State of California
Natural Resources Agency
California Department of Fish and Wildlife

STUDY PLAN
INSTREAM FLOW EVALUATION FOR CLEAR LAKE HITCH PASSAGE IN TRIBUTARIES OF THE CLEAR LAKE WATERSHED, LAKE COUNTY

STUDY PLAN

March 2024

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PREFACE

This study plan outlines the approach and methods that will be used by the California Department of Fish and Wildlife (CDFW) to evaluate instream flow needs for the Clear Lake Hitch (*Lavinia exilicauda chi*) within the Clear Lake watershed in Lake County. The Clear Lake Hitch is listed under the California Endangered Species Act as a threatened species. Executive Order N-5-23 mandates CDFW in collaboration with the State Water Resources Control Board (SWRCB) to evaluate the minimum instream flows to protect the Clear Lake Hitch. CDFW is the Trustee Agency for California's fish and wildlife resources and a Responsible Agency under California Environmental Quality Act §21000 et seq. Fish and wildlife resources are held in trust for the people of the State of California under Fish and Game Code §711.7. As Trustee Agency, CDFW seeks to maintain natural communities and native fish, wildlife, and plant species for their intrinsic ecological values and for their benefits to all citizens in the State.

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Cover photo: Clear Lake Hitch, courtesy of Matthew Young from U.S. Geological Survey.

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ABBREVIATIONS

2D	two-dimensional (physical habitat simulation model)
BVR EPA	Big Valley Band of Pomo Indians Environmental Protection Agency
CCC	California Conservation Corps
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife (previously CDFG)
cHABs	cyanobacterial harmful algal blooms
CLH	Clear Lake Hitch
CNRA	California Natural Resources Agency
cfs	cubic feet per second
DWR	Department of Water Resources
ESA	Endangered Species Act
EPA	Environmental Protection Agency
ft	foot/feet
ft/s	feet per second
HEC-RAS	Hydrologic Engineering Center's River Analysis System
HRM	Habitat Retention Method
HSC	habitat suitability criteria
HUC8	8-digit hydrologic unit code
HUC10	10-digit hydrologic unit code
IFP	Instream Flow Program
Lidar	light detection and ranging
RTK	Real Time Kinematic Global Positioning System
SGMA	Sustainable Groundwater Management Act
SOP	standard operating procedure
SWRCB	State Water Resources Control Board
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
QA	quality assurance
QC	quality control
QAPP	Quality Assurance Program Plan
U.S.	United States
WCR	Watershed Criteria Report
WPM	Wetted Perimeter Method
WSE	water surface elevation
WY	water year

1.0 INTRODUCTION

The Clear Lake Hitch (*Lavinia exilicauda chi*; CLH) is a large minnow endemic to the Clear Lake watershed. The CLH, also known as chi, are a culturally important resource to California Native American Tribes in the Clear Lake region. There are seven federally recognized Tribal Nations in the Clear Lake region: Big Valley Band of Pomo Indians, Elem Indian Colony, Robinson Rancheria of Pomo Indians, Habematolel Pomo of Upper Lake, Scotts Valley Band of Pomo Indians, Middletown Rancheria of Pomo Indians, and Koi Nation. Traditional ecological knowledge (TEK) recounted by Tribal elders indicate historical chi populations were so abundant that they were a primary food staple for several Tribes. Each spring, the chi spawning runs provided a significant cultural event for the Tribes to gather with families to harvest and preserve the fish to consume throughout the year fee. Additional historical accounts indicate the CLH population was in the millions, and that Clear Lake tributaries would be brimming with CLH during their spring migration (Miller 2012; USFWS 2020). Currently, the population has decreased with estimates of CLH being in the hundreds of thousands (Ewing 2021; Miller 2012). This decline has prompted many government agencies to consider the CLH population as imperiled. Since 2004, the Tribes in Lake County have joined efforts to respond to declining numbers of CLH. In 2014, the CLH was listed on the California Endangered Species Act list as a "threatened" species (California Natural Diversity Database (CNDDB) 2023).

Several factors may have contributed to the overall population decline of the CLH. Anthropogenic impacts have led to the degradation of habitat within the Clear Lake watershed since the beginning in the 19th century when Euro-Americans first settled into the area (Suchanek et al. 2003). The Tribes began to witness a decline in CLH populations that coincided with reduced instream flow and drastic changes in land use (BVR EPA 2023). While CLH spawning runs continue to be a significant cultural event for the Tribes, the experience and tradition of CLH harvesting has become almost inaccessible to the current youth of the Tribes (BVR EPA 2023). Degradation of habitat and its impacts on CLH threaten tribal ways of life, subsistence, community growth and wellbeing, cultural survivability, financial resources, and human rights (BVR EPA 2023).

Alterations to the Clear Lake watershed include artificially constructed instream passage obstacles, past mining activities, agricultural and urban development, flood control projects, wildfires and deforestation (CDFW 2014). These impacts have changed the hydrology, altered streamflow, and reduced the amount of water maintained in the tributaries during the CLH's spawning, juvenile rearing, and outmigration period (USFWS 2020). Passage obstacles within the watershed include stream culverts, flood conveyance structures, stream bed alterations, sedimentation, and overgrowth of vegetation that hinder access and migration of CLH. Collectively, the current conditions of rapidly drying and diminished streamflow, in addition to the passage obstacles listed above, have resulted in considerably reduced historical instream spawning habitat accessible to CLH (CDFW 2014). Future viability of CLH is dependent upon several environmental factors, the primary being those affecting habitat quality and the essential access to spawning habitat en route from the lake (USFWS 2020). Predation from invasive species such as bass, carp and goldfish also hinder CLH survival. Water quality is another key environmental stressor in the Clear Lake watershed. Poor water quality conditions in the lake and some tributaries are attributed to intensified sediment loading, nutrient enrichment, cyanobacterial harmful algal blooms (cHABs), and mercury and sulphur contamination (Suchanek et al. 2003).

On August 17, 2022, the Tribes in the Clear Lake region presented to the Fish and Game Commission requesting a call of action to protect the CLH (FGC 2022). The Fish and Game Commission quickly consulted with CDFW, to which a Task Force was formed to identify and implement short and long-term actions for the benefit of the CLH. The Task Force is facilitated by CDFW and serves as a forum where California Native American Tribes, local, state, and federal agencies can collaborate on conservation efforts. More information about the Task Force is included in section 2.3 of this document. In December 2022, the Tribes in Lake County hosted a CLH Government Summit to further heighten awareness of the declining CLH population. Following the CLH Government Summit, on March 24, 2023, Governor Newsom signed Executive Order N-5-23 that mandates the SWRCB and CDFW evaluate the minimum instream flows and other actions needed to protect CLH (State of California Executive Department). This study plan describes CDFW's efforts to identify instream flow regimes necessary to protect CLH and the habitats upon which they depend.

2.0 PROJECT DESCRIPTION

2.1 Study Goals and Objectives

The goal of this study is to characterize relationships between streamflow and habitat/fish passage in tributaries of the Clear Lake watershed. These relationships can then be utilized to protect instream flows to support critical habitat for CLH and other native species. This information may be used to protect flows in tributaries of the Clear Lake watershed in several ways, including the development of flow criteria and identification of important flow thresholds for conservation, restoration, and protection for native species. The results of this study may inform water management decisions such as emergency regulations, water rights condition development and protest resolution, and local Sustainable Groundwater Management Act (SGMA) implementation.

The objectives for this project include:

- Identify the relationships between streamflow and habitat using a combination of habitat and hydraulic modeling, and empirical approaches.
- Identify flows needed to maintain fish passage in tributary streams of Clear Lake for CLH.
- Identify habitat maintenance flows for tributary streams of Clear Lake.
- Coordinate and collaborate with California Native American Tribes, local, state, and federal agencies.

2.2 CDFW Roles and Responsibilities

CDFW is involved in various efforts to protect and conserve the CLH; however, this study plan will focus on the roles for this technical instream flow evaluation. Table 1 outlines the roles and responsibilities of each CDFW subgroup. The Water Branch Instream Flow Program's (IFP) primary role is evaluating creeks and tributary streams statewide, including the Clear Lake watershed. The IFP will lead the technical study coordination along with field data collection, engineering, quality assurance and quality control, data management, and development of a technical report. Given the diverse interests within Lake County, partner coordination and outreach will be facilitated through the North Central Region and Fisheries Branch. Study design and project consultation will be reviewed by the North Central Region, Fisheries Branch, and Conservation Engineering Branch.

Table 1. Roles and responsibilities in CDFW's Instream Flow study.

CDFW Organization Structure	Role
Water Branch	Technical Study Coordination Study Design Planning Field Data Collection Engineering Quality Assurance and Quality Control Data Management and Analysis Data Reporting
North Central Region	Policy Coordination Inter- and Intra-Agency Coordination Project Context and Objectives Study Design Review Landowner Access Field Data Collection Project Review
Fisheries Branch	Partner Outreach and Coordination Local Watershed Project Coordination Study Design Review Field Data Collection Assistance Project Review
Conservation Engineering Branch	Study Design Review Project Consultation Project Review

2.3 Coordination and Collaboration

CDFW is currently coordinating and collaborating with California Native American Tribes, local, state, and federal agencies in the Clear Lake watershed. CDFW facilitates a monthly Task Force meeting for government agencies to provide updates and promote opportunities for collaboration. This is being accomplished through data and resource sharing, project coordination, as well as providing a forum for open communication. Table 2 lists all participants in the government Task Force meetings to date. To the extent possible, nonprofits, stakeholders, or other entities who may have an interest in the results and interpretation of the study may be involved in study scoping and implementation.

Table 2. Government partners in the Task Force.

California Native American Tribes	Lake County	State	Federal
Big Valley Band of Pomo Indians	Water Resources Department	California Department of Fish and Wildlife	U.S. Geological Survey
Robinson Rancheria Tribe of Pomo Indians	Watershed Protection District	California Fish and Game Commission	U.S. Fish and Wildlife Service
Habematolel Pomo of Upper Lake	Public Works Department	California State Water Resources Control Board	U.S. Army Corps of Engineers
Scotts Valley Band of Pomo Indians	Office of Climate Resiliency	California Central Valley Regional Water Quality Control Board	U.S. Forest Service
Middletown Rancheria	--	California Natural Resources Agency	Bureau of Land Management
Koi Nation	--	California Department of Water Resources	--
--	--	California State Parks	--
--	--	California Conservation Corps	--

2.4 General Approach

Relationships between streamflow and habitat within tributaries of the Clear Lake watershed will be developed using a combination of scientifically defensible methods, which may include hydraulic habitat modeling and empirical approaches described by the Instream Flow Council in *Instream Flows for Riverine Research Stewardship* (Annear et al. 2004). The resulting relationships will serve as a basis to help identify important flow thresholds for the conservation, restoration, and protection of CLH and other aquatic resources within the tributaries of the Clear Lake watershed.

3.0 WATERSHED DESCRIPTION

3.1 Site Location

Clear Lake is the largest natural freshwater lake located wholly in California, covering 68 square miles of surface area. The Clear Lake watershed is located approximately 100 miles north of San Francisco within Lake County. Sitting in the Coastal Range at an elevation of 1,319 ft, the area has a Mediterranean climate, with hot, dry summers and relatively cool, mild, wet winters. The wet season is not continuously wet and may be broken up by periods of warm clear weather. The Clear Lake watershed receives limited snowpack in most years and relies on precipitation from November through May. The lake and tributaries are part of the Upper Cache subbasin United States Geological Survey (USGS) 8-digit hydrologic unit code (HUC8). There are three primary HUC10 watersheds that drain to the lake: Kelsey Creek-Clear Lake, Scotts Creek, and Middle Creek. Combined, these HUC10 watersheds cover an area of 488 square miles and have numerous tributaries that flow throughout. The headwaters of many of these streams begin in the mountainous regions of the watershed, flowing through various alluvial terraces and valleys before entering the lake. Nestled in a valley within the Northern Coast Ranges and with historically easy access to water, Clear Lake and the surrounding areas have been a prime location for agriculture.

Clear Lake's watershed is bounded by mountainous regions with small hills and flat valleys spread throughout and along the lake's shores. The elevations around the southeast to the southwest of Clear Lake range from 2,500 to 4,000 feet in the Mayacamas Mountains, while valleys near the lake range between 1,330 feet at the shoreline to 1,650 feet in the upland areas (Christensen Associates 2002). There are several small towns in flat areas around the lake including Upper Lake and Nice to the north, Lucerne and Clearlake to the east, Lakeport to the west, and Kelseyville in the south. The dominant land use that occurs in larger valleys is agriculture, consisting primarily of pear orchards, vineyards, pastures, and cannabis cultivation. As a result, agricultural water use is significantly higher than municipal and industrial use with nearly 82% of the Clear Lake watershed's 55,000 acre-feet total water use going to agriculture (Lake County 2010).

There are more than 15 tributaries surrounding Clear Lake that CLH may utilize. After discussions with the Task Force, six major tributaries have been identified for an in-depth instream flow study to be completed by CDFW's IFP. Figure 1 identifies the tributaries of interest on Middle, Scotts, Manning, Adobe, Kelsey, and Cole Creeks within each of their appropriate HUC10 boundaries. These tributaries provide the majority of surface water flowing into Clear Lake with Scotts, Middle and Kelsey Creeks accounting for about 73% of the inflow (Lake County 2010). The Task Force has provided sufficient evidence identifying CLH presence in each of these streams.

To account for the entire Clear Lake watershed, IFP will also complete a Watershed Criteria Report (WCR) to analyze multiple tributaries. WCRs provide instream flow information on a watershed scale for streams throughout the state using the best available hydrologic datasets (CDFW 2021). WCRs utilize existing hydrologic datasets and tools such as modeled natural functional flow metrics (CEFWG 2021b) to develop flow information and flow criteria for any number of reaches within a given watershed. The reports may also provide field-based flow information for a subset of stream reaches. While WCRs are standalone documents, flow criteria developed in these reports may be used to supplement information developed in a site-specific instream flow study.

Figure 1. Tributary streams of interest (Middle, Scotts, Manning, Adobe, Kelsey, and Cole Creeks within HUC10 boundaries). Cache Creek is identified as the main point of outflow for Clear Lake but is not a stream of interest in this study.

3.2 Biology

3.2.1 Target Species and Life Stages

The CLH is only found in Clear Lake and its surrounding tributaries. While this sub-species of hitch is genetically similar to the two other sub-species of hitch, *Lavinia exilicauda harengus* and *Lavinia exilicauda exilicauda*, CLH appear to have adapted to their lacustrine environment and the low-gradient tributaries that they use for spawning (Baumsteiger et al. 2018; USFWS 2022). Morphologically, CLH exhibit deeper bodies, larger eyes, larger scales, and more numerous fine gill rakers than the other two sub-species of hitch (CDFW 2014). Additionally, CLH have reproductive traits that help them overcome their short spawning window due to the ephemeral nature of many Clear Lake tributaries. Compared to other hitch, CLH growth is quicker, and they mature sooner leading to greater fecundity (Baumsteiger et al. 2018; USFWS 2022).

CLH can live up to six years with males maturing by their second year and females maturing within their second or third year (CDFW 2014; Miller 2012). During their spawning season, female CLH lay an average of 36,000 eggs (CDFW 2014). CLH broadcast their eggs in fine-to-medium sized gravel found in shallow riffles where water temperature is 14-18 °C (CDFW 2014; USFWS 2022). Potamodromous fish, such as CLH, complete their life cycle entirely within freshwater. Adult migration, spawning, embryo incubation, larval development, and adult/juvenile emigration all occur during a short temporal window during the spring season when dry stream beds become temporarily inundated from seasonal rains (Feyrer et al. 2019). Although spawning has been observed along the lake's shoreline, it is not ideal due to the susceptibility of egg predation by Common Carp (*Cyprinus carpio*) (Kimsey 1960). Migration of CLH usually begins in March and ends in May; however, depending on the water year (WY), adult migration may begin as early as February and juvenile rearing and outmigration can continue into summer (Luis Santana personal comm. 2023; Moyle P. 2002).

CLH spawning has diminished substantially compared to their historical distribution. It is believed that CLH once spawned throughout the Clear Lake watershed, including all major tributaries, smaller unnamed creeks, Thurston Lake, and the Blue Lakes (Miller 2012; USFWS 2022). Currently, CLH are known to spawn in a subset of tributaries, including Kelsey, Scott, Middle, Adobe, Seigler Canyon, Manning, Cole, Morrison, and Schindler Creeks. However, recent visual surveys have regularly found portions of these tributaries dry during spawning and rearing months (Ewing 2022; USFWS 2022).

3.2.2 Habitat Suitability Criteria

An accurate representation of available habitat in relation to stream discharge requires linking stream channel hydraulics, over a range of flows, with known habitat suitability criteria (HSC) for the target species and life stages (CDFG 2008). The target species and life stages for this study are CLH juveniles and adults. We will use 0.5 ft depth criteria and <5 feet per second (ft/s) velocity criteria for fish passage as utilized by BVR EPA (2020) in previous hydraulic modeling of Adobe Creek. Hydraulic habitat modeling will produce two-dimensional area estimates of depth and velocity within each study site over a range of flows.

3.2.3 Invasive Species

The introduction of invasive fish species has become a threat to CLH survival. There are approximately 20 introduced fish species estimated in Clear Lake and its tributaries. Inland Silversides and Threadfin Shad were introduced to control Clear Lake Gnats but now compete with CLH for macroinvertebrates, a shared food source (Dill and Cordone 1997). All CLH life stages are impacted by competition and predation from invasive fish species, including carp, silversides, shad, bass, bluegill, crappie, and catfish (USFWS 2022). CDFW's regional biologists have observed hitch escaping from predators when high flow conditions allow them to seek refuge in the tributaries.

3.3 Hydrology

Hydrology is the study of water in the environment, encompassing its distribution, movement, and properties. A core concept in hydrology is the water cycle, the continuous movement of water between the surface, atmosphere, and underground (i.e., groundwater). Understanding the timing of flows is essential for assessing water availability and developing sustainable management strategies. Additionally, hydrologic studies help us comprehend the ecological dynamics of stream systems, including their physical habitat, water chemistry, and biological communities, along with surface and groundwater interactions.

The Clear Lake watershed features dry, arid summers punctuated by storm events in the winter and spring months. Rain is the dominant source of water to the region, with minor amounts of snow at the highest elevations (Lake County 2022). Clear Lake is generally divided into three main areas known as the Upper Arm, Lower Arm, and Oaks Arm. The mean depth of each arm is 23, 34, and 36 feet, respectively. Average yearly precipitation values vary from about 27 inches at lake level to about 57 inches at higher elevations, with a watershed average precipitation of approximately 30 inches (Lake County 2010). Outflows from

Clear Lake are constrained by a riffle formation along lower Cache Creek, just upstream of Cache Creek dam, named the Grigsby Riffle (Figure 1). Composed of accumulated rock gravel, the Grigsby Riffle is located at the confluence of Cache and Seigler Creeks and acts as a natural constriction to streamflow (Palma-Dow 2023). Due to constrained outflows at the Grigsby Riffle, the lake's water level can fluctuate depending on the rate at which Cache Creek outflows through the Grigsby Riffle and the rate at which the lake receives inflows (i.e., precipitation, groundwater, runoff, and tributary streamflow) (Jager 1996).

Most flow in the tributaries to Clear Lake occurs during winter months, and by mid-summer flow in intermittent tributaries to Clear Lake ceases. CLH are found in Clear Lake most of the year; however, they can typically occupy Clear Lake tributaries from February to as late as summer while water is present(Luis Santana personal comm. 2023; Moyle P. 2002; USFWS 2020). The major tributaries feeding Clear Lake are Scotts and Middle Creeks entering from Rodman Slough to the northwest, and Kelsey Creek to the south (Lake County 2010). West of Kelsey Creek, Adobe Creek is a major stream in the Clear Lake watershed that still provides spawning habitat for CLH (Miller 2012). These streams can prematurely dry early due to drought conditions, water pumping, and diversion systems. When this occurs, the CLH are at risk of stranding due to changes in connectivity (CDFW 2014; Miller 2012; USFWS 2022).

Several hydrology monitoring stations have operated across select tributaries surrounding Clear Lake (Table 3), though meaningful hydrologic analysis is constrained by short periods of record, data gaps, and seasonal data collection. To address this, the SWRCB plans on expanding the stream gaging network during water year 2024. Currently, upstream of DWR gage A85005 on Kelsey Creek, USGS gage 11449500 south of Kelseyville has the longest period of record within the watershed, with 77 years of data beginning in WY 1947. This gage was deemed hydrologically least disturbed and utilized as part of a network of reference gages to develop modeled natural flows, or unimpaired flows, for streams throughout California (Zimmerman et al. 2017).

Table 3. Hydrology monitoring stations within the Clear Lake watershed. Asterisk (*) indicates code for real-time data found on DWR's California Data Exchange Center.

Agency	Station Identifier	Description	Status	Monitoring Data Type
BVR EPA	--	Adobe Creek at Soda Bay Rd Gage	Active	Pressure Transducer
BVR EPA	--	Adobe Creek at Argonaut Road	Active	Pressure Transducer
BVR EPA	--	Adobe Creek at Bell Hill Rd	Active	Pressure Transducer
BVR EPA	--	Adobe Creek at Adobe Reservoir	Active	Pressure Transducer
BVR EPA	--	Adobe Creek at Highland Springs Reservoir	Active	Pressure Transducer
DWR	ACF	Adobe Creek Near Finley At Soda Bay Rd	Active	Stage Discharge
DWR	A85005 KCK*	Kelsey Creek Near Kelseyville	Active	Stage Discharge
DWR	A85701 KCH*	Kelsey Creek near Hobergs	Active	Stage Discharge
DWR	A81845 SCS*	Scotts Creek near Lakeport	Active	Stage Discharge
DWR	A81810 MCU*	Middle Creek Near Upper Lake	Active	Stage Discharge
DWR	A85610	High Valley Creek Ab Kelsey Creek	Inactive	Stage Discharge
DWR	A85710	Alder Creek At Glenbrook	Inactive	Stage Discharge
DWR	A81940	Clover Creek Bypass near Upper Lake	Inactive	Stage Discharge
DWR	PMC*	Pumping Plant At Middle Creek	Active	Stage
USGS	11448900	Highland C Ab Highland C Dam CA	Inactive	Discharge
USGS	11448500	Adobe C Nr Kelseyville CA	Inactive	Discharge
USGS/Lake County	11449500	Kelsey C Nr Kelseyville CA	Active	Discharge

Agency	Station Identifier	Description	Status	Monitoring Data Type
USGS	11449000	Highland C Nr Kelseyville CA	Inactive	Discharge
USGS	11449010	Highland C Bl Highland Creek Dam CA	Inactive	Discharge
USGS	11449206	Middle C At Upper Lake CA	Inactive	Discharge
USGS	11449100	Scotts C Nr Lakeport CA	Inactive	Discharge
USGS	11448750	SF Scotts C Nr Lakeport CA	Active	Discharge
USGS	11448800	Scotts C Bl SF Scotts C Nr Lakeport CA	Active	Discharge
USGS	11449820	Cole C At Kelseyville CA	Active	Discharge
USGS	11451000	Cache C Nr Lower Lake	Active	Discharge
USGS	11449235	Clover C Bypass At Elk Mtn Rd Nr Upper Lake CA	Active	Discharge
USGS	11449255	Scotts C Ab State Rt 29 At Upper Lake CA	Active	Discharge
USGS	11449350	Burns Valley C Near Clearlake Highlands	Inactive	Discharge
USGS	11449370	Molesworth C Nr Clearlake CA	Active	Discharge
USGS	11449460	Seigler C At Lower Lake CA	Inactive	Discharge
USGS	11449450	Copsey C Nr Lower Lake CA	Inactive	Discharge
USGS	11450000	Clear Lake At Lakeport	Active	Gage height

BVR EPA: https://www.bvrancheria.com/epa
DWR's California Data Exchange Center Search: https://cdec.water.ca.gov/webgis/?appid=cdecstation
DWR's Water Data Library Station Search: https://wdl.water.ca.gov/waterdatalibrary/Map.aspx
USGS Water Data Site Information Search: https://waterdata.usgs.gov/usa/nwis/si

Streamflow regimes show distinct patterns according to climate, setting, and seasonal hydrology (Lane et al. 2018). These distinct patterns reflect hydrological inputs that influence inter- and intra-annual streamflow patterns that may even be designated into distinct flow regime categories (Lane et al. 2018; Zimmerman et al. 2017). Kelsey Creek at USGS gage 11449500 (COMID: 948020963) is classified as a “perennial groundwater and rain” flow regime (Lane et al. 2018). Streams of this archetype typically maintain flow throughout the year, deriving water from a combination of consistent groundwater discharge and regular rainfall. Kelsey Creek transitions into a “rain and seasonal groundwater” flow regime as it nears Clear Lake, where groundwater and surface water exchange at the stream interface varies seasonally and annually (Lake County 2022).

Flows in Kelsey Creek are variable within and between years. Daily streamflow at USGS gage 11449500 on Kelsey Creek is presented below in Figure 2 for three WY types (i.e., dry, moderate, and wet) to demonstrate the current range of flows that occur in the watershed. Note that the y-axis, or discharge, is scaled to log base 10 in Figure 2. Using the gaged period of record, WY types were determined by partitioning the range of observed annual flow into terciles, reflecting dry (lower 33% of values), moderate (34%-65% of values), and wet (upper 33% of values) conditions (CEFWG 2021a). Between WYs 1947 to 2022, the number of days stream flow fell below 0.5 cubic feet per second (cfs) averaged 16 days for dry years, 3.5 days for moderate years, and zero days for wet years.

Coinciding with the 2012-2015 drought period, a state of emergency was declared in 2014 due to rapid population decline of CLH (CDFW 2013a; Lake County 2022; Miller 2012). WY 2014 received approximately 18 inches of precipitation, whereas WYs 2016 and 2017 received 37 and 60 inches of precipitation (Lake County 2022). Daily streamflow recorded at USGS gage 11449500 during these years indicates variable spring recession flows during the CLH migration season (Figure 2)(CDFW 2014). Following winter-spring storm events, streamflow gradually decreased to below 10 cfs earlier in the spring-summer season according to the WY type. Streamflow at USGS gage 11449500 dropped below 10 cfs mid-April in the dry WY of 2014, June in the moderate WY of 2016, and July in the wet WY of 2017 (Figure 2). By August towards the end of each WY, precipitation was minimal, and streamflow was generally at its lowest. Mean August streamflow on Kelsey Creek at USGS gage 11449500 measured approximately 0.12 cfs in WY 2014 (dry), 1.40 cfs in WY 2016 (moderate), and 5.63 cfs in WY 2017 (wet), respectively (Figure 2). WY 2014 recorded 83 days of stream flow less than 0.5 cfs.

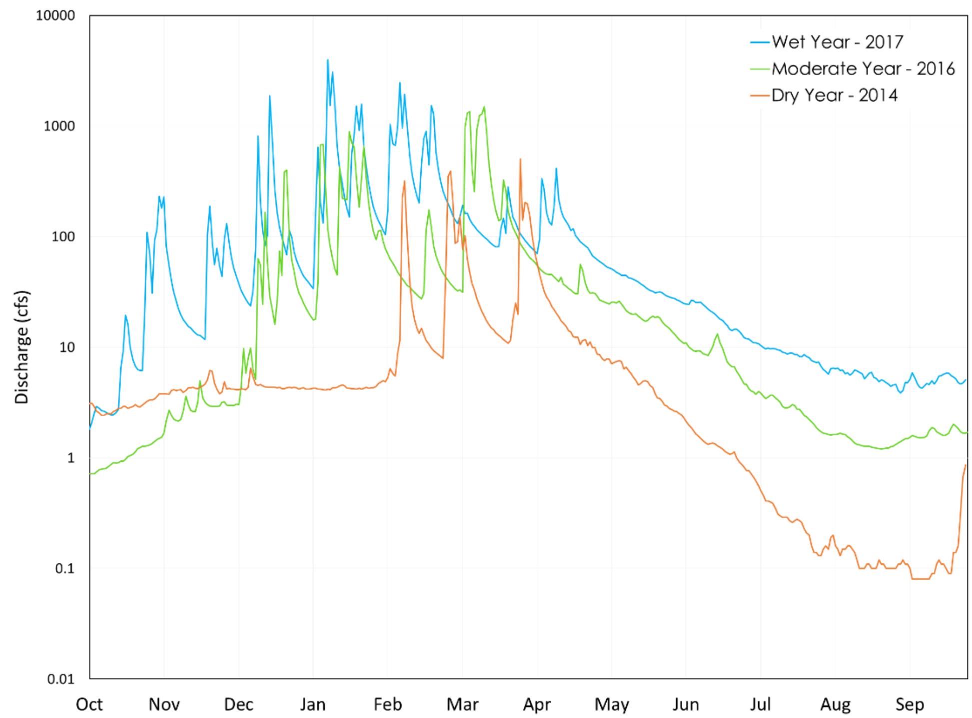

Figure 2. Variation in mean daily streamflow at USGS gage 11449500 Kelsey Creek near Kelseyville in WY 2014 (dry), WY 2016 (moderate), and WY 2017 (wet).

3.4 Groundwater

Groundwater is water that resides below the surface in the pore spaces of rock formations and unconsolidated earthen deposits, such as gravels, sands, silts, and loess. Groundwater originates from precipitation that infiltrates and percolates down through the ground, filling underground aquifers. The direction in which groundwater flows is primarily determined by gravity and topography, and influenced by local groundwater withdrawal and recharge (Pokhrel et al. 2015). Groundwater often moves slowly through these porous materials, where its availability and quality are influenced by geological, hydrological, and environmental factors. Groundwater is an often-hidden resource, serving as a crucial water supply during times of drought while also supporting the health of biological ecosystems (Saito et al. 2021). Clear Lake borders six groundwater basins identified by the DWR's Bulletin 118, though the groundwater basins' areal extents vary with respect to tributaries of the lake (DWR 2016). Of the groundwater basins identified surrounding Clear Lake, Big Valley groundwater basin (Basin Number 5-015) is the only basin designated as a medium-priority basin by DWR and therefore subject to provisions of SGMA. The priority assigned to Big Valley groundwater basin was based on components such as groundwater reliance, irrigated acreage, and total number of groundwater wells within the basin area (DWR 2020).

The geologic heterogeneity surrounding Clear Lake results from numerous northwest-trending faults associated with the San Andreas fault system, as well as volcanic activity, subsidence, and depositional processes (Hearn et al. 1988; McLaughlin and Donnely-Nolan 1981). Groundwater in this region is typically found in unconsolidated alluvial deposits, fractured sedimentary and metamorphic rocks of the Franciscan Assemblage, and in the Clear Lake volcanic deposits (Richerson et al. 1994). In addition to the aquifers identified in Bulletin 118, commercial geothermal water is produced from reservoirs of fractured and faulted bedrock of the Franciscan Formation at The Geysers, the world's largest geothermal field, located southwest of Clear Lake (Chapman 1975).

The interactions that result from the juxtaposition and interfingering of these geologic units can affect surface water and groundwater flow. For example, evidence suggests Clear Lake gains approximately 1,100 acre-feet/year of water from adjacent groundwater basins and from many groundwater springs located below the lake (Richerson et al. 1994). Just as groundwater springs can originate from faulting, faulting can also create barriers to groundwater flow. Several major faults are present in the Upper Cache Creek watershed, including the Collayomi fault, Big Valley fault, Scotts Valley fault, Kelsey Creek fault, Wight Way fault, Clear Lake fault, and the Potter Valley fault (Lake County 2003). The Wight Way fault, extending from the western side of the Mayacamas Mountains to within a few miles southwest of Kelseyville, is known as a partial barrier to groundwater flow within the Big Valley groundwater basin (Lake County 2022).

DWR Bulletin 118 identifies groundwater basins throughout the state and areas groundwater basins receive recharge from the land surface. Recharge occurs when water infiltrates and percolates into the ground to replenish underground aquifers. North of Clear Lake, recharge to the Upper Lake groundwater basin occurs on upstream reaches of Middle Creek, Clover Creek, and Alley Creek. West of Clear Lake in Scotts Valley, percolation from Scotts Creek is the principal source of recharge to the aquifer, with minor amounts of recharge from precipitation and applied irrigation water. South of Clear Lake, recharge to the Big Valley groundwater basin occurs primarily along reaches of Kelsey, Highland, and Adobe Creeks. Recharge to these groundwater basins can support adequate baseflow to most streams later into the dry season when precipitation is typically low or lacking (Yarnell et al. 2022). Currently, Highland

Springs and Adobe Creek Reservoirs provide flood control and groundwater recharge to the Big Valley basin.

Overdraft of groundwater has long been recognized as a problem in California, especially during drought periods when there is insufficient natural recharge during the winter to replenish aquifers in the groundwater basins (Lake County 2003). Based on the historical groundwater budget of the Big Valley basin, groundwater recharge through stream leakage accounts for 17% of total recharge to the basin (Lake County 2022). Groundwater recharge through stream leakage is shown to be highest during dry years when communities are more dependent on groundwater. Conversely, streams showed net gaining conditions after a prolonged wet period from 1993-1998, suggesting groundwater-surface water flow in the Big Valley basin is influenced by regional groundwater pumping and climate effects (Lake County 2022).

3.5 Connectivity

Connectivity is the unimpeded movement of organisms and flow of natural processes between habitats. In riverine habitats, low streamflow can limit hydrologic connectivity, thus impacting water quality, food production, and critical fish life history strategies. Low streamflow in tributaries of the Clear Lake watershed is due to various factors such as climate, water diversions, antecedent precipitation, and groundwater-surface water interactions, leading to tributaries of Clear Lake to become disconnected during the dry season.

Often, the importance of connectivity for fish is thought of as fish passage. Barriers to fish passage can include physical obstructions (i.e., culverts, dams, or levees) or stream conditions (i.e., sediment loads, water temperature, flow velocity and depth, or water quality). These types of barriers within a stream impact access to food sources, refuge, or spawning grounds, and are exacerbated by low flow conditions. While CLH are strong swimmers, low flows can lead to the appearance of migration barriers. CLH have adapted to migrate into the tributaries of Clear Lake to spawn typically beginning in February and ending in late May. During migration it is imperative that tributaries have enough flow for hitch to migrate upstream and return downstream to Clear Lake.

There are several known types of potential barriers that occur in tributaries of Clear Lake. These potential barriers include debris build up, dams, culverts, fish ladders, outdated flood and stormwater infrastructure, and low flows (Miller 2012; USFWS 2022). CDFW has estimated that these types of barriers have blocked over 92% of historical stream miles used as spawning habitat (CDFW

2014; USFWS 2022). CDFW is in coordination with the Task Force on the various efforts to identify and remove fish passage barriers. CDFW's North Central Region and Conservation Engineering are involved with existing fish barrier efforts identified in the SWRCB's online map layer (SWRCB 2023). For the scope of this study, CDFW will identify flows for fish passage and habitat maintenance in natural channels. However, the hydraulic models developed as part of this study will be of use in evaluating barriers.

3.6 Geomorphology

Water flow and geomorphology have a profound impact on the physical characteristics and ecological health of water bodies. Geomorphology refers to the study of landforms and the processes that shape them. Within the stream channel, water flow creates and maintains stream-forming processes. When natural flow patterns are altered, fluvial processes, condition of the valley, the stream, and all other ecological components change as a consequence (Hill and Platts 1991; Lotspeich 1980).

The Upper Cache Creek watershed is located within the Northern Coast Range geomorphic province north of the Mayacamas Mountains. The Northern Coast Range was formed as a result of complex tectonic interactions between the North American and Pacific plates, where Clear Lake is considered to be located in a volcano-tectonic depression (McLaughlin and Donnely-Nolan 1981). Streams in the Upper Cache Creek watershed have eroded the Northern Coast Range Mountains over time, transporting and depositing sediment into the mountain valleys and alluvial basins surrounding the lake.

In general, over 70% of soils around Clear Lake are shallow, with the shallowest soils found on steep slopes in the upper part of the watershed. Due to the soils' limited depth, it takes relatively little precipitation for these soils to become saturated and produce runoff (Lake County 2010). Hydrologic soil group classifications (NRCS 2007), which are based on soil properties such as permeability and soil thickness, can be a useful tool in understanding a watershed's response to precipitation. Soils surrounding Clear Lake and into the upper watershed have moderate-high runoff potential, whereas soils along several stream reaches have low-moderate runoff potential. In other words, soils in the vicinity of stream reaches that are composed of gravelly sandy loam material result in a higher infiltration rate than compared to loamy clay soils that result in low infiltration rates. Areas with soils of low-moderate runoff potential (i.e., high infiltration) occur along reaches of Adobe, Scotts, and Kelsey Creeks.

Landscape alteration and disturbance can also affect runoff, erosional processes, and sediment transport. Historical landscape changes in the Upper Cache Creek watershed include intentional burns, wildfires, logging and deforestation, stream gravel mining, stream dredging, road development, as well as shifting land use practices (e.g., grazing and vineyard development), which have all contributed to higher rates of runoff and sedimentation (Giusti 2009; Suchanek et al. 2003). In response to the Mendocino Complex Fire in 2018, the USGS is currently conducting a study on Scotts Creek near South Cow Mountain Recreation Area. This study will quantify soil erosion rates and nutrient sources within the Scotts Creek drainage area. Results from this study are expected to inform nutrient loading and watershed modeling to better understand the additional nutrients being introduced into Clear Lake (California Water Science Center 2021).

3.7 Water Quality

Clear Lake is naturally eutrophic, high in nutrients, and relatively shallow. The water quality has moderate water hardness and electrical conductivity due to inputs from the tributaries and a high evaporation rate from the lake. Generally, Clear Lake is considered well-mixed with stable water temperature stratification except during summer when wind patterns are calm.

Pursuant to section 303(d) of the Clean Water Act, the SWRCB is responsible for assessing, protecting, and restoring surface water quality and submitting a list of impaired water bodies to the U.S. Environmental Protection Agency (EPA). Located adjacent to an EPA Superfund site at the former Sulphur Bank Mercury Mine, Clear Lake is a naturally productive (eutrophic) lake that has been severely impacted by human activities over the past century (Bradbury 1988; Mioni et al. 2011). The SWRCB has listed Clear Lake as a 303(d) impaired water body for excess nutrients and has also adopted water quality objectives for methylmercury in fish tissue, as mercury from the adjacent mine bioaccumulates in aquatic systems to levels that are harmful to fish and their predators. Additionally, lower Cache Creek, located downstream of Clear Lake, is also listed as impaired on the 303(d) list for mercury, boron, and toxicity.

Since the development of the Cache Creek Dam in 1914 and further development of land in the watershed, water quality in Clear Lake and its surrounding tributaries have experienced intensified sediment loading, nutrient enrichment, and pollutant (mercury and sulphur) contamination (Suchanek et al. 2003). Warmer surface water temperatures and excess loading of nutrients such as nitrogen and phosphorous in streams surrounding the watershed has resulted in recurrent eutrophication and cHABs in the lake (Mioni et al. 2011; Suchanek et al. 2003). Eutrophication promotes the rapid growth of algae and other aquatic plants, which can disrupt the natural food chain in aquatic ecosystems. In particular, the rapid growth and decomposition of cHABS create noxious toxins that are detrimental to fish and wildlife health (Mioni et al. 2011). Additionally, the decomposition of cHABs depletes dissolved oxygen, which stress aquatic species and reduce growth rates in populations.

In a study of environmental controls on CLH distribution in the summer, Feyrer et al. (2019) conducted sampling throughout Clear Lake and found CLH to be most abundant in normoxic (>2 mg/L DO) and nearshore habitats. The prevalence of hypoxic conditions (<2 mg/L DO) in Clear Lake varied greatly between the two summer sampling events that occurred in 2017 and 2018. Despite receiving higher streamflow in 2017, DO concentrations in Clear Lake were more hypoxic throughout the lake in 2017 than in 2018 (Feyrer et al. 2019). The 2017 hypoxic conditions modeled by Feyrer et al. (2019) are consistent with the last largest fish kill recorded at Clear Lake in summer 2017 (Larson 2023). Following several years of drought, the 2017 hypoxic event is thought to be associated with nutrients and other material that washed into Clear Lake by high streamflow that occurred during the winter/spring of WY 2017 (Feyrer et al. 2019).

4.0 METHODS

4.1 Reach Delineation and Mesohabitat Mapping

Mesohabitat delineation supports hydraulic modeling by identifying mesohabitat unit types (e.g., pools, riffles, and runs). CDFW will complete or collaborate with Task Force participants on mesohabitat delineation in select reaches within the six target Clear Lake tributaries. Mesohabitat units will be classified following the Level III-IV (i.e., modified Level III) habitat type survey classifications, as described in the *California Salmonid Stream Restoration Manual* (Flosi et al. 2010). Although mesohabitat delineation will follow methods from the *California Salmonid Stream Restoration Manual*, the characterization of mesohabitat units will be adapted to describe habitat conditions specific to Clear Lake tributaries. A corresponding discharge measurement (CDFW 2013b) will also be measured each day of the survey. Upon completion of the survey, the modified Level III mesohabitat classifications will be grouped into riffle, pool, run, or glide categories. The classification of different habitat types is based on characteristics such as channel morphology, gradient, substrate composition, and hydraulic characteristics.

4.2 Two-Dimensional Hydraulic Habitat Modeling

Hydraulic habitat modeling will be used to predict hydraulic parameters to evaluate instream conditions for CLH life stages. Two-dimensional (2D) hydraulic habitat models are used to estimate the changes in water depth and velocity in complex stream habitats over a range of flow. CDFW's IFP have used 2D modeling to evaluate stream flow conditions for fish passage in various streams and rivers. Holmes et al. (2016) compared fish passage flows derived from River2D modeling with flows derived from the empirical critical riffle analysis (CRA) method (Thompson 1972). A high coefficient of correlation (r^2=0.93) was found for flows predicted using 2D modeling with flows derived from the CRA method. The IFP used 2D modeling to determine passage criteria for spring-run Chinook Salmon through a bedrock outcropping with an irregular and discontinuous flow network in Butte Creek, Butte County (Cowan et al. 2016). Most recently, the IFP used high resolution light detection and ranging (lidar) flights to estimate flows needed for fish passage through a braided portion of the Ventura River, Ventura County (Cowan et al. 2021). CDFW's IFP also used 2D modeling to develop flow-habitat relationships on Mark West Creek (Carlin et al. 2022).

Two-dimensional hydraulic modeling will be used to simulate flow conditions for CLH in lake tributaries over a range targeted of flows. Passage conditions will be evaluated using velocity, depth, and width criteria for CLH. The 2D module of the U.S. Army Corps of Engineers Hydrologic Engineering Center's River Analysis System (HEC-RAS) computer software program (USACE 2018) will be used to estimate velocity and depth in areas that are depth sensitive to CLH passage.

4.3 Hydraulic Habitat Transect Based Methods

CDFW uses two hydraulic habitat transect based methods, the Habitat Retention Method (Nehring 1979) and Wetted Perimeter Method (Annear et al. 2004; CDFW 2020), to evaluate threshold flows for aquatic resources. Hydraulic habitat transect methods require site-specific data to be collected along one or more transects within a stream reach. The site-specific data are used with a computer program to model hydraulic parameters. Transects are placed across the shallow portion (i.e., hydraulic control) of representative riffles. Hydraulic habitat transect based methods assume that if adequate conditions are maintained over the shallow portions of a stream reach, then the hydraulic habitat in other parts of the stream reach will also be sufficient (Annear et al. 2004).

4.3.1 *Habitat Retention Method*

The Habitat Retention Method (HRM) is a transect biology-based method (Nehring 1979) used to estimate hydraulic characteristics (i.e., average depth, average velocity, and percent wetted perimeter) over a range of flows (CDFW 2018). The HRM quantifies a minimum flow, sufficient to provide a basic survival level for fish during times of the year when streamflow is at its lowest (Annear et al. 2004). With a goal of sampling at least three representative riffles per reach, the method assumes that if a prescribed flow adequately meets hydraulic criteria at the shallowest part of the riffles (i.e., the hydraulic control), then conditions throughout the remainder of the reach should also be sufficient (Annear et al. 2004; Nehring 1979). The HRM may also be used to evaluate habitat maintenance flows and/or habitat connectivity flows.

4.3.2 *Wetted Perimeter Method*

The Wetted Perimeter Method (WPM) is used to establish low-flow ecological thresholds during sensitive time periods for vulnerable aquatic species. The WPM is typically applied during the summer and/or fall low flow months (Annear et al. 2004; CDFW 2020). The wetted perimeter refers to the perimeter of a cross-sectional area of the wetted streambed along a transect, which varies according to discharge (CDFW 2020). After collecting WPM data and corresponding discharges, a relationship between discharge and wetted perimeter can be developed. Historically, application of the WPM required collecting data over an expansive range of discharge events to determine the relationship between wetted perimeter and discharge at each site. Recent applications of the WPM generally use computer-based water surface profile modeling programs based on the Manning's equation to develop this relationship (Annear et al. 2004). Using the graphical relationship between wetted perimeter and discharge, the inflection point on the wetted perimeter/discharge curve is identified as a threshold where it is assumed that the corresponding flow can protect benthic macroinvertebrate production at an adequate level to sustain fish populations (Annear et al. 2004).

4.4 Field Data Collection Procedures

4.4.1 *Two-Dimensional Hydraulic Habitat Modeling Data Collection*

Hydraulic and structural parameters are measured using a combination of standard techniques from the U.S. Fish and Wildlife Service (USFWS) methodology (Bovee 1982; Bovee 1997; Trihey and Wegner 1981). Two-dimensional hydraulic habitat models use depth-averaging techniques to simulate water depth and velocity in sites with complex flow patterns. Data collection for 2D models consists of detailed bed elevations, horizontal position, estimates of substrate composition, and instream/overhead cover. Transects at the upstream and downstream extent of a site are established and used to define the boundary conditions, which are determined by water stage, flow, and channel roughness. Channel roughness is an important hydraulic parameter the model characterizes based on the bed topography, and to a lesser degree, the substrate size estimates and instream cover. Boundary conditions will consist of a constant inflow hydrograph and constant downstream water stage hydrograph. Stage-discharge ratings, consisting of three to five water surface elevation/discharge pairs, will be established at each 2D study site. If there is a hydraulic control downstream of a given transect, differential leveling is used to survey the stage of zero flow stream bed elevation, which is found in the thalweg downstream of the transect. The stage of zero flow bed elevation is used to optimize the stage-discharge rating relationship when plotting flow-water level pairs as a linear best-fit on logarithmic scales (Waddle 2001). Due to the length of each tributary, intermediary measurements of water surface elevation and discharge will be added between the upstream and downstream model boundaries to aid model calibration.

The bed topography data used to create the 2D digital terrain model can be sourced from multiple survey methods: lidar flights, total station surveying, and/or Real Time Kinematic Global Positioning System (RTK GPS) surveying. CDFW plans to use airborne lidar surveys to map the topographic and bathymetric (underwater) terrain of the identified Clear Lake tributaries. Lidar data are collected over a larger area than traditional surveying techniques and allow for a dense, highly accurate grid of georeferenced survey points. In areas with thick riparian canopy, or pools with depths beyond the penetration capabilities of the bathymetric sensors, the lidar data may also be supplemented with total station and/or RTK GPS survey methods. In the latter cases, total station or RTK-GPS topography points will be collected at a higher density in streambed areas with highly variable substrate sizes, and at a lower point density in areas with more uniform topography and substrate sizes.

4.4.2 Habitat Retention Method and Wetted Perimeter Method

CDFW will identify representative riffle sites for HRM and WPM that are representative of the overall geomorphic structure and shape of the reaches of interest within the study area (CDFW 2018; CDFW 2020). Once sites are selected, cross-sectional transects are established along the hydraulic control of each riffle with a measuring tape and a headpin and tailpin positioned on the left bank and right bank, respectively. The pins are placed at or above the bankfull elevation. For the purposes of this method, bankfull elevation is defined as the location where the vegetation emerges at the toe of the bank, there is a change in slope along the cross-sectional channel profile, and/or there is a change in substrate composition from coarser to finer material (CDFW 2018; CDFW 2020). Bed elevations are measured along each transect using an auto level and surveying stadia rod at one-foot intervals following the procedures set forth in the CDFW's standard operating procedure (SOP) for Streambed and Water Surface Elevation Data Collection (CDFW 2013c). Smaller increment measurements are taken in areas with highly variable bed topography. In addition, water surface elevations (WSE) are measured mid-channel and near each bank to determine the water surface profile along the transect (CDFW 2013c). The length of the riffle along with WSE measured near the left and right bank at the downstream extent of the riffle are used to compute the water surface slope. A temporary staff gage is used to monitor the stage at the beginning and end of each data collection event to ensure that flow levels do not fluctuate during the course of data collection. A discharge measurement is taken for each transect using a flow meter and top setting wading rod (CDFW 2013b), or if one exists, flow data from a nearby stream gage can be paired with the date and time the transect was surveyed. Discharge measurements are then associated with the survey data to estimate hydraulic properties using Manning's equation for open channel flow.

Along with the measured discharge (Q) and calculated channel slope (S), the bed elevation data are used to calculate the flow area (A), wetted perimeter (P), and hydraulic radius (R) for the cross-section. These values are then used to calculate the Manning's roughness coefficient (n) using the Manning's equation for open channel flow, given below:

$$Q = \left(\frac{1.486}{n}\right) AR^{\frac{2}{3}}S^{\frac{1}{2}}$$

While several programs are capable of modeling these hydraulic parameters, CDFW generally uses the commercially available software program Hydraulic Calculator (HydroCalc) (Molls 2010). HydroCalc is based on the Manning's equation and can be used to develop discharge rating curves in addition to estimating the listed hydraulic parameters (see HRM SOP for procedures; CDFW 2018).

For HRM, when the criteria for average depth and at least one other parameter are met (Table 4), flows are assumed to be adequate for habitat connectivity and aquatic ecosystem habitat maintenance. For the WPM analysis, a relationship between discharge and wetted perimeter is developed (CDFW 2018; CDFW 2020). The breakpoint and incipient asymptote (curve inflections) are identified as thresholds of desired habitat conditions. These curve inflections (i.e., the breakpoint and incipient asymptote) are used to determine the instream flow needs necessary to maintain riffle habitat and production of benthic macroinvertebrates. It may also be possible to develop the HRM and

WPM data from output of the 2D models. In that case, the field data collection could be used to validate the 2D model.

Table 4. Key flow parameters used to determine flow criteria in riffle habitats using the HRM.

Bankfull Width (ft)	Average Depth (ft)	Average Velocity (ft/sec)	Wetted Perimeter (%)
1-20	0.2	1.0	50
21-40	0.2-0.4	1.0	50
41-60	0.4-0.6	1.0	50-60
61-100	0.6-1.0	1.0	70

Sources: Nehring 1979; CDFW 2018.

4.4.3 Target Flows for Sampling

CDFW's IFP intends to develop predictive hydraulic models at representative study sites to estimate fish passage and habitat maintenance flows for CLH over a range of flows indicative of CLH during their riverine life stages. Flow-water rating curves are created from field measurements of discharge and WSE. The rating relationships are then used to calibrate WSE in hydraulic model simulations at target flow magnitudes. Reliable flow-WSE ratings are established by measuring discharge and WSE at three, or preferably four to five, distinct flow levels at each study site (Waddle 2001). Target flows typically fall within the exceedance range of 20 to 80 percent (CDFW 2013c).

5.0 DATA MANAGEMENT AND QUALITY ASSURANCE

5.1 Data Management

The scientific data collected in the habitat and instream flow evaluation study will follow CDFW's Scientific Data Governance Policy to ensure transparency and reproducibility. All CDFW scientific data collections require a data management plan to document the data life cycle from collection to storage. Additionally, metadata, "data about data," will clearly be documented to provide further aspects of the information collected. All data collected will comply with the Instream Flow Program's Quality Assurance Plan (QAPP), described in more detail in the next section. Scientific data will be stored and archived appropriately following all CDFW protocols and procedures. CDFW will respond to requests for scientific data within a reasonable time, in accordance with all applicable laws, including the California Public Records Act.

5.2 Quality Assurance

Quality assurance (QA) is a systematic process, including planning, implementing, assessing, reporting, and continuously improving. A component of QA is quality control (QC) to quantify levels of uncertainty and to determine the effect of those errors. This study will follow the QAQC systems outlined within the Instream Flow Program's QAPP (CDFW 2023). The QAPP is a detailed document that describes quality assurance systems within the IFP related to project management, data generation and acquisition, assessment and oversight, and data validation and usability. It follows the scope and format specified in the US Environmental Protection Agency (EPA) Region 9 document *EPA Region 9 Requirements for Quality Assurance Program Plans*. This promotes IFP comparability with other California agencies utilizing QA program plans and QA project plans.

6.0 COORDINATION AND REVIEW

The instream flow study is planned to occur during WY 2024. Field data will be collected when water is present during the winter and spring seasons. To the extent possible, entities or stakeholders who may have an interest in the field study may be involved. The Water Branch staff will conduct the analyses and hydraulic modeling that will be presented in a final technical report. The North Central Region, Fisheries Branch, and Conservation Engineering Branch will review the technical report. Findings from the study will be presented in a public outreach meeting along with the release of the final technical report. Additionally, flow criteria developed in the WCRs may be used as a tool for consideration in water management planning.

6.1 Target Audience and Management Implications

CDFW has the responsibility to conserve, protect, and manage fish, wildlife, native plants, and their associated habitats. Accordingly, CDFW has an interest in assuring that water flows within streams are maintained at levels that are adequate for long-term protection, maintenance, and proper stewardship of fish and wildlife resources. Relationships between streamflow and habitat/fish passage within tributaries of the Clear Lake watershed will be developed using a combination of scientifically defensible methods, which may include hydraulic habitat/fish passage modeling and empirical approaches described by the Instream Flow Council in *Instream Flows for Riverine Research Stewardship* (Annear et al. 2004). Using the findings generated from the flow study, CDFW intends to develop flow criteria for CLH. These criteria are not requirements that will be self-executing. Rather, they will support efforts needed to protect CLH in tributaries of the Clear Lake watershed, like voluntary measures or other actions such as emergency regulations, to mitigate impacts of drought conditions. This information is critical for protecting CLH in tributaries of the Clear Lake watershed by the Task Force, which includes California Native American Tribes, local, state, and federal agencies.

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