Salmonid Habitat Restoration Priorities (SHaRP) Action Plan for Four Lower Russian River Tributaries

2024

Recommended Citation

Russian River SHaRP. 2024. Salmonid Habitat Restoration Priorities (SHaRP) Action Plan for Four Lower Russian River Tributaries. California Department of Fish and Wildlife and National Oceanic and Atmospheric Administration Fisheries, Santa Rosa, CA. 118 pages.

Available for download at: North Coast Salmon Project

Email: NCSP@wildife.ca.gov

Acknowledgements

Our thanks to all who participated in the meetings and report review including, in alphabetical order: Alliance Redwoods, California Sea Grant, California State Parks, California Trout, North Coast Regional Quality Control Board, Camp Meeker Recreation and Parks District, Federated Indians of Graton Rancheria, Gold Ridge Resource Conservation District, Kashia Band of Pomo Indians, Mendocino Redwood Company, Natural Resources Conservation Service, North Coast Resource Conservation & Development Council, Occidental Arts and Ecology Center, O'Connor Environmental Inc./Coast Range Watershed Institute, Prunuske Chatham Inc., Permit Sonoma, Saint Dorothy's Rest, SPAWN, Sonoma County Regional Parks, Sonoma County Transportation and Public Works, Sonoma Land Trust, Sonoma Resource Conservation District, Sonoma Water, The Nature Conservancy, Trout Unlimited, UC Berkeley, U.S. Army Corps of Engineers, Westminster Woods.

Thank you, advisors and presenters, Brendan O'Neil (California State Parks), Brock Dolman (OAEC), Gregg Horton (Sonoma Water), Jeremy Kobor (CRWI), John Green (GRRCD), Lauren Hammack (PCI), Mariska Obedzinski (CSG), Matt O'Connor (CRWI), Sara Press (SLT), and Sarah Nossaman-Pierce (CSG) for sharing your experience and knowledge of the watersheds.

Thank you, GIS Support, Arthur Barros (CDFW), Martin Anderson (CDFW), Suzanne Lewis (Johns Hopkins Graduate Program) for your patience and creativity.

We would also like to extend our heartfelt thanks to landowners that attended the meetings and offered their valuable insights, and to the many landowners whose cooperation and support make this effort possible.

Steering Team

Mary Olswang (CDFW), Erin Seghesio (NMFS), Joe Pecharich (NMFS), Pete McHugh (CDFW), Manfred Kittel (CDFW), Desiree Dela Vega (CDFW), Derek Acomb (CDFW), David Hines (CDFW), Trevor Kumec (CDFW).

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Acronyms

AGOL - ArcGIS Online

BDA - Beaver Dam Analog

Broodstock Program - Russian River Coho Salmon Captive Broodstock Program

CC Chinook - California Coastal Chinook Salmon Evolutionarily Significant Unit

CCC Coho - Central California Coast Coho Salmon Evolutionarily Significant Unit

CCC Steelhead - Central California Coast Steelhead Distinct Population Segment

CDFW - California Department of Fish and Wildlife

CESA - California Endangered Species Act

CMP - California Monitoring Plan

CRWI - Coast Range Watershed Institute

CSG - California Sea Grant

DBC - Dutch Bill Creek

DPS - Distinct Population Segment

ESA - Endangered Species Act (Federal)

ESU - Evolutionarily Significant Unit

FIP - Functionally Independent Population

FRGP - Fisheries Restoration Grant Program

GVC - Green Valley Creek

GRRCD - Gold Ridge Resource Conservation District

HOR - Hatchery Origin Returns

LCM - Life Cycle Monitoring

MRC - Mendocino Redwood Company

NCSP - North Coast Salmon Project

NGO - Non-Governmental Organization

NMFS - National Marine Fisheries Service

NOAA - National Oceanic and Atmospheric Administration

NOR - Natural Origin Returns

NRCS - Natural Resources Conservation Service

OEI - O'Connor Environmental, Inc.

PACT - Priority Action Coho Team

PAD - Passage Assessment Database

PCI - Prunuske Chatham, Inc.

PIP - Potentially Independent Population

SRCD - Sonoma Resource Conservation District

SSC - Species of Special Concern

SHaRP - Salmonid Habitat Restoration Priorities

SIS - Species in the Spotlight

SLT - Sonoma Land Trust

SW- Sonoma Water

SRWQCB - State Regional Water Quality Control Board

SWRCB-– Water Boards - State Water Resources Control Board

The Coho Partnership/RRCWRP - Russian River Coho Water Resources Partnership

TU - Trout Unlimited

USACE - United States Army Corps of Engineers

WCB - Wildlife Conservation Board

WGF - Wilson Grove Formation

WRGB - Watershed Restoration Grants Branch

YOY - Young-of-year

Executive Summary

SHaRP Description

The Salmonid Habitat Restoration Priorities (SHaRP) process brings together government resource agencies, the restoration community, local experts, tribal government resource departments, and landowners to collectively discuss and recommend the most important reach-scale restoration actions needed to help anadromous salmonids complete their freshwater life cycle. The California Department of Fish and Wildlife and the National Oceanic and Atmospheric Administration Fisheries first developed and applied the SHaRP process in the South Fork Eel River tributaries, and it has since been extended to the lower Eel River, Mendocino Coast streams, Lagunitas Creek, and lower Russian River tributaries. The goal of SHaRP is to identify actions that can be implemented within a 10-year horizon. The key concepts, or pillars, that define SHaRP as a process and are essential for successful planning are:

Strength: SHaRP identifies the areas with the best potential to support source populations of salmonids, which is necessary for widespread recovery.

Community: SHaRP is a community planning effort. Fisheries agencies guide the process but do not dictate or determine the outcomes.

Agency Alignment: The resulting products will be consistent with State and Federal Recovery Plans.

Multi-Species: All listed salmonid species in a focus area are considered in the SHaRP process, although one species may direct the initial focus.

Science: Through the SHaRP process, the steering team seeks out all data and local expertise that may be relevant and makes it accessible to the SHaRP participants.

Decision: Decisions should be made while acknowledging data gaps and uncertainty rather than waiting until the optimal data are available.

Focus and Scale: Salmonid populations are restored by identifying and enhancing areas of relative strength, which will ultimately seed surrounding areas.

SHaRP in the lower Russian River Tributaries

Green Valley, Dutch Bill, Willow, and Mill creeks were selected as focus streams within the Russian River because of their potential to become regional Coho Salmon strongholds and play a prominent role in Central California Coast (CCC) Coho Salmon (*Oncorhynchus kisutch*) recovery efforts. They are also central to the Russian River Coho Salmon Captive Broodstock Program and the associated monitoring component, as well as the selected systems for monitoring trends and abundance using life cycle monitoring stations as part of the California

Monitoring Plan. Steelhead (*O. mykis*s) belonging to the CCC Distinct Population Segment (DPS) also exist in these tributaries, and in general habitat enhancements proposed for Coho Salmon are expected to benefit steelhead.

SHaRP Methods

For the Russian River SHaRP, three virtual meetings were held between January and November 2022. The workshops for Willow and Dutch Bill creeks were combined into one meeting event, whereas Mill and Green Valley creeks meetings occurred separately. Online web maps were created and shared with interested parties so that SHaRP participants could explore and review customized datasets at different spatial scales prior to and during meetings. Informative presentations given by watershed experts provided participants with knowledge and shared understanding of each focus watershed. After all the information was shared and discussed, the participants ranked different habitat attributes for their influence on freshwater salmonid life stages based on these definitions:

- Functioning: the attribute is not limiting survival at this life stage.
- Moderately Functioning: the attribute is somewhat limiting survival at this life stage.
- Not Functioning: the attribute is strongly limiting at this life stage.

SHaRP Results

The SHaRP meetings produced recommendations for restoration actions. These recommendations were guided by collectively ranking habitat attributes that corresponded to each freshwater life stage. When comparing the limiting attributes ranking for all four watersheds, participants agreed that *Water Quantity* was the attribute that most strongly limited salmonid survival, and particularly so for the summer juvenile life stage. *Channel Structure & Form* and *Water Quality* also ranked as highly limiting for all salmonid life stages.

Within the four focus streams, recommendations for restoration actions were broad, but many specific problem areas were brought to light during the discussions. Specific project locations and implementation methods will require further investigation and site-specific designs for many of these recommendations.

The SHaRP meetings in the lower Russian River tributaries provided the opportunity for community engagement surrounding the restoration of habitats needed for the recovery of Coho Salmon and steelhead, our iconic salmonid species. The SHaRP Action plan summarizes meeting results while building upon existing watershed restoration analyses and plans completed by local experts. Most of the recommendations in the plan are intended to be completed within the next 10 years, but some that address whole watershed processes will likely extend beyond.

Chapter 1. Understanding SHaRP

1.1 What is SHaRP

The Salmonid Habitat Restoration Priorities (SHaRP) project was initiated by the California Department of Fish and Wildlife (CDFW) and National Oceanic and Atmospheric Administration (NOAA) Fisheries for coastal Northern California. The SHaRP process (1) identifies potential high-quality salmon and steelhead habitat and strong extant populations (strongholds) at the watershed scale and (2) recommends restoration treatments to restore habitat and strengthen these populations.

1.2 The Need for SHaRP

In response to overall declines in salmonid populations, agencies and restoration professionals have focused restoration efforts on freshwater and estuarine life stages of salmon and steelhead. These restoration efforts have sought to address degraded habitat, reduced water availability, and poor water quality. Recovery plans have provided a framework to guide restoration and recover listed species by identifying the habitat needed to sustain species at the population level. Project proponents select actions from recovery plans to design projects, solicit funding, and implement work.

NOAA Fisheries and CDFW recognized a need to provide more focus than what is included in the recovery plans (NMFS 2012, CDFG 2004). Thus, a collaborative planning process, known as Priority Action Coho Team (PACT), was initiated in 2012 for the Central California Coast (CCC) Evolutionarily Significant Unit (ESU) of Coho Salmon (*Oncorhynchus kisutch*) to prioritize recovery actions. This effort listed focused actions for specific watersheds based on the professional judgment of agencies and partners and included recommendations for habitat restoration, water management, and hatchery supplementation. While PACT was officially published in 2019, many of the restoration recommendations were developed closer to the 2012 initiation of the process, and many of the actions outlined have been partially addressed.

With continued declines in salmonid abundance and an urgent need to improve rates of recovery with finite resources, the agencies initiated a new approach to focus habitat restoration within coastal Northern California. In 2017, SHaRP was piloted on the South Fork Eel River[1]. The SHaRP effort was then expanded to Mendocino Coast watersheds, Lower Eel River, Lagunitas Creek, and lower Russian River tributaries. A steering team for the Russian River was

[1] SHaRP Webpage: https://www.fisheries.noaa.gov/west-coast/habitat-conservation/identifying-salmon-habitat-restoration-priorities-northern

formed in early 2020 to tailor SHaRP to the specific needs and opportunities in four lower Russian River tributaries– Green Valley, Dutch Bill, Willow, and Mill creeks.

SHaRP builds on concepts and efforts identified in PACT and the recovery plans. However, SHaRP includes other listed salmonids, focusing on specific watersheds and projects with a more fine-scaled approach. The goal of SHaRP is to identify near-term habitat restoration actions as part of a watershed-level planning effort over a 10-year time horizon. The SHaRP process selects salmon and steelhead strongholds at the watershed scale and provides recommendations for specific restoration actions. This process is guided by the Pillars of SHaRP.

1.3 Pillars of SHaRP

Regional differences in the data to inform SHaRP efforts will vary slightly across the watersheds. These pillars (Figure 1) guide and define SHaRP as a process and are key to its successful implementation.

Strength: SHaRP identifies the areas with the best potential to support source populations of salmonids, which is necessary for widespread recovery of a species across its range and prioritizes actions that will improve habitat in these areas and therefore bolster these populations.

Community: SHaRP is a community planning effort. Fisheries agencies guide the process but do not dictate or determine the outcomes. Tribal resource managers or representatives, non-governmental organizations (NGOs), landowners, restorationists, fisheries experts, and habitat experts all contribute throughout the process.

Agency Alignment: Fisheries agencies (CDFW and NOAA Fisheries) are heavily involved and aligned in SHaRP efforts. The resulting products will be consistent with State and Federal Recovery Plans.

Multi-Species: All listed salmonid species in a focus area are considered in the SHaRP process, although one species may direct the initial focus.

Science: Through the SHaRP process, the steering team seeks out all data and local expertise that may be relevant and makes it accessible to the SHaRP participants. Decisions are based on the (1) available regional data, (2) relevant scientific literature, and (3) expert opinions. These data are used to determine attributes limiting salmonid growth and survival and, in turn, influence the recommendations for the type and location of the most appropriate restoration actions.

Decision: Decisions should be made while acknowledging data gaps and uncertainty rather than waiting until the optimal data are available. Decisions are based on thoroughly described and documented transparent processes bounded by data and science.

Focus and Scale: Salmonid populations are restored by identifying and enhancing areas of relative strength, which will ultimately seed surrounding areas. The SHaRP approach intends to produce a restoration plan that can most effectively focus limited restoration capacity and funding on the habitat that will most benefit salmonid populations. The resulting SHaRP plan should identify watersheds and smaller areas with potential for high-quality habitat and strong extant populations and recommend further strengthening of these areas.

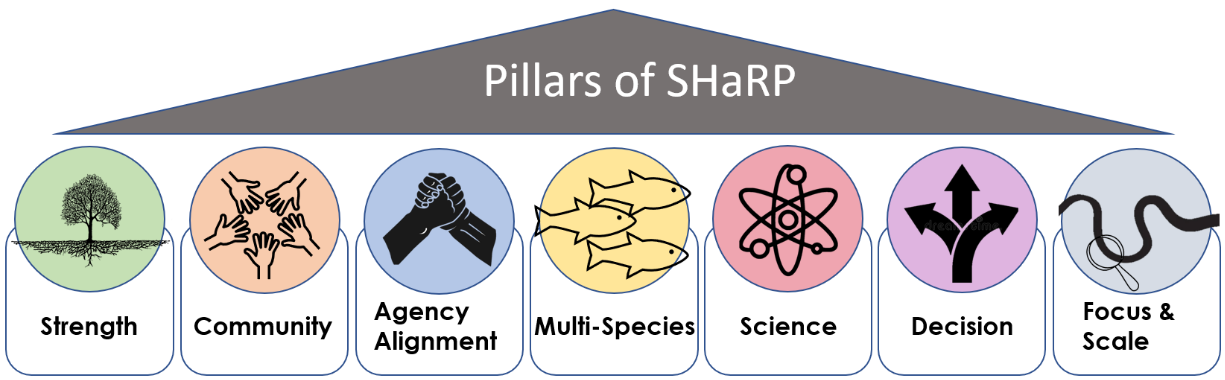

Figure 1. The SHaRP process is guided by seven key concepts, or pillars.

1.4 SHaRP in the Russian River

The North Coast Salmon Project (NCSP) was initiated by CDFW in 2018 to expedite and enhance efforts to recover threatened and endangered Coho Salmon in California. Four lower Russian River tributaries, Green Valley (GVC), Dutch Bill (DBC), Willow, and Mill creeks within the lower Russian River basin where Coho Salmon persist, were chosen to represent one of four initial focus areas (Figure 2). The other four SHaRP focus areas are the Lower Eel River, South Fork Eel River tributaries, a suite of Mendocino Coast streams (Ten Mile, Noyo, Garcia, Big, and Navarro rivers), and Lagunitas Creek. SHaRP plans have been completed for South Fork Eel River tributaries and Lagunitas Creek.

Some of the essential steps of the SHaRP process were used in developing restoration plans for the Russian River tributaries, but the process of selecting GVC, DBC, Willow, and Mill creeks was different. These watersheds were selected because they play a prominent role in two ongoing recovery efforts, the Russian River Coho Salmon Captive Broodstock Program (Broodstock Program) and its associated monitoring component, as well as the operation of life cycle monitoring stations as part of the continued implementation of the California Monitoring Plan (CMP).

Figure 2. Russian River SHaRP focus streams: Green Valley, Dutch Bill, Willow, and Mill creeks.

1.5 Salmonids in the Russian River

There are three species of salmonids listed as either threatened or endangered under Federal or California Endangered Species Act (ESA/CESA, respectively) within the Russian River watershed: Central California Coast (CCC) Coho Salmon Evolutionarily Significant Unit (ESU) is listed as endangered under both the ESA (first listed as threatened in 1996 and subsequently reclassified as endangered in 2005) and CESA (70 FR 37160, CDFW 2023a). CCC steelhead (*O. mykiss*) Distinct Population Segment (DPS) and California Coastal (CC) Chinook Salmon (*O. tshawytscha*) ESU are both listed as threatened under the ESA (71 FR 834, 70 FR 37160).

CCC Coho Salmon ESU (hereafter referred to as CCC Coho Salmon or CCC Coho), are a part of NOAA's Species in the Spotlight (SIS) initiative. The SIS initiative, launched in 2015, focuses on nine species that NOAA Fisheries manages that are on the brink of extinction. Five-Year Priority Action plans were developed as part of a strategy to marshal resources to immediately target efforts that are vital for stabilizing CCC Coho Salmon populations and preventing their extinction. SHaRP is identified in the 2021-2025 Priority Action Plan as a high-priority effort towards stabilizing the decline of CCC Coho Salmon.

The Russian River is the largest watershed in the CCC Coho current range and historically supported large populations of Coho Salmon. The Russian River population is one of twelve populations in the CCC ESU designated as historically independent (NMFS 2012). Historical estimates cite 20,000 returning adults into the Russian River (NMFS 2012), but by the year 2000, that number had dwindled to six. While conditions for some CCC Coho Salmon populations have improved slightly since the last status review, the long-term trends, while very low, have generally remained stable. CCC Coho Salmon continue to be in danger of extinction (SWFSC 2022, NMFS 2023).

The Russian River basin was included in the NCSP because it plays a central role in any CCC Coho Salmon recovery scenario, with 457.5 miles of potential habitat and a down-listing goal of 5,050 (delisting goal of 10,100) returning adults (NMFS 2012). The federal Coho Salmon Recovery Plan (NMFS 2012) divides the CCC ESU into five diversity stratum. Of these, the coastal diversity strata include the Russian River and Lagunitas Creek (both designated as historically Functionally Independent Populations (FIPs)) and Walker Creek (designated as a Potentially Independent Population (PIP)). The viability criteria outlined in the Recovery Plan requires that at least 50%, or a minimum of two, of all FIPs and PIPs in each diversity strata must be at low risk of extinction for the ESU to be viable (i.e., delisted). Consequently, for the coastal diversity strata to become viable, Lagunitas Creek, the only extant Coho Salmon population with persistent natural production, must be joined by sustainable natural production in either the Russian River or Walker Creek. Between these latter two, the Russian River was chosen for inclusion in the NCSP because of its annual adult Coho abundance (Figure

3), presence of three salmonid species (Coho, steelhead, and Chinook), operation of the Broodstock Program, and ongoing implementation of the CMP.

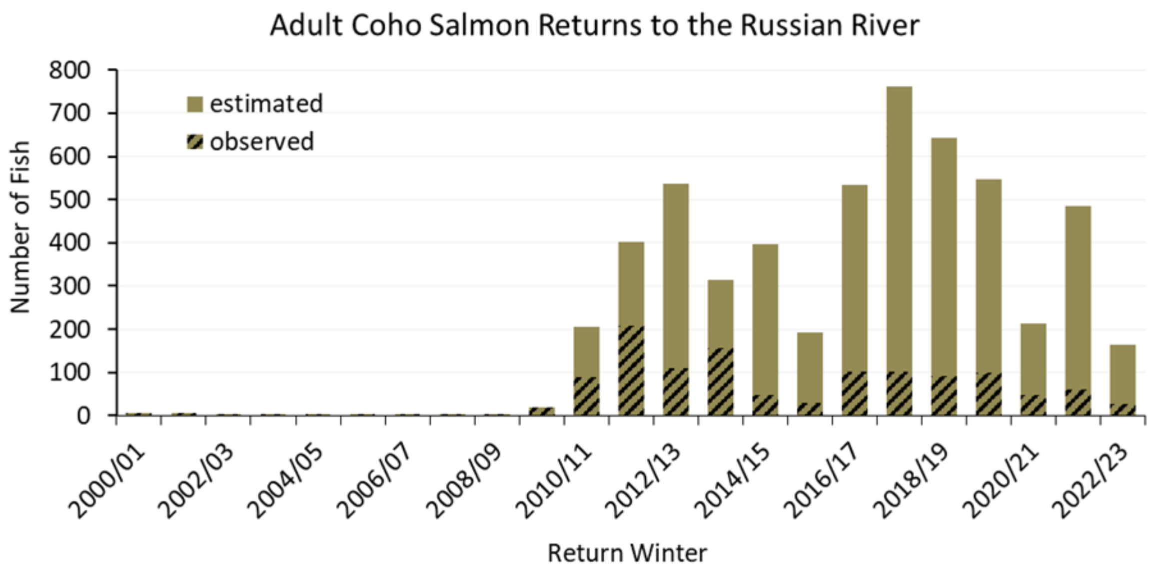

Figure 3. Estimated annual adult hatchery Coho Salmon returns to the Russian River, winter seasons 2000/01-2022/23. Methods for estimating the total number varied between years (CSG 2023).

The scarcity of information on steelhead abundance in the CCC steelhead DPS continues to make it difficult to assess whether conditions have changed appreciably since the previous assessment (Williams et al. 2016). The implementation of the CMP in the Russian River basin has improved our understanding of the overall abundance of steelhead in the watershed, providing basin-wide estimates of steelhead redd abundance (combined natural and hatchery-origin) that have ranged from about 800–2000 over three years, but as population estimates are not produced for individual populations within the basin, direct comparison with recovery targets is not yet possible (SW and CSG 2022). Importantly, this monitoring program has provided quantitative evidence that hatchery-origin steelhead constitute roughly 50% of all fish on natural spawning grounds and that these hatchery fish are being observed throughout the basin (A. Johnson, SW, personal communication, May 30, 2024). Though hatchery-origin fish are considered part of the CCC steelhead DPS, the high proportion observed is well above the recommended proportion of hatchery to natural-origin fish on natural spawning grounds (< 30%) for integrated hatchery programs to avoid erosion of population fitness (HSRG 2012). Thus, concerns expressed in prior viability assessments (Williams et al. 2011, Williams et al. 2016) about potential negative genetic consequences of interbreeding between hatchery and wild fish appear well founded.

The Russian River Chinook Salmon population has consistently numbered in the low thousands of fish in most years, making it the largest population of California Coastal (CC) Chinook Salmon (*O. tshawytscha*) ESU south of the Eel River. Recent monitoring conducted by SW documented from 600 to over 6000 Chinook returning annually over a 20-year period (SW and CSG 2023). Most of the spawning and rearing habitat for Chinook Salmon resides in the Russian River mainstem above Cloverdale, and in the lower reaches of the larger tributaries (e.g. Ackerman, Big Sulphur, and others).

Since regulatory and reservoir/flow operations tools are primarily needed to improve Chinook Salmon habitat there are relatively fewer habitat enhancement opportunities available for Chinook Salmon. Additionally, this report focuses on the four lower river tributaries which are not primary habitats for Chinook. The new NMFS Biological Opinion will address river and reservoir operations proposed by Sonoma Water (SW) and the USACE. When implemented, these efforts will support the overall recovery of the Russian River Chinook Salmon population.

Chapter 2. Russian River Watershed Overview

2.1 Watershed History

Human history in the Russian River watershed begins no less than 15,000 years ago. The greater San Francisco Bay Area was historically one of the most culturally diverse locations in the country, pre-European colonization. At least a dozen tribes inhabited the region, speaking many unique languages and dialects. The Russian River watershed sits within the ancestral lands of several tribes, including the Coast Miwok, Southern Pomo in Sonoma County; Central Pomo and Northern Pomo in Mendocino County; and Wappo in eastern Sonoma County and Napa County. These labels are broad, and each tribal group encompasses multiple diverse bands. Today, these tribal groups are represented locally by several tribal bands or federations.

Within the report entitled *Salmon Creek Estuary: Study Results and Enhancement Recommendations*, Kathleen Harris outlines in detail the human history of the Salmon Creek watershed, which is just a few miles south of the Russian River and shares a similar human history (2006). She explains that despite a few visits from explorers in the 16th and 18th centuries, the North Coast region was largely devoid of Europeans until the Spanish Mission era in the late-1700s/early-1800s. Spanish colonization in the region was largely focused near the San Francisco Bay and the town of Sonoma, leaving much of the Russian River watershed unoccupied by Europeans. Colonization still left its mark however, through the spread of smallpox and laws forbidding Indigenous land management practices (e.g. burning). An estimated 90% of the Native population living in the North Bay perished due to a smallpox epidemic during 1837 - 1838 (Dawson 2022).

In 1811, Russian fur-traders colonized the region at Fort Ross, where they established small agricultural communities, substantially changing the seascape and landscape through hunting of marine mammals for fur and logging of redwood, Douglas fir and tanoak. By 1849, the Russians sold the fort to John Sutter and abandoned their settlements. After California joined the U.S. in 1851, and the gold rush ushered in a new wave of American settlers, the landscape began to dramatically shift towards agriculture and ranchland. This also was the beginning of major road building and logging throughout the region. While American logging started around 1850, it markedly intensified after the railroad arrived in 1875, which allowed lumber to be easily transported to market. This intensive logging took place over the next 40 years, up until about 1915. At that point most of the original forest had been cut and second growth trees had not gotten big enough to be worth cutting. A second round of redwood timber harvest began in the middle of the 20th century and has continued up to the present, though at a low level.

More on the land use history for individual watersheds can be found in the following chapters.

2.2 Geography, Hydrology, and Climate

This report centers on limiting attributes and restoration priorities in four tributary watersheds within the lowermost portion of the 2,392 miles^2 Russian River watershed in western Sonoma County: GVC, DBC, Willow Creek, and Mill Creek. While each of these watersheds will be described in sections to follow, here we provide an overview of the physical geography, climate, hydrology, and land use characteristics that are common to the lower Russian River basin setting.

The four study streams are located within California's Coast Range geologic province and are underlain by predominantly sedimentary rocks and alluvium of the Franciscan Complex and Great Valley Sequence. The Franciscan Complex is a mixture of various rocks within a matrix of fine-grained sandstones and shales. Serpentinite, which occurs in pockets of the Franciscan Complex, is low in minerals and high in metals that discourage plant growth. The combination results in "thin soils with sparse, yet unique vegetation" (GRRCD and OEI 2010). The Franciscan Complex has a low groundwater holding capacity and is also highly erodible (GRRCD et al. 2021).

Across watersheds, landforms are varied and range from the gentler topography and broad valleys found in parts of GVC to the steep, erosive terrain of Willow Creek (Graymer et al. 2006). Elevations range from near sea level at the outlet of Willow Creek to approximately 1,485-1,980 ft at the highest elevations in GVC, DBC, and Mill Creek. The four watersheds also vary in size (range: 9-38 mi^2) and landcover, encompassing mesic and xeric forest types, grassland, oak savanna, as well as agricultural (vineyard, orchard, rangeland), rural residential, and urban land uses (Opperman et al. 2005). The Willow Creek watershed includes few settlements and has extensive public land holdings (approx. 65%), whereas the other three watersheds are moderately populated and characterized by land that is almost entirely privately owned.

The climate of the lower Russian River basin can be characterized as Mediterranean, featuring cool, wet winters and warm, dry summers, with the majority of precipitation falling between November and March, and most happening during intense atmospheric river events (Cao et al. 2019). Across the four watersheds, annual rainfall averages approximately 55 in, with higher amounts falling at higher elevations and nearest to the coast (USGS StreamStats 2019). Additionally, the region's rainy season exhibits high inter-annual variability and has become increasingly protracted in recent decades (Luković et al. 2021), contributing to recurrent drought- and flow-related stresses. Given this climatic setting, all four study streams exhibit a rainfall-driven hydrology that is highly variable within and between years and contributes to frequent tributary disconnection and stream channel drying, particularly in dry years and in alluvial reaches low in watersheds (Moidu et al. 2021). Climate models for California do not predict a substantial change in average annual precipitation in the coming years, but they do suggest an increase in seasonal variability, with higher amounts of rainfall over shorter periods (Pierce et al. 2018).

In addition to the effects of drought, dispersed riparian and appropriative water rights, as well as groundwater extraction (wells) adjacent to streams, place additional demand on the dry season hydrology in streams across the study area (RRCWRP 2019).

2.4 Coho Salmon Broodstock Program

Following the initial listing of CCC Coho Salmon listed as threatened under CESA and ESA in 1995 and 1996, respectively, a captive broodstock program was established in 2001 on Dry Creek below Lake Sonoma to prevent the extirpation of the Russian River Coho Salmon population. A passive integrated transponder (PIT tag) antenna situated in the mainstem at Duncans Mills records tagged hatchery Coho Salmon returning to the Russian River. The Broodstock Program is a collaboration between the U.S. Army Corps of Engineers (USACE), NOAA Fisheries, CDFW, California Sea Grant (CSG), and Sonoma Water (SW).

Initially, extremely small population size led to negative effects associated with genetic diversity loss. In 2008, the Broodstock Program began outcrossing with CCC Coho from nearby Olema Creek to facilitate gene flow while maintaining local adaptations of the CCC Coho ESU (Pregler et al. 2023). Genetic testing has shown that outcrossing with Olema Creek CCC Coho reduced relatedness and improved fitness in Broodstock Program progeny, while minimizing any potential effects of outbreeding depression (Pregler et al. 2023).

2.5 Monitoring Programs

Over the last two decades, multiple monitoring programs have been developed in the Russian River watershed. Sonoma Water began monitoring salmon and steelhead populations in 1999 with an emphasis on the Russian River mainstem and estuary. Elements of Sonoma Water's monitoring have included video monitoring of adult upstream migrants, downstream migrant trapping, beach seining in the estuary, juvenile snorkel and adult spawner surveys, water quality monitoring, invertebrate sampling, habitat surveys, and PIT tag monitoring.

In 2004, with input from CDFW, SW, and NMFS, CSG developed and began implementing a monitoring program to inform and evaluate hatchery releases by the Russian River Coho Salmon Captive Broodstock Program (Broodstock Program). This focus of work is to estimate life-stage specific abundance, survival, and growth of Coho Salmon in four life cycle monitoring streams (Green Valley, Dutch Bill, Willow, and Mill creeks) to represent an index of these parameters in the remainder of the basin. Field methods include PIT tag monitoring, downstream migrant trapping, redd surveys, and juvenile snorkel counts. In 2023, SW assumed responsibility for all field monitoring activities formerly conducted by CSG, using similar methods.

Implementation of the California Monitoring Program (CMP) in the Russian River watershed began in 2013, led by SW in partnership with CSG. The goal of this statewide program is to document status and trends of Coho Salmon, steelhead, and Chinook Salmon using standardized methods. Implementation of the CMP in the Russian River watershed extended Coho monitoring in the four life cycle monitoring streams to include steelhead and added a basinwide component to redd surveys and juvenile snorkel counts. Redd surveys show consistently low abundance estimates for Coho and slightly better for steelhead (Figures 4 and 5). Over 40 Russian River tributaries are surveyed each year to estimate basin-wide redd abundance and juvenile occupancy.

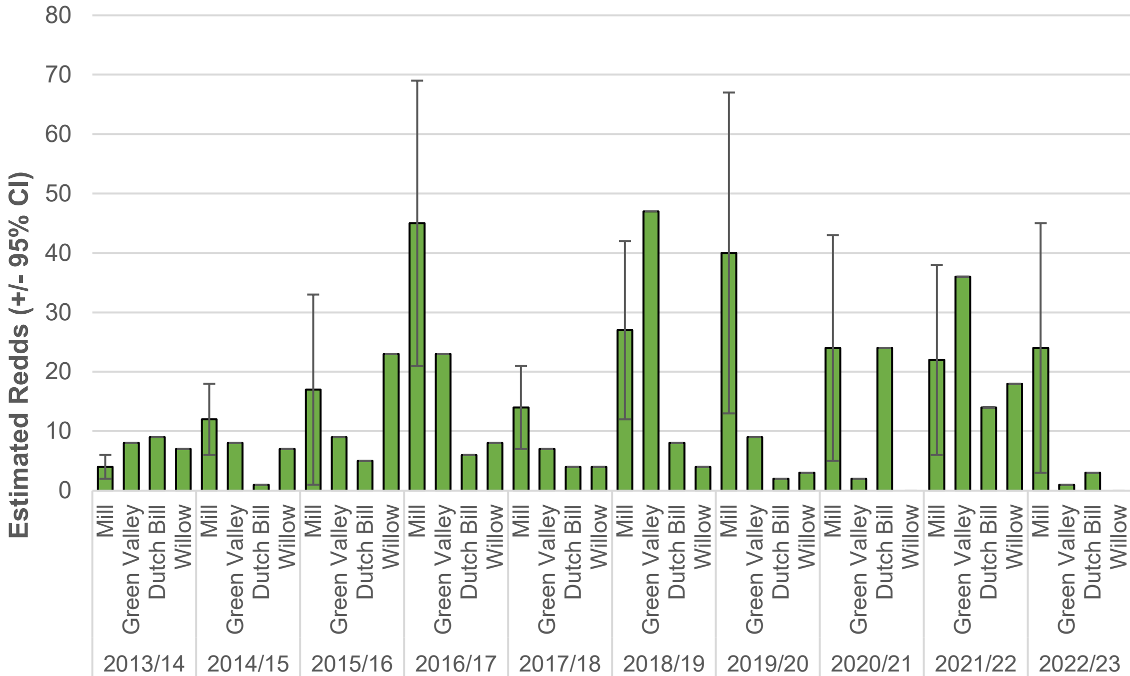

Figure 4. Estimated Coho Salmon redd abundance in LCM tributaries by spawner season, 2013/14-2022/23). Restricted access in Mill Creek caused gaps in the data, thus values were estimated using sampling expansions and confidence intervals are provided (SW and CSG 2023).

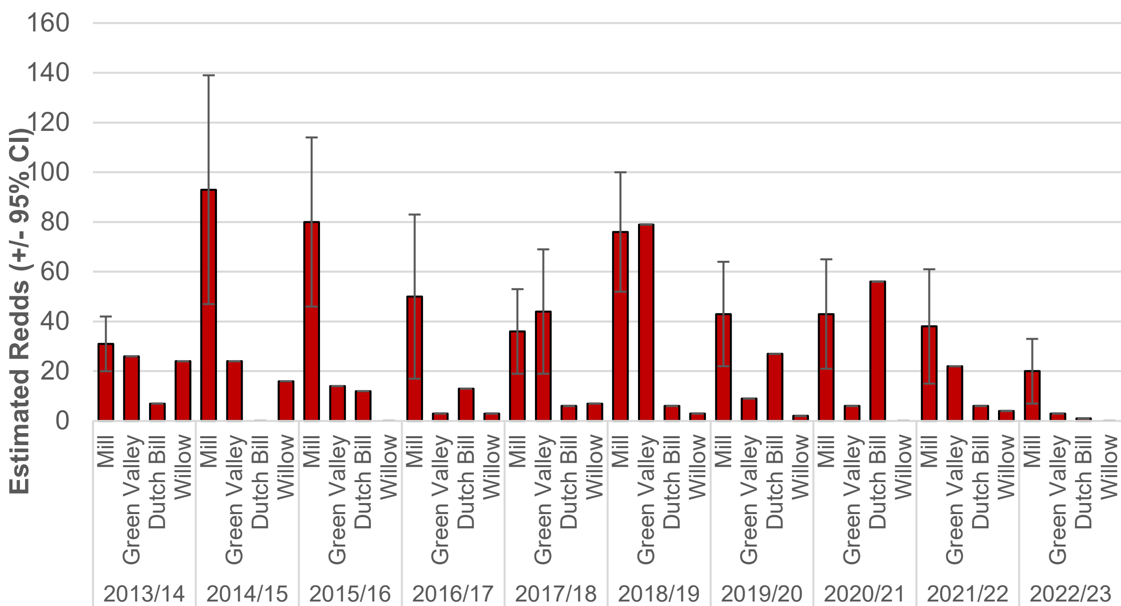

Figure 5. Estimated steelhead redd abundance in LCM tributaries by spawner season. Restricted access in Mill Creek caused gaps in the data, thus values were estimated using sampling expansions and confidence intervals are provided (SW and CSG 2023).

Monitoring data illustrate that hundreds of adult Coho Salmon return each winter, suggesting that the Broodstock program has been successful in averting Russian River CCC Coho Salmon extirpation; however, the number of adult returns continues to be lower than expected. A comparison of the numbers of natural-origin (NOR) adults and hatchery-origin adults (HOR) returning to the four SHaRP creeks shows HOR returns are substantially greater than NOR (Table 1). The returns of HOR and very low abundance of NOR suggests evidence that the Russian River, overall, is currently lacking the habitat capable of supporting self-sustaining runs of Coho Salmon (CSG and SW 2023).

Table 1. Return winter season and number of returning natural-origin (NOR) and hatchery-origin (HOR) Coho Salmon to the four focus streams (CSG and SW 2023).

Return Winter	GVC NOR	GVC HOR	DBC NOR	DBC HOR	Willow NOR	Willow HOR	Mill NOR	Mill HOR
2012/13	0	14	0	9	0	74	0	78
2013/14	0	7	0	15	0	17	0	7
2014/15	0	8	0	18	0	44	0	52
2015/16	0	0	0	33	0	17	1	13
2016/17	2	10	2	67	2	107	4	132
2017/18	3	58	0	40	2	160	0	54
2018/19	0	27	0	49	0	26	0	93
2019/20	0	17	0	42	0	94	3	93
2020/21	0	3	0	11	0	19	2	14
2021/22	1	15	0	60	0	89	0	60
2022/23	0	0	1	26	0	7	0	13

2.6 Other Aquatic Species

In addition to the three ESA/CESA-listed Pacific salmonids described in Chapter 1, the lower Russian River tributaries that are the focus of this document (GVC, DBC, Mill, and Willow creeks) are home to various other aquatic species with special protected status. California Freshwater Shrimp (*Syncaris pacifica*), which are listed as Endangered under the ESA and CESA, reside in GVC and were observed in DBC and Willow Creek. Longfin Smelt (*Spirinchus thaleichthys*) are occasionally observed in Willow Creek and are CESA-listed as Threatened.

Additionally, CDFW has designated certain vulnerable vertebrate species as "Species of Special Concern" (CDFW 2023) (SSC). In the lower Russian River tributaries, SSC include California giant salamander (*Dicamptodon ensatus*), western pond turtle (*Actinemys marmorata*), foothill yellow-legged frog (*R. boylii*), red-bellied newt (*Taricha rivularis*), Pacific lamprey (*Entosphenus tridentatus*), western brook lamprey (*Lampetra richardsoni*), California Roach (*Hesperoleucus symmetricus*), and Russian River tule perch (*Hysterocarpus traskii pomo*). California red-legged frog (*Rana draytonii*) is ESA-listed as Threatened and is also a Priority 1 Species of Special

Concern by CDFW. There are known occurrences in Willow and Mill creeks and predicted habitat in GVC and Dutch Bill creeks (R. Watanabe, personal communication, 2/28/2024).

Several non-native species have been detected during monitoring activities in the lower Russian River, including American shad (*Alosa sapidissima*), bluegill (*Lepomis marcochirus*), channel catfish (*Ictalurus* punctatus), green sunfish (*Lepomis marcochirus*), largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), striped bass (*Morone saxatilis*), western mosquitofish (*Gambusia affinis*), signal crayfish (*Pacifastacus leniusculus*), and American bullfrog (*Lithobates catesbeianus*). Sacramento blackfish (*Orthodon microlipidotus*) were observed mainly in GVC (CSG and Sonoma Water 2023). This species is native to CA but may not be native to the Russian River (Moyle 2002).

In 2023, New Zealand mudsnails (*Potamopyrgus antipodarum*) (NZMS) were detected in lower GVC and Atascadero Creek, DBC, as well as parts of lower Willow Creek. NZMS were also detected at Warm Springs Hatchery, which hosts the Broodstock Program. As of March 2024, NZMS were not detected in Mill Creek. Field and Hatchery staff are working to limit the spread of the species throughout the Russian River watershed, which has greatly limited the previous stocking protocol of the Broodstock Program to streams and locations where NZMS have not been detected. Waders and sampling gear are thoroughly cleaned following decontamination protocols between each use (CDFW 2022).

These data were sourced from multiple datasets in the CDFW Biogeographical Information and Observation System (Borros 2023, CDFW 2023b). Additional observation data were provided by Sonoma Water (Sonoma Water and CSG, unpublished data 2023) and CDFW regional biologists. Other species observed and not listed may be found in CSG and Sonoma Water 2023, Table 3.

2.7 Stream Restoration Grants Programs

There are several grants programs that have worked to improve salmonid habitat within the lower Russian River basin. This section includes a brief summary of the most noteworthy contributors.

The State of California Coastal Conservancy (Conservancy) administers restoration grants that restore and protect the California coast, expand public access, and enhance climate change resilience. This annual grant program has been funding salmonid habitat improvement projects along California’s coastal streams. In 2023, the Board of the State Coastal Conservancy authorized funding totaling $84 million for projects to protect and restore coastal lands, increase resilience to climate change, improve public access to the coast, and reduce the impact of wildfire on coastal lands (Conservancy 2023).

The California Wildlife Conservation Board (WCB) was created in 1947. WCB utilizes a grant process to fund acquisition, restoration, and public access projects throughout the state.

Eligible projects address the WCB Strategic Plan by implementing work that protects or enhances biodiversity, addresses climate change resiliency and connectivity, supports the State Wildlife Action Plan priority habitats, conserves, or enhances working landscapes, conserves or enhances water-related projects, and enhances public access. The WCB Stream Flow Enhancement Program (SFEP) is a state-wide program that funds streamflow enhancement projects. Some project type examples include water transactions, water conservation projects, groundwater storage, and habitat restoration projects that improve aquatic and riparian conditions. From 2016 to 2021, the SFEP funded approximately $134 million to 128 projects (WCB 2023).

CDFW Watershed Restoration Grants Branch (WRGB) oversees the various granting programs offered by the Department. The WRGB delivers science-informed grants for restoration of ecological function and conservation and assesses the success of those efforts at a large scale. The granting programs in this Branch include Proposition 1, Greenhouse Gas Reduction, and the Fisheries Restoration Grant Program (FRGP). FRGP has been funding instream restoration projects to benefit salmonids since 1981. In 1997, California SB271 reallocated state funds to be administered by CDFW as grants for fish habitat projects. This increase of funds greatly accelerated the pace of salmonid restoration along the Northern California coast (WRGB 2023).

NOAA has administered the Pacific Coastal Salmon Recovery Fund (PCSRF) since 2000 and has funded states and tribes to restore and recover listed salmonid populations throughout the West Coast. CDFW secures PCSRF funds with state matching funds and distributes PCSRF monies via grants from the FRGP. The infusion of PCSRF funding to FRGP cemented the modern restoration community working in the Russian River basin.

The California Fish Passage Forum receives funding through the National Fish Habitat Partnership (via the USFWS) to advance fish habitat. The Forum’s specific focus is on anadromous fish populations in California. In 2019, Forum funding provided match for an FRGP dam removal project on lower Green Valley Creek.

The United States Environmental Protection Agency provides funding to states and tribes to improve water quality through the Nonpoint Source Program. These Clean Water Act Section 319(h) Grant Program funds are administered by the State Water Boards to fund restoration projects intended to improve water quality (Water Boards 2023).

The National Resource Conservation Service (NRCS) is a partner-driven approach to conservation that funds solutions to natural resource challenges on agricultural lands. The NRCS’ Environmental Quality Incentives Program was established via the Farm Bill in 1996. This program funds agricultural producers to improve their operations through implementing best management practices and restoration projects. This cost share program has funded stream improvements that benefit salmonids. Other NRCS programs include the Conservation

Stewardship Program, Healthy Forests Reserve Program, Landscape Conservation Initiatives, and other programs that assist private landowners in managing riparian systems (NRCS 2023).

County programs include the Sonoma County Fish and Wildlife Commission (Wildlife Commission) and Sonoma Water's Fisheries Enhancement Program (FEP). The Wildlife Commission is a local governing board that recommends to the Agricultural Commissioner that certain projects be granted funds from the county's fish and wildlife propagation fund. The Commission has helped fund salmonid restoration projects in Sonoma County. The FEP-funded projects from 1996 through 2004 "Improve the native fish resources of the Russian River and its tributaries, with the focus on enhancing habitat for steelhead, Coho Salmon and Chinook Salmon." The FEP was an important catalyst in helping establish the restoration community and foundational projects in the Russian River Basin.

Chapter 3. Focus Watershed Meeting Methods

For the Russian River SHaRP, three virtual meetings were held between January and November 2022. Willow and Dutch Bill creeks were joined into one meeting. There were no in-person meetings. The invited experts included specialists with specific salmonid habitat restoration experience or knowledge of each focus watershed. Invited participants consisted of members from Federal, State, and local governmental agencies, academia, researchers, consultants, non-profits, timber companies, restoration practitioners, private landowners, and watershed groups with specific expertise in the focus watersheds. Tribes with a traditional and cultural affiliation with the four focus streams were notified about the SHaRP process before meetings commenced. Representatives from two tribes participated in meetings and shared knowledge on the natural history and ecology of local areas, and perspectives on the compatibility of restoration and traditional practices.

ArcGIS Online (AGOL) enabled the sharing of online web maps with interested parties and allowed SHaRP participants to explore and review customized datasets at different spatial scales. The SHaRP meeting aimed to provide the maximum opportunity for participants to evaluate and discuss the available data and local observations, and then determine the best course for restoration in each area. Informative presentations given by watershed experts provided the SHaRP participants' knowledge and shared understanding of each focus watershed. CSG biological data was available for viewing during the meetings along with staff presentations to dive deeper into their findings.

3.1 Limiting Attribute Analysis

The steering team used an online web application that allows virtual collaboration, where participants could provide scores for habitat attributes at each life stage to determine which was most limiting to survival. To ensure that all participants had a common understanding, the steering team presented a salmonid life stage table (Table 2) and a list of limiting attribute definitions prior to the meeting. This information was also available in the online web application for participants to reference when ranking attributes.

3.2 Salmon and Steelhead Life Stages

Pacific salmon and steelhead exhibit complex life histories involving distinct life stages (Figure 6). Those life stages use nearly every portion of a watershed network, balancing risks with rewards; however, many of the habitats these fish have evolved to use have been drastically altered. Each life stage faces challenges and risks including habitat degradation in small tributaries, cumulative effects leading to dysfunctional watershed processes, limited estuarine habitat, variable ocean productivity, and predation and competition with other native and non-native species (Good et al. 2005). Given the wide range of habitats and ecological conditions that salmon and steelhead use and depend upon, identifying the restoration actions that will most effectively aid in recovery can be challenging.

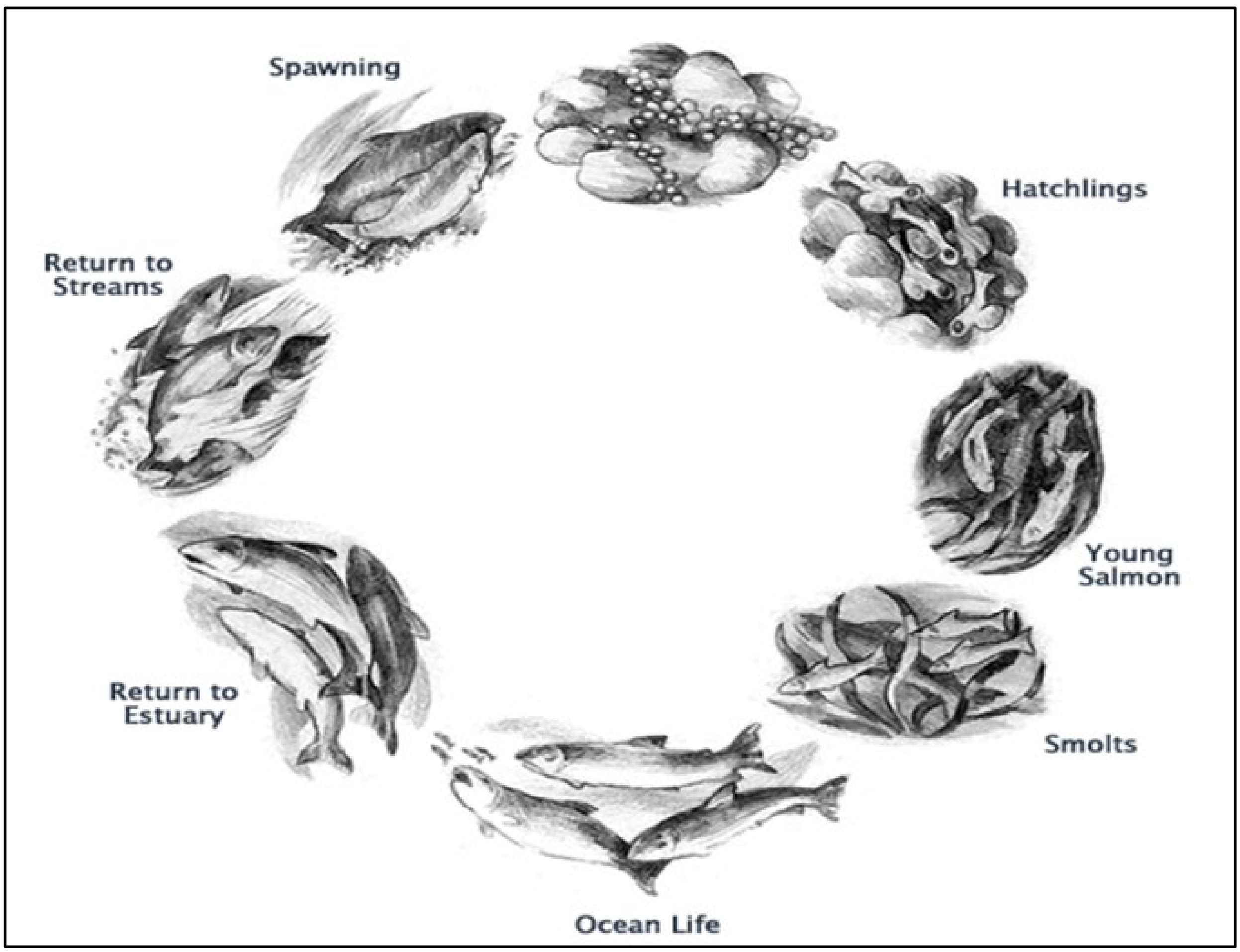

Figure 6. General salmonid life cycle. Credit: NOAA Fisheries

Table 2. Life stage descriptions and habitat needs for Coho Salmon and steelhead. YOY = Young of the Year

Life Stage	Description	Habitat Needs
Egg/Alevin	Refers to the emergence of eggs in the gravel to YOY. Eggs incubate for 1-2 months then hatch into alevins. Alevins remain in the gravel for another month. YOY emerge between December-May.	The redd site must remain stable throughout the egg incubation period and allow water to percolate through the gravel to supply oxygen to the developing embryos. Incubation requires continuous and stable surface flow of clean water, free of pollution and siltation. Egg and alevin are vulnerable to: -poor water quality -high water temperatures -scour from high flow events -early season drying of gravel
Summer Juvenile	Rearing summer juvenile salmonids include YOY (the previous spring's hatched juveniles) and parr (one-year old juvenile fish). Parr are defined by size class criteria (fork length ≥ 100mm). They redistribute throughout the summer and fall into available habitat and begin feeding. Coho prefer low velocity with woody material cover, and steelhead prefer riffles and faster moving water.	Deep, cool pools with cold water temperatures and high dissolved oxygen, available food sources, and shelter from predation are critical for the survival of summer rearing juveniles. Riparian vegetation helps support some of the insects consumed by juveniles; provides cover from predators; limits solar radiation to streams, keeping water temperatures cool; stabilizes stream banks; and creates habitat structures. Summer juvenile fish are vulnerable to: -poor water quality -low dissolved oxygen -early surface flow disconnections limiting access to more habitat
Winter Juvenile	Rearing winter juveniles include YOY (the previous spring's hatched juveniles) and parr (one-year old juvenile fish). Instream movement begins after the first winter storms and throughout the winter and early spring, in an effort to access new habitat.	Large woody material or downed wood in pools creates cover and refugia for the juvenile salmonids to reside within the active stream channel during high velocity flows. Connectivity to off-channel, floodplain, wetland, and marsh habitat provide another source of refuge from high winter flow velocity, shelter from predators, and provide a rich food source for juvenile salmonids. Winter juveniles are vulnerable to: -high flow velocities and lack of access to flow refuge -lack of access to rich food sources -predation and lack of access to shelter

Life Stage	Description	Habitat Needs
Smolt	Juvenile salmonids undergo a physiological change known as "smoltification," enabling them to transition in freshwater, estuaries, and lagoons to a life adapted to saltwater. Smolt outmigration to the lower river and estuary is typically March-June.	Smolts need adequate flow and unobstructed passage from upstream rearing areas to migrate downstream to the lower river and estuary. Lower river habitat should provide habitat complexity and shelter from predators, refuge from high velocity storm events, and a primary food source for smolts. Estuaries should be deep to provide cool temperatures and buffered with freshwater to dilute seawater (Moyle 2002), facilitating the transition into the ocean. <u>Smolts are vulnerable to</u>: -early surface flow disconnection limiting access to lower river -high flow velocities and lack of access to flow refuge areas -predation and lack of access to shelter -high water temperatures -poor water quality
Returning Adults	Migrating adults return from the ocean or nearshore environment to spawn. Coho typically return from Nov-Jan, usually after heavy rains, and steelhead typically return from late Dec-May. Steelhead adult life history uniquely requires continuously connected surface flow and unobstructed passage for upstream & downstream migration.	Adult spawners need adequate connected stream surface flow, cool water temperatures, deep pools, and shelter to rest and hide as they migrate upstream to spawning areas. Females seek clean, loose gravels of a specific size in highly oxygenated riffle habitats for laying their eggs. Maintaining continuous and stable surface flow connection throughout the spawning season provides access to upstream spawning areas and maintains cold oxygenated water for egg/alevin life stage. <u>Returning adults are vulnerable to</u>: - poor water quality - high water temperatures - periodic river mouth closures limiting access into the river - early season surface flow disconnection limiting access into spawning habitat - physical barriers limiting access into spawning habitat - predation and lack of access to shelter

3.3 Attributes

An attribute is a process, component, or condition which influences one or multiple life stages. We considered how the following attributes were limiting the survival of the life stages identified above.

- **Anthropogenic Barriers:** Insufficient quantity of total habitat due to a human derived barrier. Includes partial or ephemeral anthropogenic barriers.
- **Instream Structural Complexity:** Decline of the instream habitat quality. Based on the degree of habitat complexity and variety, includes the quantity and variability of stream depth and pools of varying sizes and depth.
- **Off-Channel Habitats:** Loss and/or degradation of the peripheral habitat of streams and rivers, including floodplains, connected channels, and areas that are periodically inundated during high flows.
- **Riparian Condition:** Degradation of the habitat adjacent to a stream. Impairment of the near-bank environment to support plants, including large trees, that provide shade and add primary production to the aquatic ecosystem. Includes the supply of mature trees into streams as large wood.
- **Sediment Conditions:** Altered inputs of the quantity or quality of habitat due to changes to the background (natural) quantity, rate, and size of sediment inputs to the stream system. Includes input of fine sediment to the streams.
- **Water Quality:** Degraded water temperature, dissolved oxygen, and turbidity, as well as toxins and pathogens.
- **Water Quantity:** Detrimental effects of deviations to the background (natural) amount and timing of water quantity instream, including low water flow.
- **Invasive Species:** An organism that causes ecological or economic harm in an environment where it is not native.
- **Channel Structure and Form:** This attribute was added by participants to GVC at the start of the meetings to describe the excess sediment in the low-gradient, valley floor area that is enhancing poor water quality and migration problems.
- **Channel Form Barrier:** This attribute is similar to channel structure and form but emphasizes the evolving high sediment conditions that create multiple barriers that trap rearing fish and negatively impact adult and juvenile migration in lower Willow Creek.

3.4 Attribute Ranking

After all the information was shared and discussed among participants, they ranked the attributes for each life stage. Each focus watershed had a separate attribute table (Figure 7). Participants ranked how limiting each attribute was to each life stage based on these definitions:

- Functioning (green box): the attribute is not limiting survival at this life stage.
- Moderately Functioning (yellow box): the attribute is somewhat limiting survival at this life stage.
- Not Functioning (red box): the attribute is strongly limiting at this life stage.

Participants used their knowledge of salmonids, the watershed, datasets in AGOL, and presentations to rank each attribute. Participants were asked to not provide a score if they were unsure about a specific attribute/life stage relationship. Ranking at a watershed scale caused problems for some who saw these attributes applying to certain parts of the watershed but maybe less so in others. This posed a challenge in how participants weighed the level of concern across the watershed. Participants decided to rank the attribute as it applied to the worst part of the watershed, even if it was only for a portion. If an attribute was ranked as not functioning, the restoration actions could be as fine scale as the group decided.

Coho/Steelhead					
Attribute	Egg/Alevin	Summer Juvenile	Winter Juvenile	Smolt	Adult
Anthropogenic Barriers	N/A				
Instream Structural Complexity					
Off-Channel Habitats					
Riparian Conditions					
Sediment Conditions					
Water Quality					
Water Quantity					
Invasive/ Non-native Species					

Figure 7. Example limiting attribute ranking table used in Russian River SHaRP meetings.

After the participants ranked the attributes, the results were automatically tallied and available for everyone to view. The steering team averaged the tallies into numerical form. Then the numbers were binned into three categories to be consistent with the ranking. The scores of 0-3.3 were colored Green (least limiting). The scores from 3.4-6.6 were colored yellow (moderately limiting), and the scores from 6.7-10 were colored red (most limiting). The limiting attribute results were discussed among the participants. If there was a disagreement on the ranking results, it was discussed until a consensus was reached.

3.5 Developing Restoration Solutions

The final element of the SHaRP meeting focused on prescribing restoration actions to address the limiting attributes identified through the attribute ranking process. Through presentations and discussion, participants provided background and overviews of current stream habitat restoration techniques used to improve physical and biological watershed processes. Treatments focused on what would be effective at improving habitat or watershed processes as most limiting for salmonids identified in the SHaRP process. Specific project locations and implementation methods will require further investigation and site-specific designs for many of these recommendations.

Tribal government resource managers that attended the meetings expressed their desire to work with the restoration community as projects are planned, designed, and implemented to ensure tribal land management practices are considered.

3.6 Restoration Treatment Types

The following restoration actions were identified as priorities for the watersheds in this SHaRP effort and are described in further detail in individual watershed chapters. Treatments were spatially assigned in ArcGIS for each watershed.

- Monitor Streamflow Year-Round
- Investigate Easements & Acquisitions to Protect Sources of Perennial Streamflow and Avoid Development
- Address Unscreened Diversions
- Enhance Instream Habitat
- Enhance Off-Channel & Floodplain Habitat
- Enhance & Preserve Streamflow
- Address Incision
- Improve Winter Refugia Habitat
- Assess and Manage Forests to Improve Watershed Processes
- Address Fish Passage
- Address County Road and Related Sediment and Erosion
- Enhance Tidal Wetlands

- Investigate Beaver Reintroduction
- Address Water Quality Issues Related to Sediment Delivery
- Conserve Water
- Manage Riparian Invasives

Chapter 4. Green Valley Creek Action Plan

4.1 Watershed Overview

The GVC watershed drains an area of approximately 38 mi². The main tributaries are Purrington and Atascadero creeks. The terrain in the watershed is a combination of gently rolling hills in the east and steep forested slopes to the west.

The GVC watershed is underlain predominantly by two geologic formations, the Wilson Grove Formation (WGF) and the Franciscan Complex (Figure 8). The WGF consists of loosely consolidated sandstone and is highly erodible. It is the primary water-bearing material in the watershed, supplying water to wells and maintaining summer baseflow in the streams due to its permeability and ability to hold water (GRRCD and OEI 2010).

The highly erodible sandstones and shales that make up the watershed, combined with changes in land use and extensive development, have resulted in increased run-off and higher volumes of storm flow that exceed natural capacities in the vicinity of Green Valley Road. Jonive Creek also shows evidence of increased stormflows associated with increased runoff in the Sexton Road area. This has caused many stream networks to incise. Incision is the process in which the stream bed begins to cut down through the alluvium, lowering the elevation of the stream bed in relation to the bank. This disconnects the stream from its floodplain, inhibits surface and groundwater connection, and creates higher and less stable banks, making it difficult for riparian vegetation to establish and grow (GRRCD et al. 2021). Incision along these alluvial reaches suggest that agricultural and residential development, channel simplification and straightening, and road construction tend to accelerate and/or increase storm runoff (ISRP 2007).

The GVC watershed is almost 100% privately owned; however, four publicly owned parcels exist within the watershed. CDFW owns the 44-acre Atascadero Creek Ecological Reserve (ACER) near Graton and the 32-acre Harrison Grade Ecological Reserve in Upper GVC. Sonoma County Regional Parks owns and operates the 157-acre Ragle Ranch Regional Park on the west side of Sebastopol. The Sonoma Land Trust owns the 27-acre Lower Pitkin Marsh Preserve, located on Hwy 116 between Graton and Forestville.

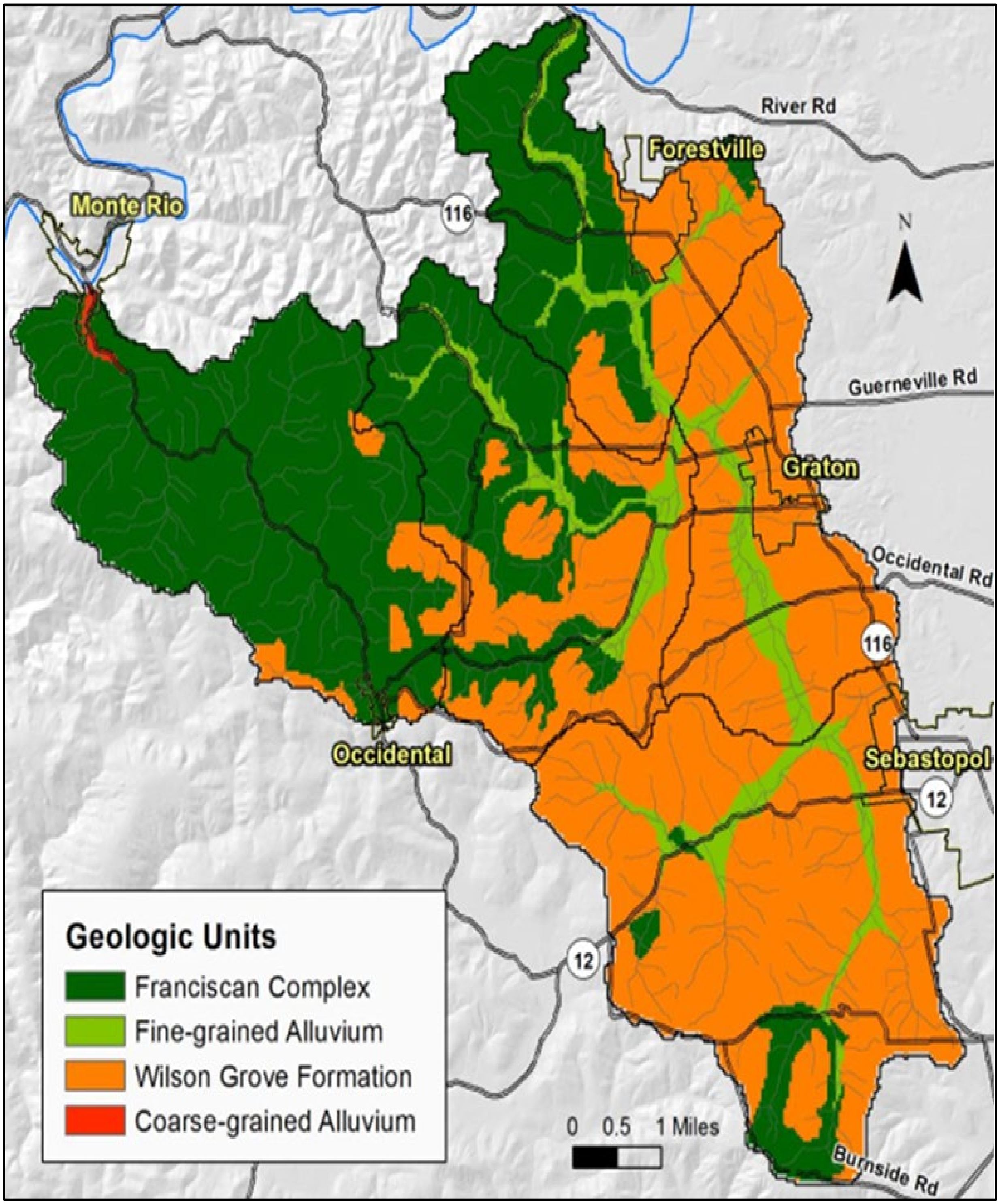

Figure 8. GVC and DBC watersheds geologic units (OEI 2016)

Upper Green Valley Creek

The headwaters of GVC begin at an elevation of approximately 800 feet. The creek initially flows southeast before looping back to the northwest, prior to joining Atascadero Creek at an elevation of approximately 100 feet. Franciscan Complex is the predominant rock type found in Upper GVC (Figure 8). During the drought of 2013 to 2015, data show that insufficient streamflow was a significant limiting attribute to juvenile salmonid survival in Upper GVC (RRCWRP 2019). Habitat assessment data collected in 2003 indicates that shelter or cover for juvenile salmonids is limited within the stream channel (CDFW 2013).

Purrington Creek drains approximately 3.7 miles^2 and is a major tributary to GVC. The headwaters of Purrington Creek begin at an elevation of approximately 700 feet, northeast of the town of Occidental, and its confluence with GVC lies about one mile west of Graton at an elevation of 110 feet (GRRCD and OEI 2010). Most of the watershed is underlain by the water-bearing WGF that sustains surface flows through the summer (GRRCD and OEI 2010). Even during the most severe conditions during drought, Purrington Creek sustained streamflow and provided critical refuge for rearing salmonids (RRCWRP 2019).

Purrington Creek provides summer flow to GVC and supports spawning and rearing habitat for salmonids, but the stream is deeply incised throughout (CDFG 2000a). A stream habitat assessment was conducted during the summer of 1994 to characterize habitat conditions for salmonids. Habitat assessment results suggest that shelter or cover for juvenile salmonids is also limited within the stream channel of Purrington Creek.

Lower Green Valley Creek

Lower GVC extends from the confluence with Atascadero Creek to the Russian River confluence. Lower GVC's bedrock is predominantly Franciscan Complex, with the eastern tributaries flowing through the WGF (Figure 8). The lower reach, extending from just above the Hwy 116 crossing downstream to the Russian River confluence, provides some of the best flow conditions for juvenile Coho Salmon and maintains optimal depths for juvenile fish passage during most water years (OEI 2016). Lower GVC and Atascadero Creek are low-gradient alluvial channels. Historically, the reaches likely had multiple channels, wetlands, and riparian floodplains with off-channel fish habitats (ISRP 2007). Water quality may limit habitat suitability and fish survival in this reach, particularly in the low-flow summer season (OEI 2016). Growth opportunity for Coho Salmon is high in GVC, and it is recommended that support for habitat improvements and water quality in lower GVC/Atascadero creeks continues (CSG 2023a).

During the winter season, this low-gradient reach backwaters during peak Russian River flows, providing refugia for salmonids. In 2014, an off-channel project was completed within this reach to provide velocity refuge for over-wintering juvenile salmonids. CSG monitoring data showed minimal detections of tagged juveniles entering the side channel; however, CSG suggests that as GVC restoration continues to expand and grow, the newly created habitat will provide important refuge for wintering juveniles. During the study, most of the juveniles were rearing in an upstream reach that encompasses the confluence of Atascadero Creek with the mainstem of GVC (CSG 2016).

Atascadero Creek

Atascadero Creek extends from the confluence with GVC, upstream to and including its tributary, Jonive Creek where Upper Atascadero begins.

The Atascadero Creek Subwatershed Chapter to the Green Valley Creek Watershed Management Plan identifies key actions that should be taken to improve watershed function In Atascadero Creek (GRRCD et al. 2021). The contents of this report are based on field surveys and complement SHaRP actions. The nine restoration recommendations are prioritized to support design and implementation project planning.

Lower Atascadero Creek

The Lower Atascadero Creek reach extends from the confluence of GVC upstream to Occidental Road and is characterized by dense marsh vegetation that slows velocities along discontinuous, shallow channels. During high winter flows, GVC floods across Green Valley Road and adjacent vineyards into Atascadero Creek, just upstream of the confluence with GVC depositing sediment. Over the years, a sediment wedge formed that created a closed depression that maintains inundation and saturation conditions that favor emergent marsh and appears to have drowned riparian trees (Dawson 2022). Water quality is the limiting attribute through this reach.

Jonive Creek is a major tributary that drains from the western side of the watershed, upstream of Walker Creek. Redwood and Sexton creeks are two main tributaries that have perennial streamflow, providing some of the best available stream habitat for salmonids in the GVC watershed (GRRCD et al. 2021).

A stream habitat assessment for Jonive Creek was conducted during the summer of 2001 (CDFG 2006). The survey began at the confluence with Atascadero Creek and extended upstream into Jonive Creek. Similar to other reaches within the watershed, habitat cover for juvenile salmonids is limited.

Upper Atascadero Creek

Upper Atascadero Creek extends from the confluence with Jonive Creek at Ragle Ranch Park, upstream to the headwaters. The reach is separated into an intermittent and incised section due to differences in hydrogeologic conditions. The intermittent section runs from the confluence of Jonive Creek and Atascadero Creek upstream to a point just downstream of

Bodega Avenue. This is a losing reach where flows typically diminish during the summer (GRRCD et al. 2021).

The incised section extends about 2.9 miles from Bodega Avenue upstream to Barnett Valley Road. This portion of Upper Atascadero Creek has also sustained perennial flows during most years, as well as good summer rearing habitat due to the water availability. However, due to the severity of incision, this reach is disconnected to floodplain habitat. Good spawning habitat is present; however, it is largely inaccessible due to downstream conditions (GRRCD et al. 2021).

4.2 Land Uses – Historic and Current

When European and American settlers began arriving in the early to mid-1800s the GVC watershed was home to several hundred Native Americans, plus elk, beaver, and the now extirpated grizzly bear (Dawson 2022). Tribal management practices of tending the oak woodlands, sedge beds, and other plants, as well as cultural burns, were being practiced as they had been for thousands of years. Settlers changed the landscape drastically with natural resource extraction occurring at scales not previously encountered; redwood forests were clear-cut for timber, and lumber mills were built. Riparian forests, woodlands, and grasslands were cleared and utilized for agriculture (GRRCD 2013). Fruit orchards were created by clearing the land and channelizing the creek and tributaries (Dawson 2022).

Rural residential development, vineyard expansion, and conversion of orchards to vineyards were significant land use changes from 1970-2000 (GRRCD 2013). Despite historic land uses and modifications, over 50% of land cover is dominated by mixed forest, coniferous forests, grasslands, and hardwoods (Figure 9).

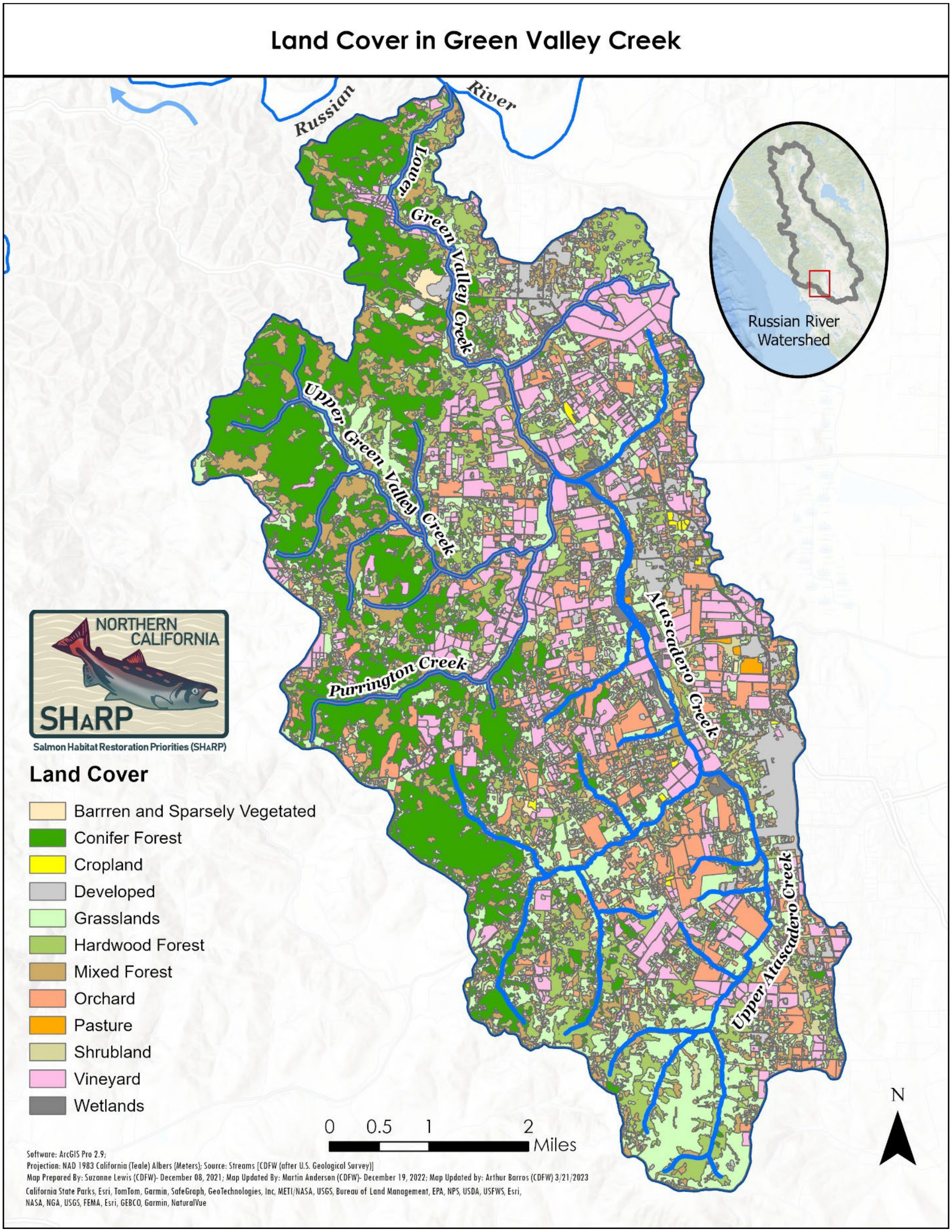

Figure 9. Overview of GVC watershed land cover. Source: Sonoma Veg Map

Water Supply

The State Water Resources Control Board (SWRCB) governs surface water supply through a series of Water Rights Decisions and Orders. Surface water in GVC is fully appropriated between June 15th and October 31st yearly, thus the SWRCB will not accept any new applications to appropriate water within the watershed (RRCWRP 2019). Based on findings from the 2015 Drought Emergency Informational Order, the number, and types of diversions within GVC watershed include 52 surface diversions, 62 springs, and 3,584 wells (Figure 10). A total of 638 wells, or 18% of all wells in the watershed, were reported in Upper GVC and Purrington Creek (SWRCB 2015).

On an annual scale, the human water needs in the Upper GVC watershed can easily be met with an average annual discharge approximately 20 times the total human water need. Even in a dry year, there is plenty of water on an annual scale. However, summer water use is significantly higher than total summer discharge (RRCWRP 2015). The mismatch of need vs. availability is the ultimate challenge associated with providing flows for fish and a sustainable water management program.

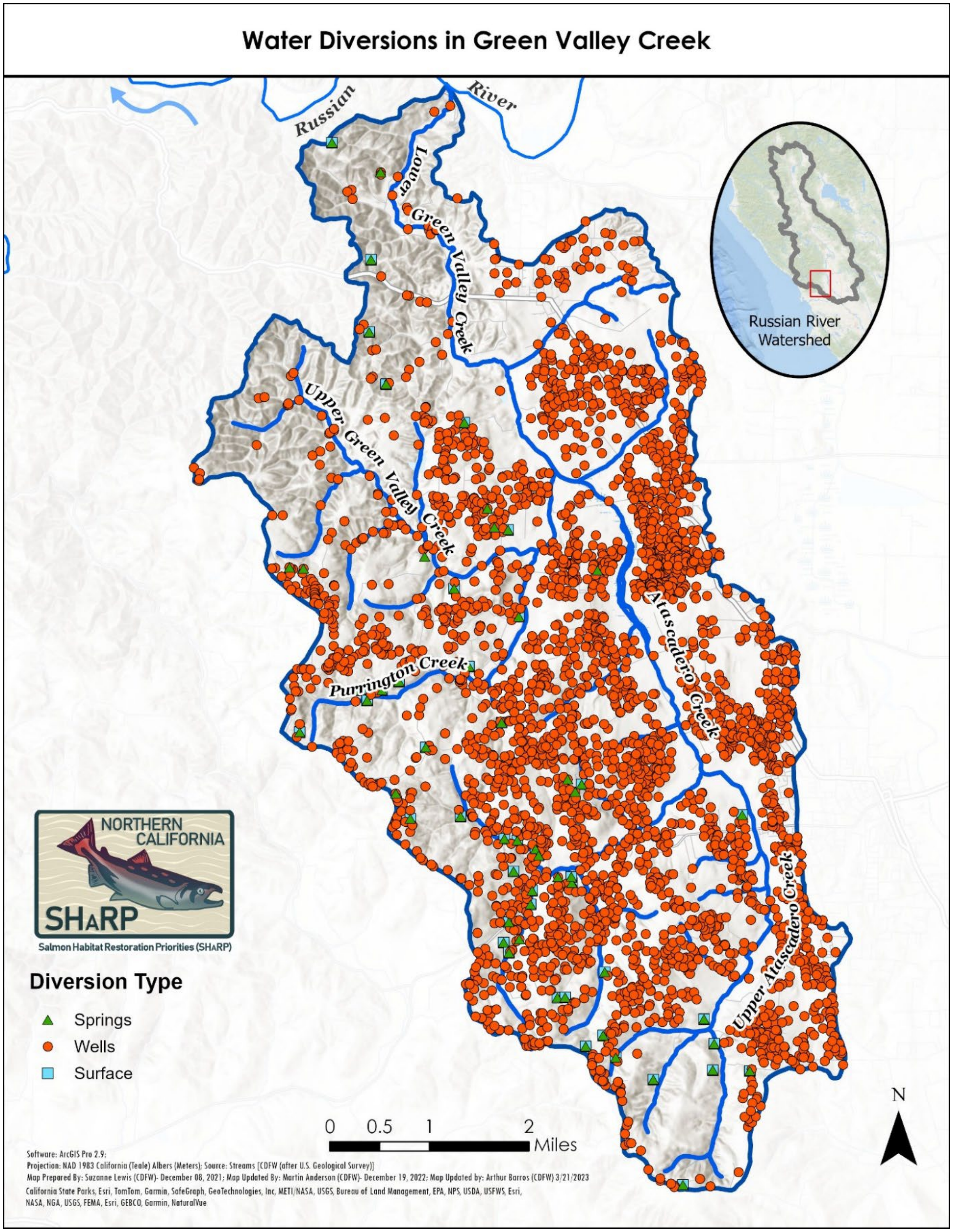

Figure 10. Locations and types of diversions within GVC watershed based on results from the State Resources Control Board (SWRCB) – Division of Water Rights 2015 Drought Emergency Informational Order, January 2014 – December 2015.

4.3 Past and Current Restoration Funding

From 2004 to 2018, the FRGP awarded nearly $2.5 million to fund or partially fund 21 projects in GVC that addressed fish passage, upslope erosion and sediment, instream habitat for fish, and bank stabilization (Hampton et al. 2021). FRGP also funded Gold Ridge Resource Conservation District (GRRCD) to complete Phase II of the GVC Management Plan. The Conservancy provided funding for Phase I of the Management Plan. The management plans provide valuable watershed insights, including project recommendations based on years of experience working in the watershed. In addition, OEI completed the Flow Availability Analysis Report for Green Valley/Atascadero and Dutch Bill watersheds in 2016 with FRGP funding. This report informed much of the watershed information found in this Action Plan as well as project site recommendations.

Other efforts have been funded by the NOAA Restoration Center and other agencies. Proposition 1 (Prop 1) and the Wildlife Conservation Board (WCB) are the most recent sources of funding for water conservation projects in GVC. Prop 1 funded the designs for Iron Horse, Atascadero Ecological Reserve, Atascadero Sediment Wedge, and the Greene property projects. The National Fish and Wildlife Foundation funded a 10-year grant to support the Russian River Coho Water Resources Partnership (Coho Partnership), of which one of the watersheds was GVC. This consortium of local agencies and non-governmental organizations (NGOs) produced scientifically based streamflow improvement plans for several Russian River Coho streams, including Upper GVC (RRCWRP 2019).

4.4 Green Valley Creek SHaRP Meeting

The GVC virtual SHaRP meeting was held on January 25, 2022, following the methods described in Chapter 3. The invited participants represented federal, state, and county agencies, tribes, NGOs, local environmental consultants, researchers, and landowners. Local watershed experts presented their work and knowledge of the area. Presentations included:

- Green Valley Creek Coho Habitat Analysis - Perspectives from Hydrologic Modeling (Coast Range Watershed Institute (CRWI))
- Salmonid Trends and Habitat Use (CDFW)

As described in Chapter 3, participants had access to public facing interactive maps via AGOL. These maps contain public data layers tailored to the GVC watershed. The steering team provided a guided overview of all data layers during the meeting (Appendix III). Collectively, the materials, presentations, and discussions informed the participants in evaluating and ranking the limiting attributes affecting salmonid survival in the creek.

Table 3. GVC watershed SHaRP attribute ranking results expressed as least limiting [green (g)], moderately limiting [yellow (y)], and most limiting [red (r)]. The N/A boxes were blocked out for ranking due to the lack of a clear connection for a particular attribute-life stage combination.

Attributes	Egg/Alevin	Summer Juvenile	Winter Juvenile	Smolt	Adult
Anthropogenic Barriers	N/A	(y)	(y)	(y)	(y)
Channel Structure & Form	(r)	(r)	(r)	(r)	(r)
Off-Channel Habitats	N/A	N/A	(r)	(r)	(r)
Riparian Conditions	(y)	(y)	(y)	(y)	(y)
Sediment Conditions	(y)	N/A	N/A	N/A	(y)
Water Quality	(y)	(r)	(y)	(y)	(y)
Water Quantity	(r)	(r)	(y)	(r)	(r)
Invasive Species	(g)	(y)	(y)	(y)	N/A

Based on results from the ranking activity, *Channel Structure & Form and Water Quantity* stand out as the most limiting attributes for all life stages. The close relationship with these two attributes affects *Water Quality* that also ranked high, especially for summer juveniles.

Off-Channel Habitats ranked as highly limiting. These habitats include floodplains, side channels, and alcoves. The deeply incised stream channels in much of the watershed prevent floodplain activation during high flows that could provide velocity refuge and rearing opportunities for winter juveniles.

4.5 SHaRP Restoration Actions

Considering the ranking results and an understanding of habitat/life stage survival relationships (Chapter 3), workshop participants leveraged their knowledge of the watershed to identify opportunities and actions with the greatest potential to address the most limiting attributes to salmonid survival (Figure 10, Table 4).

Although barriers were not heavily discussed in the SHaRP meeting, *Anthropogenic Barriers* ranked moderately high and recommendations for barrier inspection or remediation were added to the SHaRP Action Plan (Figures 11 and 12, Table 5).

Action-GV-1: Monitor Streamflow Year-Round

Attributes: Water Quantity and Quality
Location: Watershed-wide

As of January 2024, summer/dry season streamflow monitoring in GVC is conducted by Trout Unlimited (TU) at four gages on Upper GVC through short-term grant funding. Monitoring streamflow in the various and differing hydrologic reaches is essential in GVC and Atascadero

Creek due to high flow variability and inherent risks to juvenile survival of Coho Salmon and steelhead. The Coho Partnership found that insufficient streamflow during the dry season is a significant limiting attribute to Coho Salmon recovery (RRCWRP 2019).

Surface and ground water monitoring are critical to understanding where perennial groundwater discharge occurs in the watershed, as this is a primary driver of sustained summer streamflow in the GVC watershed. Groundwater enhancement projects should focus on reaches that have been identified as key generators of summer streamflow (GRRCD et al. 2021). Likewise, reaches within the watershed that are unable to maintain consistent summer streamflow can be identified and enhanced with flow releases from existing wells and/or reservoirs.

Winter streamflow is not well characterized in many reaches of the watershed. Year-round streamflow monitoring would build a baseline of average and storm-related winter streamflow and is critical to understanding what reaches within the watershed experience high water velocity that impact juvenile fish survival and movement.

A year-round streamflow gaging network needs to be established for the long-term. The current gage system needs to be expanded to include winter baseflow monitoring to assess winter drought conditions as well. In addition, information gained from groundwater monitoring will help inform and ensure cost-effective water-resource management during low-flow conditions.

Action-GV-2: Investigate Easements & Acquisitions to Protect Sources of Perennial Streamflow & Avoid Development

Attributes: Water Quantity and Quality
Location: Watershed-wide

A conservation easement is a voluntary, legal agreement that permanently limits uses of the land in order to protect its conservation values. Also known as a conservation restriction or conservation agreement, a conservation easement is one option to protect a property's conservation value in the future. Conservation easements can be an effective tool to protect land, often at lower cost to land trusts and public agencies, while offering tax benefits to the landowner.

The Sonoma Land Trust's (SLT) Russian River Subwatershed Conservation Assessment project in 2021 used high-quality reach-level information on Coho Salmon habitat, streamflow priorities, and groundwater recharge data prepared by CRWI and OEI. These data were combined with other environmental data and input from local scientists and experts to identify specific ownerships where easements, fee acquisitions, and other stewardship and land management actions could be considered as tools to protect or enhance salmonid habitats in the four focus streams (J. Conti, pers. comm. 5/22/2023).

Action-GV-3: Enhance & Preserve Streamflow

Attributes: Water Quantity and Quality

Location: Watershed Wide

Direct diversions directly affect streamflow in Upper GVC, and groundwater pumping from shallow wells adjacent to the creek likely have a significant impact on summer baseflow conditions (RRCWRP 2019). Streamflow enhancement and preservation would benefit water quality conditions for salmonids in the low flow season and would increase the available habitat for summer rearing and smolt out-migration. Streamflow enhancement projects along with watershed-scale recharge projects are recommended in reaches where high numbers of fish spawn and rear (such as Upper GVC and Purrington Creek). In addition, there may be opportunities for infiltration and drainage projects in the upland areas of the watershed. The Coho Partnership identified priority reaches that serve the focus of their effort to improve streamflow in Upper GVC. These recommendations are based on stream surveys, stream flow data, fish distribution, and wetted habitat data (RRCWRP 2019). OEI 2016 made similar recommendations in their report. It is recommended these reports be referenced.

All life stages of Coho Salmon, especially out-migrating juvenile fish moving through Atascadero Creek, are faced with anoxic conditions, especially between the Occidental Road crossing and the confluence of Upper GVC. These anoxic conditions are exacerbated by the discontinuous channels punctuated with portions of very shallow flow and emergent marsh vegetation. Lower watershed tributaries such as Sullivan (Pitkin) Creek drain uplands in the northeast corner of Atascadero Creek, including Pitkin Marsh and are underlain by WGF. This perennial source of water currently drains into a diked area adjacent to Atascadero Creek. Modification of the stream channel to provide more surface flow connectivity is recommended to improve water quality and fish passage downstream in Atascadero Creek (GRRCD et al. 2021). GRRCD has a completed design for this modification. Jones (Forestville) Creek and Sullivan (Pitkin) Creek regularly provide year-round flow to lower GVC. Investigation of water quality and availability from these two streams is recommended.

Walker Creek, a westside tributary to middle Atascadero Creek, may potentially have substantial habitat for spawning and may provide a perennial source of water to this reach of Atascadero Creek. Further investigation is needed to understand creek habitat conditions and surface flow connectivity at the confluence with Atascadero Creek (GRRCD 2013). This is being addressed with CRWI's project funded by WCB.

Streamflow enhancement and preservation in Redwood and Jonive creeks to improve water quantity can include water conservation strategies, storage projects for landowners using stream diversions or near-stream/shallow wells, and alternative water sources. Upland projects to reduce storm runoff and enhance groundwater are also recommended.

Action-GV-4: Address Unscreened Diversions

Attributes: Anthropogenic Barriers
Location: Lower GVC

One known unscreened diversion was identified in lower GVC. The diversion is meant to provide irrigation to adjacent agricultural operations. Diversion screens are needed to protect fish and other aquatic species from being pulled into irrigation ditches or pipes. Additional unscreened diversions that have yet to be identified should also be funded for screening.

Action-GV-5: Enhance Instream Habitat

Attributes: Channel Structure & Form, Sediment Conditions, Water Quantity and Quality, Riparian Conditions
Location: Upper GVC and tributaries, Purrington, Jonive, and Sexton Creeks, and Upper Atascadero Creek from Jonive Creek confluence to Lynn Creek

Many of the tributaries to GVC, including Purrington Creek, have experienced stream channel maintenance to improve flood water conveyance and land use modifications. This has resulted in a deficiency of large wood and habitat cover or shelter in the stream channel and a healthy riparian corridor. Large wood should be used to create more complex in-stream habitat, to sort and store gravels needed for spawning, to create and increase pools depth and frequency, and to aggrade the streambed to encourage floodplain connection. Riparian planting should be included in any instream habitat project.

Meeting participants agreed that large wood projects are a priority in Upper GVC, the Nutty Valley and Little GVC tributaries, and Purrington Creek, as well as lower Harrison Creek. OEI 2016 rated the mainstem upstream from Harrison Creek as being of low value for instream habitat restoration, but CSG found that even with low flows, the salmonids successfully rear in this reach, suggesting this area would benefit from restoration. Most of this reach is the remaining portion of GVC that has not become incised. GRRCD has observed root-dominated riffle mats present at pool/riffle crests in Upper GVC. These riffle mats provide grade control and stabilize the channel while providing valuable fresh-water shrimp habitat. Project design proponents should preserve these features.

Upper Atascadero Creek and Jonive Creek offer more consistent flow for juvenile rearing but lack large wood that would provide shelter and complexity for rearing fish. Adding large wood features to create complex habitat is recommended for this reach of Upper Atascadero Creek and its tributaries *after* water quality, migration, and flow limitations in Lower Atascadero Creek are addressed.

Action-GV-6: Enhance Off-Channel & Floodplain Habitat

Attributes: Channel Structure & Form, Sediment Conditions, Water Quantity and Quality, Riparian Conditions
Location: Lower GVC and Atascadero Creek to Jonive Creek Confluence

In lower GVC and Atascadero Creek, the stream channel flows through a low gradient interconnected riparian floodplain. The wetland's dense vegetation and channel modification associated with long-term changes in floodplain and channel connection have led to poor water quality, increased aggradation of streambed material resulting in fish migration barriers, and a lack of velocity refuge habitat for overwintering juvenile salmonids. Water quality (hypoxia) is effectively a barrier or significant impediment to migration at ACER marsh and to a lesser extent upstream to Occidental Road. The wetland riparian floodplain area has seen much change, and, in many areas, there is a lack of well-defined channel(s) that likely impedes migration. CRWI's WCB Grant WC-2149AD seeks to improve conditions between Occidental Road and Graton Road (M. O'Connor, pers. comm. 12/29/2023). NOAA funds granted to GRRCD will help complete designs for three floodplain and stream channel habitat projects.

The Broodstock Program released juvenile Coho Salmon into Redwood Creek, a tributary to Jonive Creek which flows into Atascadero Creek, from 2017 to 2021. PIT-tag results revealed that in most years of the study, the Atascadero Creek migration corridor posed a severe bottleneck to migration and survival. Very few fish completed their migration to GVC, and most were never observed again following their entry into Atascadero Creek (CSG 2023b).

Off-channel and floodplain habitat enhancements may include vegetation and channel modification with well-planned grading to reestablish multiple channels (GRRCD et al. 2021). Riparian forests should be enhanced with native trees, shrubs, and grasses. The habitat concerns related to Green Valley Road are further explained below.

Action-GV-7: Investigate Barriers and Remediate as Needed

Attributes: Anthropogenic Barriers
Location: Locations throughout the watershed

There are several known and suspected barriers within Upper Atascadero, many of which require an assessment, including the perched county culvert at Barnett Valley Road, just upstream of the confluence with Lynn Creek (GRRCD et al. 2021, Figure 14). Barrier site assessments are recommended in Upper Atascadero and can be used to update the Passage Assessment Database (PAD). Once sites have been assessed, priority barrier sites can be remediated, removed, or replaced with crossings that do not impede fish passage and can accommodate 100-year flow events (Figure 14, Table 5).

Action-GV-8: Address Incision

Attributes: Channel Structure & Form, Sediment Conditions, Water Quantity and Quality, Riparian Conditions
Location: Upper GVC, lower Purrington, Jonive, and Sexton Creeks, Upper Atascadero Creek upstream from Bodega Hwy to the headwaters.

Channel incision (downcutting) has degraded much of the GVC watershed including Upper GVC, lower Purrington, Jonive, and Sexton creeks, and Upper Atascadero Creek. These incised streams do not access the floodplain, and fish have little to no access to slow water refugia during high flows. Ongoing incision continues due to high velocity winter flows associated with land use development, channel straightening, removal of wood from the channel, installation of streambank revetments, weak bedrock, and highly erodible WGF. Arresting incision is recommended by increasing sediment storage and aggrading the channel to restore floodplain aquifer storage, increase summer baseflows, and decrease summer temperatures (Beechie et al. 2013). Low-tech channel spanning structures such as beaver dam analogs (BDAs) and large wood structures collect sediment, slow velocities, reduce bank erosion, and sort gravels. Landowner participation and further surveys are needed to determine the extent of incision progression.

Action-GV-9: Address Habitat Concerns Related to Green Valley Road Crossing

Attributes: Channel Structure & Form, Sediment Conditions, Water Quantity and Quality, Riparian Conditions
Location: Section of GVC between the Purrington and Atascadero confluences

This section of Green Valley Road floods frequently in the winter, inundating the road and the adjacent vineyard, depositing excess fine sediments into Atascadero Creek just upstream of the confluence with GVC. This long-term sediment transport has resulted in the formation of a sediment wedge that likely began in the mid-1980s. Water quality in this area is very poor in the low-flow summer season and may be the primary limiting attribute for Coho Salmon and steelhead survival in this area, as well as smolt outmigration from upper Atascadero Creek. There are many connected and interrelated projects underway in this area, including an analysis of the cause of anoxia in the ACER wetland, and whether removal of the sediment wedge will improve water quality. Easements and acquisition of land may also provide incentives for parcel owners to partner with agencies for possible solutions related to the bridge crossing and nearby critical Coho Salmon habitat.

Figure 11. Deep incision and trash dump, Purrington Creek at Graton Road pullout (OEI SHaRP presentation 2022).

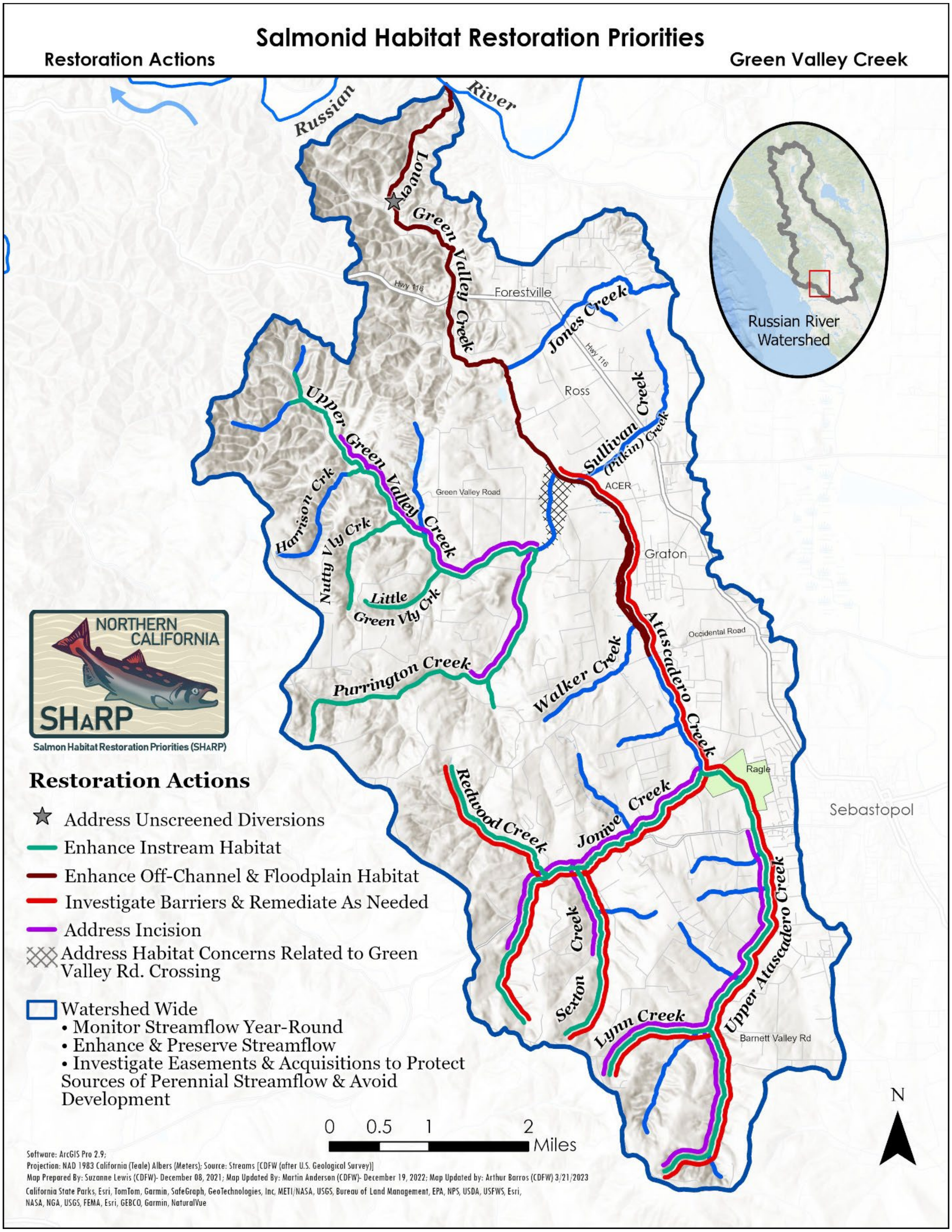

Figure 12. Green Valley Creek SHaRP Restoration Actions and Locations.

Table 4. GVC SHaRP Restoration Actions, Action Number, Map Symbols, Locations, and Comments.

Action #	Restoration Action	Map Symbol	Location	Comments
GV-1	Monitor Streamflow Year-round	Blue Outline	Watershed-wide	Steady funding needed to support year-round flow gaging in different hydrologic reaches of GVC and tributaries.
GV-2	Investigate Easements & Acquisitions to Protect Sources of Perennial Streamflow & to Avoid Development	Blue Outline	Watershed-wide	Support land conservation organizations in protecting lands that contribute to instream and watershed processes.
GV-3	Enhance & Preserve Streamflow	Blue Outline	Watershed-wide	Develop water conservation strategies including alternate water sources, water-use efficiency, and winter storage/summer forbearance projects. Implement upland groundwater recharge and other strategies to improve flows.
GV-4	Address Unscreened Diversions	Silver Star	One location in lower GVC	Build and use appropriate fish exclusion screening.
GV-5	Enhance Instream Habitat	Green Line	Upper GVC, Upper Atascadero Creek, and tributaries	Add large wood structures using the appropriate methods. Plant native vegetation to create or enhance pool cover and provide future wood recruitment. Prioritize Upper GVC and tributaries, and Purrington Creek. Then Jonive Creek, Sexton Creek, Upper Atascadero upstream from Jonive confluence, Lynn Creek.
GV-6	Enhance Off-Channel & Floodplain Habitat	Dark Maroon Line	Lower GVC and Atascadero Creek to Occidental Rd.	Create off-channel habitat via wood structures and grading. Lower Atascadero may include vegetation and channel modifications, carefully planned grading, and other strategies.

Action #	Restoration Action	Map Symbol	Location	Comments
GV-7	Investigate Barriers and Remediate as Needed	Red Line and points	GVC, Purrington, Atascadero creeks and tributaries	1) Use the OEI and GRRCD LiDAR data to prioritize assessment locations in Upper Atascadero and update the Passage Assessment Database (PAD), 2) address known barriers.
GV-8	Address Incision	Purple Line	Upper GVC, lower Purrington Creek, Jonive Creek, lower Sexton Creek, Upper Atascadero upstream from Bodega Hwy to headwaters.	Installation of wood structures, BDAs, and/or bioengineering techniques is a common strategy to limit incision, and redirect/slow streamflow velocity.
GV-9	Address Habitat Concerns Related to Green Valley Rd. Crossing	Cross-Hatched	Section of GVC between the Purrington and Atascadero confluences.	Continue to work with the county, conservation groups, and landowners to develop and implement solutions.

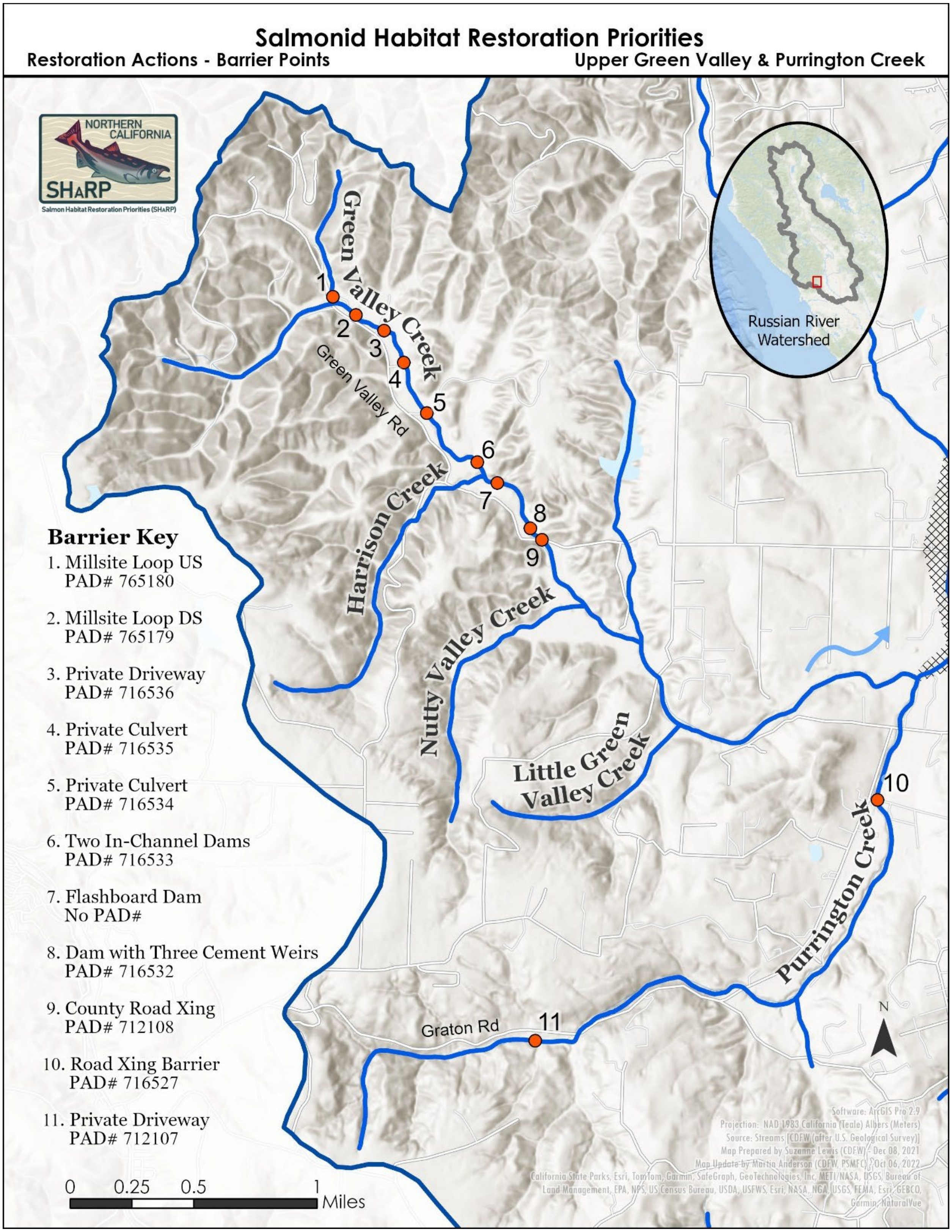

Figure 13. Upper GVC known barriers and PAD ID numbers (GV-7). Table 5 further explains each of the barriers.

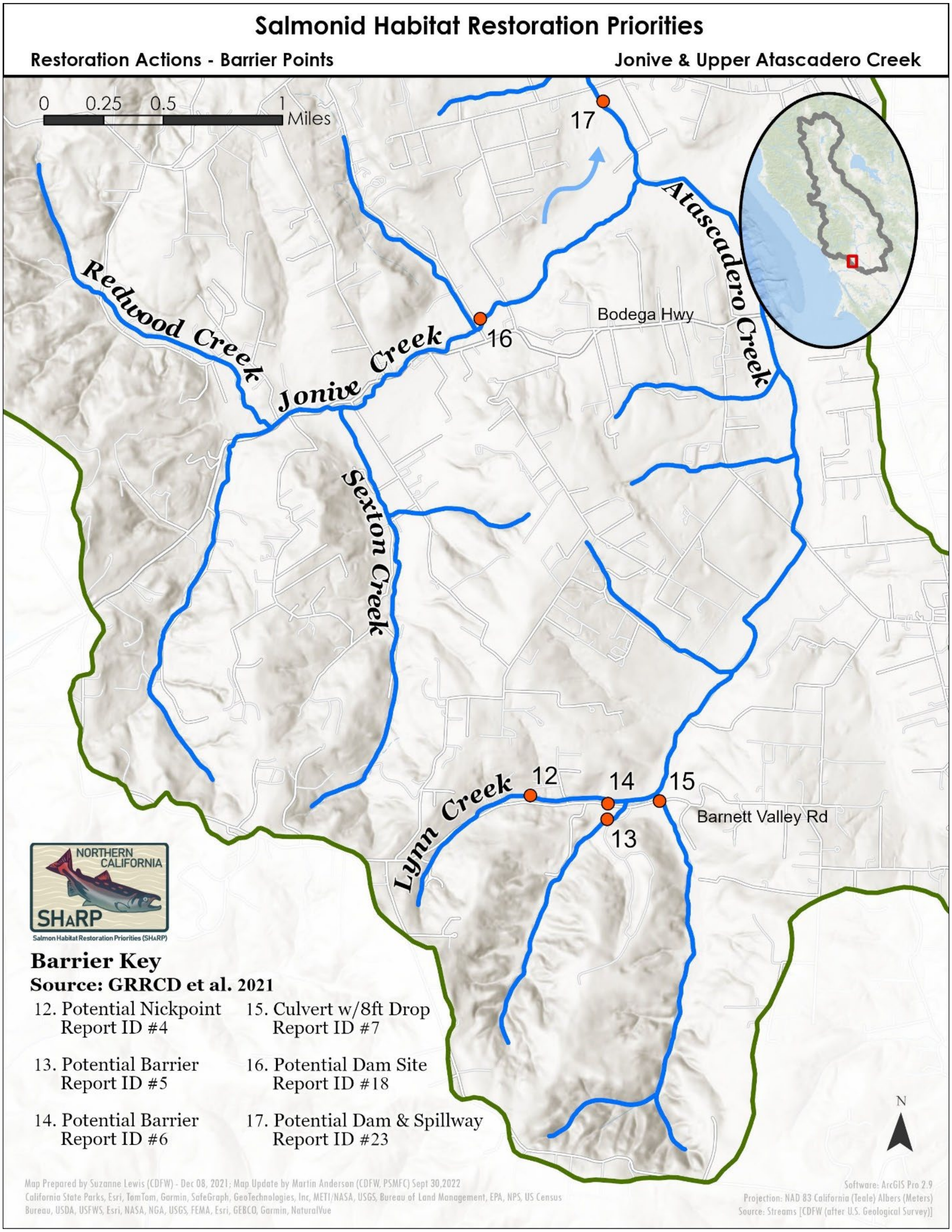

Figure 14. Verified and potential Upper Atascadero barriers (based on LiDAR observations) (GV-7). Source: (GRRCD et al. 2021). Table 5 further explains each of the barriers.

Table 5. GVC watershed barriers (GV-7), location, cross-reference, status, and passage type. CDFW surveyed and updated barrier sites 1-5 and 8-9 on June 11-12, 2023 (Appendix I). See Figures 11 and 12 for maps. *Description is from GRRCD et al. 2021.

Fish Barrier	Latitude	Longitude	Cross Reference	PAD or GRRCD Status	Passage Type
1. Millsite Loop (Upstream)	38.458	-122.935	PAD# 765180	Juvenile/Partial/Velocity	Driveway/4’ diameter culvert
2. Millsite Loop (Downstream)	38.457	-122.933	PAD# 765179	Juvenile/Partial/Velocity	Driveway/4’ diameter culvert
3. Private Driveway	38.456	-122.931	PAD# 716536	Both/Temporal/Low flow	Driveway/10’ wide concrete sill and bridge
4. Private Culvert	38.455	-122.929	PAD# 716535	Not a barrier	Driveway/8’ diameter culvert
5. Private Culvert	38.452	-122.927	PAD# 716534	Not a barrier	Driveway/14’ x 9’ bottomless arched culvert. Bottom enhanced with small boulders.
6. Two In-Channel Dams	38.448	-122.921	PAD# 716533	Unknown/Not assessed.	Two in-channel dams/ Upper Culvert Dam
7. Flashboard Dam	NA	NA	No PAD#	Unknown/Not assessed	Flashboard dam
8. Dam w/three cement weirs	38.445	-122.919	PAD# 716532	Both/Total/Jump height	Old grade control structure at the old dam-bedrock outcrop.
9. County Road Xing	38.444	-122.918	PAD# 712108	Both/Temporal/Jump height	Concrete- box culvert remediated with downstream wood board weir to backwater the culvert.

Fish Barrier	Latitude	Longitude	Cross Reference	PAD or GRRCD Status	Passage Type
10. Purr. Road Xing Barrier	38.430	-122.893	PAD# 716527	Unknown/Not Assessed	Five ft. high flashboard dam
11. Purr. Private Driveway	38.415	-122.918	PAD# 712107	Partial	Private culvert/road crossing
12. Potential Nickpoint	38.368	-122.865	ID#4	*LiDAR shows barrier, Possible Anomaly	Unknown
13. Potential Barrier	38.367	-122.859	ID#5	*LiDAR shows barrier, Possible Anomaly	Unknown
14. Potential Barrier	38.368	-122.859	ID#6	*LiDAR shows barrier, Possible Anomaly	Unknown
15. Culvert w/8ft Drop	38.368	-122.855	ID#7	*This was verified in the field. It is a complete fish barrier at Barnett Valley Road Xing.	Perched box culvert
16. Potential Dam Site	38.397	-122.870	ID#18	*LiDAR shows barrier, Possible Large Anomaly	Unknown
17. Potential Dam & Spillway	38.410	-122.861	ID#23	*LiDAR shows small barrier, Likely Anomaly	Unknown

Chapter 5. Dutch Bill Creek Action Plan

5.1 Watershed Overview

Dutch Bill Creek (DBC) drains an area of approximately 12 mi^2, and its headwaters originate east of Occidental at an elevation of approximately 800 feet (OEI 2016). The creek flows southwest for about 0.6 miles, then bends through a narrow valley and flows to the northwest for about 8 miles, entering the Russian River in Monte Rio at an elevation of 20 feet, approximately seven miles upstream of the Pacific Ocean. Named tributaries to DBC from upstream to downstream include Lancel Creek, Baumert Creek, Alder Creek, Redwood Gulch, Grub Creek, Duvoul Creek, Bohemian Creek, Perenne Creek, Tyrone Gulch, and Schoolhouse Gulch, but these creeks currently offer little or no habitat for salmonids at this time.

The DBC watershed is underlain predominantly by the Franciscan Complex with some small areas of WGF in Lancel Creek and the mainstem near Camp Meeker. Coarse-grained alluvium dominates the stream below Tyrone Gulch (Figure 15).

The 1997 CDFG stream habitat assessment suggested that large pools with substantial woody cover for juvenile salmonids are limited within DBC (CDFG 2000b). The report recommends structures that work to decrease channel incision and retain spawning gravel, upslope, and in-channel erosion projects to reduce fine sediment input, and fish passage improvements.

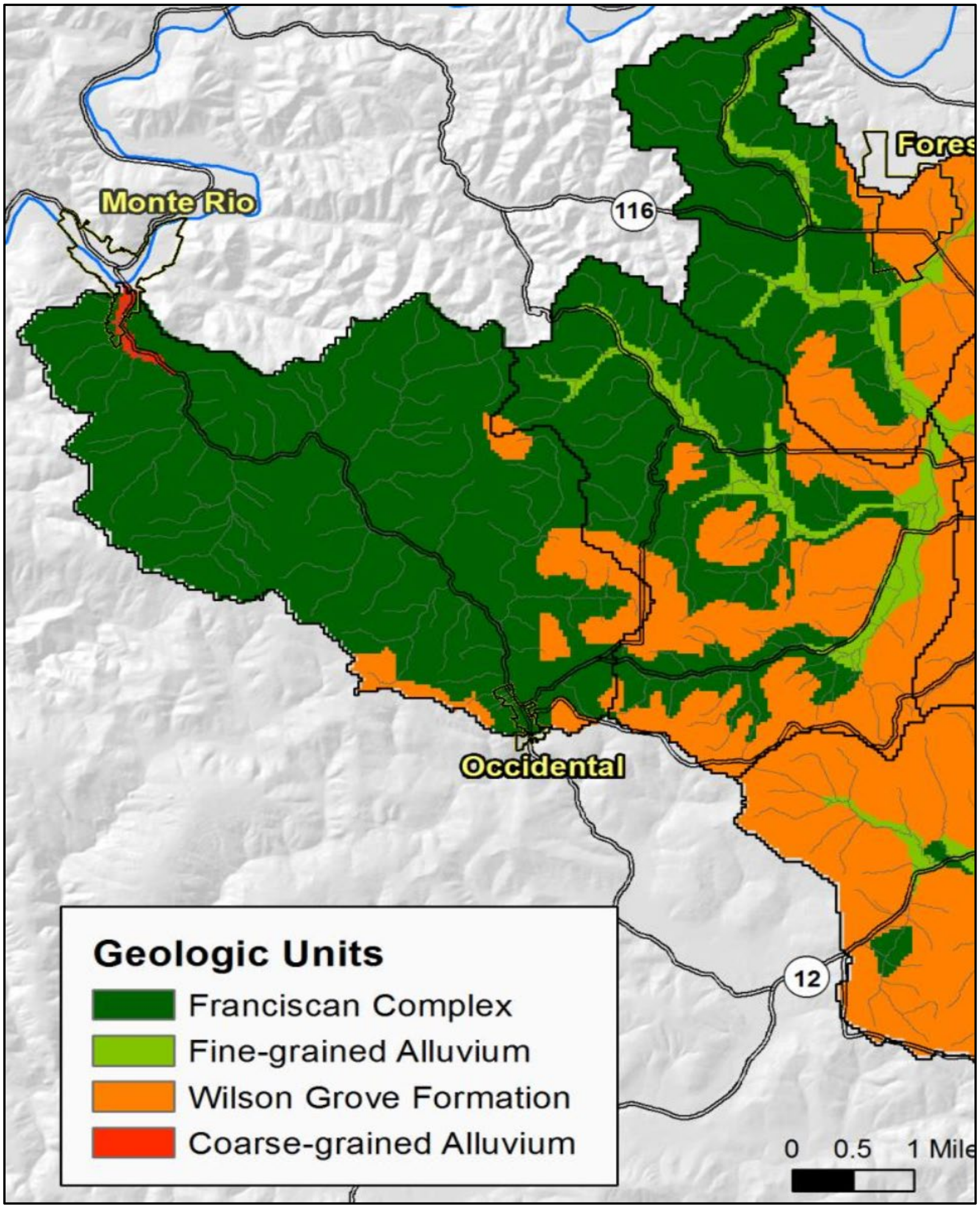

Figure 15. DBC watershed located between Occidental and Monte Rio is predominantly Franciscan Complex (OEI 2016).

5.2 Land Uses – Historic and Current

DBC was named after the Danish sailor William "Dutch Bill" Howard. He had great influence in the area, and the original name for the town of Occidental was "Howards" (Gonnella et al.

2020). European immigrants were drawn to the wealth that was possible through logging operations. The area was heavily logged beginning in the 1850s, and Melvin Cyrus Meeker's lumber mills were in full operation by the mid-1860s. The narrow-gauge railroad built along the length of the creek hastened deforestation. The significant impacts to the land and hydrological balance of the watershed resulting from 150 years of clearcutting are still impacting the watershed today, with ongoing challenges to ensure adequate flows for fish and water security for the local communities (RRCWRP 2017).

Evergreen forest dominates the DBC watershed, but there are zones of grasslands and oak woodland in the upper watershed (CDFG 2000b, Figure 16). The DBC watershed is primarily rural residential with a few exceptions. The Sonoma County Monte Rio Redwoods Regional Park located in lower DBC includes a master plan outlining recreation, education, and conservation elements. LandPaths, a non-profit land conservancy, owns and stewards the protected open space of the Bohemia Ecological Preserve within the watersheds of Duvoul and Grub creeks. This 554-acre private nature preserve is not open to the public but hosts private groups for outdoor education and stewardship programs. Westminster Woods Camp and Conference Center, Alliance Redwoods Conference Grounds, and St. Dorothy's Rest are summer camp and conference facilities located along the creek and in the upland redwood forests.

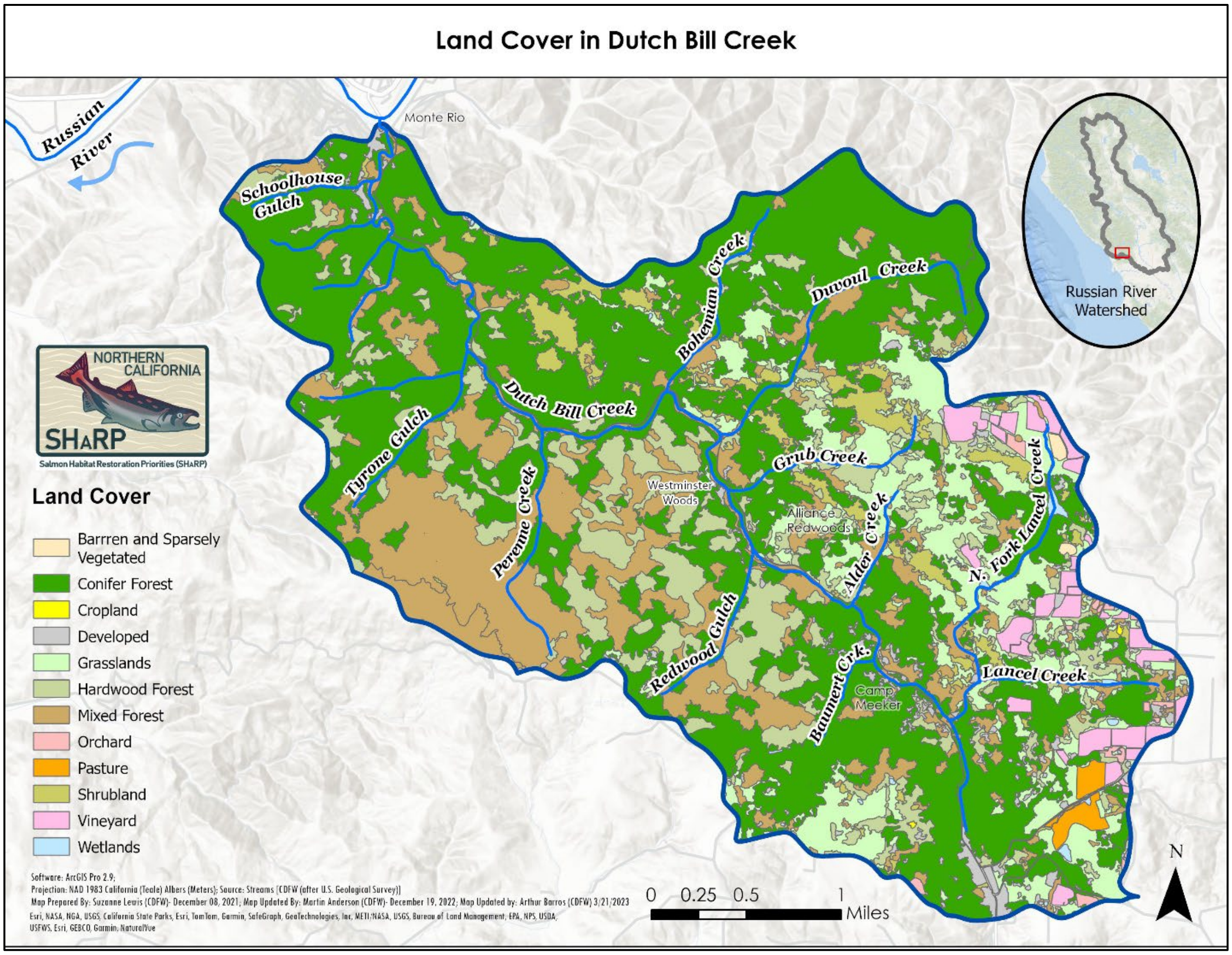

Figure 16. Overview of DBC land cover. Source: Source: Sonoma Veg Map.

Water Supply

The SWRCB governs surface water supply through a series of Water Rights Decisions and Orders. Based on findings from the 2015 Drought Emergency Informational Order, the number, and types of diversions within DBC watershed include nine surface diversions, 11 springs, and 150 wells (SWRCB 2015) (Figure 17).

The Camp Meeker Recreation and Park District Board of Directors (Camp Meeker) oversees the district's water authority. Water is sourced from the Russian River via a deep gravel well at Monte Rio and pumped upstream to storage tanks in Camp Meeker. The system serves approximately 365 customers.

Data analyzed by the Coho Partnership shows that the watershed receives approximately 100 times the amount of water needed by residents (annually) for residential, institutional, and agricultural uses, but the water is available during the winter, not the summer when it is needed (RRCWRP 2017). Diversions in operation during the dry season can draw water down, causing the stream to become disconnected. In response to the Emergency Drought Declaration in 2015, Camp Meeker agreed to release some of its stored water back into the creek to benefit juvenile Coho Salmon and steelhead survival (Figure 18). A second water release, from a reservoir owned by St. Dorothy's Rest, started in the fall of 2021. Voluntary flow releases in DBC continued annually, and successfully averted salmonid mortality due to diminishing flows.

Water releases are not considered long-term fixes to impaired watershed processes, but temporary solutions designed to sustain connectivity between pools through the dry summer and fall seasons.

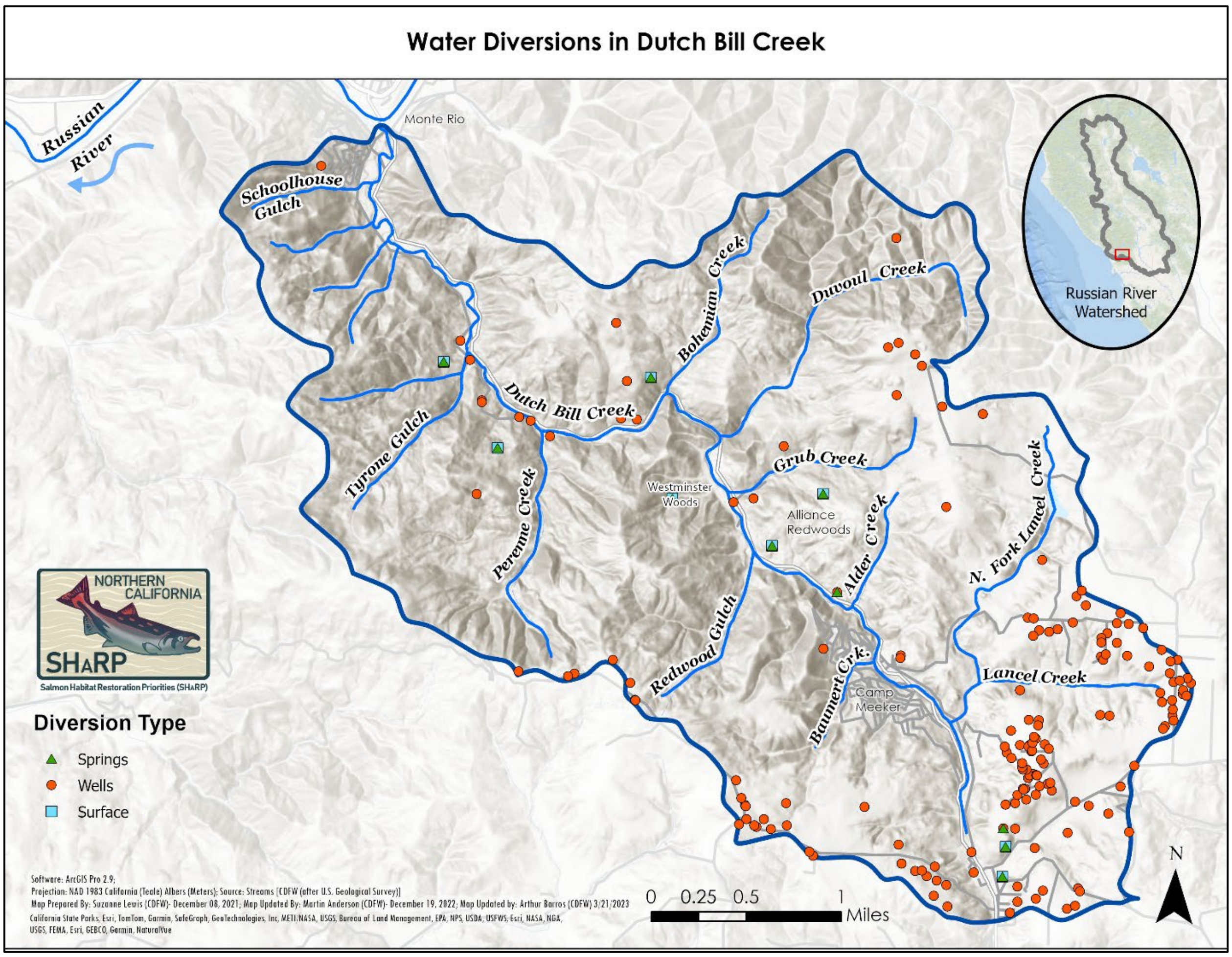

Figure 17. Locations and types of diversions within DBC watershed based on results from the State Resources Control Board (SWRCB) – Division of Water Rights 2015 Drought Emergency Informational Order, January 2014 – December 2015.

Figure 18. Camp Meeker flow release site.

5.3 Past and Current Restoration Funding

The FRGP awarded close to $2 million to fund or partially fund 11 projects in DBC watershed between 2004 and 2018 (Hampton et al. 2021). These restoration projects addressed water conservation, upslope erosion and sediment, instream habitat for fish, and fish passage.

Between 2004 and 2008, two FRGP-funded projects resulted in the removal of three fish passage barriers that opened approximately 3.4 miles of stream habitat to all life stages of Coho Salmon and steelhead. The community was highly involved in this effort that included the DBC Dam Removal and Creek Restoration Project and the Market Street Fish Passage Project. The dam removal project removed the historic dam, restored the stream channel, and installed a pedestrian bridge. The Market Street project included removal of concrete apron, culvert retrofit to disperse flow energy, and construction of downstream boulder weirs to improve fish passage. The culvert was ranked the fifth highest priority fish passage barrier in Sonoma County (Taylor 2003). In addition, OEI completed a Flow Availability Analysis Report for Green Valley/Atascadero and Dutch Bill watersheds with FRGP funding (OEI 2016). Their report provides much of the watershed information and project site recommendations included in this Action Plan.

The Wildlife Conservation Board (WCB) and FRGP are the most recent supporters of water conservation projects in DBC. The Westminster Woods Camp and Conference Center had relied on DBC surface water withdrawals to irrigate its playing fields during the summer. Partners implemented a significant water conservation project in 2015 to reduce overall irrigation demand and allowed the timing of water diversion to be shifted to the winter rainy season. WCB and FRGP are funding a similar project in Alliance Redwoods. Together, these projects provide reliable sources of water that meet operational needs, while leaving water in the creek for endangered fish.

The National Fish and Wildlife Foundation supported the Coho Partnership between 2010 and 2022. This consortium of local agencies and NGOs produced scientifically based streamflow improvement plans for several Russian River Coho Salmon streams, including DBC (RRCWRP 2017).

5.4 Dutch Bill Creek SHaRP Meeting

The DBC virtual SHaRP meeting was held on June 1 – 2, 2022, following the methods described in Chapter 3. The invited participants represented federal, state, and county agencies, tribes, NGOs, local environmental consultants, researchers, and landowners. Local watershed experts presented their work and knowledge of the area. Presentations included:

- Dutch Bill Creek Coho Habitat Analysis-Perspectives from Hydrologic Modeling (CRWI)
- Dutch Bill Creek Salmonid Use and Habitat Suitability (Nossaman-Pierce (CSG) 2022a)

As described in Chapter 3, participants had access to public-facing, interactive maps via AGOL. These maps contain public data layers tailored to the DBC watershed. The steering team provided a guided overview of all data layers during the meeting (Appendix III). Collectively, the materials, presentations, and discussions informed the participants in evaluating and ranking the limiting attributes affecting salmonid survival in the creek.

Table 6. DBC SHaRP attribute ranking results expressed as least limiting [green (g)], moderately limiting [yellow (y)], and most limiting [red (r)]. The N/A box was blocked out for ranking due to the lack of a clear connection for a particular attribute-life stage combination.

Attributes	**Egg/Alevin**	**Summer Juvenile**	**Winter Juvenile**	**Smolt**	**Adult**
Anthropogenic Barriers	N/A	(y)	(g)	(g)	(y)
Instream Structural Complexity	(y)	(r)	(r)	(y)	(y)
Off-Channel Habitats	(g)	(y)	(r)	(r)	(y)
Riparian Conditions	(g)	(y)	(y)	(y)	(g)
Sediment Conditions	(y)	(g)	(y)	(g)	(y)
Water Quality	(g)	(y)	(g)	(y)	(g)
Water Quantity	(r)	(r)	(y)	(r)	(y)
Invasive/Non-native species	(g)	(g)	(g)	(g)	(g)

Based on results from the ranking activity, *Water Quantity* stands out as the most limiting attribute for egg/alevin, summer juvenile, and smolt life stages. *Instream Structural Complexity* was ranked as the most limiting attribute for summer and winter juveniles, and *Off-Channel Habitats* was ranked as the most limiting attribute for winter juvenile and smolt life stages.

5.5 SHaRP Restoration Actions

Considering the ranking results and an understanding of habitat-life stage-survival relationships (Chapter 3), workshop participants leveraged their knowledge of the watershed to identify opportunities and actions with the potential to restore or enhance the most limiting attributes to salmonid survival. These restoration actions were organized into a table with a complimentary map (Figure 20, Table 7a). The section below describes each action in more detail.

Action-DB-1: Enhance and Preserve Streamflow

Attributes: Water Quantity and Quality
Location: Watershed-wide

The Coho Partnership found that insufficient dry season flow significantly limits Coho Salmon recovery and recommends practitioners consider and integrate flow information and instream flow project locations into their instream habitat enhancement project designs (RRCWRP 2017).

It is recommended that the DBC Streamflow Improvement Plan be referenced for flow improvement strategies and metrics to evaluate progress in restoring flow in DBC.

Community partnerships are crucial to streamflow enhancements and preservation. It is recommended that partners continue and expand current flow release agreements with possible expansion into new areas such as Lancel Creek. Ultimately, the goal is healthy self-sustaining streamflow with no need for flow augmentation to protect fish and wildlife. Note*:* See Action-DB-4: *"Assess and Manage Forests to Improve Watershed Processes"* for more about forest management and streamflow.

Action-DB-2: Investigate Easements & Acquisitions to Protect Sources of Perennial Streamflow & Avoid Development

Attributes: Water Quantity and Quality
Location: Watershed-wide

Easements and acquisitions can protect sources of water in perpetuity. The SLT's *Russian River Subwatershed Conservation Assessment Project* in 2021 used reach-level information on Coho Salmon habitat, streamflow priorities, and groundwater recharge data, combined with other environmental data and expert opinion, to identify specific parcels that may offer opportunities to protect or enhance salmonid habitats through easements, acquisitions, and other stewardship and land management actions (J. Conti, pers. comm. 5/22/2023). Based on this work, SHaRP workshop participants recommended that NGOs and agencies work together to develop community partnerships that promote easements and acquisitions.

Action-DB-3: Improve Winter Refugia Habitat - Feasibility Study, Design & Implementation

Attribute: Water Quantity, Off-Channel Habitats, Instream Structural Complexity
Location: Russian River confluence to Tyrone Bridge

A three phased approach is recommended for this action: 1) feasibility study, 2) design, and 3) implementation and monitoring. An initial feasibility study that includes 2-3 years of groundwater monitoring will improve understanding of water surface elevations for off-channel enhancements, as well as feasibility of restoring surface flow to extend surface water connectivity for the outmigrant season. Based on the results of the feasibility study, off-channel habitats can be designed. Within the Monte Rio Redwoods Regional Park property, there is an opportunity to evaluate areas along the stream for potential off-channel winter habitat for juveniles. There are several units on river-left where it may be possible to create or enhance off-channel habitat (Figure 17). Project implementation with a monitoring plan is the final phase of the recommendation. Any natural wood recruitment should remain in the stream and be allowed to accumulate onto project wood. Interpretive Regional Park signage would enhance the project goals to include educational elements.

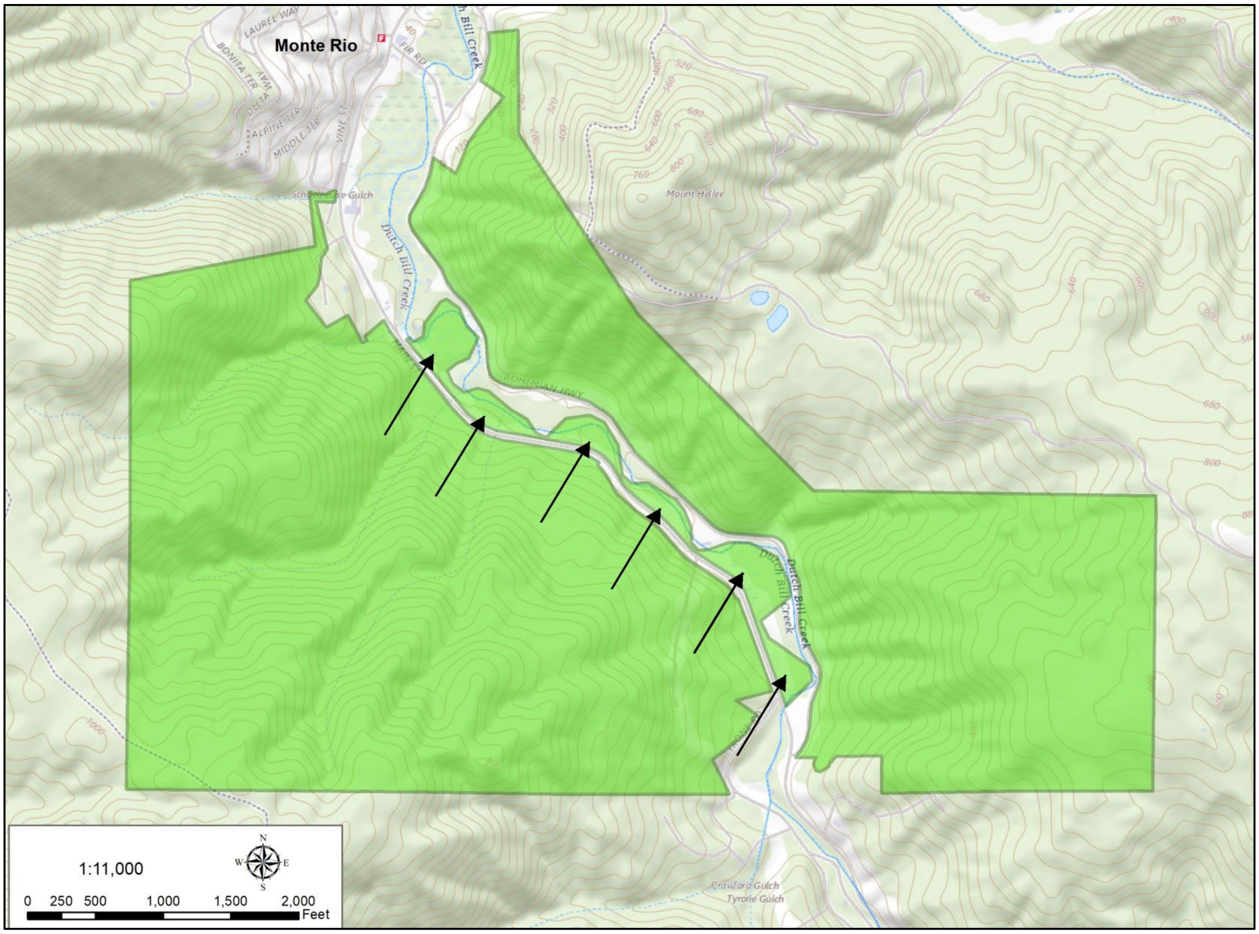

Figure 19. Monte Rio Redwoods Regional Park & Open Space Preserve, Lower DBC. Arrows point to possible areas for winter refugia projects.

Action-DB-4: Assess & Manage Forests to Improve Watershed Processes

Attribute: Water Quantity, Sediment Conditions
Location: West side of watershed, and east side from Grub Creek to the Russian River confluence

Forests in the DBC watershed are still recovering from legacy logging impacts and currently consist of young, overstocked conifers and tan oak. This type of forest draws significant water and poses a higher risk of catastrophic wildfire. Diminished summer streamflow in Sonoma County streams is partly due to high evapotranspiration associated with these dense, young forests. (Kobor and O’Connor 2021).

It is recommended that partners reach out to landowners to develop plans to assess and manage fuels, and to attain necessary funding community-wide. This includes a road network assessment. Camp Meeker Recreation & Park District can be contacted for planning and funding projects that address watershed and fire shed restoration within the publicly owned

Camp Meeker Community Forest. Also, the Safer West County's Bohemian Collaborative Steering Committee is developing a 2024 Stewardship Plan.

OAEC is available as a community resource for upland vegetation management of fuel loads and nexus with stabilization of eroding incised gullies using their "Fuels to Flows" approaches to control erosion, reduce sediment delivery, increase water holding capacity, attenuate peak flows, durably sequester carbon, and create wildlife habitat.

On a broader scale, the California Forest Improvement Program is available to help public and private landowners responsibly manage their forested lands through cost-sharing and development of a Forest Management Plan. The U.S. Forest Service and Natural Resources Conservation Service also offer several programs to assist private landowners to connect with tools, educational resources, and funding for responsibly managing their forested lands.

Action-DB-5: Enhance Instream Habitat

Attribute: Instream Structural Complexity
Location: Tyrone Gulch to just upstream of Redwood Gulch, Lower Grub, and Lower Perenne Creeks

CSG and Sonoma Water redd distribution data (2013-2023) show Coho Salmon spawn between Tyrone Gulch and Redwood Gulch, and steelhead range extends past Camp Meeker. Meeting participants specified large wood projects are needed from Tyrone Gulch to Alliance Redwoods. CDFW 2023 surveys confirmed a lack of large wood in this reach (D. Acomb, personal communication, 6/26/2023). CSG and Sonoma Water observed perennial streamflow in Perenne and Grub Creeks and suggested the lower sections of these creeks be considered for instream habitat enhancements as well.

Large wood additions in DBC would create slow-water pools and encourage gravel deposition. Since floodplain and off-channel project sites are limited, large wood projects should be designed for both summer rearing, winter rearing, and refuge from high velocity surface flows.

Revegetation with native plants can enhance habitat for numerous species. Native wildlife relies on riparian zones for shelter and forage and can provide continuous passage for animal dispersal or migration. Large wood in streams requires large streamside trees that recruit naturally to accumulate onto wood projects or create new wood jams. Revegetation with native plants and trees is recommended as a component of any instream habitat enhancement project.

Action-DB-6: Monitor Streamflow Year-Round

Attribute: Water Quantity and Quality
Location: Mainstem DBC

As of September 2023, summer/dry season streamflow monitoring in DBC is conducted by TU at four gages within the mainstem DBC through short-term grant funding. Monitoring streamflow in the various and differing hydrologic reaches is essential in DBC to understanding the annual variations in summer flow conditions and how human water use impacts summer baseflow. The monitoring effort indicated that insufficient streamflow during the dry season is a significant limiting attribute to Coho Salmon recovery (RRCWRP 2017).

Surface and ground water monitoring are critical to understanding where perennial groundwater discharge occurs in the watershed, as this is a primary driver of sustained summer streamflow in the DBC watershed. Camps and conference centers along DBC rely on spring water to meet their operational needs. The Coho Partnership found that the springs in DBC watershed play an important role in summer baseflow supporting aquatic life and humans.

Winter streamflow is not well characterized in many reaches of the watershed. Year-round streamflow monitoring would build a baseline of average and storm-related winter streamflow and is critical to understanding what reaches within the watershed experience high water velocity that impact juvenile fish survival and movement.

A year-round streamflow gaging network needs to be established for the long-term. The current gage system needs to be expanded to include winter baseflow monitoring to assess winter drought conditions. In addition, information gained from groundwater monitoring will help inform and ensure cost-effective water-resource management during low-flow conditions.

Action-DB-7: Address Fish Passage

Attribute: Anthropogenic Barriers
Location: Watershed-wide

SHaRP workshop participants identified six fish passage barriers that should be addressed, but long-term planning should begin with assessments and modeling to quantify flows and fish passage requirements (Figure 20, Table 7b). These six sites are colloquially referred to as: The “Ladder”; Flashboard Dam Sill; Grub Creek culvert; Weir #1 at Market Street culvert; private-road culverts over Lancel Creek; and Occidental Camp Meeker Road culvert over Lancel Creek. Potential habitat upstream from these barriers should be assessed. In addition to continuous access to upstream perennial habitats, eliminating these barriers will also provide opportunities for habitat enhancement and flow augmentation projects within the newly accessible reaches.

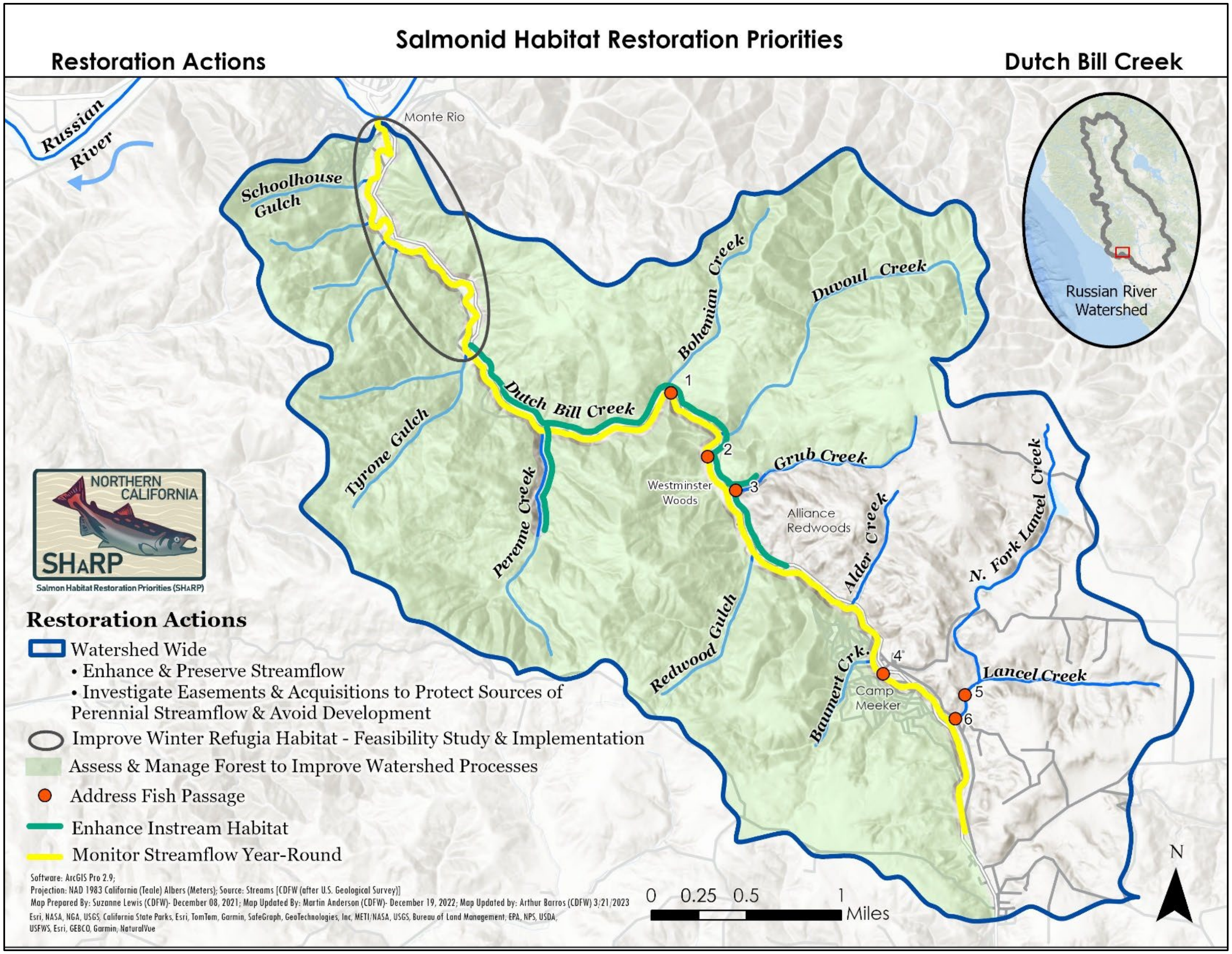

Figure 20. Dutch Bill Creek SHaRP Restoration Actions and Locations.

Table 7a. DBC SHaRP Restoration Actions, Action Number, Map Symbols, Locations, and Comments. See (Table 7b) for Fish Passage Actions (DB-7).

Action #	Restoration Action	Map Symbol	Location	Comments
DB-1	Enhance & Preserve Streamflow	Blue Outline	Watershed-wide	May include storage/forbearance, storage and flow releases, conservation for irrigation/households, etc.
DB-2	Investigate Easements & Acquisitions to Protect Sources of Perennial Streamflow & Avoid Development	Blue Outline	Watershed-wide	Support land conservation organizations for projects and funding.
DB-3	Improve Winter Refugia Habitat-Feasibility Study & Implementation	Black Oval	RR Confluence to Tyrone Bridge	Work with Monte Rio Redwoods Regional Park staff. Three-phased approach: 1. Feasibility: Includes multi-year ground/surface flow monitoring 2. Design 3. Implementation and Monitoring
DB-4	Assess & Manage Forest to Improve Watershed Processes	Green Shading	West side of watershed and East side from Grub Creek to RR Confluence	Develop community driven Forest Management Plans to assess and manage fuels and attain funding. Includes road network assessment. Work with Camp Meeker Rec & Park District within the Camp Meeker Community Forest, OAEC, and Safer West County's Bohemian Collaborative on plan developments.
DB-5	Enhance Instream Habitat	Green Line	Tyrone Gulch to just upstream of Redwood Gulch, and Lower Perenne and Grub creeks.	Large wood to reduce high winter velocities, provide refugia from high flows, shelter, sort gravels, enhance complexity of pool habitat. Plant native trees along the riparian corridor to provide future wood recruitment.
DB-6	Monitor Streamflow Year-Round	Yellow Line	DBC Mainstem	Steady funding needed to support year-round flow gaging in the different hydrologic reaches of DBC.

Table 7b. DB-7-Fish passage remediation actions (DB-7), respective ID# from the Passage Assessment Database (PAD), and comments. Based on site inspection report, June 11-12, 2023 (Appendix I).

Site Name	PAD ID#	Comments
1. The “Ladder”	PAD#707063	Total barrier due to jump height at fourth and last weirs.
2. Flashboard Dam Sill	PAD# 66339	Total barrier due to jump height.
3. Grub Creek Culvert	PAD#712086	Temporal barrier due to depth at low flow.
4. Market Street Culvert, Weir #1	PAD#712087	Total barrier due to jump height at the 2nd from downstream most weir.
5. Private Road Culvert over Lancel Creek	PAD#716490	Replace two pipes at road crossing (not part of 2023 inspection)
6. Occidental Camp Meeker Road Culvert over Lancel Creek	PAD#712089	Temporal barrier.

Chapter 6. Willow Creek Action Plan

6.1 Watershed Overview

Willow Creek drains an area of approximately 8.5 mi² into the Russian River and is located about 2 miles from the Pacific Ocean (Streamstats 2023). Elevations range from sea level at the confluence to 1,481 feet at Koerber Peak (PCI 2005).

Willow Creek geology is characterized by Franciscan Complex and the Great Valley Sequence. The Franciscan Complex in Willow Creek consists of both the highly sheared Coastal Belt, and the tectonic assemblage of sandstones and volcanics of the Central Belt. Rocks of the Great Valley Sequence consist of thick, gently folded sandstone with interbedded sedimentary layers. Due to the high erodibility of the sheared shale and sedimentary layers, this area is unstable and likely prone to mass wasting, especially earthflows (MRC 2001).

The watershed can be divided into four sections: below 1st Bridge are tidal wetlands; between 2nd and 3rd Bridges is the lower valley; above 3rd Bridge to the stream adjacent to the lower-locked gate is the upper valley; and beyond are the headwaters (L. Hammack SHaRP Meeting 2022). Winter juvenile rearing is observed in the lower valley, while spawning and summer rearing typically occurs in the upper valley.

Legacy effects primarily due to heavy logging, the subsequent removal of large wood within the stream channel, and railroad and road development have caused landslides and mass wasting in the upper watershed and severe aggradation in the lower watershed (CDFG 2000c). High-gradient tributaries are the major sources of sediment to the watershed, in addition to substantial landslides in grasslands and forested areas. In the upper valley, stream reaches are incised but beginning to widen and aggrade. Large wood projects and natural recruitment of trees are improving channel structure and helping to sort and store gravels.

In the lower valley, high sediment loads, extreme low gradient, and Russian River backwater effects have created a shifting and anastomosing wetlands complex that provides winter habitat, but the braided shallow channels through this reach also pose passage challenges for salmonids under low flow conditions. Several large aggradation events in 1987, 1997, 2004, and 2018 contributed to the current conditions. The tidal wetlands downstream from 2nd Bridge have minimal to no connectivity with the creek and wetland inundation rarely occurs. The wetlands most likely aggraded several feet after the flood conveyance channel was built in the 1940s.

On average, overwintering Coho Salmon survival is very low in Willow Creek, despite the wetland complexes in the system producing abundant prey for fish. This appears to be influenced by juvenile fish getting stranded in the maze of disconnected channel segments between 2nd and 3rd Bridges, particularly under low flow conditions. Alder forests dominate the braided channels that evolve with flow events. There is no dominant flow pathway traversing this reach, making it challenging for fish to migrate through this portion of the watershed. When CSG snorkel-surveyed this reach in spring 2022, over 600 juvenile Coho Salmon were observed rearing and feeding. It was reported that many of the channels were dead ends, and most fish would probably not survive given the low dissolved oxygen concentrations and inability to move out of isolated and stagnant habitat units (M. Obedzinski, SHaRP Meeting 2022).

6.2 Land Uses – Historic and Current

Russian occupation began in 1810, and the Fort Ross headquarters was constructed two years later. The lower valley was converted to agriculture (primarily hayfields) from the Russian settlement into the 1980s when California State Parks took over management. At some point, a channel was dredged along the north side of the valley to manage the land for agricultural production, and this channel was maintained with frequent dredging implemented by the county through 1987 (PCI 2005).

Logging began as early as 1833 and continued through the 19th and 20th centuries. Lumber mills popped up in and around Duncans Mills and lower Willow Creek. As logging operations increased, narrow gauge rail was constructed in the valley bottom to access areas of harvest and to transport materials to mill sites. The most intense logging occurred between 1953 and 1970 with the removal of any standing old growth and second growth from the lower redwood grove, within the inner gorge, up to the watershed divide (PCI 2005). “Large tracts were clear-cut, and tractor-yarded, and small channels were used as skid trails” (Trihey 1995).

As of 2024, the Willow Creek watershed is primarily owned by California State Parks. Other landowners include MRC, Sonoma Regional Parks, and several private landowners with some small parcels dispersed in the headwaters. The Willow Creek watershed is comprised of a wide diversity of land cover with mixed forests, grasslands, scrublands, wetlands, and is dominated by coniferous forest (Figure 21). Since the watershed is undeveloped, it holds great potential for restoration and the expansion of habitats for native plants and animals.

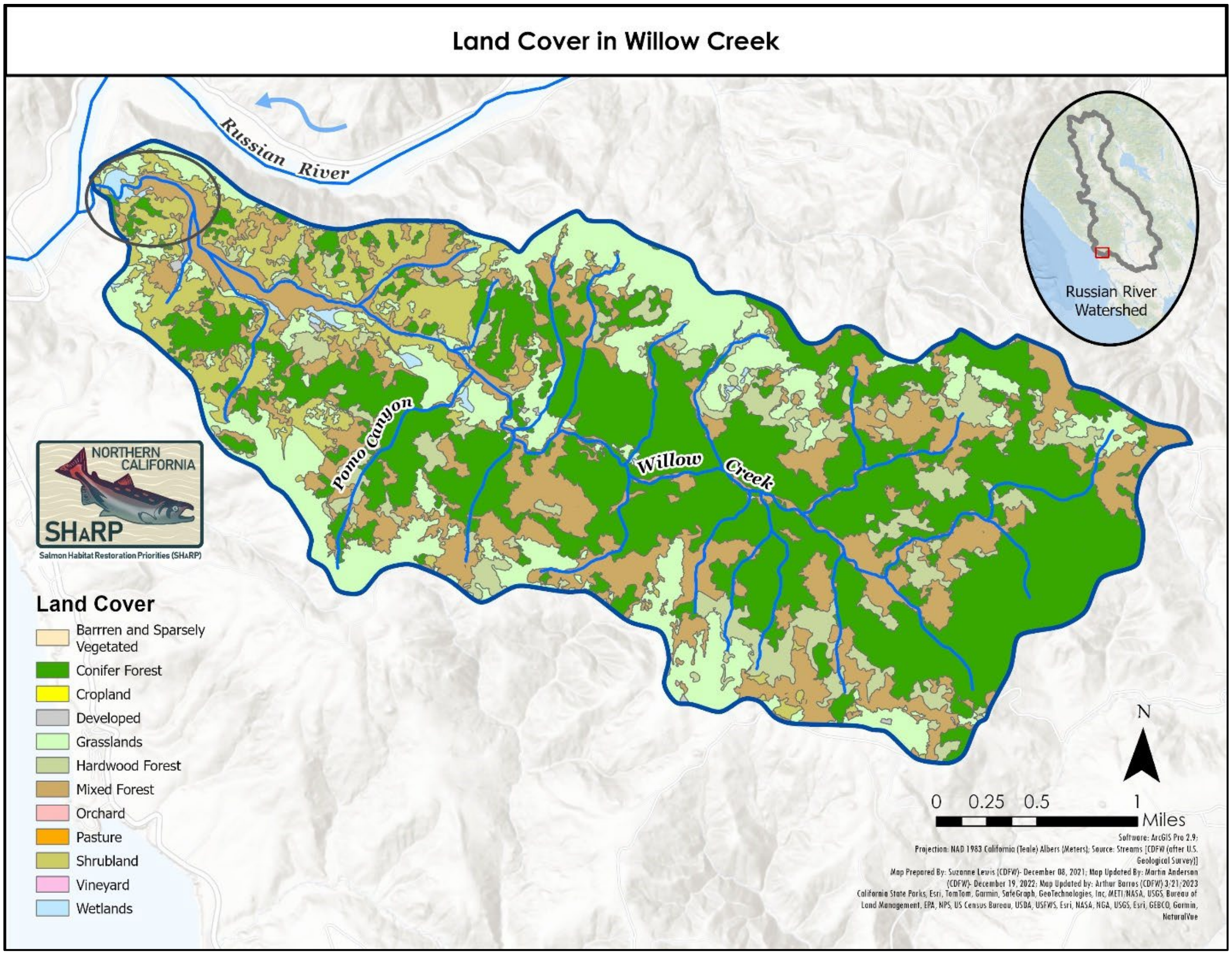

Figure 21. Willow Creek land cover. Source: Sonoma Veg Map

Water Supply

Willow Creek and its' tributaries are spring fed throughout and have a hydrology that is governed by seasonal rainfall and groundwater. There are no surface water diversions on Willow Creek. There are likely water supply wells on properties in the upper watershed; however, these are not mapped.

6.3 Past and Current Restoration Funding

In 2001, the Mendocino Redwood Company conducted a watershed analysis for both Willow and Freezeout creeks to assist their efforts to reduce non-point source pollution, evaluate current and past land management practices, and establish a baseline for monitoring of watershed conditions over time (MRC 2001).

FRGP awarded close to $1 million to fund or partially fund six projects between 2004 and 2018 (Hampton et al. 2021), and the State Water Resources Quality Control Board funded a road project in the mid-2000s. These restoration projects addressed upland erosion and sediment, fish passage at 2nd Bridge, and large wood enhancements. Eight miles of old logging roads were decommissioned as part of this large-scale project to address road-related erosion. For the 2nd Bridge project, three culverts were removed and replaced with a single-span bridge, opening over 12 miles of stream habitat. The two large wood enhancements were completed in 2014 utilizing the accelerated recruitment method. This method placed large trees into the reach upstream from 3rd Bridge without the use of any hard anchoring. Instead, the wood was wedged between standing trees, or left to move and wrack on key pieces downstream.

Willow Creek Road is maintained by Sonoma County and is essentially the only road through the watershed. GRRCD completed stream crossing and road drainage upgrades and paving up to the lower-locked gate between 2018 and 2021 through a public-private partnership.

6.4 Willow Creek SHaRP Meeting

The Willow Creek meeting was held on June 1–2, 2022, following the methods described in Chapter 3. The invited participants represented federal, state, and county agencies, tribes, NGOs, local environmental consultants, researchers, and landowners. Local watershed experts presented their work and knowledge of the area. Presentations included:

- Willow Creek - Geomorphic Conditions and Processes (PCI)
- Willow Creek - Salmonid Use and Habitat Suitability (CSG) (Nossaman-Pierce 2022b)

As described in Chapter 3, participants had access to public-facing interactive maps via AGOL. These maps contain public data layers tailored to Willow Creek watershed. The steering team provided a guided overview of all data layers during the meeting (Appendix III). Collectively, the materials, presentations, and discussions informed the participants in evaluating and ranking the limiting attributes affecting salmonid survival in the creek.

Table 8. Willow Creek watershed SHaRP attribute ranking results expressed as least limiting [green (g)], moderately limiting [yellow (y)], and most limiting [red (r)]. The N/A box was blocked out to ranking due to the lack of a clear connection for a particular attribute-life stage combination.

Attributes	**Egg/Alevin**	**Summer Juvenile**	**Winter Juvenile**	**Smolt**	**Adult**
Anthropogenic Barriers	N/A	(g)	(g)	(y)	(y)
Instream Structural Complexity	(y)	(r)	(y)	(y)	(y)
Off-Channel Habitats	(y)	(y)	(y)	(y)	(y)
Riparian Conditions	(g)	(y)	(g)	(g)	(g)
Sediment Conditions	(r)	(y)	(y)	(y)	(y)
Water Quality	(y)	(r)	(y)	(y)	(g)
Water Quantity	(r)	(r)	(r)	(r)	(r)
Invasive/Non-native species	(g)	(g)	(g)	(g)	(g)
Channel Form Barrier	(y)	(r)	(r)	(r)	(r)

Based on results from the ranking activity, *Water Quantity* and *Channel Form Barrier* ranked as the most limiting attribute for all life stages. Although *Water Quantity* ranked slightly higher, these two attributes are interrelated; excess sediment built up in the valley bottom of the watershed has led to more frequent hyporheic or subsurface flow during the low flow season. Subsequently the remaining surface flows that persist during the low flow season are subject to rapid warming and reduction in water quality conditions. *Instream Structural Complexity* and *Water Quality* attributes are limiting to summer juveniles and *Sediment Conditions* are limiting to the egg/alevin life stage.

6.5 SHaRP Restoration Actions

Considering the ranking results and an understanding of habitat-life stage-survival relationships (Chapter 3), workshop participants leveraged their knowledge of the watershed to identify opportunities and actions with the potential to restore or enhance the most limiting attributes to salmonid survival. These restoration actions were organized into a table with a complementary map (Figure 20, Table 9). The section below describes locations and actions in more detail. Federal funding for many of these actions has been granted to GRRCD in 2024.

Action-WC-1: Enhance and Preserve Streamflow

Attributes: Water Quantity and Quality
Location: Watershed-wide

Future development within the watershed would increase the demand for water. Water conservation should be incorporated into any development to preserve streamflow. Implementing improved forest management practices throughout the upper watershed, such as thinning young tree stands to reduce evapotranspiration, will also have a positive impact on streamflow. See the next action item for more information on forest health improvements.

Action-WC-2: Assess & Manage Forest to Improve Watershed Processes

Attributes: Water Quantity and Quality, Sediment Conditions, Riparian Conditions
Location: Watershed-wide

Historic logging practices have resulted in a forest overstocked with second-growth trees that may consume more water than an old-growth forest. Thinning these trees may indirectly conserve water throughout the watershed. Thinned trees generated from forest management activities can be used for instream large wood projects and smaller material for gully stuffing, though this may be cost-prohibitive.

In addition, headwater tributaries are delivering large sediment loads due to impacts from logging. Controlled burns can reduce wildfires, thus reducing erosion and sediment input to the channel. Opportunities to work with local Native American communities to integrate traditional burning practices (cultural burns) into land management should be explored.

Action-WC-3: Investigate Easements & Acquisitions to Protect Sources of Perennial Streamflow & Avoid Development on Private Lands

Attributes: Water Quantity and Quality
Location: Watershed-wide

Sonoma County Agricultural Preservation and Open Space District holds a conservation easement over much of the watershed. Easements and acquisition opportunities can be pursued with owners of other private parcels.

Action-WC-4: Address Road and Related Sediment and Erosion

Attributes: Sediment, Instream Structural Complexity
Location: Valley-bottom section of the county road before it moves away from the stream, and the hillslopes and ridgetops; watershed wide

Reroute road away from the creek and riparian zone where feasible. An updated watershed-wide assessment of road- or trail-related erosional impacts beyond the valley bottom is recommended, as opportunities to reduce sediment delivery by improving or decommissioning these features likely exist in a number of locations.

Willow Creek Road is owned by Sonoma County and is essentially the only public road through the watershed. Multiple road upgrades and decommissioning projects were completed on State Parks from 2005 through 2017. GRRCD completed road upgrades and paving up to the lower-locked gate between 2018 and 2021 through a public-private partnership. A watershed analysis was conducted in 2001 by MRC to assist their efforts to reduce non-point source pollution, evaluate current and past land management practices, and establish a baseline for monitoring watershed conditions over time (MRC 2001). Key findings pointed to high sediment inputs from past forest practices as one of the primary factors limiting salmonid production.

Tribal representatives and government resource managers present in the meeting expressed the need for early consultation when planning road upgrades or changes to ensure continued access for rite-of-passage ceremonies.

Action-WC-5: Enhance Off-Channel & Floodplain Habitat
Attributes: Off-Channel Habitats, Water Quantity, Water Quality
Location: Reach from 3rd Bridge upstream to the stream adjacent to the lower-locked gate

Near 3rd Bridge, the stream has been channelized and moved to the north side of the canyon. When stream surface flows increase due to large storm events, debris, and wood racks behind the bridge, often forcing flow around the structure. It is recommended adjacent existing levees be removed so the stream can move into the floodplain and off-channel ponds and channels for summer and winter rearing can be created or enhanced.

Action-WC-6: Improve Fish Passage for All Life Stages
Attributes: Channel Form Barrier
Location: Between 2nd and 3rd Bridges

Throughout the reach of Willow Creek between 2nd and 3rd Bridges, alder trees and other vegetation choke the multi-braided reach, hindering the migration of fish moving through the watershed. Improved fish passage and pool connectivity through the implementation of low-tech features such as BDAs is recommended. Creation of one or two dominant flow paths will ensure smolt outmigration.

Action-WC-7: Enhance Instream Habitat
Attributes: Instream Structural Complexity
Location: Willow Creek mainstem to end of anadromy, lower Pomo Canyon Creek, and lower sections of select tributaries.

Participants agreed that much of the watershed, from the stream adjacent to the lower locked gate to the end of anadromy and beyond, is in the process of incision and in need of large wood. MRC 2001 recommended large wood be added to the majority of Willow Creek to increase pool formation, provide high flow refugia, increase habitat cover, and trap sediments. Large wood enhancements can also aid in increasing downstream flow. Trees should be planted to ensure future recruitment. BDAs or other channel spanning structures should be considered to trap sediments and raise bed elevation. The accelerated recruitment method for adding large wood is also recommended. This method provides for wedging rather than traditional anchoring materials such as rebar and bolts. It uses roughness elements such as trees, stumps, and streambanks with the intent that large wood movement will be minimized, even during high winter flows.

Action-WC-8: Monitor Streamflow Year-Round
Attributes: Water Quantity and Quality
Location: Willow Creek mainstem

As of January 2024, summer/dry season streamflow monitoring in Willow Creek is conducted by TU at three gages in lower Willow Creek through short-term grant funding. A year-round streamflow gaging network needs to be established long-term. The year-round system should include winter baseflow monitoring to assess winter drought conditions as well.

A streamflow baseline should be established in Willow Creek. This action includes monitoring via an upstream gage on the mainstem but positioned sufficiently low in the watershed to detect variability in streamflow resulting from restoration activities or development. Year-round flow monitoring would also inform managers of diminishing flows that may lead to fish mortality and help plan for rescue and relocation.

Action-WC-9: Re-route and Restore Lower Pomo Canyon Creek & Confluence

Attributes: Instream Structural Complexity, Channel Form Barrier
Location: 3rd Bridge to Pomo Canyon Creek confluence and lower Pomo Canyon Creek

Above 3rd Bridge is the confluence of Pomo Canyon Creek. The Pomo Canyon Creek channel has become disconnected with Willow Creek due to channel incision and historic rerouting of the Pomo Canyon Creek channel around agricultural fields. Pomo Canyon Creek should be restored from the mouth to the campground. Consider combining this action with the planning and design for 3rd Bridge replacement.

Action-WC-10: Replace 3rd Bridge

Attributes: Anthropogenic Barriers, Channel Form Barrier
Location: 3rd Bridge

The buildup of sediment and debris has limited the space between the creek surface and the bottom of 3rd Bridge. It is estimated that between 1975 and 2002 the bed of the channel aggraded six feet (PCI 2005). Bridge flooding during high flows puts the structure at catastrophic risk for total failure that would release built up sediment downstream. This project is a high priority and could be completed in tandem with lower Pomo Canyon Creek restoration and prior to downstream enhancements.

Action-WC-11: Enhance Tidal Wetlands

Attributes: Instream Structural Complexity, Off-Channel Habitats, Invasive/Non-Native Species, Riparian Conditions
Location: Reach from Russian River confluence to 2nd Bridge

Flows in lower Willow Creek are influenced by the tides and the downstream Russian River mouth closures. In addition, the channelization of Willow Creek inhibits the downstream tidal marsh from inundation during most base flow events. Backwater influence from river mouth closures could extend into Willow Creek upstream to the left bank tributary located just downstream from 2nd Bridge. An enhanced tidal marsh/wetlands will support natal and non-natal out-migrating smolts by providing habitat for feeding and growth before continuing out to the ocean. Floodplain reconnection will provide off-channel habitats and more quality refugia for rearing juveniles. Project planning should include a broad look at the watershed to address any reaches that may be supplying excess sediment to the creek.

Tribal representatives and tribal resource managers present in the meeting expressed the importance of early consultation when planning tidal wetlands restoration to ensure their access to, and management of, basketry materials and other cultural resources.

Action-WC-12: Investigate Beaver Reintroduction

Attributes: Instream Structural Complexity, Off-Channel Habitats, Water Quantity, Water Quality
Location: Reach from the Willow Creek mouth upstream to the unnamed tributary adjacent to the lower locked gate

The low gradient, highly vegetated reach in lower Willow Creek should be considered for beaver reintroduction. This idea was well received at the meeting. More discussion and investigation are needed by the Technical Review Team (TAC) and the CDFW Beaver Management Program in pursuing this recommendation.

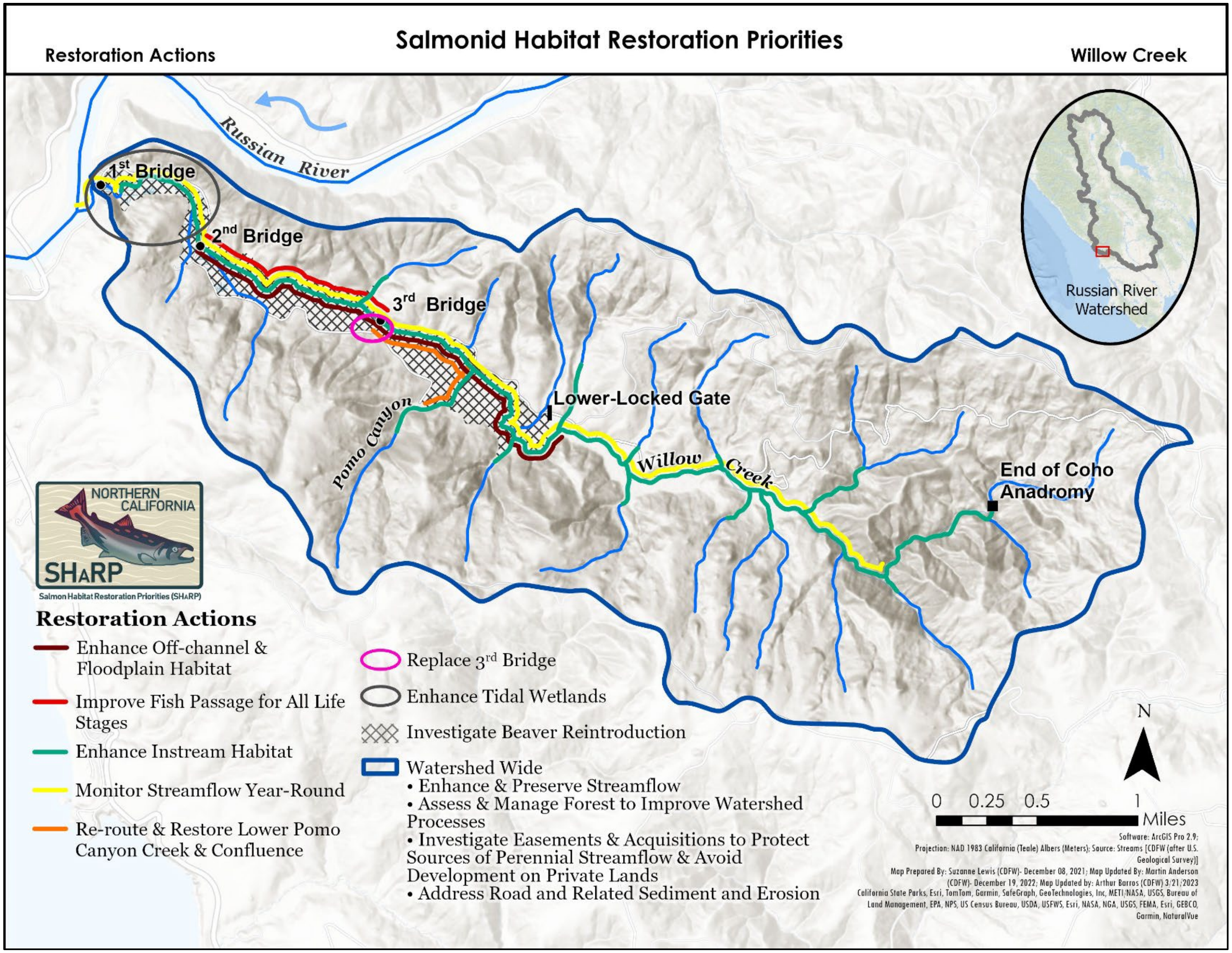

Figure 22. Willow Creek SHaRP Restoration Actions and Locations.

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Table 9. Willow Creek SHaRP Restoration Actions, Action Number, Map Symbols, Locations, and Comments.

Action #	Restoration Action	Map Symbol	Location	Comments
WC-1	Enhance & Preserve Streamflow	Blue Outline	Watershed-wide	Water conservation should be incorporated into any future development. Improve forest health.
WC-2	Assess & Manage Forest to Improve Watershed Processes	Blue Outline	Watershed-wide	Controlled burns and forest thinning can reduce wildfires and thus reduce erosion and sediment and improve groundwater recharge.
WC-3	Investigate Easements & Acquisitions to Protect Sources of Perennial Streamflow & Avoid Development on Private Lands	Blue Outline	Watershed-wide	Sonoma County Agricultural Preservation and Open Space District holds a conservation easement over much of the watershed. Easements and acquisition opportunities can be pursued with owners of other private parcels.
WC-4	Address Road and Related Sediment and Erosion	Blue Outline	Watershed-wide	Reroute county road away from the creek where feasible. Update 2001 MRC watershed analysis. Include watershed wide road- or trail-related erosional impacts beyond the valley bottom.
WC-5	Enhance Off-Channel & Floodplain Habitat	Maroon Line	3rd Bridge to the stream adjacent to the lower locked gate	Floodplain connectivity will slow velocities and provide habitat for wintering juveniles. Remove existing levees.
WC-6	Improve Fish Passage for All Life Stages	Red Line	Reach between 2nd and 3rd Bridges	Braided channels and lack of pool connectivity during low summer base flows cause fish to be stranded. Improve fish passage and pool connectivity through the implementation of low-tech features such as BDAs. One or two dominant flow paths will ensure smolt outmigration.
WC-7	Enhance Instream Habitat	Green Line	WC mainstem, lower Pomo Canyon Creek, and lower sections of tributaries	Large wood increases habitat complexity, pool frequency, and enhanced cover. It has also been shown to cause geomorphic changes such as aggradation of substrate and sort gravels. Large wood enhancement can also aid to increase downstream flow.

Action #	Restoration Action	Map Symbol	Location	Comments
WC-8	Monitor Streamflow Year-Round	Yellow Line	Willow Creek Mainstem	A year-round streamflow gaging network with reliable funding needs to be established long-term.
WC-9	Re-route & Restore Lower Pomo Canyon Creek & Confluence	Orange Line	3rd Bridge to into lower Pomo Creek	A restored Pomo Canyon Creek would provide additional winter rearing and spawning habitat. Consider combining with 3rd Bridge replacement.
WC-10	Replace 3rd Bridge	Pink Oval	3rd Bridge	PAD# 716484 - 3rd Bridge is at risk of total failure due to build-up of sediment around and underneath. High priority.
WC-11	Enhance Tidal Wetlands	Black Oval	RR confluence to 2nd Bridge	Habitat enhancements should include floodplain reconnection and off-channel habitats to provide rearing habitat for natal and non-natal juvenile salmonids.
WC-12	Investigate Beaver Reintroduction	Cross-hatched	RR confluence to the stream adjacent to the lower-locked gate	California State Parks land is well suited for a pilot study. Beaver activities may help address the problems between 2nd and 3rd Bridges and overall watershed processes.

Chapter 7. Mill Creek Action Plan

7.1 Watershed Overview

The Mill Creek watershed drains an area of approximately 24 mi², and elevations range from 1,400 feet at its headwaters to approximately 60 feet at the confluence with Dry Creek, just upstream of the confluence with the Russian River (SRCD 2015). The main tributaries to Mill Creek are Felta, Palmer, Angel, and Wallace creeks.

The majority of the Mill Creek watershed is underlain by both Coastal Belt and Central Belt Franciscan Complex. Both are highly erosive. The hydrogeologic characteristics of the Coastal Belt are different from those of the Central Belt. A significant consequence of these differences is that the large Wallace Creek sub-watershed does not provide sufficient summer baseflow to sustain habitat for juvenile Coho Salmon.

The alluvial reach below Mill Creek Falls (Falls) is hydrologically connected to the Dry Creek floodplain and dries almost every spring/summer. If dry season flows diminish early, out-migrating smolts are unable to exit the creek. Sonoma Volcanic basalt outcrops occur in lower Felta Creek, the Falls, and the short high-gradient stretch just upstream of the Falls (Kobor and O’Connor, 2022) (Figure 23).

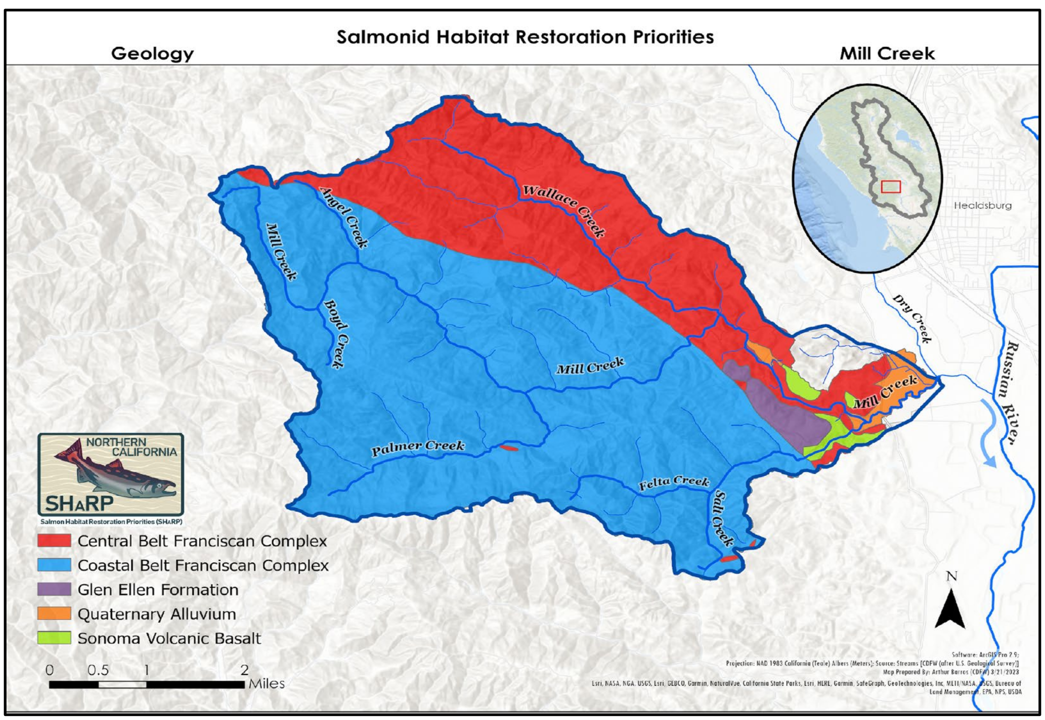
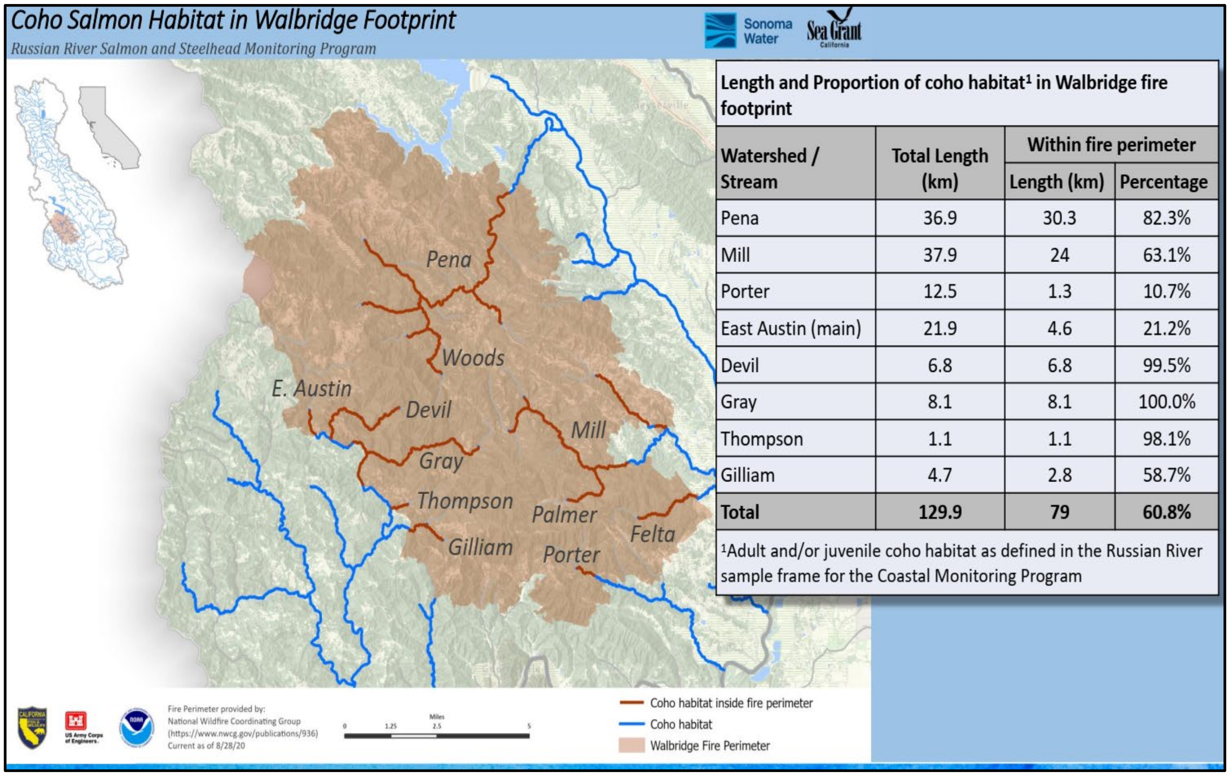


Figure 23. Map of Mill Creek watershed geology. Mill Creek is underlain by both the Coastal Belt and Central Belt Franciscan Complex.

Walbridge Fire 2020

The Walbridge Fire burned more than 55,000 acres and destroyed more than 150 residences between August 17 and October 2, 2020. Sixty three percent of the Mill Creek watershed was within the fire perimeter (Figure 24). The Walbridge Fire and subsequent salvage logging greatly reduced the amount of canopy cover within the burned areas, especially in the upper Mill Creek watershed, leaving the area susceptible to higher stream temperatures. In 2022, CSG observed the warmest stream temperatures in the uppermost reach of Mill Creek that extends from the confluence with Angel Creek upstream approximately one mile (TU and CSG 2023).



Length and Proportion of coho habitat[1] in Walbridge fire footprint

Watershed / Stream	Total Length (km)	Within fire perimeter	
		Length (km)	Percentage
Pena	36.9	30.3	82.3%
Mill	37.9	24	63.1%
Porter	12.5	1.3	10.7%
East Austin (main)	21.9	4.6	21.2%
Devil	6.8	6.8	99.5%
Gray	8.1	8.1	100.0%
Thompson	1.1	1.1	98.1%
Gilliam	4.7	2.8	58.7%
Total	**129.9**	**79**	**60.8%**

[1]Adult and/or juvenile coho habitat as defined in the Russian River sample frame for the Coastal Monitoring Program

Figure 24. Fire perimeter, stream length, and proportion of Coho Salmon habitat within the Walbridge fire footprint, 2020 (Horton 2022).

CSG's wetted-habitat (wet/dry mapping) data were used to compare the two driest drought years, 2015 (pre-fire) and 2021 (post-fire). Despite more severe drought conditions in 2021, Mill Creek retained 18% more wetted-habitat for rearing juveniles in the late summer as compared to the 2015 pre-fire drought. This can be attributed to the reduction in evapotranspiration of the heavily impacted watershed vegetation post-fire; however, it is anticipated that these short-term increases in streamflow will decrease as vegetation grows back (Kobor and O'Connor 2021). Other post-fire effects in the watershed include increased erosion and sediment delivery to streams, hillslope destabilization/landslides (of which Mill Creek was already prone), and the spread of invasive plants (Nossaman-Pierce 2022c).

7.2 Land Uses – Historic and Current

Early Native American settlements in the watershed consisted of villages in the lowland areas along the Dry Creek alluvial plain and along Mill Creek. Land was tended and cultivated in traditional ways, with the use of fire to manage the land through the seasons. Settlers began arriving in the early 1800s, and by 1841, the area was included within a 49,000-acre Mexican land grant deeded to Henry Fitch. The grant was referred to as Rancho Sotoyome after the local native community living in the area (SRCD 2015).

The Mill Creek watershed is entirely under private ownership with many small parcels. The majority of the watershed's land cover is forests and grasslands (approximately 95%), including areas that were burned in the Walbridge Fire. Vineyards make up approximately 3.5% and other agricultural and residential uses make up approximately 1.5% (Figure 25).

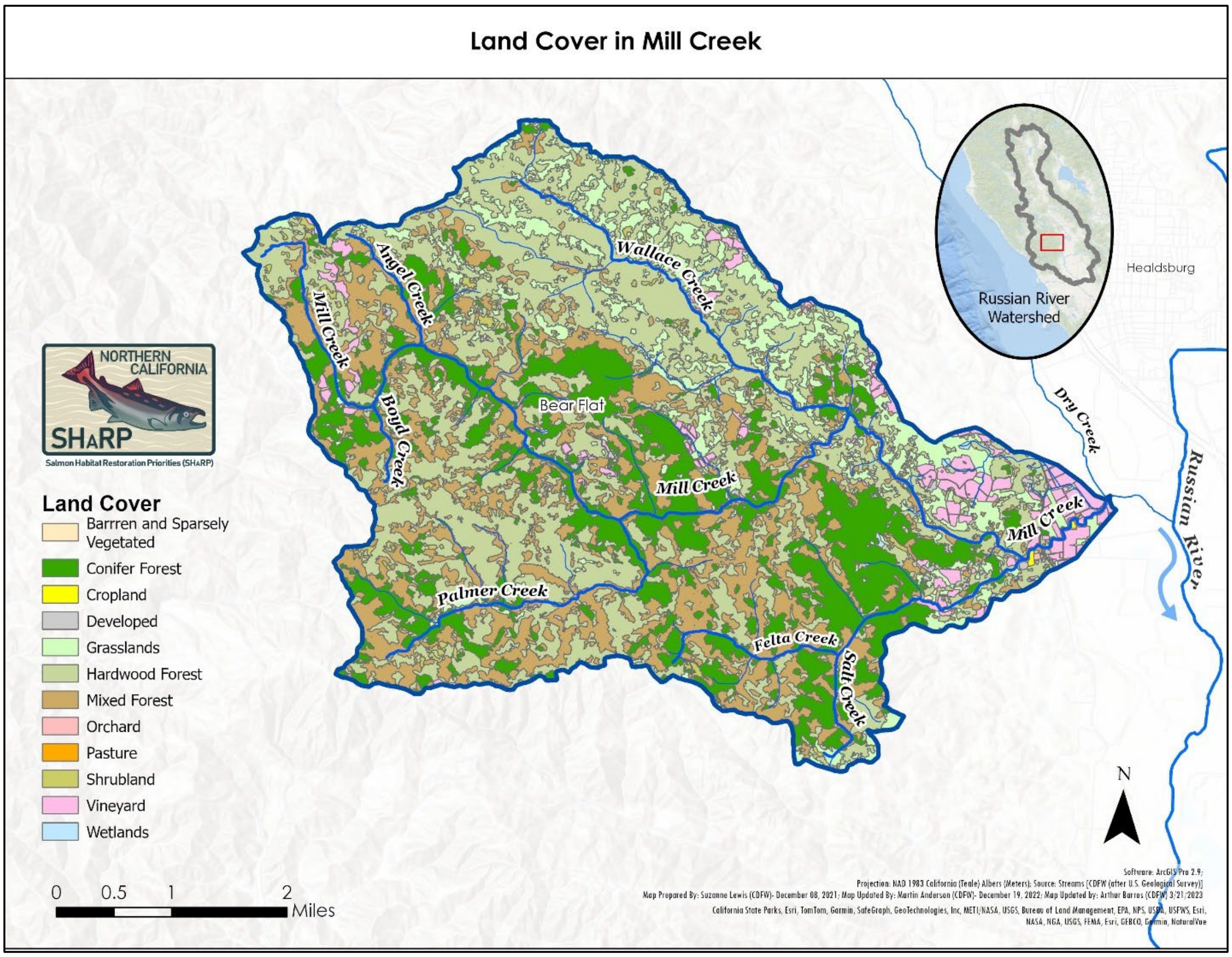


Figure 25. Land Cover in Mill Creek, 2023. Source: Sonoma Veg Map.

Water Supply

The SWRCB governs surface water supply through a series of Water Rights Decisions and Orders. Based on findings from the 2015 Drought Emergency Informational Order, diversions reported within the Mill Creek watershed include 24 surface diversions, 29 springs, and 166 wells. (SWRCB 2015) (Figure 26).

Although vineyards make up just 3.5% of land use, 63% of total water use is for vineyard irrigation (mostly in the extreme downstream portion of the watershed, including the valley floor of Dry Creek), with 8% of that sourced from recycled water. Twelve percent of water is used for residential, 11% is used for protection, 10% for other irrigation, 3% for winery operations, and 1% for cannabis cultivation (Kobor and O'Connor 2022). Like all coastal streams in the region, flow in Mill Creek is driven by rainfall and high flow events during the winter, with recession toward diminished streamflow during the dry summer months. The Mill Creek watershed receives approximately 200 times the total amount of water estimated for human residential and agricultural needs, even under dry-type conditions (RRCWRP 2015). Despite this seeming abundance, water availability is mismatched with time of need.

Winter 2020/2021 salmonid redd observations in relation to late-summer 2021 wetted-habitat conditions in the Mill Creek watershed show that of all the redds observed in Mill Creek, 62% were in locations that dried. Salmonid redds in Palmer Creek and Mill Creek above the confluence with Wallace Creek sustained flows through the summer and thus the highest chance for rearing juvenile survival (TU and CSG 2023).

Impacts from diversions are more evident during the summer. Data from several Mill Creek stream gages indicate that instream diversions are cumulatively affecting summer instream flow. Among streamflow monitoring sites, those that become intermittent earliest tend to be located downstream of clusters of residences, which are common along the middle and lower reaches of Mill Creek (RRCWRP 2015).

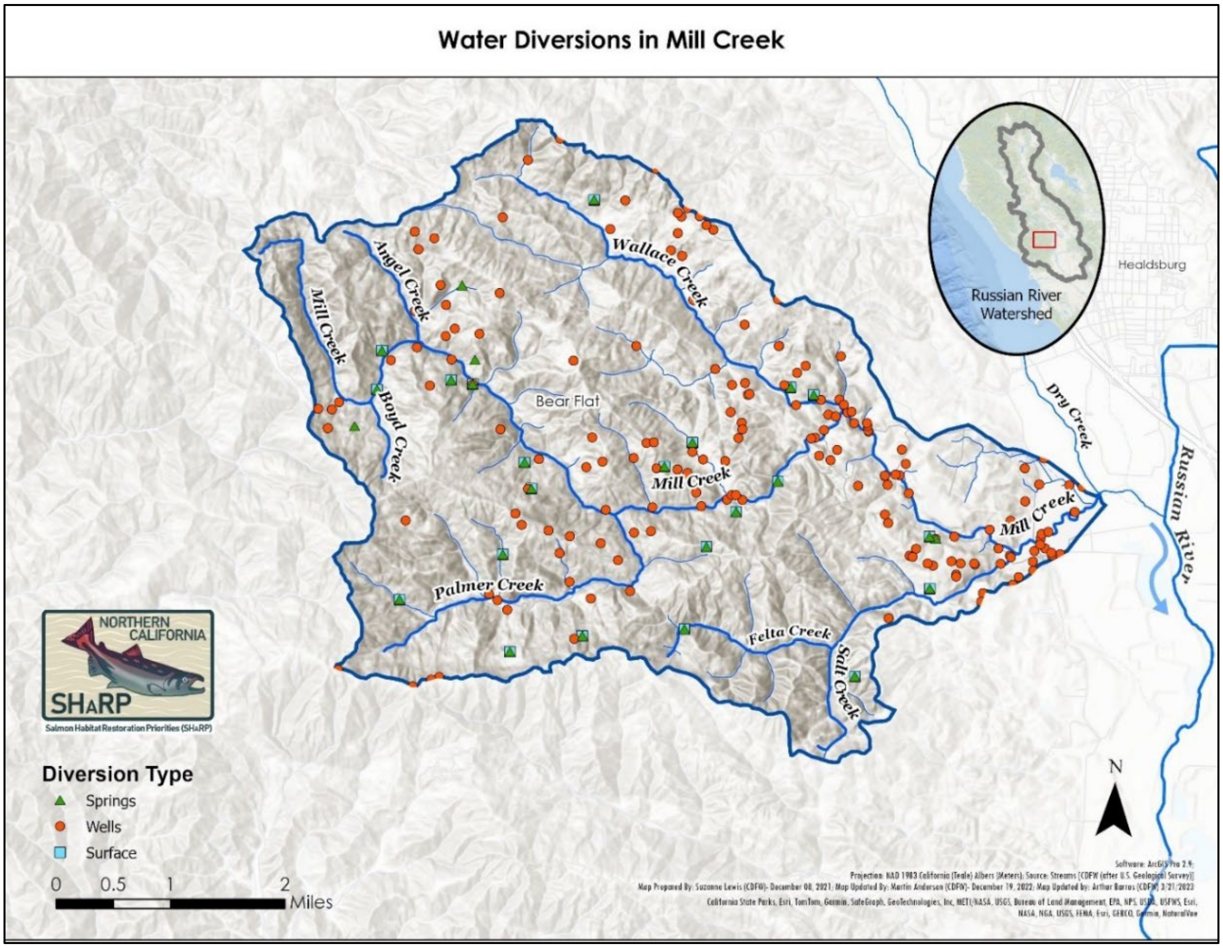


Figure 26. Locations and types of diversions within Mill Creek watershed based on results from the State Resources Control Board (SWRCB) – Division of Water Rights 2015 Drought Emergency Informational Order, January 2014 – December 2015.

7.3 Past and Current Restoration Funding

From 2004 to 2018, almost $1.1 million of grant funding has been put toward the completion of four projects in the Mill Creek watershed (Hampton et. al 2021). Project types included watershed evaluation and planning, upslope watershed restoration, instream habitat restoration, and instream barrier modification. The most notable accomplishment is the Mill Creek Dam Fish Passage Project. Completed in 2016, this project restored access to 11.2 miles of high-quality salmonid habitat that fish began to use immediately. More recently, state and federal grant programs backed projects related to water storage and forbearance, focused outreach and planning to identify additional flow enhancement opportunities, streamflow monitoring, instream habitat design, water quality protection, fire protection and fuels reduction, and defensible space management.

7.4 Mill Creek SHaRP Meeting

The Mill Creek meeting was held on November 8-9, 2022, following the methods described in Chapter 3. The invited participants represented federal, state, and county agencies, tribes, NGOs, local environmental consultants, researchers, and landowners. Local watershed experts presented their work and knowledge of the area. Presentations included:

- Mill Creek Watershed Overview (OEI)
- Mill Creek – The Importance of Habitat Monitoring in a Fire Landscape: Water Quality, Large Wood Counts, and the Need for Instream Complexity (Sonoma Water)
- Salmonid Use of the Mill Creek Watershed and Inferences about Habitat Suitability (CSG) (Nossaman-Pierce 2022c).

As described in Chapter 3, participants had access to public-facing interactive maps via AGOL. These maps contain public data layers tailored to the Mill Creek watershed. The steering team provided a guided overview of all data layers during the meeting (Appendix III). Collectively, the materials, presentations, and discussions informed the participants in evaluating and ranking the limiting attributes affecting salmonid survival in the Creek.

Table 10. Mill Creek watershed SHaRP attribute ranking results expressed as least limiting [green (g)], moderately limiting [yellow (y)], and most limiting [red (r)]. The N/A box was blocked out to ranking due to the lack of a clear connection for a particular attribute-life stage combination.

Attributes	**Egg/Alevin**	**Summer Juvenile**	**Winter Juvenile**	**Smolt**	**Adult**
Anthropogenic Barriers	N/A	(y)	(y)	(y)	(y)
Instream Structural Complexity	(y)	(r)	(r)	(r)	(y)
Off-Channel Habitats	(y)	(y)	(r)	(r)	(y)
Riparian Conditions	(y)	(r)	(y)	(y)	(y)
Sediment Conditions	(r)	(y)	(y)	(g)	(y)
Water Quality	(y)	(r)	(y)	(y)	(g)
Water Quantity	(r)	(r)	(y)	(r)	(r)
Invasive/Non-native species	(g)	(y)	(g)	(g)	(g)

Based on results from the ranking activity, *Water Quantity* stands out as the most limiting attribute for egg/alevin, summer juvenile, smolts, and adults. *Instream Structural Complexity* ranked very limiting for summer juvenile, winter juvenile, and smolts. *Off-Channel Habitats* ranked high for winter juvenile and smolts.

7.5 SHaRP Restoration Actions

Considering the ranking results and an understanding of habitat-life stage-survival relationships (Chapter 3), workshop participants leveraged their knowledge of the watershed to identify opportunities and actions with the potential to restore or enhance habitat and address the most limiting attributes to salmonid survival. These restoration actions were organized into a table with a complementary map (Figure 27, Table 11). The section below describes locations and actions in more detail.

Action-MC-1: Address Water Quality Issues Related to Sediment Delivery
Attributes: Water Quantity and Quality, Sediment Conditions
Location: Watershed-wide

Wallace and Angel creeks may be significant sediment source areas in the watershed. These sediment sources, as well as old landslides, roads, and culverts in the burned areas, and many other erosion and sedimentation sources across the watershed, need to be assessed and remediated.

Action-MC-2: Assess & Manage Forest to Improve Watershed Processes
Attributes: Water Quantity and Quality, Sediment Conditions
Location: Watershed-wide

This action includes outreach with foresters and landowners to help improve forest health and to better understand how upland forest conditions affect groundwater recharge and flow regimes.

Addressing this attribute may also present opportunities to collaborate with local Native American communities to integrate traditional burning practices (cultural burns) into land management, and simultaneously enhance the growth of culturally significant plants.

Forest management can improve watershed processes but may not directly increase streamflow. There may be a temporary increase in streamflow due to deforestation associated with the Walbridge Fire, but this may shift to a decrease in flow as the young forest grows (Kobor and O'Connor, 2021).

Action-MC-3: Conserve Water
Attributes: Water Quantity
Location: Watershed-wide

Water conservation is the practice of using water efficiently to reduce unnecessary water usage. Participants recommended projects include irrigation upgrades (for households, agriculture, and schools), rainwater catchment, and storage tanks/ponds with forbearance agreements.

The Coho Partnership recommends streamflow projects be based on modifying the timing of diversions from summer to winter, which can lead to an increase in summer base-flow, thus more flow for fish (RRCWRP 2015). Community outreach may help identify specific project opportunities and also promote general water conservation.

Action-MC-4: Monitor Streamflow Year-Round
Attributes: Water Quantity
Location: Mill Creek mainstem

As of September 2023, TU summer/dry season streamflow monitoring in Mill Creek is conducted by TU at five gages on the mainstem. Similar to other streams within the lower

Russian River, streamflow monitoring is essential due to high flow variability and inherent risks to survival of juvenile Coho Salmon and steelhead. Monitoring data informs flow enhancement decisions in real time and improves understanding of the effectiveness of flow enhancement projects. Streamflow gaging also guides real-time fish rescue and release efforts. Any future flow release programs aimed to improve spring out-migration and summer rearing conditions for fish and other water conservation activities will rely on streamflow gaging data to monitor efficacy of the programs.

A year-round streamflow gaging network needs to be established for the long-term. The current gage system needs to be expanded to include winter baseflow monitoring to assess winter drought conditions as well.

Action-MC-5: Investigate Easements & Acquisitions to Protect Sources of Perennial Streamflow & Avoid Development

Attributes: Water Quantity and Quality
Location: Southwestern portion of the watershed

Easements and acquisitions can protect sources of water in perpetuity. The SLT's *Russian River Subwatershed Conservation Assessment Project* in 2021 used reach-level information on Coho Salmon habitat, streamflow priorities, and groundwater recharge data, combined with other environmental data and expert opinion, to identify specific parcels that may offer opportunities to protect or enhance salmonid habitats through easements, acquisitions, and other stewardship and land management actions (Conti, 2023 pers. comm.). Based on this work, SHaRP workshop participants recommended that NGOs and agencies work together to develop community partnerships that promote easements and acquisitions.

This action supports protecting lands that contribute to instream flow and the revitalization of natural watershed processes. For example, CSG data shows Palmer Creek sustains perennial flows even during the worst drought conditions (TU and CSG 2023). These flows can be protected from development in perpetuity through easements and acquisitions.

Action-MC-6: Address Fish Passage

Attributes: Anthropogenic Barriers
Location: Felta Creek

Coho Salmon and steelhead need unimpeded fish passage to reach higher quality spawning and rearing habitats in upper Felta Creek. Participants recommended two barriers be addressed on Felta Creek: the historic cement/cobble dam in the lower reach, and the non-native rock barrier near the top of the gradient section. When passage projects are complete, planned habitat improvement projects can be implemented.

Action-MC-7: Remove Artificial Materials from the Falls

Attributes: Anthropogenic Barriers
Location: Mill Creek Falls

There are two parts to this action: 1) remnant pieces of cemented rock placed in the Falls years ago need to be removed, and 2) the Falls need to be monitored for passage problems due to fire-log-size wood chunks wedged between rocks. Fallen wood in the stream should be kept whole and not cut into chunks that can become wedged between rocks and boulders. Continued outreach and education to Mill Creek landowners should also be pursued to increase community understanding of impacts resulting from cutting large wood in the stream channel and disposing of biomass into the stream. Alternative biomass disposal and management methods should be included in this outreach.

Action-MC-8: Enhance Instream Habitat

Attributes: Instream Structural Complexity
Location: Mill Creek from Boyd Creek Confluence to the Falls, Felta Creek, and lower Palmer Creek

Workshop participants identified the importance and need for assessing large wood previously installed as well as naturally occurring pieces. In addition, riparian habitat should be assessed to determine the highest priority riparian enhancements needed within the assessed reaches. From this information, a plan to enhance mainstem and select tributaries with large wood and riparian enhancements can be generated. Current and future multi-purpose landowner outreach (i.e. fire issues, instream flow, etc.) should include working with streamside landowners to maintain existing large wood in the stream and repair existing structures, as well as including riparian plantings needed to restore the streamside ecosystems.

Reported post-fire flow conditions during the dry summer months of 2021 show that Palmer Creek provided the highest quality habitat refugia for juvenile salmonids and valuable hydrologic inputs into Mill Creek. In addition, Mill Creek above the confluence with Wallace Creek also provides valuable juvenile rearing habitat, although temperatures should be monitored in the fire-impacted areas (TU and CSG 2023). Instream habitat and riparian restoration in these reaches should be prioritized.

Wallace Creek dries out in the summer and is not suitable for instream habitat enhancements. Felta Creek offers limited summer rearing opportunities; however, the upper reach is quite responsive to rain events and has the capacity to support juvenile salmonids with minor increases to streamflow (TU and CSG 2023). Wallace Creek confluence to the Falls contains cold water refugia, and some wood structures could help support seasonal use. Large wood added just below the Falls could provide some winter habitat. The rest of this reach is alluvium which dries in most summers, so no instream enhancements are recommended.

Action-MC-9: Manage Riparian Invasives

Attributes: Riparian Conditions, Water Quantity, Sediment Conditions, Invasive/Non-Native Species
Location: Mill Creek from lower Angel Creek to Palmer Creek (burned areas), and Wallace Creek to Dry Creek Confluence

This management action includes removal of invasive plant species and the establishment of native plant communities. Planning for instream projects or other conservation projects should be done in tandem with stream corridor assessment to determine the need for increased riparian vegetation management such as improving canopy cover, removing invasive plant species, and revegetation with native riparian plant species.

Tribal resource managers present in the meeting expressed the need for early consultation when planning riparian zone restoration and the need to consider tribal riparian zone management techniques, including “spot-burns.”

Action-MC-10: Enhance Streamflow/Flow Augmentation

Attributes: Water Quantity
Location: Angel Creek to top of the falls; below the falls to the confluence with Dry Creek

While the water conservation measures recommended above will have diffuse benefits, more active and targeted flow-enhancement projects are also needed. This action includes adding water to the stream to benefit instream flows and water quality for rearing juveniles and out-migrating smolts.

For rearing juveniles, water augmentation from ponds or wells between Angel Creek to the top of the Falls would preserve stream connectivity and benefit water quality if augmented water temperature is cool and dissolved oxygen (DO) is acceptable.

CSG recommends the reach between the confluence of Dry Creek and Wallace Creek be managed to increase flow for out-migrating smolts only, not to increase summer rearing. To facilitate smolt out-migration below the Falls in the valley alluvium, alternative methods to increase surface flow, such as injecting treated wastewater, need to be investigated. This action recommends a hydrology study be completed for the lower reach from Westside Road to the Dry Creek Confluence to determine what conservation actions ought to be implemented to improve summer flows.

All project flow augmentation sites should be monitored for water quality prior to, during, and after releases. Flow augmentation sites should be gaged and monitored using remote cameras to determine effectiveness. This action also recommends experimental flow releases as these actions need to be documented and adaptively managed.

The Mill Creek Streamflow Improvement Plan identifies specific measures to impact the dry season water demand and improve instream flow for Coho Salmon and ecosystem function (RRCWRP 2015). Some residential projects can include water tanks to mitigate the cumulative effects of diversions and rooftop rain harvesting. Participants recommended spring and summer flow releases that would provide different benefits:

Spring Flow Release Recommendations: Maintain constant discharge near Dry Creek confluence to provide streamflow for out-migrating smolts. Spring pulses over an extended period can extend the out-migration window if necessary. Seek cooperation from landowners with existing reservoirs or with property suitable for reservoir construction to develop projects that would provide stored water for releases to improve out-migration flow conditions.

Summer Flow Release Recommendations: Look into the pipeline that is already in place on Foreman Lane to provide recycled water. This could be part of a flow enhancement feasibility study. This water could offset groundwater pumping used for irrigation between the Falls and the mouth of Dry Creek. Seek cooperation from landowners with existing reservoirs or with property suitable for reservoir construction to develop projects that would provide stored water for releases to improve summer rearing conditions.

Seek cooperation from landowners to develop fuel management programs that would both reduce fire hazard and reduce evapotranspiration demand of vegetation that could enhance streamflow.

Action-MC-11: Create/Enhance Off-Channel Habitats

Attributes: Instream Structural Complexity, Off-Channel Habitats
Location: Mill Creek Bear Flat area; Angel Creek to just below Wallace Creek confluence; lower Palmer Creek

Floodplain habitat, off-channel habitat, pockets, and alcoves provide slow velocity refugia for winter rearing juveniles that benefit from remaining in their natal stream until the spring. These habitats also provide resting places for migrating adult salmon and steelhead. Due to the constraints of the creek caused by the road, off-channel floodplain habitat opportunities may be limited. In their modeling report, OEI identified many terraces adjacent to Mill Creek where there may be potential for creation of off-channel habitat for fish refugia (OEI 2018). This action also suggests that Bear Flat would be a good site for BDAs and off-channel habitat restoration.

Action-MC-12: Restore Angel Creek

Attributes: Instream Structural Complexity, Water Quality, Sediment Conditions, Anthropogenic Barriers
Location: Angel Creek

This action recommends working with appropriate agencies and landowners in a phased approach to:

1. Address fish passage issues, investigate, and remediate culverts,
2. Improve water quality, investigate, and reduce sediment sources,
3. Enhance juvenile rearing habitat, instream habitat enhancement.

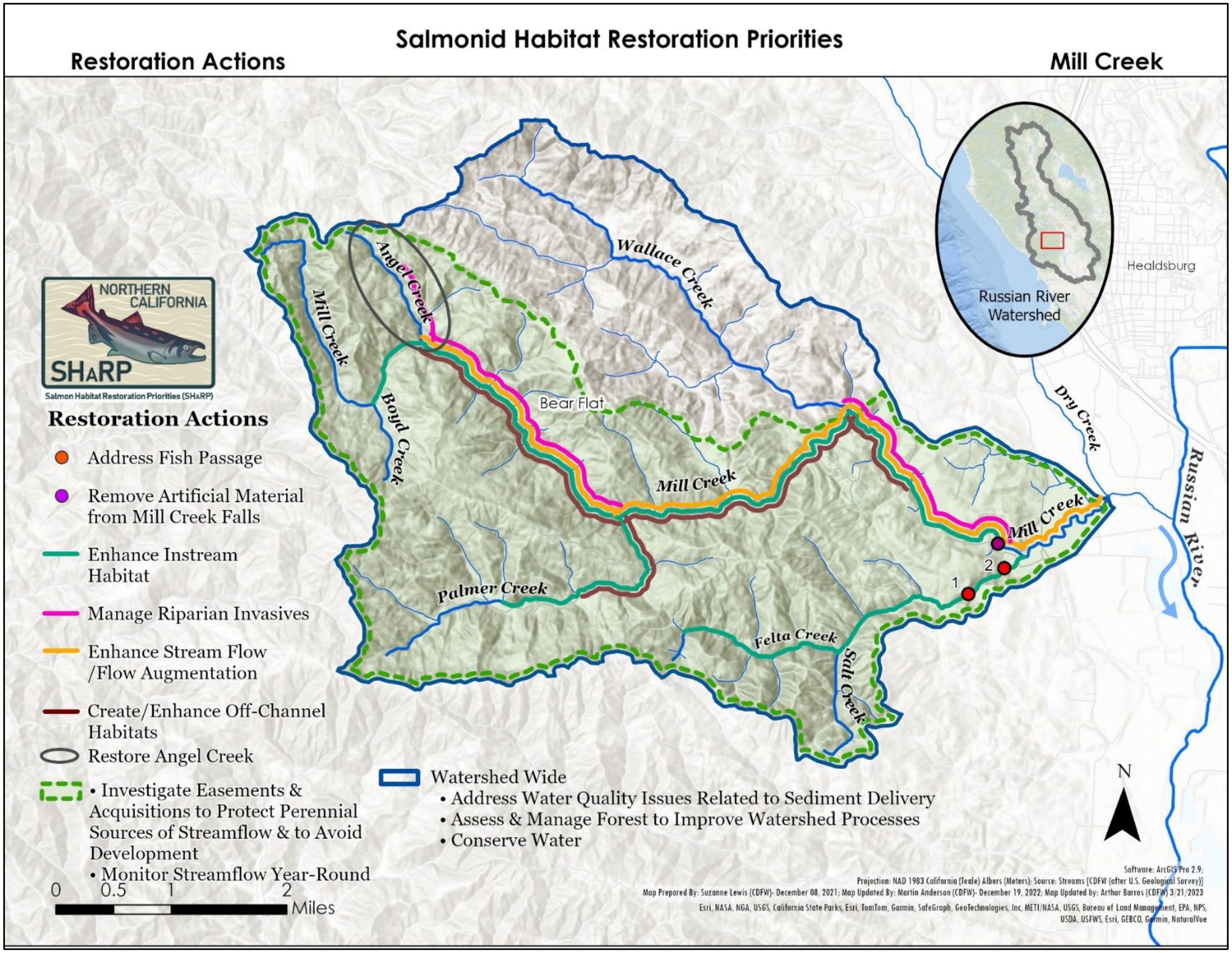


Figure 27. Mill Creek SHaRP Restoration Actions and Locations.

Table 11. Mill Creek SHaRP Restoration Actions, Action Number, Map Symbols, Locations, and Comments.

Action #	Restoration Action	Map Symbol	Location	Comments
MC-1	Address Water Quality Issues Related to Sediment Delivery	Blue Outline	Watershed-wide	Assess and remediate sediment sources, especially roads and culverts in burned areas.
MC-2	Assess & Manage Forest to Improve Watershed Processes	Blue Outline	Watershed-wide	Investigate cultural burns. Forest and fuels management using various methods. Improve canopy cover.
MC-3	Conserve Water	Blue Outline	Watershed-wide	Community outreach promoting water conservation.
MC-4	Monitor Streamflow Year-Round	Green Shading w/Dashed Outline	Southwest Portion of the watershed	Reliable gage network is needed to provide year-round information on instream flows to manage flow augmentation projects and pool connectivity, and to protect water quality.
MC-5	Investigate Easements & Acquisitions to Protect Sources of Perennial Streamflow & Avoid Development	Green Shading w/Dashed Outline	Southwest Portion of the watershed	Support land conservation organizations in protecting lands that contribute to instream flow and natural watershed processes.
MC-6	Address Fish Passage	Red Points	Lower Felta Creek	No Pad# - Assess and remediate/remove identified fish passage barriers.
MC-7	Remove Artificial Material from the Falls	Purple Point	Lower Mill Creek	PAD# 712938 - There are two parts to this action: 1) remove remnant pieces of cemented rock, and 2) monitor Falls for passage problems due to fire-log-size wood chunks wedged between rocks.
MC-8	Enhance Instream Habitat	Green Line	Boyd Creek to Falls, Palmer Creek and Felta Creek	Add large wood structures, repair existing structures, and enhance native vegetation.
MC-9	Manage Riparian Invasives	Pink Line	Mid-Angel Creek to Palmer and Wallace creeks, to mouth	Remove invasives and plant native plants, especially in the burn zone.

Action #	Restoration Action	Map Symbol	Location	Comments
MC-10	Enhance Streamflow/Flow Augmentation	Goldenrod Line	Angel to top of the Falls and Falls to Mouth	Seek landowner cooperation to develop flow enhancement projects. 1) For juvenile rearing, water augmentation from ponds or wells between Angel to top of Falls. 2) A hydrology study is needed in the lower reach from Westside Road to the Dry Creek Confluence to determine what conservation actions ought to be implemented to improve summer flows. For smolt outmigration, investigate water augmentation such as treated water injection between Falls and Dry Creek confluence.
MC-11	Create/Enhance Off-Channel Habitats	Dark Maroon Line	Bear Flat area, Angel to just below Wallace Confluence and lower Palmer Creek	Create or enhance off-channel features, pockets and/or alcoves beginning with the recommendations within (OEI 2018) and willing landowner in Bear Flat area.
MC-12	Restore Angel Creek	Black Oval	Angel Creek	1) Remediate culverts to improve fish passage (appendix II). 2) Assess and reduce sediment sources to improve water quality. 3) Instream habitat enhancements to improve juvenile rearing habitat.

Chapter 8. Discussion

The Russian River SHaRP Action Plan is the result of local tribal resource managers, agency staff, the scientific community, non-profits who focus on restoration, consultants, and landowners participating in meetings which identified high priority challenges and potential solutions for salmonid habitat restoration within four local Coho Salmon strongholds – Green Valley, Dutch Bill, Willow, and Mill Creek watersheds. Discussions during the SHaRP meetings informed recommended restoration actions that were guided by collectively ranking habitat attributes that corresponded to each salmonid freshwater life stages. When comparing the limiting attributes ranking for each watershed, the summer juvenile life stage is the most negatively impacted, and the strongly limiting attribute is *water quantity*.

Of all four watersheds, GVC has the highest number of *most limiting* attributes, with *channel structure and form* and *water quantity* ranked as affecting all life stages. Willow Creek shares similar sediment and water challenges in the lower reach where an evolving channel form barrier limits stream surface flow while degrading water quality, and impeding fish passage. It is recommended that instream habitat enhancements include elements that address water quantity and quality, ensuring habitat for rearing as well as out-migration.

Similarly, in DBC *water quantity, instream structural complexity*, and *off-channel habitat* were ranked as most limiting. The lower alluvial reach below Tyronne Gulch supports active redd building each year, but diminished surface flows desiccate redds and shorten the smolt out-migration window. The phased approach recommendation beginning with surface and groundwater monitoring is the logical first step to addressing this bottleneck. Opportunities for flow monitoring and off-channel enhancements exist within the Monte Rio Redwoods Regional Park. Mill Creek is unique in that it suffered catastrophic loss of upland canopy, riparian habitats, and instream wood material during the Walbridge Fire in 2020. *Water quantity* and *instream habitat complexity* ranked *most limiting*. Instream flow projects could prove to be most beneficial for rearing fish if paired with an increase in habitat complexity and riparian plantings.

This report reflects the urgency for action in the face of climate change as outlined in Governor Newsom's executive order to conserve 30% of our lands and coastal waters by 2030 (CNRA 2022). The SHaRP restoration actions outlined in this plan support one of the ten 30 X 30 pathways to "ensure conservation and restoration of river corridors that are essential to fish and wildlife movement, and that serve as climate refugia for native species; and develop long-term, stable capacity building for conservation and restoration efforts in local communities." This plan is also part of the Governor's *2024 California Salmon Strategy for a Hotter Drier Future* that outlines actions state agencies are taking to stabilize and recover salmonid populations, plus additional actions needed in the coming years.

Note: in the time between workshops and the completion of this report, some of the actions identified have received funding and are under way; they are nonetheless included to document the recommendations emerging from the SHaRP process.

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Appendix I

Revised Dutch Bill, Green Valley, and Willow Creek Barrier Assessments

Mark Gard, Conservation Engineering Branch, CDFW

Methods

Field investigations were conducted on June 11-12, 2023, to collect barrier dimensions and photographs for 15 barriers in the Dutch Bill, Green Valley, and Willow Creek watersheds. Dutch Bill, Green Valley, and Willow Creeks are tributaries of the Russian River, while Lancel and Grab (Grub) creeks are tributaries of Dutch Bill Creek. Most of these barriers are in the Passage Assessment Database (PAD). The purpose of this assessment is to classify the barrier status of those barriers for adult and juvenile anadromous salmonids. Low and high design flows (Table 1) were determined from flow data provided by Trout Unlimited or in Streamstats (https://streamstats.usgs.gov/ss/). For streams with gages (Dutch Bill and Green Valley Creeks), the low (50% exceedance) and high (1% exceedance) design flows were calculated from the gage record, or 3 cfs if the flows from the gage records were less than 3 cfs. For streams without gages, the high design flow was calculated as 50% of the 2-year event flow, calculated in Streamstats, while the low design flow was 3 cfs.

Table 3: Design Flows

Stream	High Design Flow (cfs)	Low Design Flow (cfs)
Dutch Bill Creek	87.33	3
Lancel Creek	70.5	3
Grab (Grub) Creek	28.4	3
Willow Creek	266.5	3
Unnamed tributary of Willow Creek	18.25	3
Green Valley Creek	47.34	3

A two-dimensional HEC-RAS model was developed for each stream using 1-meter resolution LIDAR data (downloaded fromhttps://apps.nationalmap.gov/downloader/#/) for the underlying terrain. For bridges that had not been removed from the LIDAR data topography, the topography under the bridge was developed by interpolating between cross-sections above and below the bridge. The resulting raster for the interpolated surface was exported from Arc GIS as a digital elevation model that was laid over the LIDAR data. For barriers that were not adequately represented in the LIDAR data, the topography within the barrier was developed in Civil3D, exported as a digital elevation model, and laid over the

LIDAR data to create the model terrain. The models had mesh sizes of 5 to 20 feet and a Manning's n value of 0.04. One or more Surface Area/2D Area connections were added at each barrier. The upstream boundary condition for the models were the flows in Table 1, while the downstream boundary condition was normal depth, using a friction slope calculated from the terrain at the downstream boundary. Barriers were represented in the model by a combination of weirs and culverts, using data collected during the field survey. Each model was run at the flows in Table 1.

Barriers were evaluated using the following criteria from NMFS (2022) and CDFW (2009): 1) adult jump height less than 1 foot; 2) adult depth greater than 1 foot; 3) adult velocity less than 6 ft/s; 4) juvenile jump height less than 0.5 foot; 5) juvenile depth greater than 0.5 foot; and 6) juvenile velocity less than 1 ft/s. Barriers that met all three criteria at both passage flows and for both life stages were classified as not a barrier. Barriers that did not meet at least one of the criteria at one of the passage flows were classified as a temporal barrier, while barriers that did not meet at least one of the criteria at both passage flows were classified as total barriers. Barriers that only met criteria for one of the two life stages were classified as partial barriers.

Results

Green Valley Creek

As shown in Table 2, PAD ID 765179 and 765180, which are 4' diameter culverts, are currently not adult barriers, but are barriers for juveniles due to velocity at the high fish passage flow. As a result, these would be classified as partial barriers. They are undersized to carry the 100-year flow, and thus are likely to get plugged in the future, which would make them total barriers. Remediation of these barriers would involve replacing the culverts with open-span bridges.

PAD 716536, which is a bridge with a 10' wide concrete floor, is a temporal barrier due to depth at the low passage flow. Installation of a boulder weir downstream of the bridge would remediate this barrier. PAD ID 716535, which is an 8' diameter culvert, is not a barrier, and thus no remediation is needed. PAD ID 716534 is a 14' wide, 9' tall bottomless arched culvert with the stream bottom lined with small boulders. The stream simulation technique was used to assess this barrier with respect to depth and velocity and meets criteria on this basis. As shown in Table 2, this barrier met jump height criteria at both the low and high fish passage flows, and thus is not a barrier.

Table 4: Green Valley Creek HEC-RAS Results

PAD#	Hi Q jump	Lo Q jump	Hi Q depth	Lo Q Depth	Hi Q Vel	Lo Q Vel	Status
765180	0.02	0.00	4	3.6	1.17	0.08	Partial
765179	0.28	0.02	4	1.1	2.62	0.52	Partial
716536	0.01	0.01	1.5	0.13	4.19	1.04	Temporal
716535	0.01	0.00	5.37	4.94	0.86	0.36	Not
716534	0.09	0.01	N/A	N/A	N/A	N/A	Not
712108	0.95	1.08	1.76	0.67	2.00	1.03	Temporal
716532	1.70	1.98	4.34	2.82	1.17	0.68	Total

PAD ID 712108 is a 10' x 10' box culvert which has been retrofitted with a V-shaped baffle, with height ranging from 0.5 – 0.9'. There was a one foot drop off of the weir thalweg into a 2.7' deep pool downstream of the culvert outlet. Currently, this is a temporal barrier. This barrier could be remediated by installing boulder weirs downstream of the culvert outlet that raise the water surface elevation at the outlet by 2 feet.

PAD ID 716532 consists of four concrete weirs on top of a bedrock outcropping, with concrete side walls between the weirs. The downstream three weirs have 0.6' deep notches. There was a 1.9' drop off the downstream-most weir and 1.4' drops off the two upstream-most weirs. This weir is currently a total barrier due to jump height. This barrier could be remediated by constructing a roughened channel downstream of the structure. The upstream end of the roughened channel should be high enough to backwater up to one foot below the top of the upstream-most weir.

Dutch Bill Creek

As shown in Table 3, PAD ID 712088 (Camp Meeker) is not a barrier. This is a remediated barrier; passage was evaluated for two boulder weirs that were installed as part of the barrier removal project. Jump height is the only relevant variable for boulder weirs.

PAD ID 712087 (Market Street) consists of two 12'x12' box culverts that were retrofitted with four one foot high by 12' long baffles, each of which has a 2' wide by 1' deep notch. Downstream of the culverts are six boulder weirs; with the exception of the 2nd from downstream-most weir, which had a 2' drop due to the downstream-most weir starting to fail, these weirs all had a one-foot drop. PAD ID 712087 is a total barrier due to the jump height at the 2nd from downstream-most weir. Repair of the downstream-most weir is recommended to remediate this barrier.

Table 5: Dutch Bill Cree HEC-RAS Results

PAD#	Hi Q jump	Lo Q jump	Hi Q depth	Lo Q Depth	Hi Q Vel	Lo Q Vel	Status
712088	0.23	0.24	N/A	N/A	N/A	N/A	Not
712087	1.86	2.02	1.56	1.03	2.56	2.37	Total
766339	1.06	1.26	3.48	3.07	0.08	0.00	Total
707063	1.56	1.61	2.05	0.28	2.99	0.50	Total

PAD ID 766339 (Westminster) is an old flashboard dam. The remnant 20’ wide by 5’ long concrete base of the flashboard dam is a total barrier due to jump height. Removal of the concrete structure would remediate this barrier.

PAD ID 707063 is a 16’ wide concrete channel with a series of notched concrete weirs. Most of the notches are 4.5’ wide, while the second and third most downstream weirs have 3’ wide notches, and the downstream-most weir has two notches which are 5.5’ and 2.5’ wide. Most of the weirs have a 0.7’ drop; the fourth weir has a 1.5-foot drop, and there is a 1.4- foot drop off of the downstream-most weir. Downstream of the channel are four boulder weirs, which each have a jump height of less than 1 foot. This barrier would be classified as a total barrier due to the jump heights at the fourth and last weirs. The addition of another boulder weir would remediate the jump at the last weir. Remediating the fourth weir would require construction of another concrete weir in between the fourth and fifth weirs. It should be noted that these actions would only bring the barrier from a total barrier to a temporal barrier, due to depth at the low passage flow.

Lancel Creek

PAD 712089 is an 8’ x 8’ box culvert with a 1.5’ drop at the outlet. The jump height at the outlet was 1.4’ at the low flow and 0.91’ at the high flow. The entire culvert had a depth of less than 1 foot at the low flow, but only the downstream-most 2 feet of the culvert had a depth of less than 1 foot at the high flow. At the high flow, the lower 10’ of the culvert had the entire width with velocities over 6 ft/s, but only the lower 4’ of the culvert had the entire width with velocities over 8 ft/s. At the low flow, the entire culvert had velocities under 6 ft/s. At the low flow, the culvert is a barrier both due to jump height and depth. At the high flow, adult salmonids could jump over the downstream four feet, and would then be able to swim 6 feet in velocities of up to 8 ft/s; thus, the culvert is passable at the high flow by adults, but not by juveniles. This barrier should be classified as a temporal barrier. Construction of boulder weirs downstream of the culvert that raise the water surface elevation by 3 feet at the culvert outlet would remediate this barrier.

Alternatively, the culvert could be replaced with a free-span bridge.

The other barrier evaluated on Lancel Creek, which is not currently in PAD, is a footbridge over a natural channel. Based on the stream simulation method, this would be classified as not a barrier.

Grab (Grub) Creek

PAD ID 712086 is a 6’ x 6’ box culvert that has been retrofitted with six 8” x 8” wooden baffles. There is a 0.2’ drop from the lowest baffle to the downstream pool, as a result of a series of boulder weirs that were installed downstream of the culvert. The drop at each boulder weir was less than one foot. The grade control downstream of the boulder weirs is likely to fail, potentially causing a jump barrier. The jump height at the outlet was 0.06’ at the low flow and 0.27’ at the high flow. The entire culvert had a depth of greater than 1 foot at the high flow, but the downstream-most 7 feet of the culvert had a depth of less than 1 foot at the low flow. The entire length of the culvert had velocities of less than 6 ft/s at both the low and high flows. This barrier should be classified as a temporal barrier due to depth at the low flow. The culvert could be remediated by bolting an additional 8” x 8” four-foot-long wooden baffle on top of each existing baffle. If the downstream control fails, an additional boulder weir would need to be installed to maintain passage.

Willow Creek

PAD ID 716484 (3rd Bridge) is a free-span bridge. Willow Creek has been aggrading to the extent that the channel under the bridge is backwatered three feet by a shallow downstream riffle. The jump height at the downstream end of the bridge was 0.00’ at the low flow and 0.06’ at the high flow. The entire thalweg under the bridge had a depth of greater than 1 foot at the high and low flows. At the high flow, water reaches the underside of the bridge. There was a continuous path with velocities under 1 ft/s below the bridge at both the high and low fish passage flow. Currently, the bridge would be classified as not a barrier. However, as Willow Creek continues to aggrade, the bridge will eventually become a barrier. The bridge should be replaced with a higher bridge that has sufficient capacity to carry the 100-year flow.

Unnamed tributary of Willow Creek

The barrier on the unnamed tributary of Willow Creek, which is currently not in PAD, is a 6.5’ diameter, 60’ long concrete culvert. The outlet is not perched, with the downstream stage of zero flow elevation 0.3’ higher than the culvert invert. The jump height at the outlet was 0.05’ at the low flow and 0.00’ at the high flow. The lower 19’ of the culvert has a depth of less than 0.5 foot at both the low and high flows. Thus, this barrier would be classified as a total barrier due to depth. This barrier could be remediated by replacing the culvert with a free-span bridge.

Discussion

In general, the techniques used in this analysis were successful in determining the passage status of barriers for anadromous salmonids. Information in this report should be useful in identifying how to remediate these barriers.

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Mill and Austin Creek Watersheds Barrier Assessments - Mark Gard, Conservation Engineering Branch, CDFW

Methods

Field investigations were conducted on October 6, 2023, to collect barrier dimensions and photographs for 8 barriers in the Mill and Austin Creek watersheds. Mill Creek is a tributary of Dry Creek, East Austin Creek is a tributary of Austin Creek, and Boyd, Angel and Felta Creeks are tributaries of Mill Creek. Most of these barriers are not in the Passage Assessment Database (PAD). The purpose of this assessment is to classify the barrier status of those barriers for adult and juvenile anadromous salmonids. Low and high adult and juvenile design flows (Table 1) were determined from flow data provided by Trout Unlimited or in Streamstats (https://streamstats.usgs.gov/ss/). For streams with gages (Mill Creek), the adult low (50% exceedance) and high (1% exceedance) design flows were calculated from the gage record, or 3 cfs if the flows from the gage record were less than 3 cfs. The juvenile low (95% exceedance) and high (10% exceedance) flows were also calculated from the gage record, or 1 cfs if the flows from the gage record were less than 1 cfs. For streams without gages, the high adult and juvenile design flows were calculated as, respectively, 50% and 10% of the 2-year event flow, calculated in Streamstats, while the low adult and juvenile design flows were, respectively, 3 and 1 cfs.

Table 6: Design Flows

Stream	High Design Flows (cfs) Adult	High Design Flows (cfs) Juvenile	Low Design Flows (cfs) Adult	Low Design Flows (cfs) Juvenile
East Austin Creek	274	54.8	3	1
Boyd Creek	27.45	5.49	3	1
Angel Creek	53	10.6	3	1
Unnamed Tributary to Angel	20.8	4.16	3	1
Mill Creek	38.03	7.77	3	1
Felta Creek	134	26.8	3	1

A two-dimensional HEC-RAS model was developed for each stream using 1-meter resolution LIDAR data (downloaded from https://apps.nationalmap.gov/downloader/#/) for the

underlying terrain. For bridges that had not been removed from the LIDAR data topography, the topography under the bridge was developed by interpolating between cross-sections above and below the bridge. The resulting raster for the interpolated surface was exported from Arc GIS as a digital elevation model that was laid over the LIDAR data. The models had mesh sizes of 3 to 5 feet and a Manning’s n value of 0.04. One or more Surface Area/2D Area connections were added at each barrier. The upstream boundary condition for the models were the flows in Table 1, while the downstream boundary condition was normal depth, using a friction slope calculated from the terrain at the downstream boundary. Barriers were represented in the model by a combination of weirs and culverts, using data collected during the field survey. Each model was run at the flows in Table 1.

Barriers were evaluated using the following criteria from NMFS (2022) and CDFW (2009):

1) adult jump height less than 1 foot; 2) adult depth greater than 1 foot; 3) adult velocity less than 6 ft/s; 4) juvenile jump height less than 0.5 foot; 5) juvenile depth greater than 0.5 foot; and 6) juvenile velocity less than 1 ft/s. Barriers that met all three criteria at both passage flows and for both life stages were classified as not a barrier. Barriers that did not meet at least one of the criteria at one of the passage flows were classified as a temporal barrier, while barriers that did not meet at least one of the criteria at both passage flows were classified as total barriers. Barriers that only met criteria for one of the two life stages were classified as partial barriers.

Results

East Austin Creek

The barrier on East Austin Creek is a low flow crossing consisting of a 11’ x 35’ concrete slab and a 12’ concrete slope downstream of the slab. There is a 4.15’ drop from the slab to the downstream channel. The active channel width is 26’. This is a total barrier due to jump height (Table 2). The treatment recommendation is to replace the low flow crossing with a free span bridge.

Table 7: East Austin Creek Barrier

Flow	Parameter	Value
	Lat/Long	38.616794°, -123.092552°
Adult High	Jump Height (ft)	2.16
Adult High	Velocity (ft/s)	2.45
Adult High	Depth (ft)	2.2
Adult Low	Jump Height (ft)	3.48
Adult Low	Velocity (ft/s)	0.96
Adult Low	Depth (ft)	0.87
Juvenile High	Jump Height (ft)	4.40
Juvenile High	Velocity (ft/s)	0.74
Juvenile High	Depth (ft)	1.46
Juvenile Low	Jump Height (ft)	3.51
Juvenile Low	Velocity (ft/s)	0.47
Juvenile Low	Depth (ft)	0.69
	Barrier Status	Total

Boyd Creek

The barrier on Boyd Creek (PAD ID 712165) is a 40’ long 8’ x 5.5’ box culvert with a downstream concrete apron. There is an 8’ drop from the downstream end of the concrete apron to the downstream channel. This is a total barrier due to jump height (Table 3). The treatment recommendation is to replace the culvert with a free span bridge.

Table 8: Boyd Creek Barrier PAD ID 712165

Flow	Parameter	Value
	Lat/Long	38.597411°, -122.987917°
Adult High	Jump Height (ft)	7.31
Adult High	Velocity (ft/s)	0.99
Adult High	Depth (ft)	1.26
Adult Low	Jump Height (ft)	7.30
Adult Low	Velocity (ft/s)	0.36
Adult Low	Depth (ft)	0.39
Juvenile High	Jump Height (ft)	7.18
Juvenile High	Velocity (ft/s)	0.49
Juvenile High	Depth (ft)	0.52
Juvenile Low	Jump Height (ft)	8.32
Juvenile Low	Velocity (ft/s)	0.22
Juvenile Low	Depth (ft)	0.22
	Barrier Status	Total

Angel Creek

There are two barriers on Angel Creek, consisting of plastic culverts. The downstream culvert is 18’ long and 5’ diameter, with a 21% slope and a 1.2’ drop from the outlet to the downstream channel. The upstream culvert is 31’ long and 5’ diameter; the outlet was backwatered 0.3’ but there was a 2’ drop from the upstream channel to the inlet. The lower culvert is a temporal barrier due to depth, while the upper culvert is a temporal barrier due to jump height and depth (Table 4). The treatment recommendation is to replace the culverts with bottomless arch culverts sized to the active channel width and with sufficient capacity to accommodate a 100-year flow event.

Angel Creek Tributary

The barrier on the unnamed tributary to Angel Creek is a 4’ diameter plastic culvert that is mostly blocked at the upstream end and backwatered 0.2’ at the outlet. The culvert is a total barrier due to blockage and depth (Table 5). The treatment recommendation is to replace the culvert with a bottomless arch culvert sized to the active channel width and with sufficient capacity to accommodate a 100-year flow event.

Table 9: Angel Creek Barriers

Flow	Parameter	Downstream Culvert	Upstream Culvert
	Lat/Long	38.605617°, -122.980911°	38.607581°, -122.981292°
Adult High	Jump Height (ft)	0.01	0.14
Adult High	Velocity (ft/s)	5.21	0.73
Adult High	Depth (ft)	1.35	3.23
Adult Low	Jump Height (ft)	0.00	3.40
Adult Low	Velocity (ft/s)	1.22	1.21
Adult Low	Depth (ft)	0.49	0.95
Juvenile High	Jump Height (ft)	0.00	0.64
Juvenile High	Velocity (ft/s)	0.52	0.30
Juvenile High	Depth (ft)	0.74	1.56
Juvenile Low	Jump Height (ft)	0.01	3.34
Juvenile Low	Velocity (ft/s)	0.73	0.57
Juvenile Low	Depth (ft)	0.36	0.83
	Barrier Status	Temporal	Temporal

Table 10: Angel Creek Tributary Barrier

Flow	Parameter	Value
	Lat/Long	38.607661°, -122.981186°
Adult High	Jump Height (ft)	0.75
Adult High	Velocity (ft/s)	2.14
Adult High	Depth (ft)	0.49
Adult Low	Jump Height (ft)	0.66
Adult Low	Velocity (ft/s)	0.68
Adult Low	Depth (ft)	0.30
Juvenile High	Jump Height (ft)	0.65
Juvenile High	Velocity (ft/s)	0.73
Juvenile High	Depth (ft)	0.31
Juvenile Low	Jump Height (ft)	0.46
Juvenile Low	Velocity (ft/s)	0.42
Juvenile Low	Depth (ft)	0.19
	Barrier Status	Total

Mill Creek

The barrier on Mill Creek (PAD ID 712164) is a 14’ diameter semicircular CRM culvert with a bare concrete bottom. The outlet is backwatered 0.2’. This was previously classified as not a barrier because the concrete was covered by native material. This is a temporal barrier due to depth (Table 6). The treatment recommendation is to cut a 1’ deep 3’ wide longitudinal channel through the concrete bottom.

Table 11: Mill Creek Barrier, PAD ID 712164

Flow	Parameter	Value
	Lat/Long	38.605069°, -122.980217°
Adult High	Jump Height (ft)	0.03
Adult High	Velocity (ft/s)	1.94
Adult High	Depth (ft)	1.44
Adult Low	Jump Height (ft)	0.09
Adult Low	Velocity (ft/s)	0.77
Adult Low	Depth (ft)	0.7
Juvenile High	Jump Height (ft)	0.04
Juvenile High	Velocity (ft/s)	0.42
Juvenile High	Depth (ft)	0.49
Juvenile Low	Jump Height (ft)	0.05
Juvenile Low	Velocity (ft/s)	0.17
Juvenile Low	Depth (ft)	0.38
	Barrier Status	Temporal

Felta Creek

There are two barriers on Felta Creek: Pearl's Dam and a boulder dam. Pearl's Dam is a 30' wide concrete dam with a 6.5' drop from the downstream apron to the downstream channel. The boulder dam has a 4' drop from the top of the boulder dam to the downstream channel. Both barriers are total barriers due to jump height (Table 7). The treatment recommendation for both barriers is to remove them.

Table 12: Felta Creek Barriers

Flow	Parameter	Pearl's Dam	Boulder Dam
	Lat/Long	38.579233°, -122.886231°	38.576280°, -122.891851°
Adult High	Jump Height (ft)	4.67	3.43
Adult Low	Jump Height (ft)	5.47	3.15
Juvenile High	Jump Height (ft)	3.95	3.13
Juvenile Low	Jump Height (ft)	5.55	3.19
	Barrier Status	Total	Total

Discussion

In general, the techniques used in this analysis were successful in predicting the passage status of barriers for anadromous salmonids. Information in this report should be useful in identifying how to remediate these barriers.

References

CDFW. 2009. California Salmonid Habitat Restoration Manual, Part XII Fish Passage Design, and Implementation. CDFW, Sacramento, CA.

NMFS. 2022. NOAA Fisheries WCR Anadromous Salmonid Design Manual. National Marine Fisheries Service, West Coast Region, Environmental Service Branches, Portland OR.

Appendix II

Excerpts from Appendix B: Conservation Action Planning Key Attributes, Stresses, and Threats Report, Final CCC Coho Salmon ESU Recovery Plan (Vol 3 of 3).

Habitat complexity is critically important for salmonids because complex habitats are typically highly productive, offer velocity refuges, places to hide, and lower temperatures. This attribute encompasses specific elements, such as large woody debris (LWD), and multi-faceted features such as shelter rating and the ratio of pools to riffles and flatwater. To capture the diversity and importance of this attribute, NMFS identified five different indicators for habitat complexity.

Large Woody Debris (LWD) BFW 0-10 and LWD BFW 10-100 for Adult, Summer, and Winter Rearing Targets

The LWD indicator is defined as the number of key pieces of large wood per 100 meters of stream. Separate rating criteria were developed for channels with bankfull width (BFW) less than 10 meters and greater than 10 meters. Key pieces are logs or rootwads that: (1) are independently stable within the bankfull width and not functionally held by another factor, and (2) can retain other pieces of organic debris (WFPB 1997). Key pieces also meet the following size criteria: (1) for bankfull channels 10 meters wide or less, a minimum diameter 0.55 meters and length of 10 meters, or a volume 2.5 cubic meter or greater, (2) for channels between 10 and 100 meters, a minimum diameter of 0.65 meters and length of 19 meters, or a volume six cubic meters or greater (Schuett-Hames *et al.* 1999). Key pieces in channels with a bankfull width of > 30 meters pieces only qualify if they have a rootwad associated with them (Fox and Bolton 2007).

Ratings: Number of LWD key pieces per 100 meters of stream length (BFW 0-10 and BFW 10-100)

The frequency of key pieces of LWD influences development and maintenance of pool habitat for multiple life stages of salmonids. LWD is the number of pieces (frequency) per stream length (100 meters) within each reach. Rating criteria were based on the observed distribution of key pieces of LWD in unmanaged forests in the Western Washington eco-region developed by Fox and Bolton (2007). Fox and Bolton's (2007) recommendations were followed using the top 75 percentile to represent a very good condition for LWD frequency. The California North Coast Regional Water Quality Control Board (NCRWQCB 2006) used similar information to develop indices for LWD associated with freshwater salmonid habitat conditions. Rating thresholds are as follows:

For smaller channels (0-10 meters BFW):

Poor = < 4 key pieces/100 meters
Fair = 4 to 6 key pieces/ 100 meters
Good = 6 to 11 key pieces/100 meters
Very Good => 11 key pieces/100 meters

For larger channels (10-100 meters BFW):

Poor = < 1 key pieces/100 meters
Fair = 1 to 1.3 key pieces/ 100 meters
Good = 1.3 to 4 key pieces/100 meters
Very Good => 4 key pieces/100 meters

References:

Fox, M.J., and S.M. Bolton. 2007. A regional and geomorphic reference for quantities and volumes of instream wood in unmanaged forested basins of Washington State. North American Journal of Fisheries Management 27(1): 342-359.

NCRWQCB (North Coast Regional Water Quality Control Board). 2002 Desired salmonid freshwater habitat conditions for sediment related indices. NCRWQCB, Santa Rosa, CA

Schuett-Hames, D., R. Conrad, A. Pleus, and M. Henry. 1999. TFW Monitoring Program method manual for the salmonid spawning gravel composition survey. Prepared for the Washington State Dept. of Natural Resources under the Timber, Fish, and Wildlife Agreement. TFW-AM9-99-001. DNR #101. March.

WFPB (Washington Forest Practices Board). 1997. Standard methodology for conducting watershed analysis, version 4.0. Washington Department of Natural Resources, Forest Practices Division, Olympia, WA.

Appendix III

Glossary of Data Layers in on-line Web Map

Watershed Reaches

This is a public dataset of the blue line stream for the four focus streams. It has been modified by CDFW to include the extent of accessible instream habitat for salmonids.

Boundary and Reaches

HUC 12 watershed boundary polygons are used to identify the boundary of GVC and Mill Creek HUC 12 watersheds. Dutch Bill and Willow creek boundaries are of the subwatersheds only. A mask is available to block out other watersheds.

Sea Grant- Redds per Season (Meeting Map Only)

This data was collected and provided by the California Sea Grant Russian River Salmon and Steelhead Monitoring program (CSG), partnering with Sonoma Water (SW). Coho and Steelhead redds data were collected at observed point locations along the survey reach in various tributaries within the Russian River watershed. Source: CSG. Sublayers include:

- All years- Redds (Coho)

- All Years- Redds (steelhead)

- Remaining Redd layers (Coho, steelhead, and Chinook) by broodyear: 2021/2022 -

2007/2010

Sea Grant- Snorkel Pools – All Salmonids (Meeting Map Only)

This data was collected and provided by the CSG partnering with SW. This data consists of point locations of pool units snorkeled in surveyed reaches in various tributaries to the Russian River watershed. Data associated with the point locations include snorkel observation counts of juvenile salmonids by species and age class, along with a total count of salmonids by unit per each snorkel-year sampled. Data is intended to represent the location and the associated density of salmonid juveniles observed in each snorkel pool, for each year and/or month sampled. Sublayers include:

- Snorkel Pools- All Salmonids 2022-2014

Sea Grant- Wetted Habitat Pools- Dissolved Oxygen (DO)(mg/L) & Water Temperature (°C) (Meeting Map Only)

*All Sea Grant data was collected beginning in 2008. Data collected after 2013/14 is part of the statewide Coastal Monitoring Plan (CMP) and includes stream reaches throughout the basin selected according to a GRTS sampling methodology for the CMP.

This data was provided and sourced by CSG partnering with SW. The dataset consists of point locations taken for pool units along the survey reach in each watershed. This point data is associated with water quality (DO, mg/L) and water temperature (℃) collected annually during the limited or low flow period in the water year (typically July - Oct). Source: CSG. Sublayers include:

- Wetted Habitat Pools - DO (mg/L) - 2022 - 2019 (August/Sept/Oct)

- Wetted Habitat Pools - Water Temp (°C)- 2022 - 2019 (August/Sept/Oct)

Sea Grant - Reach Wetted Habitat (Baseflow) (Meeting Map Only)

This data was collected and provided by the CSG partnering with SW. This data consists of line segments along the stream that represent different wetted conditions observed at the driest most water-limited time in the water year (typically September). Wetted habitat data has been gathered since 2012. Efforts vary year by year with the most coverage of Mill, Dutch Bill, and Green Valley creeks.

Data is intended to represent summer baseflow conditions. This can be further compared with fish abundance from the spring/early summer snorkel surveys to infer where fish have perished and where fish have the opportunity to persist throughout the low flow summer season. Source: CSG. Sublayers include:

Reach Wetted Habitat- 2022 - 2015 (Baseflow)

- Sample Frame Super Table: Coastal Monitoring Plan (CMP) sample frame was created by CDFW as part of the Coastal Monitoring Plan and modified and provided by CSG partnering with SW. CMP sample frame consists of the entire watershed divided into 2-4 km reaches. A subset of all the CMP reaches is selected annually using the GRTS (Generalized Random Tessellation Stratified) sampling draw. The GRTS sample reaches are geographically spaced to maximize the area covered across the basin. CMP GRTS reaches have been modified by Russian River Salmon and Steelhead Monitoring program (partnering with Sonoma Water) to exclude areas of stream that are not accessible for monitoring due to limited landowner access or riparian habitat conditions that create challenges for the stream to be physically accessed and surveyed. This data layer represents the finalized sample frame including all survey reaches along the four focus watersheds.

California Fish Passage Database [ds69]

The Passage Assessment Database (PAD) geospatial file contains locations of known and potential barriers to salmonid migration in California streams with additional information about each record. The PAD is an ongoing map-based inventory of known and potential barriers to anadromous fishes in California, compiled and maintained through a cooperative interagency agreement. The PAD compiles currently available fish passage information from many different sources, allows past and future barrier assessments to be standardized and stored in one place, and enables the analysis of cumulative effects of passage barriers in the context of overall watershed health. Identified sites include barrier structures such as dams, culverts, remediated structures that still require maintenance, and other types of road crossings. Source: CDFW

Water Diversions

This data set was collected by the State Water Board and provided by CDFW. It includes data from the mandated 2015 Drought Information Order for water users in four priority Russian river tributaries (which include: Mill, Dutch Bill, Green Valley, Mark West Creeks). This data represents point locations for all reported surface water, groundwater, and spring diversions existing within the watershed boundaries. Some diversions overlap with neighboring tributary watersheds however this is the most complete dataset available. This data is intended to represent the location and type of water right that exists in proximity to the stream and riparian corridor and the potential impact this diversion has on stream conditions. Source: State Water Board. Sublayers include:

- Surface_Diversions_IO_Oct.24.2019

- Groundwater_IO_Oct.24.2019

- Springs_IO_Oct.24.2019

Agency Funded Restoration Projects

Sublayers include:

- NOAA Restoration Projects

The data depicted is derived from the NOAA Restoration Center's Restoration Atlas, a project tracking database. For over 25 years, NOAA Restoration Center works in partnership to restore habitat that increases fish production, support the recovery of valuable protected species, and foster resilient coastal communities. Although projects are often represented by a single point, many involve activities that cover large areas at multiple project locations. Refer to the project descriptions and related information to better understand the full spatial extent of the project activities and their impacts. Some newly initiated projects may not yet appear on the map. For questions about the data please contact Renee Eaton at renee.eaton@noaa.gov.

- Wildlife Conservation Board (WCB) Approved Projects [ds672]

This data is to provide the spatial link to the Wildlife Conservation Boards main project database which houses an inventory of Wildlife Conservation Board projects from board inception in 1949 to present. WCB is a separate and independent Board with authority and funding to carry out an acquisition and development program for wildlife conservation (California Fish and Game Code 1300, et seq.). WCB approves and funds projects that set aside lands within the State for such purposes, through acquisition or other means, to meet these objectives. WCB can also authorize the construction of facilities for recreational purposes on property in which it has a proprietary interest. WCBs three main functions are land acquisition, habitat restoration, and development of wildlife oriented public access facilities, which are carried out through its programs.

Project boundaries are approximate and used various data sources, scale, and heads-up digitizing. Some of the project boundaries do not represent actual project area. See Wildlife Conservation Board's minutes and/or agenda for detailed information or contact the Board for additional information. WCB website

- Fisheries Restoration Grant Program (FRGP) Projects [ds168] – Years 2000-2019

This dataset was created and provided by CDFW and supported through funding by NOAA. It includes point locations for past restoration projects that were implemented using CDFW FRGP funds. This layer includes restoration projects funded and implemented in all four focus watersheds from 2000-2019. The data is represented by a centroid point location for each project which spans a reach of stream or contains multiple treatment sites within a 5-sq acre area or less. Specific restoration project reports and maps were used to update some project point locations, where multiple points with multiple sites or lines covering a stream section were used to reflect the project. Project codes are generalizations of a project's purpose and may include multiple treatments not described in the data layer. This data is intended to represent the location and total number of completed state funded watershed restoration projects within the four HUC12 focus watersheds on the Russian River. Source: CDFW

Intrinsic Potential (IP)

This data set provides an estimate to the spatial distribution of potential habitat for Central California Coast steelhead. This data layer was created and provided by NOAA and is further defined by the federal recovery plan written for CCC Coho Salmon, NC Steelhead Trout, and CCC Chinook Salmon. For our purposes, this data layer was clipped to the four focus watersheds in the Russian River (Green Valley, Dutch Bill, Willow, and Mill creeks).

At a high level, Intrinsic Potential (IP) is the viability of a certain habitat area for a particular species based on suitability requirements for a salmonid species to survive and reproduce. NOAA Fisheries describes “Intrinsic potential” as: “Intrinsic potential measures the potential for development of favorable habitat characteristics as a function of the underlying geomorphic and hydrological attributes, as determined through a Digital Elevation Model (DEM) and mean annual precipitation grid. The model does not predict the actual distribution of "good” habitat, but rather the potential for that habitat to occur, nor does the model predict abundance or productivity. Additionally, the model does not predict current conditions, but rather those patterns expected under pristine conditions as related through the input data. Thus, IP provides a tool for examining the historical distribution of habitat among and within watersheds, a proxy for population size and structure, and a useful template for examining the consequences of recent anthropogenic activity at landscape scales.”

Total stream length (kilometers) in each tributary to the Russian River watershed meets high, medium, and low thresholds for Intrinsic Potential (IP) for each of the three salmonids species present in the Russian River (Steelhead, Chinook Salmon, and Coho Salmon) (Table 1).

IP Curve Values	IP Rating
1.0-0.7	High
0.69-0.35	Medium
0.34-0.0	Low

Sublayers include:

- Coho Salmon Intrinsic Potential - Central California Coast - NOAA [ds2785]

- Steelhead Salmon Intrinsic Potential - Central California Coast - NOAA [ds2786]

- Chinook Salmon Intrinsic Potential - California Coastal - NOAA [ds2784]

EDW NorWeST Stream Temperature_01

Western United States historical and projected stream temperature data from the NorWest stream temperature model, including streamlines. This layer represents modeled stream temperatures for historical (1993-2011), mid-century (2030-2059), and end-of-century (2070-2099) scenarios, derived from the NorWeST point feature class (NorWest_TemperaturePoints).

Modeled mean August temperatures for the four focus watersheds in the Russian River, is based on data from 1993 to 2011. The United States Forest Service describes the layer:

"The NorWeST webpage hosts stream temperature data and climate scenarios in a variety of user-friendly digital formats for streams and rivers across the western U.S. The temperature database was compiled from hundreds of biologists and hydrologists working for >100 resource agencies and contains >200,000,000 hourly temperature recordings at >20,000 unique stream sites. Those temperature data were used with spatial statistical network models to develop 36 historical and future climate scenarios at 1-kilometer resolution for >1,000,000 kilometers of stream".

Temperature data and model outputs, registered to NHDPlus streamlines, are posted to the website after QA/QC procedures and development of the final temperature model within a river basin (example interactive temperature map). It is hoped that open access to the data and the availability of accurate stream temperature scenarios will foster new research and collaborative relationships that enhance management and conservation of aquatic resources.

Sublayers include:

- Stream Temperatures: 2080s in Degrees C (Regional Extent)

- Stream Temperatures: 2040s in Degrees C (Regional Extent)

- Stream Temperatures: 1993-2011 in Degrees C (Regional Extent)

Agriculture, Lands, & Forest Practices

This data set is compiled to include land use types, locations, and extent of timber harvest areas, agricultural lands, conservation easements parcels, and publicly owned and managed lands (including CDFW owned parcels). This layer was created and modified by CDFW with data sources from CDFW, Forest Practice GIS, CAL FIRE, California Conservation Easement Database (CCED), Sonoma County Vegetation Mapping and LiDAR Program, Sonoma County Water Agency, Sonoma County Agricultural Preservation and Open Space District, University of California, Berkeley, Sonoma County Winegrape Commission, The Sonoma Land Trust, the Laguna Foundation, and the UCCE. Sublayers include:

- Sonoma County Croplands 2013 (Service)- Croplands 5 1

The minimum mapping unit for this dataset is ¼ acre. The croplands were photo-interpreted by image analysts using aerial photos as ground reference – the mapped croplands represent the state of the landscape in 2013. Vineyards are the predominant crop found in this data product, representing over 80% of mapped polygons. The Orchards/Groves class includes fruit, nut, and olive groves. The Perennial Agriculture class includes cultivated perennial shrubs such as lavender, ornamental eucalyptus, Christmas trees, blueberries, and strawberries. The Annual Croplands class includes row crops such as lettuce. Source: Sonoma Veg Map, Sonoma County Water Agency, Sonoma County Agricultural Preservation and Open Space District, University of California, Berkeley, Sonoma County Winegrape Commission, The Sonoma Land Trust, the Laguna Foundation and the UCCE.

- Sonoma County Vegetation and Habitat Map 2017 (Tile Service)

The Sonoma County fine scale vegetation and habitat map is an 82-class vegetation map of Sonoma County with 212,391 polygons. The fine scale vegetation and habitat map represents the state of the landscape in 2013 and adheres to the National Vegetation Classification System (NVC). Source: Sonoma County Vegetation Mapping and LiDAR Program

- Sonoma County Ag + Open Space – Riparian, Reservoir, and Wetlands

This dataset is a derivative of the Sonoma County's countywide fine scale vegetation and habitat map (83 classes). This dataset represents a subset of the water and wetland vegetation classes that appear in the fine-scale map (see the product datasheet for more details). These map classes were mapped using a combination of field work, photointerpretation, and computer-based machine learning. Many of the vernal pools and herbaceous wetlands in the southern part of the county were taken from existing San Francisco Estuary Institute (SFEI) datasets (namely, the NCARI and BAARI datasets). Extensive manual photo interpretation and field data collection/validation was used to refine existing SFEI datasets based on new imagery. Note that this data is in no way a map of jurisdictional wetlands but is a map of wetland map classes from the Sonoma Veg Map Classification, which was developed by the California Department of Fish and Wildlife. Source: Sonoma VEG MAP.

- California Conservation Easement Database (CCED)

The California Conservation Easement Database (CCED) 2021a is a geospatial inventory of all conservation easement lands in California. CCED is a GIS database defining easements and deed-based restrictions on private land. These restrictions limit land uses to those compatible with maintaining it as open space. Lands under easement may be actively farmed, grazed,

forested, or held as nature reserves. Easements are typically held on private lands with no public access. Source: California Conservation Easements Database (CCED)

- CAL FIRE Nonindustrial Timber Management Plans and Notices TA83 - CAL FIRE

Nonindustrial Timber Management Plans TA83

Nonindustrial Timber Management Plans (NTMPs) approved by the California Department of Forestry and Fire Protection for landowners with less than 2,500 acres of land not primarily engaged in the manufacture of forest products. Data and feature representations contribute to assessment of cumulative effects from timber harvesting in planning watersheds and support the planning, regulation, enforcement, and oversight of commercial timber harvesting on nonfederal lands in California. NTMPs are living documents that do not expire but may be withdrawn. Source: Forest Practices GIS, CAL FIRE

- CAL FIRE Timber Harvest Plans - CAL FIRE Timber Harvesting Plans Historical TA83

Historical Timber Harvesting Plans (THPs) approved by the California Department of Forestry and Fire Protection, permitting timber harvest for commercial purposes on non-federal lands. Data and feature representations contribute to assessment of cumulative effects from timber harvesting in planning watersheds and support the planning, regulation, enforcement, and oversight of commercial timber harvesting on non-federal lands in California. Source: Forest Practices GIS, CAL FIRE

- CAL FIRE Forest Practice Roads TA83

Road features mainly derived from plans approved by the California Department of Forestry and Fire Protection. Features include both public and private roads. For information on classifications, see the California Forest Practice Rules. Data do not represent the complete roads network. Existing roads within the harvest area which are not being utilized for timber harvesting are not required to be mapped as part of a plan, and therefore may not be included. Skid trails and tractor roads are not included. Not all roads within a given plan’s harvest area are necessarily in use under that plan and may be associated with a previous plan. Data from 1983 to the present, but primarily from 1997 onward. Source: Forest Practices GIS, CAL FIRE

LiDAR (Sonoma County)

The Sonoma County LiDAR and Vegetation Mapping Consortium along with NASA contracted WSI to collect Light Detection and Ranging (LiDAR) data to be used for vegetation mapping and the creation of high- quality data for use in planning, conservation, and resource management. Data has been collected for all of Sonoma County, Lake Mendocino, and the Lake Sonoma watershed boundary, to the north of Sonoma County. The Sonoma area of interest (AOI) encompasses approximately 1,080,768 AOI acres, divided into four separate delivery areas (see map page 3). Acquisition of LiDAR data and orthophotography began on September 28, 2013, and was completed for the entire project area on November 26, 2013. Deliverables include LiDAR point data, digital orthophotos, intensity, forest metrics, hydro-flattened rasters, one-foot contours, and 2D building planimetric vectors of the study area.

Sublayers include:

- Sonoma 2013 Vegetation Height

LiDAR-derived vegetation height for Sonoma County and parts of Mendocino County were collected in 2013. The canopy height digital elevation model (DEM) represents the difference between the highest-hit (all vegetation and man-made structures included) and bare earth (all vegetation and man-made structures removed) digital elevation models. Source: Sonoma County Vegetation Mapping and LiDAR Program, NASA, University of Maryland, Watershed Science Inc., and Tukman Geospatial LLC.

- Sonoma Veg Map Ortho 2013 (Web Mercator)

LiDAR orthorectified aerial photographs within Sonoma County were collected in 2013. This fine-scale data will help provide an accurate, up-to-date inventory of the county’s landscape features, ecological communities and habitats. The imagery coverage corresponds to the Sonoma County 2013 LiDAR survey data extent and encompasses approximately 1,047,999 acres. Source: Sonoma County Vegetation Mapping and LiDAR Program, NASA, University of Maryland, Watershed Science Inc., and Tukman Geospatial LLC.

- Sonoma Veg Map LiDAR Hydro-flattened Bare Earth HS 2013 (Web Mercator)

This hillshade which was created from a LiDAR derived hydro-flattened bare earth digital elevation model shows the signal returns without any vegetation or human-made structures. In addition, bodies of water over 2 acres have been smoothed. The hillshade is a bare earth digital elevation model (DEM) greyscale image showing topography in the landscape. Source: Sonoma County Vegetation Mapping and LiDAR Program/Consortium, NASA, University of Maryland, Watershed Science Inc., and Tukman Geospatial LLC.

- Sonoma 2013 Bare Earth Hillshade

This hillshade which was created from a LiDAR derived hydro-flattened bare earth digital elevation model shows the signal returns without any vegetation or human-made structures. The hillshade is a bare earth digital elevation model (DEM) greyscale image showing topography in the landscape without smoothing of water bodies. Source: Sonoma County Vegetation Mapping and LiDAR Program/Consortium, NASA, University of Maryland, Watershed Science Inc., and Tukman Geospatial LLC; Data hosted by Sonoma County Information Systems Department (ISD).