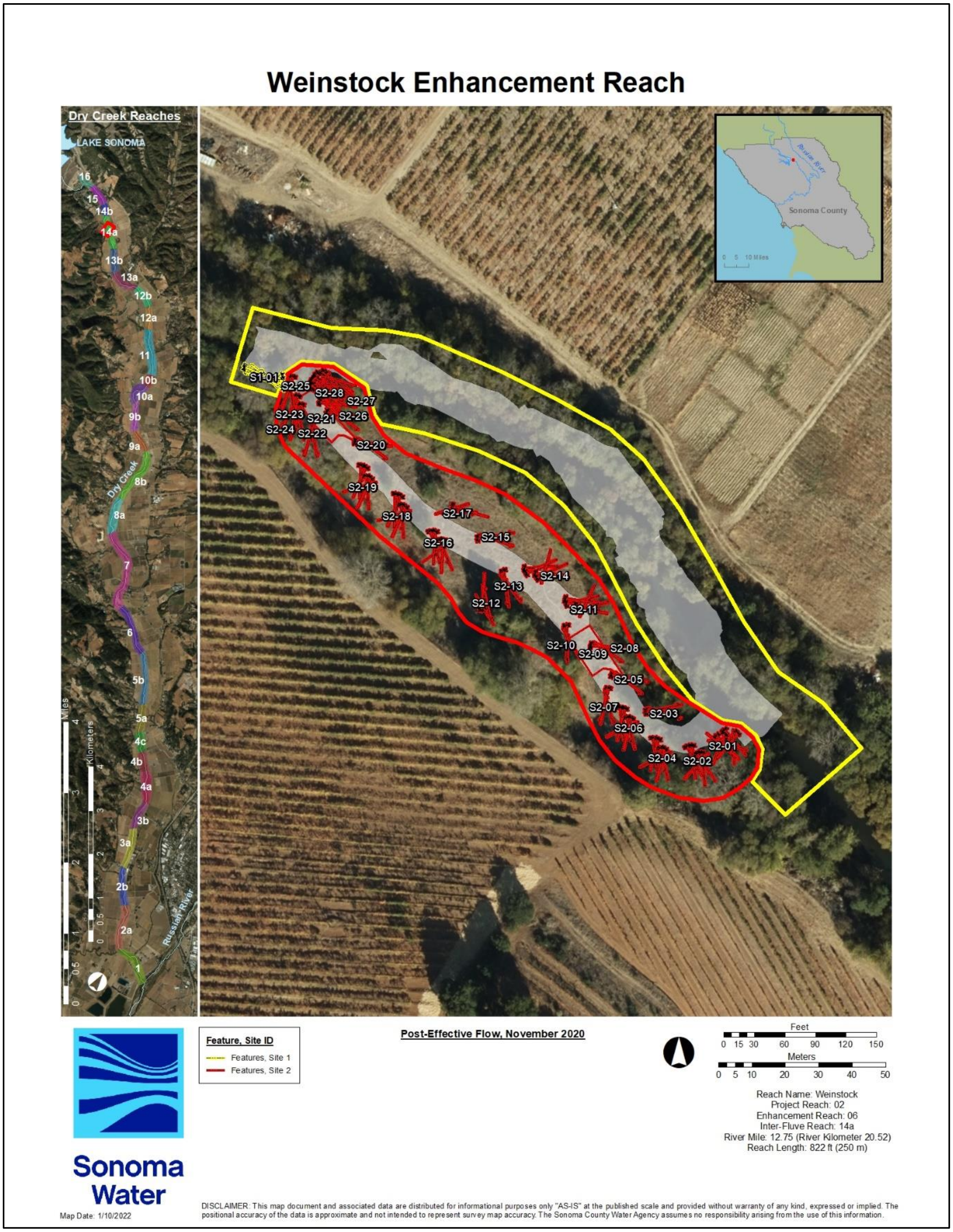


Figure 5.2.13. Enhancement sites and features within the Weinstock enhancement reach, November 2020.

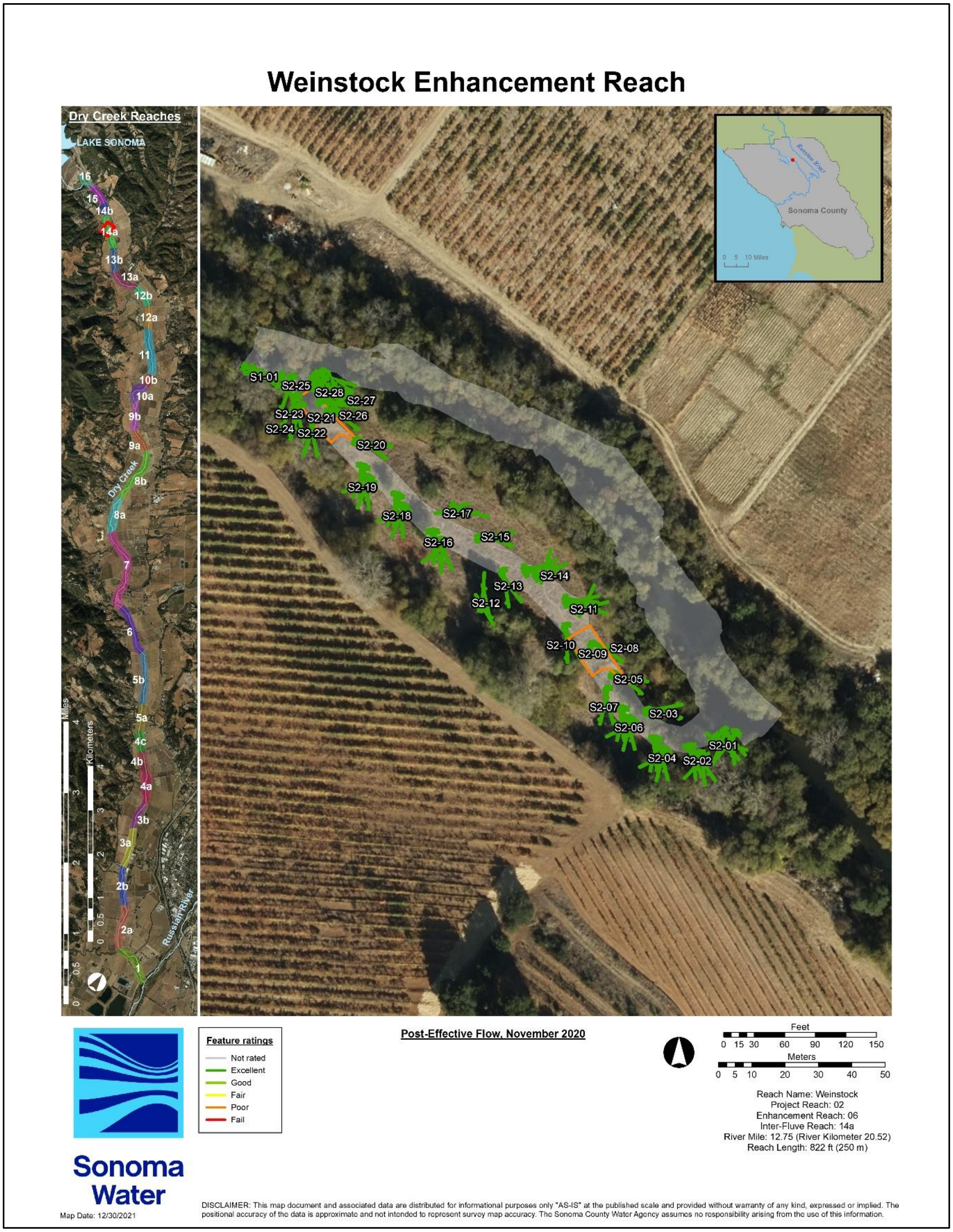


Figure 5.2.14. Feature ratings for the Weinstock enhancement reach, November 2020.

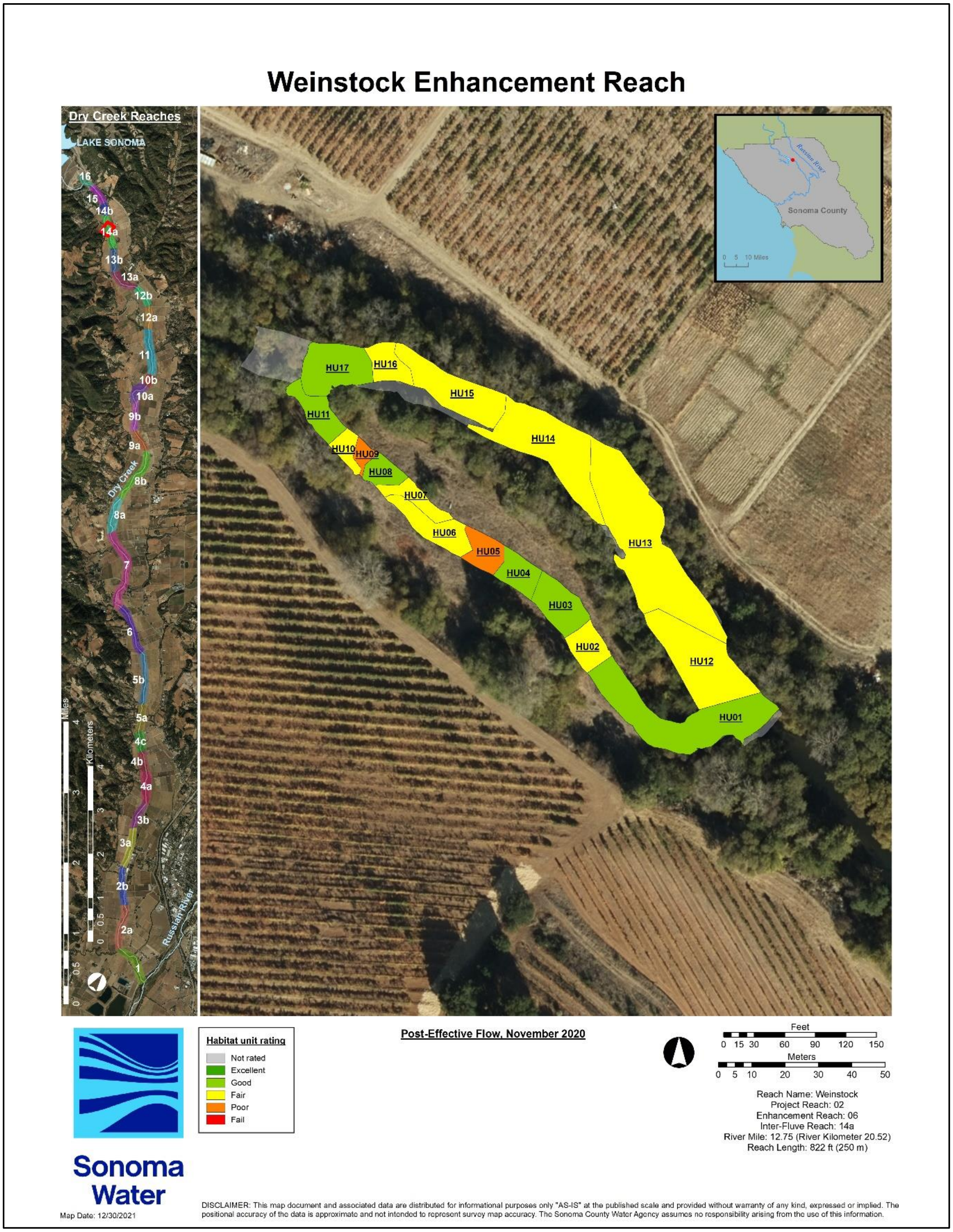


Figure 5.2.15. Habitat unit ratings for the Weinstock enhancement reach, November 2020.

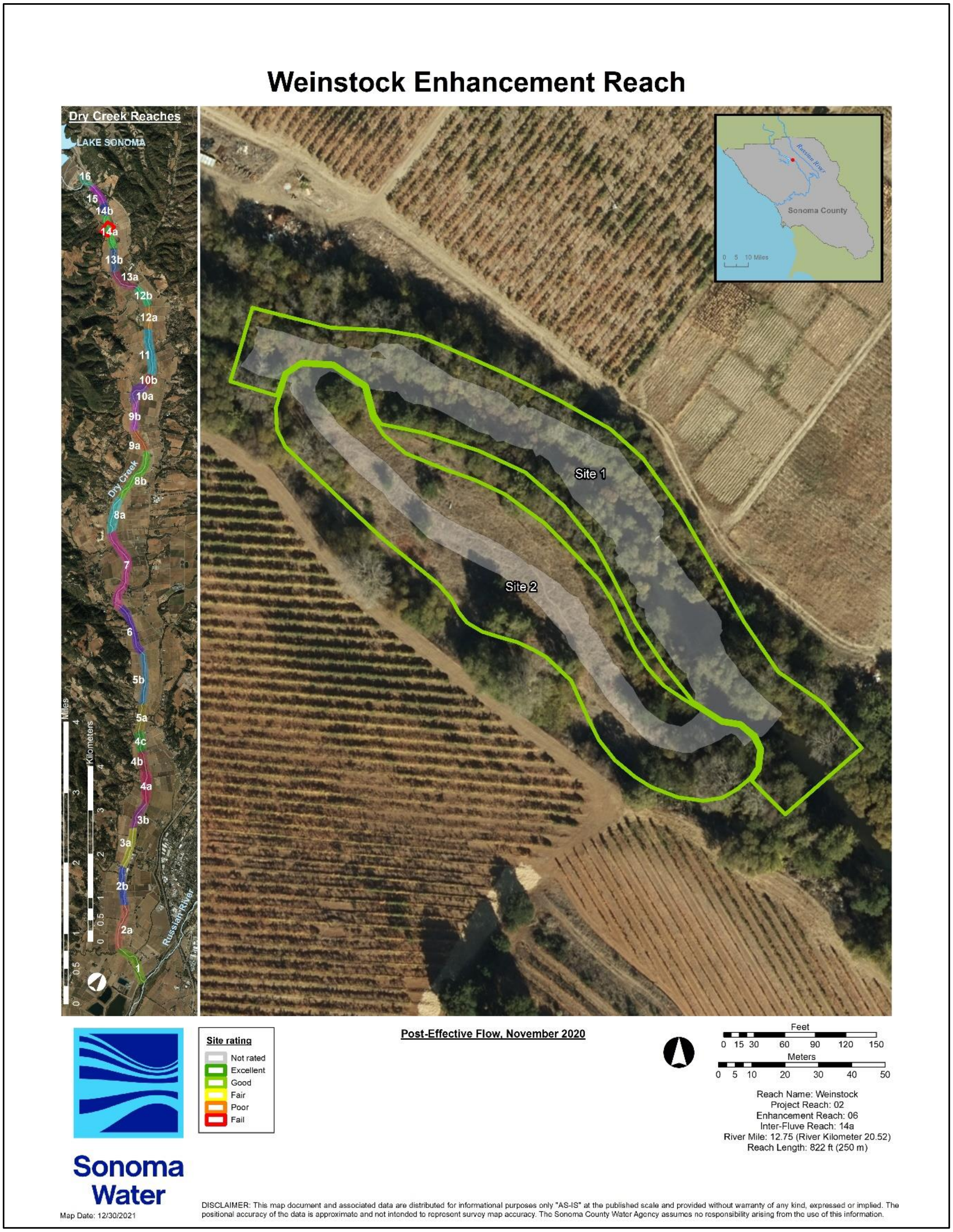


Figure 5.2.16. Post effective flow site ratings for the Weinstock enhancement reach, November 2020.

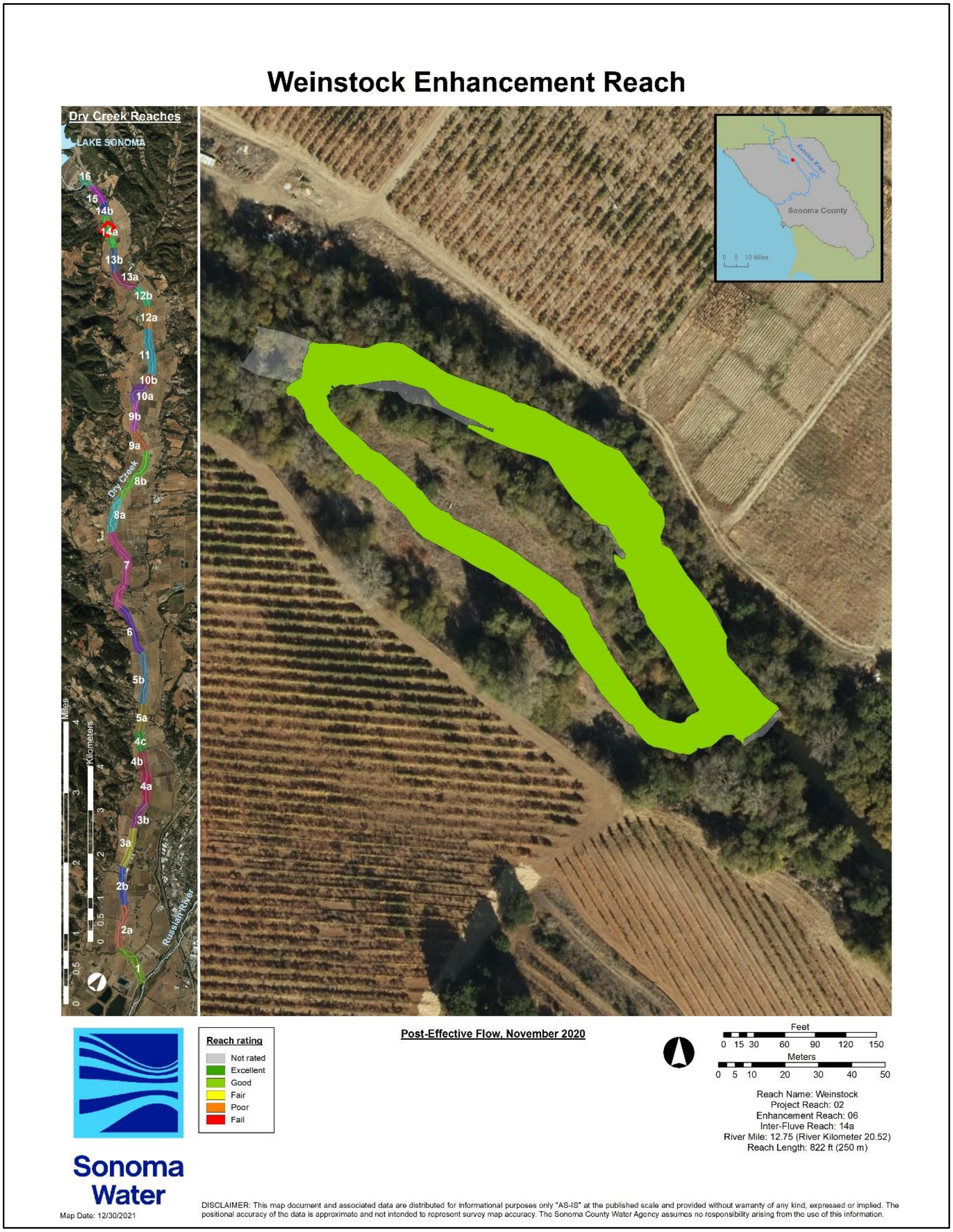


Figure 5.2.17. Post-effective flow reach rating for the Weinstock enhancement reach, November 2020.

Gallo Enhancement Reach

Sonoma Water monitored the post-effective flow condition of the Gallo enhancement reach in September 2020. Previous effectiveness monitoring surveys occurred in June 2018 (pre-enhancement) and October 2019 (post-enhancement),receiving fair and good ratings, respectively. In 2020, the enhanced reach encompassed 83.576 ft^2 within main- and off-channel areas of Dry Creek with 34% of the total area meeting optimal depth and velocity criteria (Table 5.2.18, Figure 5.2.18). The monitoring characterized 34,399 ft^2 of side channel area, of which 45% met optimal depth and velocity criteria, compared with 49,177 ft^2 and 27% for the main channel area. Eighteen habitat units composed the enhancement reach, with a pool to riffle ratio of 7:10 (0.70) and average shelter score of 104 (Table 5.2.19, Figure 5.2.19, Figure 5.2.20). Ten habitat units met or exceeded the optimum shelter score of 80. The enhancement reach comprised two enhancement sites (one main-channel, one side channel (Figure 5.2.21), with excellent site average feature ratings, and fair average habitat unit ratings (Table 5.2.20, Figure 5.2.22, Figure 5.2.23). Enhancement sites received fair to good ratings (Figure 5.2.24). Overall, the City of Healdsburg Yard enhancement reach received a good effectiveness monitoring rating (Table 5.2.20,Figure 5.2.25; see Appendix 5.2 for all measured values, scores, and ratings).

Depth and velocity

Table 5.2.18. Areas and percentages of: wetted area, optimal depth and velocity, and optimal hydraulic habitat within the Gallo enhancement reach, September 2020.

Gallo Post-enhancement September 2020	Wetted area (ft^2)	0.5 – 2.0 ft	2.0 – 4.0 ft	Total	< 0.5 ft/s	0.5 – 2.0 ft < 0.5 ft/s	2.0 – 4.0 ft < 0.5 ft/s	Total
Main channel area	49,177	18,907	17,256	36,163	20,406	6,818	6,216	13,034
Side channel area	34,399	12,613	11,707	24,319	23,838	7,282	8,304	15,587
Total area	**83,576**	**31,520**	**28,963**	**60,483**	**44,244**	**14,100**	**14,521**	**28,621**
Main channel % of wetted area	59%	38%	35%	74%	41%	14%	13%	27%
Side channel % of wetted area	41%	37%	34%	71%	69%	21%	24%	45%
Total % of wetted area	**100%**	**38%**	**35%**	**72%**	**53%**	**17%**	**17%**	**34%**

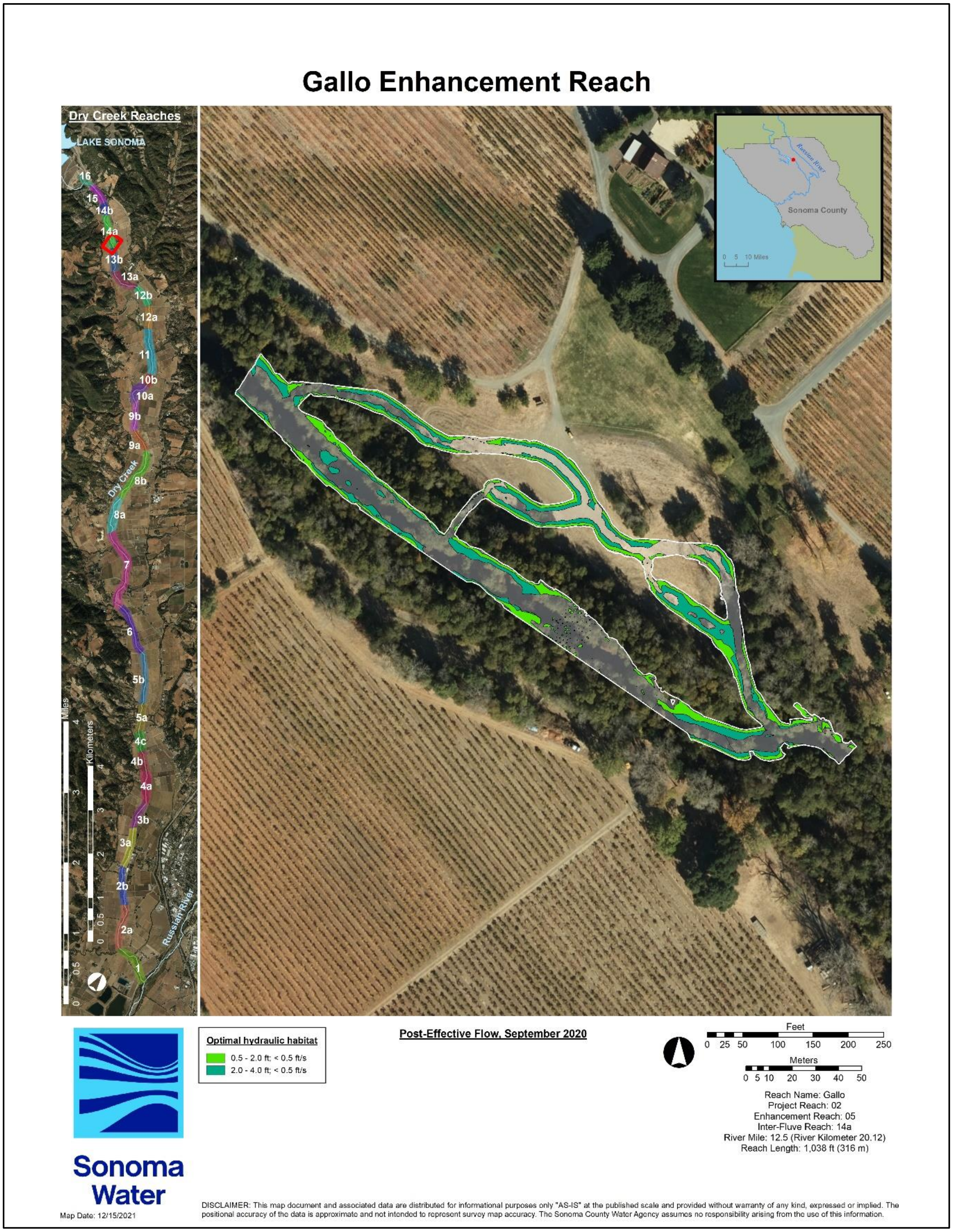


Figure 5.2.18. Optimal hydraulic habitat for fry (<0.5 ft/s, 0.5-2.0 ft) and parr (<0.5 ft/s, 2.0-4.0 ft) within the Gallo enhancement reach, September 2020.

Habitat types, pool to riffle ratio, and shelter scores

Table 5.2.19. Habitat, types, shelter value, percent cover, and shelter score for habitat units within the Gallo enhancement reach, September 2020.

Habitat Unit #	Habitat Type	Shelter Value	Percent Cover	Shelter Score
HU01	Riffle	2	15	30
HU02	Pool	3	45	135
HU03	Alcove	3	80	240
HU04	Riffle	3	30	90
HU05	Riffle	2	25	50
HU06	Pool	3	30	90
HU07	Riffle	1	5	5
HU08	Pool	3	30	90
HU09	Pool	3	80	240
HU10	Riffle	1	10	10
HU11	Pool	3	30	90
HU12	Riffle	1	5	5
HU13	Pool	3	90	270
HU14	Riffle	2	20	40
HU15	Riffle	3	55	165
HU16	Riffle	2	25	50
HU17	Pool	3	65	195
HU18	Riffle	2	35	70
Pool: riffle	**7:10 (0.70)**			**Avg = 104**

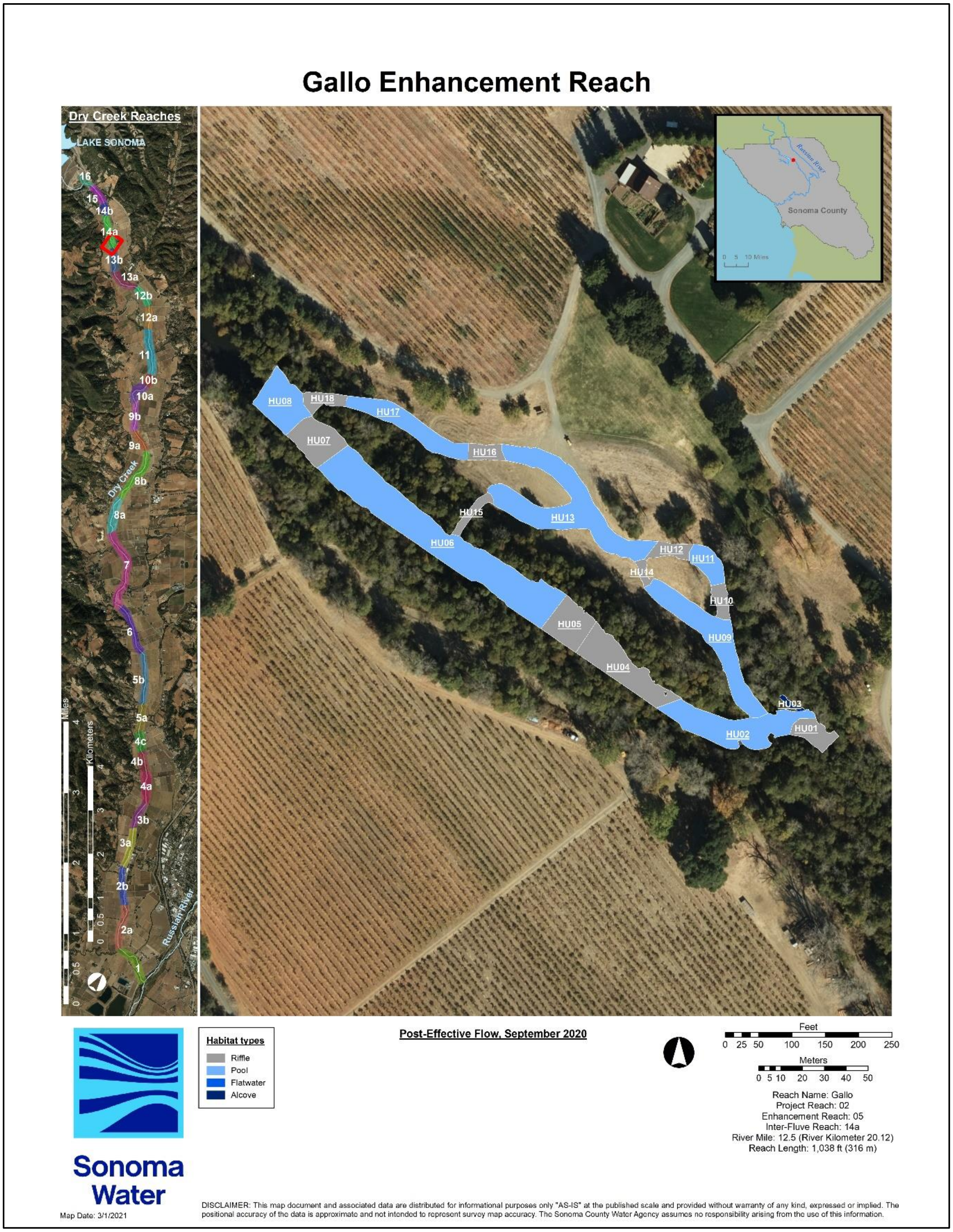


Figure 5.2.19. Habitat unit number and type within the Gallo enhancement reach, September 2020.

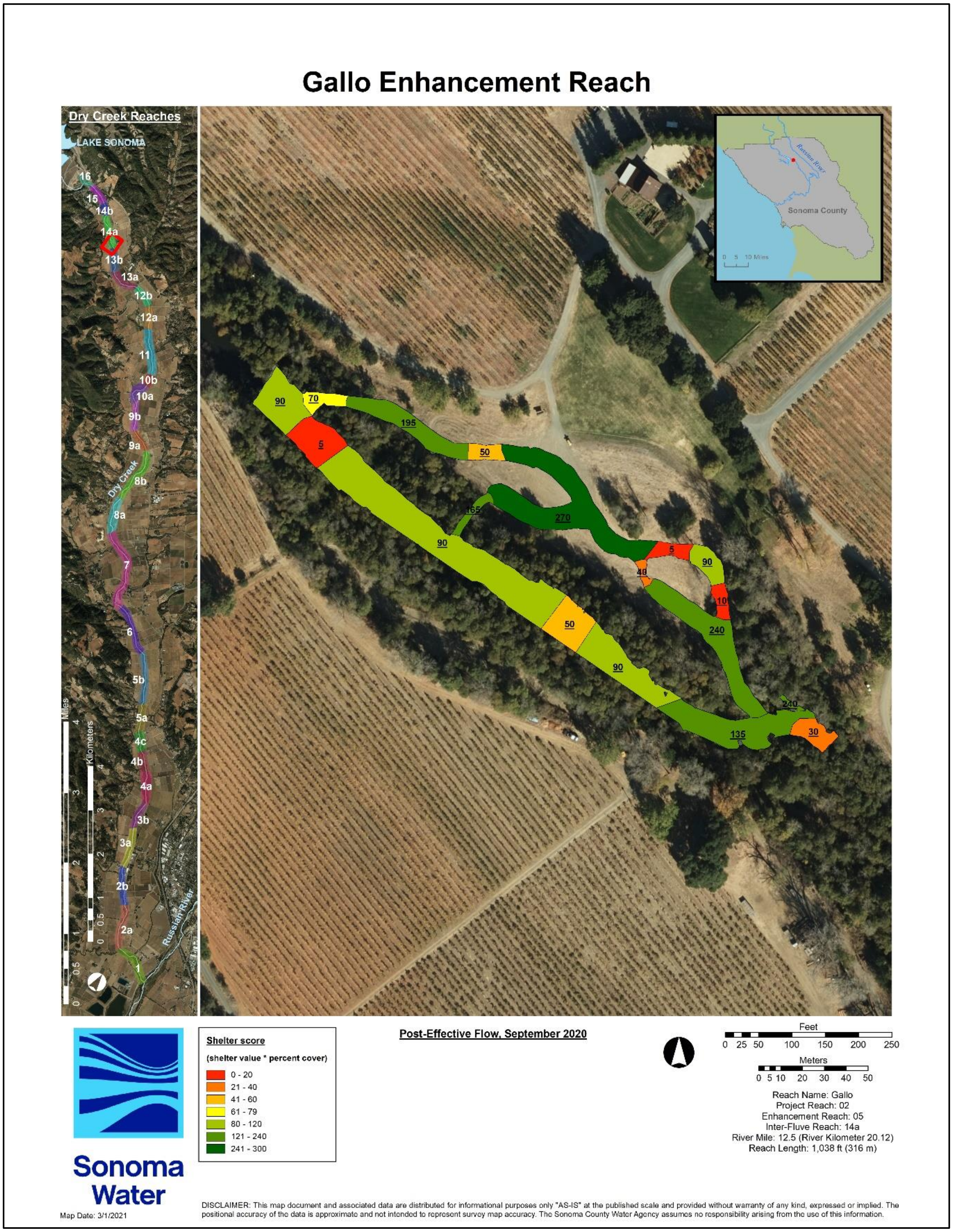


Figure 5.2.20. Habitat unit shelter scores within the Gallo enhancement reach, September 2020.

Feature, habitat unit, site, and reach ratings

Table 5.2.20. Post-enhancement average feature, average habitat unit, site, and reach ratings (rounded to the nearest whole number) for the Gallo enhancement reach, September 2020.

Site number	1	2		
Site type	Main channel	Side channel		
Site average feature quantitative rating[a]	14	14		
Site average feature qualitative rating[a]	Excellent	Excellent		
Site average habitat unit quantitative rating[b]	18	20		
Site average qualitative rating[b]	Fair	Fair		
Site quantitative rating (sum of site average feature and habitat unit rating)[c]	32	34		
Site qualitative rating[c]	Good	Good		
Enhancement reach quantitative rating (average of site rating)[c]	33			
Enhancement reach qualitative rating[c]:	Good			

[a]out of 15; Excellent (>=12), Good (>=9), Fair (>=6), Poor (>=3), Fail (<3)
[b]out of 35; Excellent (>=28), Good (>=21), Fair(>=14), Poor (>=7), Fail (<7)
[c]out of 50; Excellent (>=40), Good (>=30), Fair (>=20), Poor (>=10), Fail (<10)

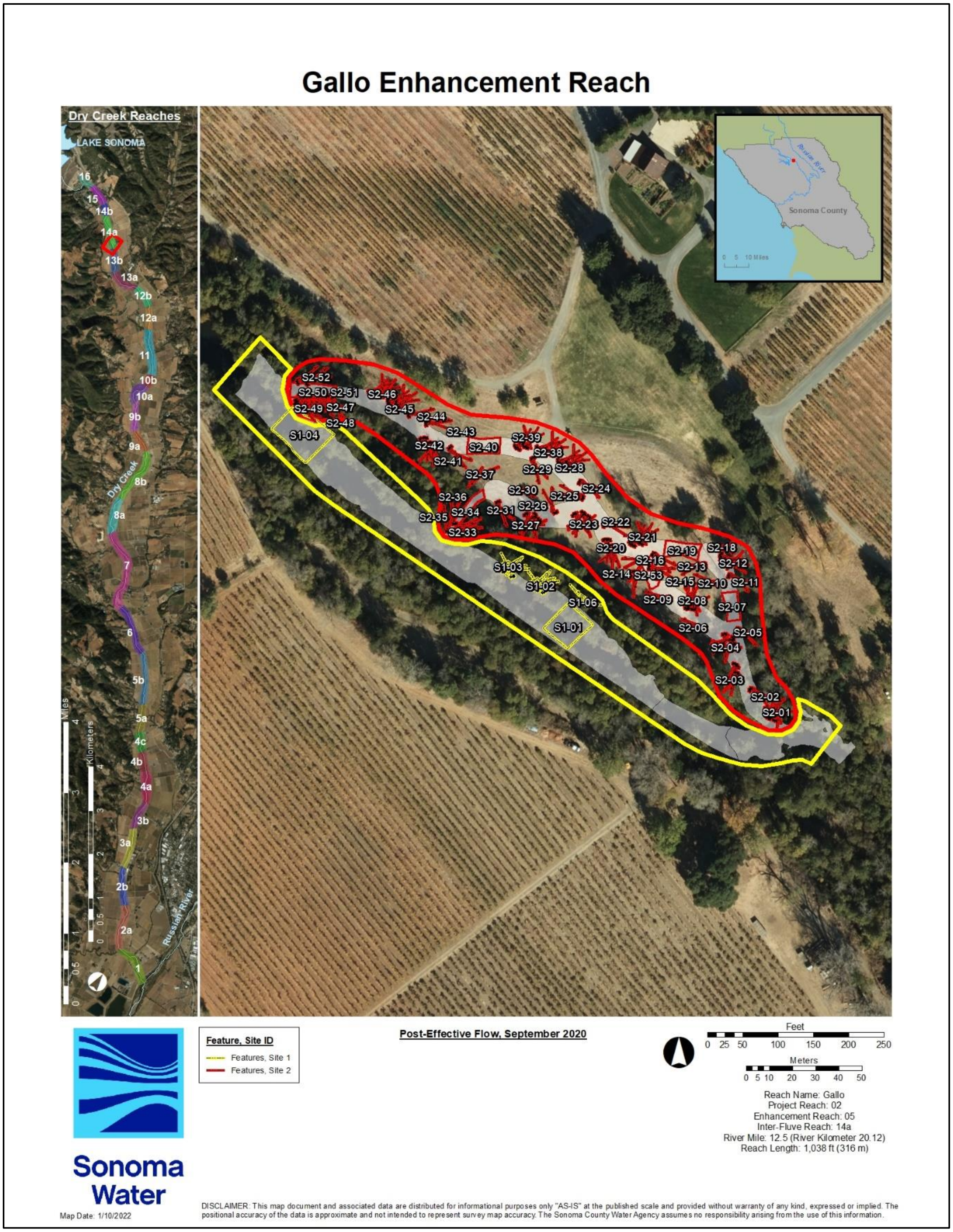


Figure 5.2.21. Enhancement sites and features within the Gallo enhancement reach, September 2020.

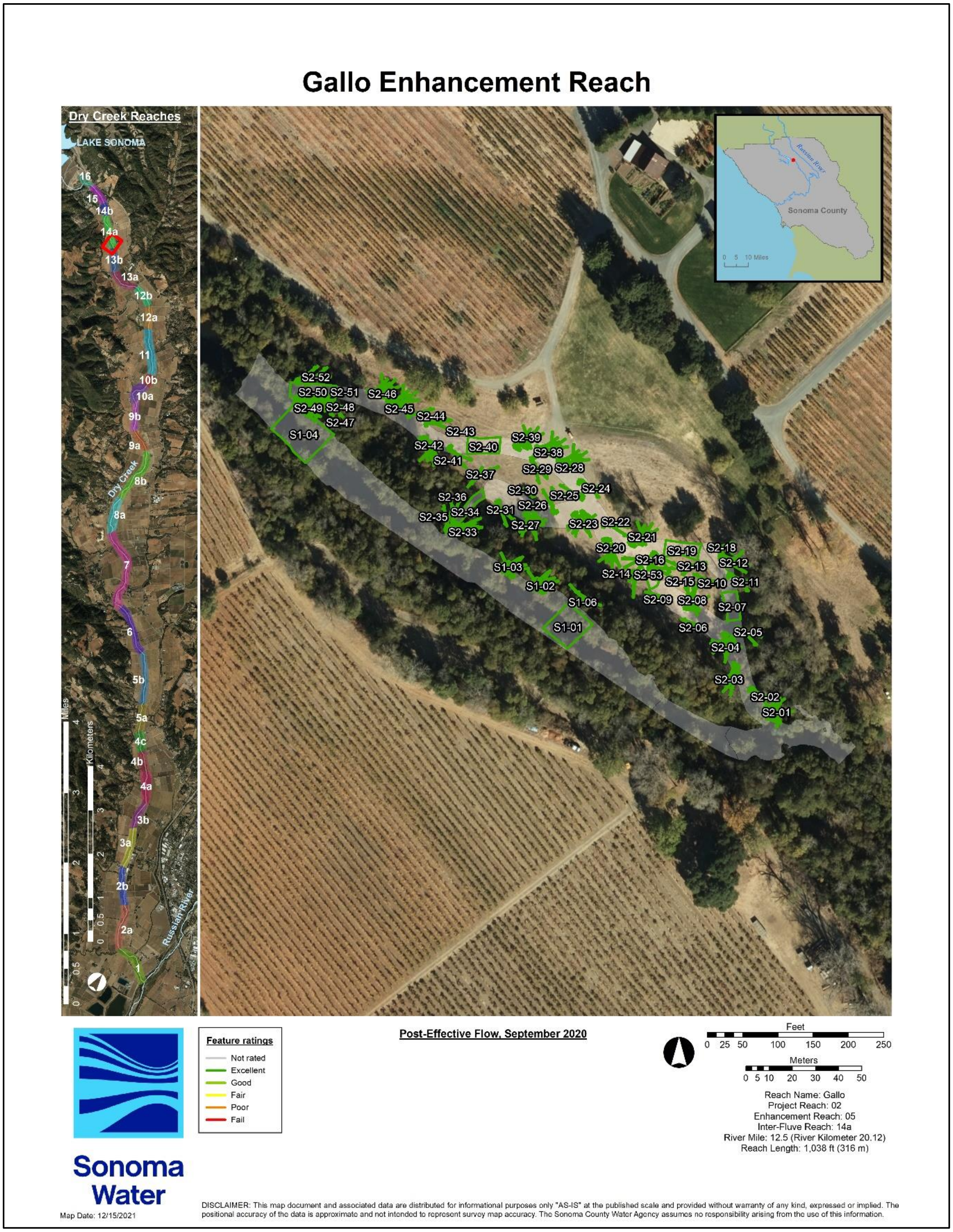


Figure 5.2.22. Feature ratings for the Gallo enhancement reach, September 2020.

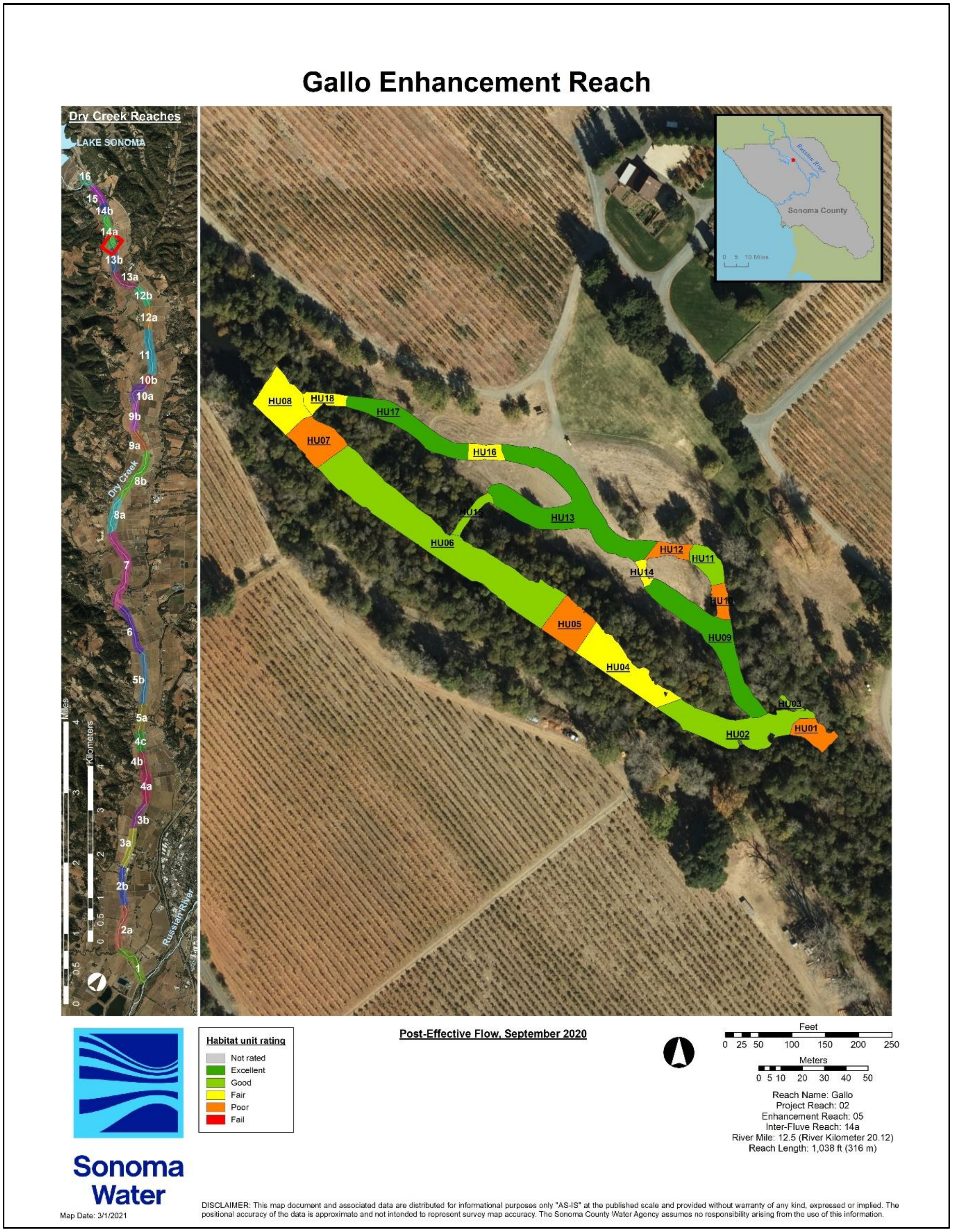


Figure 5.2.23. Habitat unit ratings for the Gallo enhancement reach, September 2020.

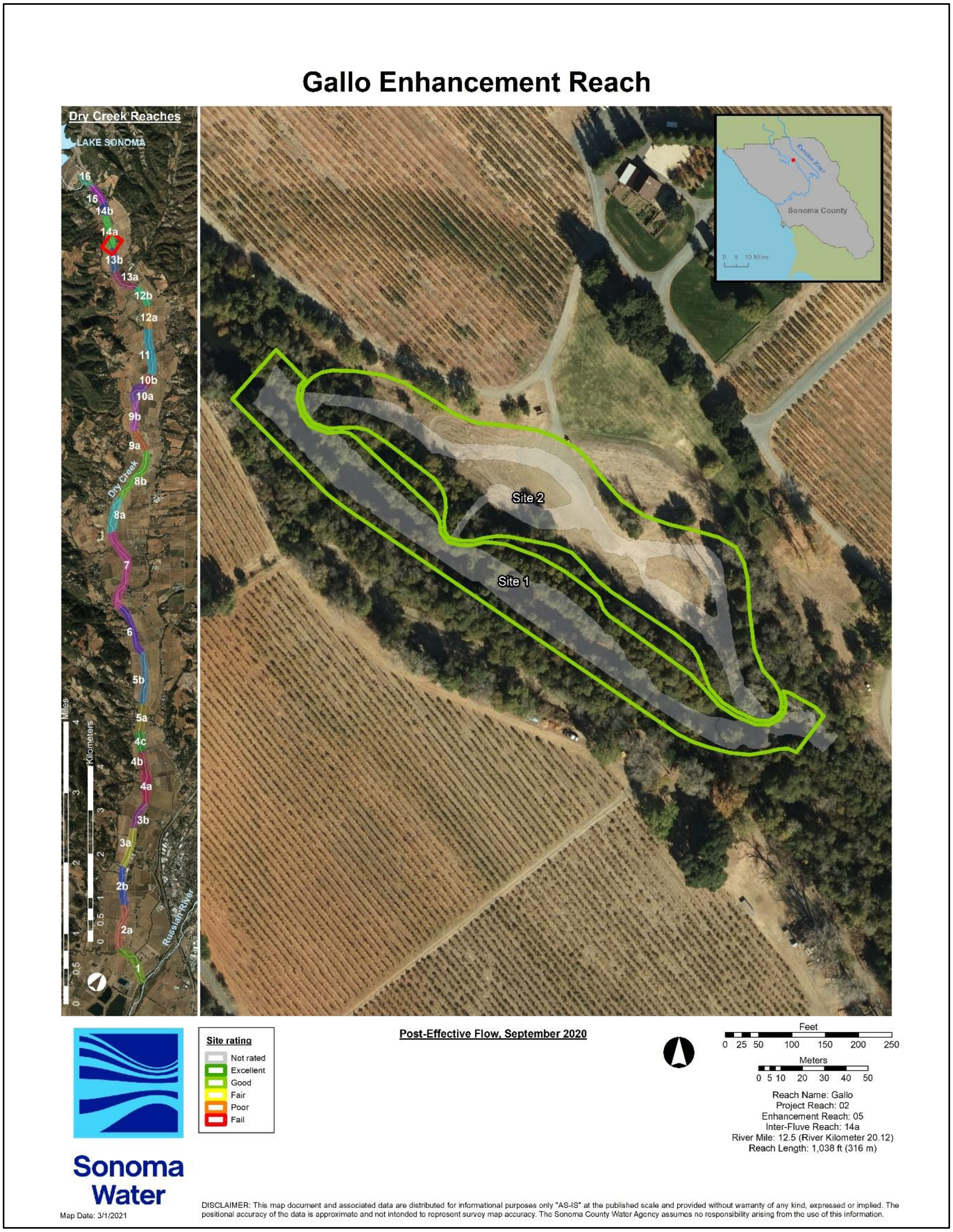


Figure 5.2.24. Post enhancement site ratings for the Gallo enhancement reach, November 2020.

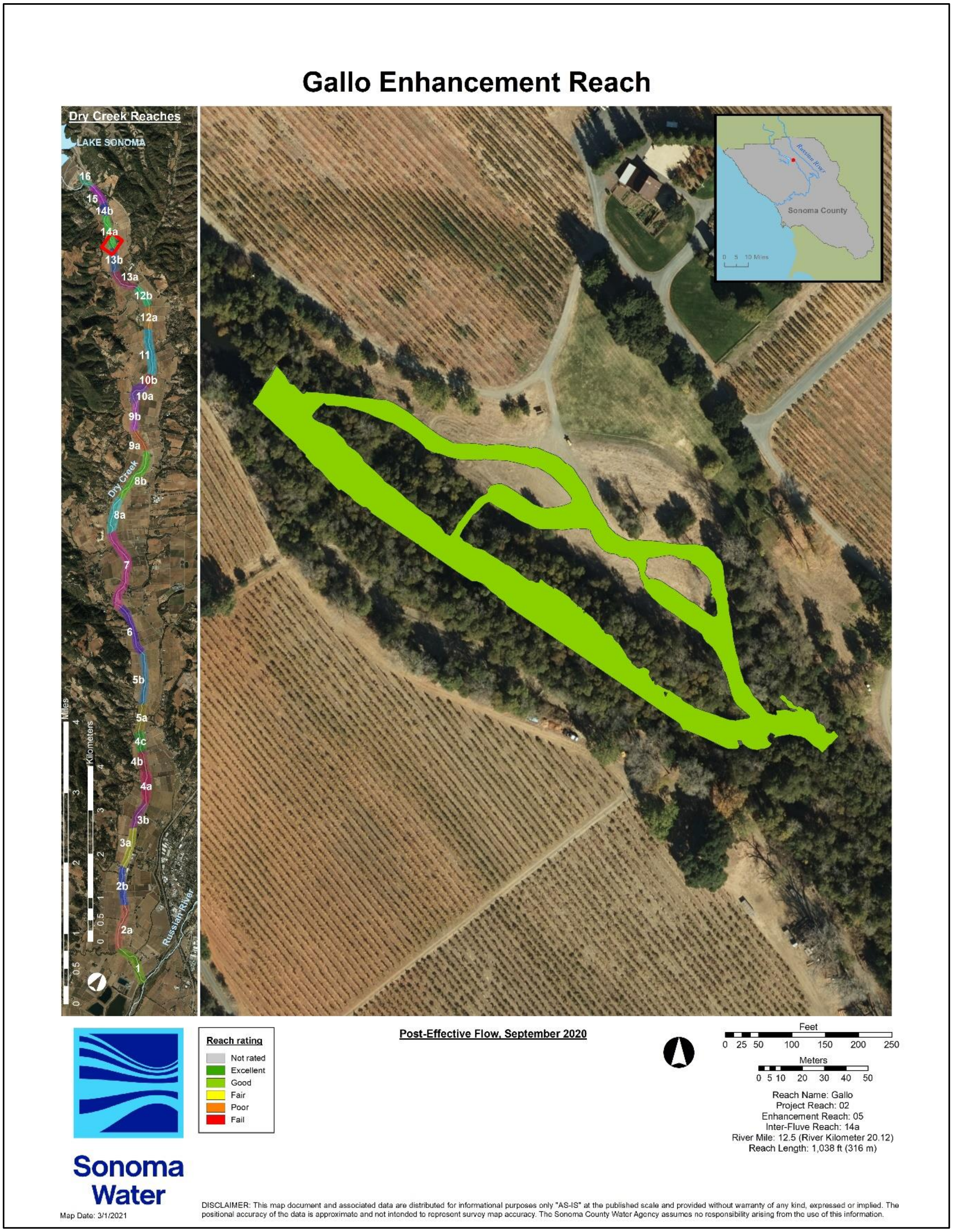


Figure 5.2.25. Post-enhancement reach rating for the Gallo enhancement reach, November 2020.

Truett Hurst Enhancement Reach

Sonoma Water monitored the post-effective flow condition of the Truett Hurst enhancement reach in August 2020. Sonoma Water originally constructed the Truett Hurst enhancement reach in November 2016, but aggradation caused by large storms in winter 2016/2017 led to a poor effectiveness monitoring rating in July 2017 and subsequent repairs in summer 2017. Crews monitored again in October 2017 and the enhancement reach received a good post-repair rating (see 2018 report for results). Sonoma Water monitored the post effective flow habitat condition in August 2018 and August 2019 with the enhancement reach receiving good and fair ratings, respectively (see 2019 and 2020 reports for results).

The 2020 monitored area encompassed 65,887 ft^2 within main and off channel areas with 28% of the total area meeting optimal depth and velocity criteria (Table 5.2.21, Figure 5.2.26). The monitored area included 25,055 ft^2 of side channel and 978 ft^2 of side channel alcove area, of which 47% and 60%, respectively met optimal depth and velocity criteria, compared with 39,854 ft^2 and 15% for the main channel area. Thirty two habitat units composed the enhancement reach post-effective flow 2020, with a pool to riffle ratio of 13:12 (1.08) and an average shelter score of 78 Table 5.2.22, Figure 5.2.28, Figure 5.2.27,). Fourteen habitat units met or exceeded the optimal shelter value of 80. The enhancement reach comprised five enhancement sites (one main channel, a side channel, two alcoves, and a bank site; Table 5.2.23, Figure 5.2.29) that received fair to excellent site average feature ratings (we did not rate enhancement site 1 as it contained no features), and fair to good site average habitat unit ratings (Table 5.2.23, Figure 5.2.30, Figure 5.2.31). Enhancement site ratings ranged from fair to good, with the main channel site (site 1) receiving a fair rating, the two alcove sites receiving good ratings, and the side-channel and bank sites receiving good ratings (Table 5.2.23, Figure 5.2.32). Overall, the Truett Hurst enhancement reach received a good effectiveness monitoring rating Table 5.2.23, Figure 5.2.33; see Appendix 5.2 for all measured values, scores, and ratings).

Depth and velocity

Table 5.2.21. Areas and percentages of: wetted area, optimal depth and velocity, and optimal hydraulic habitat within the Truett Hurst enhancement reach, August 2020.

Truett Hurst Post-effective flow August 2020	Wetted area (ft^2)	0.5 – 2.0 ft	2.0 – 4.0 ft	Total	< 0.5 ft/s	0.5 – 2.0 ft < 0.5 ft/s	2.0 – 4.0 ft < 0.5 ft/s	Total
Main channel area	39,854	23,093	8,971	32,064	10,599	4,357	1,789	6,146
Side channel area	25,055	12,689	2,868	15,556	18,393	8,983	2,716	11,699
Side channel alcove area	978	549	34	583	978	549	34	583
Total area	**65,887**	**36,331**	**11,873**	**48,204**	**29,970**	**13,889**	**4,540**	**18,429**
Main channel % of wetted area	60%	58%	23%	80%	27%	11%	4%	15%
Side channel % of wetted area	38%	51%	11%	62%	73%	36%	11%	47%
Side channel alcove area % of wetted area	1%	56%	3%	60%	100%	56%	3%	60%
Total % of wetted area	**100%**	**55%**	**18%**	**73%**	**45%**	**21%**	**7%**	**28%**

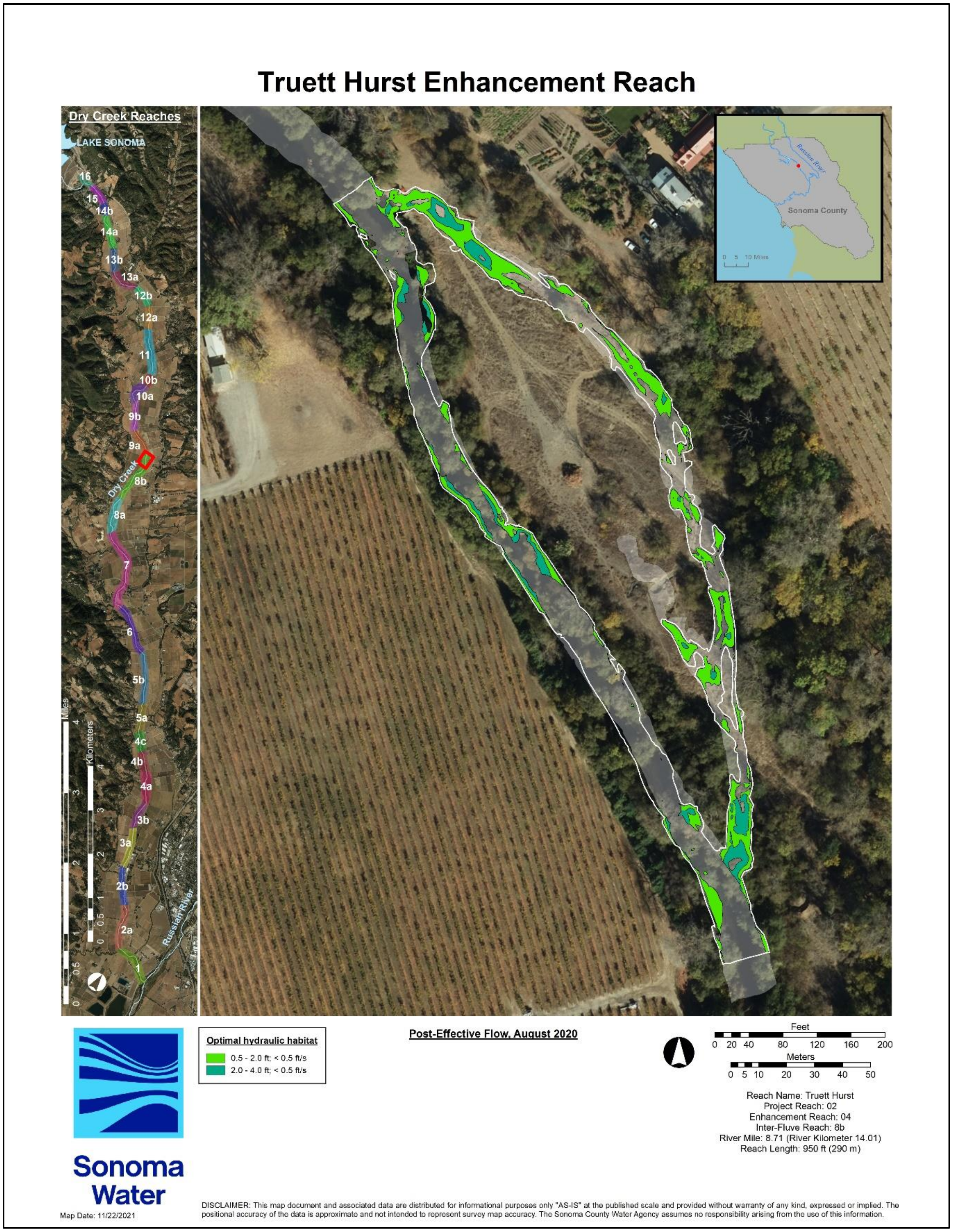


Figure 5.2.26. Optimal hydraulic habitat for fry (<0.5 f/s, 0.5-2.0 ft) and parr (<0.5 f/s, 2.0-4.0 ft) within the Truett Hurst enhancement reach, August 2020.

Habitat types, pool to riffle ratio, and shelter scores

Table 5.2.22. Habitat, types, shelter value, percent cover, and shelter score for habitat units within the Truett Hurst enhancement reach, August 2020.

Habitat Unit #	Habitat Type	Shelter Value	Percent Cover	Shelter Score
HU01	Flatwater	1	10	10
HU02	Riffle	2	20	40
HU03	Pool	2	25	50
HU04	Riffle	1	5	5
HU05	Flatwater	1	10	10
HU06	Pool	3	60	180
HU07	Riffle	2	20	40
HU08	Pool	1	10	10
HU09	Pool	3	15	45
HU10	Riffle	2	20	40
HU11	Flatwater	1	25	35
HU12	Pool	3	70	210
HU13	Riffle	1	25	25
HU14	Pool	3	45	135
HU15	Riffle	1	20	20
HU16	Pool	3	30	90
HU17	Pool	3	40	120
HU18	Riffle	3	45	135
HU19	Alcove	3	50	150
HU20	Riffle	1	30	30
HU21	Pool	3	20	60
HU22	Alcove	3	90	270
HU23	Riffle	2	15	30
HU24	Pool	3	25	75
HU25	Riffle	1	10	10
HU26	Flatwater	3	50	150
HU27	Riffle	3	15	45
HU28	Pool	3	30	90
HU29	Riffle	3	35	105
HU30	Pool	3	30	90
HU31	Pool	3	35	105
HU32	Flatwater	3	35	105
Pool: riffle	**13:12 (1.08)**			**Avg = 78**

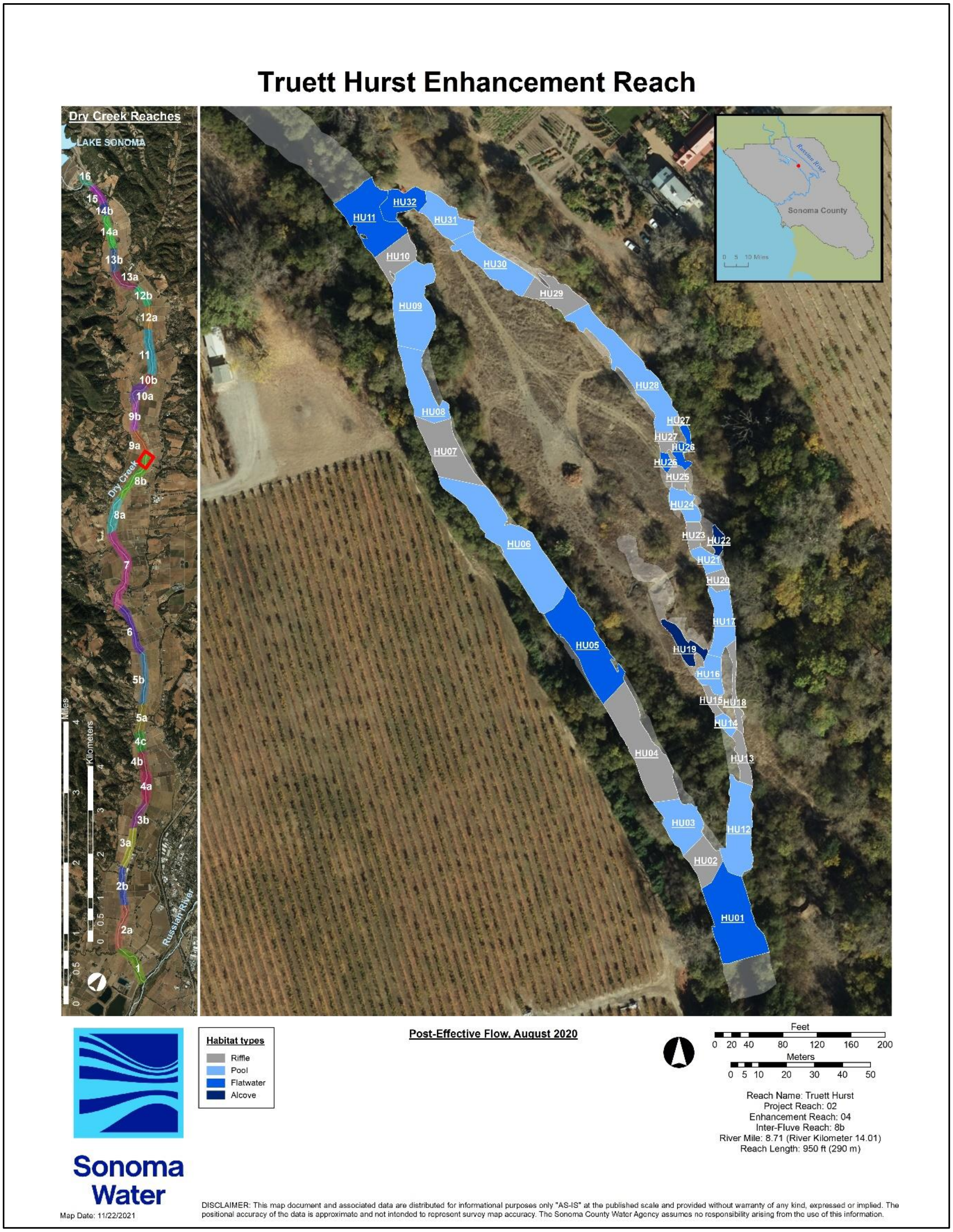


Figure 5.2.27. Habitat unit number and type within the Truett Hurst enhancement reach, August 2020.

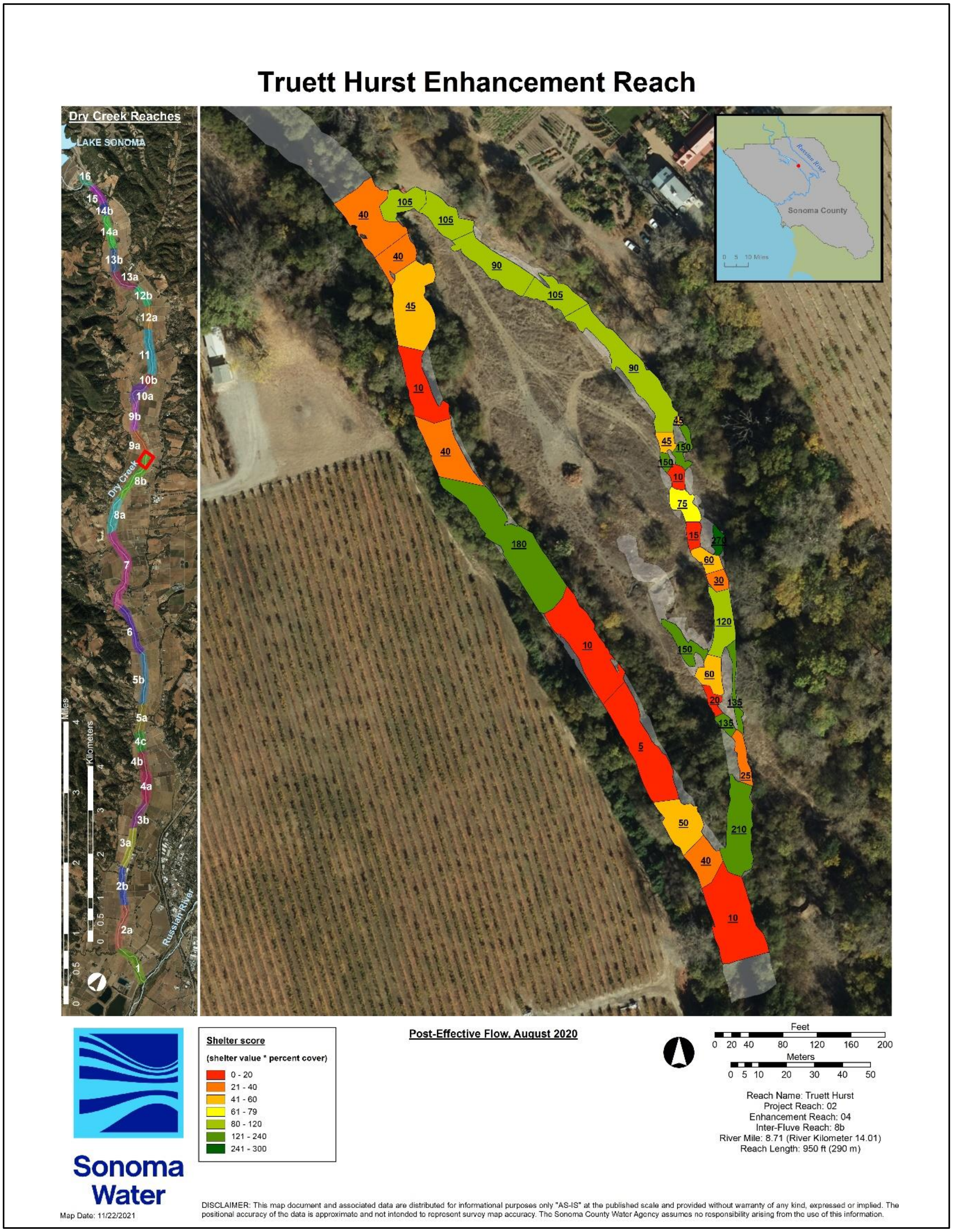


Figure 5.2.28. Habitat unit shelter scores within the Truett Hurst enhancement reach, August 2020.

Feature, habitat unit, site, and reach ratings

Table 5.2.23. Post-effective flow average feature, average habitat unit, site, and reach ratings (rounded to the nearest whole number) for the Truett Hurst enhancement reach, August 2020.

Site number	1	2	3	4	5
Site type	Main channel	Side channel	Alcove	Alcove	Bank
Site average feature quantitative rating[a]	0	12	6	11	12
Site average feature qualitative rating[a]	Not rated	Excellent	Fair	Good	Excellent
Site average habitat unit quantitative rating[b]	14	19	24	21	19
Site average qualitative rating[b]	Fair	Fair	Good	Good	Fair
Site quantitative rating (sum of site average feature and habitat unit rating)[c]	14[b]	32[c]	30[c]	32[c]	31[c]
Site qualitative rating[c]	Fair[b]	Good[c]	Good[c]	Good[c]	Good[c]
Enhancement reach quantitative rating (average of site rating)[c]	28				
Enhancement reach qualitative rating[c]:	Good				

[a]out of 15; Excellent (>=12), Good (>=9), Fair (>=6), Poor (>=3), Fail (<3)
[b]out of 35; Excellent (>=28), Good (>=21), Fair(>=14), Poor (>=7), Fail (<7)
[c]out of 50; Excellent (>=40), Good (>=30), Fair (>=20), Poor (>=10), Fail (<10)
[d]out of 47; Excellent (>=38), Good (>=28), Fair (>=19), Poor (>=9), Fail (<9)

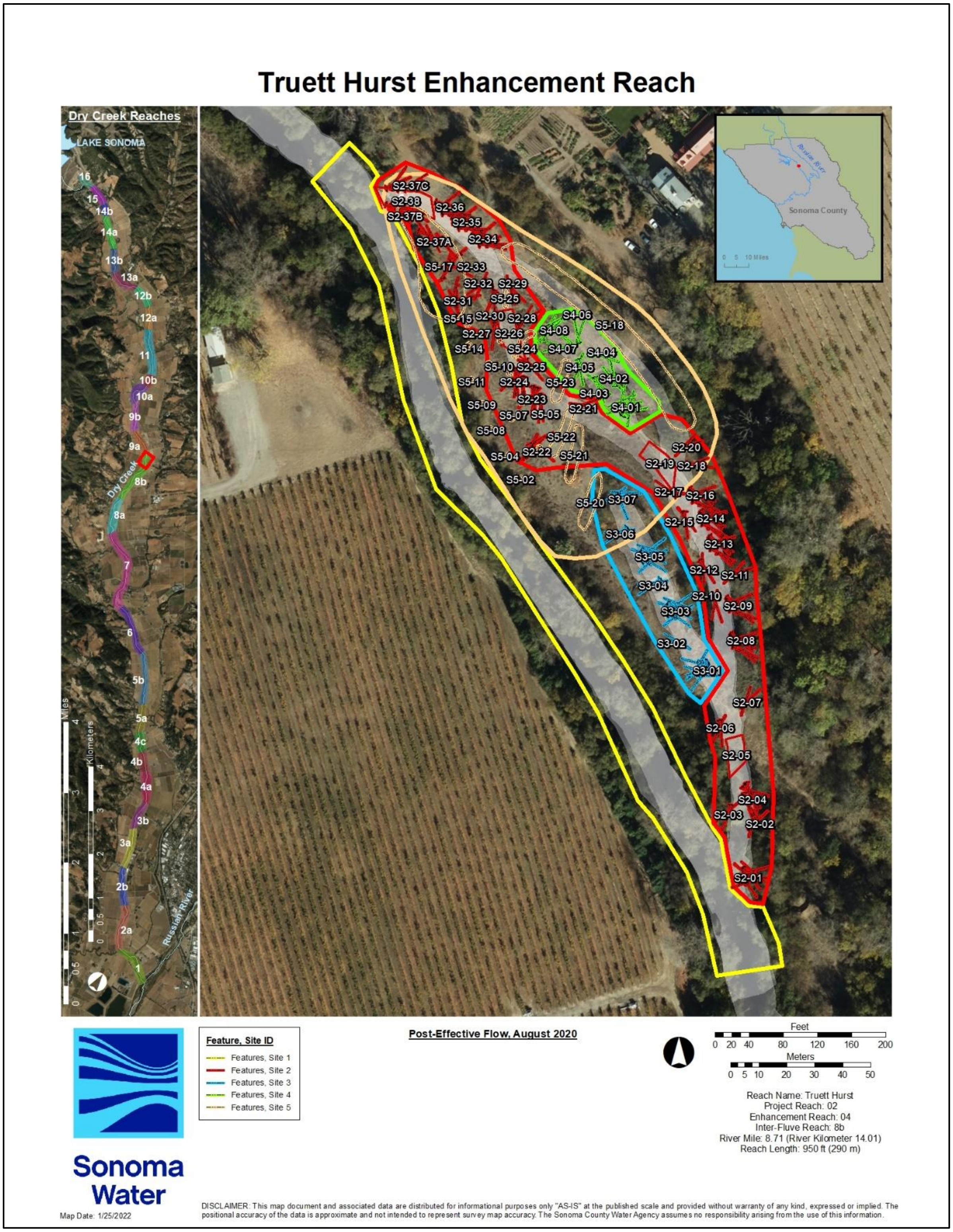


Figure 5.2.29. Enhancement sites and features within the Truett Hurst enhancement reach, August 2020.

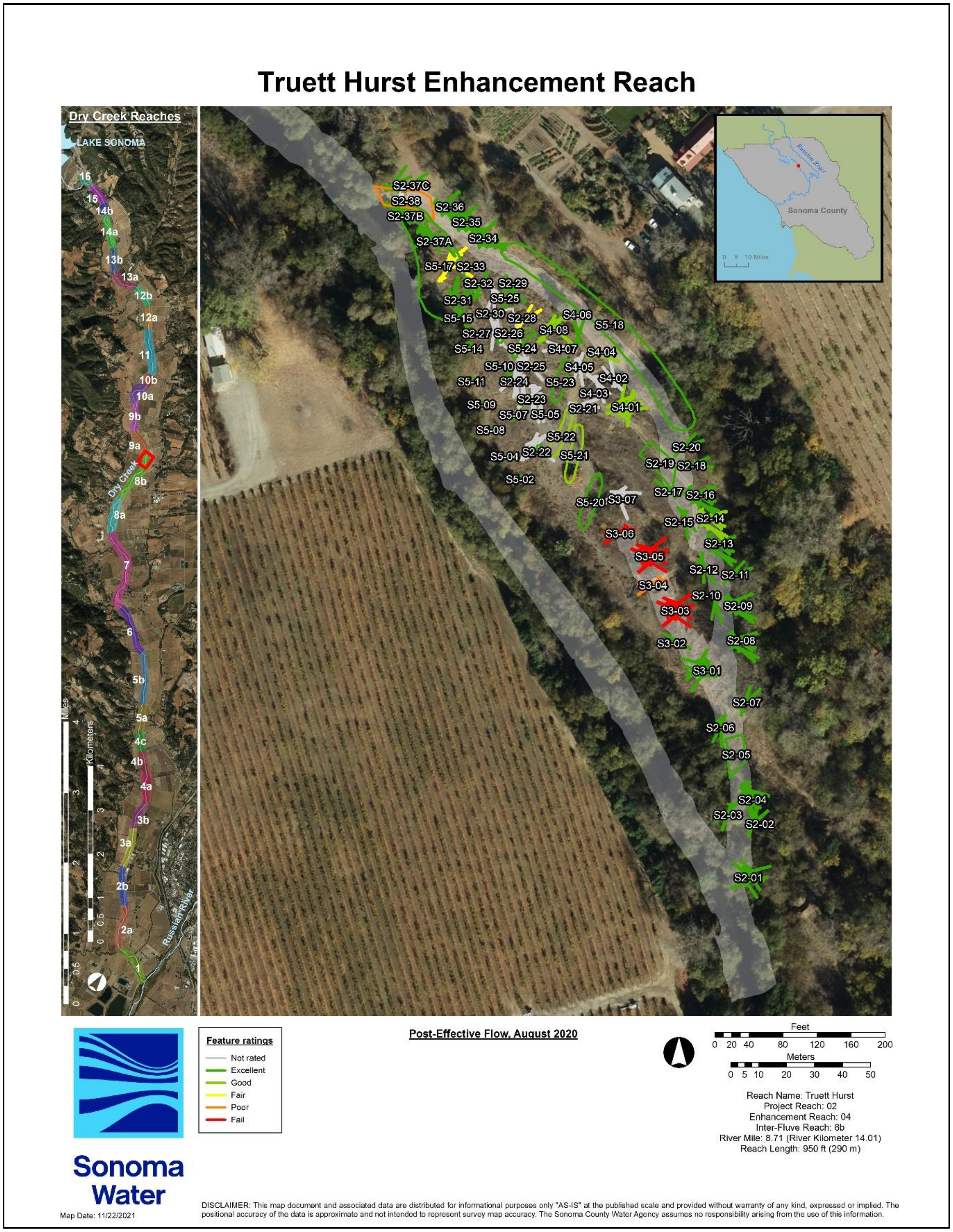


Figure 5.2.30. Feature ratings for the Truett Hurst enhancement reach, August 2020.

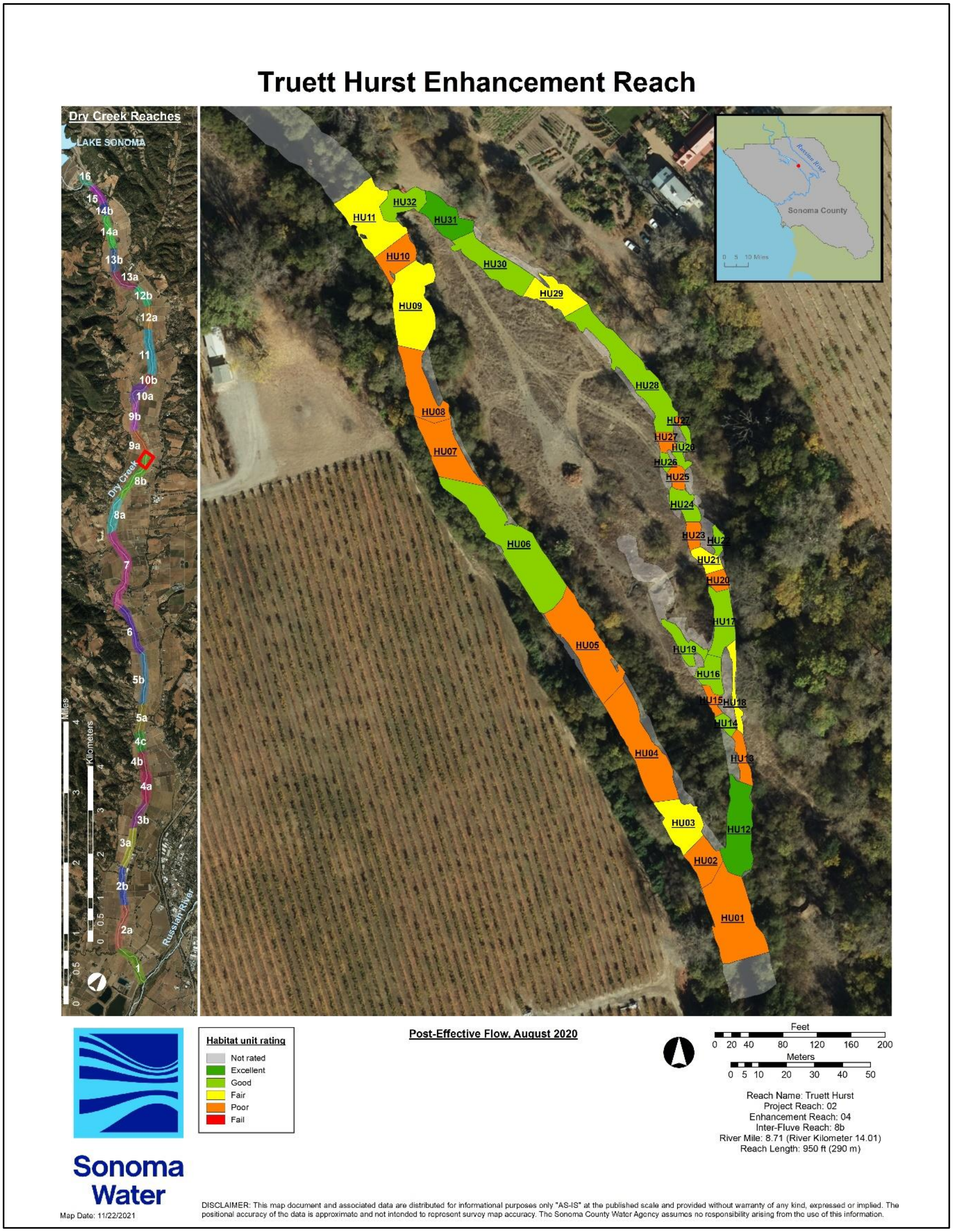


Figure 5.2.31. Habitat unit ratings for the Truett Hurst enhancement reach, August 2020.

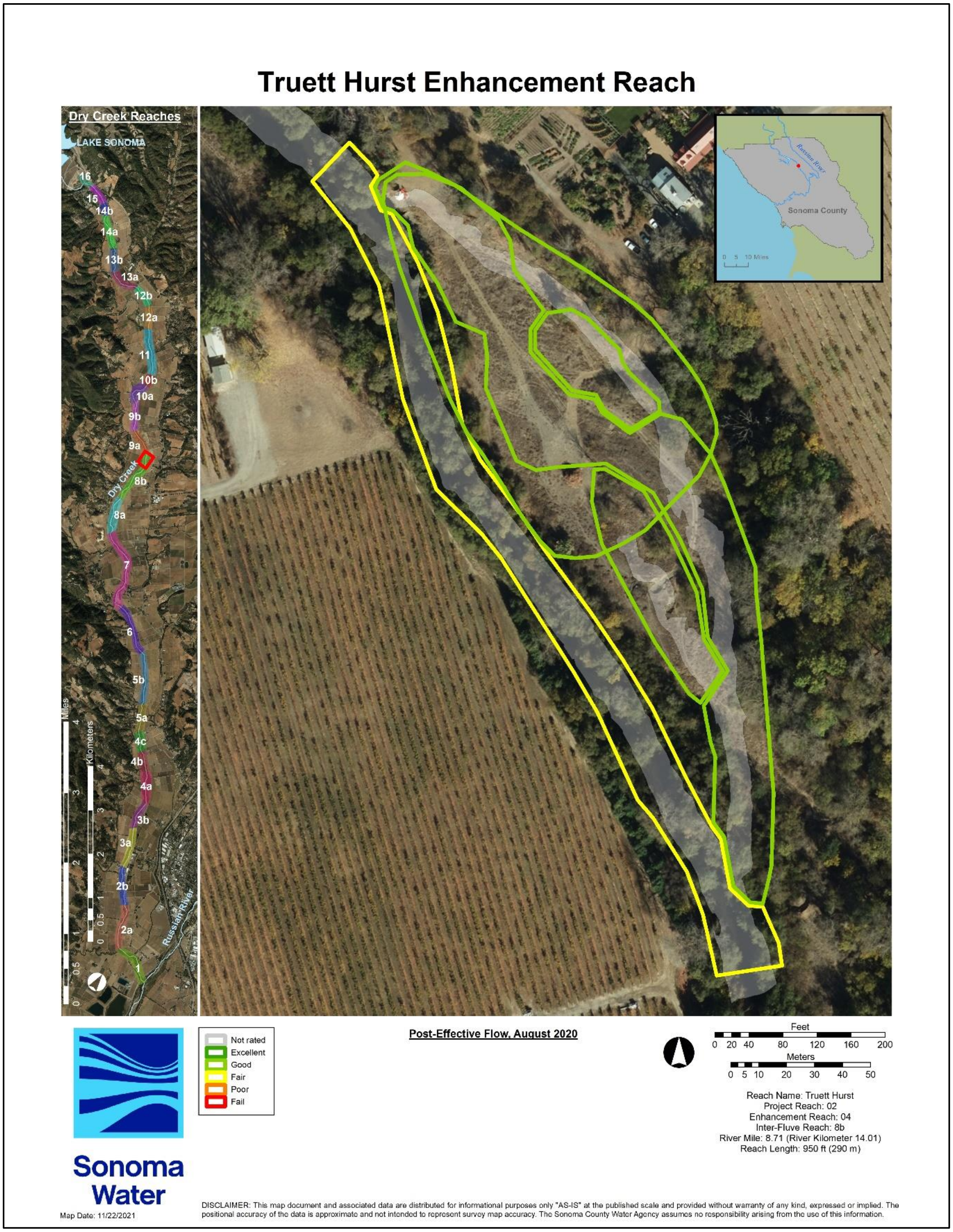


Figure 5.2.32. Post-effective flow site ratings for the Truett Hurst enhancement reach, August 2020.

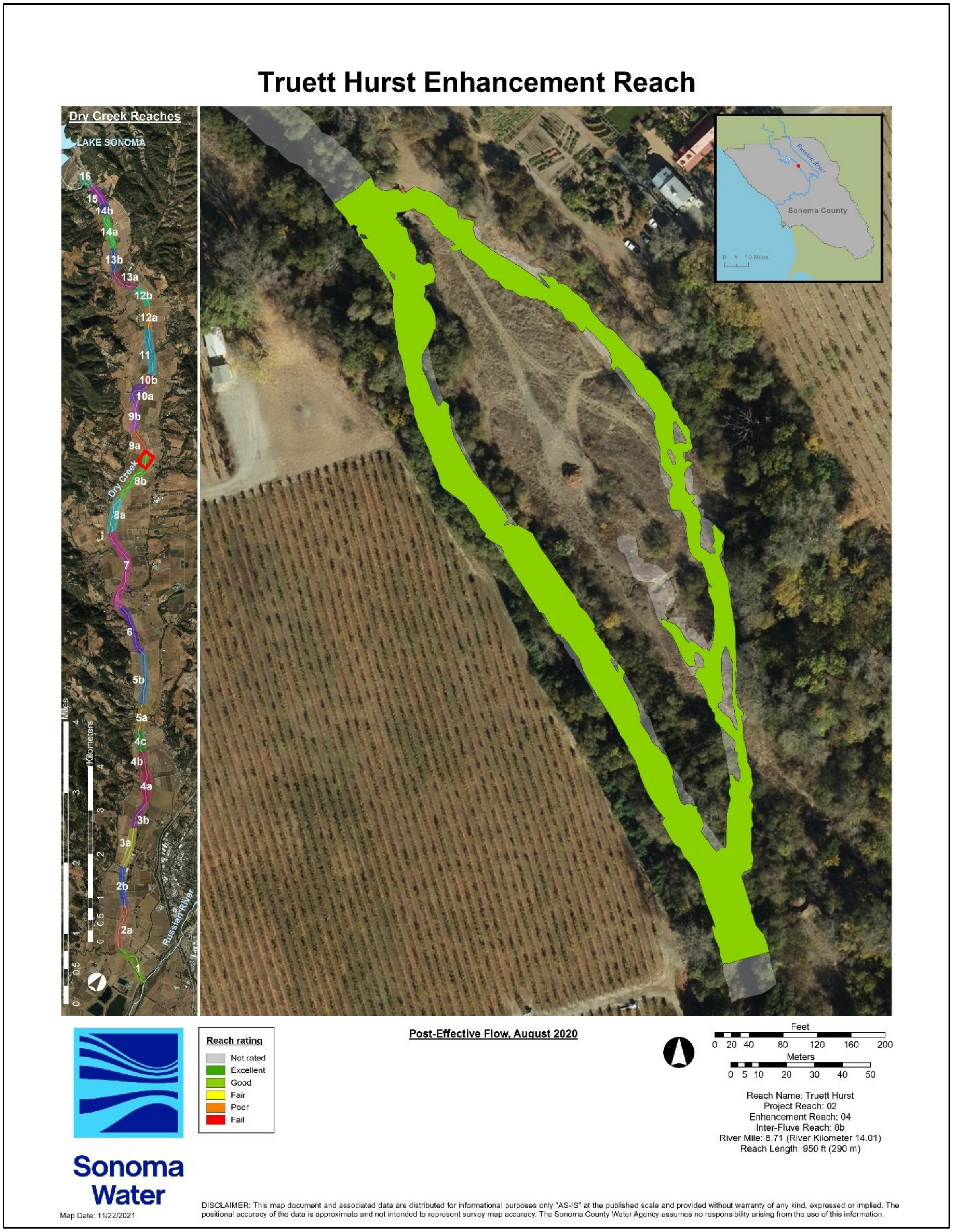


Figure 5.2.33. Post-effective flow reach rating for the Truett Hurst enhancement reach, August 2020.

Van Alyea Enhancement Reach

Sonoma Water monitored the post-effective flow condition of the Van Alyea enhancement reach in June 2020. Previous effectiveness monitoring surveys occurred in August 2015 (post-effective flow) and April 2017 (post-effective low), receiving good and good ratings, respectively. The monitored portion of the reach covered 73,138 ft^2 within main channel and alcove areas, with 46% of the total meeting optimal depth and velocity criteria (Table 5.2.24, Figure 5.2.34). The monitoring characterized 52,405 ft^2 of main channel area and 20,733 ft^2 of main channel alcove area, of which 40% and 60% met optimal depth and velocity criteria. Nine habitat units composed the enhancement reach post effective flow 2020, with a pool to riffle ratio of 3:2 (1.50) and an average shelter score of 109 Table 5.2.25, Figure 5.2.35, Figure 5.2.36). Four habitat units met or exceeded the optimum shelter value of 80. The enhancement reach comprised three enhancement sites (one main channel, one alcove, one bank site; Table 5.2.26, Figure 5.2.37) that received good to excellent site average feature and habitat unit ratings (Table 5.2.26, Figure 5.2.38, Figure 5.2.39). Accordingly, enhancement sites received good to excellent qualitative ratings (Table 5.2.26, Figure 5.2.40). Overall, the Van Alyea enhancement reach received an excellent effectiveness monitoring score (Table 5.2.26, Figure 5.2.41; see Appendix 5.2 for measured values, scores, and ratings).

Depth and velocity

Table 5.2.24. Areas and percentages of: wetted area, optimal depth and velocity, and optimal hydraulic habitat within the Van Alyea enhancement reach, June 2020.

Van Alyea Post-effective flow June 2020	Wetted area (ft^2)	0.5 – 2.0 ft	2.0 – 4.0 ft	Total	< 0.5 ft/s	0.5 – 2.0 ft < 0.5 ft/s	2.0 – 4.0 ft < 0.5 ft/s	Total
Main channel area	52,405	16,860	25,704	42,564	27,657	8,202	12,677	20,878
Main channel alcove area	20,733	4,870	7,664	12,534	20,733	4,870	7,664	12,534
Total area	**73,138**	**21,730**	**33,368**	**55,098**	**48,390**	**13,071**	**20,341**	**33,413**
Main channel % of wetted area	72%	32%	49%	81%	53%	16%	24%	40%
Main channel alcove % of wetted area	28%	23%	37%	60%	100%	23%	37%	60%
Total % of wetted area	**100%**	**30%**	**46%**	**75%**	**66%**	**18%**	**28%**	**46%**

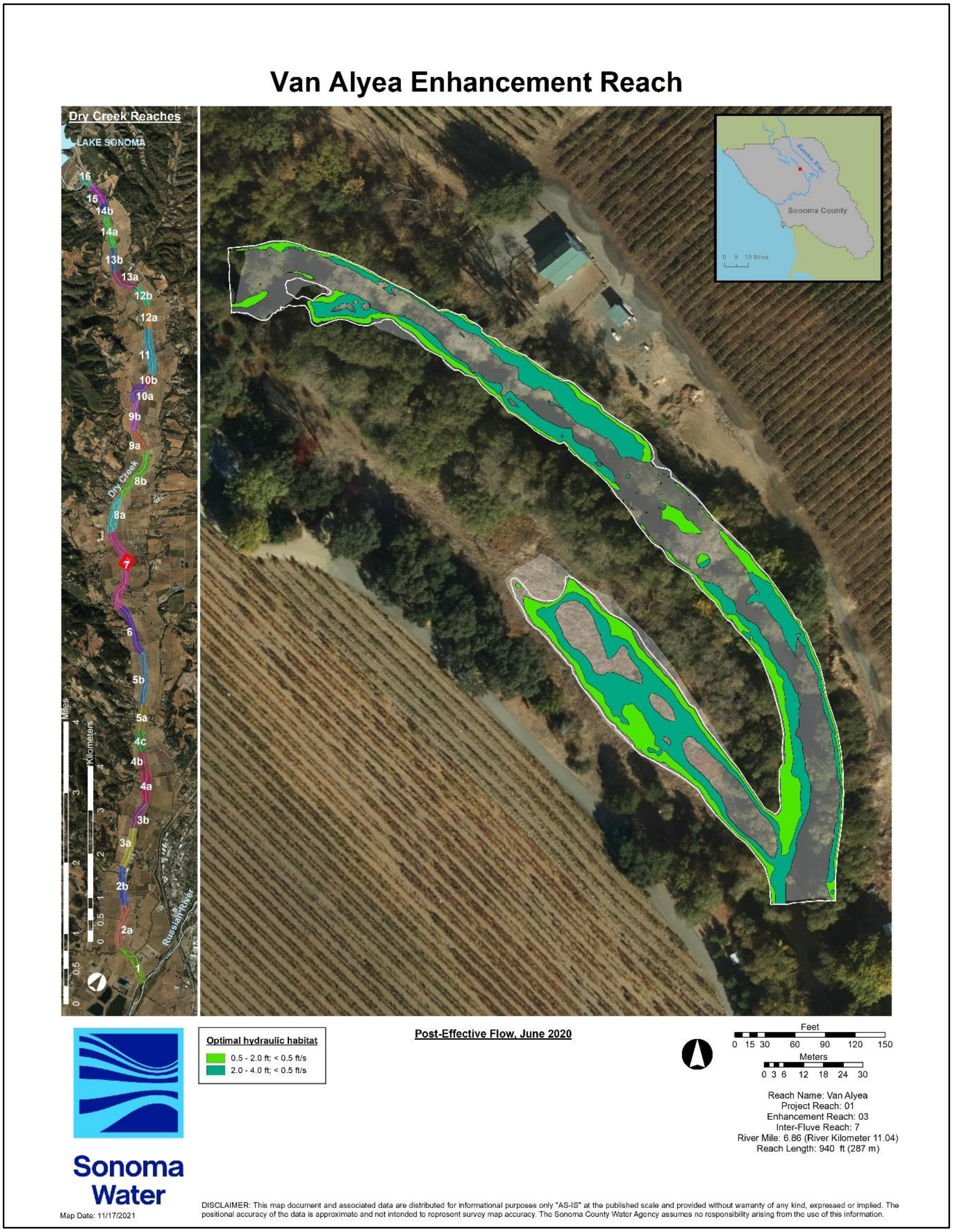


Figure 5.2.34. Optimal hydraulic habitat for fry (<0.5 ft/s, 0.5-2.0 ft) and parr (<0.5 ft/s, 2.0-4.0 ft) within the Van Alyea enhancement reach, June 2020.

Habitat types, pool to riffle ratio, and shelter scores

Table 5.2.25. Habitat, types, shelter score, percent cover, and shelter value for habitat units within the Van Alyea enhancement reach, June 2020.

Habitat Unit #	Habitat Type	Shelter Value	Percent Cover	Shelter Score
HU01	Pool	3	30	90
HU02	Flatwater	3	15	45
HU03	Riffle	2	40	80
HU04	Pool	3	20	60
HU05	Flatwater	3	25	75
HU06	Pool	3	80	240
HU07	Riffle	2	35	70
HU08	Alcove	3	95	285
HU09	Flatwater	2	20	40
Pool: riffle	**3:2 (1.50)**			**Avg = 109**

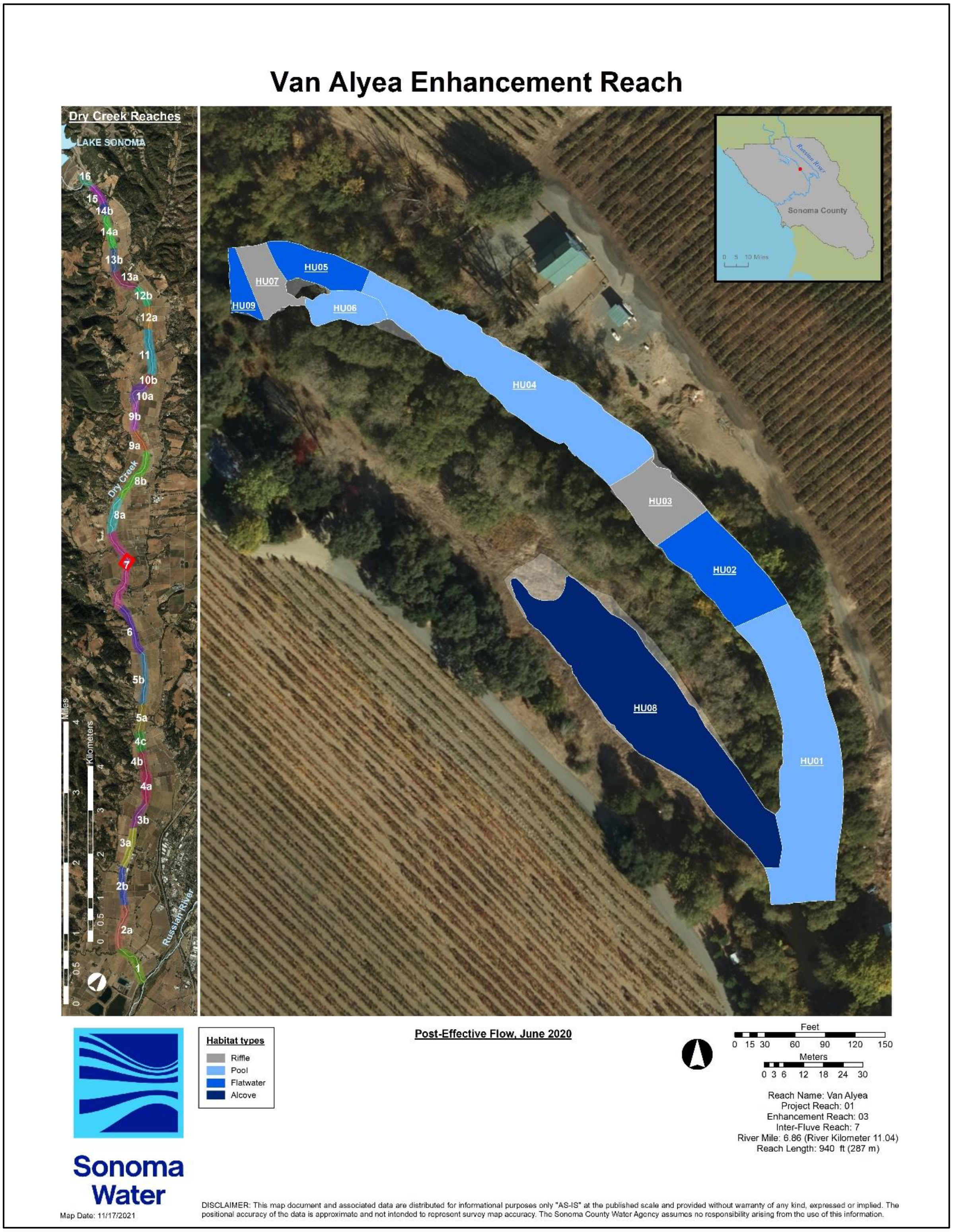


Figure 5.2.35. Habitat unit number and type within the Van Alyea enhancement reach, June 2020.

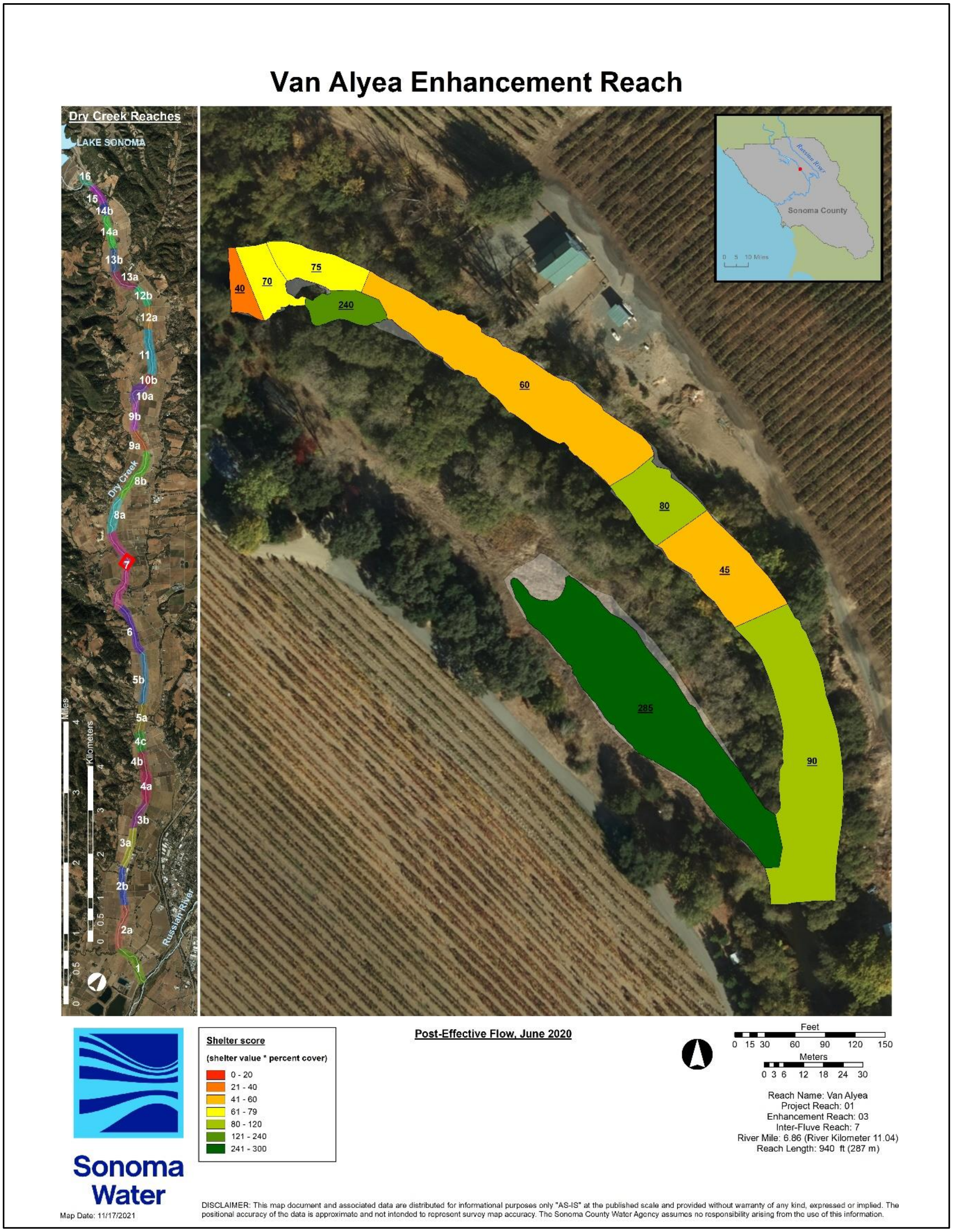


Figure 5.2.36. Habitat unit shelter scores within the Van Alyea enhancement reach, June 2020.

Feature, habitat unit, site, and reach ratings

Table 5.2.26. Post-effective flow average feature, average habitat unit, site, and reach ratings (rounded to the nearest whole number) for the Van Alyea enhancement reach, June 2020.

Site number	1	2	3	
Site type	Main channel	Bank	Alcove	
Site average feature quantitative rating[a]	13	13	12	
Site average feature qualitative rating[a]	Excellent	Excellent	Good	
Site average habitat unit quantitative rating[b]	22	31	29	
Site average qualitative rating[b]	Good	Excellent	Excellent	
Site quantitative rating (sum of site average feature and habitat unit rating)[c]	36	44	41	
Site qualitative rating[c]	Good	Excellent	Excellent	
Enhancement reach quantitative rating (average of site rating)[c]	40			
Enhancement reach qualitative rating[c]:	Excellent			

[a]out of 15; Excellent (>=12), Good (>=9), Fair (>=6), Poor (>=3), Fail (<3)
[b]out of 35; Excellent (>=28), Good (>=21), Fair (>=14), Poor (>=7), Fail (<7)
[c]out of 50; Excellent (>=40), Good (>=30), Fair (>=20), Poor (>=10), Fail (<10)

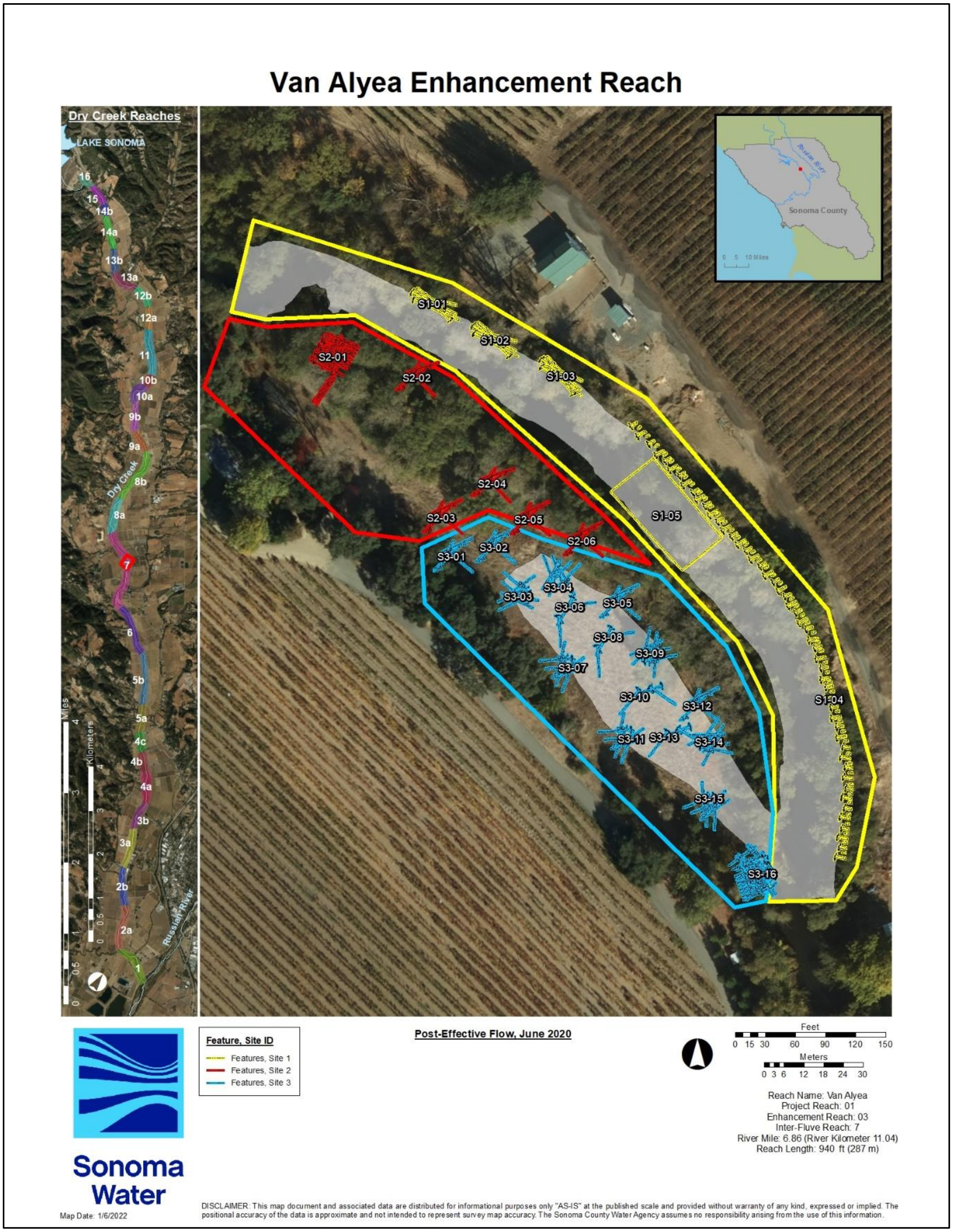


Figure 5.2.37. Enhancement sites and features within the Van Alyea enhancement reach, June 2020.

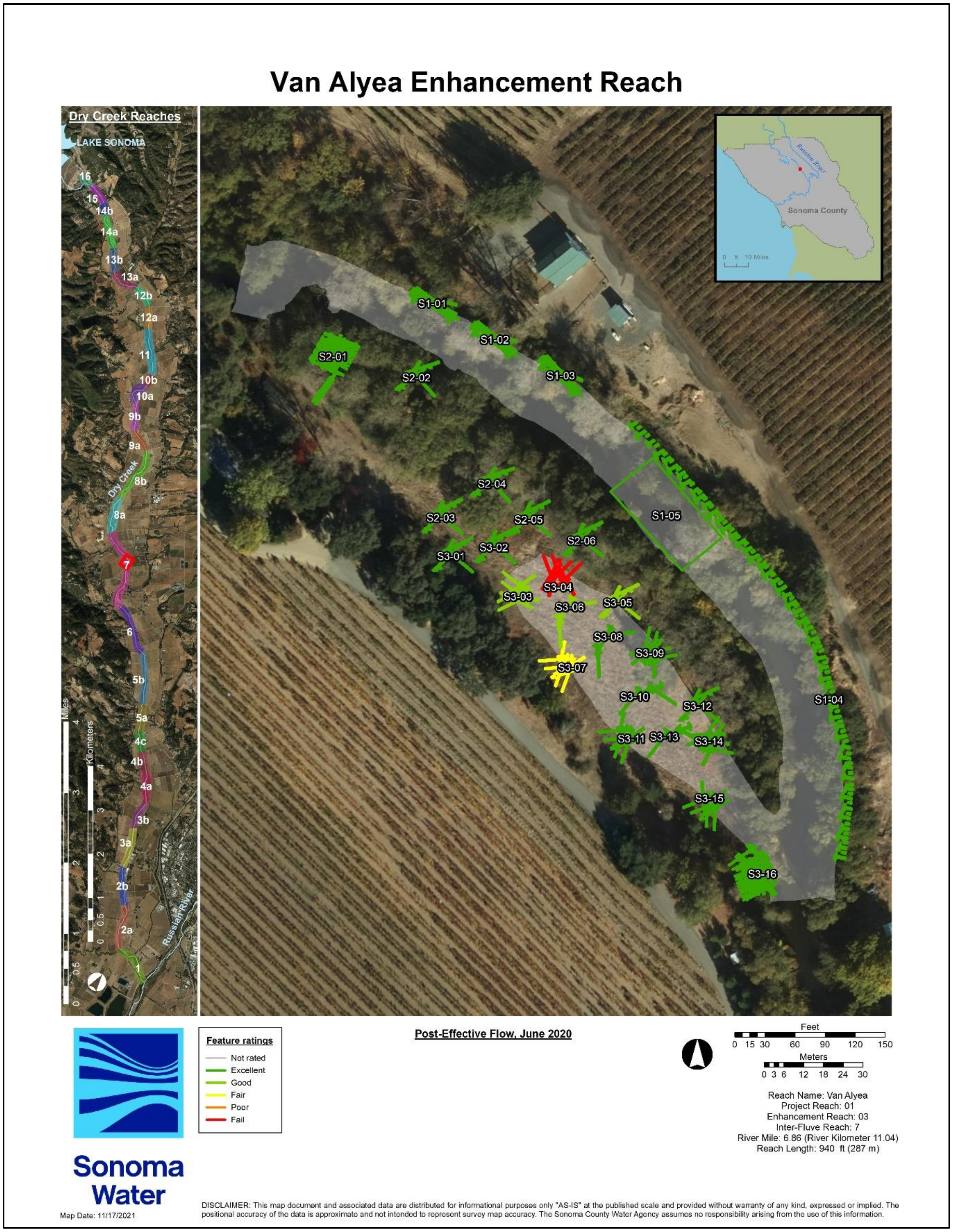


Figure 5.2.38. Feature ratings for the Van Alyea enhancement reach, June 2020.

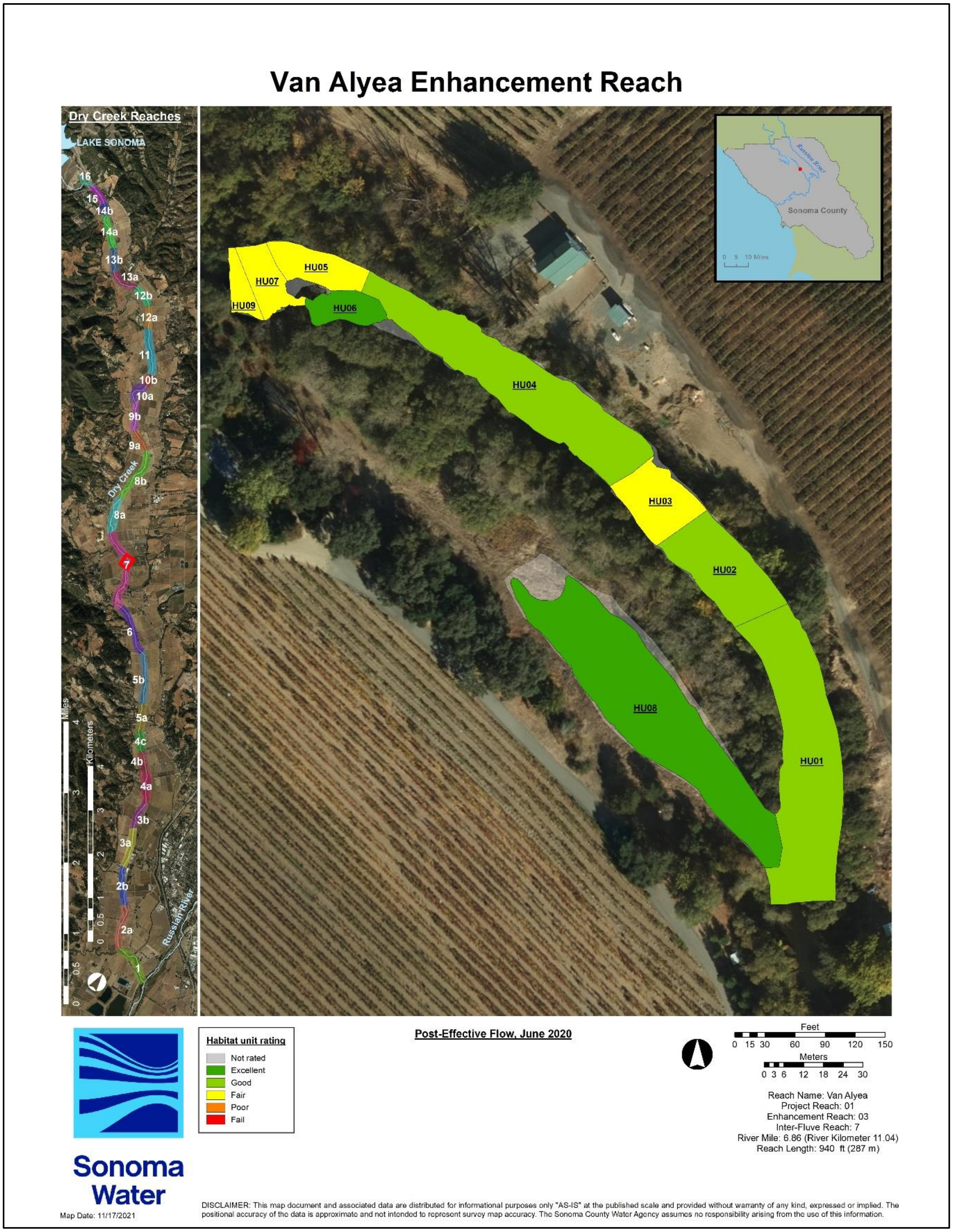


Figure 5.2.39. Habitat unit ratings for the Van Alyea enhancement reach, June 2020.

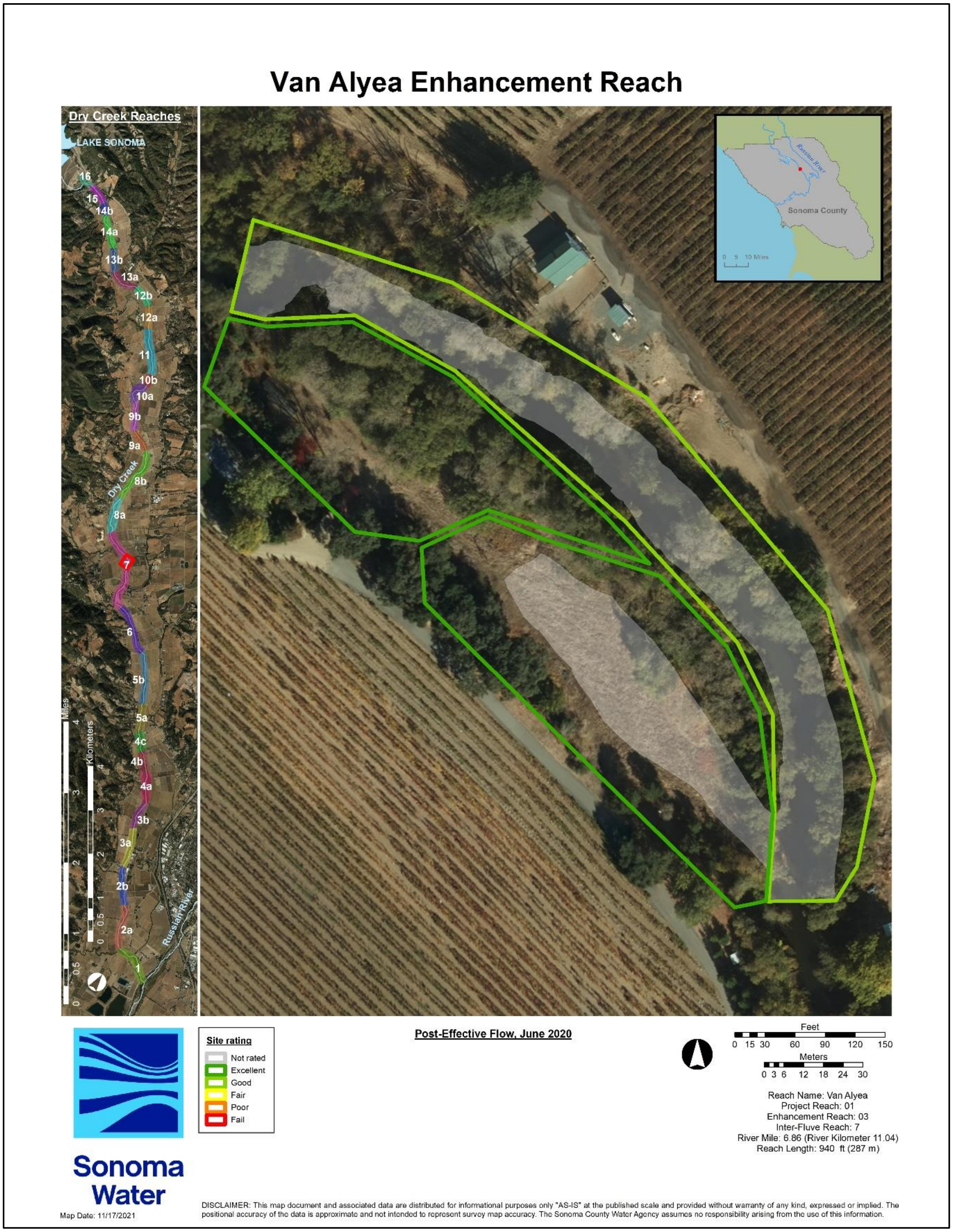


Figure 5.2.40. Post-effective flow site ratings for the Van Alyea enhancement reach, June 2020.

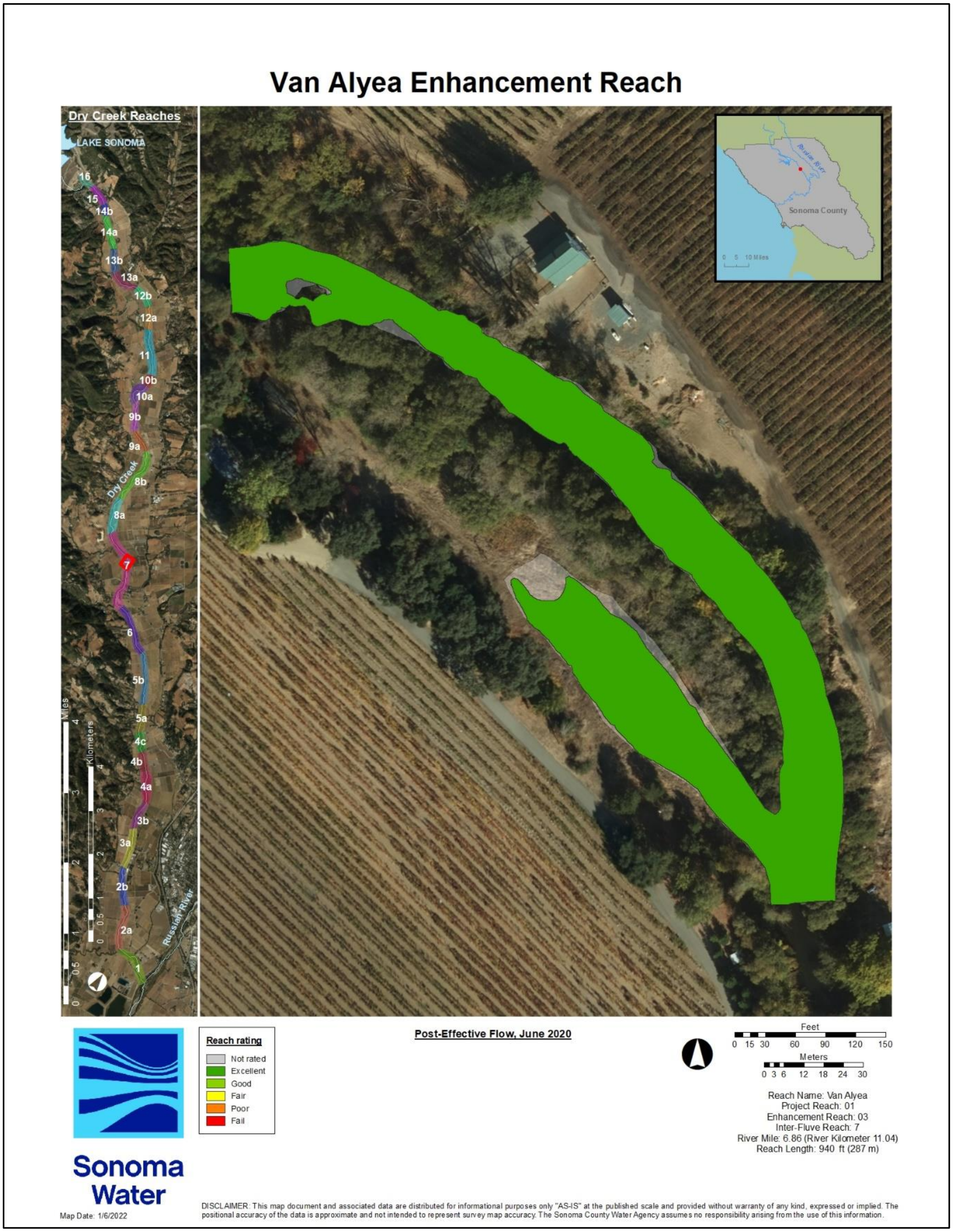


Figure 5.2.41. Post-effective flow reach rating for the Van Alyea enhancement reach, June 2020.

Farrow Wallace Enhancement Reach

Sonoma Water monitored the post-effective flow condition of the Farrow, Wallace enhancement reach in July 2020. Previous effectiveness monitoring surveys occurred in August 2015 (post-effective flow), August 2017 (post-effective low), and November 2019 receiving good, fair, and good ratings, respectively. The 2020 monitored area encompassed 80,913 ft^2 within main- and off-channel areas of Dry Creek with 32% of the total area meeting optimal depth and velocity criteria (Table 5.2.27, Figure 5.2.42). The monitoring characterized 15,817 ft^2 of main channel alcove area and 19,351 ft^2 of side channel area, of which 52% and 53% met optimal depth and velocity criteria, compared with 45,745 ft^2 and 16% for the main channel area. Sixteen habitat units composed the enhancement reach, with a pool to riffle ratio of 5:5 (1.00) and average shelter score of 112 (Table 5.2.28, Figure 5.2.43, Figure 5.2.44). Eleven habitat units met or exceeded the optimum shelter score of 80. The enhancement reach comprised seven enhancement sites (four main-channel sites, one alcove, one side channel, one bank site; Table 5.2.29,Figure 5.2.45), with excellent site average feature ratings (we did not rate enhancement site 1 as it contained no features), and poor to good site average habitat unit ratings (we did not rate site 4 as it contained no aquatic habitat; Table 5.2.29, Figure 5.2.46, Figure 5.2.47). Enhancement sites received fair to excellent ratings (Table 5.2.29, Figure 5.2.48). Overall, the Farrow, Wallace enhancement reach received a good effectiveness monitoring rating (Table 5.2.29, Figure 5.2.49; see Appendix 5.2 for all measured values, scores, and ratings).

Depth and velocity

Table 5.2.27. Areas and percentages of: wetted area, optimal depth and velocity, and optimal hydraulic habitat within the Farrow, Wallace enhancement reach, July 2020.

Farrow, Wallace Post-effective flow July 2020	**Wetted area (ft^2)**	**0.5 – 2.0 ft**	**2.0 – 4.0 ft**	**Total**	**< 0.5 ft/s**	**0.5 – 2.0 ft < 0.5 ft/s**	**2.0 – 4.0 ft < 0.5 ft/s**	**Total**
Main channel area	45,745	22,075	16,245	38,320	10,193	3,823	3,379	7,203
Main channel alcove area	15,817	5,773	6,296	12,069	10,853	4,245	3,949	8,195
Side channel area	19,351	9,835	5,748	15,583	13,824	6,140	4,133	10,273
Total area	80,913	37,683	28,289	65,971	34,871	14,209	11,461	25,670
Main channel % of wetted area	57%	48%	36%	84%	22%	8%	7%	16%
Main channel alcove % of wetted area	20%	36%	40%	76%	69%	27%	25%	52%
Side channel % of wetted area	24%	51%	30%	81%	71%	32%	21%	53%
Total % of wetted area	100%	47%	35%	82%	43%	18%	14%	32%

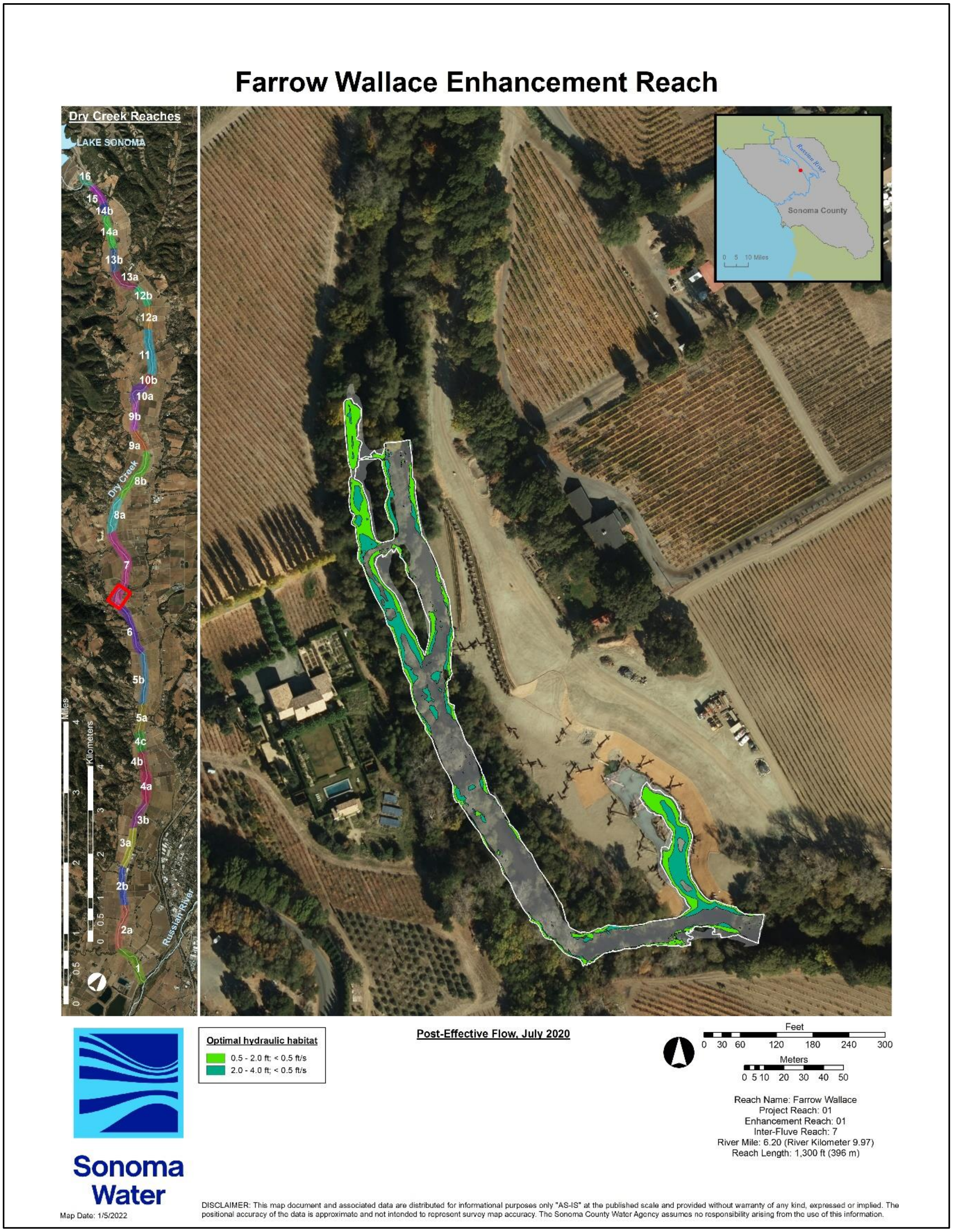


Figure 5.2.42. Optimal hydraulic habitat for fry (<0.5 ft/s, 0.5-2.0 ft) and parr (<0.5 ft/s, 2.0-4.0 ft) within the Farrow, Wallace enhancement reach, July 2020.

Habitat types, pool to riffle ratio, and shelter scores

Table 5.2.28. Habitat, types, shelter value, percent cover, and shelter score for habitat units within the Farrow, Wallace enhancement reach, July 2020.

Habitat Unit #	Habitat Type	Shelter Value	Percent Cover	Shelter Score
HU01	Flatwater	3	35	105
HU02	Alcove	3	80	240
HU03	Riffle	3	35	105
HU04	Pool	3	45	135
HU05	Riffle	2	15	30
HU06	Flatwater	1	10	10
HU07	Pool	3	40	120
HU08	Riffle	2	20	40
HU09	Flatwater	3	35	105
HU10	Pool	3	50	150
HU11	Pool	3	40	120
HU12	Flatwater	3	60	180
HU13	Alcove	3	80	240
HU14	Riffle	3	55	165
HU15	Riffle	2	15	30
HU16	Pool	1	15	15
Pool: riffle	**5:5 (1.00)**			**Avg = 112**

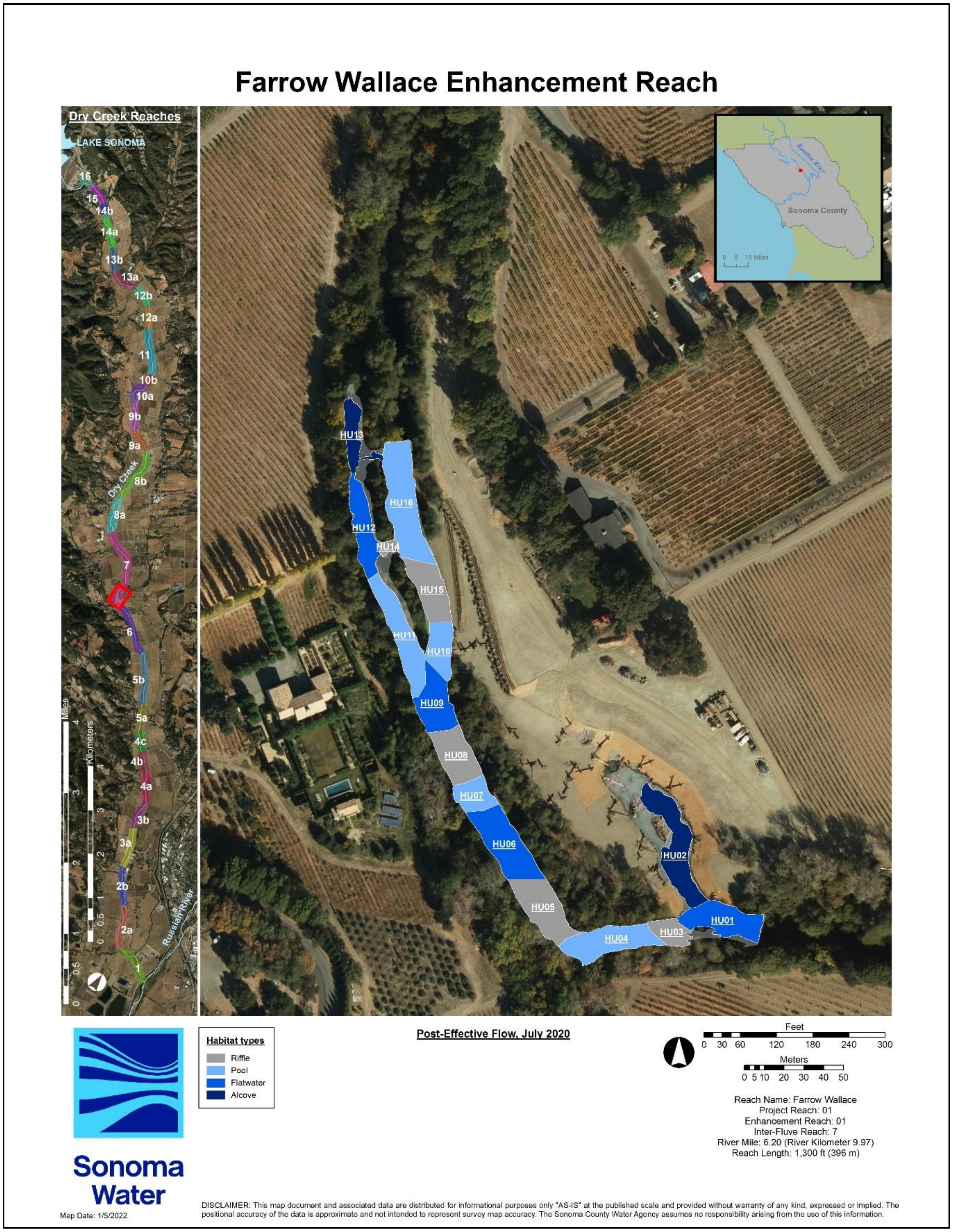


Figure 5.2.43. Habitat unit number and type within the Farrow, Wallace enhancement reach, July 2020.

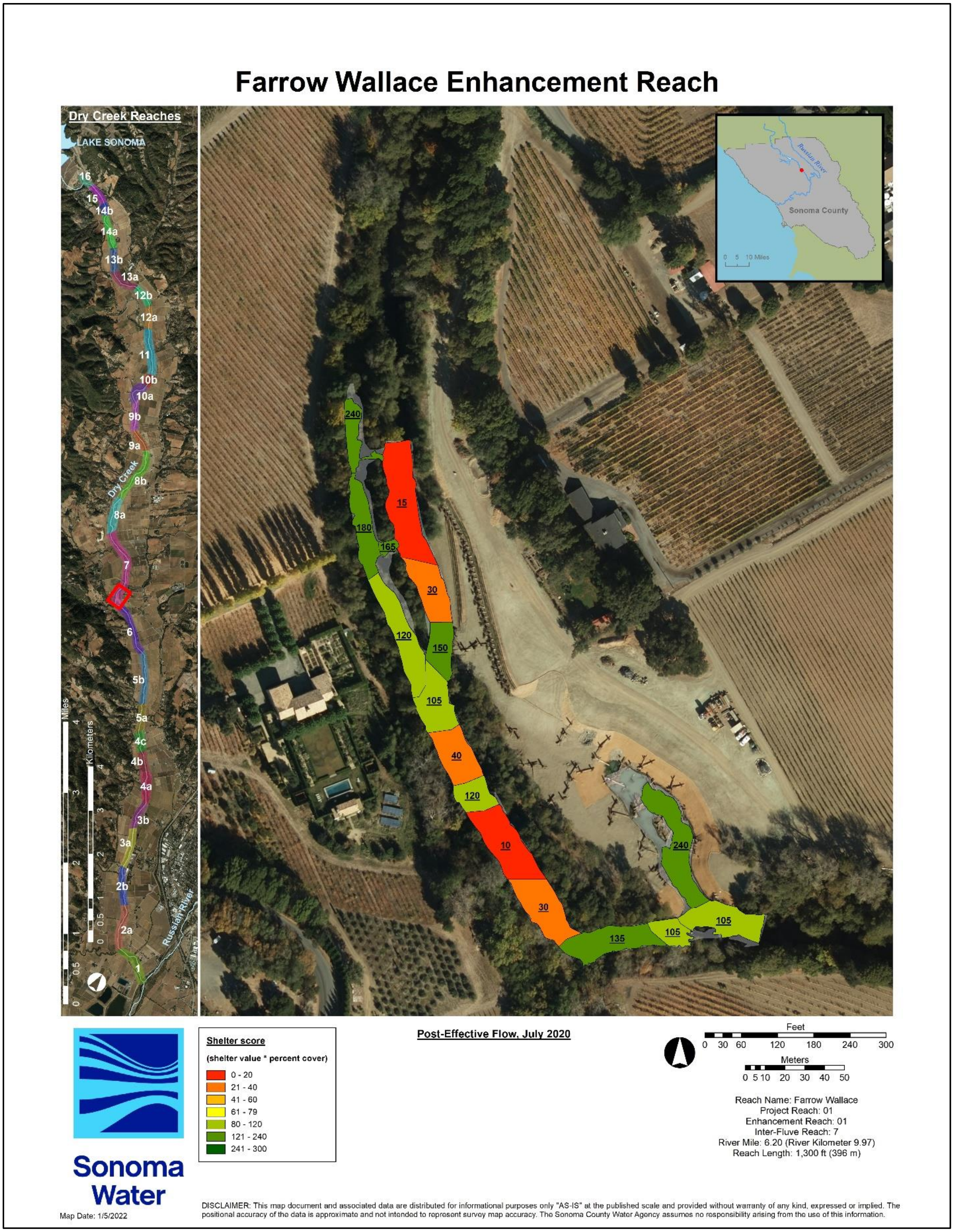


Figure 5.2.44. Habitat unit shelter scores within the Farrow, Wallace enhancement reach, July 2020.

Feature, habitat unit, site, and reach ratings

Table 5.2.29. Post-effective flow average feature, average habitat unit, site, and reach ratings (rounded to the nearest whole number) for the Farrow, Wallace enhancement reach, July 2020.

Site number	1	2	3	4	5	6	7
Site type	Alcove	Main chan	Main chan	Bank	Main chan	Side chan	Main chan
Site average feature quantitative rating[a]	12	0	13	13	13	13	13
Site average feature qualitative rating[a]	Excellent	Not rated	Excellent	Excellent	Excellent	Excellent	Excellent
Site average habitat unit quantitative rating[b]	25	16	14	0	22	21	11
Site average qualitative rating[b]	Good	Fair	Fair	Not Rated	Good	Good	Poor
Site quantitative rating (sum of site average feature and habitat unit rating)	37[c]	16[b]	27[c]	13[a]	35[b]	33[b]	24[b]
Site qualitative rating	Good[c]	Fair[b]	Fair[c]	Excellent[a]	Good[b]	Good[b]	Fair[b]
Enhancement reach quantitative rating (average of site rating)[d]	27						
Enhancement reach qualitative rating[d]:	Good						

[a]out of 15; Excellent (>=12), Good (>=9), Fair (>=6), Poor (>=3), Fail (<3)
[b]out of 35; Excellent (>=28), Good (>=21), Fair(>=14), Poor (>=7), Fail (<7)
[c]out of 50; Excellent (>=40), Good (>=30), Fair (>=20), Poor (>=10), Fail (<10)
[d]out of 43; Excellent (>=34), Good (>=26), Fair (>=17), Poor (>=9), Fail (<9)

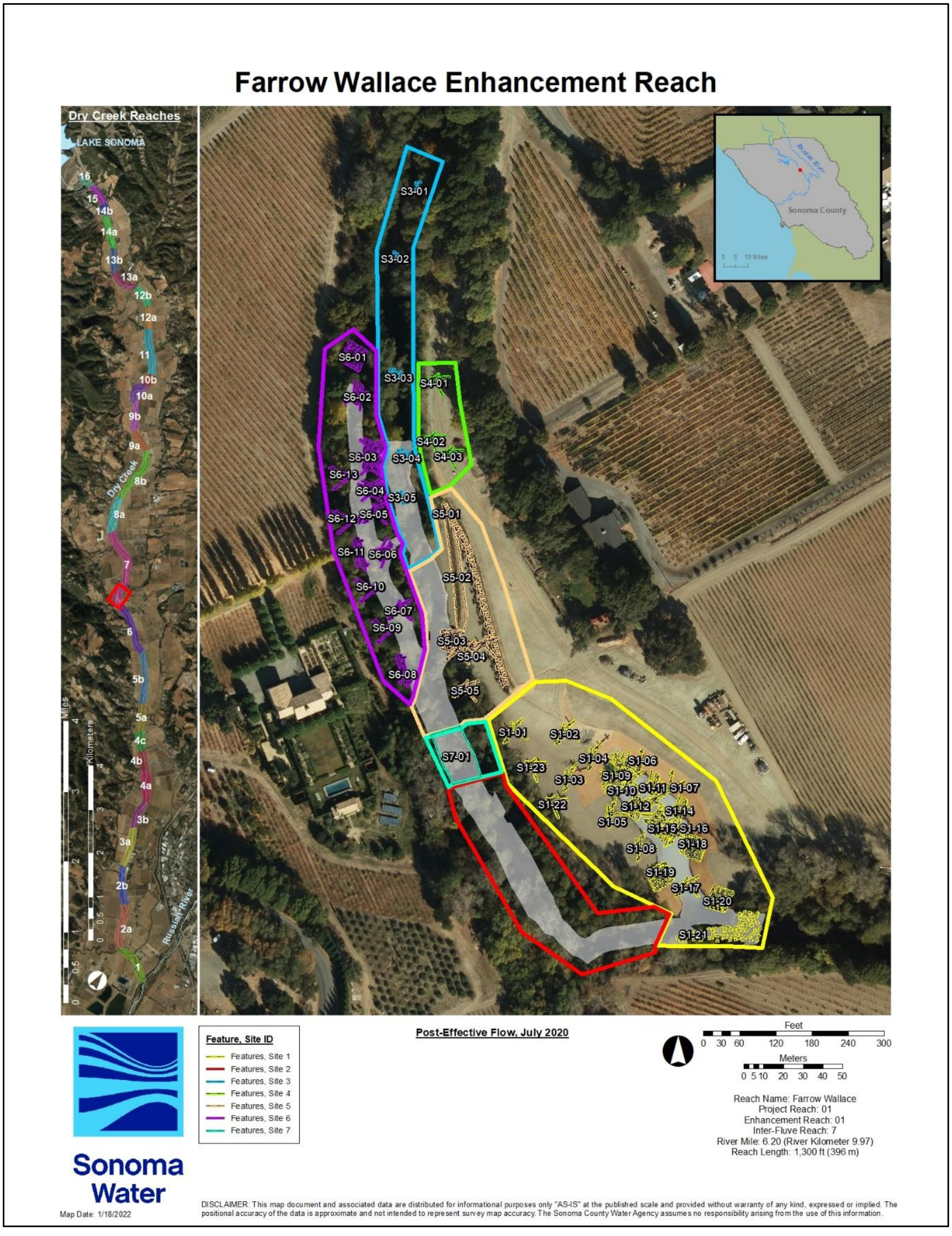


Figure 5.2.45. Enhancement sites and features within the Farrow, Wallace enhancement reach, July 2020.

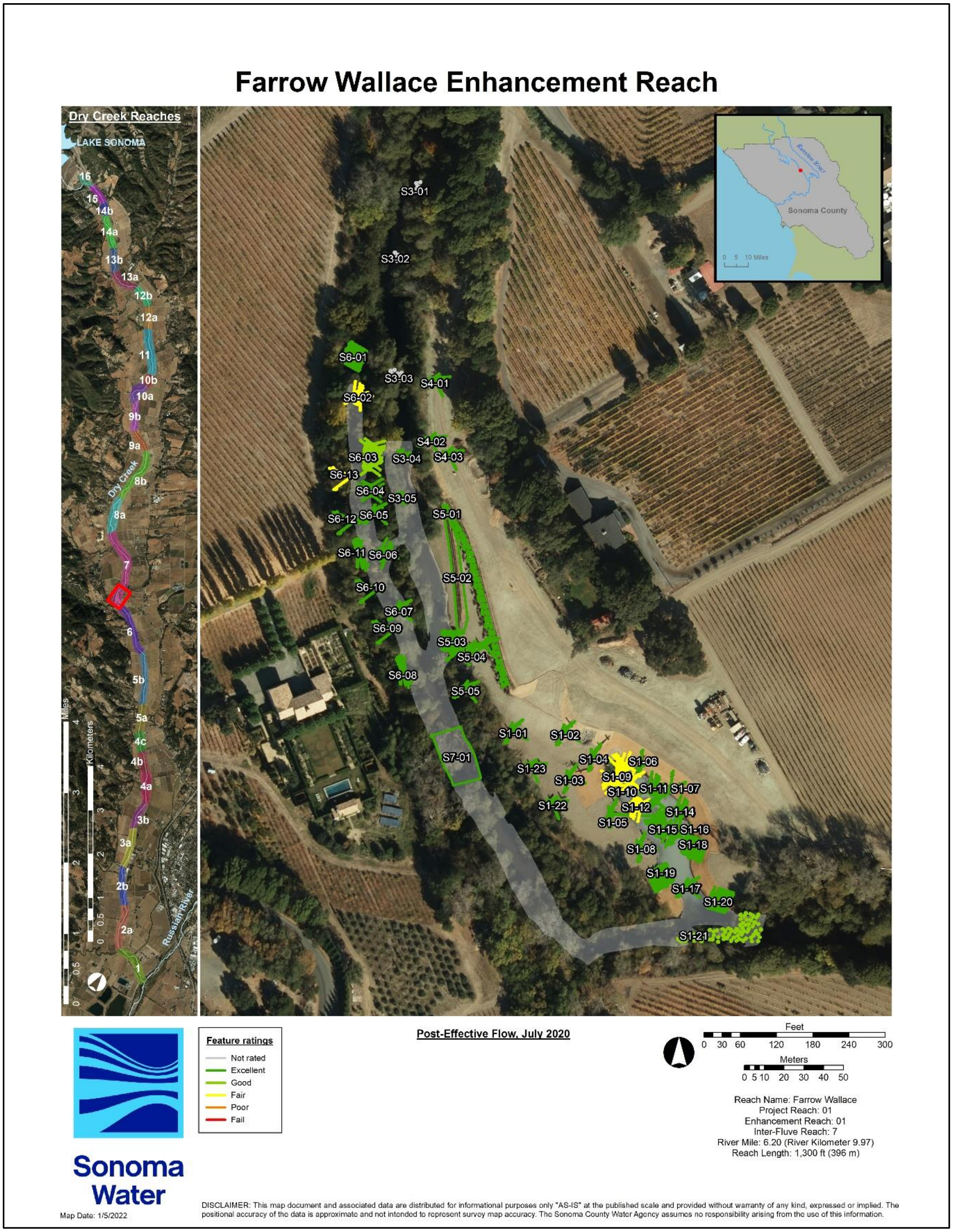


Figure 5.2.46. Feature ratings for the Farrow, Wallace enhancement reach, July 2020.

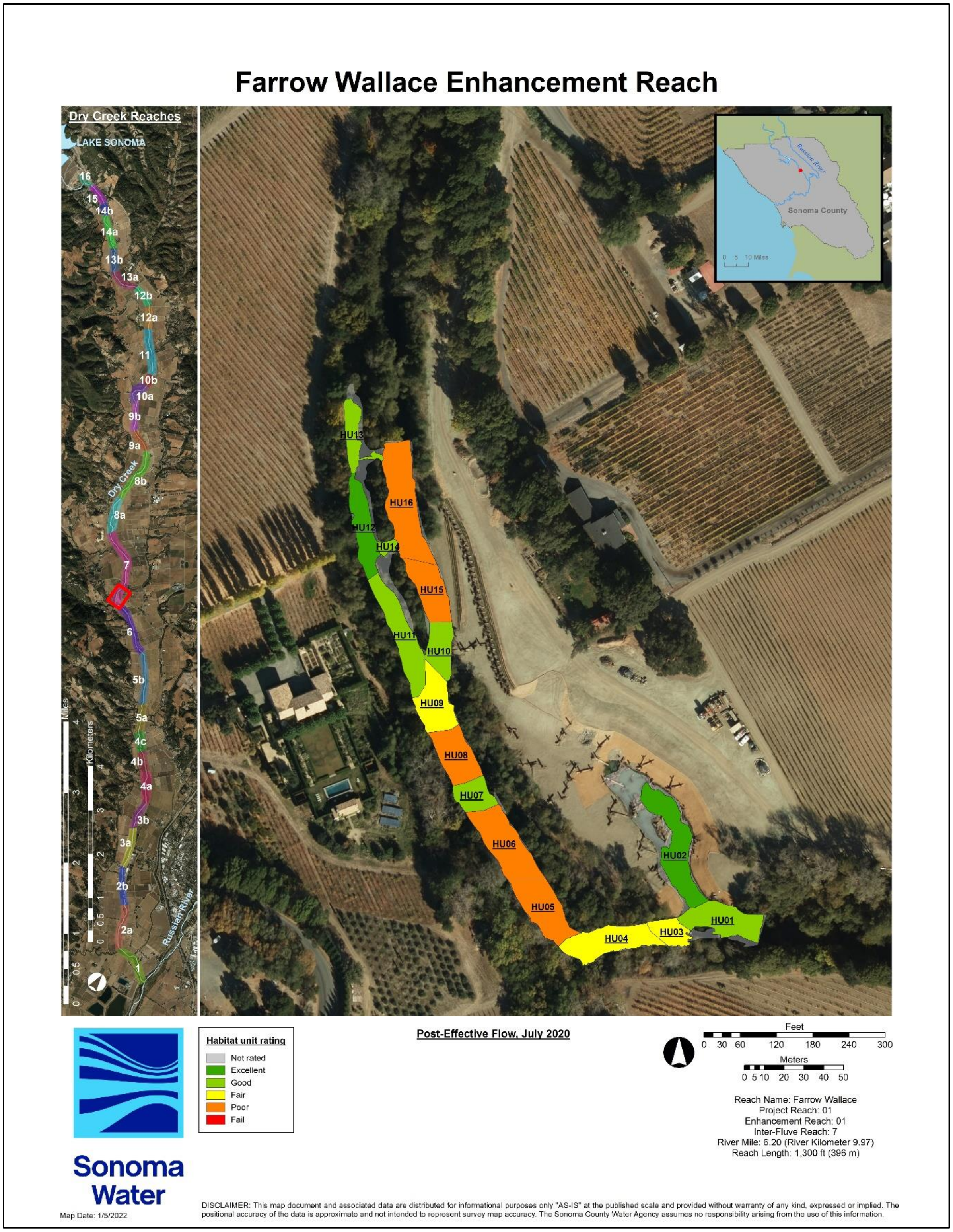


Figure 5.2.47. Habitat unit ratings for the Farrow, Wallace enhancement reach, July 2020.

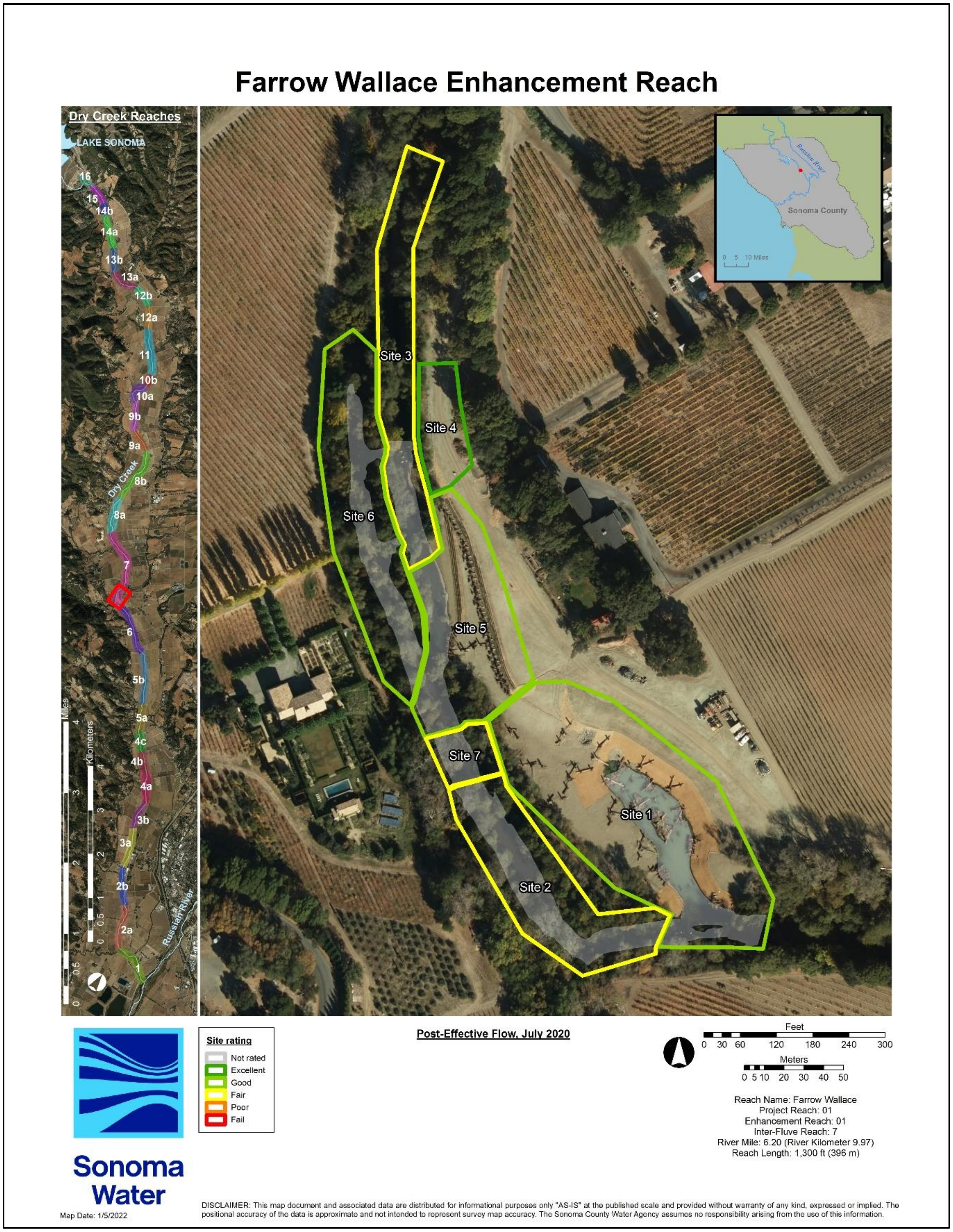


Figure 5.2.48. Post-effective flow site ratings for the Farrow, Wallace enhancement reach, July 2020.

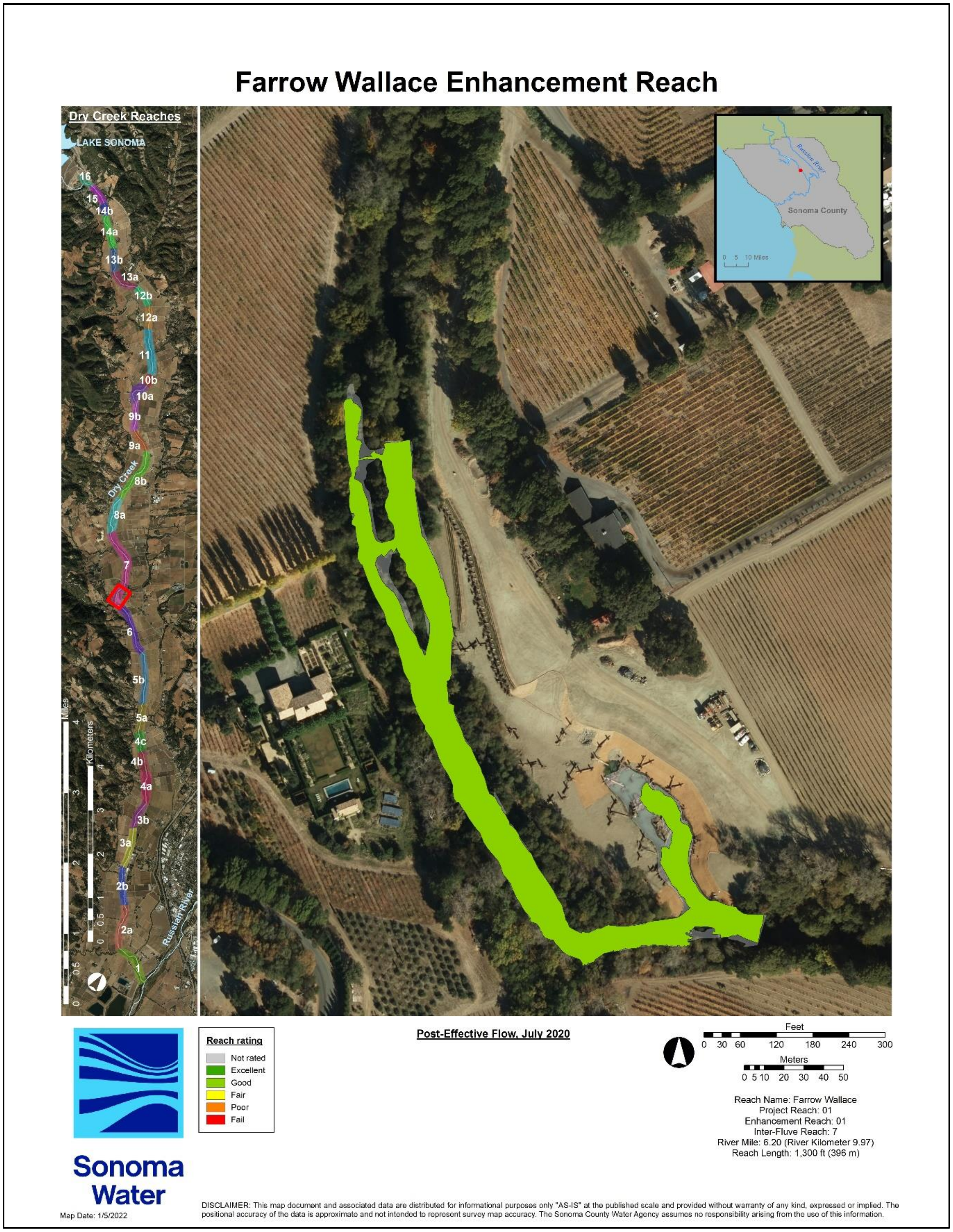


Figure 5.2.49. Post-effective flow reach rating for the Farrow, Wallace enhancement reach, July 2020.

Ferrari-Carano, Olson Enhancement Reach

Sonoma Water monitored the post-effective flow condition of the Ferrari-Carano, Olson enhancement reach in June 2020. Previous effectiveness monitoring surveys occurred in May 2018 (pre-enhancement), October 2018 (post-enhancement), June 2019 (post-effective flow) receiving fair, good, and fair enhancement reach ratings, respectively. The post-effective flow 2020 enhancement reach encompassed 111,237 ft^2 within main and off channel areas with 25% of the total area meeting optimum depth and velocity criteria (Table 5.2.30, Figure 5.2.50). The enhancement initially added 63,666 ft^2 of side channel in May 2018 (reported as 83,833 ft^2 in 2019 report and revised in this report), but aggradation caused by storms in winter 2018/2019 reduced off channel area to 53,142 ft^2. The enhancement also included 87,361 ft^2 of main channel in May 2018 (reported as 67,194 ft^2 in 2019 [2018 data] report and revised in 2020 report), but aggradation by storms in winter 2018/2019 reduced side channel area to 53,142 ft^2 in 2019 (see 2020 report for 2019 data). Side channel area in June 2020 increased to 60,314 ft^2, with 26% meeting optimal depth and velocity criteria (Table 5.2.30). Monitoring recorded 50,932 ft^2 of main channel area, of which 23% met optimal depth and velocity criteria (Table 5.2.30, Figure 5.2.50). Forty-seven habitat units composed the enhancement reach post-effective flow, with a pool to riffle ratio of 17:15 (1.13) and an average shelter score of 114 (Table 5.2.31, Figure 5.2.51,Figure 5.2.52). Twenty-nine habitat units met or exceeded the optimal shelter value of 80. The enhancement reach comprised three enhancement sites (one main channel, two side channels) that received poor to fair site average feature ratings and poor to fair site average habitat unit ratings (Table 5.2.32, Figure 5.2.53, Figure 5.2.54, Figure 5.2.55). Sites 1 and 2 partially aggraded in winter 2018/2019, burying some enhancement features, while Site 3 almost completely aggraded, burying nearly all enhancement features, leading to fair, fair, and poor site ratings (Table 5.2.32, Figure 5.2.56). Overall, the Ferrari-Carano, Olson enhancement reach received a fair enhancement reach rating (Figure 5.2.57) (See Appendix 5.2 for measured values, scores, and ratings).

Depth and velocity

Table 5.2.30. Areas and percentages of: wetted area, optimal depth and velocity, and optimal hydraulic habitat within the Ferrari-Carano, Olson enhancement reach, June 2020.

Ferrari-Carano, Olson Post-effective flow June 2020	Wetted area (ft^2)	0.5 – 2.0 ft	2.0 – 4.0 ft	Total	< 0.5 ft/s	0.5 – 2.0 ft < 0.5 ft/s	2.0 – 4.0 ft < 0.5 ft/s	Total
Main channel area	50,923	26,565	13,648	40,212	20,316	9,166	2,662	11,828
Side channel area	60,314	30,090	15,973	46,063	27,042	9,954	5,573	15,526
Total area	**111,237**	**56,655**	**29,621**	**86,276**	**47,358**	**19,119**	**8,235**	**27,354**
Main channel % of wetted area	46%	52%	27%	79%	40%	18%	5%	23%
Side channel % of wetted area	54%	50%	26%	76%	45%	17%	9%	26%
Total % of wetted area	**100%**	**51%**	**27%**	**78%**	**43%**	**17%**	**7%**	**25%**

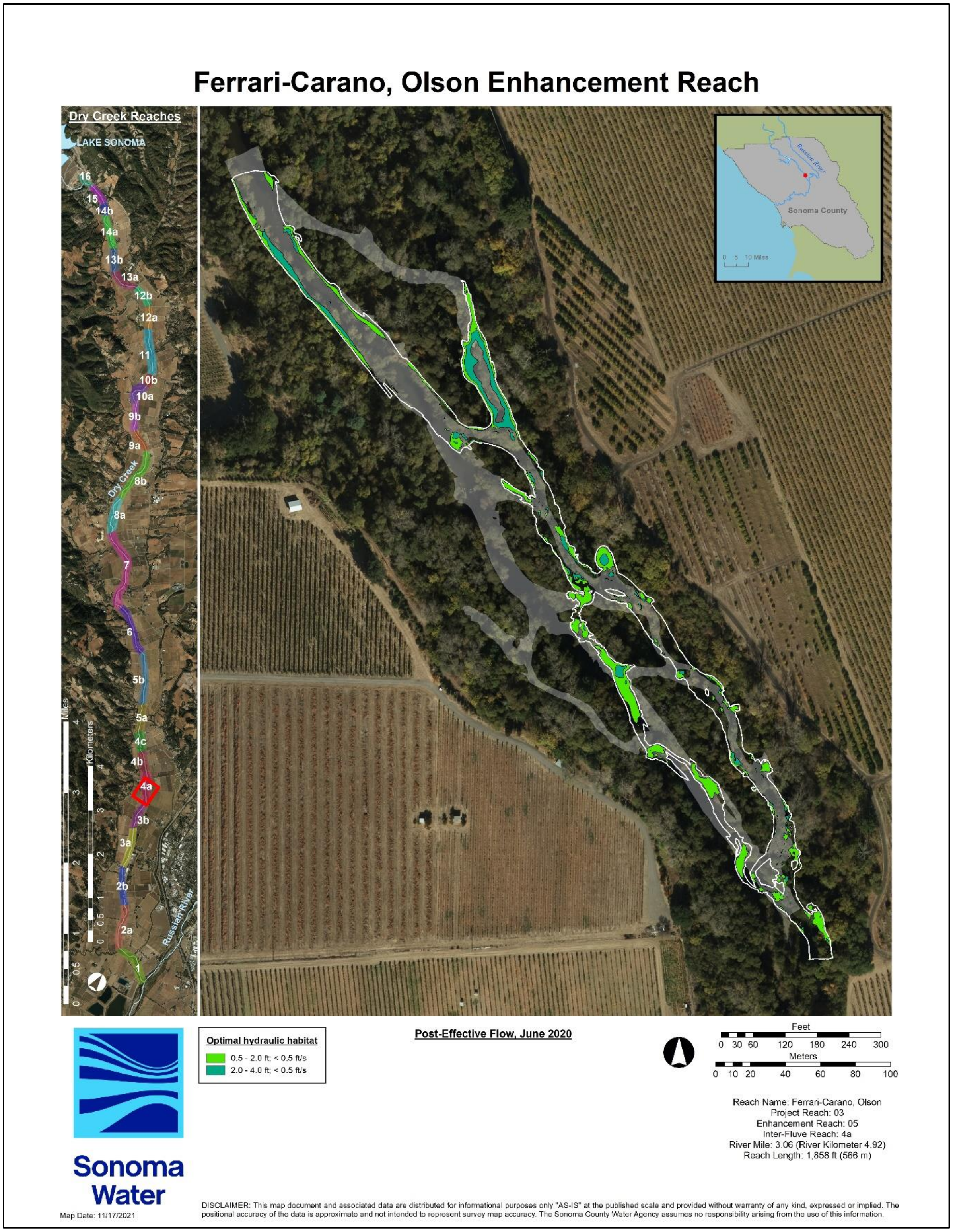


Figure 5.2.50. Optimal hydraulic habitat for fry (<0.5 ft/s, 0.5-2.0 ft) and parr (<0.5 ft/s, 2.0-4.0 ft) within the Ferrari-Carano, Olson enhancement reach, June 2020.

Habitat types, pool to riffle ratio, and shelter scores

Table 5.2.31. Habitat, types, shelter value, percent cover, and shelter score for habitat units within the Ferrari-Carano, Olson enhancement reach, June 2020.

Habitat Unit #	Habitat Type	Shelter Value	Percent Cover	Shelter Score
HU01	Riffle	3	60	180
HU02	Flatwater	2	25	50
HU03	Flatwater	3	90	270
HU04	Alcove	3	95	285
HU05	Pool	3	30	90
HU06	Flatwater	3	55	165
HU07	Riffle	2	10	20
HU08	Pool	3	35	105
HU09	Alcove	3	65	195
HU10	Pool	3	35	105
HU11	Riffle	3	20	60
HU12	Alcove	2	15	30
HU13	Pool	3	50	150
HU14	Riffle	3	10	30
HU15	Pool	3	35	105
HU16	Riffle	3	45	135
HU17	Alcove	3	95	285
HU18	Pool	3	35	105
HU19	Flatwater	3	10	30
HU20	Riffle	3	35	105
HU21	Alcove	3	85	255
HU22	Pool	2	15	30
HU23	Riffle	1	10	10
HU24	Alcove	3	95	285
HU25	Pool	3	20	60
HU26	Riffle	2	10	20
HU27	Pool	2	15	30
HU28	Pool	3	20	60
HU29	Flatwater	3	15	45
HU30	Riffle	3	30	90
HU31	Flatwater	3	10	30
HU32	Riffle	1	50	50
HU33	Pool	3	50	150
HU34	Riffle	1	65	65
HU35	Pool	3	90	270
HU36	Riffle	2	75	150
HU37	Pool	3	90	270
HU38	Riffle	1	60	60
HU39	Flatwater	2	35	70
HU40	Pool	3	50	150
HU41	Pool	3	40	120
HU42	Flatwater	2	35	70
HU43	Riffle	2	30	60
HU44	Pool	3	50	150
HU45	Pool	1	30	30
HU46	Riffle	3	60	180
HU47	Flatwater	3	30	90
Pool: riffle	**17:15 (1.13)**			**Avg = 114**

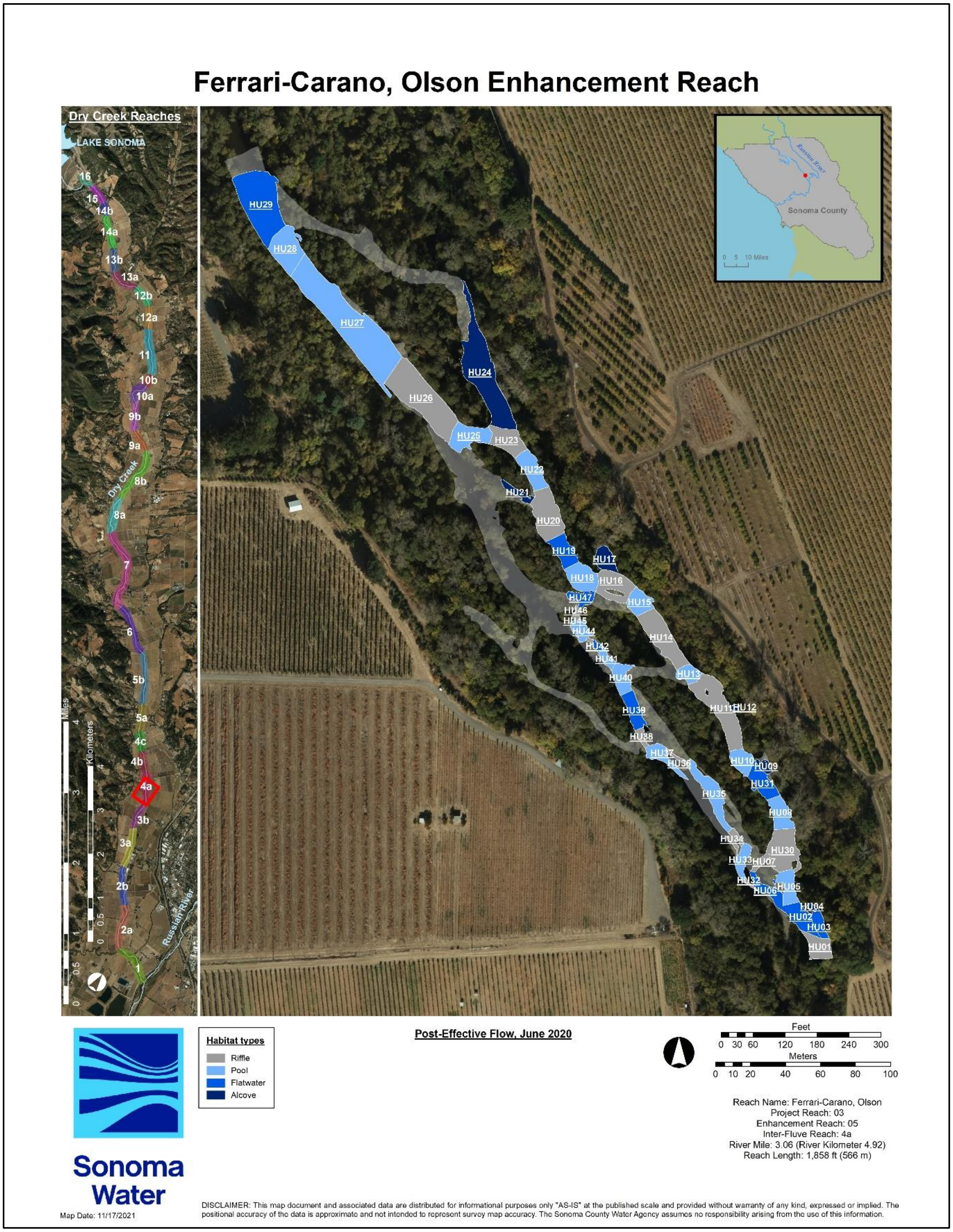


Figure 5.2.51. Habitat unit number and type within the Ferrari-Carano, Olson enhancement reach, June 2020.

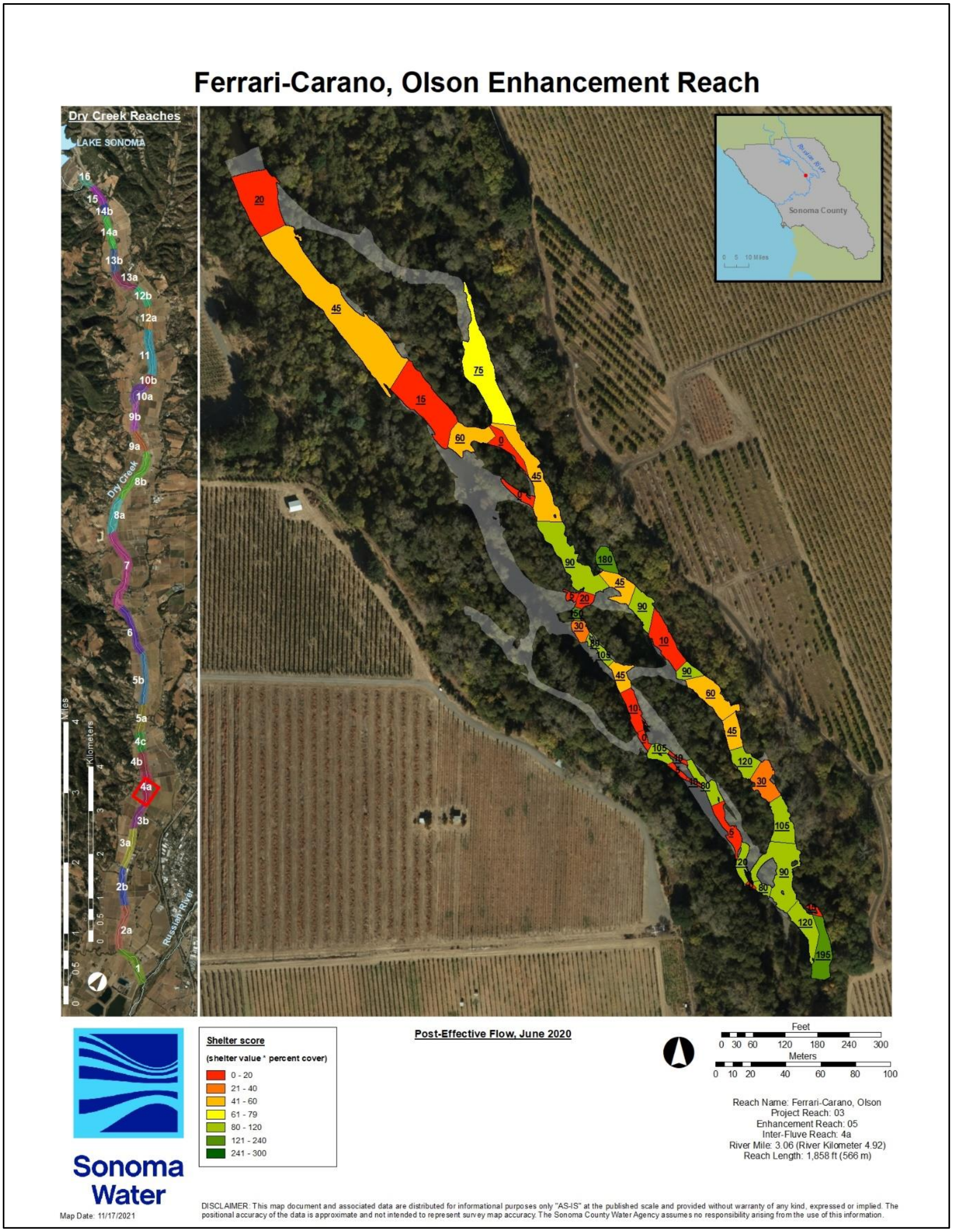


Figure 5.2.52. Habitat unit shelter scores within the Ferrari-Carano, Olson enhancement reach, June 2020.

Feature, habitat unit, site, and reach ratings

Table 5.2.32. Post-effective flow average feature, average habitat unit, site, and reach ratings (rounded to the nearest whole number) for the Ferrari-Carano, Olson enhancement reach, June 2020.

Site number	1	2	3	
Site type	**Main channel**	**Side channel**	**Side channel**	
Site average feature quantitative rating[a]	6	9	5	
Site average feature qualitative rating[a]	Poor	Fair	Poor	
Site average habitat unit quantitative rating[b]	18	19	10	
Site average qualitative rating[b]	Fair	Fair	Poor	
Site quantitative rating (sum of site average feature and habitat unit rating)[c]	24	28	14	
Site qualitative rating[c]	Fair	Fair	Poor	
Enhancement reach quantitative rating (average of site rating)[c]	22			
Enhancement reach qualitative rating[c]:	Fair			

[a]out of 15; Excellent (>=12), Good (>=9), Fair (>=6), Poor (>=3), Fail (<3)
[b]out of 35; Excellent (>=28), Good (>=21), Fair(>=14), Poor (>=7), Fail (<7)
[c]out of 50; Excellent (>=40), Good (>=30), Fair (>=20), Poor (>=10), Fail (<10)

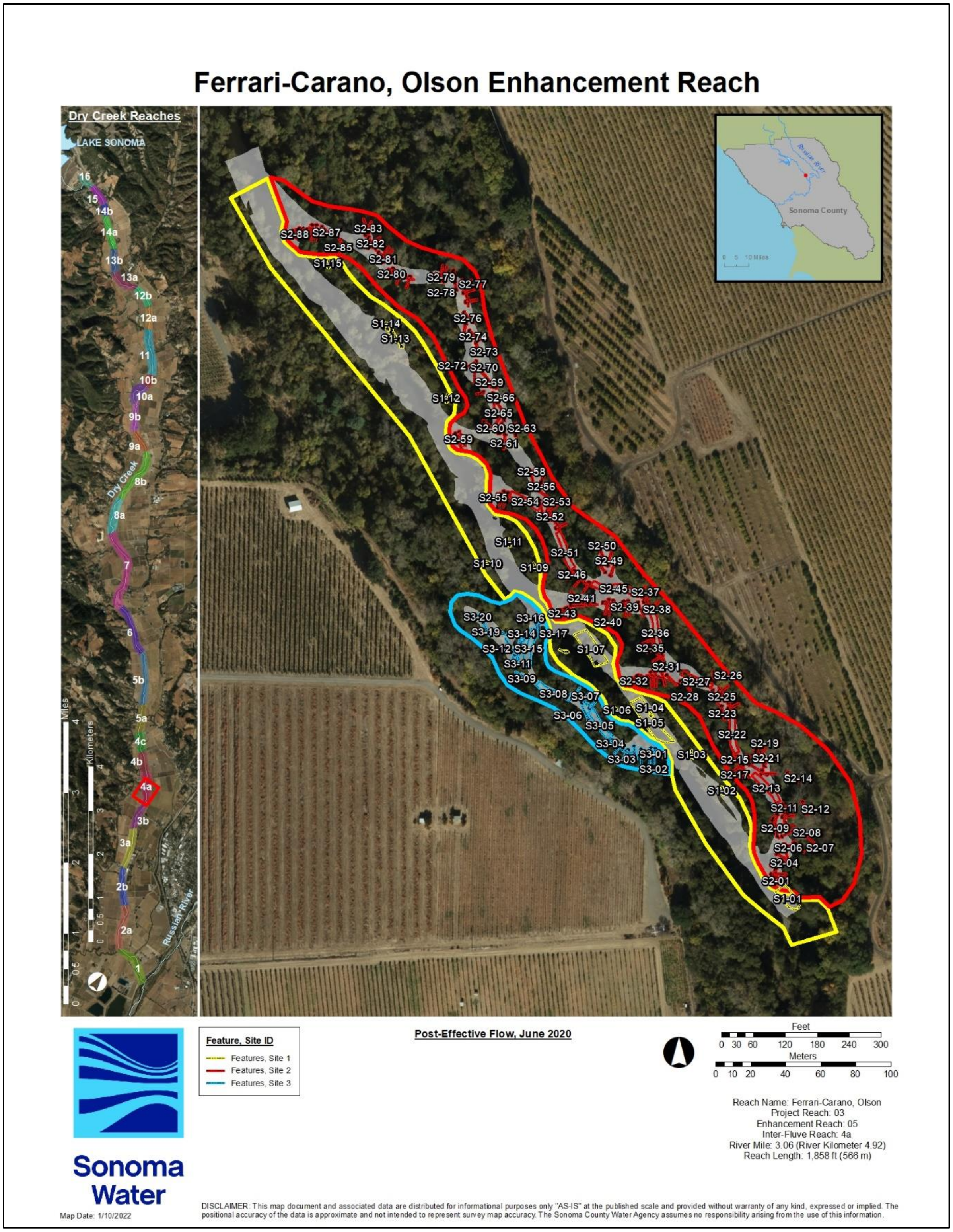


Figure 5.2.53. Enhancement sites and features within the Ferrari-Carano, Olson enhancement reach, June 2020.

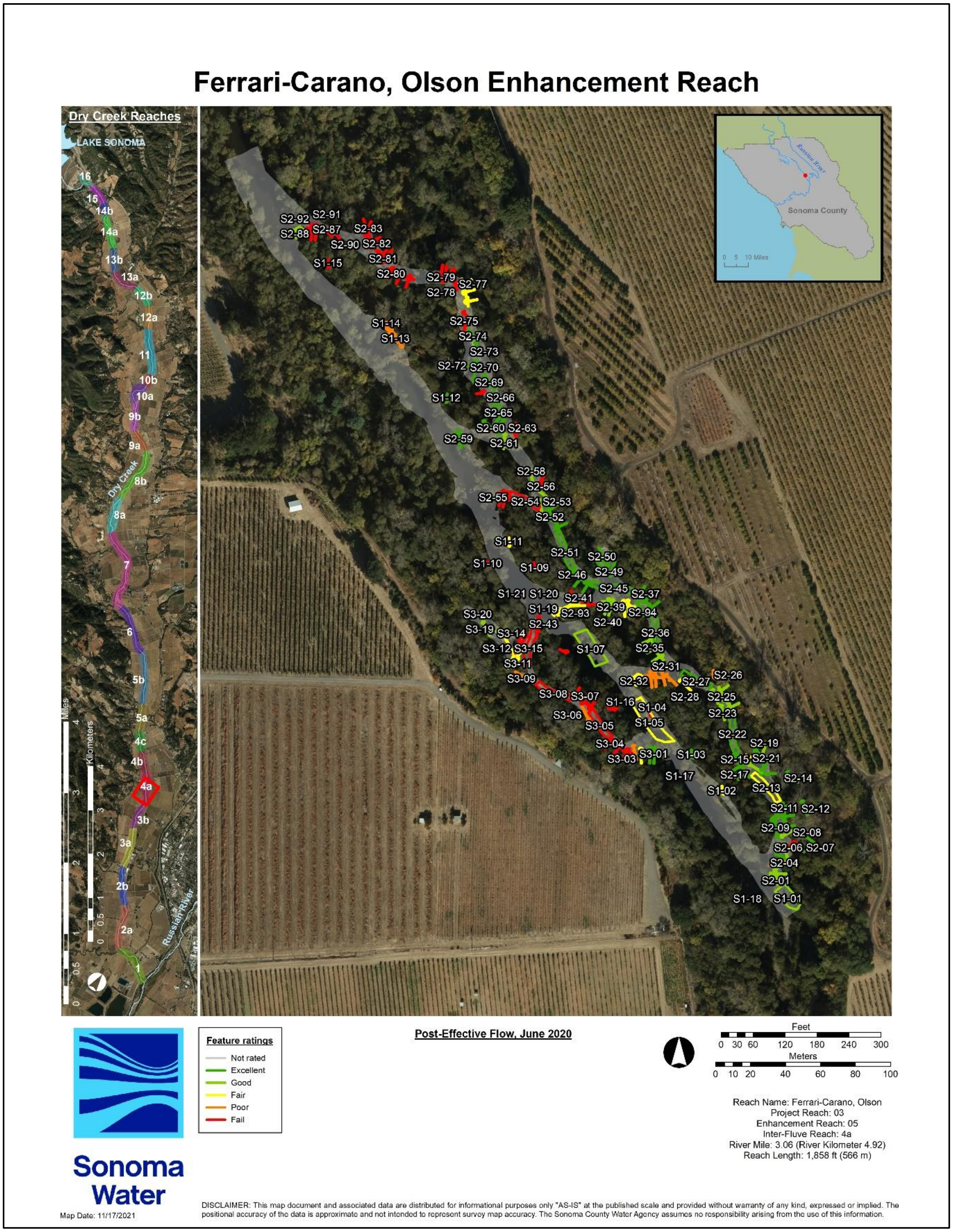


Figure 5.2.54. Feature ratings for the Ferrari-Carano, Olson enhancement reach, June 2020.

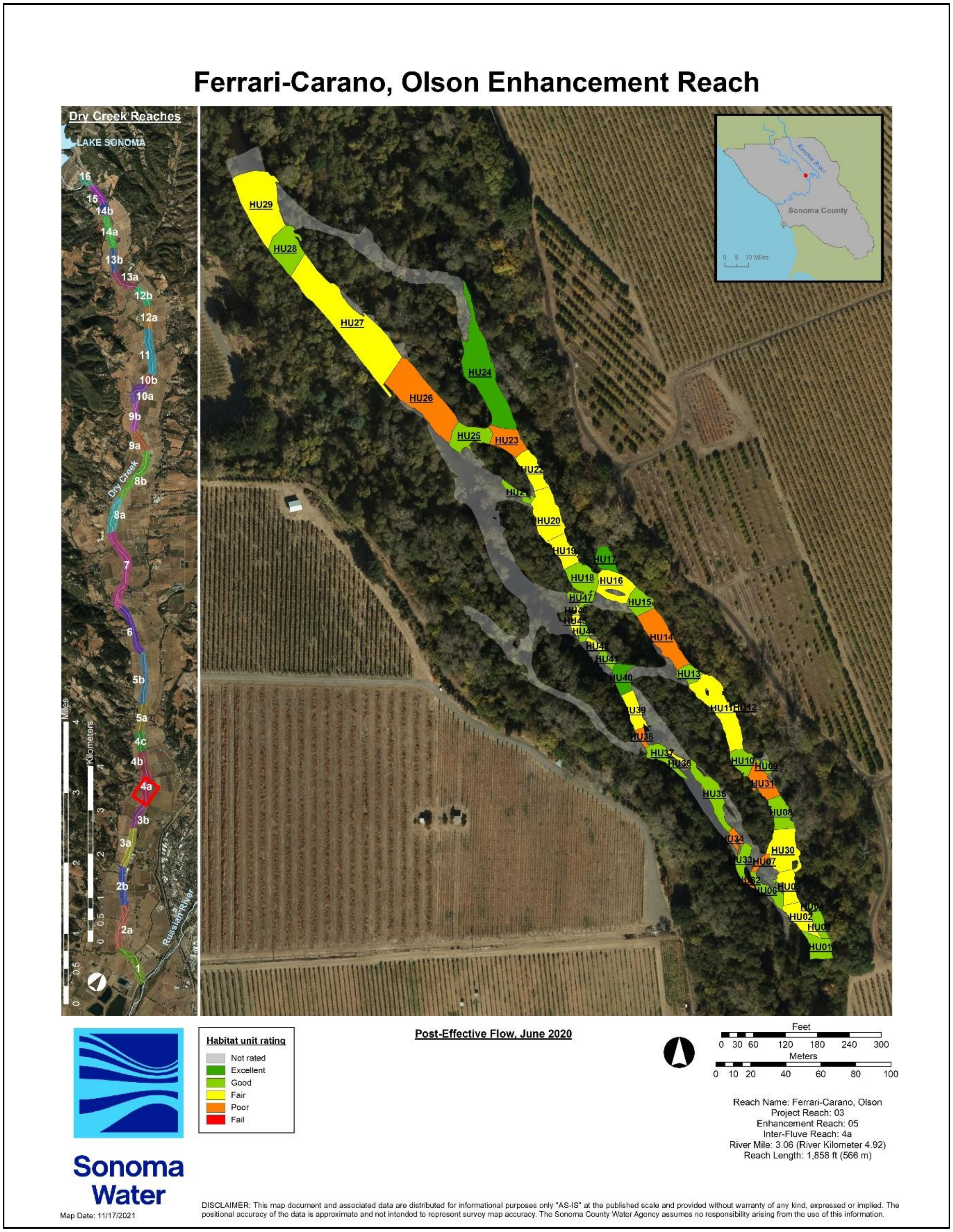


Figure 5.2.55. Habitat unit ratings for the Ferrari-Carano, Olson enhancement reach June 2020.

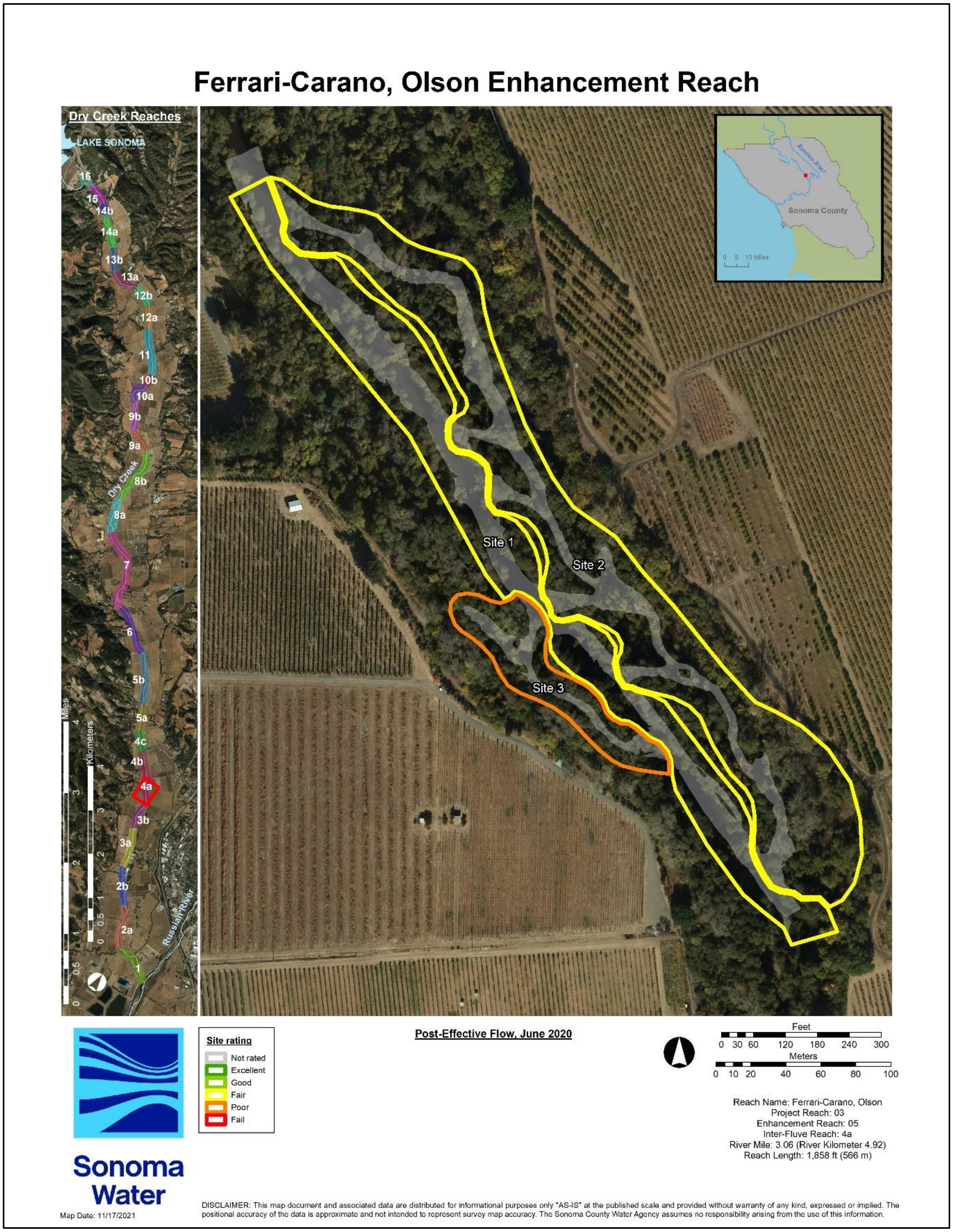


Figure 5.2.56. Enhancement site ratings for the Ferrari-Carano, Olson enhancement reach, June 2020.

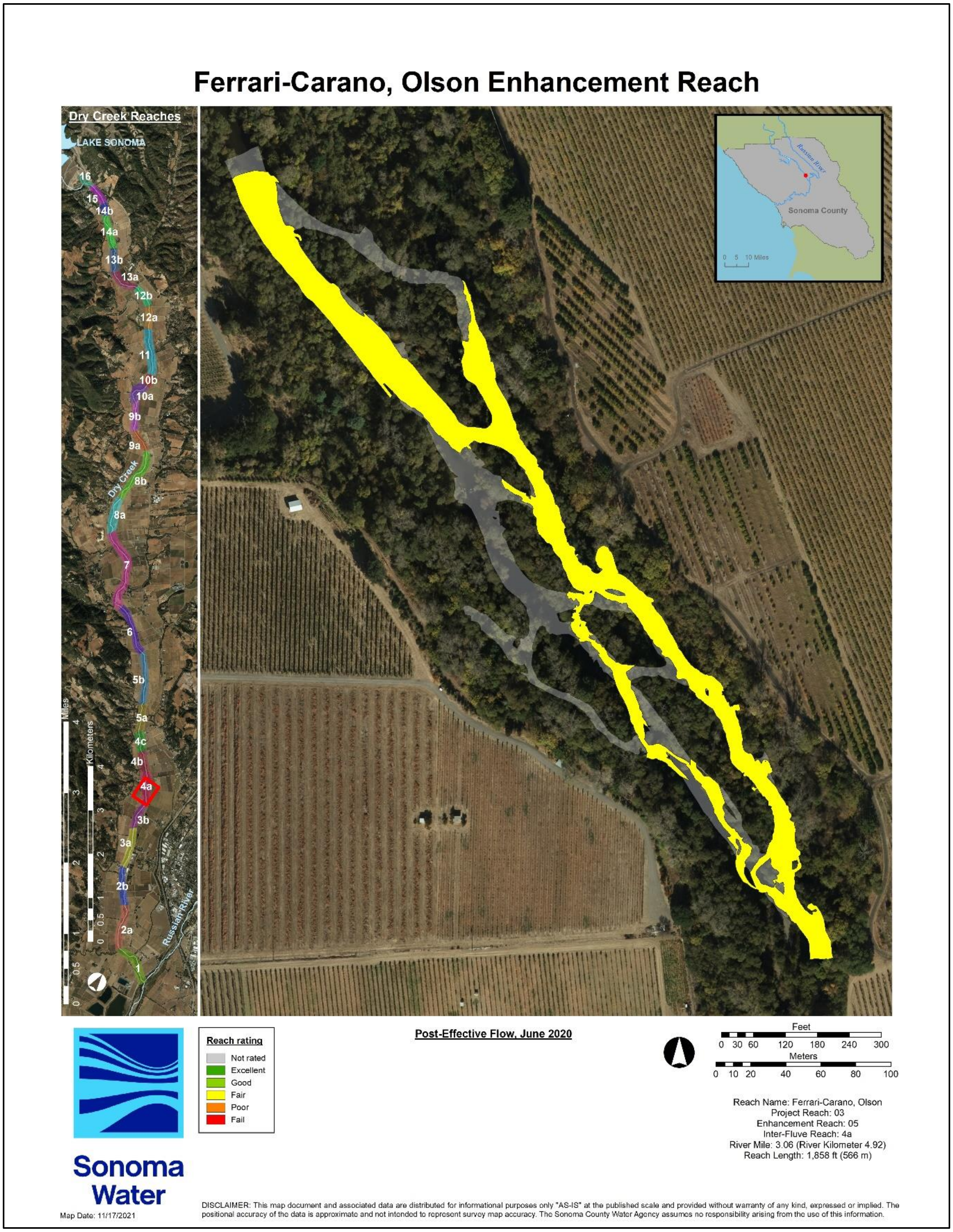


Figure 5.2.57. Enhancement reach rating for the Ferrari-Carano, Olson enhancement reach, June 2020.

Geyser Peak Enhancement Reach

Sonoma Water monitored the post-effective flow condition of the Geyser Peak enhancement reach in April 2020. Sonoma Water originally constructed the Geyser Peak enhancement reach in October 2016, adding 8,244 ft^2 of side-channel. Aggradation caused by large storms in winter 2016/2017 reduced side channel area to 0 ft^2, leading to a fail effectiveness monitoring rating in July 2017 and repairs in summer 2017. The repair re-excavated 8,721 ft^2 and crews monitored again in October 2017 giving the enhancement reach a fair post-repair rating (see 2018 report for results). Sonoma Water subsequently monitored the post-effective flow condition in July 2018, finding that side channel area expanded slightly to 9,588 ft^2, and giving the enhancement reach a fair effectiveness monitoring rating (see 2019 report for results). But, similar to 2016/2017, aggradation caused by large storms in winter 2018/2019 reduced side channel area to 0 ft^2 in July 2019. Main channel area increased from 2018 (26,170 ft^2) to 2019 (42,954 ft^2) likely due to an increase in habitat at the downstream end of the enhancement reach. In April 2020, the enhanced reach encompassed 39.452 ft^2, most occurring as main channel area (37,851 ft^2) with a small amount of off-channel area (1,602 ft^2) as the off-channel areas remain aggraded following 2018/2019 storms (Table 5.2.33, Figure 5.2.58). In 2020, 16% of total habitat area met optimal depth and velocity criteria, mainly along the channel margins in the mainstem (14% of total area) and within the outlet at the downstream end of the side channel (75%).

Fifteen habitat units made up the enhancement reach, with a pool to riffle ratio of 3:7 (0.43) and an average shelter score of 79 (Table 5.2.34, Figure 5.2.59, Figure 5.2.60). Six habitat units met or exceeded the optimum shelter value of 80. The enhancement reach comprised four enhancement sites (one main channel and two side channel sites, and one bank site) that received fail to excellent site average feature ratings, and fail to excellent site average habitat unit ratings (Table 5.2.35, Figure 5.2.61, Figure 5.2.62,Figure 5.2.63). Site 4 (bank) included features installed above water surface elevation, but no aquatic habitat. As such, site 4 did not receive a site average habitat unit rating. Site 2 (side channel) completely aggraded from July 2018 to July 2019, burying nearly all features and aquatic habitat, leading to fail site average feature and site average habitat unit ratings. Enhancement site ratings ranged from fail (site 2) to poor (site 1) to good (site 4) to excellent (site 3) (Table 5.2.35, Figure 5.2.64). Overall, the Geyser Peak enhancement reach received a fair effectiveness monitoring score in April 2020 (Table 5.2.35, Figure 5.2.65; see Appendix 5.2 for all measured values, scores, and ratings).

Depth and velocity

Table 5.2.33. Areas and percentages of: wetted area, optimal depth and velocity, and optimal hydraulic habitat within the Geyser Peak enhancement reach, April 2020.

Geyser Peak Post-effective flow April 2020	Wetted area (ft^2)	0.5 – 2.0 ft	2.0 – 4.0 ft	Total	< 0.5 ft/s	0.5 – 2.0 ft < 0.5 ft/s	2.0 – 4.0 ft < 0.5 ft/s	Total
Main channel area	37,851	22,949	5,120	28,069	11,015	4,410	859	5,270
Side channel area	1,602	931	267	1,198	1,602	931	267	1,198
Total area	**39,452**	**23,880**	**5,386**	**29,266**	**12,617**	**5,341**	**1,126**	**6,468**
Main channel % of wetted area	96%	61%	14%	74%	29%	12%	2%	14%
Side channel % of wetted area	4%	58%	17%	75%	100%	58%	17%	75%
Total % of wetted area	**100%**	**61%**	**14%**	**74%**	**32%**	**14%**	**3%**	**16%**

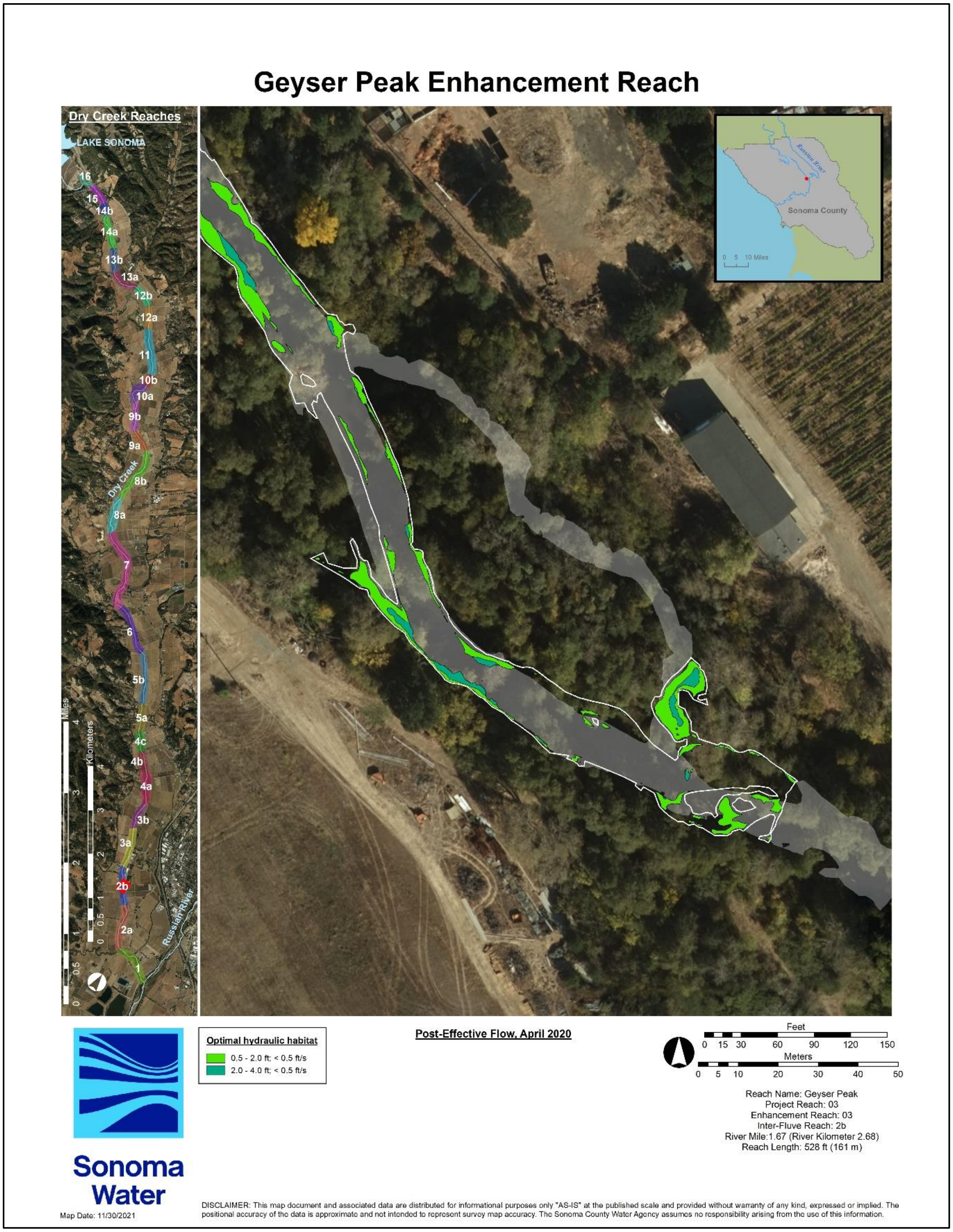


Figure 5.2.58. Optimal hydraulic habitat for fry (<0.5 ft/s, 0.5-2.0 ft) and parr (<0.5 ft/s, 2.0-4.0 ft) within the Geyser Peak enhancement reach, April 2020.

Habitat types, pool to riffle ratio, and shelter scores

Table 5.2.34. Habitat, types, shelter value, percent cover, and shelter score for habitat units within the Geyser Peak enhancement reach, April 2020.

Habitat Unit #	Habitat Type	Shelter Value	Percent Cover	Shelter Score
HU01	Riffle	3	30	90
HU02	Riffle	1	5	5
HU03	Pool	3	30	90
HU04	Pool	3	40	120
HU05	Riffle	2	10	20
HU06	Riffle	3	15	45
HU07	Alcove	3	50	150
HU08	Riffle	2	10	20
HU09	Pool	3	25	75
HU10	Flatwater	2	20	40
HU11	Alcove	3	60	180
HU12	Riffle	2	5	10
HU13	Alcove	3	90	270
HU14	Flatwater	2	15	30
HU15	Riffle	2	20	40
Pool: riffle	**3:7 (0.43)**			**Avg = 79**

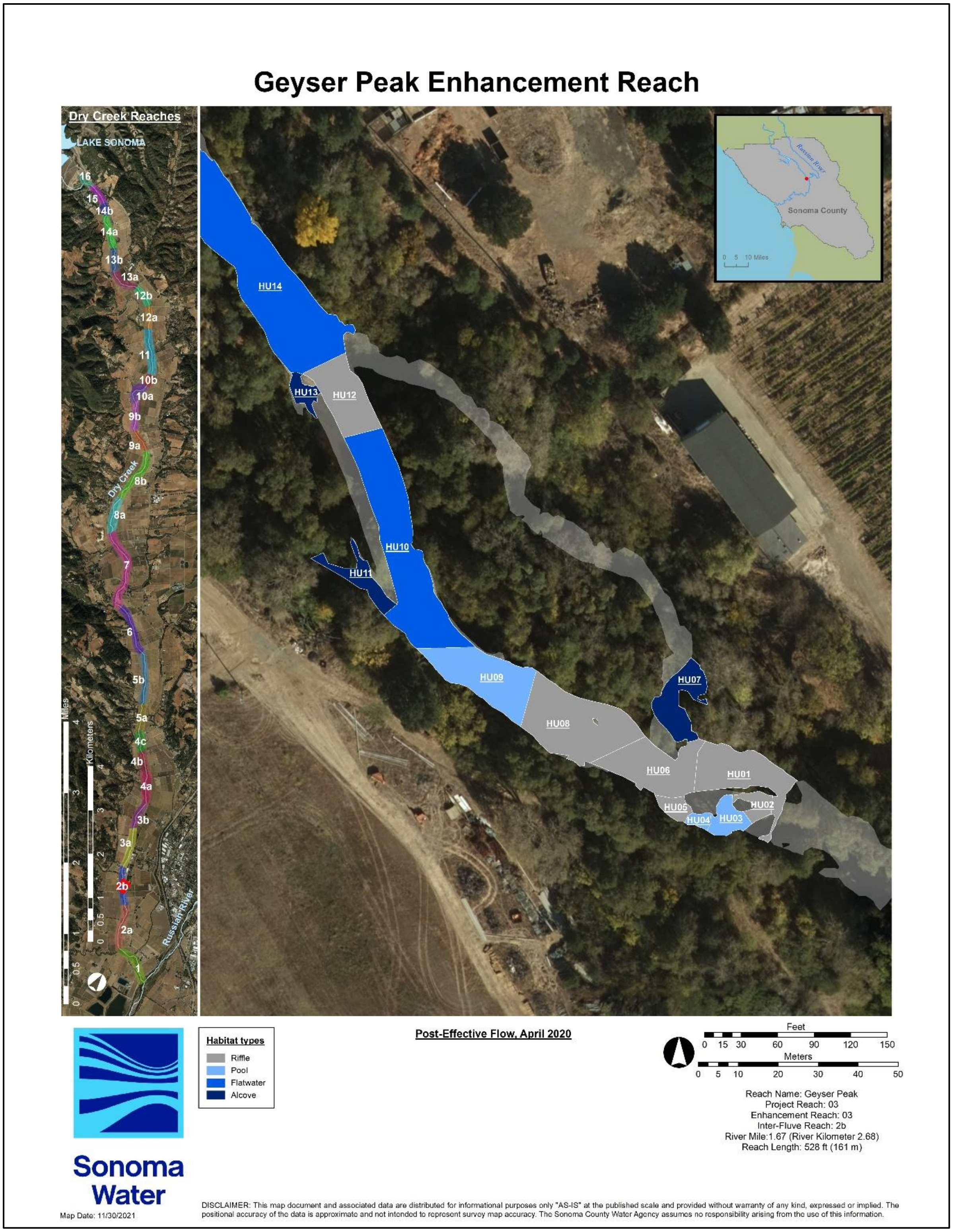


Figure 5.2.59. Habitat unit number and type within the Geyser Peak enhancement reach, April 2020.

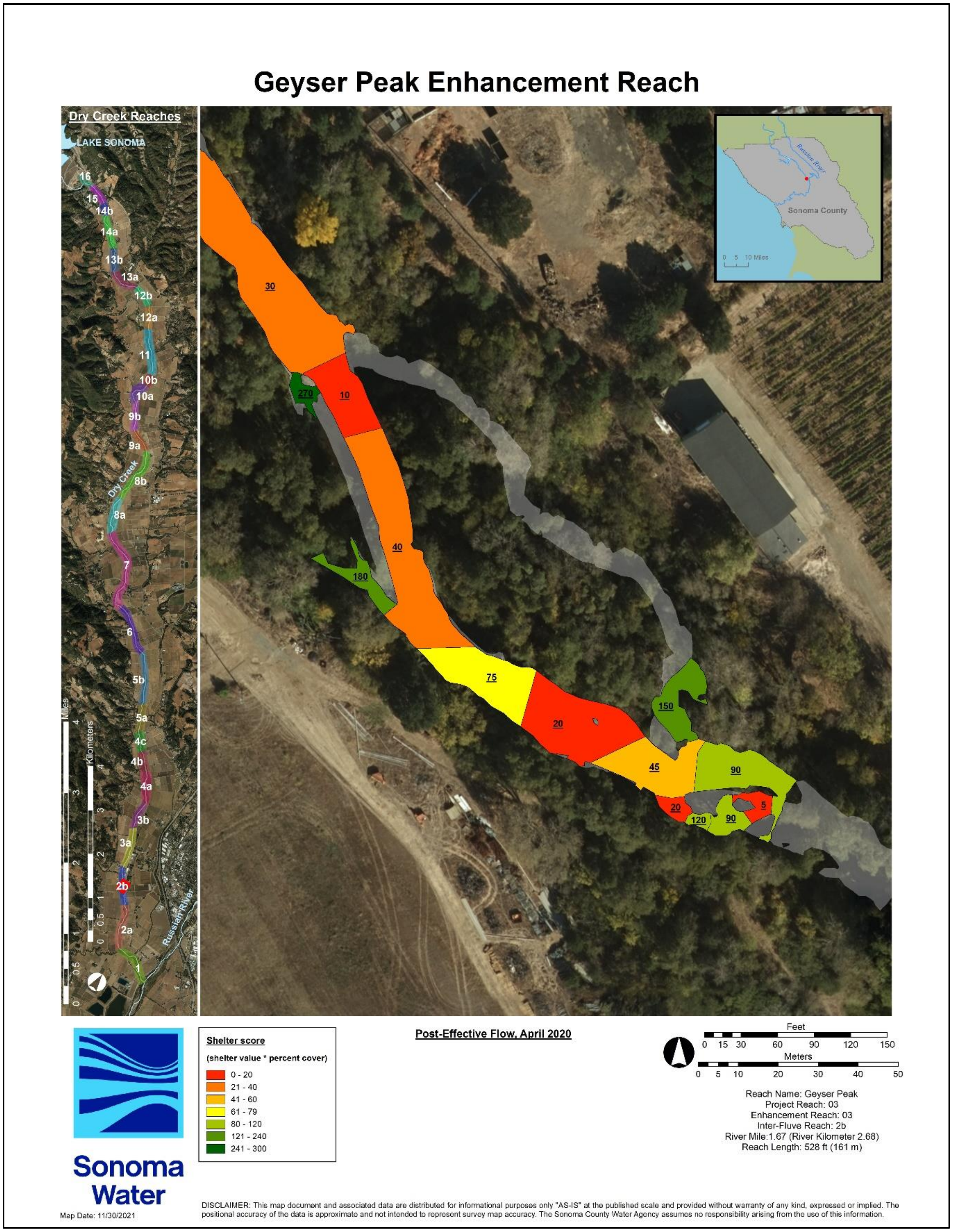


Figure 5.2.60. Habitat unit shelter scores within the Geyser Peak enhancement reach, April 2020.

Feature, habitat unit, site, and reach ratings

Table 5.2.35. Post-effective flow average feature, habitat unit, site, and reach ratings (rounded to the nearest whole number) for the Geyser Peak enhancement reach, April 2020.

Site number	1	2	3	4
Site type	**Main channel**	**Side channel**	**Side channel**	**Bank**
Site average feature quantitative rating[a]	3	3	12	11
Site average feature qualitative rating[a]	Poor	Fail	Excellent	Good
Site average habitat unit quantitative rating[b]	16	0	30	0
Site average qualitative rating[b]	Fair	Fail	Excellent	Not rated
Site quantitative rating (sum of site average feature and habitat unit rating)[c]	19[c]	3[c]	42[c]	11[a]
Site qualitative rating[c]	Poor[c]	Fail[c]	Excellent[c]	Good[a]
Enhancement reach quantitative rating (average of site rating)[c]	19			
Enhancement reach qualitative rating[c]:	Fair			

[a]out of 15; Excellent (>=12), Good (>=9), Fair (>=6), Poor (>=3), Fail (<3)
[b]out of 35; Excellent (>=28), Good (>=21), Fair(>=14), Poor (>=7), Fail (<7)
[c]out of 50; Excellent (>=40), Good (>=30), Fair (>=20), Poor (>=10), Fail (<10)
[c]out of 42; Excellent (>=33), Good (>=25), Fair (>=17), Poor (>=8), Fail (<8)

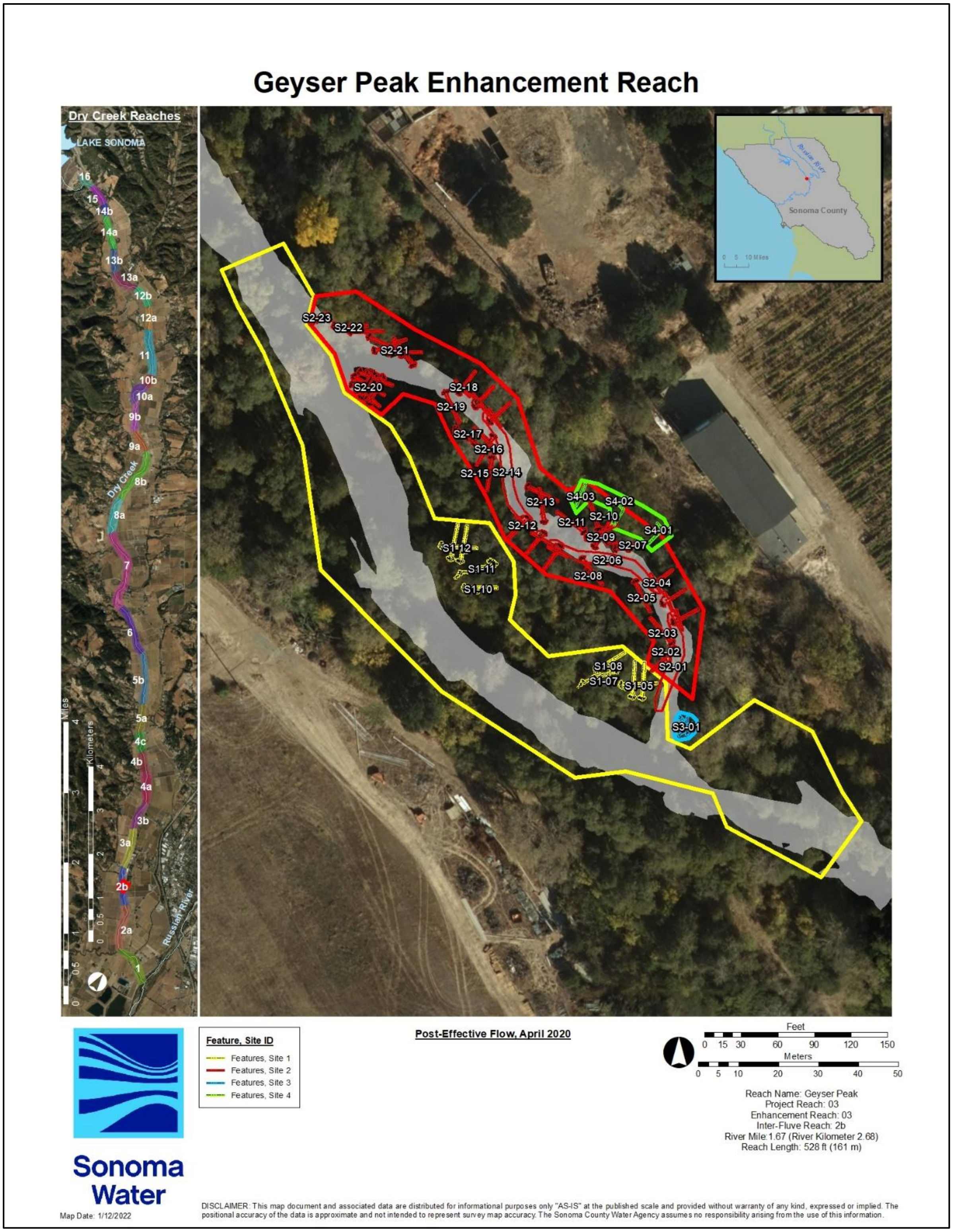


Figure 5.2.61. Enhancement sites and features within the Geyser Peak enhancement reach, April 2020.

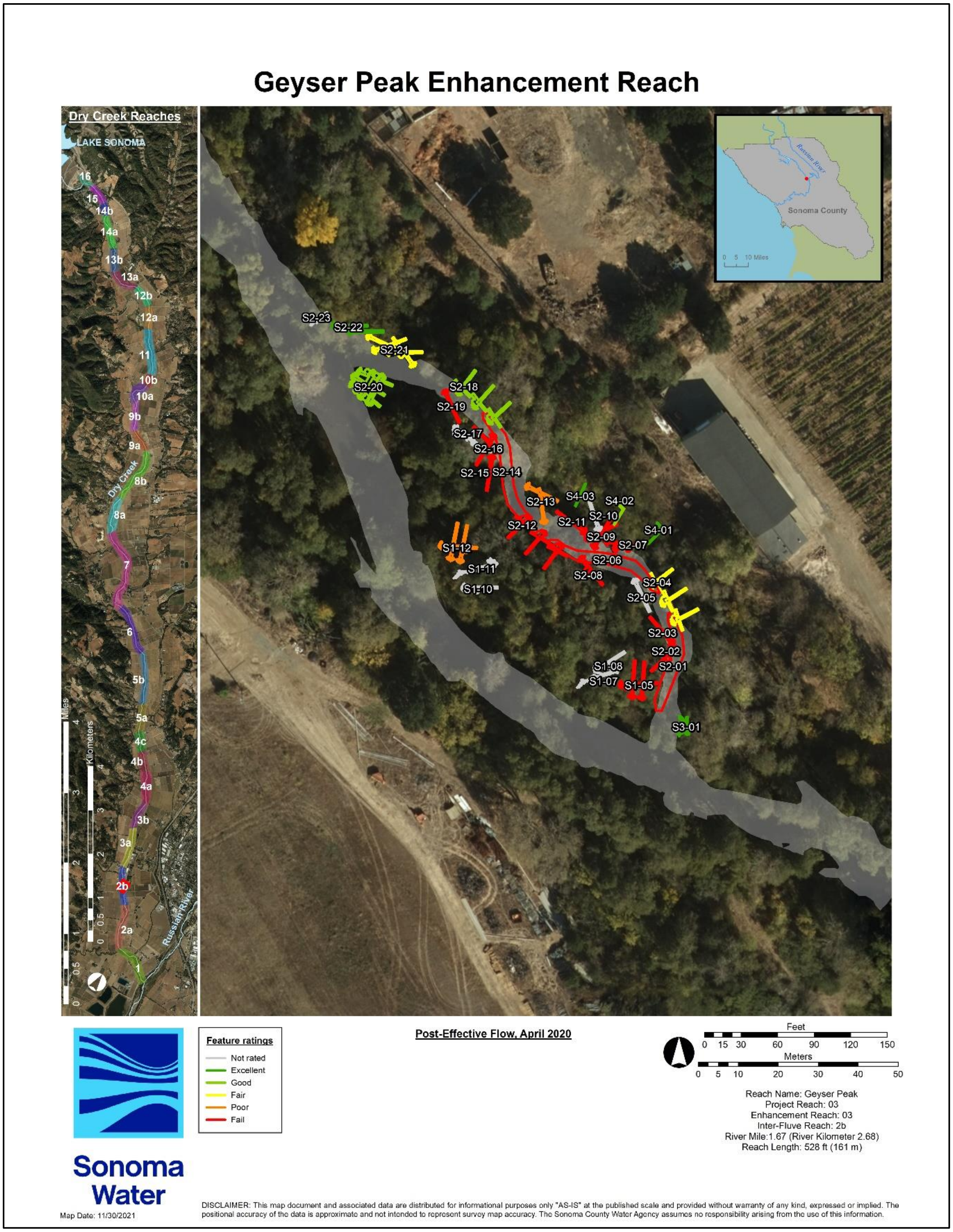


Figure 5.2.62. Feature ratings for the Geyser Peak enhancement reach, April 2020.

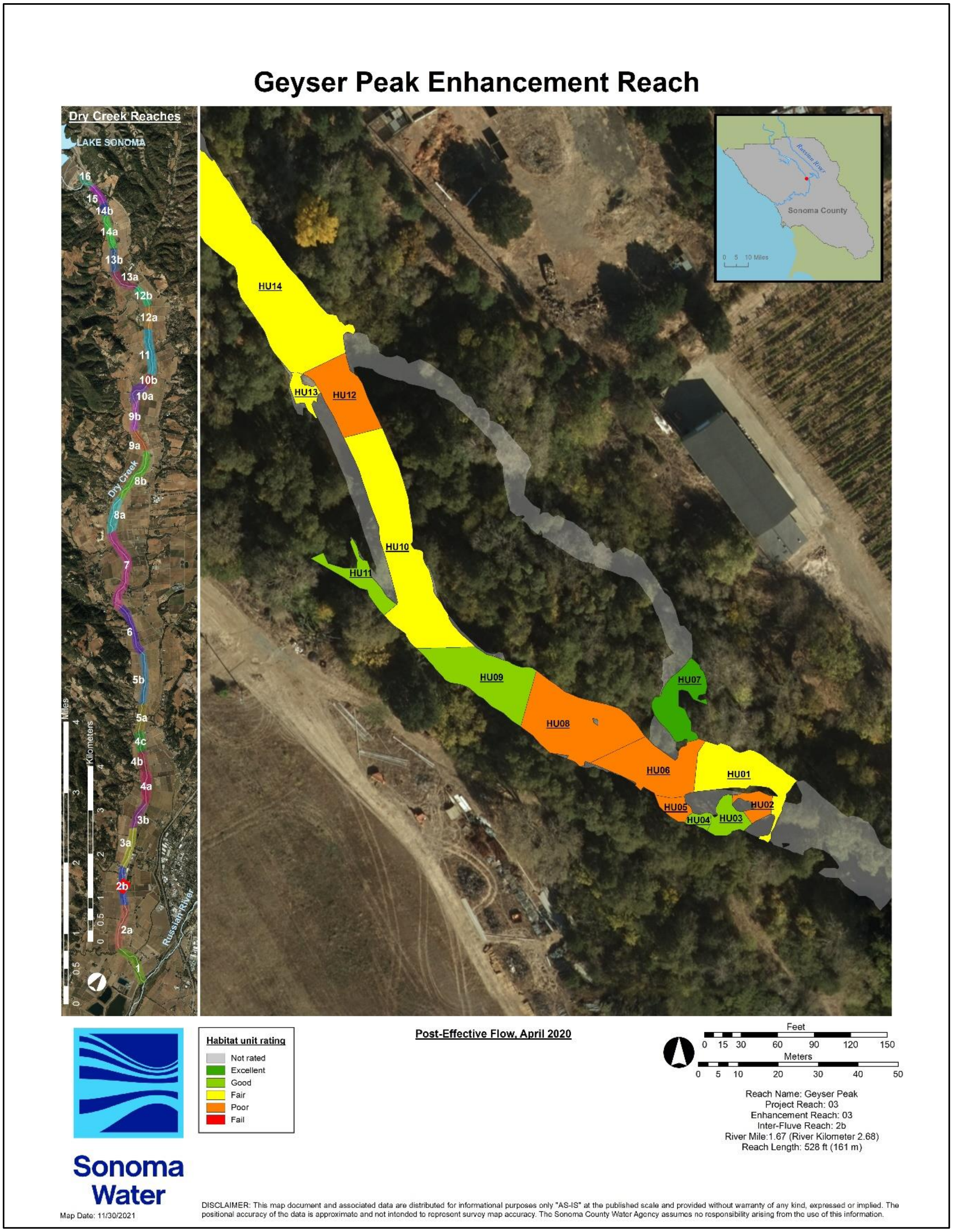


Figure 5.2.63. Post-effective flow habitat unit rating for the Geyser Peak enhancement reach, April 2020.

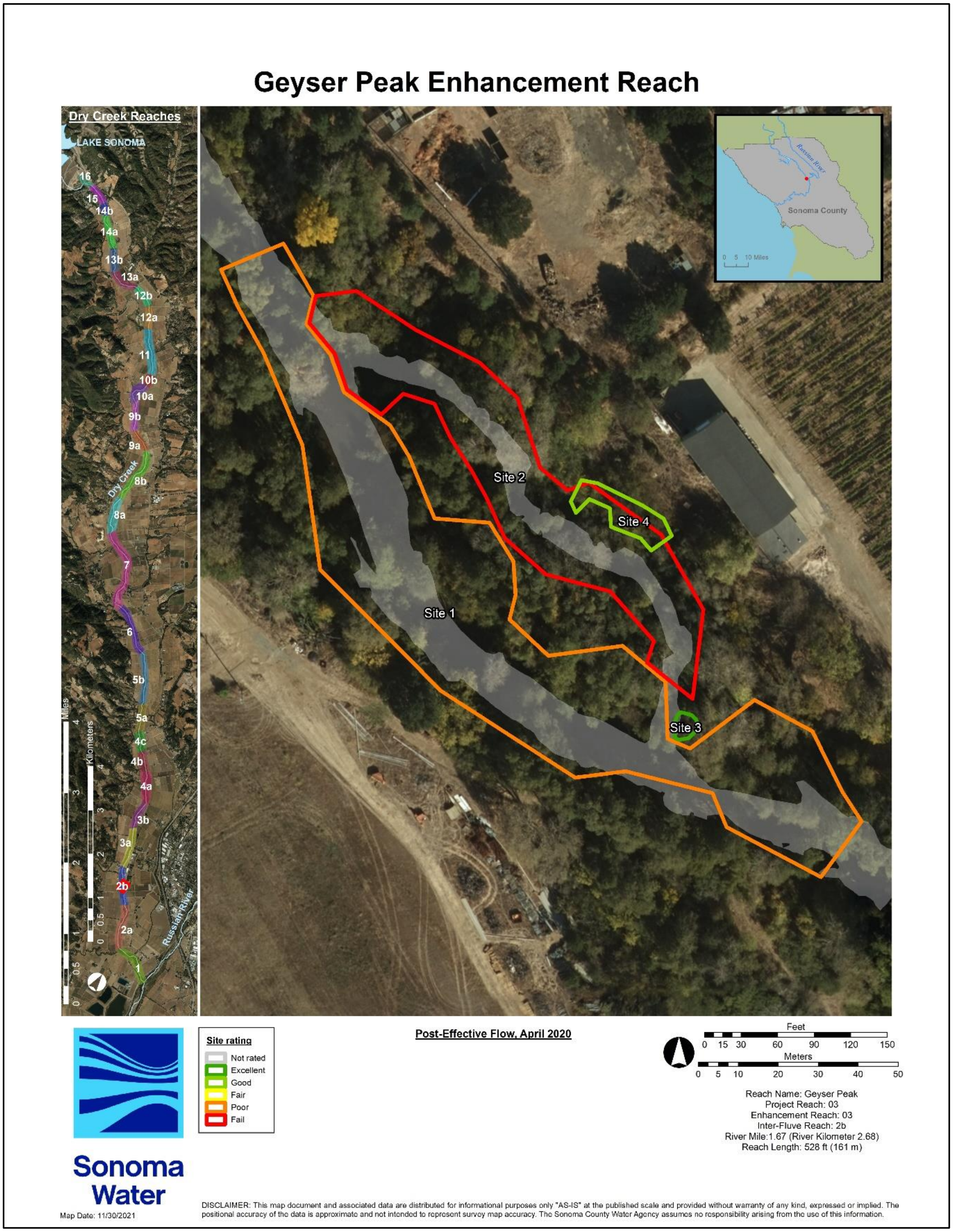


Figure 5.2.64. Post-effective flow site ratings for the Geyser Peak enhancement reach, April 2020.

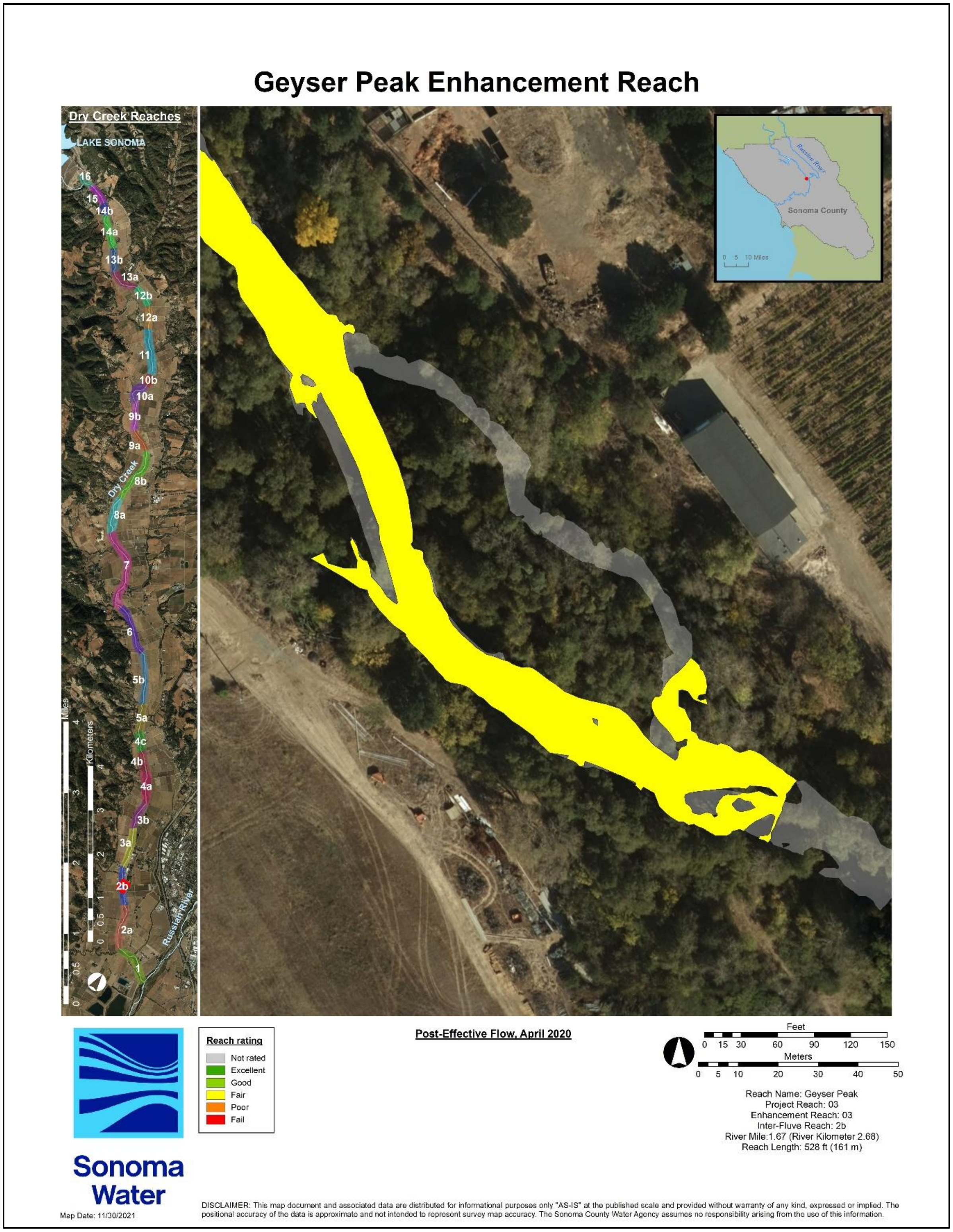


Figure 5.2.65. Post-effective flow reach rating for the Geyser Peak enhancement reach, April 2020.

Post-repair

Ferrari-Carano, Olson Enhancement Reach

Sonoma Water monitored the post-repair condition of the Ferrari-Carano, Olson enhancement reach in October 2020.Previous effectiveness monitoring surveys occurred in May 2018 (pre-enhancement), October 2018 (post-enhancement), June 2019 (post-effective flow) receiving fair, good, and fair enhancement reach ratings, respectively, and in June 2020, receiving a fair rating. The post-effective flow monitoring in June of 2020 encompassed 111,237 ft^2 within main and off channel areas with 25% of the total area meeting optimum depth and velocity criteria (Table 5.2.30, Figure 5.2.50) and overall, the reach received a fair enhancement reach rating (Table 5.2.32, Figure 5.2.57) (See Appendix 5.2 for measured values, scores, and ratings). Still, the June 2020 monitoring showed poor site average feature ratings for two sites (site 1 [main channel] and a poor average habitat rating for site 3 (side channel).

As noted above, the enhancement initially added 63,666 ft^2 of side channel in May 2018 (reported as 83,833 ft^2 in 2019 report and revised in this report), but aggradation caused by storms in winter 2018/2019 reduced off channel area to 53,142 ft^2. The enhancement also included 87,361 ft^2 of main channel in May 2018 (reported as 67,194 ft^2 in 2019 [2018 data] report and revised in 2020 report), but aggradation by storms in winter 2018/2019 reduced side channel area to 53,142 ft^2 in 2019 (see 2020 report for 2019 data). Side channel area in June 2020 increased to 60,314 ft^2, with 26% meeting optimal depth and velocity criteria (Table 5.2.30). Still, the June 2020 monitoring showed poor site average feature ratings for two sites (site 1 [main channel] and a poor average habitat rating for site 3 (side channel), likely caused by aggradation from the 2018/2019 storms. Sonoma Water excavated buried features and two additional lateral connections between the main and side channels at the upstream and downstream end of the reach (Figure 5.2.66).

Post-repair monitoring recorded 46,355 ft^2 of main channel area and 58,413 ft^2 of side channel area, of which 20% and 26% met optimal depth and velocity criteria (Table 5.2.36, Figure 5.2.66). Thirty one habitat units composed the enhancement reach Post-repair, with a pool to riffle ratio of 9:11 (0.82) and an average shelter score of 85 (Table 5.2.37, Figure 5.2.67, Figure 5.2.68). Thirteen habitat units met or exceeded the optimal shelter value of 80. The enhancement reach comprised three enhancement sites (one main channel, two side channels) that received excellent site average feature ratings and fair site average habitat unit ratings post-repair (Table 5.2.38, Figure 5.2.69, Figure 5.2.70, Figure 5.2.71). Site ratings improved to fair and good (Table 5.2.38, Figure 5.2.72). Overall, the Ferrari-Carano, Olson enhancement reach received a good enhancement reach rating (Figure 5.2.73) (See Appendix 5.2 for measured values, scores, and ratings).

Depth and velocity

Table 5.2.36. Areas and percentages of: wetted area, optimal depth and velocity, and optimal hydraulic habitat within the Ferrari-Carano, Olson enhancement reach, October 2020.

Ferrari-Carano, Olson Post-repair October 2020	Wetted area (ft^2)	0.5 – 2.0 ft	2.0 – 4.0 ft	Total	< 0.5 ft/s	0.5 – 2.0 ft < 0.5 ft/s	2.0 – 4.0 ft < 0.5 ft/s	Total
Main channel area	46,355	20,527	15,194	35,722	15,020	5,828	3,651	9,479
Side channel area	58,413	29,260	14,972	44,232	23,984	9,207	6,024	15,231
Total area	**104,768**	**49,787**	**30,166**	**79,954**	**39,004**	**15,036**	**9,674**	**24,710**
Main channel % of wetted area	44%	44%	33%	77%	32%	13%	8%	20%
Side channel % of wetted area	56%	50%	26%	76%	41%	16%	10%	26%
Total % of wetted area	**100%**	**48%**	**29%**	**76%**	**37%**	**14%**	**9%**	**24%**

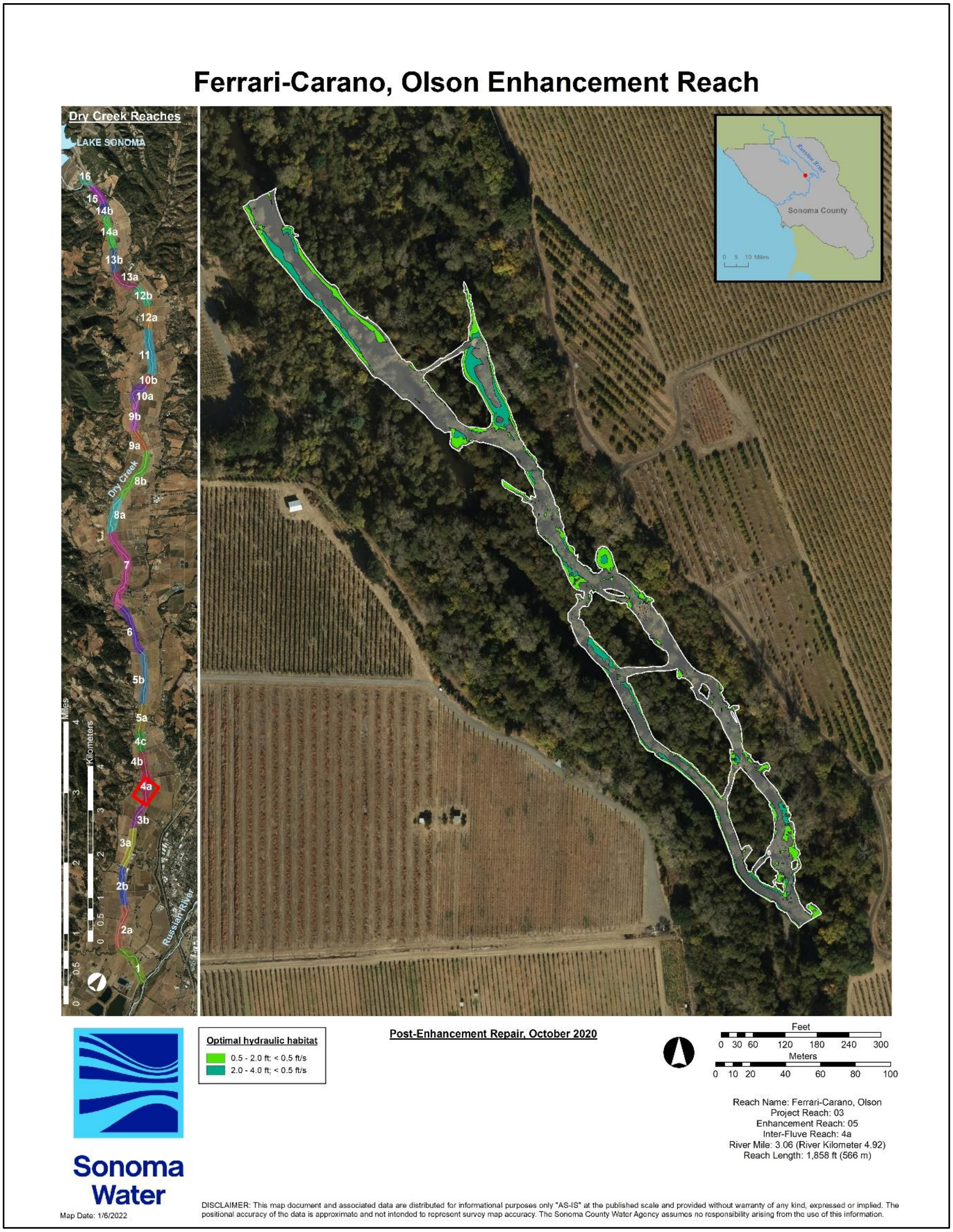


Figure 5.2.66. Optimal hydraulic habitat for fry (<0.5 ft/s, 0.5-2.0 ft) and parr (<0.5 ft/s, 2.0-4.0 ft) within the Ferrari-Carano, Olson enhancement reach, October 2020.

Habitat types, pool to riffle ratio, and shelter scores

Table 5.2.37. Habitat, types, shelter value, percent cover, and shelter score for habitat units within the Ferrari-Carano, Olson enhancement reach, October 2020.

Habitat Unit #	Habitat Type	Shelter Value	Percent Cover	Shelter Score
HU01	Riffle	2	30	60
HU02	Pool	3	25	75
HU03	Flatwater	3	30	90
HU04	Pool	3	45	135
HU05	Riffle	1	5	5
HU06	Pool	3	40	120
HU07	Riffle	3	30	90
HU08	Riffle	3	25	75
HU09	Pool	3	45	135
HU10	Riffle	3	30	90
HU11	Alcove	3	90	270
HU12	Pool	3	35	105
HU13	Flatwater	2	15	30
HU14	Pool	3	15	45
HU15	Riffle	2	10	20
HU16	Riffle	3	75	225
HU17	Riffle	3	15	45
HU18	Flatwater	2	10	20
HU19	Riffle	1	5	5
HU20	Riffle	3	25	75
HU21	Pool	2	25	50
HU22	Flatwater	2	15	30
HU23	Pool	3	40	120
HU24	Riffle	2	20	40
HU25	Flatwater	2	30	60
HU26	Alcove	2	75	150
HU27	Alcove	3	65	195
HU28	Flatwater	1	10	10
HU29	Pool	3	25	75
HU30	Flatwater	2	10	20
HU31	Alcove	2	90	180
Pool: riffle	**9:11 (0.82)**			**Avg = 85**

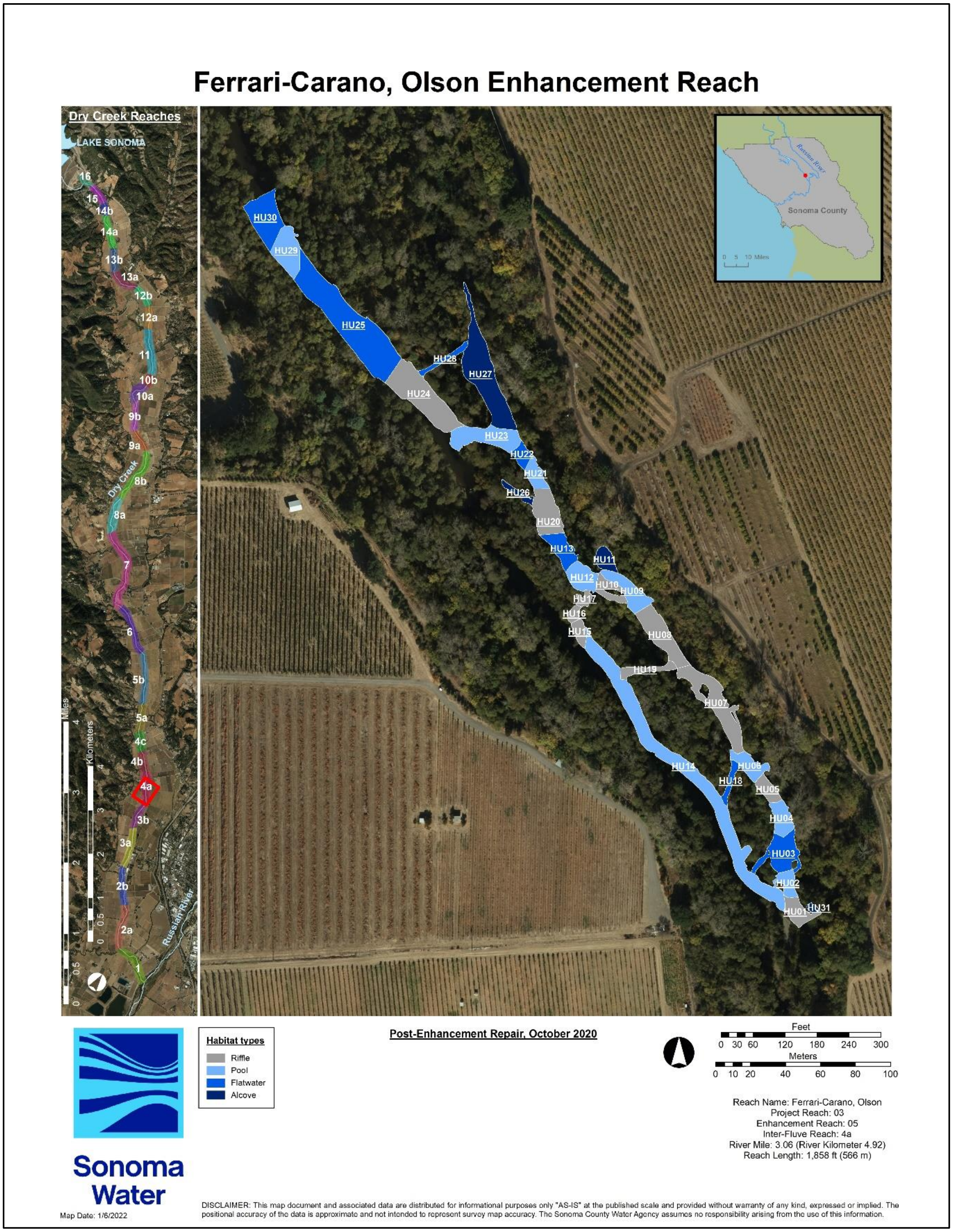


Figure 5.2.67. Habitat unit number and type within the Ferrari-Carano, Olson enhancement reach, October 2020.

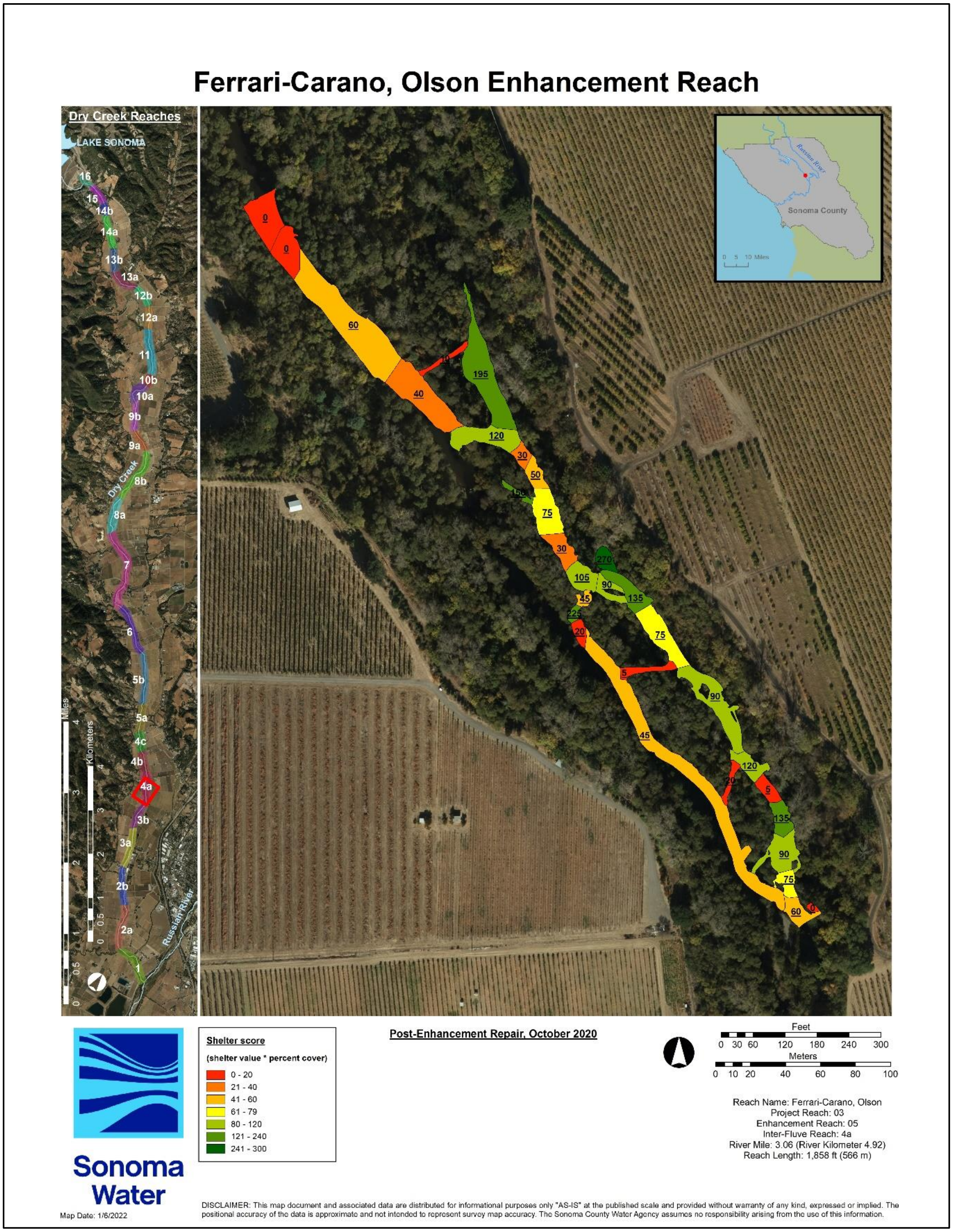


Figure 5.2.68. Habitat unit shelter scores within the Ferrari-Carano, Olson enhancement reach, October 2020.

Feature, habitat unit, site, and reach ratings

Table 5.2.38. Post-effective flow average feature, average habitat unit, site, and reach ratings (rounded to the nearest whole number) for the Ferrari-Carano, Olson enhancement reach, October 2020.

Site number	**1**	**2**	**3**	
Site type	Main channel	Side channel	Side channel	
Site average feature quantitative rating[a]	12	12	13	
Site average feature qualitative rating[a]	Excellent	Excellent	Excellent	
Site average habitat unit quantitative rating[b]	15	19	18	
Site average qualitative rating[b]	Fair	Fair	Fair	
Site quantitative rating (sum of site average feature and habitat unit rating) [c]	28	31	31	
Site qualitative rating[c]	Fair	Good	Good	
Enhancement reach quantitative rating (average of site rating) [c]	30			
Enhancement reach qualitative rating[c]:	Good			

[a]out of 15; Excellent (>=12), Good (>=9), Fair (>=6), Poor (>=3), Fail (<3)
[b]out of 35; Excellent (>=28), Good (>=21), Fair(>=14), Poor (>=7), Fail (<7)
[c]out of 50; Excellent (>=40), Good (>=30), Fair (>=20), Poor (>=10), Fail (<10)

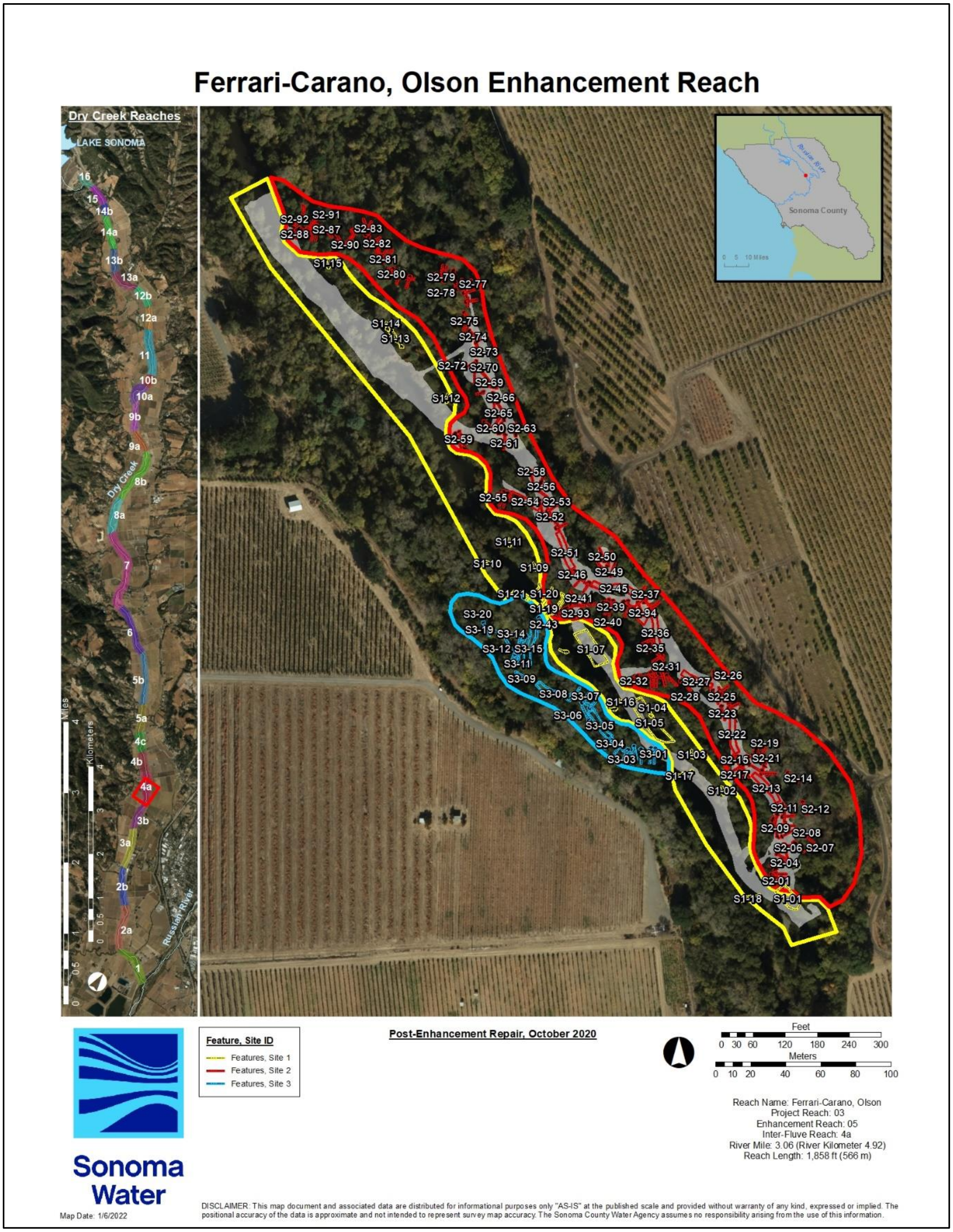


Figure 5.2.69. Enhancement sites and features within the Ferrari-Carano, Olson enhancement reach, October 2020.

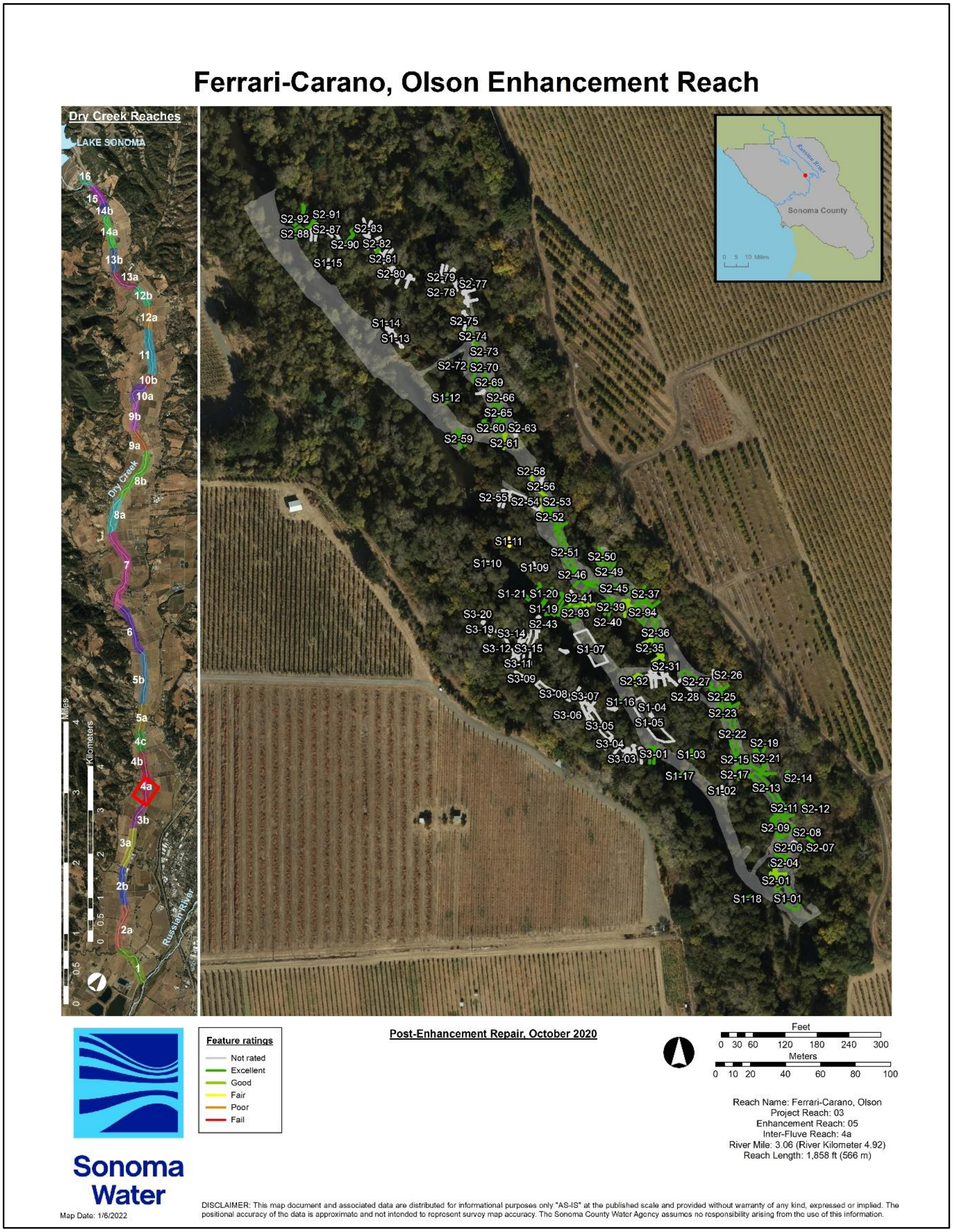


Figure 5.2.70. Feature ratings for the Ferrari-Carano, Olson enhancement reach, October 2020.

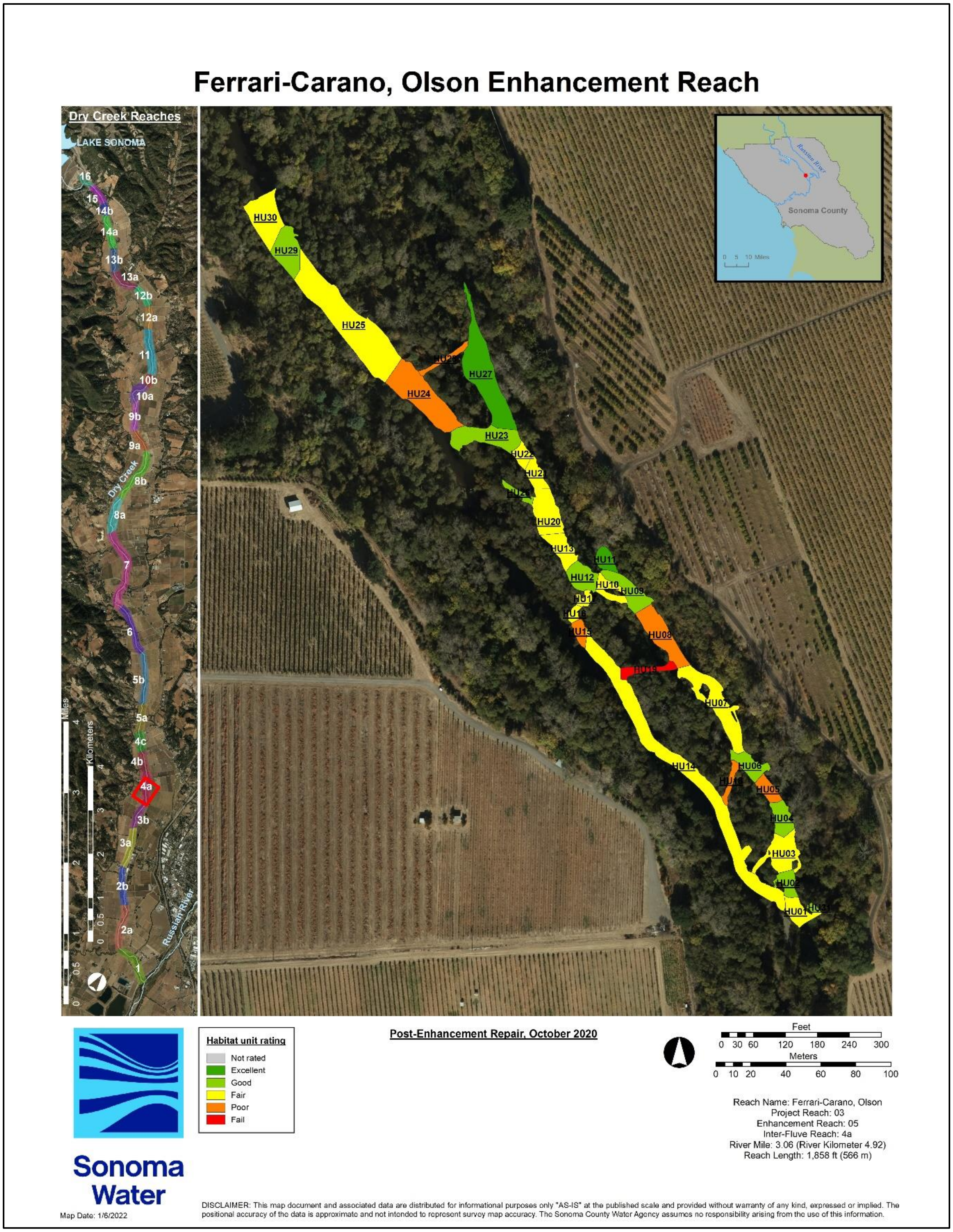


Figure 5.2.71. Habitat unit ratings for the Ferrari-Carano, Olson enhancement reach October 2020.

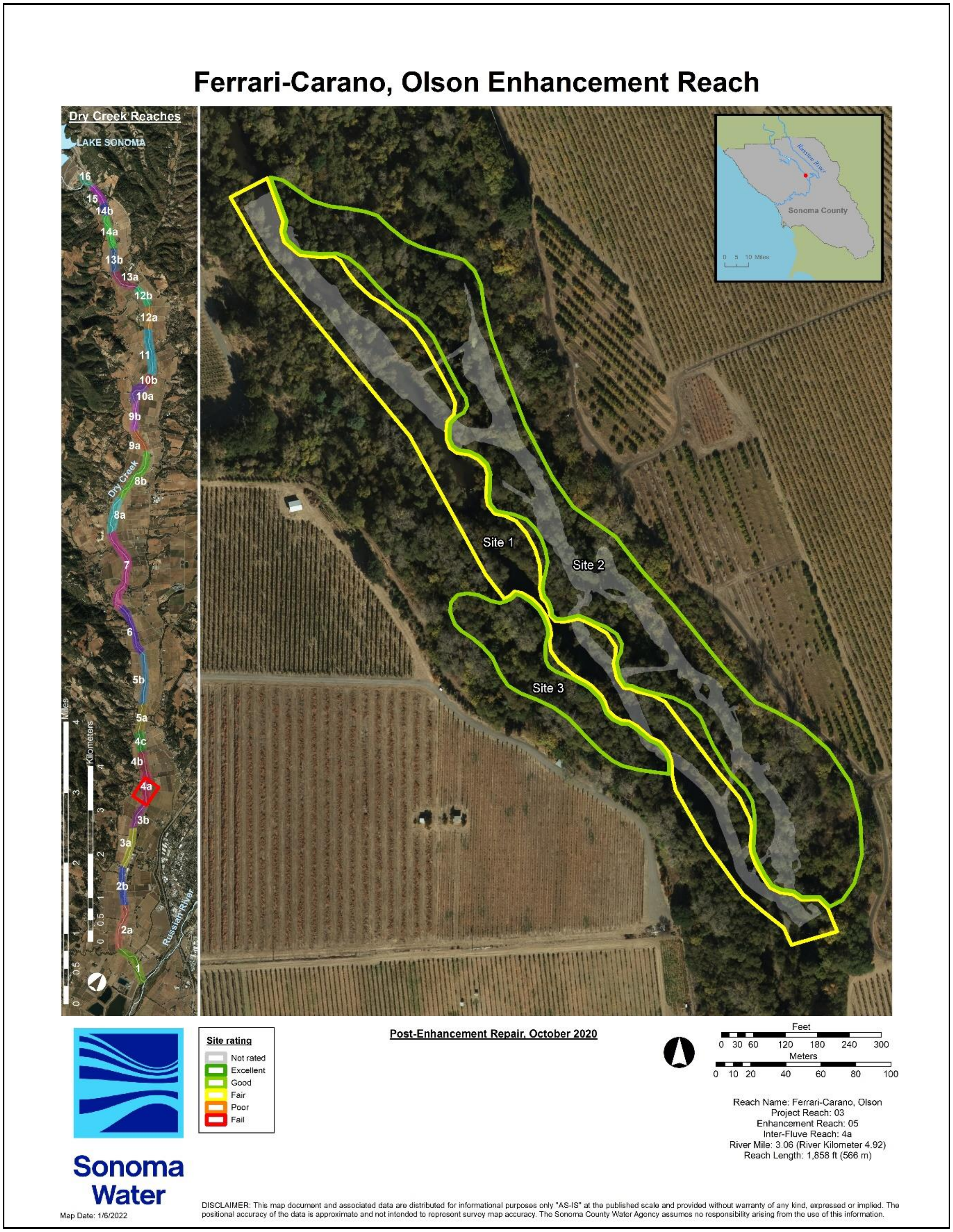


Figure 5.2.72. Enhancement site ratings for the Ferrari-Carano, Olson enhancement reach, October 2020.

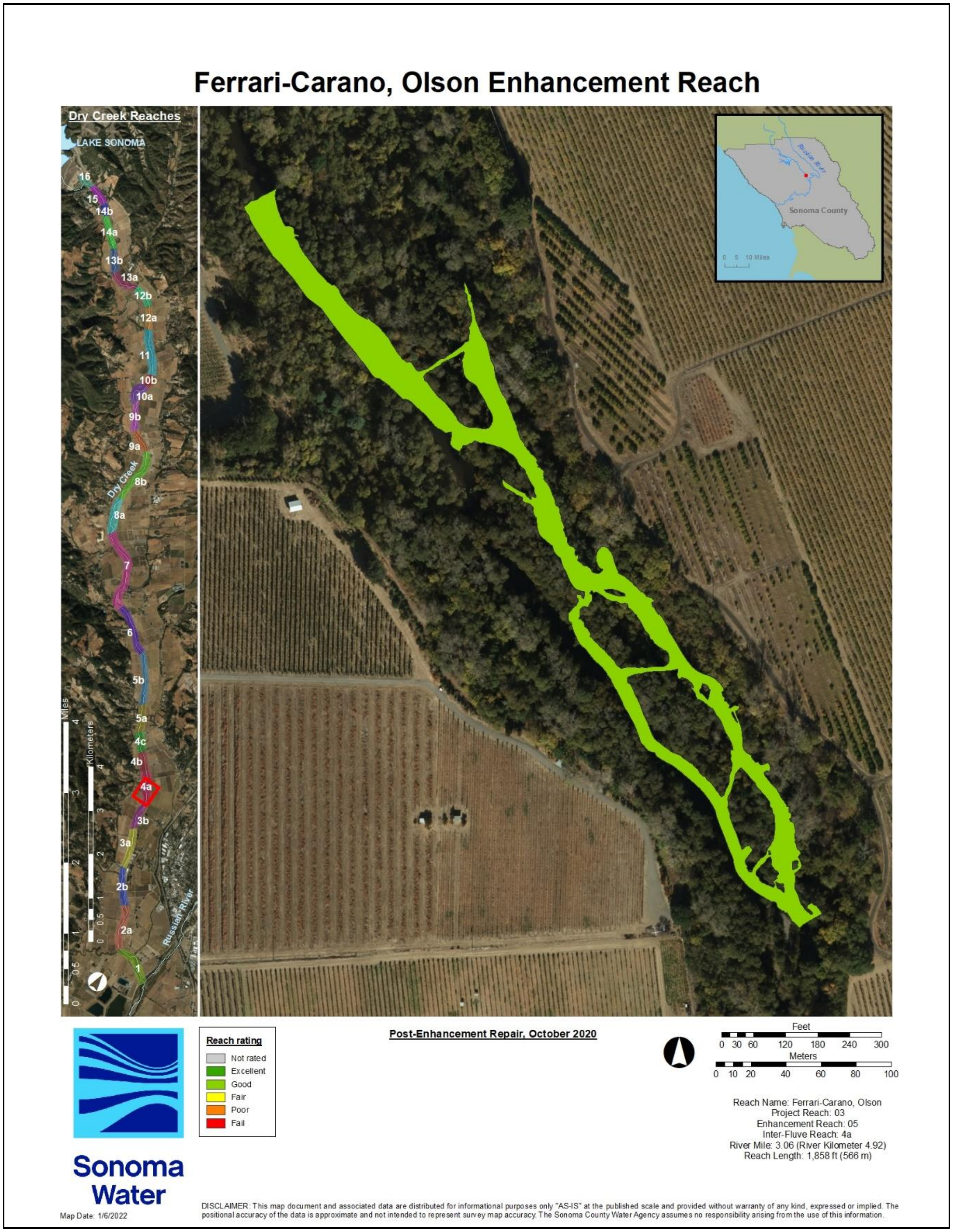


Figure 5.2.73. Enhancement reach rating for the Ferrari-Carano, Olson enhancement reach, October 2020.

Discussion

Summary

Effectiveness monitoring in 2020 showed an increase in the percent of optimal depth and velocity area from pre-enhancement (20%) to post-effective flow (30%). Average shelter scores decreased from pre--enhancement (120) to post-effective flow (97), both greater than the optimal shelter value of 80 (Table 5.2.39). Observed pool to riffle ratio remained within 1:2 to 2:1 (0.50 to 2.00) during pre-enhancement and post-effective flow effectiveness monitoring surveys.

Table 5.2.39. Summary of percent optimal depth and velocity, average shelter score and pool to riffle ratio for all monitoring time periods.

Monitoring time-period	% optimal depth and velocity	Average shelter score	Pool to riffle ratio
Pre-enhancement	20%	120	1:2 (0.50)
Post-effective Flow	30%	97	57:55 (1.04)
Post-repair	24%	85	9:11 (0.82)

Depth and Velocity

Effectiveness monitoring data from all monitoring time periods in 2020 showed substantial differences in the amount of optimal depth and velocity habitat between main and off-channel areas, and between habitat types (Figure 5.2.74). Overall, 29% of main and off-channel area supported optimal depth and velocity, compared with 26% in main channel areas, and 36% in off-channel areas. Alcoves supported the greatest area of optimal depth and velocity, regardless of channel location (main and off-channel [63%], main channel [64%], off-channel [62%]), followed by pools (main and off-channel [37%], main channel [33%], off-channel [44%]). The percentage of optimal depth and velocity in flatwaters and riffles remained consistently lower than alcoves or pools across all channel areas. Inter-Fluve (2010) recorded similar observations for flatwaters during pre-enhancement habitat surveys in 2010, prompting recommendations to construct low velocity habitats, such as alcoves and side channels, as a primary strategy to enhance Dry Creek. Riffles typically have higher water velocity and shallow depths at low flows, and by character do not support the optimal depth and velocity conditions recommended by the BO or the AMP, but still perform important ecological roles, such as nutrient retention and food production.

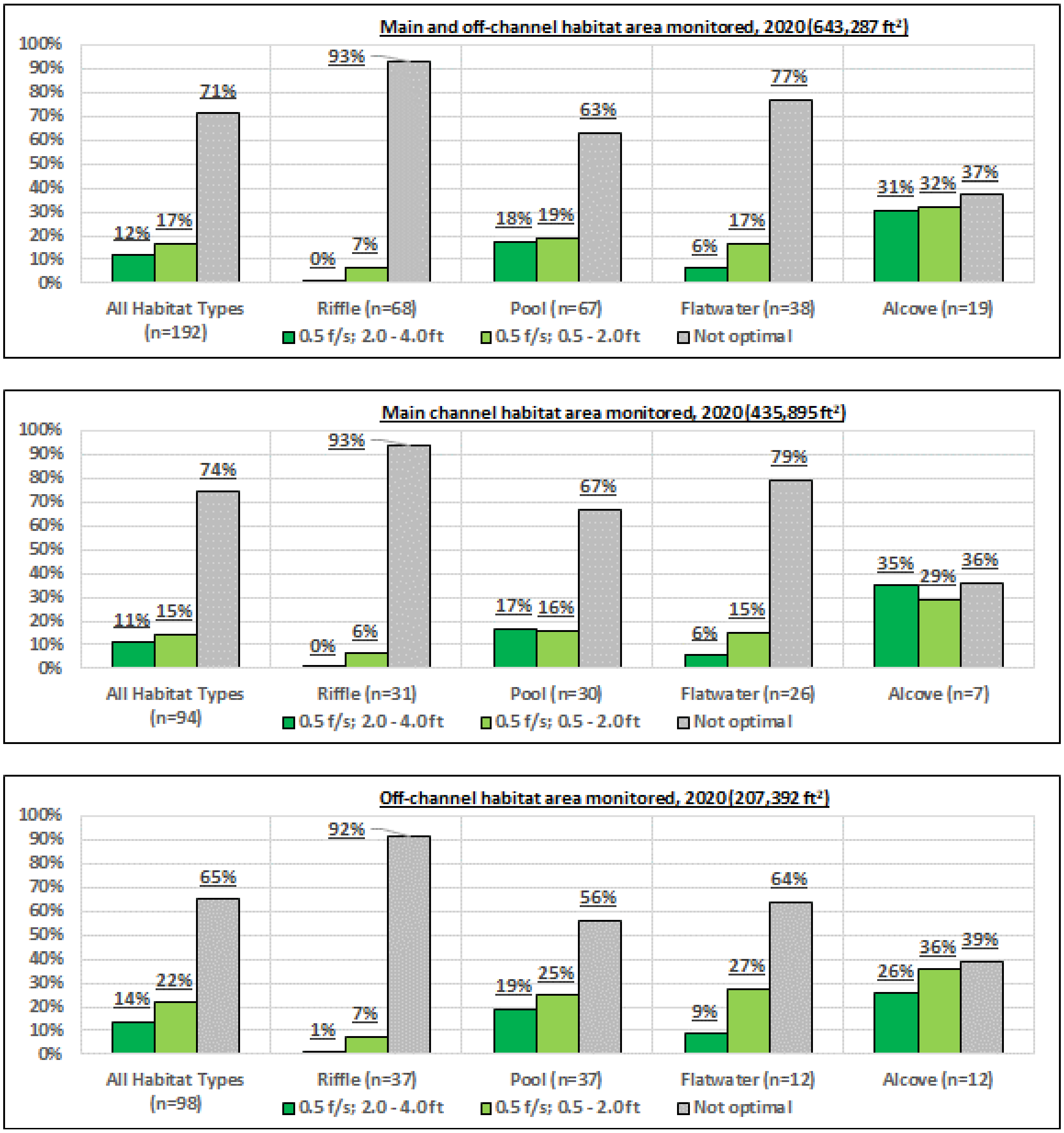


Figure 5.2.74. Percentages of optimal depth and velocity within main and off-channel areas (top panel), main, channel areas (middle panel), and off-channel areas (lower panel), and across riffle, pool, flatwater, and alcove habitat type.

Habitat Types, Pool to Riffle Ratio, and Shelter Scores

Effectiveness monitoring data from all monitoring time periods in 2020 did show differences in average shelter score between main and off-channel areas, and differences between habitat types (Figure 5.2.75). Overall, main and off-channel areas supported an average shelter score of 96, compared with 87 in main channel areas, and 104 in off-channel areas. Alcoves supported the highest average shelter score in all areas, followed by pools. As with the percentage of optimal depth and velocity, average shelter score in flatwaters and riffles remained consistently lower than alcoves and pools across all channel locations. The results reinforce depth and velocity observations (above) that side-channels and alcoves are effective at providing habitat conditions recommended in the RRBO and in the AMP.

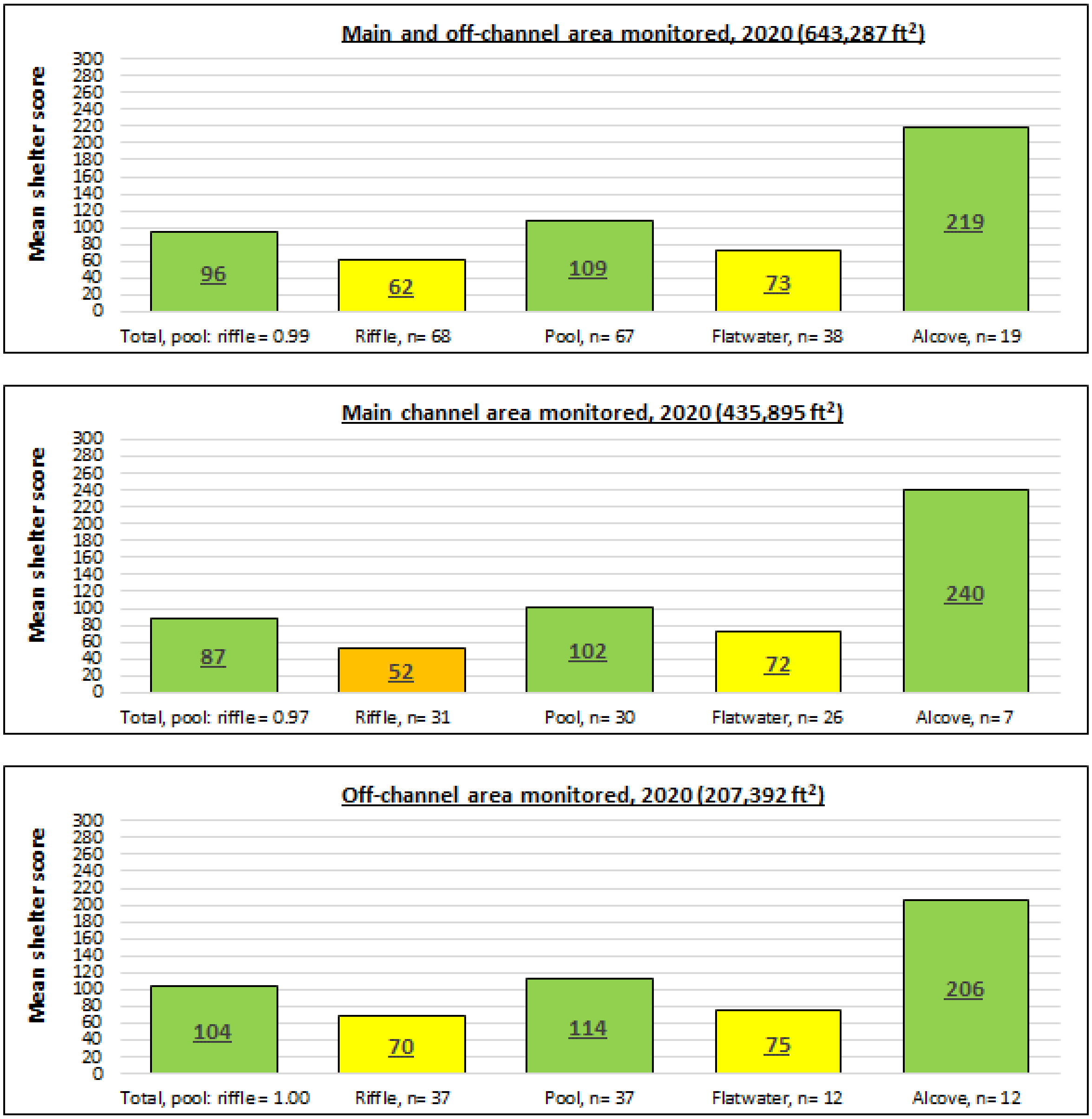


Figure 5.2.75. Average shelter scores within main and off-channel areas (top panel), main, channel areas (middle panel), and off-channel areas (lower panel), and across riffle, pool, flatwater, and alcove habitat type.

Reach Ratings

Enhancement reach ratings from 2020 effectiveness monitoring vary according to monitoring time period (Table 5.2.40). The Boaz, Gros-Balthazard enhancement reach received a fair pre-enhancement rating, while Weinstock, Gallo, Truett Hurst, and Farrow Wallace received a good rating, with Van Alyea earning an excellent rating. Both Geyser Peak and Ferrari-Carano Olson received fair ratings, but Ferrari-Carano, Olson improved to a good rating post repair.

Table 5.2.40. Dry Creek enhancement reaches monitored in 2020 and reach ratings for each monitoring time period. Reaches listed from upstream (closest to Warm Springs Dam) to downstream (closest to confluence with Russian River) (-- indicates monitoring not conducted).

Enhancement Reach	Pre-enhancement	Post-enhancement	Post-effective Flow	Post-repair
Weinstock	--	--	Good	--
Gallo	--	--	Good	--
Truett Hurst	--	--	Good	--
Van Alyea	--	--	Excellent	--
Farrow, Wallace	--	--	Good	--
Boaz, Gros Balthazard	Fair	--	--	--
Ferrari-Carano Olson	--	--	Fair	Good
Geyser Peak	--	--	Fair	--

Conclusion

Qualitative ratings describe the relative success of habitat enhancement measures within enhancement sites and enhancement reaches, and determine potential future outcomes. Post-effective flow enhancement reach ratings occur after exposure to at least one effective flow and likely reflect restored habitat conditions more accurately than post-enhancement ratings determined just after construction. As such, the ratings that determine management actions should be the most recent post-effective flow ratings. The latest post-effective flow ratings, as of 2020, show two excellent ratings, eight good ratings, three fair ratings, and one poor rating (Table 5.2.41). With 71% (10/14) of ratings either good or excellent, the AMP suggests developing and implementing plans to correct site or metric deficiencies, adding sites/features, and increasing monitoring of sites and features exhibiting negative performance (Table 5.2.2). Sonoma Water is currently implementing the above suggestions, and will continue to monitor habitat units, features, sites, and enhancement reaches according the AMP. Any future actions will be guided by monitoring data.

Table 5.2.41. Creek enhancement reaches monitored, year(s) of post-effective flow effectiveness monitoring and effectiveness rating, and latest post effective flow effectiveness monitoring score. Reaches listed from upstream (closest to Warm Springs Dam) to downstream (closest to confluence with Russian River).

Enhancement Reach	2015	2016	2017	2018	2019	2020	Latest post-effective flow rating
Army Corps		Excellent			Good		Good
Army Corps Reach 14					Good		Good
Weinstock					Good	Good	Good
Gallo						Good	Good
Truett Hurst			Poor	Good	Fair	Good	Good
Meyer			Fair	Fair			Fair
Carlson, Lonestar				Good			Good
Quivira		Excellent					Excellent
Van Alyea			Good			Excellent	Excellent
Rued	Good						Good
Farrow Wallace			Fair		Good	Good	Good
Ferrari-Carano, Olson					Fair	Fair	Fair
City of Healdsburg Yard				Good	Poor		Poor
Geyser Peak			Poor	Fair	Fair	Fair	Fair

5.3 Validation Monitoring

Part of the Adaptive Management Plan (AMP) for validating the effectiveness of habitat enhancement in mainstem Dry Creek calls for a multiscale monitoring approach in both space and time (Porter et al. 2014). The current section of this report focuses on the results of validation monitoring for juvenile and smolt salmonid populations in mainstem Dry Creek in 2020. These data are part of an ongoing monitoring effort begun in 2008 and outlined in the Reasonable and Prudent Alternative section of NMFS' Russian River Biological Opinion. Validation monitoring data collected in newly constructed habitats are reported as well as continued efforts to monitor trends in juvenile and smolt abundance at the reach and watershed scale.

In the Russian River Biological Opinion status and data report year 2009-10 (Manning and Martini-Lamb 2011), Sonoma Water outlined six possible metrics that could be considered for validation monitoring of juvenile salmonids with respect to eventual habitat enhancements in Dry Creek: habitat use, abundance (density), size, survival, growth, and fidelity. In 2009-2010, a major focus of validation monitoring in Dry Creek was on evaluating the feasibility of sampling methods to accurately estimate each of those metrics while simultaneously attempting to understand how limitations in sampling approaches may affect our ability to validate project success. These same validation metrics and associated limitations and uncertainties have been discussed in the context of the results of those evaluations and are incorporated into the Dry Creek AMP (Porter et al. 2014). The methods currently employed for validation monitoring in Dry Creek are largely based on the outcome of that work (Manning and Martini-Lamb 2011; Martini-Lamb and Manning 2011).

Table 5.3.1. Proposed target life stages, validation metrics, spatiotemporal scale and monitoring tools for validation monitoring in Dry Creek.

Spatial scale	Target life stage	Target metric(s)	Temporal scale	Primary monitoring tools
Site/feature	Juvenile (non-smolt)	Habitat use, abundance (density), size, growth	Post-construction	Snorkeling, electrofishing, PIT tags and antennas
Reach	Juvenile (non-smolt)	Abundance (density), size, survival, growth, fidelity	Pre-construction (baseline) vs. post-construction	Electrofishing, PIT tags and antennas
Mainstem Dry Creek	Smolt	Abundance	Ongoing to capture long-term trend	Downstream migrant trap, PIT antennas

Methods

In order for juvenile Coho Salmon to take advantage of the habitat enhancements created in Dry Creek, fish will need to come from somewhere and although there is a substantial population of juvenile steelhead that rear in mainstem Dry Creek, Coho are extremely scarce. Therefore, our strategy for juvenile Coho validation monitoring relies largely on hatchery releases coupled with observations of Coho in the backwaters and side channels, and detections of passive integrated transponder (PIT)-tagged fish on antennas within habitat enhancement sites. While much of our juvenile salmonid monitoring has been focused on steelhead, in 2020 we conducted targeted releases of over 40,000 juvenile Coho Salmon in Dry Creek to evaluate how a phased release after allowing in-stream acclimation would impact the behavior of Coho Salmon post-release.

In order to address use of newly created habitat by juvenile steelhead at the site and feature scale, sampling consisted of PIT-tagging in the summer, operation of stationary PIT antennas in the late summer into winter and snorkeling in summer. We also conducted mark-recapture electrofishing in enhancement areas to estimate juvenile population density where possible. To better isolate how data collected at the site-scale indicate the effect of habitat enhancement, we also conducted backpack electrofishing in stream sections (reach-scale) that were not enhanced. Finally, we continued to operate a downstream migrant trap seasonally and an antenna array operated year-round in lower Dry Creek to assess trends in smolt production over time. Broad-scale efforts that are part of the Coastal Monitoring Program (CMP) now being implemented in the Russian River provide a framework for placing our results in the context of watershed-scale patterns in those population metrics identified in Fish Bulletin 180 (the guiding document for California Coastal Salmonid Monitoring Program implementation, Adams et al. 2011).

Juvenile Coho Salmon hatchery releases

Impacts from the 2019 Walbridge Fire (in the Mill Creek and Austin Creek sub-watersheds) made conditions in tributary streams potentially unsuitable for releases of hatchery-reared juvenile Coho Salmon in 2020. Instead, the Russian River Coho Salmon Broodstock Committee (RRCSBSC) decided that Dry Creek would provide the best habitat for approximately 40,000 Coho juveniles that needed to be released in the spring and fall of 2020 (Table 5.3.2). In an effort to conduct Dry Creek releases in a way that would increase the residency time of these juvenile Coho most fish were held in instream net pens for a period of time prior to volitional release. We anticipated that an increase in residency time could increase the chances that Coho released from the hatchery would complete their freshwater rearing in Dry Creek before entering the mainstem Russian River as smolts.

Approximately 15,000 of the 40,000 hatchery Coho available for release into Dry Creek were released directly into constructed habitat enhancement areas without being held first in a net pen. In the spring approximately 10,000 fish were released on July 15, 2020 in the Truett Hurst (rkm 14.01) and Carlson-Lonestar (rkm 13.49) side channels and the Wallace backwater (rkm 10.70) (Figure 5.3.1). In the fall, approximately 5,000 fish were released on October 15, 2020 in the Army Corps Reach 15 side channel (rkm 21.4). Due to space limitations in the hatchery none of the fish released into the Army Corps Reach 15 side channel were PIT-tagged.

The remaining 25,000 fish were released into 5 constructed side channels within Dry Creek: Army Corps Reach 14 (rkm 21.15), Weinstock (rkm 20.62), Gallo (rkm 20.34), Meyer (rkm 13.88), and Ferrari-Carano Olson (rkm 5.30) (Figure 5.3.1). At each location a 12' X 4' X 4' net with ¼" mesh was suspended inside a rigid pen anchored to the bottom of the channel. The net was equipped with a zipper opening to facilitate placing fish into and releasing fish from the net pen (Photo 5.3.1, Figure 5.3.2). Beginning on October 21, 2020 a phased release schedule was used where each net pen received approximately 1,667 juveniles each during three releases (Table 5.3.2). Each release group was held inside the net pens for 5-8 days before opening the net so they could enter the side channel. The next release group was added to the net pen the following day after the earlier group had left the net pen. If fish from the previous group remained in the open net pen a diver was used to clear the fish from the net pen before the next group was released into the net pen.

Residency time and minimum survival index

Based on PIT antenna detections and captures at downstream migrant traps, we evaluated Dry Creek residency time as the number of days between release and detection on the stationary PIT antenna located at the mouth of Dry Creek (rkm 0.36) plus PIT-tagged smolts captured at the Dry Creek smolt trap (rkm 3.30). We assumed that the latest detection date of an individual at rkm 0.36 or 3.30 meant that it was leaving Dry Creek. In addition, the proportion of PIT-tagged individuals detected leaving Dry Creek during the smolt emigration season served as a minimum survival of fish leaving Dry Creek as smolts. Similarly, the proportion of PIT-tagged individuals detected at the Mirabel fish ladder (rkm 28.14) during the smolt emigration season served as a minimum survival of fish that made it to the Mirabel dam as smolts. The minimum survival rate (corrected for site detection efficiency) was applied to the total number of Coho juveniles released to estimate the number of Coho smolts produced from the juvenile hatchery releases. We evaluated these three metrics for each release type (stream vs. net pen): 1) Dry Creek residency time, 2) smolt survival to the mouth of Dry Creek, and 3) smolt survival to the Mirabel dam, for fish that were released directly into constructed off channel habitats and fish that were held in net pens within off channel habitats prior to release into the stream.

Table 5.3.2. Detail of juvenile Coho broodstock releases into Dry Creek during the spring and fall of 2020. Fish released into the site without first being held in a net pen are indicated as stream release type and those first held in a net pen, prior to release in the stream are indicated as net pen release type.

Season	Site	River km	Release type	Date	Number released	Number PIT-tagged
Spring	Wallace backwater	10.70	stream	Jul-15	3339	505
Spring	Carlson-Lonestar side channels	13.49	stream	Jul-15	3339	505
Spring	Truett-Hurst side channel	14.01	stream	Jul-15	3339	505
Fall	Ferrari Carano side channel	5.30	net pen	Oct-28	1669	300
			net pen	Nov-03	1670	299
			net pen	Nov-17	2132	375
Fall	Meyer side channel	13.88	net pen	Oct-28	1669	299
			net pen	Nov-03	1670	300
Fall	Gallo Side Channel	20.34	net pen	Oct-29	1669	300
			net pen	Nov-03	1670	299
			net pen	Nov-17	2132	379
Fall	Weinstock side channel	20.62	net pen	Oct-28	1669	300
			net pen	Nov-03	1670	299
			net pen	Nov-17	2133	380
Fall	USACE 14 side channel	21.15	net pen	Oct-28	1670	299
			net pen	Nov-03	1670	297
			net pen	Nov-17	2134	388
Fall	USACE 15 side channel	21.40	stream	Oct-15	5047	0

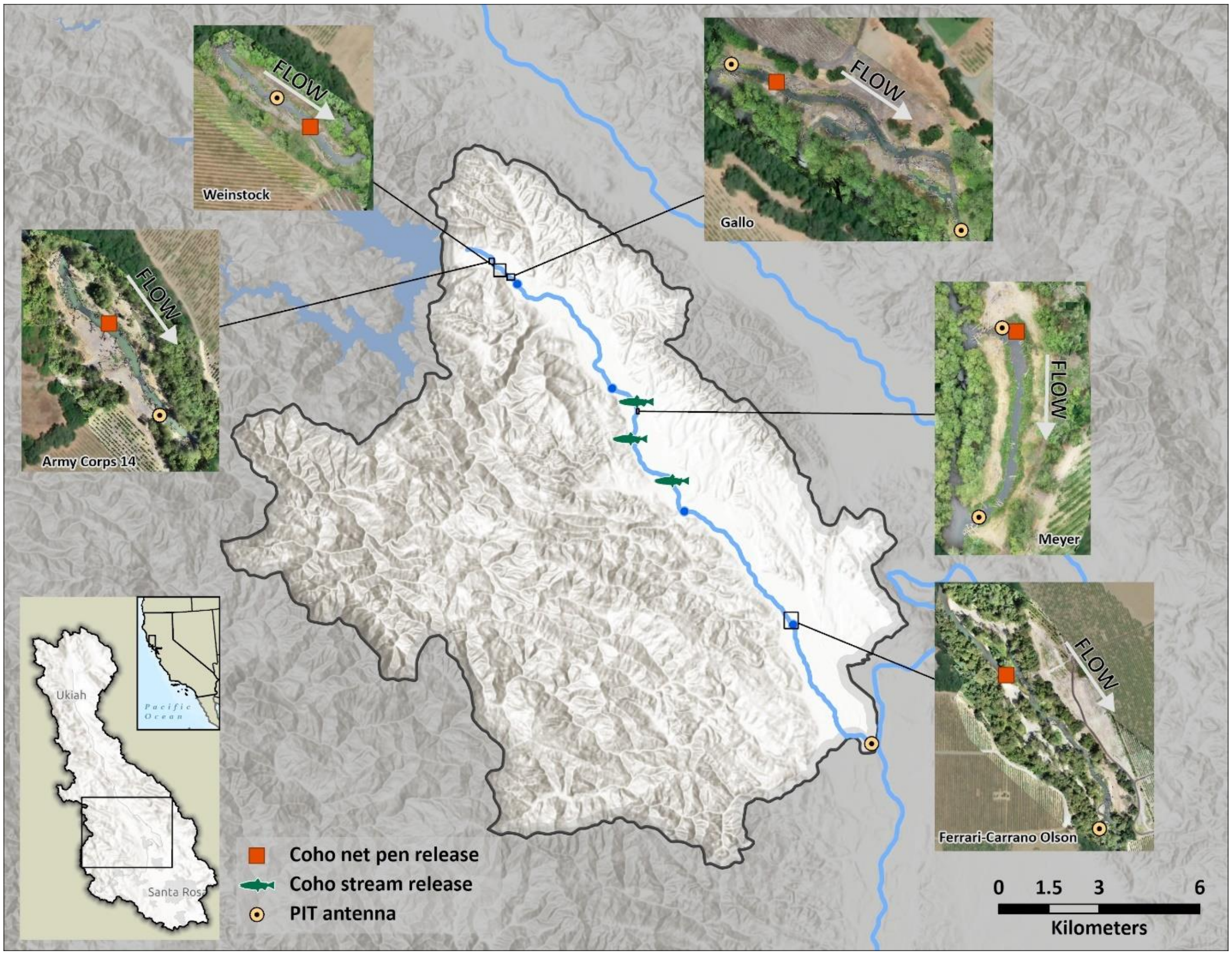


Figure 5.3.1. Location of Coho broodstock juvenile release locations in Dry Creek in 2020. Net pens were located in five constructed side channels (red squares), releases directly into the stream were located in three constructed side channels (green fish) and in-stream PIT antennas were located at each side channel with a net pen as well as at the mouth of Dry Creek (yellow circle). Blue circles indicate a distance of 5 km along the stream channel.

Photo 5.3.1. Installation of net pen and rigid frame (left photo) and hatchery-reared juvenile Coho Salmon being placed inside completed net pen enclosure (right photo) at Ferrari-Carano Olson backwater (rkm 5.36).

Survival estimates

A secondary validation metric listed in the Dry Creek AMP is survival of juvenile salmonids. Although we have developed ad hoc ways to somewhat quantitatively evaluate survival (see section Residency time and minimum survival index above), we are working toward a more formal and structured approach that should allow consistent evaluations over time as long as winter flows do not compromise PIT antenna equipment in Dry Creek.

For the 2020 juvenile Coho Salmon releases, we were able to begin evaluation of a mark-recapture model (Cormack-Jolly-Seber, CJS) to estimate survival of hatchery-reared juveniles to the smolt stage after they were released into Dry Creek. CSG has successfully used a formulation of the CJS model, called the multistate model, that allows combining early emigrant detections (emigration prior to March 1) on continuously operating PIT antennas with detections of smolt detections (emigration after March 1) as individuals exit a stream during their seaward migration. Data necessary to use this approach include a population of known PIT-tagged individuals and continuous operation of PIT antenna arrays consisting of two or more channel spanning antennas (e.g., one antenna immediately upstream of the other) at tributary mouths (i.e., downstream of the PIT-tagged population). Antennas within the array should be close enough together to satisfy the assumption of no mortality as individuals move downstream between antennas within the array.

In most years, CSG has been able to consistently collect the data necessary to decouple early emigration from true survival using the multistate model in smaller tributaries to the Russian River; however, continuous operation of antennas on larger tributaries (e.g., Dry Creek) has proven more challenging. In years when we can operate the paired array located at the mouth of Dry Creek throughout the winter season, we should be able to use the multistate for estimating overwinter survival in the manner described above. Although we were unable to operate a paired array at the Dry Creek mouth during the winter of 2020/21, we were able to operate a single channel spanning antenna throughout the winter. Due to low flow conditions in late winter 2021, we were also able to operate an antenna in the Mirabel dam fish ladder (approximately 11.9 km downstream of Dry Creek) from April 15-June 9 as well as a downstream migrant trap immediately downstream of the ladder. Along with the release occasion, detection data from these three sources was used to construct 4 occasion encounter histories. Although use of the multistate model was not possible from these data, we were able to use the CJS model to estimate apparent survival from the release point in Dry Creek in July ("spring release") or October/November ("fall release") to the Dry Creek mouth, as well as apparent survival from Dry Creek mouth to the Mirabel dam.

Habitat utilization

Validating the use of constructed enhancement sites has primarily been accomplished through traditional monitoring methods such as snorkel surveys and PIT antenna systems, both of which provide a snapshot in time of habitat use at the site scale. Snorkel surveys have been used in previous years during the summer with varying success depending on water clarity and conditions specific to a given site such as aquatic vegetation or other material that fish may be using for cover thus obscuring them from detection. Although PIT antenna monitoring occurs at some sites in Dry Creek year-round, in this report we focus on PIT antenna detections beginning in late summer, 2020 through as much of the winter season as possible then again into the following spring and early summer, 2021.

Summer, 2020

In 2020 snorkel surveys were conducted in five habitat enhancement side channels: Lonestar, Meyer, Gallo, Weinstock, and Army Corps Reach 14. Surveys were conducted with two snorkelers working in tandem. Species and approximate size class was noted for each individual observed. Though length of sections snorkeled in habitat enhancement sites was not recorded, we attempted to survey as much of the length and width of each habitat enhancement site as possible.

Late summer, 2020 – Early summer, 2021

We again operated PIT antennas in habitat enhancement sites as a means to evaluate habitat use by juvenile salmonids: Meyer side channel (one antenna at the outlet rkm 13.81 and a second antenna at the inlet rkm 13.94); Gallo side channel (one antenna at the outlet rkm 20.16 and a second antenna at the inlet rkm 20.40); midway along the Weinstock side channel (rkm 20.72); the inlet of the Army Corps Reach 14 side channel (rkm 20.99) (Figure 5.3.3). Although antennas did not necessarily span the wetted width of channels, they did cover the majority. The source of PIT-tagged fish included: (1) wild (natural-origin) juvenile steelhead that were PIT-tagged during mainstem Dry Creek electrofishing surveys (Table 5.3.3); (2) adult anadromous salmonids that had been previously PIT-tagged as juveniles.

Table 5.3.3. Number and location of juvenile steelhead PIT tagged during electrofishing surveys of Dry Creek during the summer of 2020.

Dry Creek Reach	Upper (rkm)	Lower (rkm)	Number PIT-tagged
Middle	**5.27**	**17.71**	**173**
Main channel	*13.71*	*14.14*	*173*
Upper	**17.73**	**22.00**	**112**
Main channel	*20.88*	*21.09*	*25*
Army Corps Reach 14 side channel	*20.48*	*20.58*	*87*
		Total	**285**

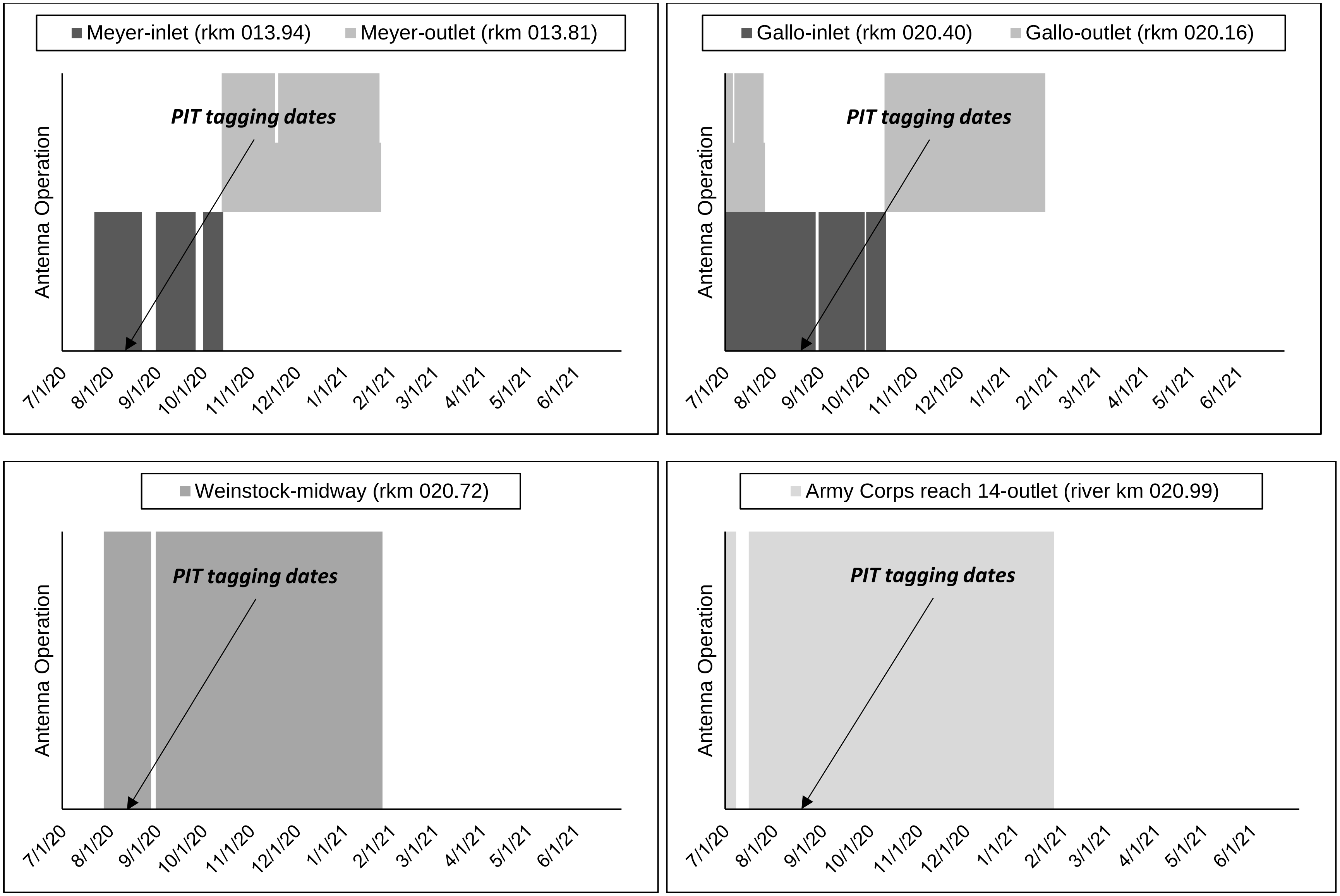


Figure 5.3.2. Dates of PIT antenna operation in constructed off-channel habitat in Dry Creek, 7/1/2020 to 6/30/2021.

Figure 5.3.3. Approximate location of PIT antennas (yellow ovals) in Dry Creek habitat enhancements monitored in 2020. Rkm refers to the downstream end of the side channel. Note that the original antenna location at Meyer (upstream end) was moved to the downstream end of the side channel on October 10, 2020

Late summer population density

Site-scale sampling

We conducted sampling to estimate population density in the Truett Hurst (rkm 14.01), Weinstock (rkm 20.48) and Army Corps Reach 14 (rkm 21.02) constructed side channels in the summer of 2020. A depletion estimator was used for two sections within the Truett Hurst side channel to estimate end-of-summer abundance ($\widehat{N}$). The population closure assumption of the depletion model was met in each section by temporarily closing the section with block nets while multiple passes were made through each section with a backpack electrofisher on the same day. Fish captured on each pass were counted and temporarily "removed" from the stream section by holding them in live cars while subsequent passes were conducted.

A seine net was used to sample the other two side channels that were too deep to sample with backpack electrofishers. Sampling was conducted with a single seine pass through a portion of the side channel on day 1 (the marking event) followed by a second pass four days later (the recapture event). Individuals captured on day 1 were marked either with a PIT-tag or upper caudal fin clip, released near their capture location, and subject to recapture on day 2. We used the Petersen mark-recapture model in Program MARK (White and Burnham 1999) to estimate end-of-summer $\widehat{N}$. Density estimates at all sites were calculated as the quotient of $\widehat{N}$ and wetted area of the sample site.

Reach-scale sampling

The Biological Opinion as well as the primary literature (e.g., Roni 2005) acknowledge the problem of biological monitoring that is too limited in time and space to accurately detect changes in population that may result from artificial habitat enhancements as opposed to other factors. To overcome this, we sought to place our results in a broader context. To isolate the effect of habitat enhancements on juvenile salmonid populations as opposed to broader watershed- and/or marine-level impacts, we conducted juvenile sampling that allowed comparisons between enhanced and non-enhanced habitats. Similar to 2019 we sampled each of the three geomorphically-based reaches identified by Inter-Fluve (2011). Unlike previous years, electrofishing surveys were paired with snorkel surveys to calculate a calibration ratio that would allow us to expand snorkel counts to a population estimate for longer stream sections. This is a modification of the basinwide visual estimation technique of Hankin and Reeves (1988). We have successfully used a similar method in smaller tributary streams as part of CMP life cycle monitoring (Sonoma Water 2020). The ability of divers to sample areas in mainstem Dry Creek that are not suitable for electrofishing is the primary benefit for sampling in this manner. Secondarily, this sample method reduced the number of staff required to work closely together and the frequency of our activities, helping to accommodate the COVID safety protocols in place.

First stage sampling consisted of a single snorkel pass conducted by three divers swimming side-by-side downstream. Visual identification was used to record the total number of juvenile salmonids by species observed in each of three lanes encompassing the wetted width of the stream channel. Four total sections were snorkeled: one in the lower reach, two in the middle reach, and one in the upper reach. The total length of snorkeled sections varied between 110 and 2,108 meters. Snorkeled sections were further sub-divided into units that would later be sampled with electrofishing. Electrofishing surveys occurred within 0-4 days of the snorkel surveys. A total of four electrofishing units within the snorkeled reaches were sampled, 2 in the middle and 2 in the upper reach. The average ratio of steelhead parr recorded during snorkel and electrofishing surveys was calculated as the calibration ratio. This ratio was then applied to the total snorkel counts of steelhead parr for each snorkeled section to calculate an estimate for the total steelhead parr in that section. Density estimates were calculated as the quotient of $\hat{N}$ and wetted area of the section stream section sampled.

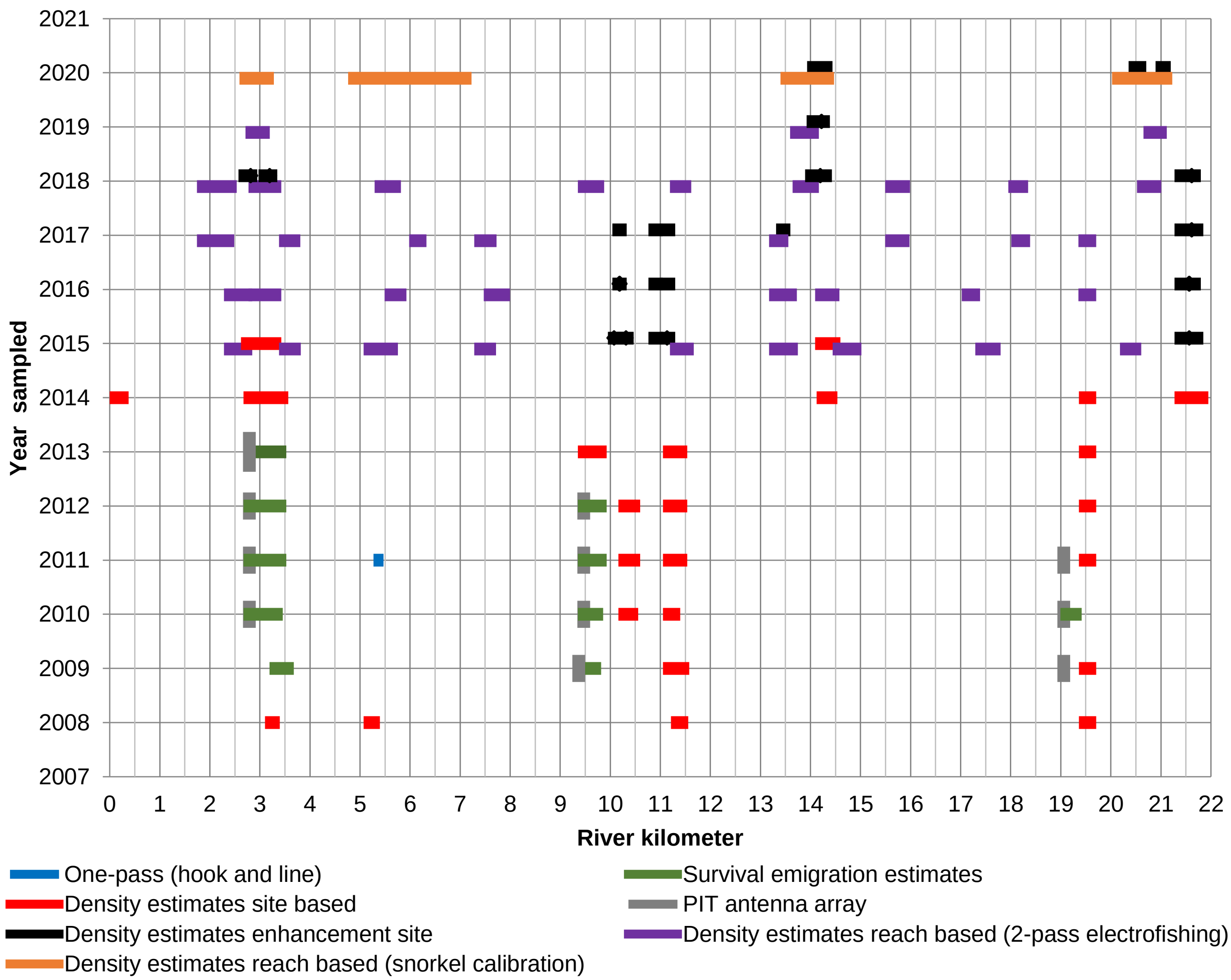


Figure 5.3.4. Years sampled and river kilometer (from the mouth) where juvenile steelhead populations were sampled in mainstem Dry Creek, 2008-2020. Line length for each site is scaled to the length of stream sampled. Data collected at the site scale were analyzed using mark-recapture (either a multiple-pass depletion or Petersen model) and reach-scale data collected in 2009 were analyzed with the core-sampling approach (see Manning and Martini-Lamb 2011 for details) while reach scale data collected in 2011-13 were analyzed with the multistate model using program MARK (White and Burnham 1999) to estimate survival and emigration.

Smolt abundance

A rotary screw trap with a 1.5 m diameter cone was anchored to the Westside Road bridge, located 3.3 km upstream from the confluence of Dry Creek and the Russian River. Wood-frame mesh panels were installed adjacent to the rotary screw trap in order to divert downstream migrating salmonids into the trap that may have otherwise avoided the trap.

Fish handling methods and protocols were like those used in previous years (see Manning and Martini-Lamb 2011). Fish captured in the trap were identified to species and enumerated. A subsample of each species was anesthetized and measured for fork length each day, and a subsample of salmonid species was weighed each week. Except for 50 Chinook Salmon smolts each day that were released upstream for the mark-recapture model, all fish were released downstream of the first riffle located downstream of the trap.

Coho Salmon

Because of the small numbers of Coho Salmon smolts captured in the Dry Creek trap, a population estimate is not possible based on mark-recapture methods available for Chinook Salmon smolts. Therefore, we report trap catch as the minimum count in the Dry Creek trap each year.

Chinook Salmon

Each day, up to 50 Chinook smolts (≥60 mm) were marked and released upstream of the trap for the purpose of estimating trap efficiency and constructing a population estimate. An upper caudal fin clip was used to mark fish. Marked fish that were recaptured in the trap were noted and released downstream (the lengths and weights of recaptured fish were not recorded a second time). The population estimate of Chinook Salmon smolts produced in the Dry Creek watershed upstream of the trap is based on the period of time that fish were marked and recaptured (April 24-July 22).

Steelhead

Much of the steelhead smolt migration period occurs prior to the time the migrant trap can safely be installed and operated in mainstem Dry Creek; therefore, the catch of steelhead smolts in the trap does not adequately account for the abundance of steelhead smolt emigrating from Dry Creek. To account for this discrepancy, we employed a pre-smolt abundance model that relied on backpack electrofishing in the late summer/early fall and year-round, stationary PIT antenna monitoring to estimate smolts and/or juvenile steelhead leaving Dry Creek. To estimate the number of steelhead emigrants leaving Dry Creek in the 2020 smolt season we relied on the detection of PIT-tagged individuals on the antenna array located at the mouth of Dry Creek (rkm 0.36). In the absence of trapping and handling steelhead to determine which individuals are smolts, steelhead were classified as smolts if they were detected leaving Dry Creek during the period from November 1, 2019 through June 30, 2020. Based on empirical observations of juvenile steelhead growth, it is reasonable to assume that all or most of these individuals could have reached a size large enough to smolt by the following late winter/early spring.

Juvenile steelhead were PIT tagged in the summer of 2019 during electrofishing surveys in the mainstem of Dry Creek and the Truett Hurst side channel. The proportion of these individuals that were detected leaving Dry Creek as smolts in 2020 was calculated as a “survival” index, corrected for antenna efficiency. The survival index (si) was then applied to the estimate of juvenile steelhead density in the fall ($fish * m^{-1}$) multiplied by the total reach length ($length_r$) to calculate an estimate for the number of smolts from Dry Creek in 2020 ($\hat{Y}$).

$$\hat{Y} = \sum_{i=1}^{r} si(length_r * (fish * m^{-1}))$$

Results

Juvenile Coho Salmon hatchery releases

Spring releases

A single array of antennas was operating at the mouth of Dry Creek, and a swim through antenna was operating in the westside Mirabel fish ladder for the majority of the time between Coho releases and the following smolt emigration season (Figure 5.3.5). A total of 10,017 Coho juveniles (1,515 of which were PIT-tagged) were released directly into the stream and not into net pens (i.e., stream release type) into one of three constructed side channel or alcove habitats on July 15, 2020. While some fish were detected leaving Dry Creek immediately after release, the median time of detection ranged from 232 to 287 days post release by site, occurring in March and April 2021 (Figure 5.3.6). The proportion of juveniles released in the spring detected at the mouth of Dry Creek ranged from 0.24 to 0.30. Estimated survival for Coho during the smolt emigration period at Dry Creek ranged from 11% to 20% while estimated survival of the same group to the Mirabel dam was 6% to 10% (Figure 5.3.7).

Of the 1,515 PIT tagged fish released directly into side channels in July, 87 were detected in at least one constructed side channels in the fall and winter (Table 5.3.4). Most fish were detected in the side channel located less than 0.5 km from their release location (Table 5.3.4).

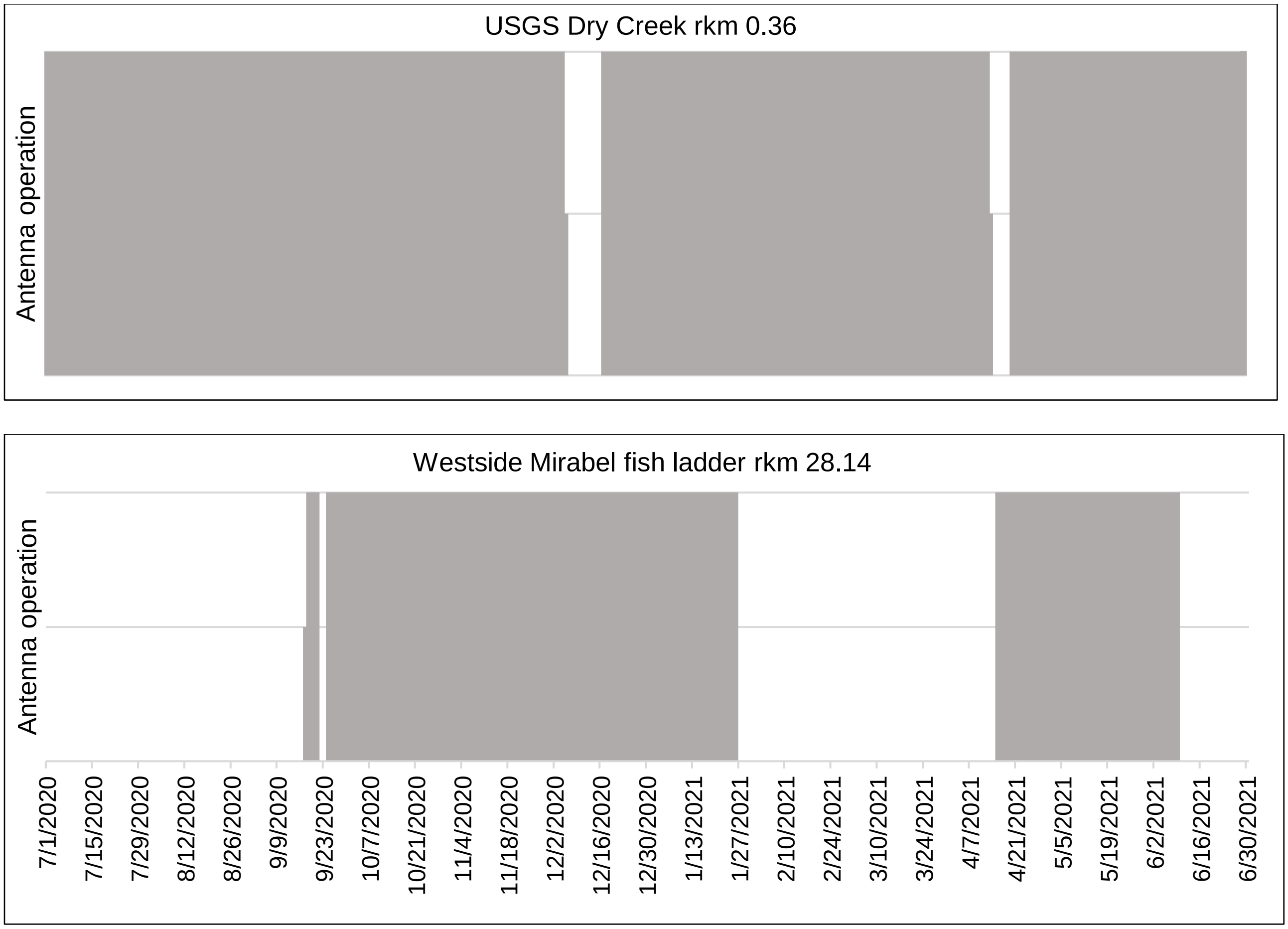


Figure 5.3.5. Antenna operation at the mouth of Dry Creek and Mirabel fish ladder (Wohler dam) for the period of July 1, 2020 through June 30, 2021.

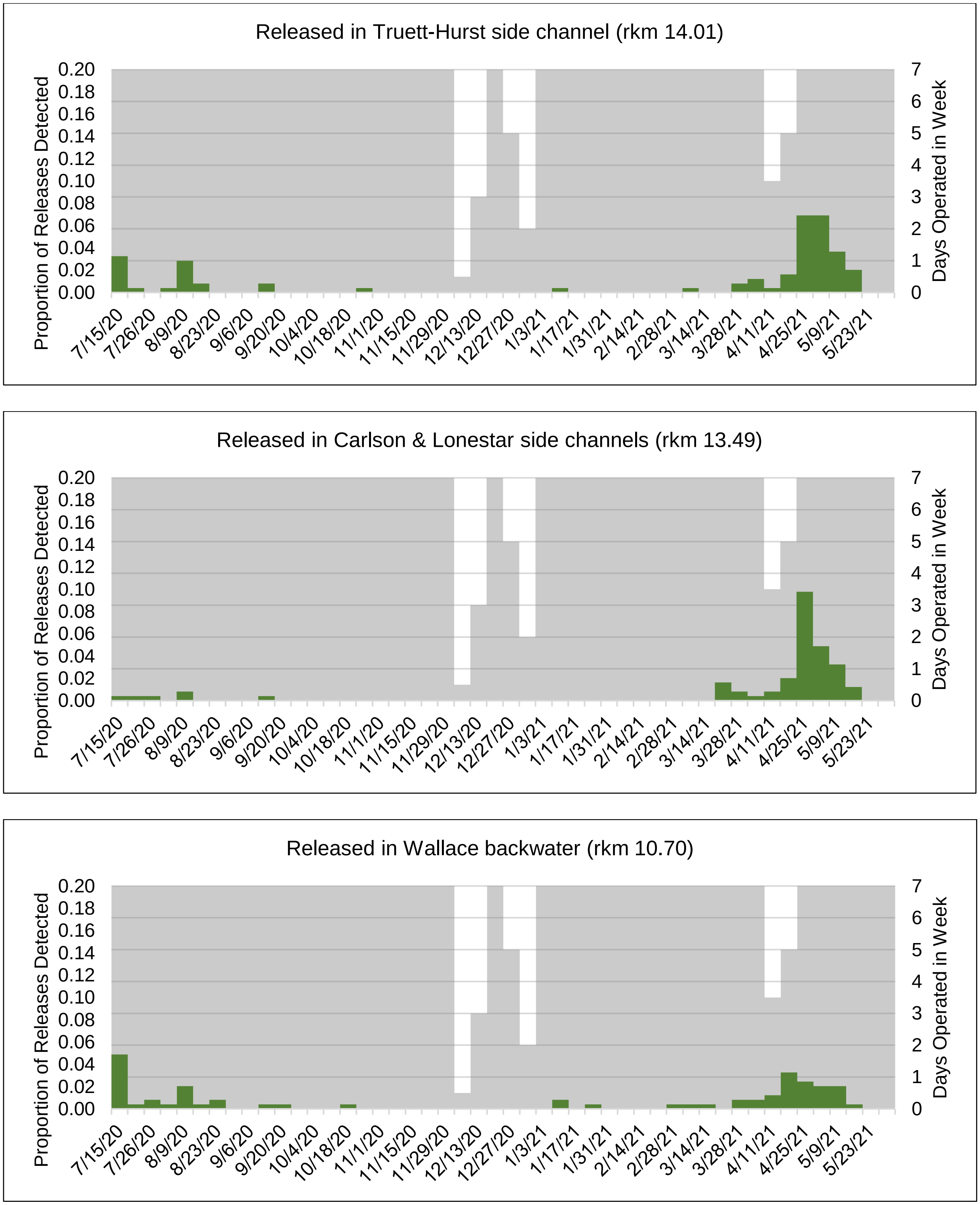


Figure 5.3.6. Proportion of PIT-tagged Coho juveniles released into constructed habitats on July 15, 2020 that were detected each week on the Dry Creek mouth antenna (rkm 0.36) by release location. Detections are grouped by week. Antenna operation is indicated by the grey bars, where a value of 7 on the right-hand vertical axis indicates the antenna was operational for the entire week.

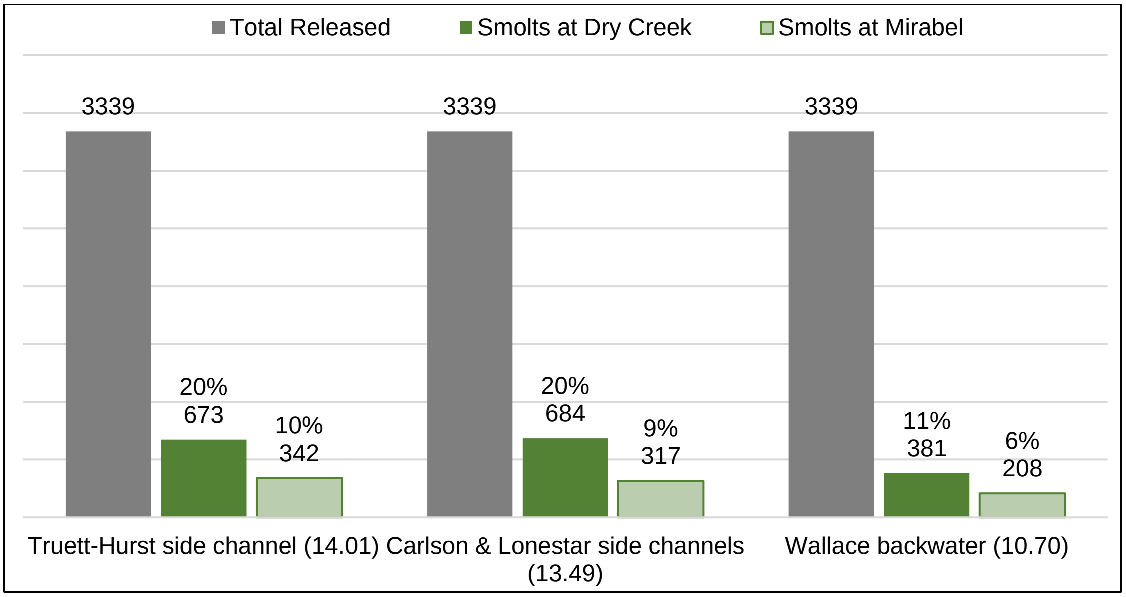


Figure 5.3.7. Estimated percent and expanded number of Coho hatchery juveniles released into Dry Creek during spring 2020 that were detected during the subsequent smolt emigration period at the mouth of Dry Creek and at the Mirabel dam on the Russian River, by release location.

Table 5.3.4. Detection summary for PIT tagged juvenile (age-0+) Coho Salmon released into enhancement sites (i.e., released directly into stream and not into net pens) and subsequently detected in other side channel locations in Dry Creek, summer 2020. Note that individuals that were detected at more than one detection site are counted more than once.

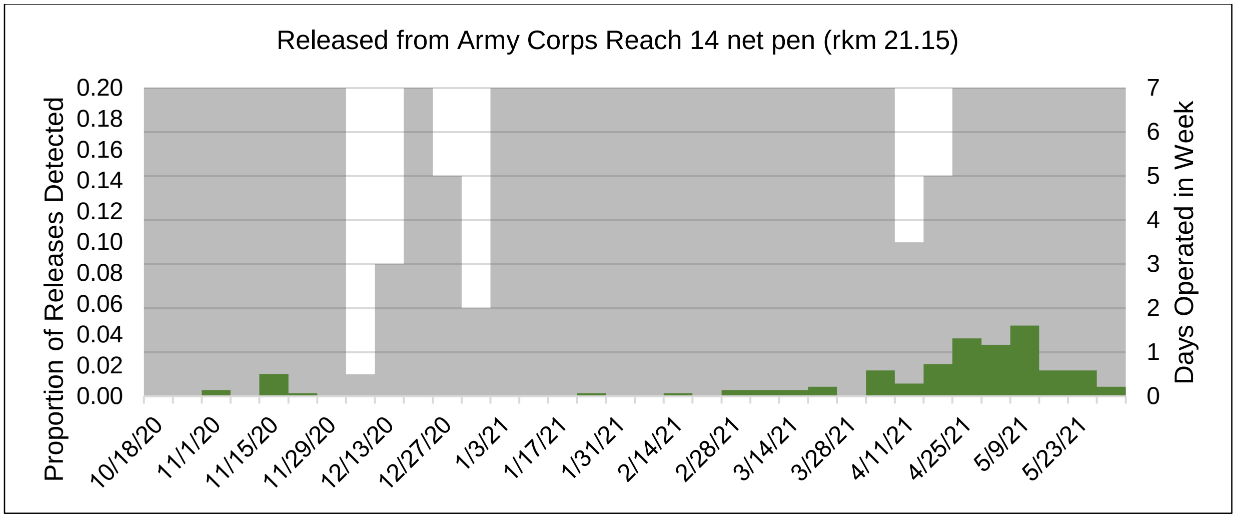
Release site	Detection site	Number detected(%)
Wallace backwater (rkm 10.70)	Meyer (rkm 13.81, 13.94)	4 (0.8%)
	Army Corps 14 (rkm 20.99)	1 (0.2%)
Carlson Lonestar side channels (rkm 13.49)	Meyer (rkm 13.81, 13.94)	37 (7.3%)
	Gallo (rkm 20.16, 20.40)	5 (1.0%)
	Weinstock (rkm 20.72)	2 (0.4%)
	Army Corps 14 (rkm 20.99)	4 (0.8%)
Truett Hurst side channel (rkm 14.01)	Meyer (rkm 13.81, 13.94)	26 (5.1%)
	Gallo (rkm 20.16, 20.40)	5 (1.0%)
	Weinstock (rkm 20.72)	5 (1.0%)
	Army Corps 14 (rkm 20.99)	6 (1.2%)
	Combined total	**85 (5.6%)**

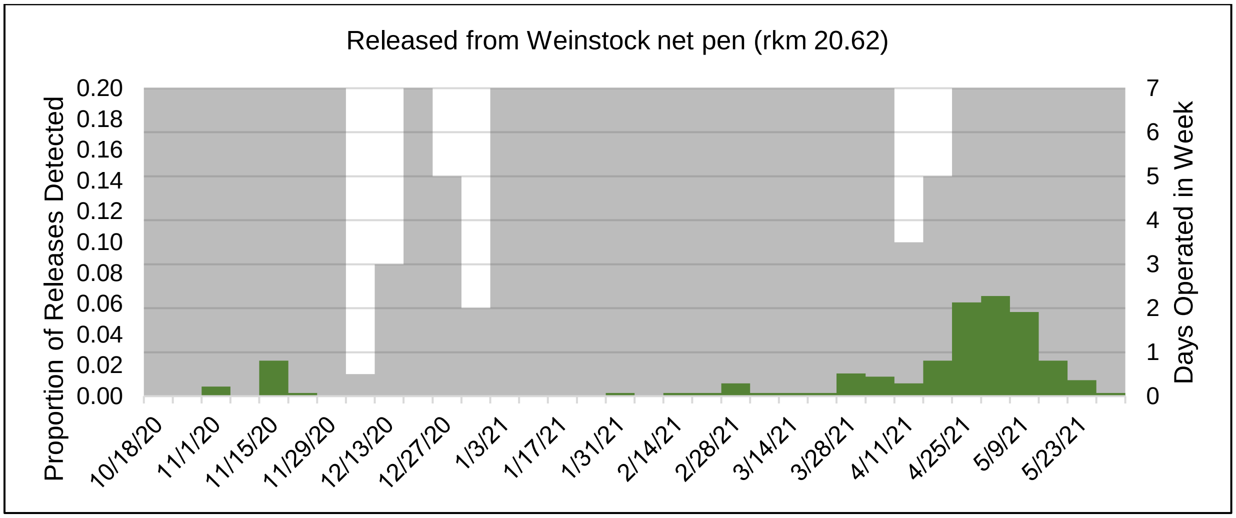
Fall releases

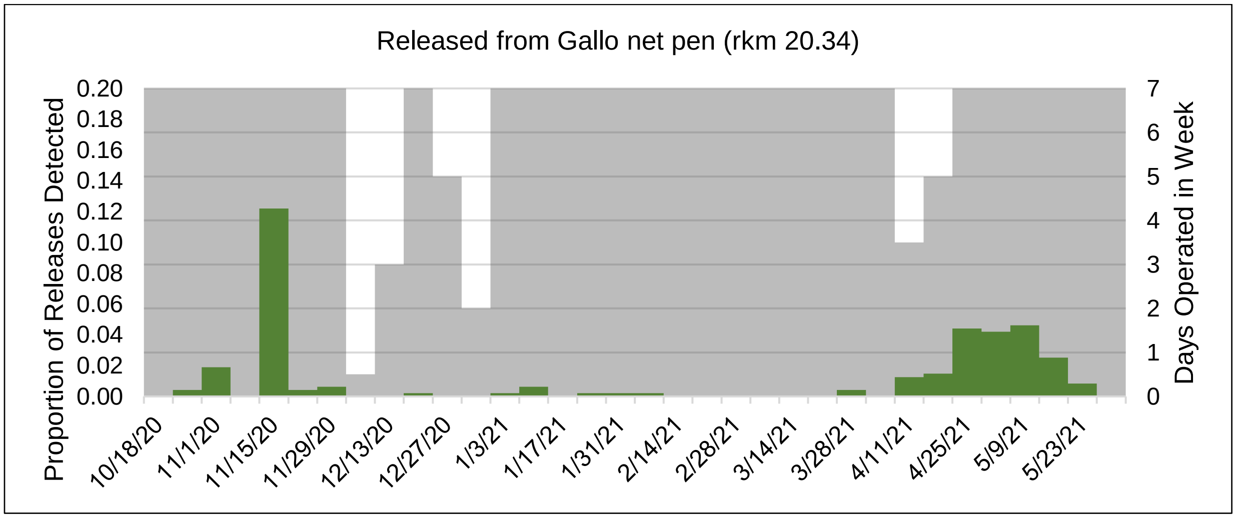
A total of 25,227 Coho juveniles were released into one of five net pen enclosures (i.e., net pen release type) located within constructed side channels from October 21 through November 9, 2020. For each net pen, releases were staged in three groups approximately one week apart with between 1,669 to 2,134 individuals released into each enclosure at one time. Each group was held in the net pens for 5 to 8 days before the nets were opened to allow volitional release from the pens.

With the exception of fish from the Ferrari-Carano Olson side channel, the median time of detection at the mouth of Dry Creek ranged from 160 to 181 days post-release, occurring in April and May 2021 (Figure 5.3.8). The proportion of juveniles detected at the mouth of Dry Creek released in the fall ranged from 0.24 to 0.39. Estimated survival for Coho in the fall release group to the smolt emigration period at Dry Creek ranged from 0.08 to 0.24 while estimated survival of the same group to the Mirabel dam was 0.03 to 0.14 (Figure 5.3.9).

Stationary antennas located within each side channel were in operation at the time of release and used to detect movement into and out of the enhanced habitats and estimate residency time. Between 30% and 60% of tagged fish released from the net pens were detected on any side channel antenna, including the antenna array in their release location (Table 5.3.5). Of the fish that were detected most (an average of 81%) were only detected in the side-channel of their release, however, up to 33% were detected in additional side channels (Table 5.3.5). Fish that were released in the two side channels located furthest upstream: Army Corps 14 and Weinstock, were more likely to be detected in multiple side channels.







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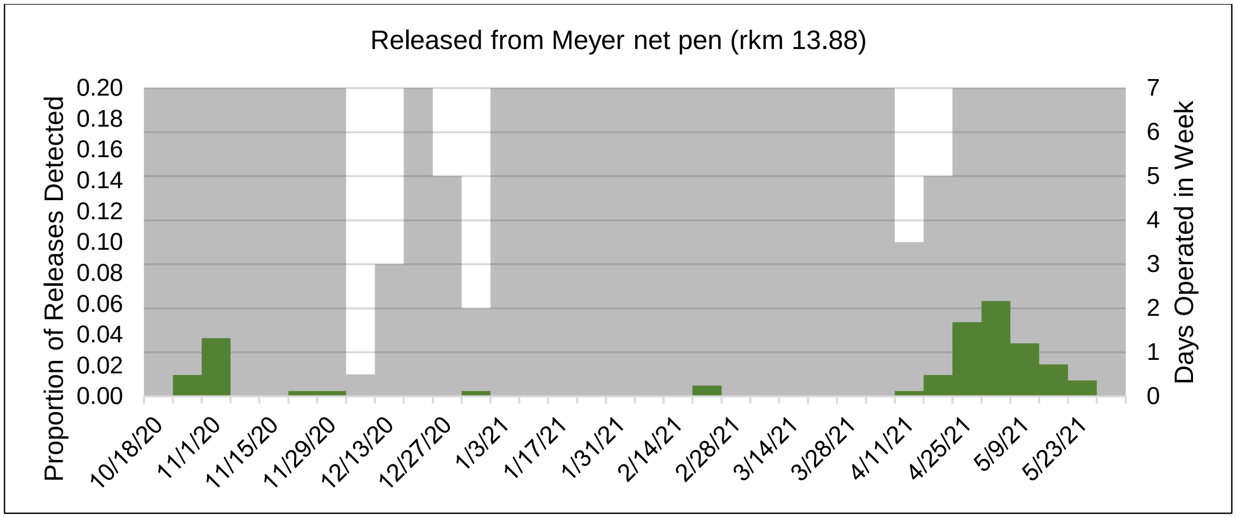


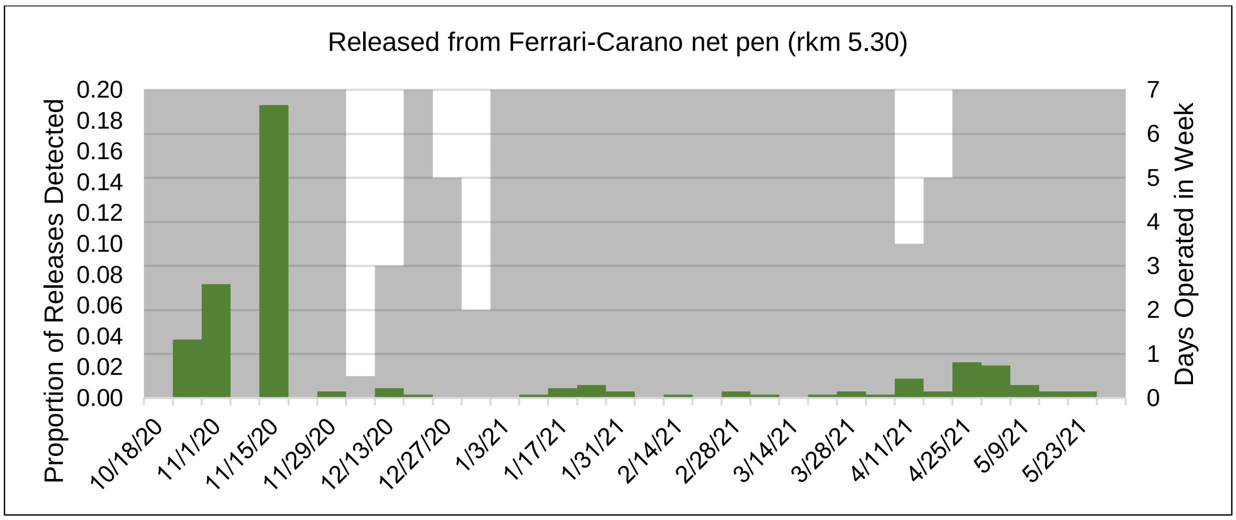


Figure 5.3.8. Proportion of PIT-tagged Coho juveniles released into net pens within constructed habitats during the fall 2020 on the Dry Creek mouth antenna (rkm 0.36) by net pen location. Detections are grouped by week. Antenna operation is indicated by the grey bars, where a value of 7 indicates the antenna was operational for the entire week.

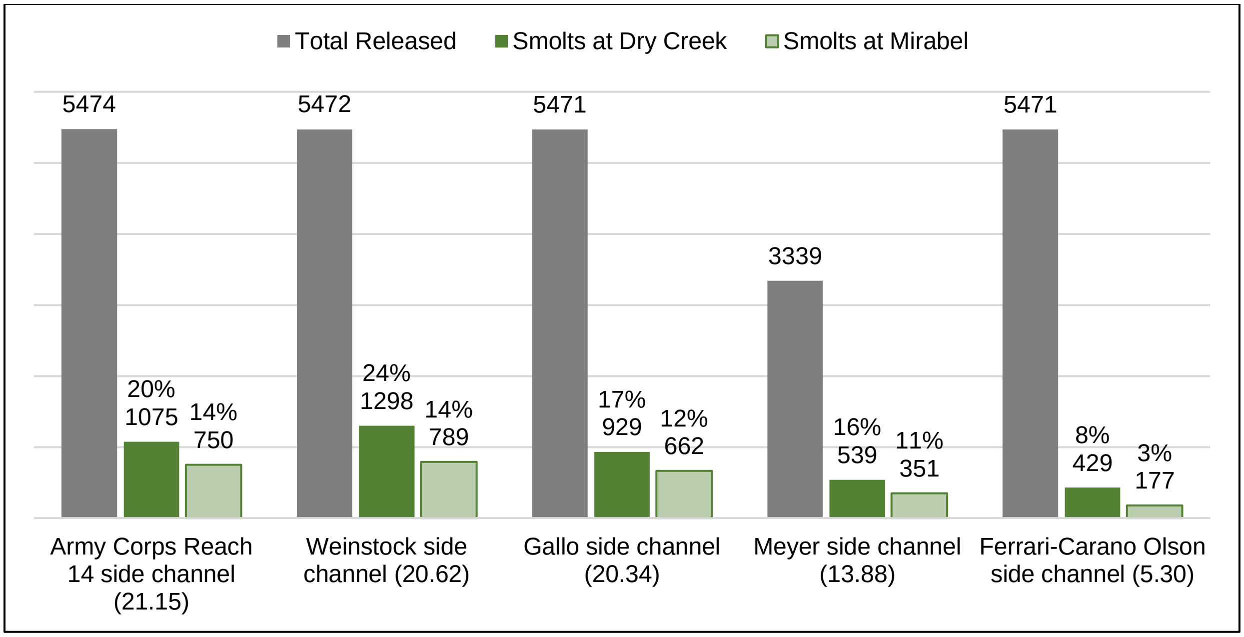


Figure 5.3.9. Percent and estimated number of Coho hatchery juveniles released into Dry Creek during the fall 2020 that were detected during the subsequent smolt emigration period at the mouth of Dry Creek and at the Mirabel dam on the Russian River, by release location.

Table 5.3.5. Percent of Coho juveniles held in net pens and released into constructed side channels during the fall of 2020 that were detected post-release on antennas located within the side channels and the proportion of those fish that were detected in 1, 2, or 3 side channels.

Release location				
Army Corps 14 (21.15)	45%	0.62	0.33	0.05
Weinstock (20.62)	40%	0.78	0.21	0.01
Gallo (20.34)	54%	0.78	0.21	0.01
Meyer (13.88)	60%	0.89	0.11	0
Ferrari-Carano Olson (5.30)	30%	1.0	0	0

Apparent survival

Of the 6,030 juvenile Coho Salmon released in Dry Creek in 2020, during the period April 15-June 9 we detected 466 smolts migrating out of Dry Creek and 490 smolts migrating past the Mirabel dam. The higher number at Mirabel was because of higher detection probability at Mirabel (CJS estimate of 0.90) as compared to Dry Creek (0.55). Apparent survival to the mouth of Dry Creek was only marginally lower for the spring release group (0.13; 95% CI: 0.11, 0.15) as compared to the fall release group (0.14; 95% CI: 0.13, 0.16) with a somewhat larger difference in apparent survival between Dry Creek mouth and Mirabel dam (0.58; 95% CI: 0.48, 0.68 for fall vs. 0.66; 95% CI: 0.60, 0.72 for spring) (Figure 5.3.10).

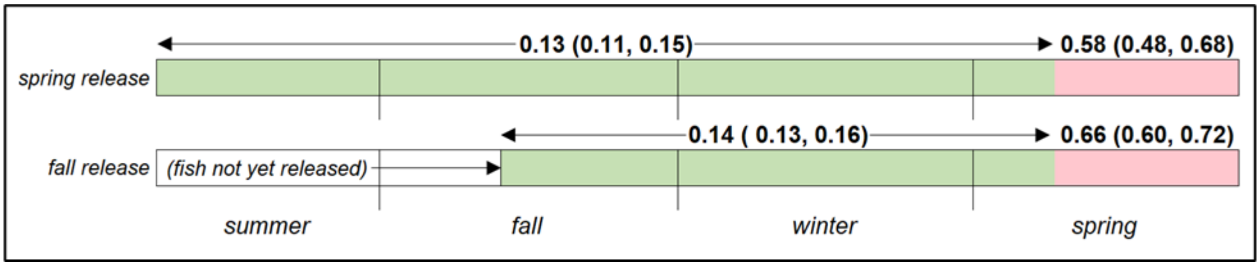


Figure 5.3.10. Survival intervals for spring release (released on 7/15), fall release (released on 10/28, 11/3, 11/17) and survival intervals (green and red shading). Numbers above shaded bars represent apparent survival (±95% CI).

Habitat utilization

Summer, 2020

In 2020 snorkel surveys were conducted in the Lonestar, Meyer, Weinstock, Gallo, and Army Corps Reach 14 side channels. Water clarity allowed very good visibility ranging from 3 to 7 meters depending on the site sampled; however, aquatic vegetation limited our ability to observe fish in the Lonestar side channel. In total, 47 Chinook, 22 coho, and 673 steelhead (126 of the 673 steelhead were over 100 mm FL) were observed in these side channels (Table 5.3.6). Some of the effort used for snorkel surveys in the habitat enhancements was re-allocated to conduct a juvenile steelhead acoustic telemetry pilot study aimed at a more detailed evaluation of how fish are using constructed habitat. Those results are not reported here.

Table 5.3.6. The site and date of snorkel surveys conducted in Dry Creek in 2020, shown with the number of Chinook, Coho, and steelhead in 50-100 mm fork length (FL) and greater than 100 mm FL size bins.

		Chinook	Coho	Steelhead	
Site	**Date**	**50-100 mm**	**50-100 mm**	**50-100 mm**	**+100 mm**
Lonestar	8/12/2020	0	20	3	0
Meyer	8/12/2020	0	2	63	0
Weinstock	8/12/2020	0	0	0	32
Gallo	6/8/2020	35	0	307	70
Army Corps Reach 14	6/8/2020	12	0	87	20
	8/12/2020	0	0	87	4
Grand Total		**47**	**22**	**547**	**126**

Late summer, 2020 – Early summer, 2021

Of the 285 juvenile steelhead that were PIT-tagged in 2020 during late summer sampling (Table 5.3.3), 88 individuals were detected in one or more of the four constructed side channels where PIT antennas were operated in late summer/winter. Of those 88, however, 33 were tagged in the Army Corps Reach 14 side channel and later detected on the Army Corps Reach 14 side channel antenna(s). After discounting those 33 detections, the total number of individuals detected was 55 with 50 of those individuals tagged within 2 km of the enhancement site they were detected in (Figure 5.3.11). Nine individuals (9/55=16%) were detected in two of the side channels and one was detected in three of the side channels. The median residence time for fish released in the Army Corps Reach 14 side channel was 42 days.

As in past years, from these data it is reasonable to conclude that a significant portion of all juveniles are making use of these enhanced off-channel habitats during late summer to winter, but, not surprisingly, the highest use is by fish that were tagged in the main channel close to habitat enhancements.

In addition to juvenile salmonid detections in habitat enhancements, we also documented use by adult Coho Salmon. We detected 29 adults moving into Dry Creek as evidenced by detection on one or more PIT antennas in Dry Creek. Twenty-eight individuals were detected at the mouth of Dry Creek (rkm 0.36). One additional individual was detected in the Army Corps Reach 14 side channel but not detected at the mouth of Dry Creek. Of the 29 PIT-tagged individuals moving into Dry Creek, 15 were detected on at least one of the four side channel antennas.

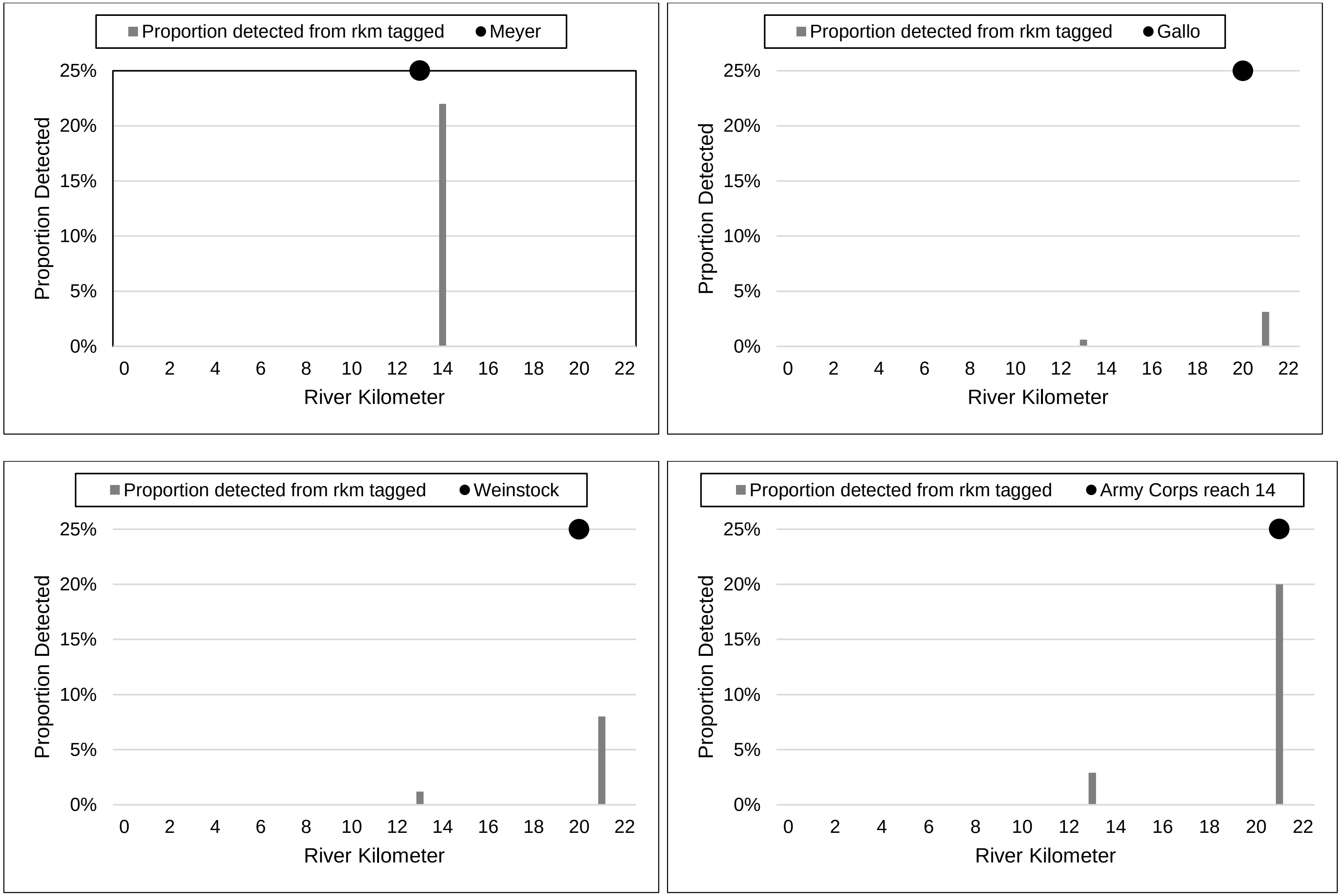


Figure 5.3.11. Proportion of fish detected by river kilometer at each of the four constructed off-channel habitats in Dry Creek monitored with PIT antennas, 7/1/2020 to 6/30/2021.

Late summer population density

Site-scale sampling

The estimated density of juvenile steelhead was greatest in the Truett Hurst side channel (Table 5.3.7). As expected, we encountered many hatchery-origin Coho in the Truett Hurst side channel (132), since electrofishing was conducted after the release of over 3,000 juveniles in July. However, we also encountered natural origin Coho juveniles in each side channel sampled during electrofishing (Table 5.3.7).

Reach-scale sampling

The average density of juvenile steelhead in mainstem sections was 0.07 fish*m^{-2} (range 0.04 fish*m^{-2} to 0.09 fish*m^{-2}). When averaged for all sites within a year, densities in 2020 were 0.02 fish*m^{-2} higher than the twelve-year average from 2008-2019 (Figure 5.3.12). While lower than the previous year, the average population density for enhanced sites was greater than for un-enhanced sites (Figure 5.3.12).

Table 5.3.7. Density of steelhead juveniles and total non-hatchery-origin Coho juveniles in constructed enhancement side channels sampled in the summer 2020.

Enhancement site	River km	Density (fish * m^{-2})	Number natural-origin Coho observed
Truett Hurst	14.06	0.52	7
Weinstock	20.48	0.41	3
Army Corps Reach 14	21.02	0.28	4

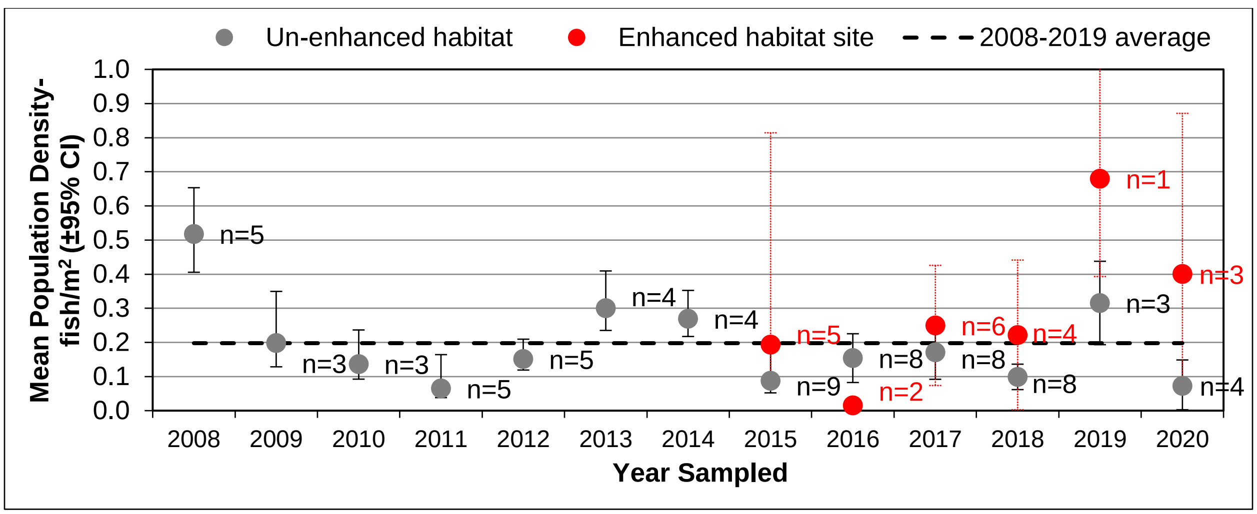


Figure 5.3.12. Mean juvenile steelhead density among all sites sampled within a year in mainstem Dry Creek, 2008-2020. "n" refers to the number of sites sampled per year.

Smolt abundance

We installed the rotary screw trap on April 24 (Figure 5.3.13). Except for brief periods when trapping was suspended because of high debris loading in the trap from high winds, the trap was checked daily during operation until it was removed on July 28.

Figure 5.3.13. Begin and end dates and data gaps (spaces in lines) for operation of the Dry Creek downstream migrant trap, 2009-2020.

The peak capture of Chinook Salmon smolts (267) occurred during the week of 5/10 (Figure 5.3.14). Based on the estimated average weekly capture efficiency (range: 2% to 23%), the resulting population size of Chinook smolts passing the Dry Creek trap between April 24 and July 22 was 109,869 (±95% CI: 44,135, Figure 5.3.15).

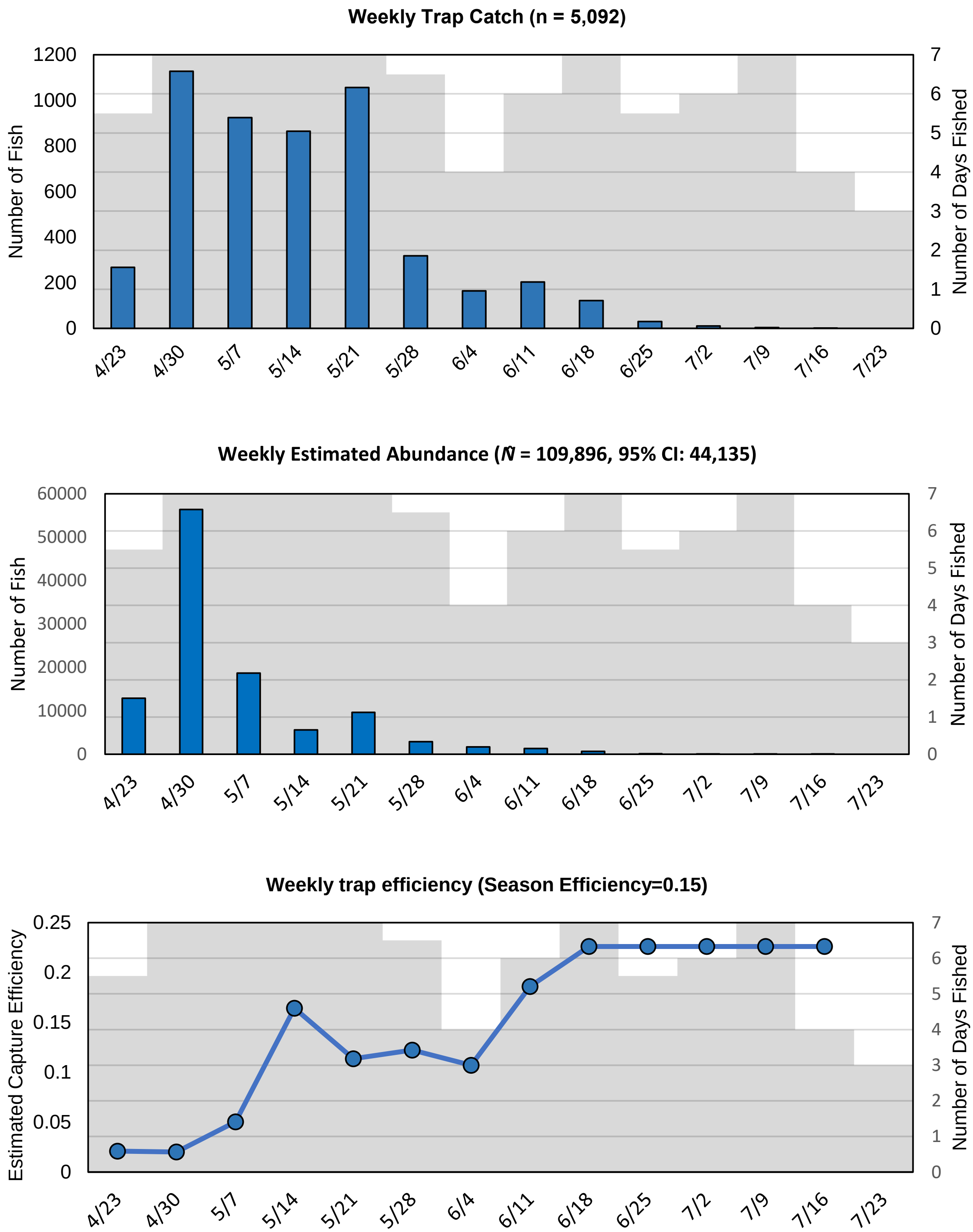
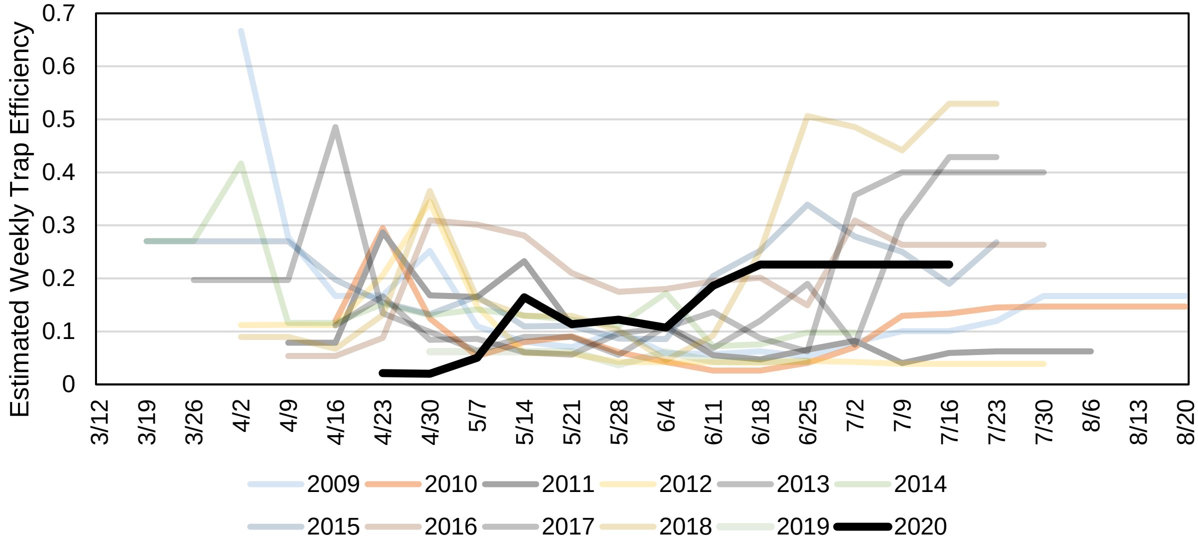


Figure 5.3.14. Weekly trap catch (upper panel), estimated average weekly capture efficiency (middle panel) and population estimate of Chinook Salmon smolts in the Dry Creek rotary screw trap (lower panel), 2020. Estimates are from the one-trap DARR estimator (Bjorkstedt 2005). The number of days each week the trap was fished is represented by the shaded area.



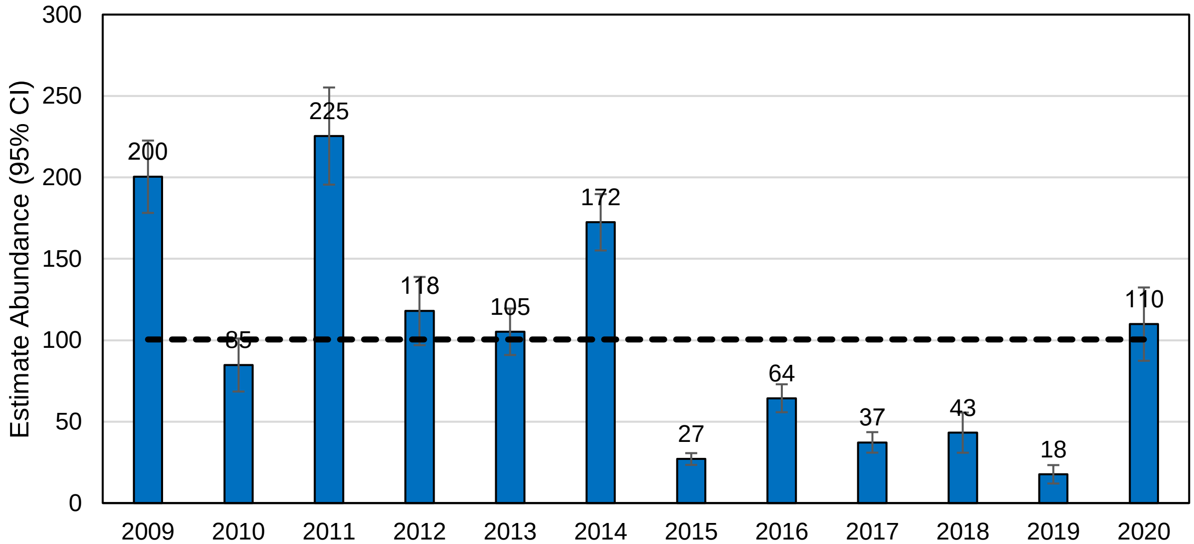
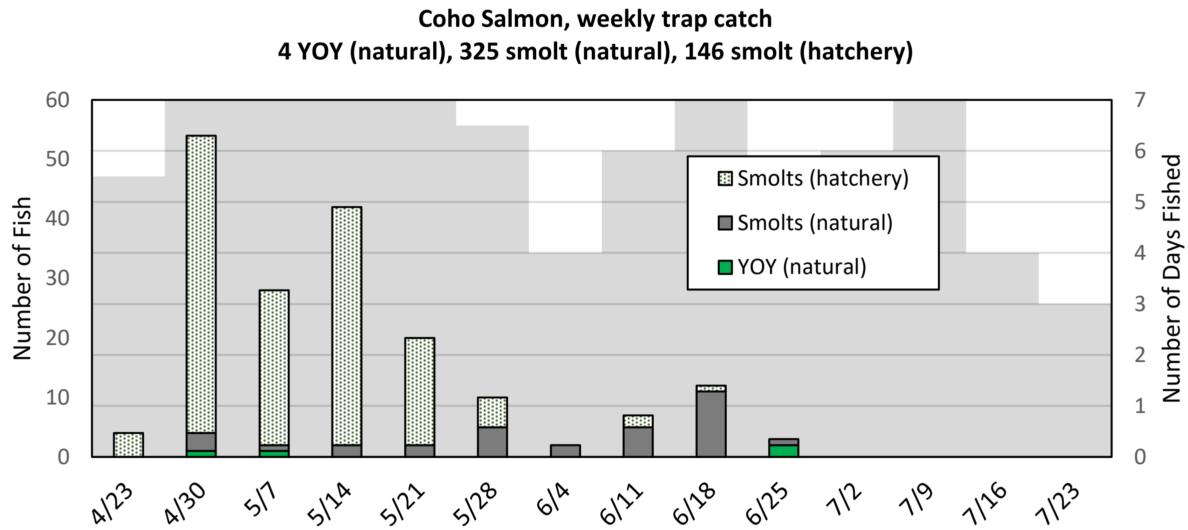


Figure 5.3.15. Estimated average weekly capture efficiency (upper panel) and population estimate of Chinook Salmon smolts (x1000) produced from the Dry Creek watershed upstream of Westside Road smolt trap site (rkm=3.30) (lower panel), 2009-2020. Estimates are from the one-trap DARR estimator (Bjorkstedt 2005) Dashed line is the twelve-year average abundance for all years combined.

Coho Salmon were the least abundant of the three salmonid species captured. Hatchery smolts dominated the catch with a total of 146 individuals captured. Steelhead parr capture was highest in June (Figure 5.3.16).



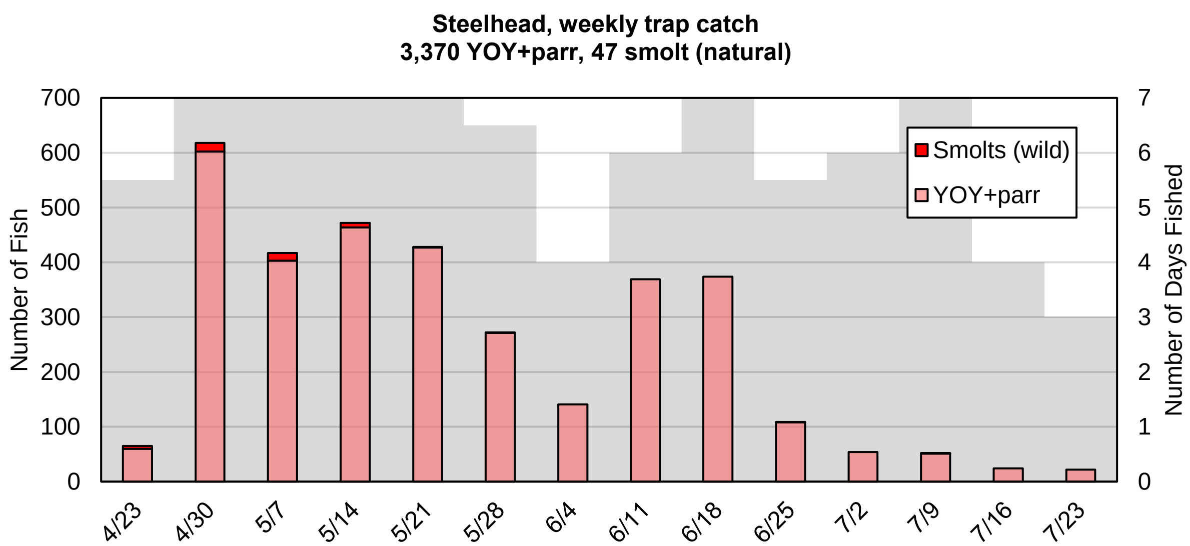
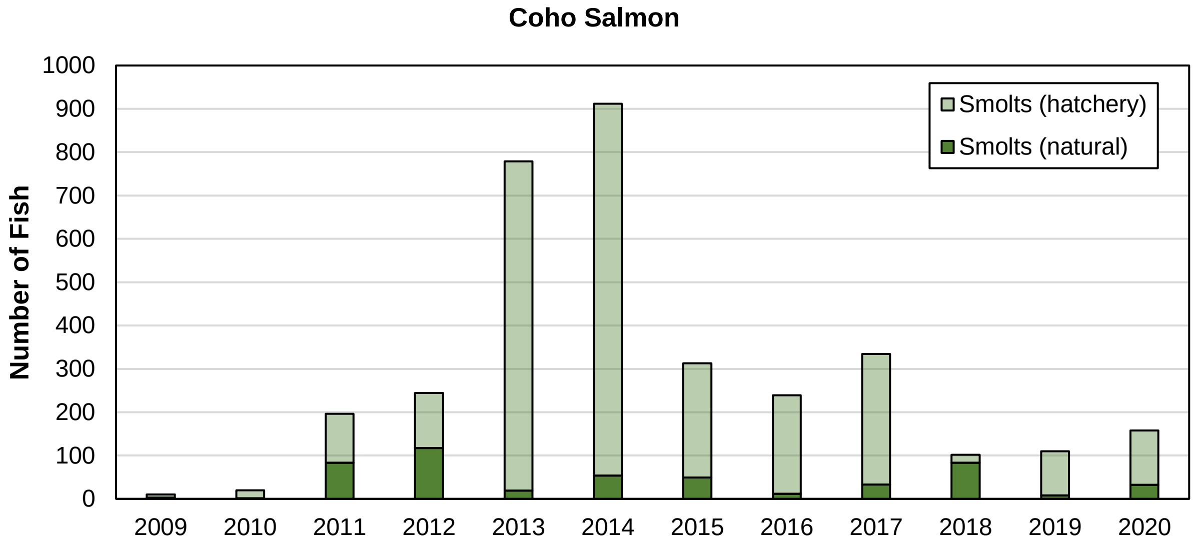


Figure 5.3.16. Weekly trap catch of Coho Salmon and steelhead in the Dry Creek rotary screw trap, 2020.

Coho smolt trap catch for the season was relatively low and similar to catch in recent years (Figure 5.3.17). Steelhead smolt and YOY/parr captures (47 and 3,370) were similar to totals in 2017 and 2018 but noticeably lower than catches in 2019.



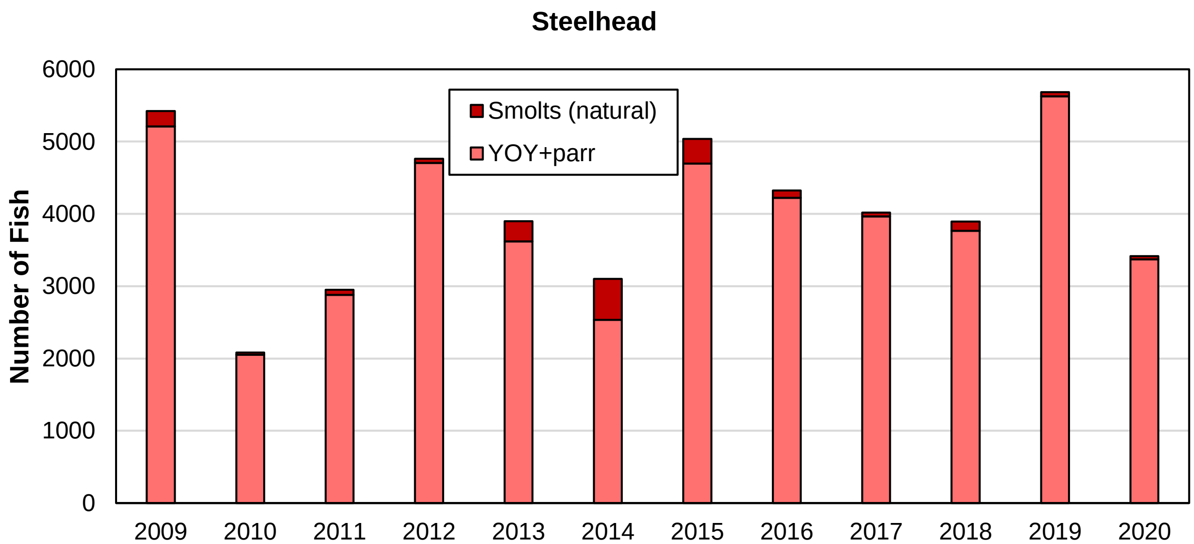


Figure 5.3.17. Trap catches of Coho Salmon smolts and steelhead smolts and parr, 2009-2020.

Weekly sizes of all salmonids captured at the Dry Creek trap increased over the course of the trapping season in 2020 (Figure 5.3.18).

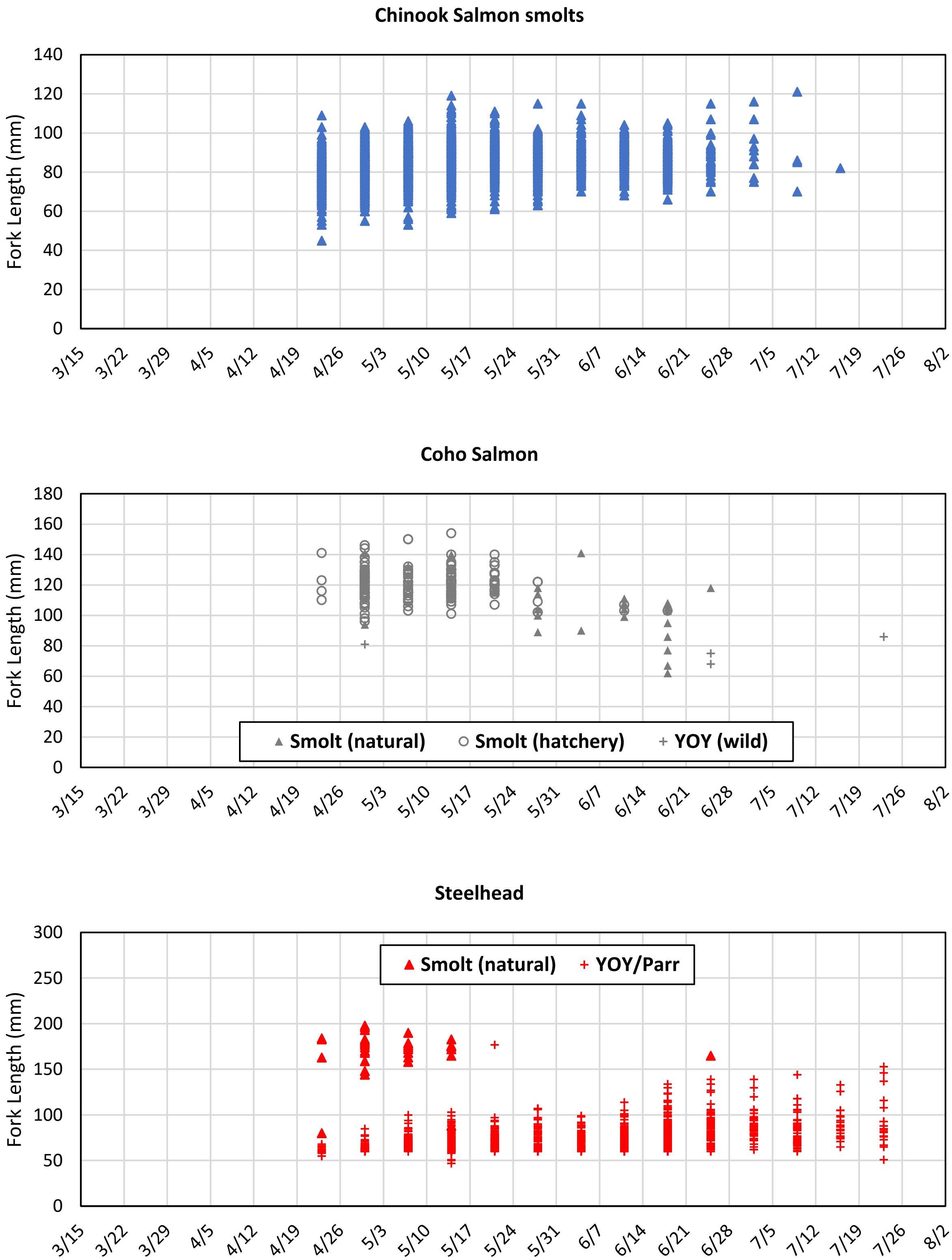


Figure 5.3.18. Fork lengths of individual juvenile salmonids captured in the Dry Creek trap by week, 2020.

Steelhead smolt survival index

Antenna detections of PIT tagged steelhead during the emigration (smolt) period was used to calculate a survival index for juveniles that left Dry Creek during the subsequent smolt season. A survival index was calculated separately for the mainstem and enhancement sites, and this was applied to the respective expanded population estimates to generate the smolt estimate (Table 5.3.8). The proportion of individuals surviving to smolts (survival index) was greater in the enhanced side channel compared to the mainstem reaches.

Table 5.3.8. Estimated number of steelhead smolts in Dry Creek in mainstem and side channel reaches for 2020 based on number of juvenile steelhead estimated in summer 2019 and calculated survival index to the 2020 emigration season.

Location	River km	Density (fish * m^{-1})	Expanded count (juvenile)	Survival index	Smolt estimate
Lower reach	00.00 – 06.87	7.40	51,041	0.09	4,681
Middle reach	06.87 – 18.90	2.93	35,339	0.09	3,241
Upper reach	18.90 – 21.81	3.39	10,013	0.09	918
Total mainstem					***8,840***
Truett Hurst SC	14.01 – 14.30	3.81	1,104	0.12	133

Conclusions and Recommendations

Juvenile Coho Salmon hatchery release strategies

Dry Creek provided a useful alternative release location for hatchery-reared juvenile Coho Salmon that could not be safely released into some of the tributaries impacted by the Walbridge fire. These fish served both as a source to estimate survival to the smolt stage at the mouth of Dry Creek and as a source to evaluate habitat enhancement site fidelity.

Acclimating fish in net pens within side channels prior to releases succeeded in increasing use of constructed side channel habitats and increased survival to the smolt stage (calculated as the proportion of PIT-tagged individuals detected at a given site after correcting for site efficiency). Juvenile to smolt survival as estimated at the mouth of Dry Creek averaged over all release sites was slightly greater for fall releases than the average survival for spring releases (0.30 and 0.26 respectively). The average survival from release to the Mirabel dam (river km ~39 on the mainstem Russian River) was much greater for the fall group compared to the spring group (0.24 and 0.13 respectively) but it is not possible to attribute the difference to release type (spring: stream type; fall: net pen) vs difference in release season (spring vs. fall). By comparison, the estimated survival of juvenile hatchery Coho juveniles released during the fall into the four CMP lifecycle monitoring streams (tributaries to the Russian River) ranged from 0.26 to 0.35 in 2020 (California Sea Grant 2020).

Survival

To decouple early emigration from juvenile overwinter Coho Salmon survival, we would like to implement the multistate mark-recapture model in Dry Creek each year if possible. By carefully planning releases of hatchery-reared juvenile Coho, we could evaluate differences in survival among groups of fished released in different seasons (e.g., spring vs. fall) or using different release strategies (net pen acclimated vs. direct stream release). The multistate model could also be useful for estimating overwinter survival of steelhead in Dry Creek (and elsewhere), and it offers promise for incorporating PIT antenna detection information to estimate the joint probabilities of surviving but not smolting vs. surviving and smolting. However, use of the multistate for these purposes will only be possible in years when the paired antenna array at the mouth of Dry Creek is not compromised by high winter flows. A way to decrease the chances of that occurring is to add additional antennas to the existing array so that in case an antenna is compromised, there would be a backup already in place.

Even though the recent drought conditions present challenges to fish populations in the Russian River watershed, the exceptionally low flow conditions in winter 2020/21 afforded us the opportunity to estimate apparent survival between release and Dry Creek mouth and from Dry Creek mouth to Mirabel dam. Because stream fidelity and survival are confounded, the apparent survival estimates are certainly lower than they would be if we could account for early emigration. Nevertheless, it is interesting that there was very little difference between spring and fall release groups in apparent survival to Dry Creek mouth despite fish spending different amounts of time in the wild. This suggests that, overall, survival of juvenile Coho Salmon during the summer in Dry Creek is probably high. We hypothesize that the greater difference in apparent survival of smolts migrating from Dry Creek to Mirabel dam for these same release groups (i.e., higher apparent survival for fall release) may be due to differences in body size at the time of release. Though we did not measure individual body size (fork length and mass) at release, we did measure all individuals when they were PIT-tagged at the hatchery. This revealed that the average fork length of fall releases (83 mm) was 15 mm greater than the average fork length of spring releases (68 mm). We evaluated whether there was an effect of size at tagging on apparent survival using fork length in a logistic sub-model of the CJS. The result clearly showed a positive relationship between size and apparent survival from Dry Creek mouth to Mirabel dam but no such relationship between size and apparent survival from release to Dry Creek mouth.

Validation metrics

In 2020, we continued data collection to inform the validation performance measures outlined in the Dry Creek AMP (Table 5.3.1 and Table 5.3.9). Target water depths and the high amount of cover in newly constructed enhancement sites that are characteristic of good juvenile rearing habitat make it difficult to effectively use sampling gear in Dry Creek that is often useful for estimating abundance in smaller streams (e.g., backpack electrofishing, snorkeling). Because of this, we are not always confident in the accuracy of our abundance estimates based on mark-recapture estimates at the site scale. We attempted to overcome the limitations of electrofishing and snorkeling by beach seining in some of the enhancement sites. Although this was somewhat more effective it was still not completely satisfactory because of the net hanging up on root wads, etc. that allowed fish to evade capture. We anticipate that using these methods to obtain accurate abundance estimates at the site scale will continue to be challenging and, in some cases, impossible. Largely because of PIT tag monitoring, however, we have had greater success in evaluating habitat utilization of enhancement sites (a primary metric) as well as fidelity and survival (secondary metrics) at reach and stream scales. Our approach for these evaluations necessarily relies on a source of PIT-tagged fish so while electrofishing and seining are limited for estimating abundance directly, they are the only means to capture juvenile fish residing in Dry Creek for PIT-tagging. Strategic placement of PIT antennas near side channel inlets/outlets and the fact that we can operate them from spring into winter in deeper water regardless of cover and visibility has facilitated fish detection in places where and at times when electrofishing, seining and snorkeling would be impossible. We anticipate that PIT tags will be a similarly effective tool for measuring growth.

In 2020, density estimates of juvenile steelhead in enhancement sites were higher when compared to non-enhanced sites in the main channel (Figure 5.3.12). We observed a continuing trend of relatively consistent and high use of enhancement sites by juvenile steelhead, and we observed a tendency for many individuals to make use of more than one enhancement site especially in upper Dry Creek where sites are close to one another. The median residence time of juvenile steelhead in the Army Corps 14 side channel of 42 days indicates that some fish are making use of at least this particular enhancement site for a significant period of time.

Because of the low number of Coho Salmon in the Dry Creek watershed upstream of the Dry Creek trap site, we continue to only be able to obtain a minimum count. The Chinook Salmon smolt estimate was significantly higher than the previous five years and slightly higher than the long-term average (Figure 5.3.15). This is somewhat surprising given the somewhat later date of trap installation in 2020 as compared to other years (Figure 5.3.13). The PIT-based model to approximate juvenile steelhead survival to the (presumed) smolt stage has become the only practical way to achieve a relative idea of annual steelhead smolt production from Dry Creek. We are still developing approaches to inform this model but early results offer promise for eventually giving us at least a qualitative idea of annual steelhead smolt abundance so we can make comparisons among years.

Table 5.3.9. Outcomes from validation monitoring conducted in 2020 in Dry Creek habitat enhancements.

Metric	Life stage	Species	River km	Enhancement site	Method	Season	Outcome
habitat use	juvenile	Coho Salmon	13.53	Lonestar	snorkel	summer	present
			13.82	Meyer	snorkel	summer	present
					PIT antenna	summer/ fall/ winter	present
			14.01	Truett Hurst	electrofish	summer	present
			20.15	Gallo	PIT antenna	summer/ fall/ winter	present
			20.48	Weinstock	electrofish	summer	present
					PIT antenna	summer/ fall/ winter	present
			21.02	Army Corps Reach 14	electrofish	summer	present
					PIT antenna	summer/ fall/ winter	present
		steelhead	13.53	Lonestar	snorkel	summer	present
			13.82	Meyer	snorkel	summer	present
					PIT antenna	summer/ fall/ winter	present
			20.15	Gallo	snorkel	spring	present
					PIT antenna	Summer/ fall	present
			20.48	Weinstock	PIT antenna	summer/ fall/ winter	present
			21.02	Army Corps Reach 14	snorkel	spring/ summer	present
					PIT antenna	summer/ fall/ winter	present
		Chinook Salmon	20.15	Gallo	snorkel	spring	present
			21.02	Army Corps Reach 14	snorkel	spring	present
habitat use	adult	Coho Salmon	20.15	Gallo	PIT antenna	summer/ fall/ winter	present
			20.48	Weinstock	PIT antenna	fall/ winter	present
			21.02	Army Corps Reach 14	PIT antenna	fall/ winter	present
		steelhead	20.15	Gallo	PIT antenna	fall/ winter	present
			20.48	Weinstock	PIT antenna	fall/ winter	present
			21.02	Army Corps Reach 14	PIT antenna	fall/ winter	present
		Chinook Salmon	13.82	Meyer	PIT antenna	fall/ winter	present
			20.15	Gallo	PIT antenna	fall/ winter	present
			20.48	Weinstock	PIT antenna	fall/ winter	present
			21.02	Army Corps Reach 14	PIT antenna	fall/ winter	present
density (fish * m^{-2})	juvenile	steelhead	14.06	Truett Hurst	electrofish	summer	0.52^{-2}
			20.48	Weinstock	electrofish	summer	0.41^{-2}
			21.02	Army Corps Reach 14	electrofish	summer	0.28^{-2}

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CHAPTER 6 Coho Salmon Broodstock Program Enhancement

NMFS' Russian River Biological Opinion compels the USACE to continue operation of a conservation hatchery to provide a source of genetically appropriate juvenile Coho Salmon to release into the Russian River watershed. The hatchery program is instrumental to Russian River Coho population recovery and Coho releases are widely recognized as the main reason the Russian River population was not extirpated. The Biological Opinion and Consistency Determination obligate Sonoma Water to provide hatchery support by increasing the production of Coho smolts. This support has primarily been in the form of funding for fish-rearing tanks, purchase of PIT tags, and technical staff to assist with hatchery operations including PIT-tagging of hatchery-reared juveniles. Sonoma Water has also contributed a significant amount of information through direct data collection, financial and staff support to partner entities, and consistent participation on the Russian River Coho Salmon Captive Broodstock Program (RRCSCBP) Technical Advisory Committee (TAC).

In addition to hatchery operations, USACE must also conduct annual monitoring of the distribution and survival of stocked juvenile salmon and the subsequent return of adult Coho to the Russian River. Much of the Coho monitoring in the Russian is implemented by CSG with base funding from USACE. However, Sonoma Water has and will continue to make significant contributions to the collection of monitoring data to allow evaluation of program success. These contributions include data collected at Sonoma Water operated fish monitoring sites (i.e., downstream migrant traps and stationary PIT antenna arrays) as well as assistance to CSG in conducting studies to identify population bottlenecks (e.g., low flow studies) and inform solutions to overcoming those bottlenecks (e.g., Russian River Coho Water Resources Partnership).

The technical aspects of Coho Salmon population recovery are complex, and it is often difficult to evaluate recovery strategies and program success in light of the host of factors operating at a variety of scales to shape Coho populations. The RRCSCBP TAC is a multi-partner effort involving USACE, CDFW, NMFS, CSG, and Sonoma Water. The TAC provides invaluable advice to ensure genetically sound broodstock management, and it develops annual plans for hatchery Coho releases with the primary objective of balancing survival of early life stages in the wild against the risk of artificial selection from releasing older life stages that are reared in the hatchery for a longer period of time. Many of the innovative monitoring methods spearheaded by CSG and Sonoma Water feedback to inform these plans while at the same time providing metrics of program success such as tributary-specific smolt production and numbers of adult returns (see CSG data reports 2004 through present) – both of which have been identified as key metrics in state and federal recovery plans.

A component that has been lacking until recently is a better understanding of the broader context in which salmonid demographic processes operate. In 2013, Sonoma Water and CSG began implementing CDFW's Coastal Monitoring Program (CMP, Adams et al. 1980). The broad-scale metrics from this coastwide effort have and will continue to inform Coho Salmon recovery in the Russian River watershed and elsewhere by helping to decouple those factors that are largely outside our control (e.g., marine survival) from in-watershed recovery efforts.

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CHAPTER 7 Adult Salmonid Returns

7.1 Adult Salmonid Escapement

Since 2000, Sonoma Water has been operating video cameras in the east and west fish ladders to assess the adult Chinook salmon run passing the Mirabel inflatable dam (rkm 39).

Methods

A digital camera and lighting system was installed in the east and west Mirabel fish ladders. Individuals were counted as moving upstream once they exited the upstream end of the camera's view. For each adult salmonid observed, the reviewer recorded the species, date, and time of upstream passage. During periods of low visibility, it was not always possible to identify fish to species although identification as an adult salmonid was usually possible. Adult salmonids that could not be identified to species were lumped into a general category called "unknown salmonid." Unknown salmonids were then partitioned into species by taking the proportion of each species positively identified in the ladder on a given day and multiplying the number of unknown salmonids on that same day by these proportions. On days when no salmonids could be identified to species, an average proportion from adjacent days was used to assign species for the unidentified salmonids on that day.

Results

In 2020, the Mirabel fish ladder cameras were in operation from September 1 to January 26, 2021 (Figure 7.1.1). With a few exceptions these cameras were operated 24 hours/day after installation until they were removed (Figure 7.1.2).

Chinook Salmon

For the 2020 video monitoring season, 626 adult Chinook Salmon were observed passing the Mirabel fish counting station (including "unknown salmonids" prorated as Chinook) (Table 7.1.1). A total of 63 fish were categorized as an "unknown salmonid" (i.e., they possessed the general body shape of an adult salmonid but could not be identified to species). Of these 63 unknown salmonids 21 were partitioned to Chinook Salmon.

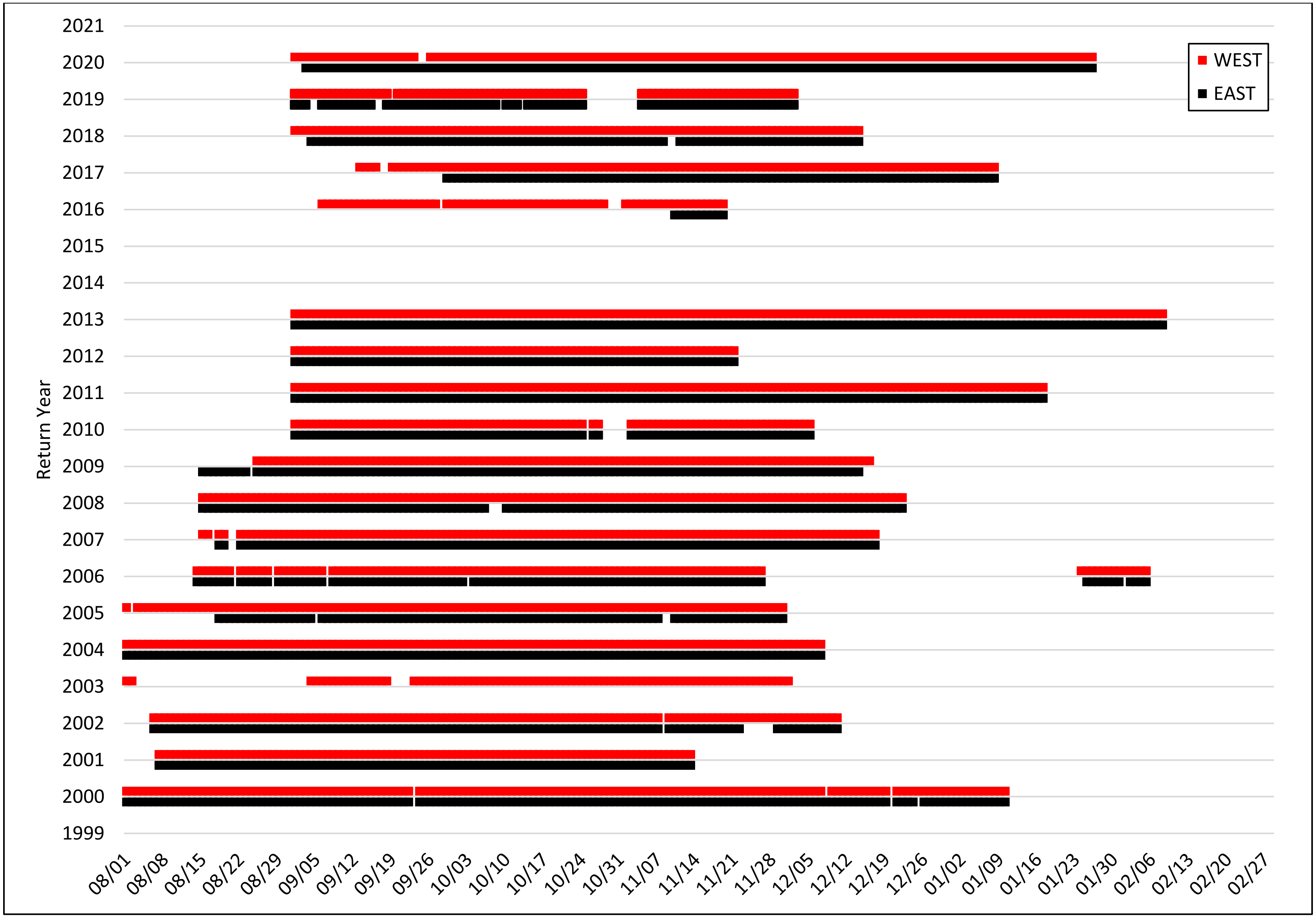

Figure 7.1.1. Period of operation by adult salmonid return year for the video counting station at the Mirabel dam.

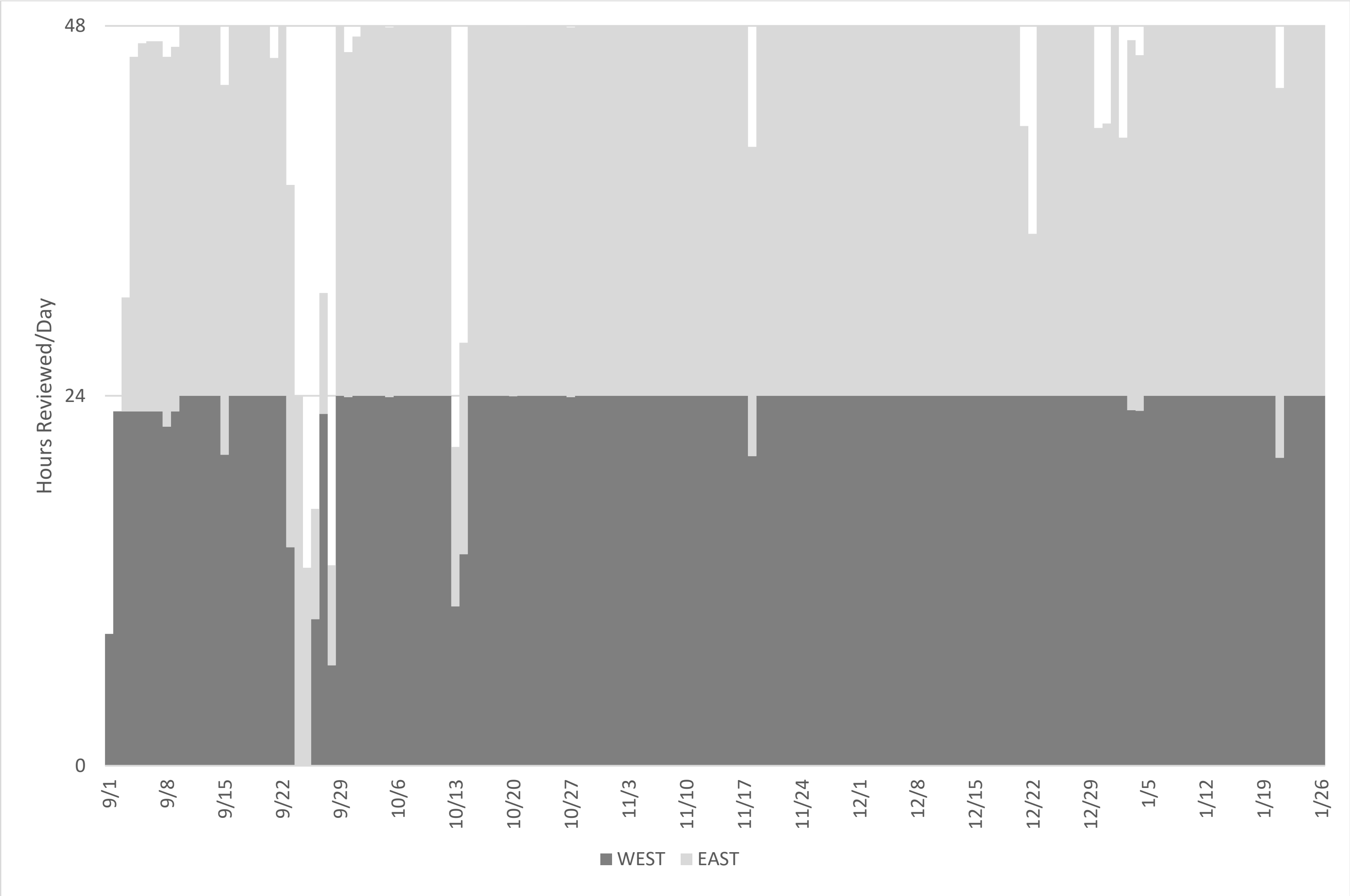

Figure 7.1.2. Number of hours/per day that the west and east fish ladder cameras were in operation at the Mirabel dam in 2020.

Table 7.1.1. Weekly count of adult Chinook salmon at the Mirabel dam fish ladders, 2000-2020. Dashes indicate that no sampling occurred during that week.

Week	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
15-Aug	0	0	1	--	0	0	0	0	0	0	--	--	--	--	Not operated	Not operated	--	--	--	--	--
22-Aug	1	0	8	--	0	1	1	0	0	0	--	--	--	--			--	--	--	--	--
29-Aug	0	3	7	2	1	4	0	0	1	0	0	0	0	1			--	--	2	0	0
5-Sep	9	1	18	7	1	4	0	0	0	0	0	0	1	1			0	--	0	0	1
12-Sep	36	7	19	20	3	14	3	0	2	0	0	0	2	2			0	0	1	0	0
19-Sep	25	12	65	23	8	14	4	1	17	0	3	1	0	1			0	3	4	4	0
26-Sep	50	17	1223	181	16	31	8	4	84	0	1	158	70	17			8	2	37	43	12
3-Oct	31	240	113	146	42	27	317	10	126	78	669	534	51	44			32	91	77	29	3
10-Oct	115	51	628	515	52	112	87	39	82	562	896	390	551	4			291	50	47	26	0
17-Oct	81	10	272	232	651	556	532	26	13	177	153	1070	1886	8			392	125	158	52	1
24-Oct	465	300	153	532	2287	309	114	106	22	285	280	273	996	27			131	81	50	2	80
31-Oct	64	661	505	2969	185	613	1531	250	511	135	94	223	1654	315			56	612	68	22	40
7-Nov	23	81	2337	1289	1189	699	298	429	174	335	169	90	619	731			50	366	60	170	135
14-Nov	182	--	20	47	221	127	459	154	15	38	43	120	851	1063			103	508	145	110	216
21-Nov	201	--	37	95	57	63	53	96	24	129	113	266	50	179			--	71	461	333	64
28-Nov	110	--	14	45	60	33	--	425	19	24	76	6	--	99			--	82	66	131	9
5-Dec	19	--	53	--	16	--	--	476	18	9	5	1	--	172			--	24	38	--	14
12-Dec	15	--	--	--	--	--	--	4	8	28	--	2	--	125			--	24	6	--	36
19-Dec	17	--	--	--	--	--	--	--	13	--	--	10	--	73			--	16	--	--	2
26-Dec	1	--	--	--	--	--	--	--	--	--	--	16	--	32			--	27	--	--	4
2-Jan	0	--	--	--	--	--	--	--	--	--	--	2	--	53			--	11	--	--	5
9-Jan	0	--	--	--	--	--	--	--	--	--	--	10	--	58			--	--	--	--	3
16-Jan	--	--	--	--	--	--	--	--	--	--	--	1	--	28			--	--	--	--	2
23-Jan	--	--	--	--	--	--	0	--	--	--	--	--	--	73			--	--	--	--	0
30-Jan	--	--	--	--	--	--	0	--	--	--	--	--	--	36			--	--	--	--	--
6-Feb	--	--	--	--	--	--	--	--	--	--	--	--	--	10			--	--	--	--	--
Total	**1,445**	**1,383**	**5,474**	**6,103**	**4,788**	**2,607**	**3,407**	**2,021**	**1,129**	**1,800**	**2,502**	**3,173**	**6,730**	**3,152**	**--**	**--**	**1,062**	**2,093**	**1,219**	**922**	**626**

*Video cameras were reinstalled and operated from 4/1-6/27/2007 but no Chinook were observed.

**Video cameras not operated in 2014 and 2015 because the site was under construction in order to construct the new fish screens and ladder.

***Typically 1 camera is operated in both fish ladders but in 2016 a video camera was only operated in the east ladder for the final 10 days of the season.

Coho Salmon

During the monitoring period for the 2020 return year, we observed 324 adult Coho Salmon. These images were reviewed by fisheries biologist from Sonoma Water and California Sea Grant (CSG). Because of the timing of camera operations, which are tied to dam operations, and the location of these monitoring sites upstream of significant amounts of Coho habitat in the basin, these counts are not the best indicator of adult Coho returns to the basin. Instead, we suggest the basinwide redd survey estimate of 139 (95% CI: 58-220) as the most comprehensive and accurate indicator of all adult Coho (hatchery- and natural-origin) returning to the Russian River basin in 2020-21. This estimate is based on spawner surveys in the Coho stratum of the Russian River Coastal Monitoring Program sample frame (see Adams et al. 2011 for details).

Steelhead

Based on hatchery returns, steelhead migrate and spawn in the Russian River primarily between December and March; however, we removed the Mirabel cameras in January and there is significant portion of the steelhead run occurs after January. In total, 685 steelhead were observed migrating through the Mirabel Fish ladder between September 1, 2020 and January 26, 2021.

Conclusions and Recommendations

In 2020 we were able to successfully operate video cameras in both fish ladders for the duration of the Chinook migration, but this was not without some difficulty. In 2016 Sonoma Water decided that it is unsafe to supply 110-volt power to the east side video camera and lights by routing the cable underwater along the stream bottom. There appeared to be few alternative ways to supply power to east side of the river. In 2020 we relied on deep cycle batteries to supply power to the lights on the east side of the river. This required frequent battery changes. In addition to the difficulties supplying power to the east side Chinook continued to spend an unusually long time in front of the west video camera in 2020. Frequently there were many Chinook milling in front of the camera. These fish would move upstream out of view of the camera and then drop back downstream out of the view of the camera. When many fish were exhibiting this behavior at the same time double counting became a possibility. The reviewers had to watch the video at a slower speed, which made the review process more laborious.

The Mirabel video system continues to provide useful data on the Russian River Chinook run. We recommend continuing to operate the camera system in future years.

7.2 Chinook Salmon Spawning Ground Surveys

Although not an explicit requirement of the Biological Opinion, the Sonoma Water performs spawning ground surveys for Chinook salmon in the mainstem Russian River and Dry Creek. This effort compliments the required video monitoring of adult fish migration and has been stipulated in temporary D1610 flow change orders issued by the State Water Resources Control Board to satisfy the Biological Opinion (see CHAPTER 3 Pursue Changes to Decision 1610 Flows of this report). Sonoma Water began conducting Chinook salmon spawning surveys in fall 2002 to address concerns that reduced water supply releases from Coyote Valley Dam (Lake Mendocino) may affect migrating and spawning Chinook salmon (Cook 2003). Spawner surveys in Dry Creek began in 2003.

Background information on the natural history of Chinook salmon in the Russian River is presented in the 2011 Russian River Biological Opinion annual report (Manning and Martini-Lamb 2011). The primary objectives of the spawning ground surveys are to (1) characterize the distribution and relative abundance of Chinook salmon spawning sites, and (2) compare annual results with findings from previous study years.

Methods

Chinook salmon redd (spawning nest) surveys are conducted annually in the Russian River during fall. Typically, the upper Russian River basin and Dry Creek are surveyed (Figure 7.2.1).

The study area includes approximately 114 km of the Russian River mainstem from Riverfront Park (40 rkm), located south of Healdsburg, upstream to the confluences of the East and West Forks of the Russian River (154 rkm) near Ukiah. River kilometer (rkm) is the meandering stream distance from the Pacific Ocean upstream along the Russian River mainstem and for Dry Creek the distance from the confluence with the Russian River upstream. In 2003, the study area was expanded to include 22 rkm of Dry Creek below Warm Springs Dam at Lake Sonoma to the Russian River confluence.

The Chinook salmon spawning ground study consists of a single-pass survey during the estimated peak of Chinook salmon fall spawning. A crew of two biologists in kayaks visually searched for redds along the streambed. Riffles with several redds are inspected on foot. The locations of redds are recorded using a global positioning system (GPS).

Surveys are cancelled or postponed if increased turbidity from heavy rainfall and subsequent high flows that obscures the detection of redds. During high flows surveys are often possible in Dry Creek due to regulated, clear water releases from Lake Sonoma. Also, increases in turbid water releases from Coyote Dam at Lake Mendocino since around 2011 have prevented an accurate count of redds in Ukiah and Canyon study reaches.

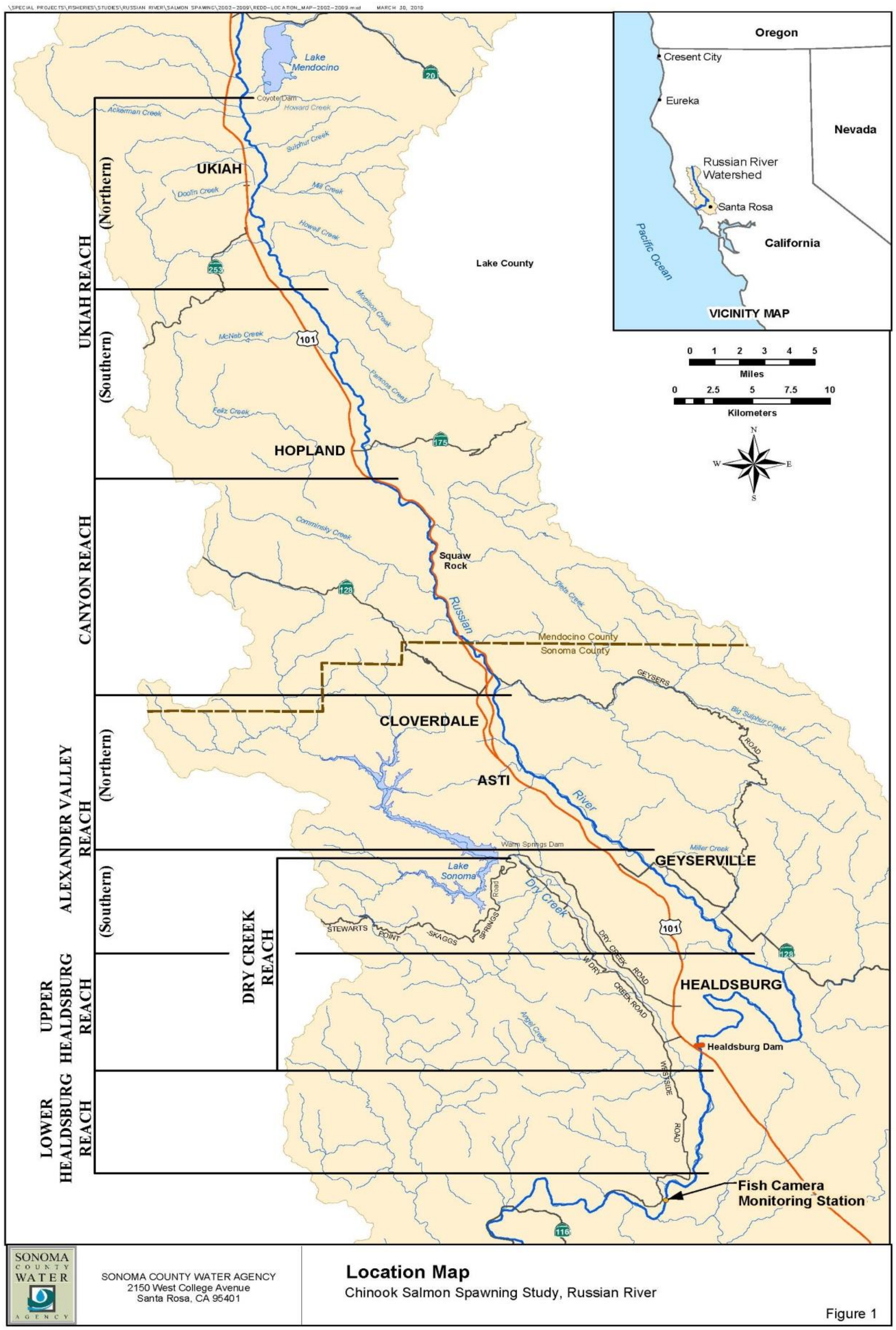

Figure 7.2.1. Chinook salmon spawning survey reaches. Only Canyon (middle and lower sections), Alexander Valley, Upper Healdsburg, Lower Healdsburg, and Dry Creek reaches were surveyed in 2020.

Results

Chinook spawning surveys were conducted in the Russian River from Alexander Valley to Upper Healdsburg between December 7 and December 15, 2020. Chinook salmon spawning surveys were curtailed in Ukiah and Canyon reaches due to high turbidity from Lake Mendocino water releases. Dry Creek surveys were conducted on December 7-8, 2020.

Most of the Chinook salmon spawning typically occurs in the upper Russian River mainstem and Dry Creek (Table 7.2.1). During 2020, there were 47 redds observed in the Alexander Valley and Upper Healdsburg reaches of the Russian River. The redd count for Alexander Valley at 29 was the second lowest on record, while Upper Healdsburg redd count at 18 was the third lowest since surveys began in 2002. In Dry Creek there were 91 Chinook salmon redds detected, which is below the average in Dry Creek at 190/year. The highest count of redds in Dry Creek was 362 redds in 2012. Overall, there has been a substantial decline in the number of Chinook redds in the Russian River watershed since around 2015 (Table 7.2.1).

Conclusions and Recommendations

Although Chinook salmon surveys were restricted to three reaches in 2020 the distribution of redds appear to be similar to other study years. The abundance of Chinook salmon redds have shown a sharp decline since 2015. There are many factors that could be driving this trend. It is likely that several years of severe drought in the region is a major contributor to the low abundance of redds.

Table 7.2.1. Chinook Salmon redd abundances by reach, upper Russian River, and Dry Creek, 2002-2020. Redd counts are from a single pass survey conducted during the peak of fall spawning activity. *Survey either not completed or incomplete.

Reach	River km	2002	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	2020
Ukiah	33.1	511	464	284	*	248	118	20	38	*	*	90[2]	81	*	*	*	*		*	*
Canyon	20.8	277	190	169	*	68	88	36	38	*	*	*	43	*	*	16[2]	*		*	*
Alexander Valley	26.2	163	213	90	*	62	131	65	129	*	97	185	163	*	61[2]	41[2]	39	25	*	*
Upper Healdsburg	25.6	79	40	8	*	23	67	48	38	*	66	53	57	*	*	1[2]	14		*	29
Lower Healdsburg	8.2	6	0	7	*	1	2	9	30	*	7	4	18	*	*	*	6		*	18
Russian River	**113.9**	**1036**	**907**	**558**	*	**402**	**406**	**178**	**273**	*	**170**	**332**	**362**	*	*	*	*	*	*	*
Dry Creek	21.7	*	256	342	*	201	228	65[1]	223	269	229	362	325	*	78	90	112	86	15	91

[1]Redd numbers are an estimate.
[2]Redd numbers are presumably an underestimate due to poor survey conditions.

References

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CHAPTER 8 Synthesis

Introduction

Many of the monitoring approaches used by Sonoma Water and recommended in NMFS' 2008 RRBiOp have proven effective in collecting the data necessary to address objectives outlined in the RPA. Since we began implementing the RRBiOp, Sonoma Water has consistently collected data on salmon and steelhead populations from the Russian River estuary, the mainstem upstream to Lake Mendocino, Dry Creek, and three lower basin tributaries (Mark West, Dutch Bill and Austin creeks) (Figure 8.1 and Figure 8.2). Monitoring conducted by CA Sea Grant in Mill, Green Valley, and Willow creeks has yielded similar data that has been important for addressing these same objectives as well as objectives related to the post-release performance of hatchery-reared Coho Salmon in the watershed. In addition to illustrating the spatial and temporal extent of monitoring activities in the basin, this chapter is intended to highlight some of the important ways that a combination of monitoring approaches in a variety of locations addresses RPA objectives while serving the broader goal of salmonid recovery in the basin.

To better understand how flood control and water supply operations may be impacting salmon and steelhead populations in the watershed and whether efforts to offset those impacts are successful, much of our fish and habitat monitoring is focused on specific locations at specific times. Although results from these targeted efforts on their own have been useful for addressing some RPA objectives, the extent to which operations and mitigation are responsible for the observed patterns is not always clear. What is clear, however, is that focused RPA monitoring alone cannot account for all broadscale drivers (e.g., drought, marine survival) that are profoundly impacting anadromous salmonid populations.

To help address this issue, additional monitoring that is currently being implemented in the watershed is helping to provide the broader context in which operations and mitigation may be impacting and benefiting salmonid populations. An important example includes Sonoma Water and CA Sea Grant implementation of the California Coastal Monitoring Program (Adams et al. 2011) in tributaries of the lower watershed. This work along with results from Russian River Coho Salmon Broodstock Program monitoring and flow/water quality monitoring compelled by Temporary Urgency Change Orders issued to Sonoma Water has improved our understanding regarding when and why a particular population or life stage may be more or less abundant.

Despite the extensive monitoring being conducted in the watershed, some of the monitoring methods and approaches that may be effective in smaller streams (e.g., backpack electrofishing to estimate population abundance, beach seining to describe steelhead habitat use) are only marginally useful in some of the larger streams where Sonoma Water conducts fish population monitoring (e.g., Dry Creek, estuary). Additionally, downstream migrant traps which can often be operated during periods that encompass Coho and Chinook Salmon smolt migration seasons cannot be operated during periods that encompass steelhead smolt migration. Furthermore, our experience operating traps to count adult returns to the basin have only been marginally effective and only possible in small tributaries that would not necessarily give an accurate picture of the total number of returns to the watershed.

The limitations of certain monitoring approaches that depend on fish capture have spurred us to develop and rely on remote monitoring approaches including video monitoring and year-round operation of PIT antenna arrays. These approaches have allowed us to evaluate habitat use by juvenile salmonids in Dry Creek, estimate annual abundance of steelhead and Coho Salmon smolts, calculate expanded counts of adult Coho Salmon and achieve annual counts of adult Chinook Salmon to the basin. For an indicator of adult steelhead abundance, we use estimates of redd abundance from CMP spawner surveys throughout tributaries of the lower basin. Because these redd estimates are only in the lower basin, perhaps a better indicator of adult steelhead returns (though still only relative) are counts of adult steelhead returning to Warm Springs and Coyote Valley fish hatcheries.

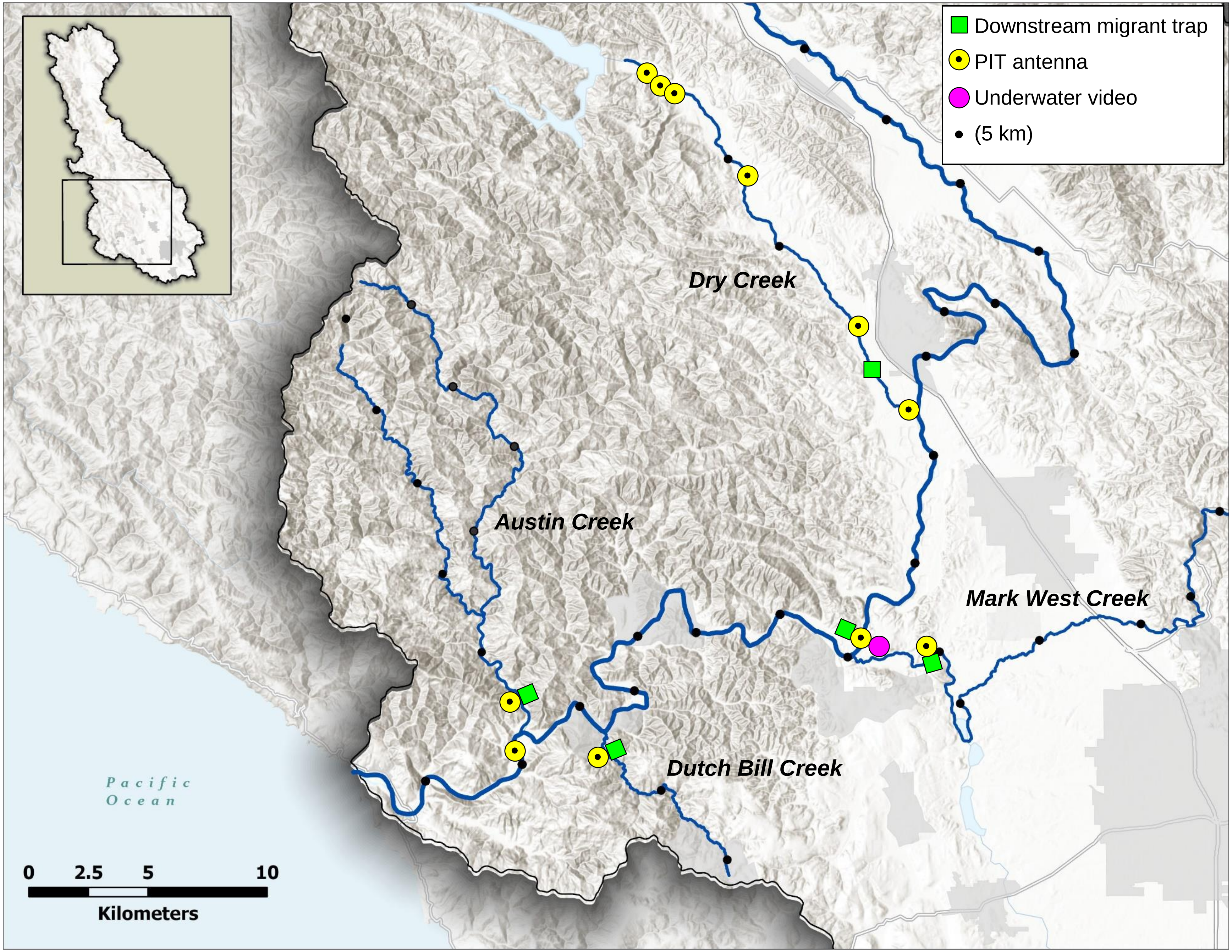

Figure 8.1. Spatial extent of fisheries monitoring related to the Russian River Biological Opinion.

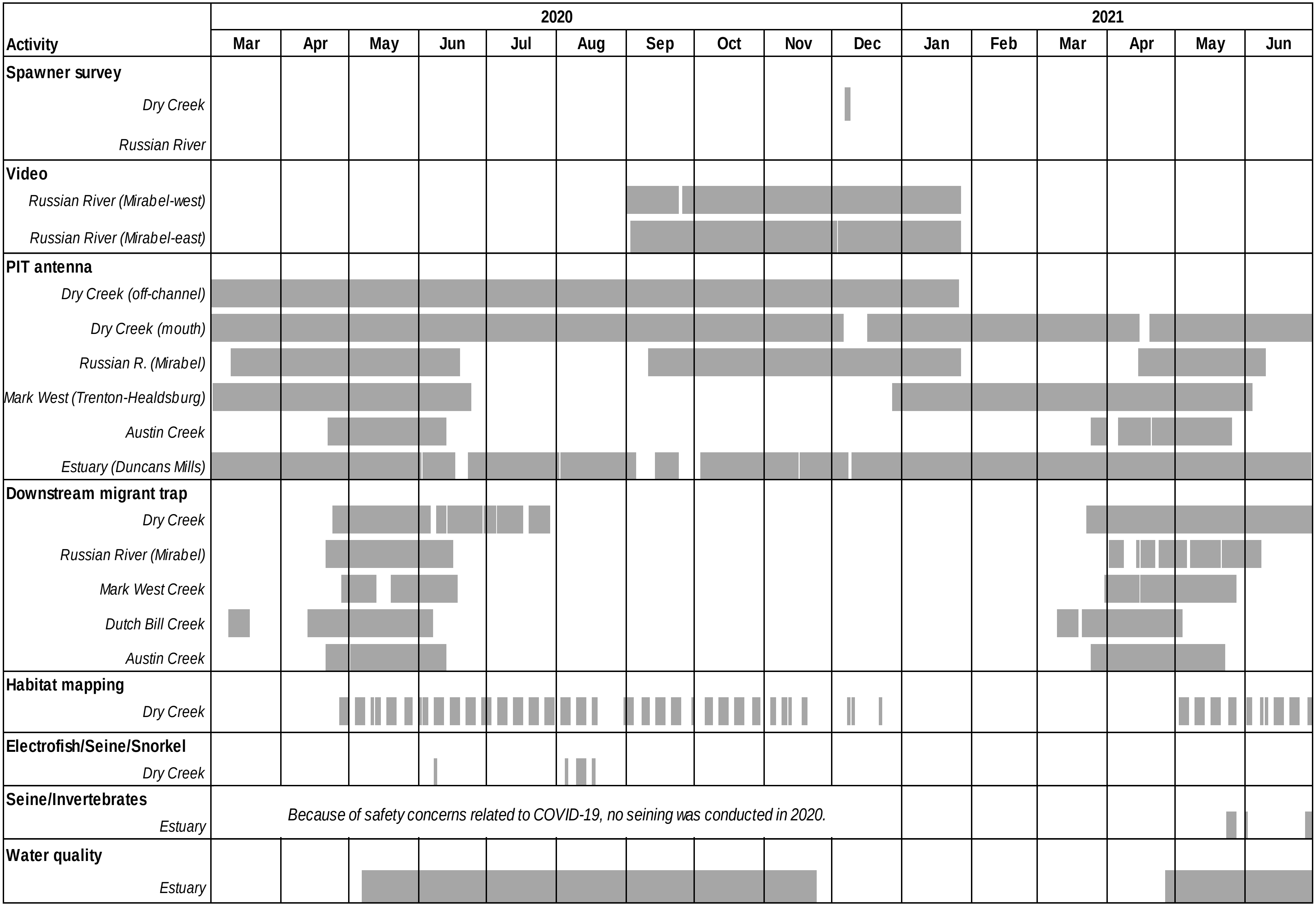

Figure 8.2. Temporal extent of fish and water quality monitoring related to the Russian River Biological Opinion, late winter 2020-early summer 2021.

Methods

The methods leading to the results provided in this chapter are detailed in previous chapters of this data report as well as previous data reports.

Results

Juvenile steelhead downstream migrant trap catch at all five traps, combined, was similar to 2018 and 2019 with a decided increase in Dutch Bill Creek and decrease in Dry Creek (Figure 8.3). Juvenile steelhead density from backpack electrofishing in Dry Creek showed a decrease relative to recent years (Figure 8.4, top panel) but the Chinook smolt estimate in both Dry Creek and at Mirabel showed an increase over previous years (Figure 8.4, middle panel). Captures of natural-origin Coho smolts were low everywhere, as has been the case since we began monitoring, but there were a significant number captured in Dutch Bill Creek (Figure 8.4, bottom panel). Relative to previous years, adult steelhead returns to Russian River hatcheries were even lower than 2019-20 (Figure 8.5, top panel) and the adult Chinook run continued to be disappointingly low and trending down (Figure 8.5, middle panel) as were the number of Coho Salmon returnees (Figure 8.5, bottom panel).

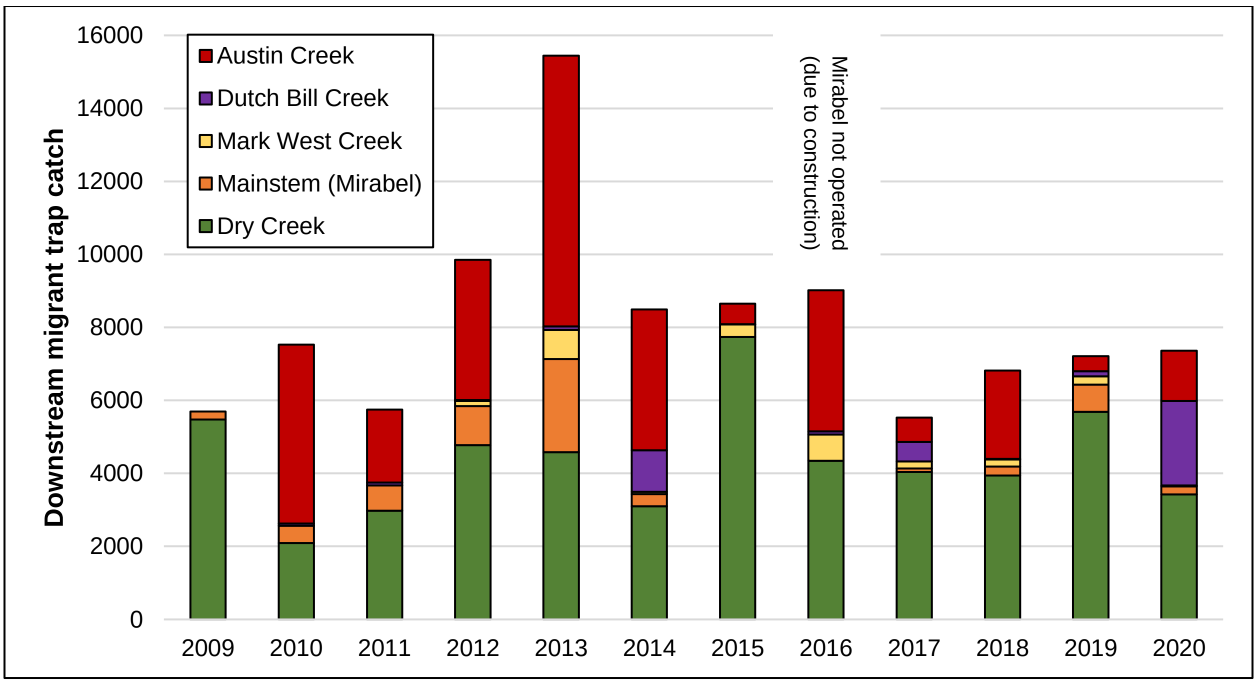

Figure 8.3. Number of juvenile steelhead (YOY and smolt combined) captured at downstream migrant traps operated by Sonoma Water, 2009-2020.

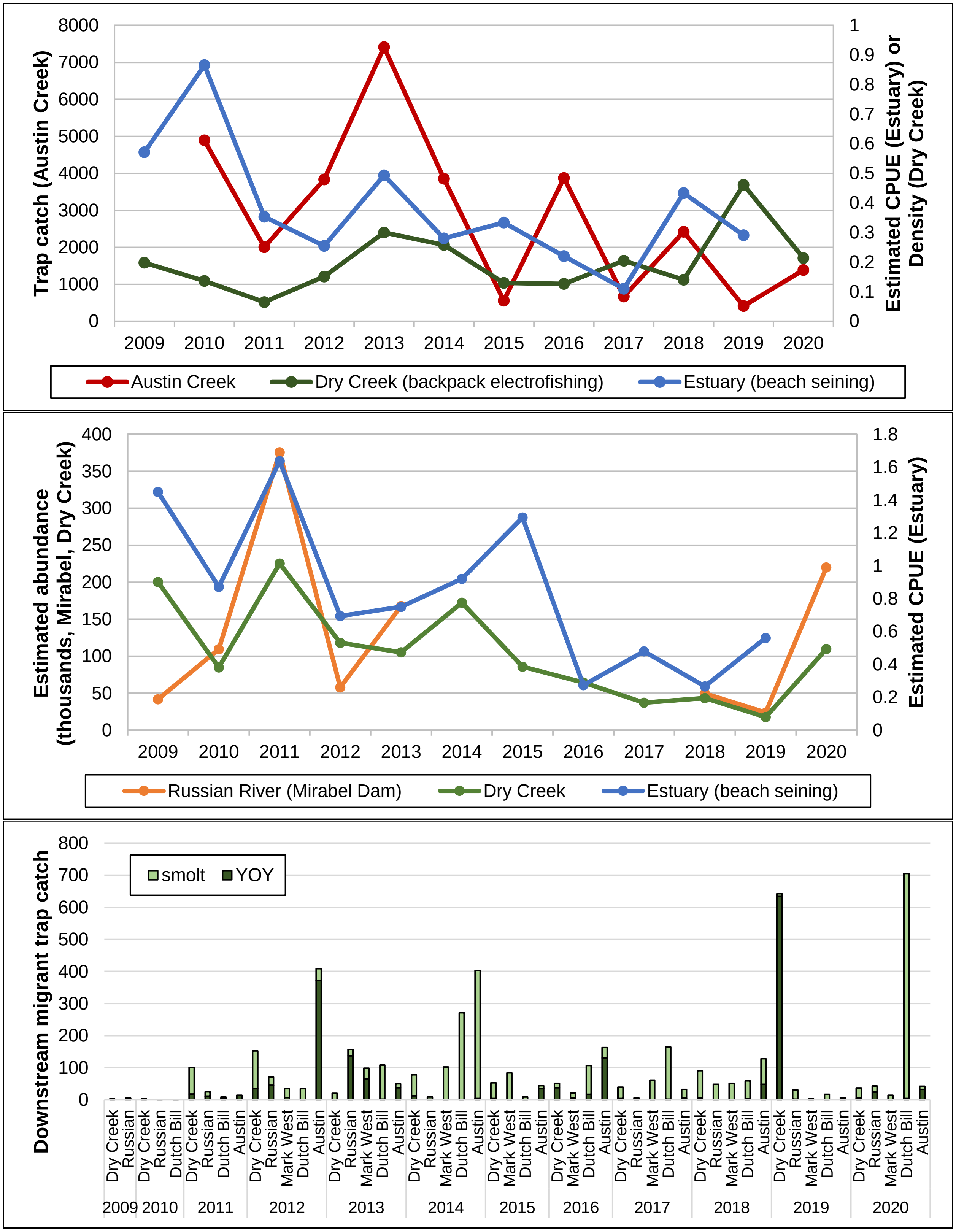

Figure 8.4. Indicators of trends in natural-origin juvenile steelhead (top panel), Chinook smolts (middle panel) and natural-origin Coho smolts and YOY (lower panel).

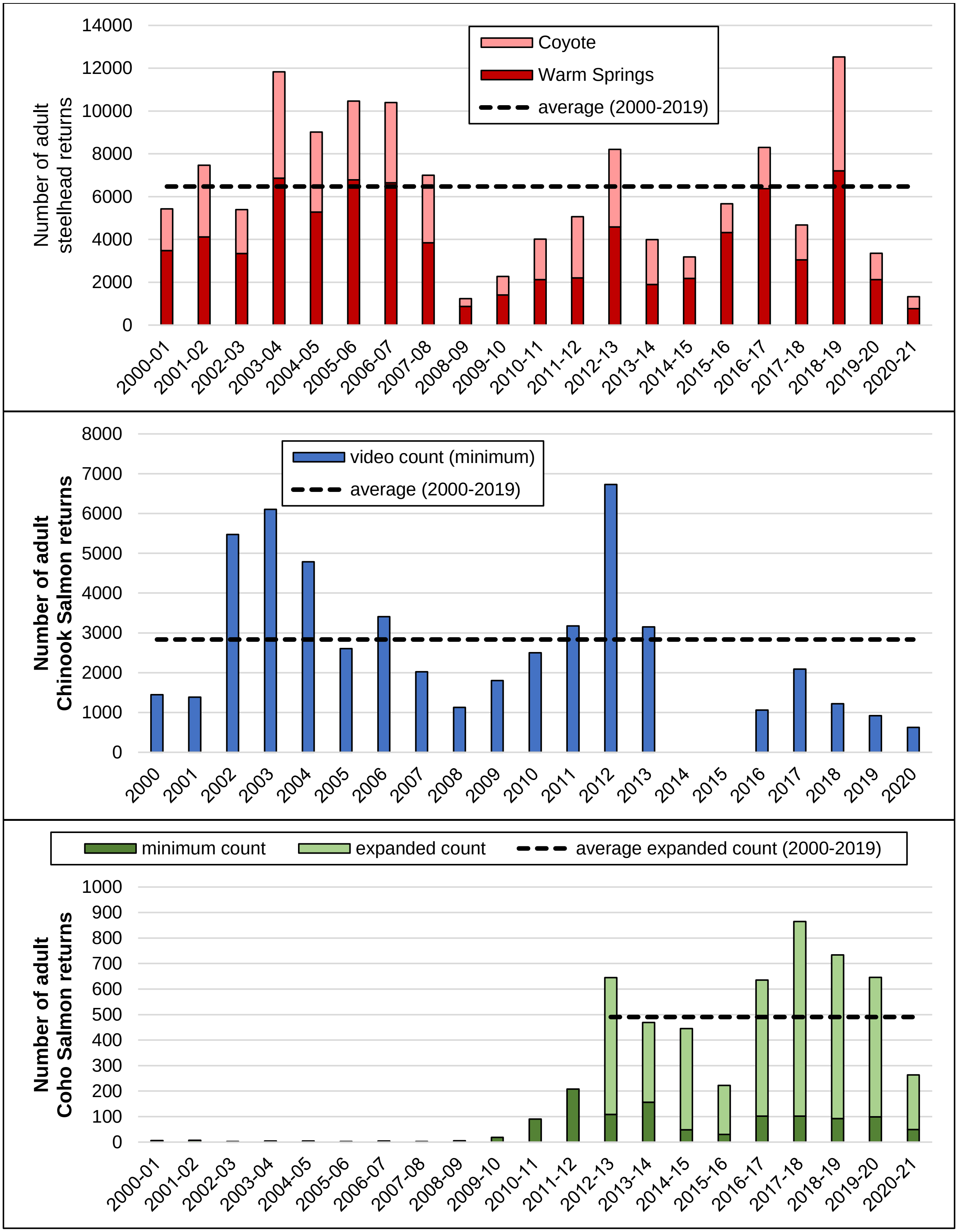

Figure 8.5. Indicators of adult steelhead (counted at Russian River hatcheries), adult Chinook (based on video counts at Wohler-Mirabel) and Coho Salmon returns (from CA Sea Grant).

Conclusions and Recommendations

The salmonid monitoring program in the Russian River has provided extremely valuable data for evaluating the impacts of flood control and water supply operations on salmon and steelhead populations. We recommend continuing existing monitoring that has proven effective while simultaneously seeking ways to overcome weaknesses in monitoring approaches. A primary example of a weakness in our monitoring includes steelhead smolt estimation. We developed a conceptual framework (smolt abundance model) to overcome the issue of depending solely on downstream migrant trapping to gain these abundance estimates. Now that we have begun implementing this model, we can begin to evaluate its efficacy and refine the approach as necessary.

We will also continue to continue seek ways to incorporate data sources collected at different scales to view the data we collect within broader watershed and regional scales. This should allow us to more isolate and more accurately evaluate the benefits of mitigation measures as we implement them.

References

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