California Department of Fish and Wildlife

North Central Region

Wallace Weir Fish Trapping and Relocation Efforts

2022 – 2023

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Purpose

The purpose of this document is to summarize the fish salvage efforts during the 2022-2023 trapping season in the Knights Landing Ridge Cut (KLRC) using the Wallace Weir Fish Collection Facility (Facility). The information in this document is intended to 1) provide historical context describing why a permanent fish collection facility was constructed, 2) document fish salvage efforts in the KLRC using the facility, 3) show species composition observed in the facility and 4) compare salvage efforts between the facility and temporary trapping methods (i.e., fyke traps).

Introduction

Non-natal straying is a natural occurrence for adult salmonids and serves to increase genetic diversity among populations of different watersheds (Quinn, 1984). Anthropogenic impacts to natural waterways such as damming of rivers, water diversions, and the creation of artificial waterways have led to increased straying of adult salmonids in the California Central Valley. Adult salmonids can be attracted to the outflow from man-made canals and become entrained in them. These canals are usually not connected to a river upstream and oftentimes have poor habitat and water quality for adult salmonids and can make them vulnerable to predation and poaching. The entrainment of these fish leads to a reduction in the adult spawning population. These losses are especially detrimental to Central Valley winter-run and spring-run Chinook salmon *(Oncorhynchus tshawytscha). S*outhern distinct population segment (sDPS) of North American green sturgeon (*Acipenser medirostris*) have also been rescued as part of these efforts. *These* species are listed as threatened or endangered under the federal Endangered Species Act (ESA) and state of California Endangered Species Act (CESA). To reduce and prevent entrainment losses, the California Department of Fish and Wildlife (CDFW) has implemented salvage efforts in these man-made canals where salmonids have been observed. Beginning in 2013, CDFW has seasonally installed temporary traps in the Colusa Basin Drainage Canal (CBDC), KLRC, and the eastern toe drain of the Yolo Bypass (Toe drain) for salvaging ESA listed anadromous species (Figure 1). Although these efforts may reduce the impacts from artificially augmented straying, they are not a permanent solution.

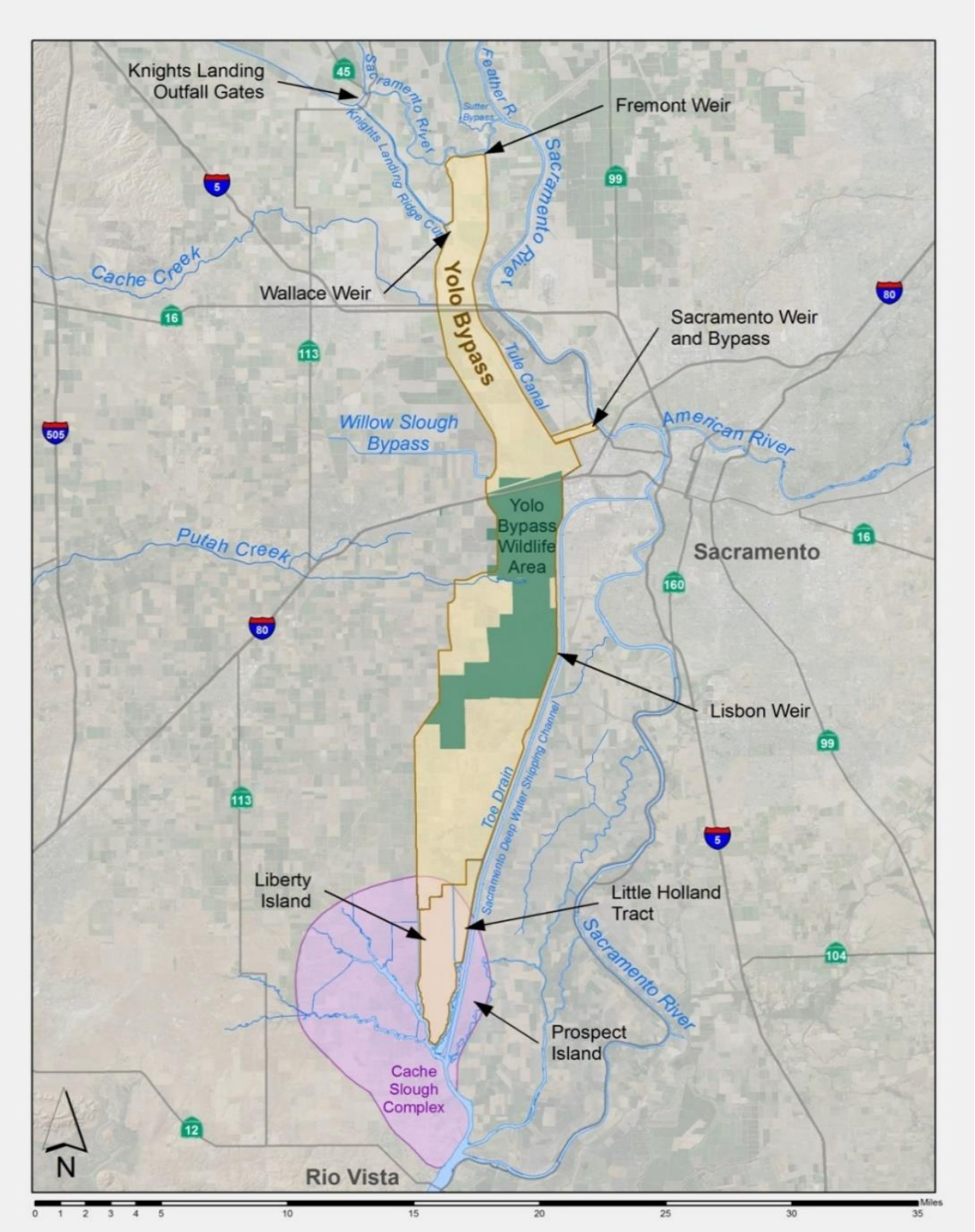

Figure 1. Map of the Yolo Bypass showing the Knights Landing Outfall Gates, Wallace Weir, and the Cache Slough Complex.

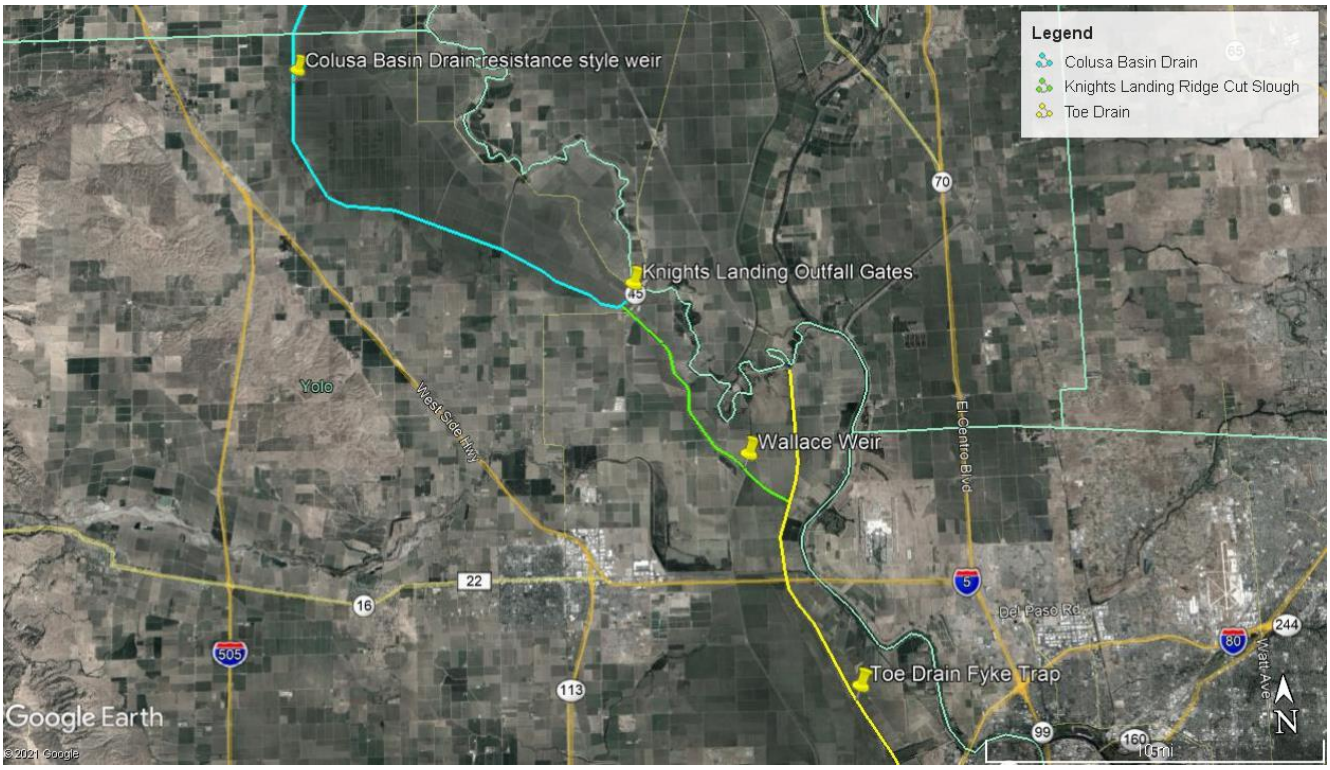

Figure 2. Map showing temporary trap site locations since 2013 in the Colusa Basin Drain (blue), Knights Landing Ridge Cut (green), and the eastern toe drain of the Yolo Bypass (yellow).

Background

During the spring of 2013, the California Department of Fish and Wildlife (CDFW) rescued 312 adult Chinook salmon from the CBDC, a man-made canal that drains approximately one million acres of agricultural land from Glenn, Colusa, and Yolo counties. Genetic and coded wire tag analysis revealed that many of the Chinook salmon rescued were federally listed winter-run and spring-run origin fish. Following this rescue effort, CDFW implemented trapping efforts upstream of two possible entry points into the CBDC: The Knights Landing Outfall Gates (KLOG) and the Cache Slough Complex (CSC) (Figure 1). Multiple years of trapping in these locations has revealed that much of the salmonid entrainment occurs in the KLRCS via the CSC. Conditions allowing for entrainment into the KLRCS occur more frequently throughout the year and under a wider range of water years compared to the number of days KLOG is passable in a given year (Gahan et al., 2016). As such, it was deemed necessary to have a more permanent means of salvaging listed salmon and sturgeon from the KLRC. Trapping efforts in the KLRCS historically took place approximately 200 meters downstream of an agricultural water control structure known as Wallace Weir (Figure 2). The weir consisted of an earthen berm and manually operated culvert with a wooden slide gate. During high flow events in the KLRC and Yolo Bypass, the weir was subjected to overtopping flows and erosion and needed to be repaired after such events. Similarly, the temporary fyke trap used for salvage operations was also subject to severe damage during these high flow events and needed to be removed beforehand. In an effort between CDFW, California Department of Water Resources (CDWR), and Reclamation District 108 (RD108), the weir was modified to be more robust and include a

fish collection facility. Construction on the improved weir and collection facility began in the summer of 2016 and was finished in the summer of 2019.

Wallace Weir

Flow Control Structure – The current Wallace Weir flow control structure consists of a built-up earthen berm armored with rip rap and six concrete box culverts through which water flows. Obermeyer dams are located on the upstream side of each culvert to regulate flow. On the downstream side of each culvert are bottom hinged metal fish screens that prevent fish from swimming upstream of the weir and further into the KLRC and CBDC. Each of the screens are raised and lowered via an overhead hoist and cable system mounted on the downstream end of the retaining walls. The Obermeyer dams and fish screens are controlled through a user interface housed in a control building on the top of the levee west of the weir. Air compressors that regulate the air pressure in each of the bladder dams are also stored in this control building. The fish screens can be programmed to raise and lower at different time intervals. Lowering of the fish screens can also be triggered by the amount of force being applied to the screens. This is to prevent debris build up which could cause a mechanical failure in the hoist system and result in an uncontrolled drop of the screens.

Fish Collection Facility - The Wallace Weir Fish Collection Facility (facility) is a concrete structure adjacent to the improved Wallace Weir water control structure, located in the KLRC, approximately 9.7 kilometers southwest of the town of Knights Landing.

The facility has four major components: the downstream entrance pool, holding pool, facility intake pool, and energy dissipation basins (Figure 3). The entrance pool is where fish enter the facility and leads to the holding pool, where fish are collected. The facility intake pool is at the upstream end of the facility, where water is diverted from the KLRC into the facility. A mechanized trash rack is mounted at the intake of the facility to block large debris from entering. The trash rack is driven by a Rotork actuator. After entering the facility intake pool, water can be diverted into two energy dissipation basins within the facility: one at the upstream end of the holding pool and one running parallel to the west side of the holding pool. Water routed through the western energy dissipation basin drains out to the upstream end of the entrance pool to provide auxiliary attraction or maintenance flow when needed.

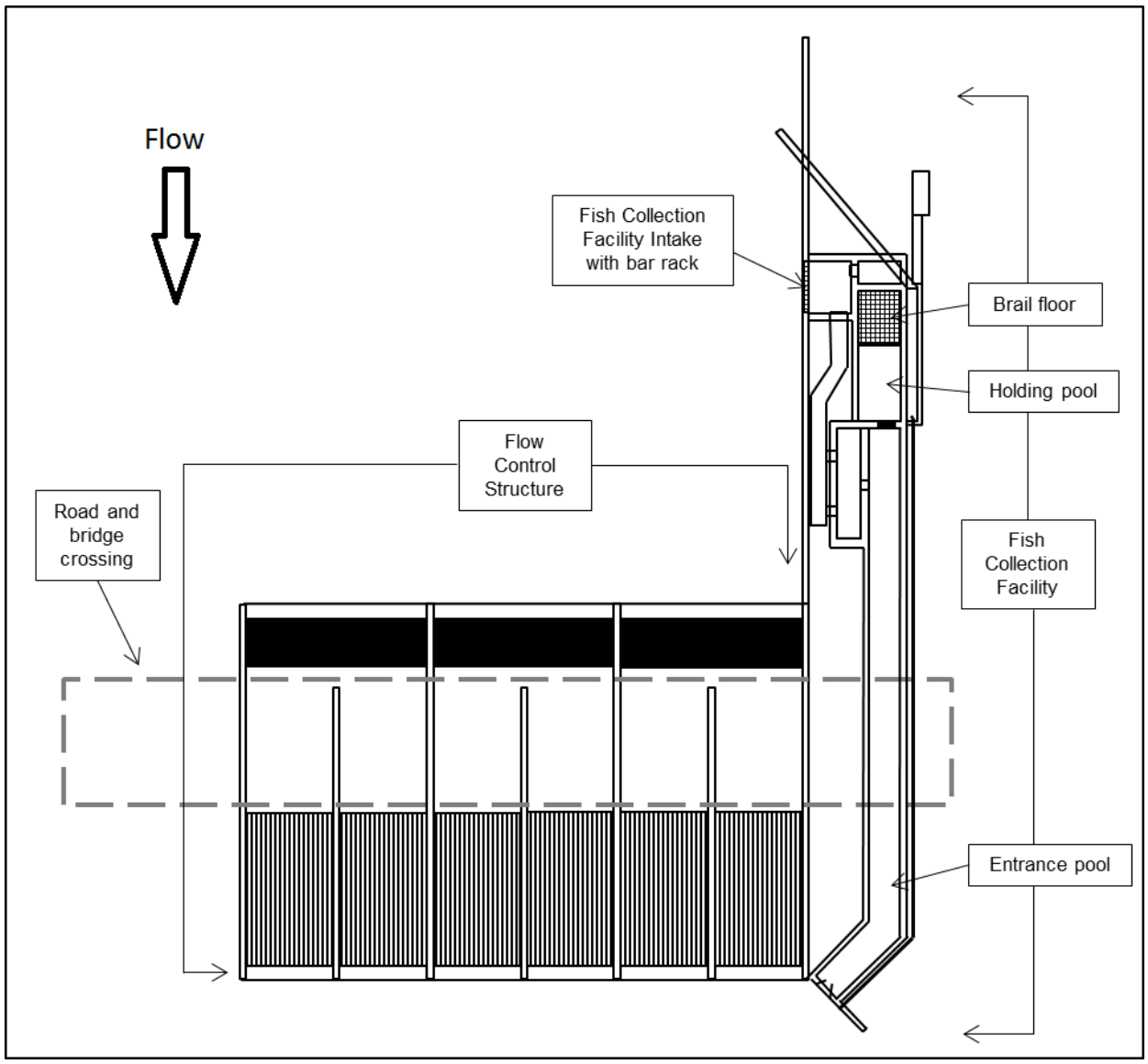

Figure 3. An overhead diagram of the new Wallace Weir including the flow control structure and fish collection facility.

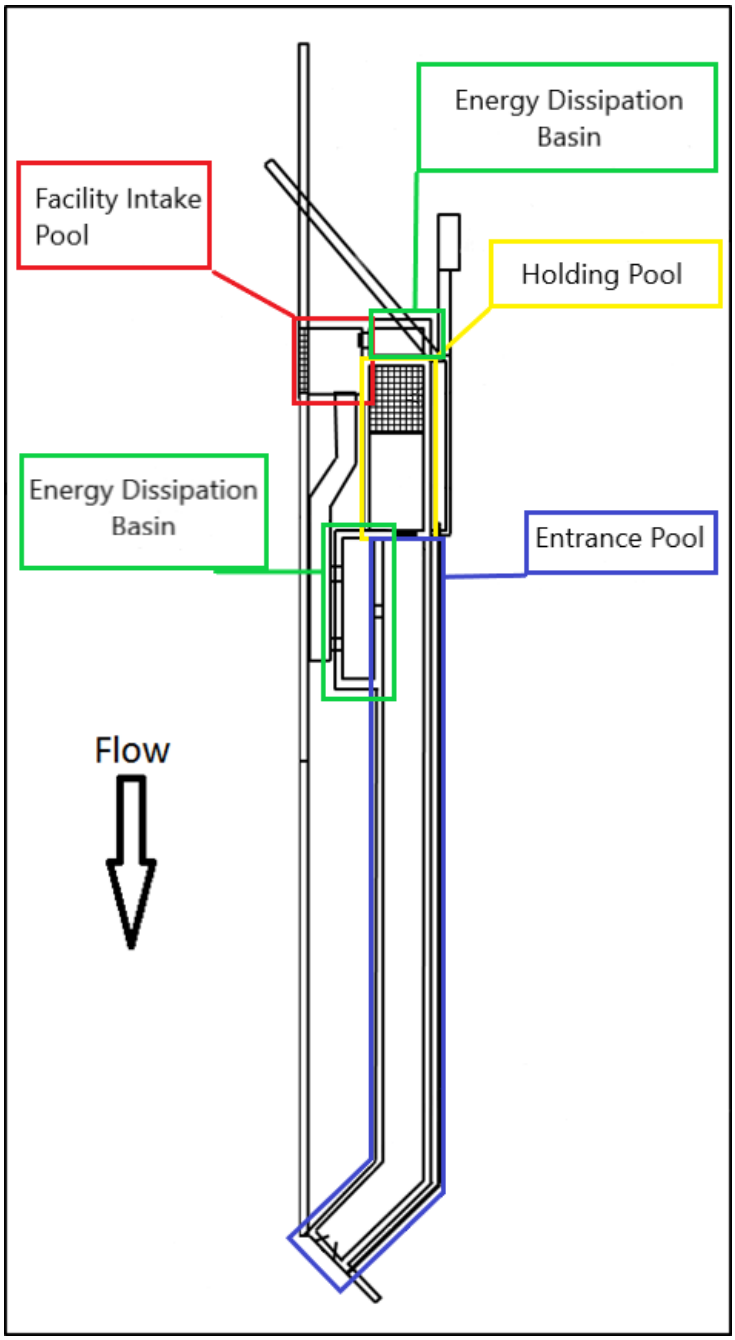

Figure 4. An overhead diagram of the Wallace Weir Fish Collection Facility with the four major components highlighted. The facility intake pool (red), holding pool (yellow), entrance pool (blue) and the energy dissipation basins (green).

Five gates separate the major components of the collection facility: the upstream Waterman gate, western auxiliary Waterman gate, slide gate, screened panel dual leaf holding pool LOPAC gate, and solid panel dual leaf entrance pool LOPAC gate (Figure 4). The upstream Waterman gate regulates flow from the KLRC to the facility intake pool. The western auxiliary gate regulates flow from the facility intake pool to the western energy dissipation bay. The slide gate is a stainless-steel plate used to hydraulically isolate the holding pool from the entrance

pool. The screened panel dual leaf LOPAC gate opens inwards into the holding pool and prevents fish from swimming back out into the entrance pool. These screened panels allow water to flow through even when closed, but block fish passage. The solid panel dual leaf LOPAC gates are used to adjust the head height of the water inside the facility as well as to close the facility.

The holding pool contains two components for collecting fish: a crowder rack and floor brail. The crowder rack is located at the downstream end of the holding pool. The top portion of the crowder rack consists of a platform with four wheels that ride along two metal rails that run lengthwise on the top of the holding pool walls. Metal handlebars mounted to either end of the crowder rack are used to manually push the crowder rack back and forth in the holding pool. The lower part of the crowder rack consists of two screen panels made of metal frames with 1" metal tubing running vertically within the frames. The metal tubes are spaced approximately 1" apart. The bottom of the two panels is raised and lowered mechanically via a chain driven by a Rotork actuator. This allows operators to control when fish pass through or to block them in when crowding in the holding pool occurs. The floor brail is a 10' by 8' metal basket consisting of 1" tubing spaced out approximately 1" apart. The floor brail sits in the upstream half of the holding pool and is raised and lowered by two steel threaded stems that are mechanically driven by a Rotork actuator. The floor brail is used to crowd fish towards the surface of the pool when staff are ready to collect fish and transfer them to a workup tub.

The mechanized components of the collection facility are operated from a control panel mounted in a cabinet located on the northeast corner of the collection facility. The controls are connected to the actuator of the crowder rack, floor brail, and traveling trash rack, providing power and a user interface. The two LOPAC gates and slide gate are operated via corded hand drills. Both LOPAC gates are operated via a drive nut and ball valves. The LOPAC gates open or close depending on which way the drive nut is spun, and which ball valves are opened or closed. The slide gate opens and closes via an operator nut that is rotated with a corded hand drill.

Although the facility is intended to be operated during a wide range of river and bypass flow conditions, the area it is in is still subject to flooding when the Fremont Weir overtops during high Sacramento River flows. As such, several of the components of the facility are removable, including: the Rotork actuators for the crowder rack, floor brail, traveling trash rack, and control cabinet. While these components need to be removed before overtopping events, the rest of the facility can remain in place. This enables trapping to begin quickly after flooding recedes.

The facility's flexibility, and ability to be operated under a wide range of flow conditions, allow for safer and easier fish salvage operations than using temporary trapping methods.

Methods

Facility Procedures – Salvage operations at the facility started on January 23, 2023. The dual leaf solid panel LOPAC gates, screened panel LOPAC gates, slide gate, and crowder rack gate

were opened with the floor brail in the fully lowered position. While the facility was fishing, the crowder rack was left on the downstream end of the holding pool with the gate open, allowing fish to swim into the holding pool and access the floor brail. The upstream Waterman gate at the intake pool was fully opened to allow flow through the facility.

Environmental data were measured and recorded prior to checking the facility. Water velocity (cubic feet per second) going into the facility was measured using a Global Water flow probe. Water samples were taken upstream of the facility for measuring turbidity. Water temperature (degrees Celsius) and dissolved oxygen (milligrams per liter) were measured in the holding pool using a YSI temperature/dissolved oxygen meter.

Once environmental data were recorded, staff would close the gate on the crowder rack and push the crowder upstream in the holding pool until it became flush with the downstream edge of the floor brail. This concentrated fish in the holding pool above the floor brail. Once the crowder was pushed into position, the floor brail was lifted until the top of the brail was visible. If fish were present, the screened panel LOPAC gate and slide gate were closed, hydraulically sealing the holding pool from the entrance pool, and blocking any other fish from entering the holding pool. After closing the gates, the holding pool was filled with water using the upstream Waterman gate until the water level in the holding pool equalized with the water level in the KLRCS. Then a diesel-powered water pump was used to fill the holding pool, and the floor brail was raised to the surface to allow for easy capture of fish. Fish were netted out using large D-ringed dip nets and salmonids were transferred to a 150-gallon (568 liter) workup tub to be processed. The workup tub was filled halfway with water from the KLRC and approximately 50 milliliters of API stress coat for every 3.8 liters of water. All bycatch were identified to species, enumerated, and returned to the KLRCS, next to the facility.

Salmonids were identified to species, examined for any external markings or tags (adipose fin clips, Floy tags, etc.), measured to fork length to the nearest 0.5 centimeter, and examined for sex. Two external t-bar anchor tags marked with individual four-digit ID numbers and a contact phone number were implanted into the muscle tissue behind the dorsal fin. A subset of Chinook salmon was implanted with a HDX23 passive integrated transponder (PIT) tag. All salmonids were sampled for genetics via a fin clip from the upper lobe of the caudal fin. Genetic samples were stored on filter paper and placed inside individually labeled sample envelopes. After salmonids were measured, tagged, and sampled for genetics, they were evaluated for Reflex Action Mortality Predictors (RAMP) (Davis, 2010). RAMP scoring has been used by other researchers as an early indicator of stress and predictor of delayed mortality by testing five reflexes:

Tail grab – If fish respond to handlers grabbing the tail by bursting forward. No response gives a score of 1.

Body flex – If fish attempts to struggle free of handlers grip when held out of the water with both hands around the center of the fish's body. No struggling gives a score of 1.

Vestibular-ocular response – If the fish's eye rolls to track the handler when rolled on its side out of the water. Eye not rolling to track handler gives a score of 1.

Head complex – If fish are exhibiting a regular pattern of operculum ventilation when held above the surface of the water. If fish are not ventilating or if ventilation is highly irregular, gives a score of 1.

Orientation – if fish right themselves within 3 seconds after being turned upside down in the water. Fish not rolling over within 3 seconds gives a score of 1.

One point for any of the five reflex tests indicated impairment of that reflex. The higher the score, the more impaired the fish was. Higher scores are also likely to lead to delayed mortality post release. If there was doubt as to whether a reflex was impaired or not, it was assumed that the reflex was impaired, and a point was given. If fish were vigorously struggling to the point where the handler could not control the fish, it was assumed that the fish's reflexes were not impaired and a total RAMP score of 0 was given.

After processing was complete, salmonids were transferred from the workup tub to a trailer mounted 400-gallon transport tank. The transport tank was equipped with two water recirculators and air stones hooked up to oxygen tanks to maintain dissolved oxygen levels while fish were in transit. The transport tanks were filled approximately 3/4 of the way full and API stress coat was added to the water in the same amount as the workup tub. A maximum of 12 fish were loaded into the transport tank at a time. Fish were transported to the Elkhorn Boat Launch on the Sacramento River, approximately 1.8 km downstream of the I-5 bridge. Dissolved oxygen inside the transport tank as well as in the river at the release point were measured and recorded. Temperatures between the transport tank water and river water needed to be within 2 degrees Fahrenheit for fish to be released. If the difference in water temperature was greater than 2 degrees, the water in the transport tank was acclimated to the river water by slowly removing water from the tank and adding river water to the tank. Once the difference between the two water temperatures was less than 2 degrees, the transport tank was backed down the boat ramp into the water and fish were released out of the back of the tank via a slide gate.

Results

Facility Operations - The facility was fished for 2893 hours during the 2022-2023 season. Trapping operations started on January 23 and ended on June 9, 2023. Trapping this season started later than previous seasons due to both low and high flow conditions leading up to the start date. Sensitive mechanical equipment such as the floor brail, crowder rack and trash rack motors, and the controls inside of the control panel cabinet were removed to avoid flood damage during an overtopping event at Fremont Weir on March 15, 2023. During the last trap check before the equipment was removed, as the floor brail was being lifted in the holding pool to check for fish, the threading on a large brass nut inside of the Rotork actuator that raises and lowers the floor brail stripped out. This caused the stem to slide out of the actuator and leave

the floor brail uneven and inoperable. A replacement nut was installed on March 30, 2023, and trapping continued at the facility.

Environmental Conditions - Mean weekly flows in the KLRC ranged from 4 cfs (week 21) to 2204 cfs (week 4) (Figure 5 and Table 1). Mean weekly water temperatures at the facility ranged from 7.9°C (week 9) to 23.4°C (week 20) (Figure 5 and Table 1). Mean weekly dissolved oxygen levels in the facility ranged from 5.8 milligrams per liter (week 21) to 13.5 milligrams per liter (week 8) (Table 1). Mean weekly turbidity ranged from 21.0 NTUs (week 8) to 177.4 NTUs (week 4) (Table 1).

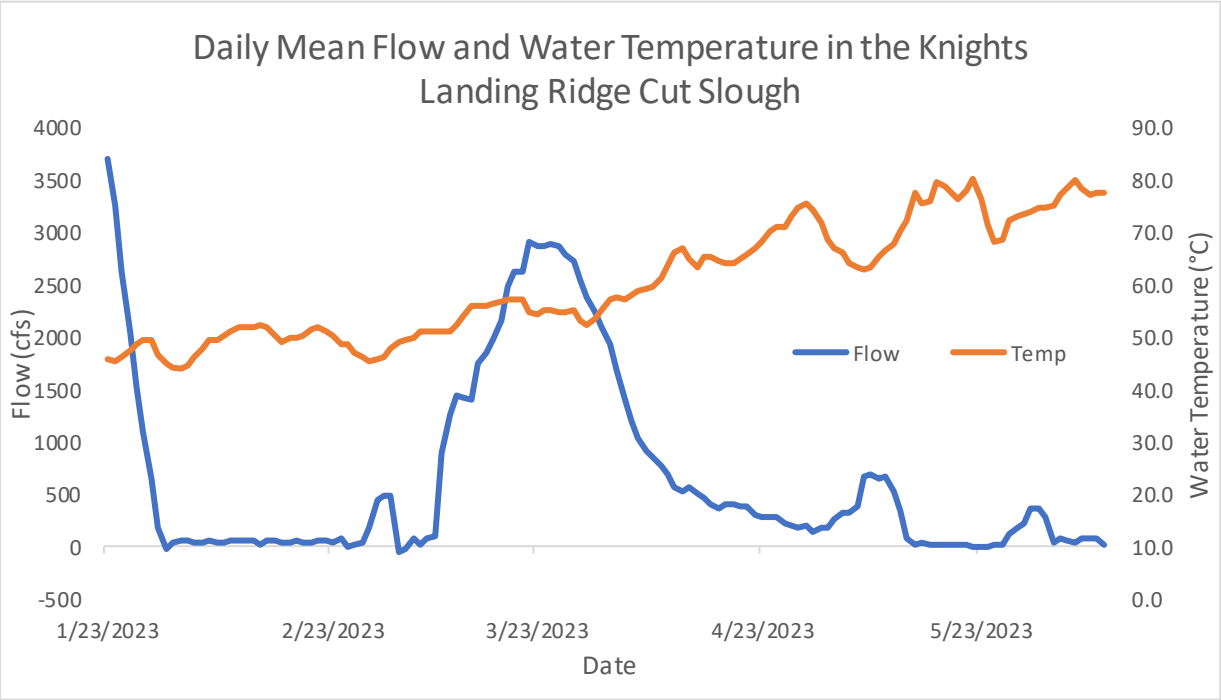

Figure 5. Mean weekly water temperatures (in degrees Celsius) and flow (in cubic feet per second) measured at the Wallace Weir Fish Collection Facility during the sampling season (Julian week 4 to 23). Water flow was reported by CDEC, Ridge Cut Slough (RCS) gage in cubic feet per second.

Table 1. Weekly average turbidity, dissolved oxygen, flow in the KLRCS, and water temperature, measured at the facility.

Julian Week	Flows (cfs) @ RCS	Water Temp (˚C)	Turbidity (NTU)	D.O. (mg/L)
4	2204	8.7	177.4	12.9
5	147	8.2	91.7	10.8
6	47	9.0	58.6	8.8
7	47	9.3	32.9	10.3
8	62	9.5	21.0	13.5
9	223	7.9	26.2	13.4
10	359	9.5	91.3	12.0
11	1578	11.8	164.3	10.3
12	N/A	N/A	N/A	N/A
13	2155	11.9	90.0	10.9
14	1311	13.9	55.7	9.9
15	613	16.8	28.6	9.2
16	389	18.1	31.5	11.9
17	233	21.9	35.3	9.0
18	246	19.4	62.5	7.0
19	550	18.8	73.7	7.8
20	13	23.4	31.3	6.6
21	4	22.1	60.6	5.8
22	303	22.5	70.2	7.0
23	45	23.3	55.3	6.9

Fish catch – During the 2022/2023 season, a total of 754 fish were caught at the facility. The catch was comprised of 21 confirmed species, 5 of which were native (Table 2). Due to the high volume of water being released through the water control structure of the weir this season, the fish screens in each of the bays were raised to block fish passage as much as possible. While the screens block upstream passage, fish have also been known to be entrained on the upstream sides of the screens due to high water velocities pinning them down. Staff would inspect the screens, identify, and enumerate the fish trapped on the screens to the best of their abilities (Table 3). Accurate identification and enumeration of these fish was difficult at times since the only way to safely view them was from a catwalk located directly above the screens. Counts were only made when staff were present for trap checks, so the number of fish observed on the pickets does not necessarily represent all fish that may have been entrained on the screens.

Table 2. Total catch of all fish species at the Wallace Weir fish collection facility for the 2022/2023 season. *California native fish species.

Common Name	Scientific Name	Number Caught at WW
American Shad	*Alosa sapidissima*	2
Black crappie	*Pomoxis nigromaculatus*	15
Bluegill	*Lepomis macrochirus*	3
Brown bullhead	*Ameiurus nebulosus*	12
Bullhead	*Ameiurus sp.*	1
Common Carp	*Cyprinus carpio*	155
Channel catfish	*Ictalurus punctatus*	81
Chinook salmon*	*Oncorhynchus tshawytscha*	5
Crappie	*Pomoxis spp.*	1
Goldfish	*Carassius auratus*	12
Largemouth Bass	*Micropterus salmoides*	22
Sacramento pikeminnow*	*Ptychocheilus grandis*	40
Red ear sunfish	*Lepomis microlophus*	1
Sacramento sucker*	*Catostomus occidentalis*	19
Smallmouth Bass	*Micropterus dolomieu*	17
Sacramento splittail*	*Pogonichthys macrolepidotus*	295
Spotted bass	*Micropterus punctulatus*	5
Striped bass	*Morone saxatilis*	2
Tule Perch*	*Hysterocarpus traskii*	1
UNID bass	*Micropterus sp.*	5
UNID catfish	*Ictalurus sp.*	4
UNID crappie	*Pomoxis sp.*	2
UNID sculpin	*Cottus sp.*	1
Warmouth	*Lepomis gulosus*	3
White catfish	*Ameiurus catus*	50

Table 3. Approximate counts of fish observed entrained on the upstream side of the picket weirs of the water control structure throughout the 2022/2023 season. *California native species.

Common Name	Scientific Name	Number on pickets
Largemouth bass	*Micropterus salmoides*	5
Smallmouth bass	*Micropterus dolemieu*	3
Channel catfish	*Ictalurus punctatus*	16
Chinook salmon*	*Oncorhynchuys tshawytscha*	1
Common carp	*Cyprinus carpio*	1209
Black crappie	*Pomoxis nigromaculatus*	16
Golden shiner	*Notemigonus crysoleucas*	1
Goldfish	*Carassius auratus*	19
Sacramento pikeminnow*	*Ptycocheilus grandis*	58
Sacramento splittail*	*Pogonichthys macrolepidotus*	1439
Sacramento sucker*	*Catostomus occidentalis*	80
Striped bass	*Morone saxatilis*	1
Warmouth	*Lepomis gulosus*	1
Unidentified catfish	*Ictalurus sp.*	18
Unidentified crappie	*Pomoxis sp.*	11
Unidentified sunfish	*Lepomis sp.*	2

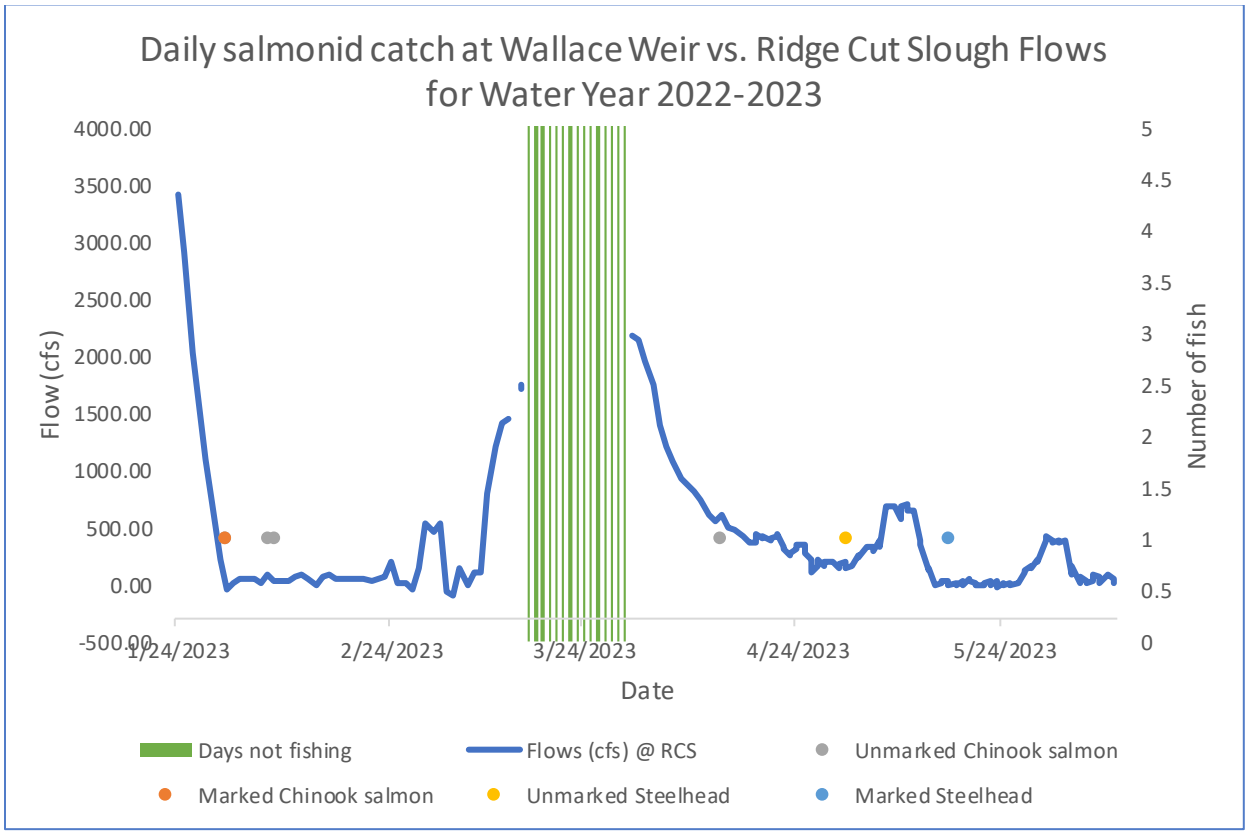

Figure 6. Daily total salmon catch for trapping below Wallace Weir and daily flows recorded on CDEC at time of trap check on the Ridge Cut Slough at Knights Landing gauge for water year 2022 – 2023. River flows reported by CDEC, Ridge Cut Slough at Knights Landing (RCS) and reported in cubic feet per second (cfs).

Salmonids – A total of 5 live Chinook salmon (1 adipose fin clipped, 4 adipose intact) were captured in the facility and one Chinook salmon mortality was observed on the upstream side of the picket weirs during the 2022/2023 season, along with 2 steelhead, one adipose intact and one adipose fin clipped (Table 4). One adipose fin clipped Chinook salmon released from the facility was captured post release (Table 5). Genetic analysis of tissue samples collected from the Chinook salmon showed there were 4 winter-run, 1 spring-run and 1 late fall-run (Table 6). The first two Chinook salmon were captured on January 31, 2023, one of which was the only adipose fin clipped salmon captured in the facility this season. The next two salmon came on February 6 and 7. The last salmon was captured in the facility on April 13 (Figure 6 and Table 7). All 5 Chinook salmon were tagged with two floy tags and a PIT tag. The Chinook salmon mortality was observed on the upstream side of one of the picket weirs of the water control structure on May 31, 2023 (Table 4 and 7). A coded wire tag was recovered from this fish and read. The tag code showed this fish was a San Joaquin Hatchery origin spring-run from brood year 2020 (Table 8). The two steelhead were captured in the facility on May 1 and 16, 2023, the first of which was adipose intact and the second adipose clipped (Figure 6 and Table

7). The steelhead captured on May 1 was first observed in the holding pool of the facility but was small enough to slip through the floor brail and crowder rack bars. Similarly, the second steelhead captured on May 16 was initially observed in the holding pool on May 15 and was small enough to swim between the bars of the crowder rack and floor brail. The first steelhead measured 28 cm fork length. Although the second steelhead was not measured to reduce handling stress under high water temperatures, it appeared to be of similar size to the previous fish.

Table 4. Total catch and recovery of mortalities of adipose fin intact adipose clipped and unknown status of adipose fin Chinook salmon and steelhead at and below the Wallace Weir collection facility between January 23 and June 9, 2023.

	Chinook Salmon Total	Chinook Salmon (Adipose Fin Intact)	Chinook Salmon (Adipose Fin Clipped)	Steelhead Total	Steelhead (Adipose Fin Intact)	Steelhead (Adipose Fin Clipped)
Alive	**5**	4	1	**1**	1	1
Mortalities	**1**	0	1	**1**	0	0
Grand Total	**6**	4	2	**2**	1	1

Genetics – Genetic samples taken from the 5 Chinook salmon captured in the facility showed there were 4 winter-run and 1 spring-run Chinook (Table 4). The Chinook salmon mortality collected from the picket weir was also sampled for genetics and analyzed. The sample came back as late fall-run, though the CWT extracted from this fish indicated it was a San Joaquin Hatchery origin spring-run.

Post release recoveries – One adipose fin clipped Chinook salmon captured at the facility on January 31, 2023, was recaptured post release. The recapture occurred on April 25, 2023, at the Keswick trap on the Sacramento River. This fish was kept for brood stock spawning (Table 5).

Table 5. Recovery date and location of floy tagged Chinook salmon released on the Sacramento River from the facility during the 2022/2023 season.

Tag & release date	Recovery Date	Species	Recovery time (days)	Recovery Condition	Recovery Location	Disposition
1/31/2023	4/25/2023	Chinook salmon	84	Alive	Keswick trap, Sacramento River	Brood stock

Table 6. Summary of run-assignments based on genetic analysis of Chinook salmon caught at and below the Wallace Weir collection facility.

Run Assignment	2022/2023 Season
Fall	0
Late Fall	1
Winter	4
Spring	1
Total	**6**

Table 7. Chinook salmon observed at Wallace Weir and associated capture dates, release location and biological information.

Date	Species	Fork length (cm)	Ad clip?	Sex	Release location	Mortality
1/31/2023	CS	76.5	Y	U	Elkhorn Boat Launch	N
1/31/2023	CS	70.5	N	U	Elkhorn Boat Launch	N
2/6/2023	CS	73.5	N	U	Tisdale Boat Launch	N
2/7/2023	CS	78.0	N	U	Elkhorn Boat Launch	N
4/13/2023	CS	63.5	N	F	Elkhorn Boat Launch	N
5/1/2023	SH	28	N	U	Elkhorn Boat Launch	N
5/16/2023	SH	N/A	Y	U	Fremont Weir	N
5/31/2023	CS	75	Y	F	N/A	Y

Table 8. Coded wire tag (CWT) information from the Chinook salmon mortality recovered from the upstream side of the picket weirs on May 31, 2023.

CWT #	Recovery Date	Hatchery of Origin	Run	Brood year	Release year
061810	5/31/2023	San Joaquin River Conservation Hatchery	Spring-run	2020	2021

RAMP Scores- The 5 Chinook salmon captured in the facility during the 2022/2023 season were evaluated for a RAMP score. Three of the five salmon had a RAMP score of 0, indicating no impairment to any of the tested reflexes, while the other two scored a 1 and a 2. Both of those fish were scored for the tail grab test, while the fish scoring 2 also scored for the body flex test (Table 9). None of these fish were recovered post release from the facility.

Table 9. Total count of Reflex Action Mortality Predictor (RAMP) scores of Chinook salmon caught at and below the Wallace Weir collection facility.

Total RAMP Score	Number of Fish
0	3
1	1
2	1
3	0
4	0
5	0
Grand Total	**5**

Discussion

The 2022/2023 trapping season was unprecedented due to the extreme environmental conditions observed on site. At the time of the normal start date for the trapping season, the KLCR was completely dry upstream of Wallace Weir. The KLRC then became inundated by high flows starting in December and conditions at the facility were not safe to operate equipment until late January. Due to these extreme conditions, the start of the trapping season was delayed. With such high flows observed throughout the valley during the late winter and early spring of this year, this presented an opportunity for carrying out trapping operations at the facility while flows were released through the water control structure of the weir. Although this would not be the first-time trapping at the facility has occurred with a substantial amount of flow through the water control structure, it has not occurred at this magnitude or during this time of the year.

Like the 2021/2022 trapping season, a relatively small number of salmonids was captured this season. For both seasons during the migration window for adult Central Valley fall-run Chinook salmon, conditions in the bypass were not conducive to fish passage and/or trapping at the facility. Both were the case this season as the Central Valley was experiencing severe drought conditions until December 2022, leaving the KLRC upstream of Wallace Weir completely dry, and subsequent rain events caused high flows in the CBD and bypass to flood the surrounding areas of the facility. In prior years where trapping occurred during the fall-run migration timing, salmonid catch was as high as 827 fish (unpublished data). Considering Central Valley fall-run Chinook salmon are the most prolific of the four runs in the valley, it stands to reason that salmonid capture is greatly reduced when trapping does not occur, or passage conditions are impaired during that run timing.

The ability to operate the facility during high flow and flooding events provided further insights into how capture rates of salmonids are affected. Flows from the CBD and Fremont Weir overtopping inundated the KLRC during the late winter and early spring, elevating flows in the

KLRC to over 4500 cfs. Due to the flooding risk and concern for staff safety at the facility, trapping operations at the start of the season were delayed until the flooding from the Fremont Weir overtopping was forecasted to stop. As a result, the highest flows observed in the KLRC while trapping occurred was 3414 cfs. During this time, it was expected that attraction flows from the KLRC going into the CSC would be high enough to draw adult salmonids towards the facility. However, after observations from trapping during a high flow event as observed during the first season of using the facility in the KLRC, it was postulated that salmonids may not actually be captured in the facility, but instead key in on the flows coming from the water control structure of the weir (Kilgour and Kubo, 2022). The maximum flow rate of the facility is only 50 cfs compared to the 4000 cfs coming from the weir. During high flow events through the water control structure and overtopping events at Fremont Weir, water velocity seems to be slowed due to a backwatering effect at the entrance of the facility, further muting the attraction into the facility. Chinook salmon were not observed in the facility this season until flows from the CBD and Fremont Weir overtopping subsided and the water control structure ramped down flows (Figure 6). Although the facility provides a means of carrying out fish salvage operations during high flow events, successful capture of salmonids during these high flows is not guaranteed.

High volume flow releases through the water control structure of the weir present other issues such as entrainment of resident fishes in the area. The picket weirs that are raised in each of the bays of the water control structure, meant to block upstream fish passage, also act as a strainer for any debris moving downstream from the CBD, including fish. As fish approach the upstream side of the picket weirs, the water velocity is too high for them to avoid entrainment and they are then pinned to the pickets and will perish unless they are flushed off. Regular maintenance activities performed by Reclamation District 108 include regular lowering of the picket weirs to flush off debris and fish. However, there are opportunities for salmonids to swim through the water control structure and upstream of the weir, so the number of flushes in a day had to be limited to minimize upstream passage opportunities. The depth at which the pickets were lowered to be flushed was also difficult to control and often had to be done manually. Unfortunately, this led to an accumulation of fish entrained on the upstream side of the screens and subsequent mortalities. A possible solution for this issue includes programing more frequent flush cycles of the pickets and shallower pre-set depths at which they lower that would allow for debris to still be flushed while minimizing the time the pickets are lowered and upstream passage opportunities for fish.

The two steelhead observed in the facility were relatively small compared to other steelhead captured at the facility or in temporary traps in the KLRC. The one measured steelhead had a fork length of 28 cm, and the second one, although not measured, was similar in size. On April 28, 2023, the Adult Fish Passage (AFP) structure was opened to allow volitional passage for fish through Fremont Weir and out of the bypass that had possibly been stranded in the deep pond or other parts of the bypass after the declining limb of the hydrograph from the previous overtopping event. Considering both steelhead were relatively small, they were likely smolts

from a previous hatchery release upstream and came through the AFP down into the bypass and turned into the KLRC as opposed to swimming upstream from the CSC into the bypass.

Due to the small size of the steelhead, capture of these fish was made quite difficult as they could fit between the gaps in the bars of the floor brail and crowder rack. During the initial crowding and raising of the floor brail, both fish swam between the gaps in the bars before the floor brail reached the surface of the holding pool. Both fish were finally captured with a long-handled dip net and upon the first check for fish in the holding pool, before it was filled completely with water and the floor brail being raised to the surface. Capture of salmonids this small is infrequent at the facility but has now been proven possible during events such as the AFP structure being opened to allow for volitional passage of adult fish out of the bypass. While this may not happen every time AFP is open, it may be a likely occurrence, depending on the timing, especially if the opening of the structure follows a hatchery release or coincides with juvenile downstream migration. To prepare for this in the future, mesh material will be installed on the surfaces of the floor brail and crowder rack to reduce the size of the gaps between the bars on each structure.

RAMP scores for the Chinook salmon captured in the facility this season ranged from 0 to 2 out of a possible 5. Of the five fish evaluated for a RAMP score, one was recovered post release. This fish received a RAMP score of 1 on the tail grab test. Only one other fish scored on the tail grab test, along with the body flex test, but was not recovered. The other three fish tested scored zero for all tests and were also not recovered. Although the percentage of fish captured this season was relatively high compared to other seasons overall, the number of recovered fish identified as winter-run via genetic analysis remains somewhat consistent. It is still uncertain if the total RAMP scores are truly indicative of post release mortality or if the likelihood of mortality is more weighted towards certain reflexes. There may be other underlying factors preventing post release recovery such as tag shedding, predation, or lack of detection. A larger sample size is needed to fully understand the lack of recoveries.

Before the salmon was recovered from the pickets, flows in the CBD upstream of Wallace Weir increased, raising the stage height. To minimize flooding in the CBD, both the Knights Landing Outfall Gates (KLOG) and the water control structure at Wallace Weir were opened to drain water out into the Sacramento River and downstream into the KLRCS, respectively. Although there are fish screens on the downstream side of both structures to block fish passage upstream while flows are being released, both need to be periodically flushed to reduce the build-up of debris and minimize the risk of damage occurring to the structure. The fish screens are temporarily submerged under the surface of the water at varying depths, depending on the amount of debris. As such, the flushing of the screens likely provided passage opportunities at both structures for this salmon to get through. At the start of the flow releases from KLOG, the water surface elevation of the Sacramento River on the downstream side of KLOG was higher than the retaining walls of the outflow gates and fish screens. Even if the screens had been

kept up in the full upright position, fish could have potentially swam over the retaining walls and screens to get through the gates.

During the trap check on March 15, 2023, before the equipment at the facility was removed to prepare for a possible overtopping event, the nut inside of one of the Rotork actuators that drives the floor brail stems up and down failed due to the threading being stripped out. This issue has occurred during past trapping seasons (Diep and Kubo, 2023), though the cause of it this season is unknown. Each of the Rotork actuators have custom made parts that vary in size and other specifications, making fabrication of extra parts a potentially long and expensive process. Fortunately, a spare nut had already been made from the previous year after this same failure occurred, which greatly expedited the repair process, though flooding from the recent Fremont Weir overtopping event had delayed the installation process, along with sending in the already existing spare part to be measured and replicated by a vendor. The facility was inoperable for 30 days when this occurred during the 2021/2022 season, and 15 days this season. Having the exact specifications of the parts in the actuator will make future repair work for this piece of equipment much easier and faster, though it will not make it less susceptible to such malfunctions.

The early season flooding provided opportunities for trapping under high flow conditions that have otherwise been avoided in previous seasons with temporary traps. Although we were able to carry out trapping operations under such conditions, the facility seems less effective at capturing salmonids due to the flow distribution between the water control structure and the facility. Flooding conditions and extreme drought can both render the facility less effective at capturing salmonids or completely inoperable depending on the severity, with the former seemingly becoming a more regular occurrence from season to season. Repairs to the facility were carried out much faster than before, but this does not change the design aspects of the equipment nor reduce the risk of the same equipment malfunctions happening in the future. Repairs and upgrades to the facility are scheduled for this summer and fall that will hopefully minimize malfunctions and provide a more user-friendly interface. As observed in the previous trapping season, very few salmonids were captured in the facility and fewer recovered post release, despite relatively low RAMP scores. Thus, questions regarding the actual success rate of fish released from these salvage efforts and the cause behind the lack of post release recoveries remain unanswered.

References

California Department of Water Resources Data Exchange Center, Ridge Cut Slough at Knights Landing. 2023. https://cdec.water.ca.gov/dynamicapp/QueryF?s=rcs

Davis, M.W. 2010. Fish stress and mortality can be predicted using reflex impairment. Fish and Fisheries 11: 1-11.

Diep, W., and H.S. Kubo, 2023. Wallace Weir Fish Trapping and Relocation Efforts. California Department of Fish and Wildlife; 6/26/2023.

Gahan, G., M. Healey, C. McKibbbin, H. Kubo and C. Purdy. Colusa Basin Drain and Wallace Weir Fish Trapping and Relocation Efforts. California Department of Fish and Wildlife; 1/23/2017.

Kilgour, M., and H.S. Kubo, 2022. Wallace Weir Fish Trapping and Relocation Efforts. California Department of Fish and Wildlife; 1/5/2022.

Quinn, T.P. (1984). Homing and Straying in Pacific Salmon. In: McCleave, J.D., Arnold, G.P., Dodson, J.J., Neill, W.H. (eds) Mechanisms of Migration in Fishers. NATO Conference Series, vol 14. Springer, Boston, MA. http://doi.org/10.1007/978-1-4613-2763-9_21