



January 2026
Study of Physical Data Gaps to Inform the Implementation
of Nur Rematriation Upstream of Shasta Dam
(AB 211 Drought Grant Agreement Number – Q2396040)



Appendix M

Summary of Previous Development and Evaluation of Trap and Haul Passage Alternative

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Summary of Previous Development and Evaluation of Trap and Haul Alternative

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TABLE OF CONTENTS

1	Introduction	1
2	Data Sources	4
3	Previously Considered Upstream Trap and Haul Concepts	5
4	Previously Considered Downstream Trap and Haul Concepts.....	8
5	Summary and Conclusions	16
6	Additional Considerations	17
7	References	18

TABLES

Table 1	Data Sources Summarized in this Document.....	4
Table 2	Excerpt from “Matrix of Upstream and Downstream Fish Passage Alternatives at Shasta Dam” (USBR 2013b).....	6

FIGURES

Figure 1	Study Area, Key Features, and Vicinity.....	3
Figure 2	Aerial Image of JSCS Components - Fall 2022 Deployment.....	9
Figure 3	2023 JSCS Deployment Locations.....	11
Figure 4	Aerial Image of JSCS Components - Fall 2023 Deployment.....	12
Figure 5	2024/2025 JSCS Deployment Locations	13
Figure 6	Aerial Image of JSCS Components - Fall 2024/2025 Deployment.....	14

ABBREVIATIONS

Background Compendium	<i>Background Compendium and Design Criteria Report for the Feasibility of Volitional Fish Passage Above Keswick and Shasta Dams</i>
CDFW	California Department of Fish and Wildlife
Consultant Team	Anchor QEA; HDR Engineering, Inc.; U.S. Geological Survey; and QEDA Consulting, LLC
CVP	Central Valley Project
DWR	California Department of Water Resources
HDR	HDR Engineering, Inc.
IFPSC	Interagency Fish Passage Steering Committee
JSCS	Juvenile Salmonid Collection System
LSNFH	Livingston Stone National Fish Hatchery
NMFS	National Marine Fisheries Service
Nomtipom Waywaket	Winnemem Wintu words for Sacramento River
Nur	Winnemem Wintu word for Chinook Salmon
QEDA	QEDA Consulting, LLC
SWP	State Water Project
USBR	U.S. Bureau of Reclamation
USGS	U.S. Geological Survey
Winnemem Waywaket	Winnemem Wintu words for McCloud River

1 Introduction

A team of engineering and fisheries science consultants consisting of Anchor QEA; HDR Engineering, Inc. (HDR); U.S. Geological Survey (USGS); and QEDA Consulting, LLC (QEDA) known herein as the "Consultant Team," has received funding from the California Department of Fish and Wildlife (CDFW) to implement studies to gather data, compile information, and identify data gaps related to physical and biological conditions in the Study Area. These studies will be referred to within this document as the "Project." The results of the Project will support an investigation of the feasibility of providing volitional passage for fish, particularly Chinook Salmon (*Oncorhynchus tshawytscha*), above Keswick and Shasta dams on the Nomtipom Waywaket (also known as the Sacramento River) and into the Winnemem Waywaket (also known as the McCloud River) in northern California. In this document, Chinook Salmon is used to generally describe the species because once connectivity is re-established through reintroduction, fish will adapt to the new environments and could display run timing consistent with multiple runs. It is inclusive of Nur, which the Winnemem Wintu Tribe uses for Chinook Salmon that have been raised by the Tribe. The formal, Evolutionarily Significant Unit (ESU)-specific name (e.g., Sacramento River winter-run Chinook Salmon) is used when discussing federal Endangered Species Act (ESA)-listed Chinook Salmon or steelhead (*O. mykiss*). This document is an appendix to the overarching report documenting the results of the Project, which is called the *Background Compendium and Design Criteria Report for the Feasibility of Volitional Fish Passage Above Keswick and Shasta Dams* (Background Compendium). This larger report contains additional background information for the Project and this document should be considered within this context.

The Project Study Area extends from the confluence of Cow Creek and the Nomtipom Waywaket and includes the Winnemem Waywaket from Shasta Reservoir to the McCloud Dam (Figure 1). It includes portions of the Winnemem Waywaket; the Nomtipom Waywaket, including Keswick and Shasta dams and reservoirs; Cow Creek; Little Cow Creek; and Dry Creek. These water bodies vary in hydrology, geomorphology, and water quality, with seasonal fluctuations in temperature and flow; these parameters are being measured during this Project to evaluate habitat suitability and passage for salmonids. Understanding these physical conditions is essential to evaluating the feasibility of restoring fish passage to historical spawning and rearing areas upstream of the dams.

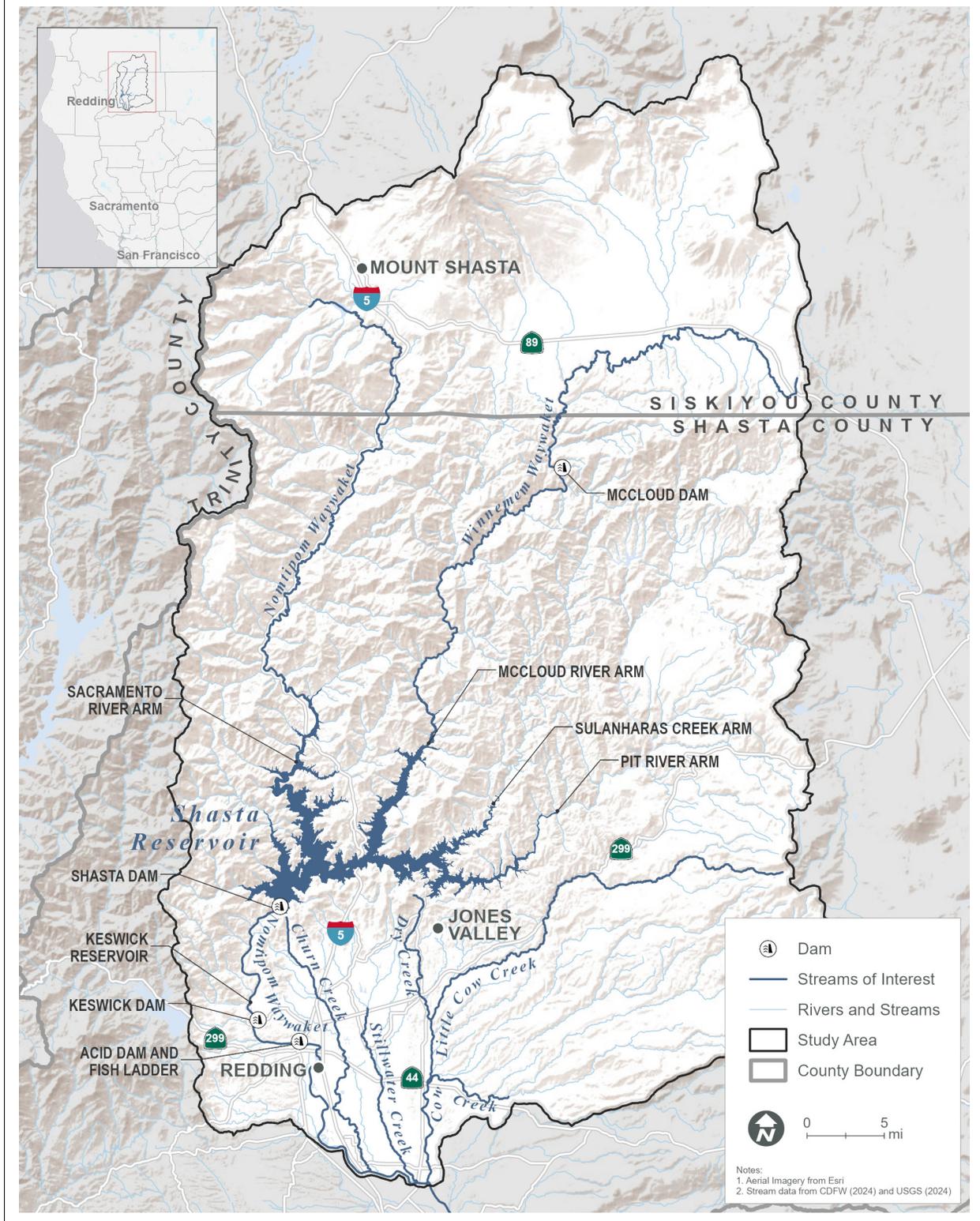
The objectives of this document are to summarize the Consultant Team's approach and methods of gathering information and collect and synthesize available information prepared by others on existing trap and haul concepts for Chinook Salmon reintroduction above Shasta Dam. Information obtained from this document review will be used to compare to volitional fish passage alternatives being developed and evaluated under a separate contract. A summary of the document contents following this section is provided below.

- Section 2 – provides an overview of readily available information used in the development of this document,

- Section 3 – summarizes information on previously considered trap and haul concepts for upstream passage,
- Section 4 – summarizes information on previously considered trap and haul concepts for downstream passage,
- Section 5 – summarizes findings of this document review, and outlines potential data gaps and next steps,
- Section 6 – discusses considerations for further development of upstream and downstream trap and haul passage alternatives,
- Section 7 – provides references for data and information sources used to develop this document.

Readers should understand that on December 12, 2025, the Consultant Team received an email stating that the Winnemem Wintu Tribe does not endorse these reports (referring to the Background Compendium and appendices and *Alternatives Formulation and Evaluation Report* [Anchor QEA and HDR 2026]).

Figure 1
Study Area, Key Features, and Vicinity



2 Data Sources

Documents provided by United States Bureau of Reclamation (USBR) regarding the reintroduction program were reviewed for information relevant to the development of upstream and downstream trap and haul concepts. Relevant information was compiled and summarized in this document; the information sources used are listed in Table 1:

Table 1
Data Sources Summarized in this Document

Source	Upstream Passage	Downstream Passage
United States Bureau of Reclamation. 2013. Shasta Dam Fish Passage Evaluation, Fish Passage Technology Subcommittee Meeting Minutes. December 13, 2013.	X	
United States Bureau of Reclamation. 2023. Livingston Stone National Fish Hatchery Infrastructure Review and Alternative Analysis. March 2023.	X	
Department of Water Resources. Juvenile Salmonid Collection System: Report on Field Operations 2023. 2024.		X
Environmental Science Associates. Water Temperature Considerations for Head-of-Reservoir Juvenile Salmonid Collection Systems, undated.		X
Department of Water Resources. Juvenile Salmonid Collection System for Shasta Dam Fish Passage Yuba Reintroduction Working Group Presentation. May 8, 2024.		X
Department of Water Resources. Juvenile Salmonid Collection System for Shasta Dam Fish Passage Winnemem Wintu Nur/Salmon Rematriation Project Monthly Scientific Meeting Presentation. July 31, 2024.		X
Department of Water Resources and Winnemem Wintu Tribe. Bringing Salmon Home: Lessons Learned from the Juvenile Salmonid Collection System on the Winnemem Waywaket.		X

3 Previously Considered Upstream Trap and Haul Concepts

In 2009, the National Marine Fisheries Service (NMFS) published the Biological Opinion and Conference Opinion on the Long-Term Operation of the Central Valley Project (CVP) and State Water Project (SWP) concluding that, without intervention, operation of the CVP and SWP as planned would likely jeopardize several federally listed fish species, including the Sacramento River winter-run Chinook Salmon and Central Valley spring-run Chinook Salmon. NMFS prescribed in a Reasonable and Prudent Alternative a series of actions required for continued operation of the CVP and SWP in compliance with the federal ESA. One of these prescribe actions was to evaluate reintroduction of winter-run and spring-run Chinook Salmon upstream of Shasta Dam and implement a fish passage pilot program (Pilot Program) on the Nomtipom Waywaket (USBR 2016). In response, USBR formed the Interagency Fish Passage Steering Committee (IFPSC) in 2010, which subsequently initiated the Shasta Dam Fish Passage Evaluation to evaluate feasibility for fish passage and inform decisions regarding long-term reintroduction strategies (IFPSC 2017).

In 2013, the Fish Passage Technology Subcommittee, a subcommittee of the IFPSC, focused on assessing passage technologies to achieve SDPFE goals (USBR 2013a), developed and evaluated a matrix of potential upstream and downstream passage alternatives for consideration in both the Pilot Program, and long-term reintroduction (USBR 2013b). Of the upstream passage alternatives, three trap and haul options were considered for passage above Shasta Dam: Trap and Haul at Keswick Dam, Trap and Haul at Shasta Dam, and Trap and Haul from Coleman Hatchery on Battle Creek. Trap and haul at Shasta Dam was ultimately removed by the subcommittee from consideration as a viable path forward for both the Pilot Program and as a long-term passage strategy due to the high costs and potential for alteration to dam operations associated with constructing a new facility, as well as the need for fish handling at both Keswick and Shasta dams. Trap and haul from Coleman Hatchery was considered a potentially viable Pilot Program option, while trap and haul from Keswick Dam was favored for both a Pilot Program and long-term implementation due to the lower costs associated with use of the existing facilities (USBR 2013b) and fewer points of fish handling.

Table 2 provides an excerpt from the alternative matrix included as Attachment 1 of the meeting minutes from the December 2013 bi-monthly Fish Passage Technology Subcommittee Meeting.

Table 2

Excerpt from “Matrix of Upstream and Downstream Fish Passage Alternatives at Shasta Dam” (USBR 2013b)

Alternative	Description	Pros	Cons	Worth Further Evaluation for Long-term ?	Potential Use in Pilot Program?
Trap and Haul at Keswick Dam	Uses existing fish collection facility at Keswick Dam. Includes fish ladder, trap, braille-lift, elevator, and trucking or barging to release site upstream of Shasta Dam.	Uses existing facilities. Does not alter current project operations. Releases adults directly into tributaries or at head-of-reservoir location. Low cost.	Non-volitional passage. Requires handling and trucking.	Yes	Yes
Trap and Haul at Shasta Dam	Requires new construction of fish collection facility at Shasta Dam. Will include trapping, lifting, and trucking or barging to release site upstream of Shasta Dam.	Takes advantage of 9 miles of habitat between Keswick and Shasta dams. Potential to use Livingston Stone National Fish Hatchery as collection location. Releases adults directly into tributaries or at head-or-reservoir location.	Non-volitional passage. Requires new construction. Requires handling at Keswick Dam and handling and trucking at Shasta Dam. Habitat in Keswick Reservoir is not suitable for spawning.	No	No
Trap and Haul from Coleman Hatchery	Use exiting hatchery facilities (barrier, trap, holding area) to collect adults, hold as needed, and truck to desired tributary.	Uses existing facilities. Does not alter current project operations. Releases adults directly into tributaries or at head-of-reservoir location. Low cost.	Desirable broodstock may not be present in Battle Creek for initial Pilot study. Availability of fall and late fall runs only. Fish brought over from Battle Creek may wander from desired tributary. Requires handling. Would only apply to the initial pilot studies.	No	Yes

To date, none of the upstream passage alternatives have been implemented as a Pilot Program or long-term passage. There is concern that the release of adult winter-run Chinook Salmon above Shasta Dam may introduce diseases into the reservoir, which is the water source for Livingston Stone National Fish Hatchery (LSNFH) just below Shasta Dam. LSNFH currently does not have a water treatment system to prevent diseases from infecting the hatchery fish. Thus, the current strategy for pilot reintroduction above Shasta Dam is to transport winter-run Chinook Salmon eggs from the LSNFH captive broodstock program to incubation stations in the Winnemem Waywaket (USBR 2023). Winter-run broodstock are trapped at Keswick Dam and trucked to LSNFH. Trapping occurs from mid-February through the end of July, with generally one transport trip made per day (USBR 2023). Progeny of captive broodstock are also released into Battle Creek to support reintroduction of winter-run Chinook Salmon in that tributary to the Nomtipom Waywaket.

4 Previously Considered Downstream Trap and Haul Concepts

Trap and haul for downstream passage of out-migrating juvenile salmonids is generally considered more challenging than for upstream passage and must carefully consider a number of siting, design, and environmental factors to be successful. Trapping efficiency can be affected by attraction, fish behavior, risk of predation, water temperature, reservoir fluctuations, varying flow rates, among a myriad of other factors. Effective collection of juveniles is an important step in the reintroduction of winter-run Chinook Salmon to historical spawning and rearing tributaries above Shasta Dam.

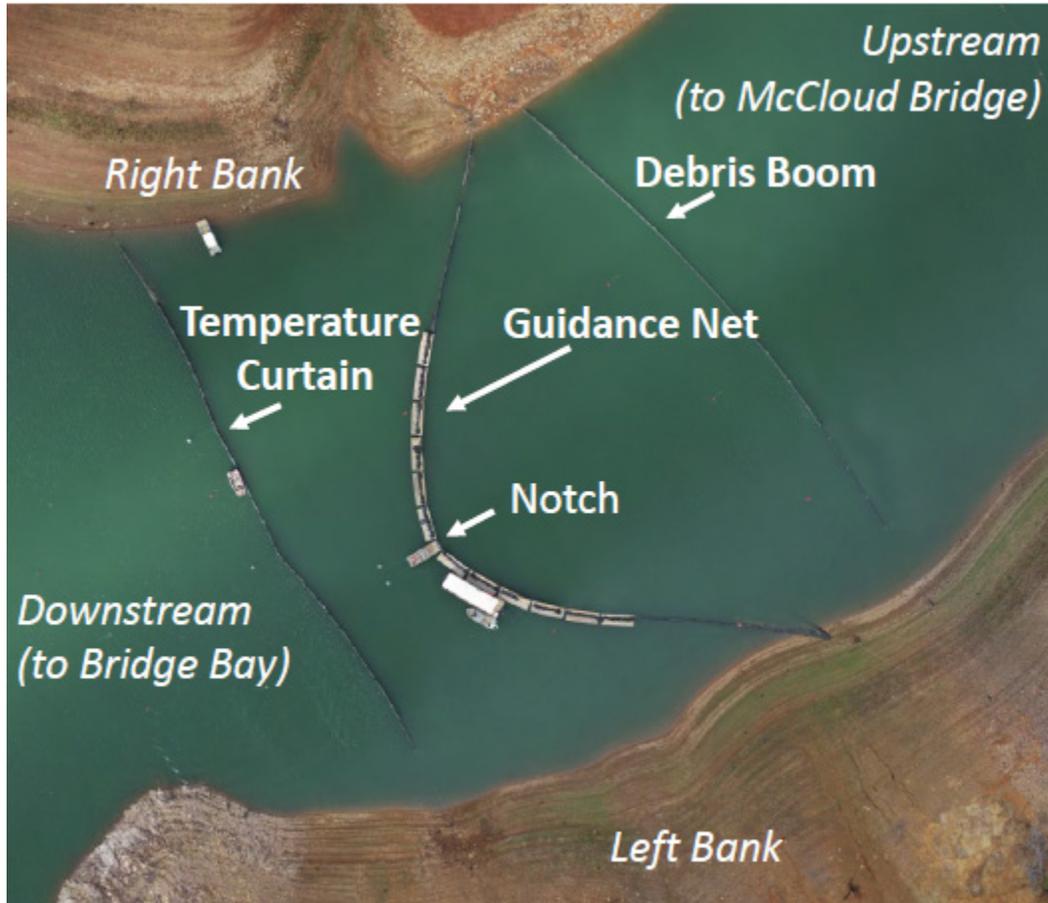
One of the objectives of the Pilot Program was to evaluate feasibility of collection and downstream transport of juvenile Chinook Salmon. The Juvenile Salmonid Collection System (JSCS) Pilot Study was implemented to address this goal. Efforts and findings of the JSCS Pilot Study are briefly summarized below. Additional details regarding the JSCS Pilot Study can be found in *Head of Reservoir Collection* (Appendix O of the Background Compendium) and provided in the data sources listed in Table 1.

In 2015 agency experts from the IFPSC brainstormed design concepts for a juvenile collection system to be deployed as part of the Pilot Program. The IFPSC determined that survival rates would be low for juvenile Chinook Salmon migrating through the Shasta Reservoir to a collection system at or near the dam (USBR 2016 as cited in DWR 2024a). Therefore, brainstorming concepts focused on siting a collection facility at in-river and head of reservoir locations on the McCloud Arm of Shasta Reservoir. Siting locations were further narrowed down to a head of reservoir system, since incline plane traps and rotary screw traps are not likely to withstand the potential higher flows that occur in the Winnemem Waywaket. The chosen pilot system consists of a 15-foot-long passive trap on a 40-foot by 24-foot platform with guidance that relies on induced velocity and fish behavior for attraction instead of pumped attraction flows. Components were fabricated between 2018 and 2023 and deployed in the fall of 2022, 2023, and 2024.

The 2022 deployment focused on evaluation of function of the JSCS components (ESA n.d.), which consisted of a debris boom, guidance net, notch with six docks on each side, and a temperature curtain. Figure 2 shows the 2022 JSCS components and layout. The purpose of the temperature curtain was to retain cooler water at the notch, and the guidance net had optional impermeable panels installed to alter the flow velocity at the notch to direct juveniles towards a trap. Because the goal of this deployment was to evaluate system function, rather than collection performance, no trap was included in the system and no fish were collected. Deployment ran from September 19 to November 12, 2022, approximately 1.5 miles downstream of the riverine-reservoir interface. The initial water surface elevation of the reservoir was 930 feet North American Vertical Datum 1988 (NAVD 88) at the start of deployment; water depths ranged from approximately 20 to 40 feet

throughout the deployment (DWR 2024a). Water quality, depth, and velocity was also monitored throughout the deployment.

Figure 2
Aerial Image of JSCS Components - Fall 2022 Deployment



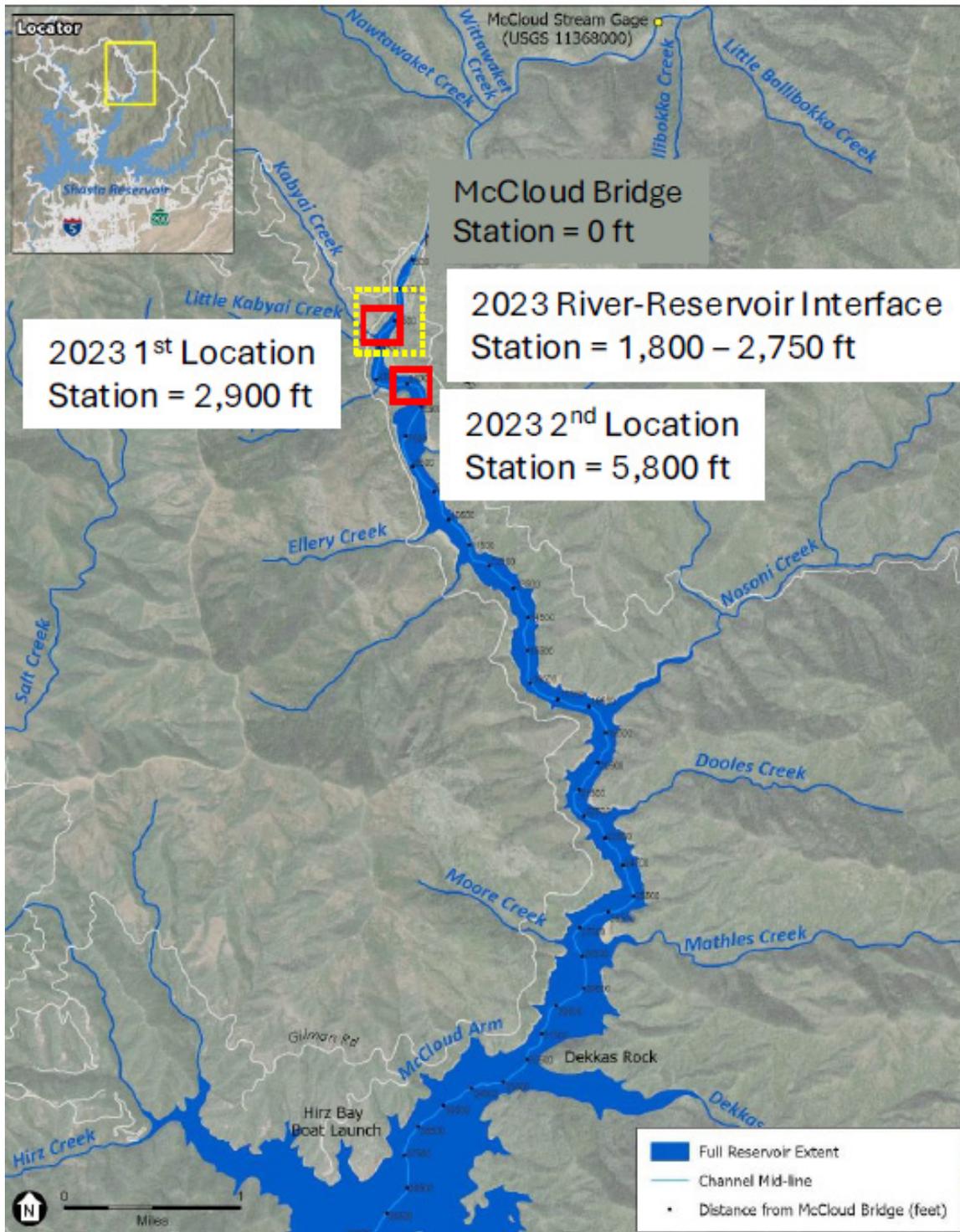
Source: DWR 2024c

In 2023, the JSCS was deployed in a narrower portion of the reservoir between Ellery Creek Campground and the McCloud Bridge Campground due to increased reservoir water surface elevation (1,040 feet NAVD 88) shifting the head of reservoir upstream (DWR 2024a). Deployment took place at two locations, shown on Figure 3. The downstream location operated from September 20 to October 25, when operation ceased due to inadequate water depths, and the upstream location operated from November 1 through November 15.

For the 2023 collection season, the JSCS consisted of the fish trap, platform, guidance nets, debris booms, temperature curtain, and boat gates. The fish trap consisted of a 15-foot-long stainless steel and aluminum passive trap set into the notch of the JSCS platform (DWR 2024a). Figure 4 shows the

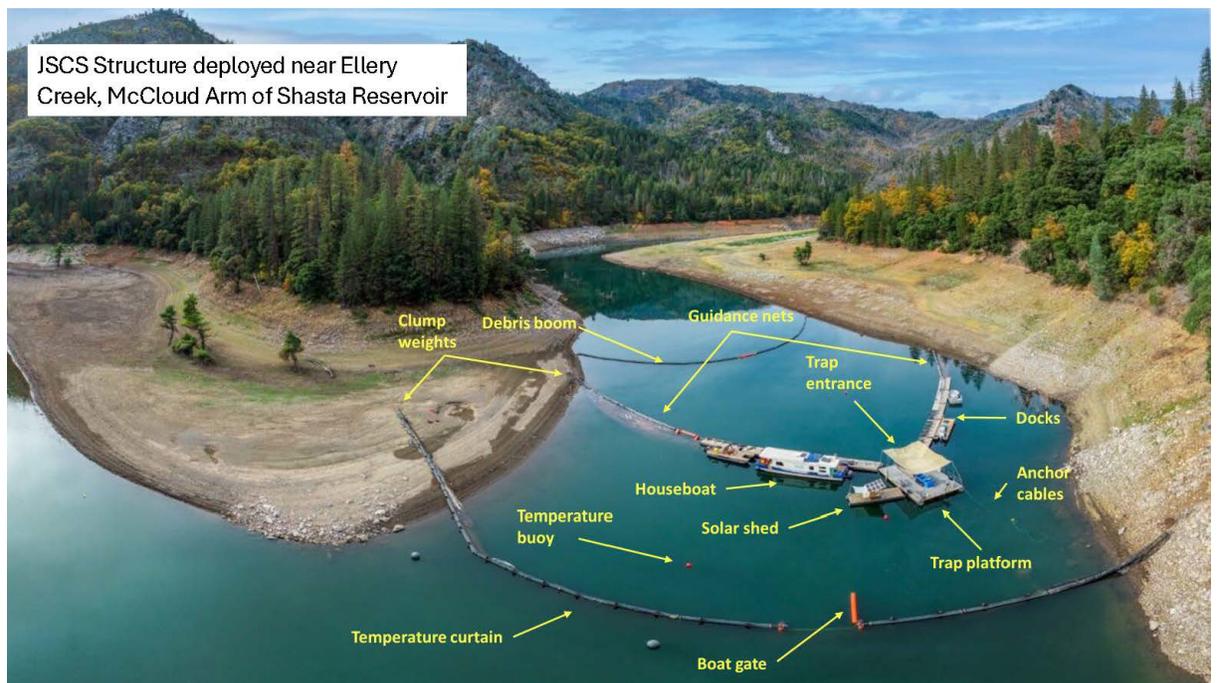
2023 facility layout. As with the 2022 deployment, water quality, depth, and velocity were monitored throughout the deployment to provide context for evaluating JSCS performance.

Figure 3
2023 JSCS Deployment Locations



Source: DWR 2024b

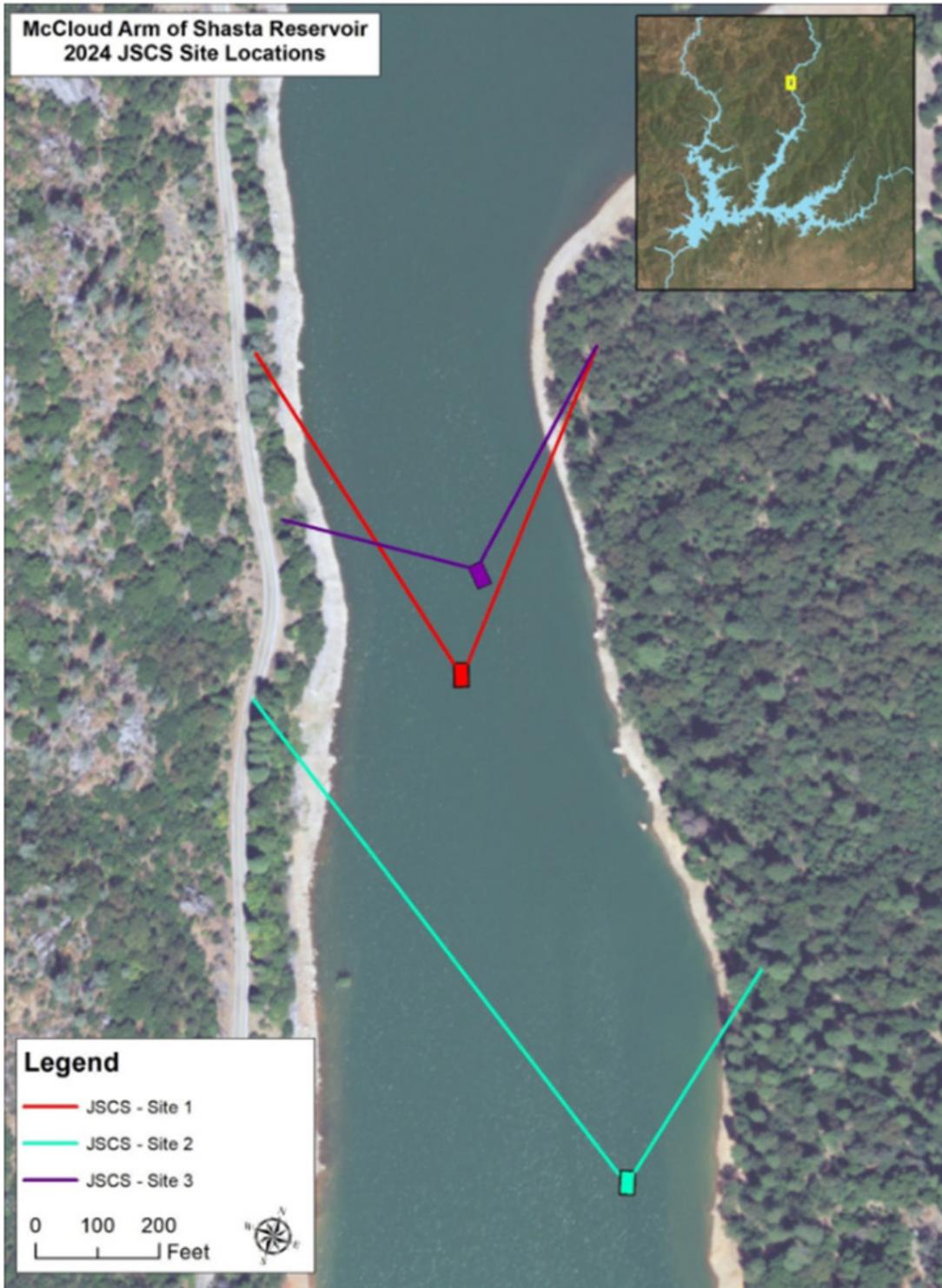
Figure 4
Aerial Image of JSCS Components - Fall 2023 Deployment



Source: DWR 2024c

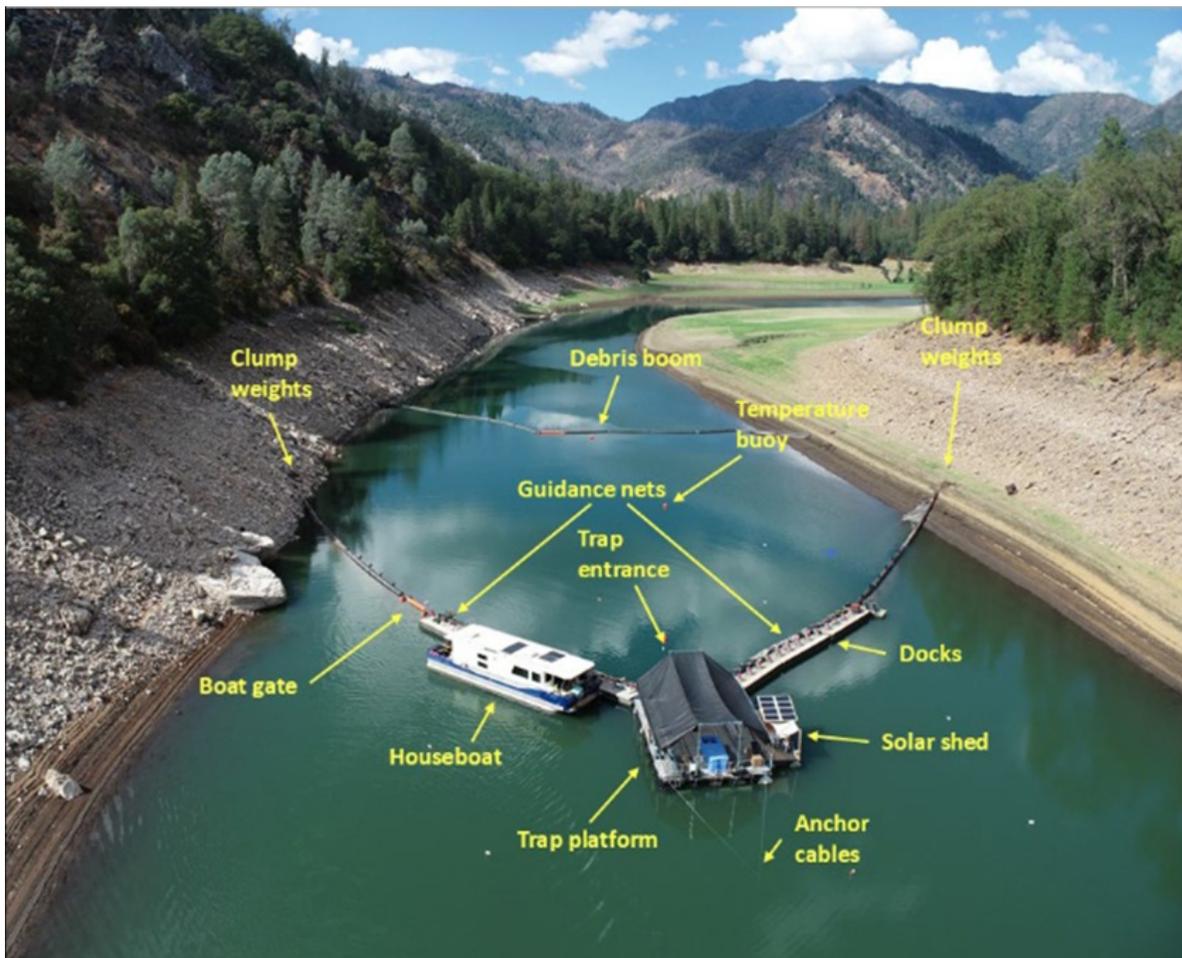
For the 2024/25 deployment, the JSCS was located between Ellery Creek Campground and the Pine Point Campground to target the head of reservoir and was deployed at three different locations during the season (Figure 5). Minor modifications were made to the JSCS configuration from the 2023 configuration, the primary change being use of impermeable vinyl panels around the perimeter of the trap for temperature control rather than a temperature curtain (Figure 6). Similar to the 2023 season, the purpose of this deployment was to assess JSCS collection efficiency, and investigate factors (e.g., hydraulics, water quality, predation) that may influence collection efficiency (DWR 2025).

Figure 5
2024/2025 JSCS Deployment Locations



Source: DWR 2025

Figure 6
Aerial Image of JSCS Components - Fall 2024/2025 Deployment



Source: DWR 2025

During the 2023 deployment, a total of 823 juvenile Chinook Salmon were collected at the JSCS (including juveniles released and recaptured during the efficiency trials) and subsequently transported in to CDFW for release into the Nomtipom Waywaket downstream of Keswick Dam. Five capture efficiency trials were conducted during the 2023 deployment. Collection efficiencies ranged from 0.3 percent to 51.5 percent, with an average collection efficiency of 22.3 percent. Poor performance of the JSCS was attributed in part to suboptimal water depths and velocities at the trap entrance, with peak performance at depths and velocities from 10 to 13 feet and 1.2 to 2.1 feet per second, respectively, as well as predation and unsuitable temperature conditions.

During the 2024/2025 deployment, a total of 78 juvenile Chinook Salmon were collected at the JSCS (including juveniles released and recaptured during the efficiency trials) and subsequently transferred

into the care of the Winnemem Wintu Tribe and transported for release into the Nomtipom Waywaket downstream of Keswick Dam. Nine capture efficiency trials were conducted during the 2024/2025 deployment. Capture efficiencies were lower than observed in 2023, with average collection efficiencies at the three sites ranging from 0.0 to 3.5 percent, and an overall average collection efficiency of 1.4 percent. Similar to observations made in 2023, most juvenile Chinook Salmon were captured when flow velocities through the trap were 0.25 – 1.5 feet per second and water depths were less than 15 feet, with depth being a stronger indicator of capture (DWR 2025). Juvenile Chinook Salmon released closer to the trap exhibited greater capture efficiencies than those released further upstream, indicating that predation may influence capture efficiencies; however, clear conclusions regarding predation could not be drawn due to insufficient data. Poor collection efficiencies were attributed to deep, low velocity flows at the trap resulting from increased reservoir levels following winter storms. Trap operations were also interrupted several times due to storms and associated debris accumulation and removal. Due to the challenges and low collection efficiencies experienced during the 2023 and 2024/2025 deployments, DWR has considered reconfiguration of the JSCS to operate at the riverine-reservoir interface where hydraulics and water temperatures are anticipated to create more suitable conditions for juvenile collection.

Additional details regarding the JSCS Pilot Study can be found in *Head of Reservoir Collection* (Appendix O) and provided in the data sources listed in Table 1.

5 Summary and Conclusions

As required by CDFW's grant, trap and haul is a fish passage strategy being compared to the volitional passage alternatives for reintroducing winter-run and spring-run Chinook Salmon above Shasta Dam in the feasibility study. Three trap and haul alternatives were initially considered by the IFPSC for upstream passage of adult salmonids: trap and haul at Shasta Dam, trap and haul at Keswick Dam, and trap and haul at Coleman Hatchery. None of the options considered were developed beyond initial consideration, and no upstream passage pilot studies were conducted, primarily due to concerns regarding potential for adult Chinook Salmon from Nomtipom Waywaket to introduce pathogens into Shasta Reservoir, which is the water source for LSNFH. Due to the complex nature of collecting juvenile salmonids for downstream passage, efforts of the IFPSC focused on evaluating the feasibility and efficacy of juvenile collection facilities through the JSCS Pilot Study. As part of the Pilot Study, deployments of the JSCS took place in 2022, 2023, and 2024/2025. The 2022 deployment focused on functional performance of the different facility components, while the 2023 and 2024/2025 deployments focused on collection performance and incorporated lessons learned from each previous deployment. Poor collection performance during the 2023 and 2024/2025 deployments of the JSCS reinforced the importance of facility siting for optimal channel geometry and hydraulics (flow depths and velocities). Future deployments may consider design and implementation of a facility that operates at the riverine-reservoir interface where conditions are anticipated to improve collection efficiencies. The Pilot Study has not yet investigated the efficacy of transporting juveniles following collection.

6 Additional Considerations

Trap and haul at Shasta Dam was initially removed from consideration as an upstream passage alternative by USBR due to the higher costs and potential for disrupting existing dam operations associated with construction of new facilities. As required by CDFW's grant, the strategy is now being compared to volitional passage alternatives as part of the feasibility study. The current demands and future production targets of the captive broodstock program and its other objectives exceed the capacity of the existing LSNFH facilities. A 2023 Infrastructure review and alternative analysis (USBR 2023) identified construction of a new hatchery facility with an expanded footprint at a new location with fewer site constraints as the preferred alternative for meeting program goals. One potential location being considered is adjacent to left bank (looking downstream) of the Nomtipom Waywaket just downstream of Shasta Dam. Incorporation of a trap and haul facility at the proposed new LSNFH site on the riverbank opposite the existing hatchery downstream of Shasta Dam would help consolidate efforts for fish passage and hatchery goals. Thus, the upstream passage strategy of trap and haul at Shasta Dam is also being given new consideration, as it would allow consolidation of passage and LSNFH facilities and takes advantage of Keswick Reservoir as a temperature-controlled refuge for fish during warmer months as cooler water is released from Shasta Dam.

If this strategy is further considered, pilot testing is recommended to inform design of the permanent trap and haul facility. Prior to upstream passage pilot testing, a water treatment system would need to be installed at LSNFH to minimize risk of biohazards from adult fish in Shasta Reservoir impacting fish health at LSNFH. If a facility is designed, it should be designed according to relevant agency guidance (e.g., National Marine Fisheries Service's Anadromous Salmonid Fish Passage Facility Design Manual, California Department of Fish and Wildlife's California Salmonid Stream Habitat Restoration Manual) and minimize the excess stress on upstream migrating Chinook Salmon induced by facility features.

If trap and haul is further considered as a strategy for downstream passage, a configuration that can accommodate the range of hydraulic conditions and maximize collection efficiency and fish health needs to be identified. Findings of the JSCS pilot study indicate that influence from the reservoir decreases JSCS performance at the head-of-reservoir. A facility at the riverine-reservoir interface may experience improved collection efficiencies; however, potential for fluctuating reservoir levels to change the location of riverine-reservoir interface throughout the juvenile Chinook Salmon outmigration period and interruptions to collection operations during relocation and potential impacts on collection efficiency should be considered as the JSCS concept is further developed. Ability to accommodate high flow and associated debris loads, effects of predation and pathogens on juvenile collection and survival rates will also need to be investigated further and taken into consideration when siting and designing the facility. In addition to identification of a suitable configuration, efficacy of juvenile transport following collection will need to be assessed, including but not limited to transport mortality rates, release facility siting, and predation management at the release site.

7 References

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