Lower Putah Creek

Gravel Bed Scarification

Final Report (Amended)

April 30, 2021

Prepared for:
Richard Marovich
Putah Creek Streamkeeper

Prepared By:

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Amendments to Original Report
(Per Request from CDFW and others)

Amendment #	Request	Page
1.	Map of Scarification sites	47 & 48
2.	Tables identifying gravel scarification sites and whether salmon spawned in response to scarification.	50 - 86
3.	Data on Turbidity during Scarification	88
4.	Benthic Macroinvertebrate survey discussion	93-97 & 99
5.	Results from 2020 Salmon Run (without scarification immediately prior to the run)	98

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12-21-2018: Several bald eagles were feeding daily on salmon carcasses. The eagles were on site for about two weeks.

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April 30, 2020 (Note: Report amended April 30,2021)

To: Richard Marovich
Putah Creek Streamkeeper

Subject: Final Lower Putah Creek Gravelbed Scarification Report

Full Disclosure: This report does contain some opinions about scarification and gravel resources in Lower Putah Creek (LPC) that are contrary to impressions expressed by others. Unfortunately, some recommendations and opinions, have in my opinion, negatively affected the course of restoration in Lower Putah Creek. Without any doubt, gravelbed Scarification has been the most effective and economical project relative to increasing the salmon population and the overall restoration of Lower Putah Creek.

In all cases, I have provided observations, subsurface video footage, images, or background information to support my opinions. In some cases, I have provided direct quotes from papers that have been proved especially wrong or expressed opinions that have been demonstrated to be unsupported by factual or scientifically proven data. Considering the history and nature of the Lower Putah Creek salmon runs, it is my opinion that we must remember that good science must reign, not just opinions without documentation.

In most cases, my observations and supported opinions are expressed to assist the Streamkeeper in making management decisions.

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TABLE OF CONTENTS

U.C. Davis researcher with large male Chinook carcass during the 2016 salmon run.

Executive Summary

On December 12, 2004, while conducting New Zealand mudsnail surveys near Yolo Housing, I observed several salmon "spawning" in an area that was somewhat consistent with other areas of Lower Putah Creek (LPC). The salmon succeeded in moving some cobble, only to expose benthic areas that were claypan and / or embedded gravel. The salmon eggs proceeded to roll downstream. Benthic macroinvertebrate (BMI) populations were also affected by the embedded cobble which prevented them from seeking safe harbor within interstitial spaces. The open gravel is necessary for BMIs to thrive in conditions that are otherwise acceptable. While my concern was more for the aquatic invertebrates than salmon, watching the large fish certainly peaked interest in the embedded condition of the Lower Putah Creek streambed. Unfortunately, existing studies, literature and opinions at that time were misleading and contrary to the actual conditions in LPC. One report, (Yates 2003), that possibly affected management decisions, surveyed the gravel resources, by digging down only 6 inches and testing the suitability for salmon spawning by:

> *"...a hydrographer firmly swishing his hand (fingers pointed down) back and forth close to the gravel surface, mimicking the hydraulic effect of a fish tail."*

The Yates study apparently had impact on other work concerning the gravel resources and viability for salmon spawning in Lower Putah Creek. One was grossly misleading with citations such as:

> *"Gravel is a limiting resource in Putah Creek for salmon; it occurs in only small patches and is often only a thin veneer over the underlying clay (Small 2004).*

Interest in scarification was motivated by the presence of thousands of juvenile salmon in May 2013 and during the 2013 salmon spawning period when 8 salmon spawned (caught on subsurface video) downstream of the Pickerel W-weir. A section (12 x 30 feet) downstream of the weir had been "scoured" by the water action going through the weir. The "naturally scarified" gravelbed and the flow regime was perfect for the migrating salmon.

More recent and complete surveys undertaken by SCWA staff have shown that Lower Putah Creek has copious deposits of gravel and cobble that are ideal for Chinook salmon. In some areas gravel beds are 5-6 feet deep. Initial scientific surveys concerning sand and silt "cementation" of those gravel beds, and the impacts on benthic macroinvertebrates, were conducted beginning in 2006 after the Dry Creek Realignment (Davis 2007). That work was not directly concerned with salmon spawning.

Cross section of large chuck of embedded gravel. Note the layers of small gravel (top), a layer of gravel, and a thick layer of sand and fines. Collected from a section of Lower Putah Creek in an area that is plagued by embedded and cemented gravel.

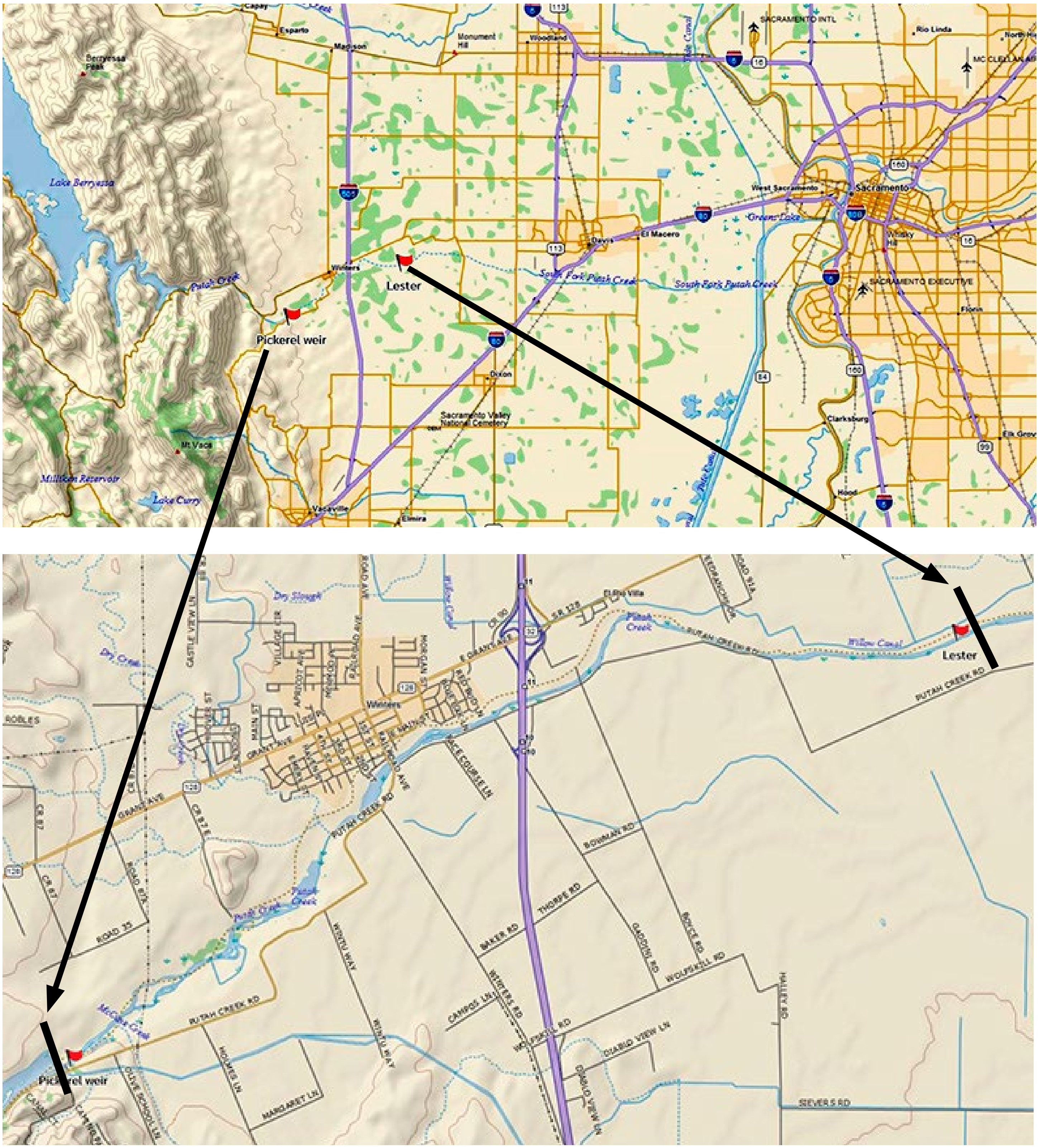
The work on mechanical scarification for improving and / or developing salmon spawning beds was started on May 5, 2014 when a SCWA operator provided an on-site demonstration for two CDFW biologists. That year, we scarified 4 (four) sites prior to arrival of spawning salmon (Davis 2014). A report is attached to this document.

A more formal project was initiated in 2015 when 500+ salmon used the scarified beds for spawning. In the following years, scarified sites supported as many as 2000 spawning salmon. Unfortunately, scarification efforts have been impacted by three successive years of wildfires in the Putah Creek watershed that were responsible for tons of tainted sediment and sand that covered scarification sites. In addition, two high-water events carried tons of additional sand and other material into the scarification study areas. Despite the aforementioned impacts, it has been proven that the scarification project provides ideal areas for Chinook salmon entering Lower Putah Creek. Of the project's Success Criteria the "Use of Scarification Sites by Salmon" and "Salmon Enlarging the Scarification Sites" are probably the most significant. The results show that between 2014 and 2019, 89 -100% of spawning salmon used scarification areas.

The source of the spawning salmon (natal or stray) remains to be answered. That question, in my opinion, is mute as in either situation we are providing spawning areas for migrating salmon and resident trout. In spite of the unanswered questions, public support is strong for the return of the Chinooks to Lower Putah Creek. It is prudent that we remain diligent in the effort to support and protect the migrating salmon.

Failed 2004 salmon spawning site near Yolo Housing. Salmon moved a single layer of cobble and gravel exposing a thick layer of claypan. Salmon eggs were rolling downstream unprotected. Redds noted with yellow arrows.

Lower Putah Creek - Scarification Project Work Area



Scarification process prior to the 2016 salmon spawning season. Using expert operators, riparian damage is minimal. A biologist is always on-site before and during the process to watch for wildlife. Image Ken W. Davis.

Embeddedness:

Streambed embeddedness is a condition best understood by those who measure communities of benthic macro-invertebrates. Having to enter a waterway and dig your hands into the benthic gravel will quickly determine the amount of open, loose gravel versus a loose veneer of surface gravel and a hardened layer of cobble, and fines below. In severe cases it is impossible to dig out larger cobble with your hands or with small hand tools.
Gravel beds can appear healthy from the bank, when in fact the gravel bed can be essentially cemented in place. As outlined below, the scientific literature is replete with descriptions of embeddedness with no appreciable suggestion(s) about how to cure or correct the condition. The quote below from Sennatt (2008) reveals the scientific confusion about embeddedness and even its measurement:

> *"Embeddedness is a seemingly simple concept regarding the degree of streambed sedimentation. Waters (1995) defines it as the percent saturation of interstitial spaces. As Sennatt et al. (2006) point out, numerous studies have correlated the concept of high embeddedness with degraded benthic habitat and a decline in macroinvertebrates. However, measurement of embeddedness in the field has always been problematic (Sylte and Fischenich, 2002). Validated standard methods are lacking and there is no common precise definition of embeddedness. While embeddedness is generally defined as the ''degree to which fine sediments surround coarse substrates on the surface of streambeds'' (Sylte and Fischenich, 2002), most measurement techniques measure embeddedness as the depth of fines surrounding larger substrate while visual techniques tend to estimate the percentage of the streambed surface covered by fines. To further complicate the matter, the weighted Burns Quantitative (BSK) Method, combines an estimate of surface coverage with a measurement of embeddedness depth."*

Cementation:

Over time, the condition of "embeddedness" can turn to a condition that we call "cementation." When the streambed becomes cemented, it is even difficult for an excavator to break through the crust, and essentially impossible for benthic invertebrates or salmonids to use.

Causes of Embeddedness / Cementation:

The cause of the embedded condition appears to the settling of sand, silt, fines and other material. Cementation, from our observation is a more complex condition that is certainly understudied. We suspect a complex chemical reaction in water combined with fines and sand creates the cemented condition. This is similar to the formation of concrete using powdered cement, gravel and water.

Some important groups of benthic macroinvertebrates can only survive when the spaces between cobble particles are open and allow them to forage and seek harbor from predators such as trout and other predatory fish. Ken W. Davis

Impact(s) of Embedded Gravels on Macroinvertebrates (BMIs): The aquatic food web, and a significant portion of the riparian food web, are driven by the BMI community. The aquatic phase of BMI species are a primary food source for native fish, including trout and juvenile salmon. The adult phase of aquatic BMIs are a major food source for several avian species that nest along the banks of Putah Creek. Other wildlife are also affected. BMI communities are negatively impacted by cementation. Closed interstitial spaces, called embeddedness or in severe cases cementation, prevents sensitive BMI species from seeking safe harbor among the streambed cobble. Mechanical scarification opens up the interstitial spaces allowing BMIs to seek safe areas within the cobble spaces and avoid predatory fish.

Scarification demonstration site in 2014. Image shows line of embedded cobble that was opened by a medium-reach excavator operating from the bank. Image Ken W. Davis.

Impact(s) of Embedded Gravels on Spawning Salmon and Trout:
Benthic scarification significantly improved salmon and trout spawning areas as documented in 2014 - 2019. Spawning improved dramatically without additional water releases, other management actions, or at additional cost. While other factors, such as the Accord Flows and stray hatchery-born salmon are contributory to the number of salmon in the system, the spawning success is solely driven by the scarification projects. Since 2004, and prior to the scarification projects I observed sporadic attempts by a few salmon to construct redds in embedded conditions that were suboptimal. Additional water releases would have minimal or NO positive effect on the spawning salmon. The Accord Flows, while potentially important for salmon attraction did not increase the Chinook population in Lower Putah Creek between 2000 and 2013. Salmon straying from Central Valley hatcheries can only successfully spawn when gravelbed conditions allow the females to construct effective redds. That was not possible to any significant level prior to specific areas being scarified. Several studies of the gravel resources and viability for salmon spawning in Lower Putah Creek were grossly misleading with citations such as:

> *"Gravel is a limiting resource in Putah Creek for salmon; it occurs in only small patches and is often only a thin veneer over the underlying clay (Small 2004).*

Unfortunately another report (Yates 2003), which possible affected management decisions, surveyed the gravel resources, by digging down only 6 inches and testing the suitability for salmon spawning by

> *"...a hydrographer firmly swishing his hand (fingers pointed down) back and forth close to the gravel surface, mimicking the hydraulic effect of a fish tail."*

Fortunately, more recent and complete surveys have shown that Lower Putah Creek has copious deposits of gravel that are ideal for Chinook salmon. In some areas, gravel is 5-6 feet deep.

Open interstitial spaces between cobble is crucial to the protection and survival of salmonid eggs and alevin. Ken W. Davis

Impacts on Salmon Eggs and Alevin:
Open interstitial spaces between cobble particles allows water to flow through salmonid redds keeping eggs oxygenated. It also creates safe harbor for alevin (sac fry) until they emerge from the rocky nests. Alevin remain within a healthy redd for up to two months, or after utilizing the food resources within the egg sac. The embedded condition closes those spaces and prevents the survival of salmonid eggs and alevin. Of course, when the gravel is embedded, survival of alevin is a mute point because the adults can not successfully spawn.

Benefits of Scarification for Riparian Wildlife:
Scarified gravel beds can have positive impacts on salmon, trout, and benthic macroinvertebrates. An increase in aquatic invertebrate populations can be beneficial for riparian birds foraging and to feed growing chicks. Resident rainbow trout benefit from the massive number of salmon eggs and invertebrates attracted to decaying salmon carcasses. Fur-bearing wildlife, such as river otters, bobcats, and bear can directly benefit due to any increase in spawning salmon. Scavenging wildlife including bald eagles, mink, raccoons, and turkey vultures are attracted to the spawning beds in search of salmon carcasses. During smaller salmon runs, dead salmon are difficult to find (by survey biologists) possibly due to actions of scavengers. It appears that a certain number of carcasses, such as 200, are necessary for the scavengers to become satiated and begin leaving carcasses in the creek.

Female Tree Swallow with a beak full of mayflies to feed her chicks. She caught the mayflies over the creek and riparian interface. Image Ken W. Davis.

Wildfire and High-water Impacts to Lower Putah Creek:

Since 2015, Lower Putah Creek has endured numerous impacts that include five wildfires and two high-water events. Tons of sediment and wildfire dregs have inundated spawning beds. For example, the Harris Control scarification site was covered with three feet of sand after the 2017 high-water event. Likewise, the upstream wildfires and subsequent runoff carried copious amounts of burnt material and sediment that corresponded with a dramatic increase in New Zealand Mudsnail (NZMS) density. See photos on Page 14 and 15. The impact(s) were potentially tripled by copious amounts of wildfire residue, an increased density of filamentous algae and a dramatic increase of the NZMS population.

Long-term Upstream Sediment Issues:

Several tributaries to Putah Creek are highly incised and slough significant amounts of sediment into Lower Putah Creek. See Pleasant Creek image on page 15.

Scarification Site Selection - Discussion:

Site selection is based on areas with significant gravel deposits, ease of access, landowner cooperation, riparian conditions, width of channel, flow regime, former studies, known salmon spawning areas, canoe survey data, and visual streamside examination. CDFW Agreement No. 1600-2016-0058-R3 (Weightman 2016) allowed for 13 sites to be scarified per year. Typically, we select 16 sites, of which only 13 are scarified. Three backup sites were chosen in the event that unknown circumstances would exclude one or more of the original sites from the project.

3-15-2016 image: Sediment and wildfire dregs from the Wragg fire near Lake Berryessa. In some areas, the sediment bank was 6 feet deep. Image Ken W. Davis.

April 5, 2017 Lower Putah Creek image: Sand and sediment left by a high water event in Putah Creek. Site at a former scarification site about one-quarter mile downstream from the Putah Diversion Dam. Sand was approximately 6 feet deep. Image Ken W. Davis.

Pleasant Creek. Shows incised bank which characterizes much of the waterway. Current projects are attempting to remedy the situation.

Control Sites:

Several control sites were selected, the most interesting one was a original scarification site (2014 Harris C-2) that has been used by Chinook salmon for spawning in all years from 2014 -2019. They have effectively kept the gravelbed in a condition that would probably not require scarification. The salmon have also enlarged the site significantly every year. They have essentially tripled the size of the spawning area in three years (after the original scarification) by digging away at the edges. Once the embedded crust is opened with an excavator, it appears that salmon in the system annually can maintain the open gravel condition and enlarge the spawning area.

On-site Monitoring for Wildlife:

Before and during all scarification operations, an experienced biologist is on site. The area scheduled for scarification is checked twice for all signs of wildlife. The wildlife check includes all aquatic, riparian and aerial wildlife. If species are encountered that are not mobile, such as native mussels, the area will be abandoned and scarification will not occur.

Scarification Technique:

Scarification methodology used in Lower Putah Creek. (Quote from Agreement 1600-2016-0058-R3):

> *"Operating from the top of the bank, a small excavator fitted with a bucket rake attachment will mechanically scarify or rake the creek bottom to a depth approximately 12-18 inches to loosen cemented gravels. Over the term of the Agreement, scarification will occur at approximately 40 locations along 13 miles impacting approximately 1.5 miles (5 acres) of Putah Creek. If a pre-existing road is not available, then an excavator will remove vegetation to create an access road. The excavator will not grade or cut the access road and no trees larger than 4-inches in diameter will be removed. Riparian areas disturbed by the excavator will be restored with native grasses, trees and shrubs.*

2016: One of initial wave of 30-40 pound Chinook that arrived at Putah Diversion Dam

Salmon Run Timing Example: 2016

Timing: 2016 Salmon Run:

The Lower Putah Creek Salmon run effectively begins with the removal of the boards at the Los Rios Dam which allows the Chinook salmon to enter the system (Note: The board removal has varied since 2014 as much as 30+ days). In 2016, the boards were removed on November 14th. The Fall Pulse flow of 50 CFS started at the Putah Diversion Dam on 11/18/2016. The required five-day pulse flow was terminated on 11/23/2016. The salmon can reach the Putah Diversion Dam within 24 hours if they are in the system and there are no obstructions preventing their upstream movement. By November 18th we could not find any salmon at spawning sites where we can reasonably predict they will initially appear. Being that salmon had been observed near the Los Rios Dam soon after the boards were removed, we assumed that an obstacle (such as a large beaver dam) was possibly preventing the salmon from moving upstream. Indeed, a significant beaver dam was located in an area where the fish could not navigate around or over the structure because it was built between two levee walls. Many large salmon were seen attempting to pass the dam. After the dam was legally notched, the large Chinooks immediately raced through and continued upstream. It should be noted that the salmon almost knocked over the SCWA employee who opened a slot for the salmon to continue upstream. On the morning of November 19th, we had many salmon working areas within the scarification sites downstream from the Putah Diversion Dam. On November 20th, an estimated 100 salmon had reached the Putah Diversion Dam and were milling around in the forebay. By the end of the run, more than 1800 salmon entered LPC in 2016.

November 29, 2016 Putah Diversion Dam (PDD) Forebay: Shows small group of Chinook salmon in the PDD Forebay. Many remained for several days then moved downstream. Some even attempted to spawn in area of forebay that has very large boulders. Image Ken W. Davis.

2016 - Initial Wave of Salmon:

Several waves of very large salmon (30-40 pounds) were the first to arrive at the spawning grounds. Important to note that the first wave captured on subsurface video (approximately 50 fish) had their adipose fin. (Note: Approximately 25% of the Central Valley Chinook hatchery-raised salmon have their adipose fin clipped.) This is important because prior to 2014, the estimates of hatchery-raised salmon was by observation from the bank or a drifting canoe. In 2016, the Solano County Water Agency contracted with University of California, Davis to study the genetics of adult salmon and juvenile salmon in Lower Putah Creek. The results of otolith collections to determine natal origin of the adult salmon and other studies are pending.

2016 - Number of Observed Spawning Areas:

Although we had thirteen scarification sites in 2016, salmon spawning was observed at more than fifty sites between the Putah Diversion Dam and one-half mile down stream from the I -505 Bridge. At least 30 of those sites were former scarification areas and / or small gravel beds that were partially scarified (such as the Winters Putah Creek Park). The non-scarification sites ranged from marginal areas such as the edges of the creek in Winters Putah Creek Parkway, to areas near existing weirs that were constructed prior to 2010, and suboptimal sites on angular cobble in vehicle crossings.

Monitoring - Counting Salmon on Daily Basis:

Every day possible, the main spawning sites were visited and the salmon counted. This included holidays such a Thanksgiving to maintain the integrity of the counts. Because the majority of the scarification sites are separated spatially, the counts can be more accurate by redd mapping and counting the salmon on specific redds. Control sections and other identified spawning areas were also mapped and salmon counted. Fish seen moving between spawning areas were not counted. This protocol, which is still used, is in contrast to salmon counts via a drifting canoe on a weekly basis when conditions allowed.

Salmon over a redd developed in a Scarification Site. Note the smaller cobble in the middle of the "pot" and the larger cobble used to armor the redd. Image Ken W. Davis.

Flow regime vs. Substrate:

It appears that in some cases, the female salmon selected sites for spawning that featured ideal flows (depth and water speed) versus benthic conditions. At some sites, the females proceeded to attempt redd construction despite almost impossible conditions for egg and alevin survival.

Size of gravel recommended for salmon spawning:

After significant observations of salmon spawning sites on the West Coast, Canada and Alaska, and direct observations and video surveillance of redds in several California waterways, I believe that the size of spawning gravels suggested for Lower Putah Creek (LPC) is too small. Direct observation in LPC and elsewhere has documented that when larger cobble are available, the female moves them to the outside of the redd and effectively creates an armored condition that protects the inside of the pot against high-water or flash-flood events. After reviewing articles relative to the suggested spawning gravel size, I suspect that the gravel measured (and suggested size) was collected from the redd in the bottom of the "pot." A sample of all the cobble from the outside of the redd to the inside was not collected or measured. In other words, the cobbles used to armor the redd on the outside were not considered. See the image above taken during the 2016 salmon run

Redd Superimposition:

Although, I'm certain that some redd superimposition occurs during salmon spawning runs in LPC, it has not been significant. There appears to be more redd coalescence where there was minor overlap and actual enlargement of the scarification sites increased the amount of prime spawning areas. The salmon at one site, that was scarified in 2014, have tripled the size of the original site. They accomplished that feat by digging at the edges of the scarification area (See Success Criteria No 3 on page 24).

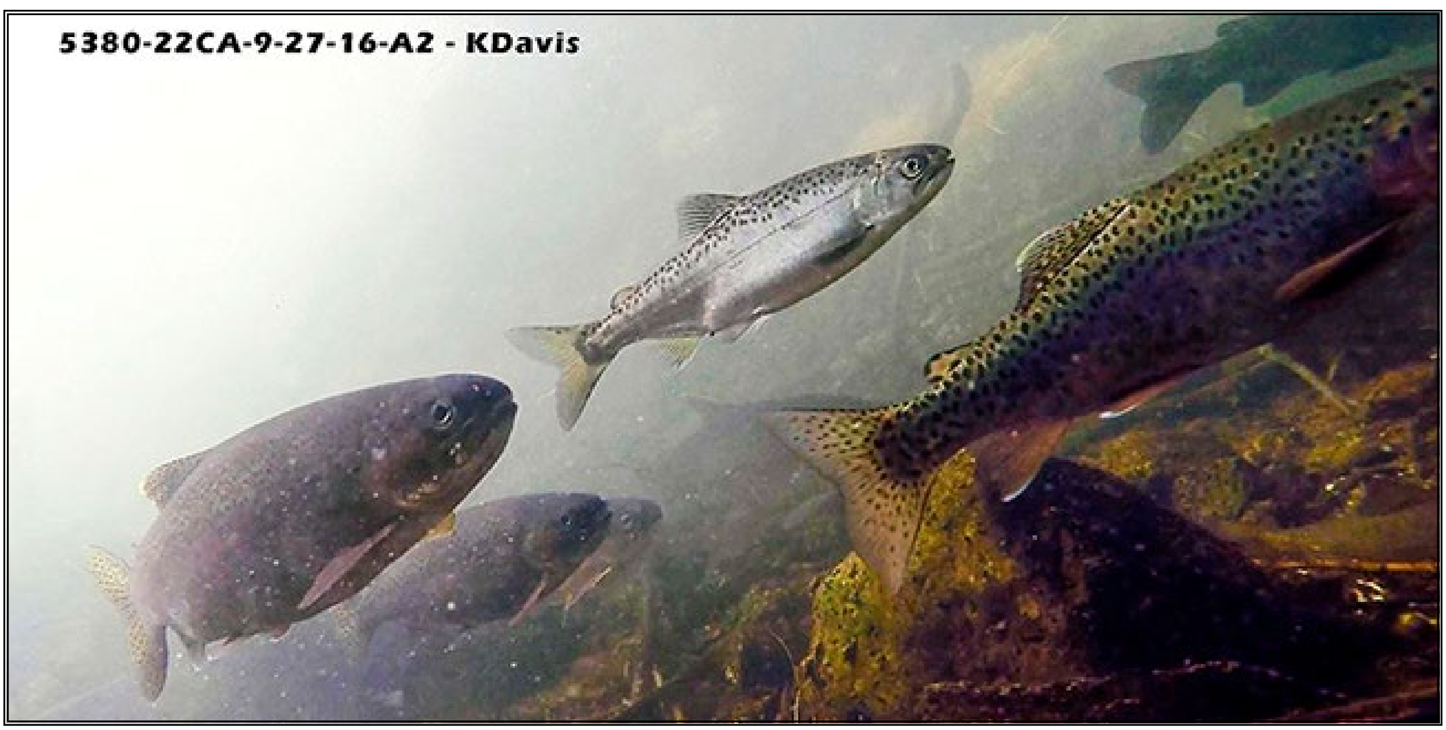
Other Possibilities for Increased Number of Salmon in Lower Putah Creek:

Stray Fish: Without a doubt, there has been a significant number of stray salmon that have entered Lower Putah Creek. According to CDFW, 25% of the salmon raised in Central Valley Hatcheries have their adipose fin clipped. Because many of the juvenile salmon have been released in the Sacramento-San Joaquin River Delta, they have no sense of their natal origin and will stray into other waterways.

Drought: The extended drought has also been cited as a reason for the salmon to select Lower Putah Creek rather than seeking their natal waterway. In theory, Putah Creek, due to numerous beaver pond breaches and the Accord Pulse Flow, might have a superior "signature" or attraction flow when compared to other waterways.

Fingerings not exiting the system:

Juvenile salmon have a history of remaining in the LPC system well past the Spring Pulse Flow that are designed to mimic spring storms and to signal the juveniles to migrate downstream. The fact that thousands of juveniles remained in the system at least until late May 2013 is highly curious and important to managing the creek. It has been well documented that a few salmon even remain near the Putah Diversion Dam all year due primarily to conditions that include cool water, some safe harbor, and excellent food supply.



Subsurface image of a juvenile salmon with several rainbow trout. It's not unusual for juvenile salmon to remain in the system rather than migrate downstream with the Accord pulse flow. Image Ken W. Davis.

Scarification Comparison Images

Morales Scarification Site taken on 4-8-2020. Salmon have spawned in this site every year since 2014. Image Ken W. Davis.

Morales Scarification Site. Salmon have spawned throughout the Morales site every year since 2014. Image Ken W. Davis.

Scarification Comparison Images

11-18-2016. Aerial image of the Morales site prior to scarification. Site was primarily wide, slow and not used by spawning salmon. Image Ken W. Davis.

5-1-2018 image of the Morales Scarification Site after high water event. Image will be repeated in 2020. Note the sand deposited near the creek bed and in the in Mc Cune Creek on the right side of the picture. Image Ken W. Davis.

Success Criteria

Discussion:

Success criteria are defined by the reasonable objectives used to determine if the project has achieved certain goals, met specific numbers, and maybe most important, identified concepts that were not considered prior to the project initiation. The criteria identified below were significantly affected by external forces such as high-water events and wildfires that were explained on Pages 14 I now suspect that rationale for selecting certain criteria in a couple of cases, was at least flawed, probably misguided by desire to increase the salmon population. The success criteria are listed below in order of relevance, the flawed criteria noted.

1. Use of scarification sites by spawning salmon
2. Use of scarification sites by rainbow trout
3. Scarified area Increased by spawning salmon
4. Level of "embeddedness" maintained by spawning salmon
5. Increase in BMI diversity
6. Increase in EPT diversity
7. Increase in BMI density
8. Increase in total estimate of salmon (Possibly flawed)

1	USE of SCARIFICATION SITES BY SPAWNING SALMON
	Success achieved? YES
	Comments: Generally, salmon spawned within the confines of the scarification areas. In 2016, we had an estimated 1800 (plus) salmon. During that spawn, numerous fish chose to spawn in areas that were outside the scarification areas or in areas that were disturbed such as vehicle crossings. A distinct advantage of scarification - for the salmon - is the open gravel that allowed the fish to digg redds and spawn (documented on film) within hours after arrival to the spawning beds.

2014 image. Pair of salmon that spawned in a scarified area within 8 hours after arrival in the spawning beds. Ken Davis image

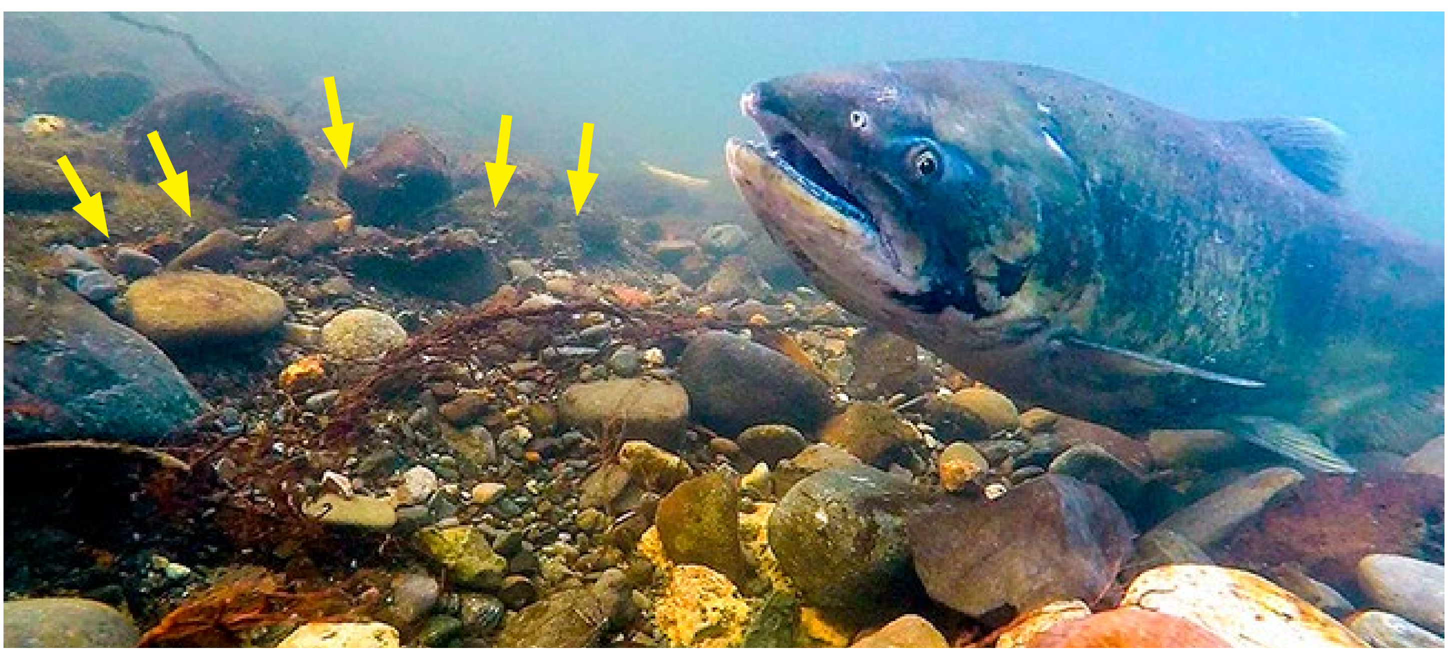
2	USE of SCARIFICATION SITES BY SPAWNING TROUT
	Success achieved? YES
	Comments: Between 2004 and 2013, I conducted New Zealand Mudsnail surveys in Lower Putah Creek I did not see rainbow trout spawning during that time period. At that time, I could not find anyone that could confirm or deny that rainbow trout spawn in LPC in spring or fall. That included residents, U.C. Davis Fishery biologists, and CDFW biologists. Alas, during the 2014 spawning period, we identified four sites where trout were spawning on the periphery of the scarification areas. Chinook salmon were spawning nearby. We have observed trout spawning in several scarification areas every year since 2014. Unfortunately, adequate refugia for juvenile trout and salmon is wanting in Lower Putah Creek.

Female rainbow trout over a redd that she is constructing. Ken Davis image

Pair of rainbow trout preparing to spawn in a scarified area. Trout can utilize cobble for redd building that is not as large as required for Chinook salmon. Ken Davis image

3	SCARIFIED AREA INCREASED BY SPAWNING SALMON
	Success achieved? YES
	Comments: The Harris Control site was the best example of how spawning salmon dramatically increase the size of the scarified section. In 2014 the site was approximately 9.7 meters in length with 6.1 meters width. The creek width did not change due to stable banks.

Dimension Change of Harris Control Site by Spawning Salmon				
	Before Salmon	After Salmon		
Year	Total Length (m)	Total Length (m)	Distance Change (m) from 2014	% Change
2014	9.7	18.8	9.1	93 %
2015	18.8	31.3	12.5	222.6 %
2016	31.3	54.8	23.2	464.9 %
2017	Site entered into scarification maintenance due to inundation by sand.			



Female Chinook salmon working the “edge” of a scarification site. The arrows show the upstream edge. The female continued digging at the open edge. Ken Davis image

4.	LEVEL OF "EMBEDDEDNESS" MAINTAINED BY SPAWNING SALMON
	Success achieved? YES
	Comments: This is probably the most intriguing factor about scarification that was not considered as a success criteria. It represents the most frequently asked question about the scarification process: "Do you have to mechanically maintain the site or can the spawning salmon keep the gravel beds open." The answer to both questions is "Yes." In a system such as Putah Creek that has a significant sediment load, the spawning beds will need regular maintenance. During years without major high-water events, and high sediment loads, a decent number of spawning salmon can certainly clean up the spawning beds.

Subsurface image of a salmon redd approximately six months after it was constructed. You can see the "pot" of the redd which is highly visible. The interstitial spaces remain mostly open. The area is being colonized by a caddisfly, Glossosoma sp. Ken Davis image

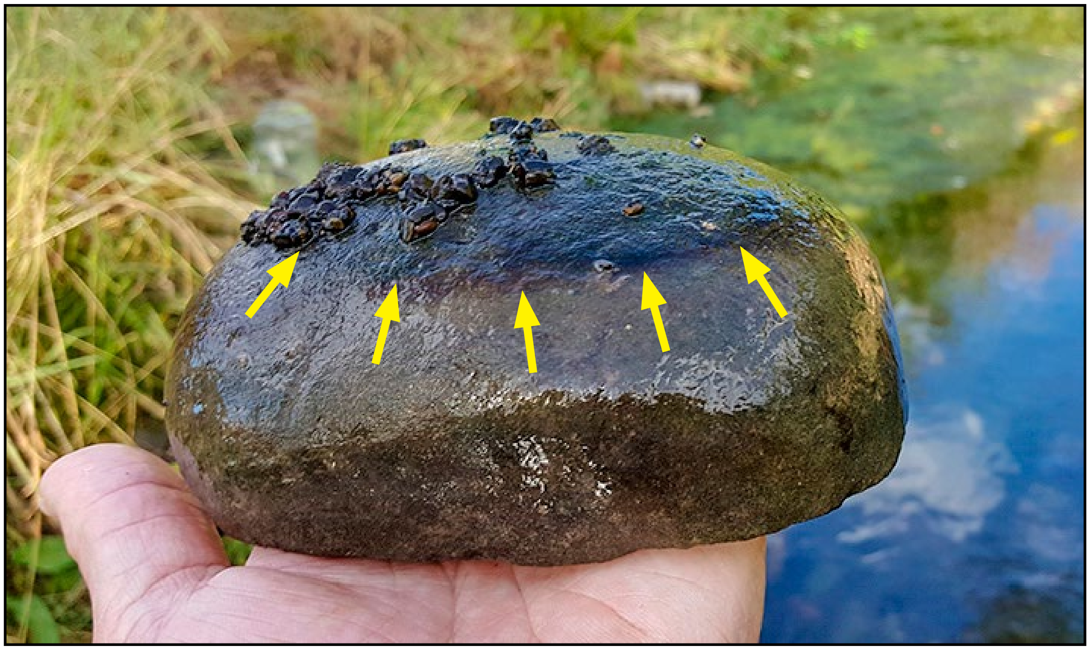
Depth of Salmon Redds

Subsurface image from inside a recently developed salmon redd. Ken Davis image

Depth of Redds 2017
(In scarified and non-scarified sections)

Study Section	Redd #	Scarified	Depth (cm.) (inside redd minus outside)
1	1A	Control (No)	7
	2B		8
	3C		10
2		No gravel	No Redds
3	3A	Yes	25
	3B		20
	3C		27
4	4A	Yes	30
	4B		31
	4C		41
	4D		37
5	5A	Yes	25
	5B		33
6	6A	Yes	26
	6B		44
	6C		40
	6D		32
	6E		25
	6F		28

% Embeddedness in salmon redd - Post spawn



Shows a cobble that was approximately 80% embedded. The clean area was buried. Algae and caddisfly (Glossosoma) larval cases cover the top of the rock.

% Embeddedness in salmon redd - Post spawn

Site: Harris Control Site - Redd 1

Date: May 25, 2017

Cobble #	Length (cm)	Depth (cm)	% Embedded
1	12	9	0
2	18	12	0
3	9	10	0
4	14	9	0
5	15	9	0
6	10	7	0
7	15	10	**5**
8	9	8	0
9	17	13	0
10	12	7	0
11	10	8	0
12	6	4	0
13	11	9	0
14	14	8	0
15	12	9	0

% Embeddedness in salmon redd - Post spawn

Site: Harris Control Site - Redd 2

Date: May 25, 2017

Cobble #	Length (cm)	Depth (cm)	% Embedded
1	9	8	0
2	8.5	6	0
3	16	10	0
4	11	9	0
5	8	5	0
6	10	8	0
7	12	6.5	**5**
8	20	11	**20**
9	17	6	0
10	12	10	**2**
11	8	7	0
12	11	4	0
13	6	4	0
14	7	5	0
15	9	4	0

% Embeddedness in Parker Control Area. Site has never been scarified

% Embeddedness in salmon redd - Post spawn

Site: Parker Control Site - No Scarification

Date: May 25, 2017

Cobble #	Length (cm)	Depth (cm)	% Embedded
1	10	7	90
2	9	4	95
3	20	10	90
4	14	8	90
5	10	8	80
6	24	12	80
7	20	12	90
8	17	12	60
9	14.5	7	90
10	14	12	80
11	14	10	70
12	27	15	90
13	20	12	70
14	15	8	0
15	14	10	80
16	12	8	90
17	20	12	80
18	20	11	0
19	15	12	80
20	15	11	90
21	22	15	95
22	20	12	80
23	12	8	90
24	22	12	80
25	18	12	95
26	15	10	95
27	15	8	90
28	22	14	80
29	15	8	95
30	20	12	80

Shows a section of non-scarified creek bed at the Parker Study area The arrow points to a foot print of a surface cobble that was removed. All material below and around the cobble footprint are severely embedded. Ken W. Davis image.

5.	INCREASE IN BENTHIC MACROINVERTEBRATE DIVERSITY
	Success achieved? Significant, but negatively impacted from upstream sediment and fire dregs.
	Comments: Due to the sporadic nature of the sediment load and wildlife debris experienced during the scarification (study period), I would expect inconstant results as we have seen in Lower Putah Creek. We have seen up to 12 new (mayflies, stoneflies and caddisflies) that have shown up at a couple of scarification sites. Unfortunately, the same sites have been inundated with sediment and dregs from the upstream wildfires and high-water events. The upstream taxa pools appear to be sufficient to eventually increase the BMI diversity if the sediment can be diminished. Upstream projects are ongoing to decrease the sediment load.

Amiocentrus aspilus (caddisfly) larvae is now somewhat common in LPC. Ken W. Davis image

Isoperla sp., (stonefly) is showing up in LPC for the first time. Ken W. Davis image

Epeorus sp. (mayfly) larvae is now somewhat common in LPC depending on the openness of the interstitial spaces in scarification areas. Ken W. Davis image

6.	INCREASE IN EPT DIVERSITY
	Success achieved? YES
	Comments: EPT (Ephemeroptera - Plectoptera - Tricoptera) diversity has increased sporadically depending on the sediment load from upstream. I expect that when we determine the ideal velocity through scarification sites that the natural flows will substantially move sediment downstream for deposition in pools. That condition will favor benthic macroinvertebrates. We have seen a small increase in a couple of stonefly species, several mayfly species and a couple caddisfly species.

Epeorus sp. (Mayfly nymph)

Calineuria californica. (Stonefly nymph)

Paraleptophelbia sp. (Mayfly nymph)

Hesperoperla pacifica (Stonefly nymph)

Ameletus sp. (Mayfly adult)

Drunella coloradensis (Mayfly nymph)

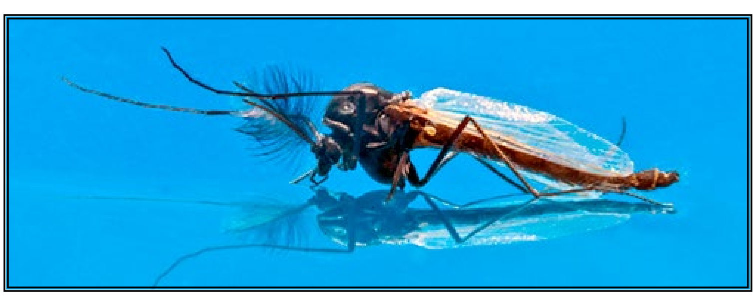
7.	INCREASE IN BMI DENSITY
	Success achieved? YES
	Comments: Density has increased and decreased dramatically depending on the site and the amount of sediment and wildfire dregs from upstream. In general, scarification increases the density of several species including Glossosoma, Hydropsyche and Baetis. Depending on the water velocity, blackflies and midges (Chironomidae) dominate the BMI community.

Subsurface image of blackfly larvae on surface of rock

Glossosoma larvae inside a protective rock case.

Glossosoma caddisfly larvae and pupae on rock surface

Subsurface image of blackfly larvae on Alder twig.



Chironomid (midge) adult on surface of water.

New Zealand Mudsnail moving under water surface

8.	INCREASE IN TOTAL ESTIMATE OF SALMON
	Success achieved? YES with consideration for other factors
	Comments: This success criteria was possibly a poor choice due to the myriad of other factors that can affect the estimate of migrating salmon. Those factors include stray salmon from other waterways, the Los Rios Board Dam removal, and high-water events. That said, the number of salmon entering Lower Putah Creek has increased substantially. The reasons for the increase are unknown due to the lack of tagging information.

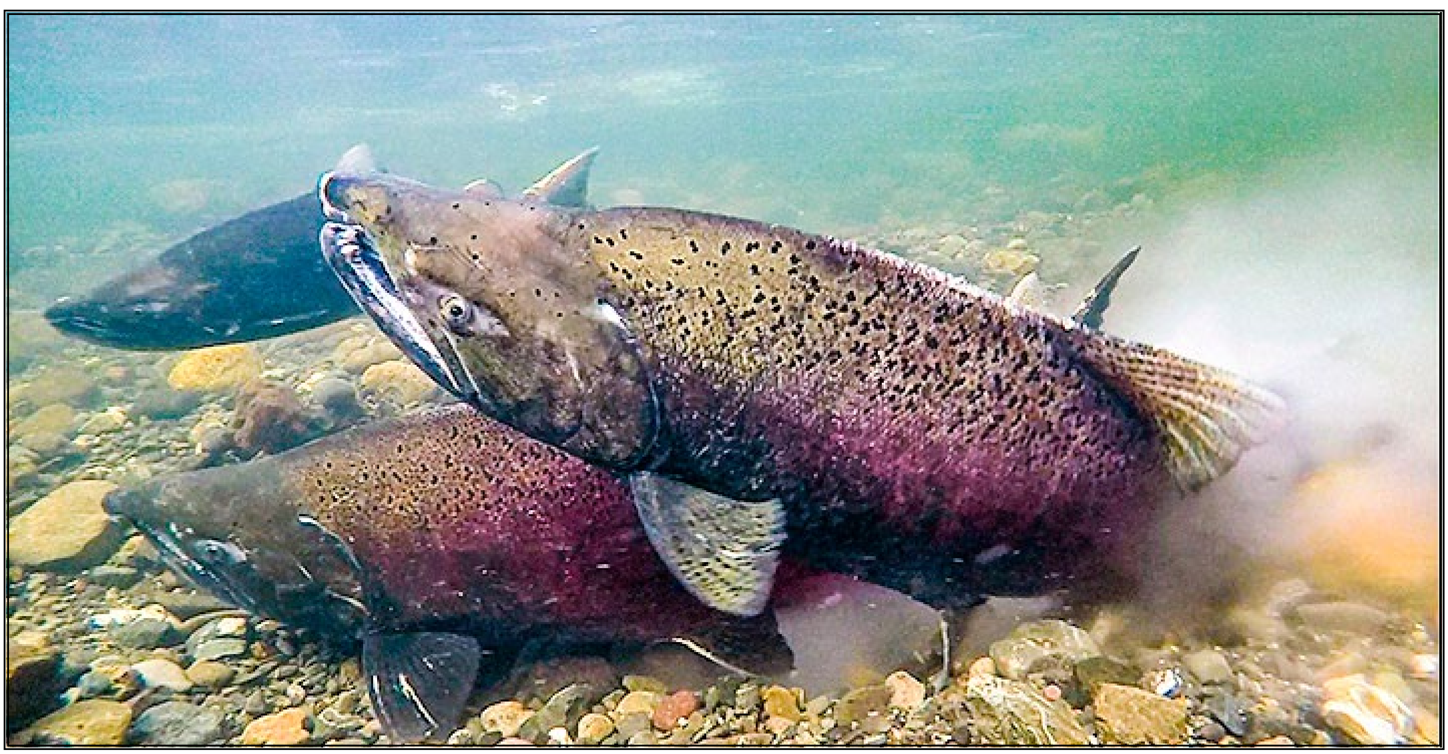
Yearly Salmon Estimates - Lower Putah Creek		
Year	Estimate of Salmon Run	Comments
Prior 2013	Varied	Typical run cited a few salmon
2013	8	Documented with daily observation and subsurface video
2014	200	Documented with daily observation and subsurface video
2015	500	Documented with daily observation and subsurface video
2016	1800 - 2000	Documented with daily observation and subsurface video
2017	700	Documented with daily observation and subsurface video
2018	483+	Documented with daily observation and subsurface video
2019	48	Documented with daily observation and subsurface video
2020	52	* In scarified areas only.

Pair of Chinook salmon over a redd developed within a scarification site.

SUCCESS CRITERIA NOT CONSIDERED	
1.	Document that juvenile salmon stay in system all year
	Success achieved? YES
	Comments: An estimated 40 juvenile salmon remained in Lower Putah Creek for a year after they hatched in 2017. The juveniles were actively feeding on salmon eggs as they were laid by the 2018 spawners.

Image shows a 2018 Chinook female with a 2017 juvenile salmon that remained in the system for a year. We filmed the juvenile salmon feeding on eggs laid by the female. I estimated there was 40 juvenile salmon that remained in the system after the 2017 spawn. Ken Davis image.

SUCCESS CRITERIA - NOT CONSIDERED PRE-PROJECT	
2.	INCREASE ABILITY FOR SALMON TO SPAWN QUICKLY
	Success achieved? YES
	Comments: This is a very positive outcome of the project that was not considered during project planning. Daily monitoring of the scarification sites during the salmon run are beneficial for many reasons including the observation (and documentation on film) that female salmon can quickly construct their redds because the gravel / cobble beds have been loosened. In many cases we have observed salmon spawning within 8-12 hours after arrival on site. This rapidity of spawning allows the females to remain in a healthier state throughout the spawning period. The healthy state permits the females to chase away no-dominate males and to protect the redd and eggs post spawn.



Group of spawning Chinook salmon in a scarification site. Ken Davis image

SUCCESS CRITERIA NOT CONSIDERED	
11.	INCREASE IN RIPARIAN WILDLIFE AND SCAVENGERS
	Success achieved? YES
	Comments: Spawning salmon bring a wealth of nutrients into the Lower Putah Creek watershed. Many wildlife species including raccoons, river otters, mink, bobcats, turkey vultures, bald eagles and eventually (I believe) black bear.

Raccoon filmed at night feeding on salmon carcass.

Turkey Vultures feeding on salmon carcass.

Bald eagle feeding on salmon carcass near the Putah Diversion Dam.

SUCCESS CRITERIA NOT CONSIDERED	
11.	Increase in spacial distribution of Benthic Macroinvertebrates
	Success achieved? YES
	Comments: Glossosoma sp., a caddisfly, has the same basic requirements for clean, cool water that closely matches the requirements for rainbow trout. The range for this sensitive macroinvertebrate has been extended by approximately 4 miles. Glossosoma is sensitive due to the fact that the larvae have no gills.

Subsurface image of Glossosma larvae within it's rock case. ken Davis image

Glossosoma larvae taken out of their protective rock case. Note, they have no gills for oxygen uptake. Ken Davis image

Scarification Site Information				
Site No	Site Name	N:	W:	Site Description
C-1	Cody Control	38.495283	-122.001722	Shallow Run
C-2	Harris Control	38.496501	-122.000124	Shaded riffles
C-3	Morales Control	38.500546	-122.996012	Run / pool
1	PDD North	38.493618	-122.00423	Lg. Boulder
2	Pickerel Island North	38.493882	-122.004108	Ideal spawning area
3	Pickerel Weir	38.494219	-122.00363	W-Weir
4	Pickerel North Side Channel - 1	38.494379	-122.003386	Side Channel - gravel
5	Pickerel North Side Channel - 2	38.494553	-122.00319	Side Channel - gravel
6	Pickerel North Side Channel - 3	38.494855	-122.003015	Side Channel - gravel
7	Pickerel North Side Channel - 4	38.495028	-122.002786	Side Channel - gravel
8	Pickerel North Side Channel - 5	38.49524	-122.002334	Side Channel - gravel
9	Pickerel South Side Channel -1	38.493732	-122.003939	Side channel. Shaded riffles
10	Pickerel South Side Channel -2	38.493772	-122.003917	Side channel. Shaded riffles
11	Pickerel South Side Channel - 3	38.493911	-122.00393	Side channel. Shaded riffles
12	Pickerel South Side Channel - 4	38.49049	-122.0039	Side channel. Shaded riffles
13	Pickerel Run -1	38.494217	-122.003413	Riffle / run
14	Pickerel Run -2	38.494261	-122.00317	Riffle / run
15	Pickerel Run - 3	38.494478	-122.002941	Riffle / run
16	Pickerel Run - 4	38.494768	-122.002742	Riffle / run
17	Cody -1	38.495573	-122.001528	Riffle / run
18	Cody -2	38.495841	-122.001383	Run
19	Harris - 1	38.495999	-122.001091	Run
20	Morales 1	38.498439	-121.997444	Riffles
21	Morales 2	38.498806	-121.997005	Riffles
22	Morales 3	38.499304	-121.996735	Run
23	Morales 4	38.499671	-121.99503	Pool
24	Morales 5	38.50003	-121.996447	Riffles

25	Morales 6	38.500519	-121.99602	Run / pool
26	Parker - 1	38.501686	-121.990388	Run
27	Parker - 2	38.502343	-122.989755	Run
28	Wimmer -1	38.50304	-121.987845	Run / pool
29	Wimmer - 2	38.503422	-121.98697	Run / pool
30	Wimmer -3	38.50391	-121.986227	Run / pool
31	Dry Creek Confluence	38.513522	-121.974611	Riffle
32	Bertinoia 1	38.513679	-121.974394	Riffle
33	Bertinoia 2	38.513923	-121.973975	Riffle
34	Bertinoia 3	38.514735	-121.973375	Riffle
35	Bertinoia 4	38.515003	-121.972722	Riffle
36	Neil Crossing	38.518768	-121.968926	Cobble Crossing
37	Neil Weir	38.519073	-121.968895	Run / pool
38	WPCP Phase 1 - 1	38.519441	-121.968759	Run
39	WPCP Phase 1 - 2	38.519597	-121.968436	Run
40	WPCP Phase 1 - 3	38.519845	-121.968168	Run
41	Winters Car Bridge	38.520227	-121.967755	Run / pool
42	WPCP Phase 1 - 4	38.522898	-121.960872	Deep Run
43	WPCP Phase 1 - 5	38.523419	-121.959081	Medium Deep Run
44	WPCP Phase 3 - 1	38.522898	-121.960872	Wide Shallow Run
45	WPCP Phase 3 - 2	38.523419	-121.959081	Wide Shallow Riffle / Run
46	WPCP Phase 2 - 1	38.522898	-121.960872	Old Crossing
47	WPCP Phase 2 - 2	38.523419	-121. 959081	Deep Run / pool
48	WPCP Phase 2 - 3	38.523876	-121.957919	Deep Run / pool
49	WPCP Phase 2 - 4	38.524227	-121.956793	Deep Run / pool
50	NAWCA - 1	38.524529	-121.956289	Riffles
51	NAWCA - 2	38.524776	-121.956066	Run
52	NAWCA - 3	38.52498	-121.955835	Run
53	NAWCA - 4	38.525339	-121.95444	Run
54	I-505-1	38.526091	-121.951247	Riffle (deep)
55	I-505 -2	38.526249	-121.9503	Riffle / run
56	I-505 - 3	38.526369	-121.99503	Riffle / run
57	I-505 - North Channel -1	38.526533	-121.949948	Riffle / run
58	I-505 - North Channel -2	38.526671	-121.949599	Riffle / run

59	I-505 - North Channel -3	38.526818	-121.949157	Riffle / run
60	I-505 - North Channel - 4	38.526807	-121.951672	Riffle / run
61	Kilkenny -1	38.531425	-121.931807	Pool
62	Kilkenny -2	38.531267	-121.931202	Pool / Poor benthos
63	Kilkenny - 3	38.53116	-121.9308	Pool
64	Kilkenny - 4	38.531025	-121.930413	Deep Run
65	McNamera -1	38.529741	-121.91667	Shallow riffles
66	Vickrey - 1	38.529456	-121.9194	Riffle / Run
67	Vickrey - 2	38.529542	-121.918357	Riffle / Run
68	Vickrey - 3	38.529848	-121.915942	Riffle / Run
69	Vickrey - 4	38.530485	-121.906092	Riffle
70	Lester - 1	38.531575	-121.90325	Riffle
71	Lester - 2	38.532003	-121.902086	Riffle
71	Lester- 3	38.532322	-121.900842	Riffle
END				

Salmon viewers watching fish that were spawning below the Winters Car Bridge in December 2016. Difficult to debate the positive response of the local citizens and visitors to Winters. This is the new "Fanny Bridge." Image Ken W. Davis

Lower Putah Creek - Project Comparison

Matrix lists projects and actions (2003 - present) with emphasis on developing, enhancing or facilitating spawning salmon. Considers relevance, effectiveness, and cost. Projects ranked 1 - 5. Prudent to consider score when making management recommendations.

No.	Project	Deliverable(s)	Impact on Salmon Spawning Success	SCORE (0-5)
1.	Gravelbed Scarification	Open spawning gravel. Increase in salmon spawning success. Increase in BMI density and species.	Proven to be significant by providing numerous spawning areas.	5
2	Beaver dam monitoring and notching	Passable for salmon. Levee to levee dams can prevent salmon passage.	Major when dams are large. Possible to have 100% blockage.	5
3.	Downed / Submerged Alders & Other	Can impact water flow and enhance spawning areas. (Also habitat for juvenile salmon)	Significant impact for complex spawning areas	3
4	Gravel /Cobble size	Cobble size that matches need for quality salmon redds	Size can impact protection for eggs and juveniles	3
5.	Gravel Injection	More gravel for spawning fish (appropriate size) gravel mix	Potentially significant	3
6.	Los Rios Dam (board removal)	Salmon passage (timely)	Potential to affect salmon run reaching spawning area.	3
7.	Weirs	Wildlife habitat for aquatic and riparian species	Potentially significant	2
8.	Water Velocity Studies	Appropriate velocity aids in spawning, egg and juvenile survival, and BMI communities.	Significant when velocity is appropriate for width and depth	2
9.	Dry Creek Realignment	Increase in wildlife.	Has required Scarification adjustments	2
10.	Riparian Planting	Thriving riparian plants.	Possible positive impact by riparian plants shading the creek.	1
11.	Salmon Video Project	Video of salmon, spawning salmon, quality of redds. Other fish. Public Relations and educational materials.	Some impact in showing successful spawning, health of salmon and quality of the redds.	1

12.	Putah Creek ACCORD	Provided consistent water flows. Wildlife monitoring.	Small or negligible impact after 18+ years of flow regime.	0
13.	WPCP - Phase 1	Increase in Wildlife. Depth and cementation require scarification.	None (without scarification)	0
14.	WPCP - Phase 2	Increase in Wildlife. Depth and cementation require scarification.	None (without scarification)	0
15.	WPCP - Phase 3	Increase in Wildlife. Depth and cementation require scarification.	None (without scarification)	0
16.	Electrofish	Fish Data	None	0
17.	NAWCA 3	Wildlife Habitat and flood plain	None (without scarification)	0
18.	Otolith Study	Determination of origin of adult salmon.	None	0
19.	NAWCA 2	Flood Plain development	None (without scarification)	0
20.	Screw Trap	Data on down migrant juvenile salmon.	None	0
21.	Salmon Festival	Entertainment, education, PR.	None	0
22.	Juvenile Snorkel Project	Determine number of juvenile salmon relative to escapement	None	0
23.	Riparian soil studies	Improve success of riparian plantings.	None	0
END				

Recommendations

1. Scarification: That the scarification project continue as planned within the "Lower Putah Creek Gravelbed Construction and Monitoring Plan." I suggest that we propose additional scarification sites.

2. Gravel Injection(s):
There are numerous areas of the creek that have copious amounts of ideal spawning gravel on the banks. I submit that those sites be flagged and the gravel be cleaned, and relocated pending the necessary permits.

3. Site Enhancement:
Several sites that were used by spawning salmon were certainly suboptimal, but had some essential aspects such as good overhead cover, acceptable flow regime but lacked optimum benthic conditions. Several such sites are within the Winters Putah Creek Park and are possibly covered by existing permits. I suggest those site be selected for enhancement.

4. Juvenile Refugia:
One essential condition for successful juvenile down migration is having effective cover or refugia for them to seek safe harbor. At the earliest opportunity, I suggest we have that discussion with the Streamkeeper to identify what actions need to be taken to improve the refugia for juvenile salmon and trout.

5. Importance of crossings and weirs and protecting salmon that are spawning on the crossings:
Possibly due to the flow regime and the plunge pool below the crossing / weirs, salmon and lamprey eels have both chosen to spawning in angular gravel and sub-gravel conditions. We have discussed options for improving this situation and closing the vehicle crossings during the spawning period and several months after the spawning period to protect salmon eggs and alevin that might survive in the crossing. The inconvenience seems minor with the state of salmon in California and protecting the developing salmon run in Lower Putah Creek. Those discussions are on-going.

6. Restoration in Upper Reaches for the main stem and tributaries within five miles of restoration sites:
Scientific literature is replete with studies that document effective restoration projects must be within five miles of benthic macroinvertebrate (BMI) taxa pools. I think the restoration projects in the InterDam Reach, Miller Creek and Pleasant Creek are certainly contributory to increasing BMI diversity and density within the Lower Creek. The ongoing scarification project is also crucial for the increase in BMI diversity and density as the open-gravel condition provides safe areas for many species of BMIs. Some species are also essential as prey for juvenile salmon.

7. Importance of Benthic Macroinvertebrates for juvenile salmon:
Several studies have shown opposing views about the importance of certain BMI species for foraging juvenile Chinook salmon (Albertson 2010). Ongoing surveys in Lower Putah Creek (Davis) have demonstrated that the preferred taxa for juvenile salmon are well represented. Captured and videotaped juveniles certainly show physical conditions that represent healthy conditions.

8. Development of Salmon Observation from Winters Car Bridge:
The development of a salmon viewing on and below the Winters Car Bridge is important for several reasons including keeping the public off private property, educating large numbers of visitors to Winters, and helping to keep the public away from research areas essential to understanding the effectiveness of scarification, salmon using the scarification sites, and documenting BMI communities.

9. Are Salmon Returning to Putah Creek or Simply Lost:
Although this discussion might be academic, I believe the subject is too important to be pushed aside as simply, "These are lost hatchery salmon!" This is especially important when we consider the immense amount of work, dedication, project funding, and interest from the public. I believe that a certain percent (to be determined) are

fish that have a natal origin in Lower Putah Creek (Davis 2017). Numerous questions remain that will hopefully be determined by studies funded by the Solano County Water Agency. My contention is based on years of observation of the limited salmon runs in Lower Putah Creek and certain events and situations that cannot be explained by proclaiming the salmon are all strays. The image on Page 44 was taken in 2010 and happens to be the exact site (GPS documented) where salmon have spawned since then in 2014, 2015, 2016, 2017, 2018 and 2019. While I certainly understand that salmon might select ideal conditions for spawning, it seems a stretch to assume that a series of stray hatchery fish will pick the exact same site in consecutive years. Contrary to the stray fish theory, I will place my confidence in salmon returning to their natal stream and selecting sites specific to the site of their origin.

I suggest that it is important to numerous individuals working on the restoration of Putah Creek, volunteers, local citizens, and the salmon who seek to return home that we remember the salmon are more than mere numbers or someone's legacy. Treating these amazing animals as "all strays," diminishes the work, dedication and millions spent for restoration. I recommend that we treat each of the returning salmon as the reward for many years of permit acquisition, planning, funding, difficult work, patience and belief in Putah Creek.

Submitted via e-mail on 5-3-2020

Sincerely,

Ken W. Davis
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Salmon redd on 12-13-2010. Image Ken W. Davis

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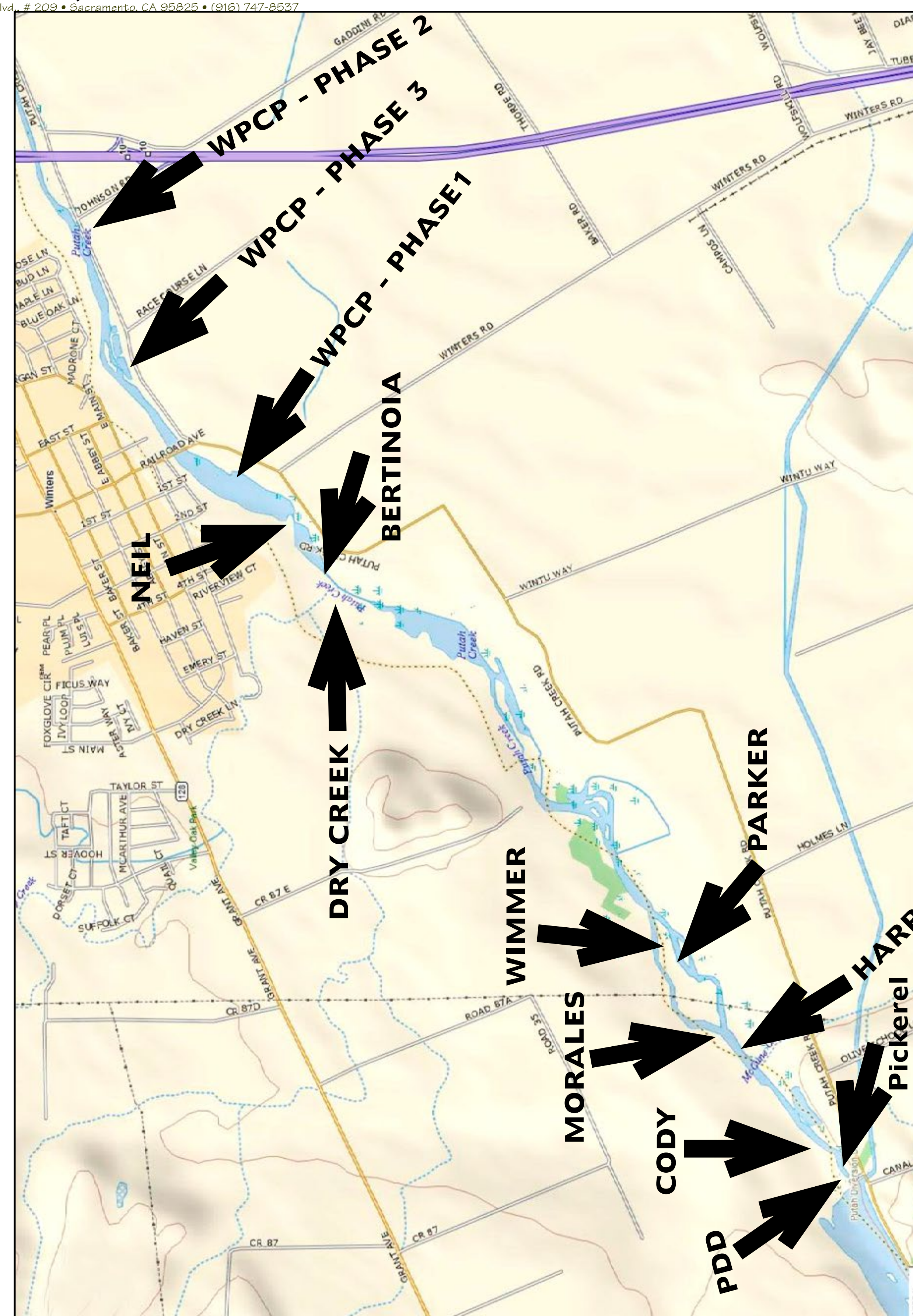
END

Amendments & Additions to Original Report

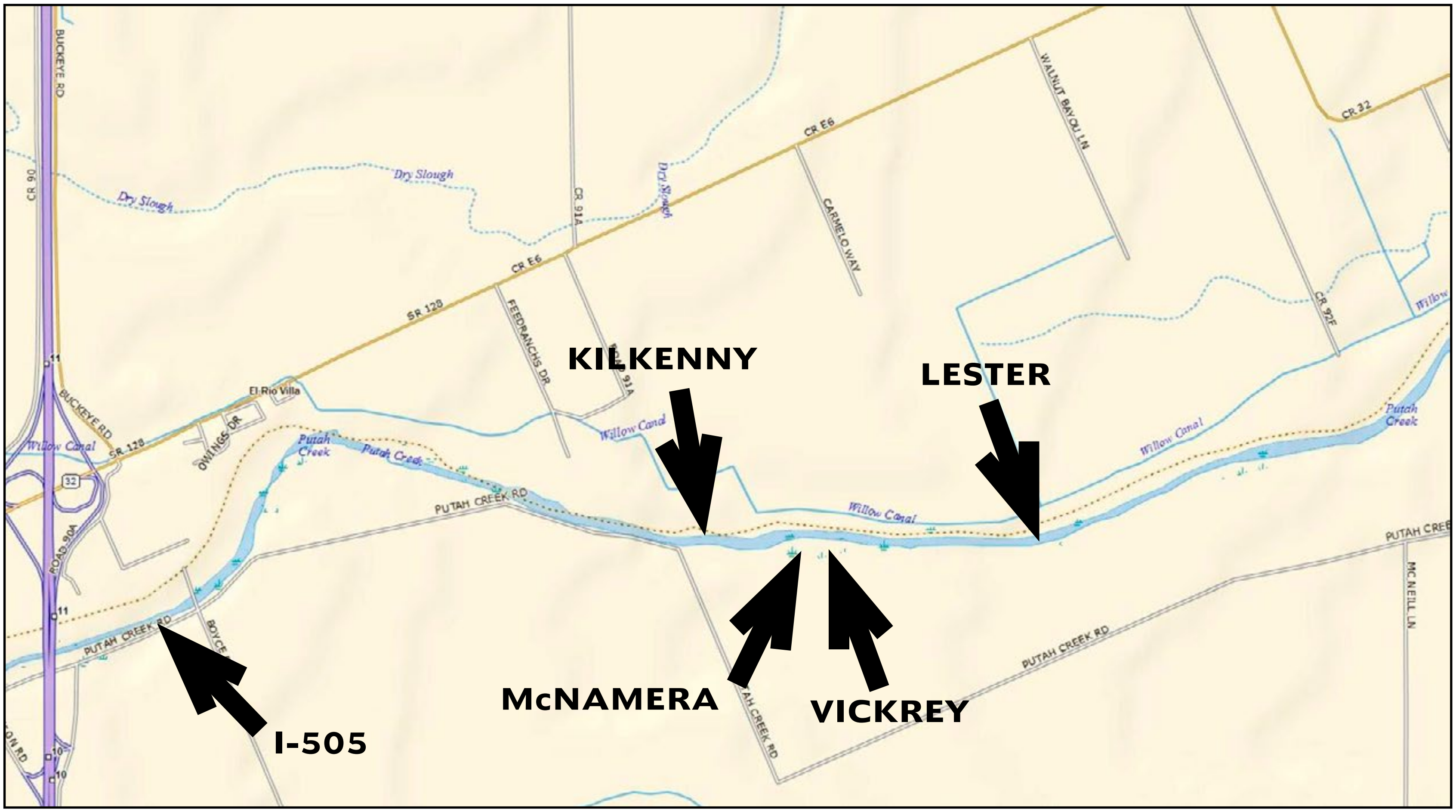
(Per Request from CDFW and others)

Amendment #	Request	Link to Page
1.	Map of Scarification site (as presented in these appendices)	47 & 48
2.	Gravel scarification sites, control sites, test sites and whether salmon spawned in response to scarification.	49 - 86
3.	Data on Turbidity during Scarification	88
4.	Benthic Macroinvertebrate Discussion	93-97 & 99
5.	Results from 2020 Salmon Run (without scarification immediately prior to the run)	98

Scarification Sites & Salmon Spawning: PDD - WINTERS



Scarification Sites & Salmon Spawning: I-505 - LESTER



Scarification and Salmon Spawning Sites - History

Background: The following pages describe 72 sites from the Putah Diversion Dam to the Lester Property which is approximately 6.5 miles from the Dam. Not all of the listed sites were selected for scarification, some were eliminated for access issues, existing benthic condition(s) and some were "tested" and failed due to lack of gravel or heavy presence of sediment. Decisions were made by the on-site biologist and the excavator operator.

Over the six years of the Scarification Project all the sites were impacted by flood conditions when the Lake Berryessa Glory Hole blew (2017 and 2019). Five years of significant wildfires also had effects at many of the scarification sites with copious amounts of sediment and fire dregs that washed downstream.

I have provided numerous images, subsurface and above the water level photos to document the challenge and difficulty in delivering some of the requested data. The subsurface image below was taken after the 2017 flood event which deposited copious amounts of sand and sediment throughout the Scarification Project area. This image shows the surface of the Cody Control site (Cody - Control 1) that was covered by 4-5 feet of sand in some areas. The added amount of sand throughout the project area is problematic for measuring salmon redds (which were covered), comparing benthic macroinvertebrate densities, and measuring the cobble used by spawning salmon.

Image taken in 2018 after the 2017 floods: Sand deposited by flood waters over the Cody - Control site. Image Ken W. Davis

Scarification Sites & Salmon Spawning History

<table>
<tr><th>Site #</th><th>Site Name</th><th>GPS: N</th><th>GPS - W</th><th>Comments</th></tr>
<tr><td>Control - 1</td><td>Cody Control</td><td>38.495283</td><td>-122.001722</td><td>Shallow Run</td></tr>
</table>

<table>
<tr><th colspan="4">Scarification and Salmon Spawning - History at Site</th></tr>
<tr><th>Year</th><th>Scarified?</th><th>Salmon Spawn at Site?</th><th>Comments</th></tr>
<tr><td>Pre-2013</td><td>NA</td><td></td><td>Shallow, sandy run</td></tr>
<tr><td>2013</td><td rowspan="8">No</td><td></td><td>Shallow, weedy, sandy run</td></tr>
<tr><td>2014</td><td></td><td></td></tr>
<tr><td>2015</td><td></td><td></td></tr>
<tr><td>2016</td><td>Yes</td><td>Shallow, sandy redds</td></tr>
<tr><td>2017</td><td></td><td></td></tr>
<tr><td>2018</td><td></td><td></td></tr>
<tr><td>2019</td><td></td><td></td></tr>
<tr><td>2020</td><td></td><td></td></tr>
</table>

<table>
<tr><th>Site #</th><th>Site Name</th><th>GPS: N</th><th>GPS - W</th><th>Comments</th></tr>
<tr><td>Control - 2</td><td>Harris Control</td><td>38.496501</td><td>-122.000124</td><td>Shaded Riffles</td></tr>
</table>

<table>
<tr><th colspan="4">Scarification and Salmon Spawning - History at Site</th></tr>
<tr><th>Year</th><th>Scarified?</th><th>Salmon Spawn at Site?</th><th>Comments</th></tr>
<tr><td>Pre-2013</td><td>NA</td><td>Yes</td><td rowspan="4">One of the few sites in LPC where I could identify that salmon used the same site prior to scarification. The site had sufficient cobble but was significantly embedded. Salmon would build wide, very shallow redds.</td></tr>
<tr><td>2013</td><td>No</td><td>No</td></tr>
<tr><td>2014</td><td>No</td><td>Yes</td></tr>
<tr><td>2015</td><td>No</td><td>Yes</td></tr>
<tr><td>2016</td><td>No</td><td>Yes</td><td rowspan="2">Scarified. Salmon enlarged spawning area by digging at edges of scarified area.</td></tr>
<tr><td>2017</td><td>Yes</td><td>Yes</td></tr>
<tr><td>2018</td><td>Yes</td><td>Yes</td><td></td></tr>
<tr><td>2019</td><td>No</td><td>Yes</td><td></td></tr>
<tr><td>2020</td><td>No</td><td>No</td><td></td></tr>
</table>

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
Control -3	Morales Control	38.500546	-122.996012	Shaded Run / Riffles

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA		Area wide, deep in some areas.
2013		No	
2014		No	
2015		No	
2016		Yes	Shallow, very wide redds. Sandy area
2017	No	No	
2018		No	
2019		No	
2020		No	

Site #	Site Name	GPS: N	GPS - W	Comments
1	PDD North	38.493618	-122.00423	Dam Forebay

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Area is immediately below the Putah Diversion Dam (PDD). Characterized by large boulders and some spawning gravel. Would have preferred to dump spawning gravel on the site. As of 2020, the site has not had gravel injections.
2013		No	
2014		No	
2015		No	
2016		YES (attempt)	
2017	No	No	
2018		No	Recommendation: Excellent area for spawning near PDD. Large boulders. Site needs gravel / cobble injection for effective spawning.
2019		No	
2020		No	

Scarification Sites & Salmon Spawning History

<table>
<tr><th>Site #</th><th colspan="2">Site Name</th><th>GPS: N</th><th>GPS - W</th><th>Comments</th></tr>
<tr><td>2</td><td colspan="2">Pickerel Island North</td><td>38.493882</td><td>-122.004108</td><td>Ideal spawning area</td></tr>
<tr><td colspan="6">Scarification and Salmon Spawning - History at Site</td></tr>
<tr><td>Year</td><td>Scarified?</td><td colspan="2">Salmon Spawn at Site?</td><td colspan="2">Comments</td></tr>
<tr><td>Pre-2013</td><td>NA</td><td colspan="2"></td><td colspan="2" rowspan="5">Section scarified in 2019. Area has large boulders, marginal cobble, copious riparian vegetation. Site ideal for salmon and trout spawning. Some areas for juvenile refugia.</td></tr>
<tr><td>2013</td><td rowspan="6">No</td><td colspan="2" rowspan="6">No</td></tr>
<tr><td>2014</td></tr>
<tr><td>2015</td></tr>
<tr><td>2016</td></tr>
<tr><td>2017</td><td colspan="2"></td></tr>
<tr><td>2018</td><td colspan="2"></td></tr>
<tr><td>2019</td><td>Yes</td><td colspan="2">Yes</td><td colspan="2"></td></tr>
<tr><td>2020</td><td>No</td><td colspan="2">Yes</td><td colspan="2">No scarification in LPC</td></tr>
</table>

Site #	Site Name	GPS: N	GPS - W	Comments
3	Pickerel Weir	38.494219	-122.00363	Established Weir (2009)

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	
2013	NO	Yes	In Weir Plunge Pool (8 Salmon)
2014	Yes	Yes	
2015	Surface	Yes	Debris removed / Surface scratched
2016	N0	Yes	
2017	Surface	Yes	Surfaced Scratched
2018	Yes	Yes	
2019	No	Yes	Plunge pool cobble
2020	No	Yes	No Scarification in LPC

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
4	Pickerel N Side Channel - 1	38.494379	-122.003386	Narrow Side Channel

Scarification and Salmon Spawning - History at Site			
Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Old side channel
2013	No	No	
2014	No	Yes	Narrow Side Channel
2015	No	Yes	Narrow side channel
2016	No	Yes	Narrow side channel
2017	No	No	Filled with flood debris and sand
2018	Yes	Yes	Scarified / Cleaned channel
2019	No	No	Channel inundated with copious amount of sand and debris from early 2019 flood.
2020	No	No	
NOTE: Strongly recommend opening the N Side Channel as it was a highly effective spawning area and refugia			

Site #	Site Name	GPS: N	GPS - W	Comments
5	Pickerel N Side Channel -2	38.494553	-122.00319	Shallow Side Channel

Scarification and Salmon Spawning - History at Site			
Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Old side channel
2013	No	No	
2014	No	Yes (minor)	Narrow Side Channel
2015	No	Yes	Narrow side channel
2016	No	Yes	Narrow side channel
2017	Yes	No	Filled with flood debris and sand
2018	Yes	Yes	Scarified / Cleaned channel
2019	No	No	Channel inundated with copious amount of sand and debris from early 2019 flood.
2020	No	No	
NOTE: Strongly recommend opening the N Side Channel as it was a highly effective spawning area and refugia			

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
6	Pickerel N Side Channel - 3	38.494855	-122.003015	Shallow Side Channel

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Old Side Channel
2013	No	No	
2014	No	Yes	Several pair salmon spawning in this area
2015	Yes (minor)	Yes	Used by juvenile salmon
2016	Yes	Yes	3 pair salmon spawned in this section
2017	No	No	Used by juvenile salmon
2018	Yes	Yes	
2019	No	No	
2020	No	No	

NOTE: Strongly recommend opening the N Side Channel as it was a highly effective spawning area and refugia

Site #	Site Name	GPS: N	GPS - W	Comments
7	Pickerel N Side Channel - 4	38.495028	-122.002786	Shallow Side Channel

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Old Side Channel
2013	No	No	
2014	No	Yes	
2015	No	Yes	
2016	Yes	Yes	2 pair salmon spawned in this section
2017	No	No	Used by juvenile salmon
2018	Yes	Yes	
2019	No	No	
2020	No	No	

NOTE: Strongly recommend opening the N Side Channel as it was a highly effective spawning area and refugia

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
8	Pickerel N Side Channel - 5	38.49524	-122.002334	Shallow Side Channel

Scarification and Salmon Spawning - History at Site			
Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Shallow, sandy run
2013	No	No	
2014	No	Yes	
2015	No	Yes	
2016	Yes	Yes	
2017	No	No	
2018	Yes	Yes	
2019	No	No	
2020	No	No	
NOTE: Strongly recommend opening the N Side Channel as it was a highly effective spawning area and refugia			

Site #	Site Name	GPS: N	GPS - W	Comments
9	Pickerel S Side Channel - 1	38.493732	-122.003939	Shallow Shaded Riffles

Scarification and Salmon Spawning - History at Site			
Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	
2013	No	No	
2014	No	No	
2015	No	No	
2016	No	Yes	
2017	Yes	Yes	
2018	Yes (minor)	Yes	
2019	Yes	No	
2020	No	Yes	Nice cobble / Riparian & Instream cover

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
10	Pickerel S Side Channel - 2	38.493772	-122.003917	Shallow Side Channel

Scarification and Salmon Spawning - History at Site			
Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	
2013	No	No	
2014	No	No	
2015	No	No	
2016	Yes	Yes	
2017	No	Yes	
2018	Yes (minor)	Yes	
2019	No	No	
2020	No	Yes	

	Site Name	GPS: N	GPS - W	Comments
11	Pickerel S Side Channel -3	38.493911	-122.00393	Shaded Riffles

Scarification and Salmon Spawning - History at Site			
Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	
2013	No	No	
2014	No	No	
2015	No	No	
2016	No	Yes	
2017	No	Yes	
2018	No	Yes	
2019	Yes	No	
2020	No	Yes	Some excellent cobble in area

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
12	Pickerel S Side Channel - 4	38.49049	-122.0039	Shallow Side Channel
Scarification and Salmon Spawning - History at Site				
Year	Scarified?	Salmon Spawn at Site?	Comments	
Pre-2013	NA	No		
2013	No	No		
2014	No	No		
2015	No	No		
2016	No	Yes	Excellent flow regime / Cobble	
2017	No	Yes		
2018	No	Yes		
2019	No	No		
2020	No	Yes	Excellent flow regime / Cobble	

Site #	Site Name	GPS: N	GPS - W	Comments
13	Pickerel Run - 1	38.494217	-122.003413	Riffle / Run
Scarification and Salmon Spawning - History at Site				
Year	Scarified?	Salmon Spawn at Site?	Comments	
Pre-2013	NA	No		
2013	No	No		
2014	Yes	Yes	Okay cobble / excellent flow regime	
2015	Yes	Yes	Due to the ideal area of this riffle / run, I recommend annual scarification / maintenance for this site. Section can support 15 - 20 spawning salmon. Addition of appropriate size (local) cobble is also warranted. Site could use instream structure for juvenile refugia. Opening the ancillary North Side Channel is also warranted for use by salmon, trout and lamprey eels.	
2016	Yes (minor)	Yes		
2017	No	Yes		
2018	Yes	Yes		
2019	Yes	Yes		
2020	No	Yes		

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
14	Pickerel Run - 2	38.494261	-122.00317	Riffle / Run
Scarification and Salmon Spawning - History at Site				
Year	Scarified?	Salmon Spawn at Site?	Comments	
Pre-2013	NA	No		
2013	No	No	Okay cobble / excellent flow regime	
2014	Yes	Yes		
2015	Yes	Yes	Due to the ideal area of this riffle / run, I recommend annual scarification / maintenance for this site. Section can support 15 - 20 spawning salmon. Addition of appropriate size (local) cobble is also warranted. Site could use instream structure for juvenile refugia. Opening the ancillary North Side Channel is also warranted for use by salmon, trout and lamprey eels.	
2016	Yes (minor)	Yes		
2017	No	Yes		
2018	Yes	Yes		
2019	No	Yes		
2020	No	Yes		

		GPS: N	GPS - W	Comments
15	Pickerel Run - 3	38.494478	-122.002941	Riffle / Run
Scarification and Salmon Spawning - History at Site				
Year	Scarified?	Salmon Spawn at Site?	Comments	
Pre-2013	NA	No	Due to the ideal area of this riffle / run, I recommend annual scarification / maintenance for this site. Section can support 15 - 20 spawning salmon. Addition of appropriate size (local) cobble is also warranted. Site could use instream structure for juvenile refugia. Opening the ancillary North Side Channel is also warranted for use by salmon, trout and lamprey eels.	
2013	No	No		
2014	No	Yes		
2015	No	Yes		
2016	Yes	Yes		
2017	No	Yes		
2018	No	Yes		
2019	Yes	Yes		
2020	No	Yes		

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
16	Pickerel Run - 4	38.494768	-122.002742	Riffle / Run

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Due to the ideal area of this riffle / run, I recommend annual scarification / maintenance for this site. Section can support 15 - 20 spawning salmon. Addition of appropriate size (local) cobble is also warranted. Site could use instream structure for juvenile refugia. Opening the ancillary North Side Channel is also warranted for use by salmon, trout and lamprey eels.
2013	No	No	
2014	No	Yes	
2015	Yes	Yes	
2016	Yes	Yes	
2017	No	Yes	
2018	No	Yes	
2019	Yes	Yes	
2020	No	Yes	

		GPS: N	GPS - W	Comments
17	Cody - 1	38.495573	-122.001528	Riffle / Run

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Complex that originally had an island with two channels, one significantly smaller. Both channels were used for spawning by salmon, trout and lamprey eels. Unfortunately, nearby residents frequently spooked spawning fish while attempting to watch the spawning behavior. Bald eagles also used this site for foraging on salmon carcasses.
2013	No	No	
2014	No	no	
2015	Yes	Yes	
2016	No	Yes	
2017	Yes	Yes	
2018	Yes	No	
2019	No	No	The site is now one channel with a wide, deep area that I recommend be reconnected to the main stem.
2020	No	No	

Scarification Sites & Salmon Spawning History

		GPS: N	GPS - W	Comments
18	Cody - 2	38.495841	-122.001383	Run

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Section has changed significantly due to flood events. Some areas in this site are composed of claypan which is difficult to remove and impossible for salmon to use for spawning
2013	No	No	
2014	No	No	
2015	No	No	
2016	Yes	Yes	
2017	Yes	Yes	
2018	No	No	
2019	No	Yes	
2020	No	Yes	

		GPS: N	GPS - W	Comments
19	Harris --1	38.495999	-122.001091	Run

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	
2013	No	No	
2014	No	No	
2015	Yes	No	Ideal cobble in section. Salmon from the adjacent Harris Control have extended the Control Site into this scarification site.
2016	No	Yes	
2017	Yes	Yes	
2018	No	No	
2019	No	No	
2020	No	Yes	

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
20	Morales - 1	38.498439	-121.997444	Pool / Riffles

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	This was the original test site for a demonstration for CDFW.
2013	No	No	
2014	Yes	Yes	
2015	No	No	
2016	No	No	
2017	No	Yes	Site ruined by flood waters and inundation of sand. A small attempt to fix the site failed due to copious sand deposited from the flood waters.
2018	Yes	No	
2019	Yes	No	
2020	No	No	

		GPS: N	GPS - W	Comments
21	Morales - 2	38.498806	-121.997005	Riffles

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	Yes (2004 Observed)	Site where McCune Creek (at one time) joined the main stem of LPC. Found dead salmon at this site in 2004
2013	No	No	
2014	Yes	Yes	
2015	No	Yes	
2016	Yes	Yes	
2017	No	Yes	
2018	No	Yes	
2019	No	No	
2020	No	Yes	

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
22	Morales - 3	38.499304	-121.996735	Run

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Site of OLD Crossing
2013	No	No	
2014	Yes	Yes	Potential for ideal spawning site. Has good cobble, some riparian cover. Salmon like this area for spawning. Ideal cobble in section.
2015	Yes	Yes	
2016	No	Yes	
2017	Yes	Yes	
2018	No	Yes	
2019	Yes	No	
2020	No	No	

Site #	Site Name	GPS: N	GPS - W	Comments
23	Morales - 4	38.499671	-121.99503	Shaded Riffles

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Potential for ideal spawning site. Has good cobble, some riparian cover. Salmon like this area for spawning. Ideal cobble in section.
2013	No	No	
2014	Yes	Yes	
2015	Yes	Yes	
2016	No	Yes	
2017	No	Yes	
2018	No	Yes	Great riparian cover
2019	Yes	No	
2020	No	No	

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
24	Morales - 5	38.50003	-121.996447	Riffles / Run / Pool

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Potential for ideal spawning site. Has good cobble, some riparian cover. Salmon like this area for spawning. Ideal cobble in section.
2013	No	No	
2014	Yes	Yes	
2015	No	No	
2016	Yes (minor)	Yes	
2017	No	Yes	
2018	No	No	
2019	No	No	
2020	No	Yes	

Site #	Site Name	GPS: N	GPS - W	Comments
25	Morales - 6	38.500519	-121.99602	Run / Pool

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Potential for ideal spawning site. Has good cobble, some riparian cover. Salmon like this area for spawning. Ideal cobble in section.
2013	No	No	
2014	No	Yes	
2015	No	No	
2016	No	Yes	
2017	Yes	Yes	
2018	No	No	
2019	No	No	
2020	No	No	

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
26	Parker - 1	38.501686	-121.990388	Run

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	No		
2013	No		
2014	No		
2015	No		
2016	No	No	
2017	Test Site		Site was tested for adequate cobble. Site failed due to downstream impoundment: Mertz Dam.
2018	No		
2019	No		
2020	No		

Site #	Site Name	GPS: N	GPS - W	Comments
27	Parker - 2	38.502343	-121.989755	Run

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA		Site was tested for adequate cobble. Site failed due to downstream impoundment: Mertz Dam.
2013	No		
2014	No		
2015	No		
2016	No	No	
2017	Test Site		
2018	No		
2019	No		
2020	No		

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
28	Wimmer - 1	38.50304	-121.987845	Run / Pool

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Site has great potential to be a significant spawning site for salmon, trout and lamprey eels. Unfortunately, a downstream impoundment has inundated this area.
2013	No		
2014			
2015			
2016			
2017			
2018			
2019			
2020			

Site #	Site Name	GPS: N	GPS - W	Comments
29	Wimmer - 2	38.503422	-121.98697	Run / Pool

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Site has great potential to be a significant spawning site for salmon, trout and lamprey eels. Unfortunately, a downstream impoundment has inundated this area.
2013	No		
2014			
2015			
2016			
2017			
2018			
2019			
2020			

Scarification Sites & Salmon Spawning History

<table>
<tr><th>Site #</th><th colspan="2">Site Name</th><th>GPS: N</th><th>GPS - W</th><th>Comments</th></tr>
<tr><td>30</td><td colspan="2">Wimmer - 3</td><td>38.50391</td><td>-121.986227</td><td>Run / Pool</td></tr>
<tr><td colspan="6">Scarification and Salmon Spawning - History at Site</td></tr>
<tr><td>Year</td><td>Scarified?</td><td colspan="2">Salmon Spawn at Site?</td><td colspan="2">Comments</td></tr>
<tr><td>Pre-2013</td><td>NA</td><td colspan="2" rowspan="9">No</td><td colspan="2" rowspan="6">Site has great potential to be a significant spawning site for salmon, trout and lamprey eels. Unfortunately, a downstream impoundment has inundated this area.</td></tr>
<tr><td>2013</td><td rowspan="8">No</td></tr>
<tr><td>2014</td></tr>
<tr><td>2015</td></tr>
<tr><td>2016</td></tr>
<tr><td>2017</td></tr>
<tr><td>2018</td><td colspan="2"></td></tr>
<tr><td>2019</td><td colspan="2"></td></tr>
<tr><td>2020</td><td colspan="2"></td></tr>
</table>

<table>
<tr><th>Site #</th><th colspan="2">Site Name</th><th>GPS: N</th><th>GPS - W</th><th>Comments</th></tr>
<tr><td>31</td><td colspan="2">Dry Creek Confluence</td><td>38.513522</td><td>-121.974511</td><td>Shallow riffles</td></tr>
<tr><td colspan="6">Scarification and Salmon Spawning - History at Site</td></tr>
<tr><td>Year</td><td>Scarified?</td><td colspan="2">Salmon Spawn at Site?</td><td colspan="2">Comments</td></tr>
<tr><td>Pre-2013</td><td>NA</td><td colspan="2">No</td><td colspan="2" rowspan="6">Site is the confluence of Dry Creek and Lower Putah Creek. The site was realigned in 2006. The realignment developed a healthy reach of spawning gravels.</td></tr>
<tr><td>2013</td><td>No</td><td colspan="2">No</td></tr>
<tr><td>2014</td><td>No</td><td colspan="2">No</td></tr>
<tr><td>2015</td><td>Yes</td><td colspan="2">No</td></tr>
<tr><td>2016</td><td>Yes (minor)</td><td colspan="2">Yes</td></tr>
<tr><td>2017</td><td>No</td><td colspan="2">Yes</td></tr>
<tr><td>2018</td><td>Yes</td><td colspan="2">Yes</td><td colspan="2"></td></tr>
<tr><td>2019</td><td>No</td><td colspan="2">No</td><td colspan="2"></td></tr>
<tr><td>2020</td><td>No</td><td colspan="2">Yes</td><td colspan="2"></td></tr>
</table>

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
32	Bertinoia - 1	38.513679	-121.974394	Shallow Riffles

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Site has great potential to be developed into a significant spawning grounds
2013	No	No	
2014	No	No	
2015	Yes	No	
2016	Minor	Yes	
2017	No	Yes	
2018	No	Yes	
2019	No	No	
2020	NO	No	

Site #	Site Name	GPS: N	GPS - W	Comments
33	Bertinoia - 2	38.513923	-121.973975	Shaded Riffles

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	
2013	No	No	
2014	No	No	Site has great potential to be developed into a significant spawning grounds
2015	No	No	
2016	Yes	Yes	
2017	No	Yes	
2018	No	Yes	
2019	No	No	
2020	No	No	

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
34	Bertinoia - 3	38.514735	-121.973375	Shallow Run / Shaded

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	
2013	No	No	
2014	No	No	
2015	No	No	
2016	No	Yes	Nearby to scarified section
2017	Yes	Yes	
2018	No	Yes	
2019	No	No	
2020	No	No	

Site #	Site Name	GPS: N	GPS - W	Comments
35	Bertinoia - 4	38.515003	-121.972722	Shaded Riffles

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Section has great potential.
2013	No	No	
2014	No	No	
2015	No	No	
2016	Yes	Yes	
2017	No	Yes	
2018	No	Yes	
2019	No	No	
2020	No	No	

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
36	Neil Crossing	38.518768	-121.968926	Cobble Crossing

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	No	No	Site is a crossing that was routinely “scarified” by vehicles crossing the creek. Salmon routinely attempt to spawn in all the crossings. Unfortunately, the applied cobble is angular and NOT ideal for building redds. The area immediately downstream from the crossing is also used by salmon.
2013	No	No	
2014	No	No	
2015	No	Yes	
2016	Yes	Yes	
2017	No	Yes	
2018	No	No	
2019	No	No	
2020	No	No	

Site #	Site Name	GPS: N	GPS - W	Comments
37	Neil Weir	38.519073	-121.968895	Weir / Plunge Pool

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Weir built in 2011 during the Winters Putah Creek Park Project.
2013	No	No	
2014		No	
2015		Yes	
2016		Yes	
2017		No	
2018		No	Weir inundated (buried) with sand and flood debris. Recommend that it be recovered and maintained.
2019		No	
2020		No	

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Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
38	Winters Putah Cr. Park - 1A	38.519441	-121.968759	Medium Pool / Run

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Site is part of the Winters Putah Creek Park - Phase 1 project in 2011. Site is characterized by poor benthic quality, deep runs and insufficient flow regime. Salmon have occasionally attempted to spawn on the edges where cobble had gathered.
2013	No	No	
2014	No	No	
2015	No	Yes	
2016	Failed	Yes	
2017	No	No	
2018	No	No	
2019	No	No	
2020	No	No	

Site #	Site Name	GPS: N	GPS - W	Comments
39	Winters Putah Cr. Park - 1B	38.519597	-121.968436	Run / Pools

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Site is part of the Winters Putah Creek Park - Phase 1 project in 2011. Site is characterized by poor benthic quality, deep runs and insufficient flow regime. Salmon have occasionally attempted to spawn on the edges where cobble had gathered.
2013	No	No	
2014	No	No	
2015	No	No	
2016	No	Yes (One pair salmon)	
2017	No	No	
2018	No	No	
2019	No	No	
2020	No	No	

Scarification Sites & Salmon Spawning History

<table>
<tr><th>Site #</th><th>Site Name</th><th>GPS: N</th><th>GPS - W</th><th>Comments</th></tr>
<tr><td>40</td><td>Winters Putah Cr. Park - 1 C</td><td>38.519845</td><td>-121.968168</td><td>Run / Pool</td></tr>
</table>

<table>
<tr><th colspan="4">Scarification and Salmon Spawning - History at Site</th></tr>
<tr><th>Year</th><th>Scarified?</th><th>Salmon Spawn at Site?</th><th>Comments</th></tr>
<tr><td>Pre-2013</td><td>NA</td><td>No</td><td rowspan="7">Site is part of the Winters Putah Creek Park - Phase 1 project in 2011. Site is characterized by poor benthic quality, deep runs and insufficient flow regime. Salmon have occasionally attempted to spawn on the edges where cobble had gathered.</td></tr>
<tr><td>2013</td><td>No</td><td>No</td></tr>
<tr><td>2014</td><td>No</td><td>No</td></tr>
<tr><td>2015</td><td>No</td><td>Yes (One pair salmon)</td></tr>
<tr><td>2016</td><td>Minor</td><td>Yes (2 Pair salmon)</td></tr>
<tr><td>2017</td><td>No</td><td>No</td></tr>
<tr><td>2018</td><td>No</td><td>No</td></tr>
<tr><td>2019</td><td>No</td><td>No</td><td></td></tr>
<tr><td>2020</td><td>No</td><td>No</td><td></td></tr>
</table>

<table>
<tr><th>Site #</th><th>Site Name</th><th>GPS: N</th><th>GPS - W</th><th>Comments</th></tr>
<tr><td>41</td><td>Winters Car Bridge</td><td>38.520227</td><td>-121.967755</td><td>Pool / Run</td></tr>
</table>

<table>
<tr><th colspan="4">Scarification and Salmon Spawning - History at Site</th></tr>
<tr><th>Year</th><th>Scarified?</th><th>Salmon Spawn at Site?</th><th>Comments</th></tr>
<tr><td>Pre-2013</td><td>NA</td><td>No</td><td></td></tr>
<tr><td>2013</td><td>No</td><td>No</td><td rowspan="6">Site under the Winters Car Bridge. Ideal area for the public to view spawning salmon. Needs annual maintenance, addition of cobble and medium size rocks.</td></tr>
<tr><td>2014</td><td>No</td><td>No</td></tr>
<tr><td>2015</td><td>No</td><td>No</td></tr>
<tr><td>2016</td><td>Yes</td><td>Yes</td></tr>
<tr><td>2017</td><td>No</td><td>Yes</td></tr>
<tr><td>2018</td><td>Yes (minor)</td><td>Yes</td></tr>
<tr><td>2019</td><td>No</td><td>No</td><td></td></tr>
<tr><td>2020</td><td>No</td><td>No</td><td></td></tr>
</table>

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
42	Winters Putah Cr. Park - 1D	38.522898	-121.960872	Deep Run

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	No	No	Site characterized by deep pools, lack of benthic structure, and water velocity that is too slow. The section is inappropriate for salmon spawning. I have watched these sites since 2011 and have never witnessed salmon using the area. The exception is a small area with injected gravel that is used by dog walkers.
2013			
2014			
2015			
2016			
2017			
2018			
2019			
2020			

Site #	Site Name	GPS: N	GPS - W	Comments
43	Winters Putah Cr. Park -1 E	38.523419	-121.959081	Deep Run

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Site characterized by deep pools, lack of benthic structure, and water velocity that is too slow. The section is inappropriate for salmon spawning. I have watched these sites since 2011 and have never witnessed salmon using the area.
2013	No		
2014			
2015			
2016			
2017			
2018			
2019			
2020			

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
44	Winters Putah Cr. Park - 3-1	38.522898	-121.960872	Deep Run

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	No	No	The last phase of the Winters Putah Creek Park. Phase three was constructed in 2019. The section is too wide and shallow for salmon spawning. One area has some injected gravel but to my knowledge, it has not been used by spawning salmon. In the future, the area might be considered for Scarification.
2013			
2014			
2015			
2016			
2017			
2018			
2019			
2020			

Site #	Site Name	GPS: N	GPS - W	Comments
45	Winters Putah Cr. Park -3-2	38.523419	-121.959081	Deep Run

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	The last phase of the Winters Putah Creek Park. Phase three was constructed in 2019. The section is too wide and shallow for salmon spawning. One area has some injected gravel but to my knowledge, it has not been used by spawning salmon. In the future, the area might be considered for Scarification.
2013	No		
2014			
2015			
2016			
2017			
2018			
2019			
2020			

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
46	Winters Putah Cr. Park: 2-1	38.523876	-121.957919	Deep Run

Scarification and Salmon Spawning - History at Site			
Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA		Site characterized by deep pools, lack of benthic structure, and water velocity that is too slow. The section is inappropriate for salmon spawning.
2013	No		
2014	No		
2015	No	Yes	
2016	No	Yes	Salmon did attempt to spawn in the vehicle crossing between Phase 3 and Phase 2. Redds looked marginal.
2017	No		
2018	No		
2019	No		
2020	No		

Site #	Site Name	GPS: N	GPS - W	Comments
47	Winters Putah Cr. Park: 2-2	38.524227	-121.956793	Deep Run

Scarification and Salmon Spawning - History at Site			
Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Site characterized by deep pools, lack of benthic structure, and water velocity that is too slow. The section is inappropriate for salmon spawning.
2013	No	No	
2014	No	No	
2015	No	No	
2016	No	Yes	
2017	No	No	
2018	No	No	
2019	No	No	
2020	No	No	

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
48	Winters Putah Cr. Park - 2-3	38.522898	-121.960872	Deep Run

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	No	No	Site characterized by deep pools, lack of benthic structure, and water velocity that is too slow. The section is inappropriate for salmon spawning.
2013			
2014			
2015			
2016			
2017			
2018			
2019			
2020			

Site #	Site Name	GPS: N	GPS - W	Comments
49	Winters Putah Cr. Park: 2-4	38.524227	-121.956793	Deep Run

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Site characterized by deep pools, lack of benthic structure, and water velocity that is too slow. The section is inappropriate for salmon spawning.
2013	No		
2014	No		
2015	No		
2016	No		
2017	No		
2018	No		
2019	No		
2020	No		

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
50	NAWCA - 1	38.524529	-121.956289	Shallow Run / riffles

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	
2013	No	No	
2014	No	No	
2015	No	No	
2016	Yes	Yes	
2017	Yes	Yes	
2018	No	No	Homeless camp on bank of scarification site. Site configuration changed.
2019	No	No	
2020			

Site #	Site Name	GPS: N	GPS - W	Comments
51	NAWCA - 2	38.4524776	-121.956066	Shaded Run

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA		Site was dramatically changed during the NWCA Project. Site has potential as an effective spawning area.
2013	No		
2014	No		
2015	No		
2016	No	No	
2017	Yes		
2018	No		
2019	No		
2020	No		

Scarification Sites & Salmon Spawning History

<table>
<tr><th>Site #</th><th colspan="2">Site Name</th><th>GPS: N</th><th>GPS - W</th><th>Comments</th></tr>
<tr><td>52</td><td colspan="2">NAWCA -3</td><td>38.52498</td><td>-121.955835</td><td>Run / Pool</td></tr>
<tr><td colspan="6">Scarification and Salmon Spawning - History at Site</td></tr>
<tr><td>Year</td><td>Scarified?</td><td colspan="2">Salmon Spawn at Site?</td><td colspan="2">Comments</td></tr>
<tr><td>Pre-2013</td><td>NA</td><td colspan="2" rowspan="9">No</td><td colspan="2" rowspan="6">Site was dramatically changed during the NWCA Project. Site has potential as an effective spawning area.</td></tr>
<tr><td>2013</td><td rowspan="8">No</td></tr>
<tr><td>2014</td></tr>
<tr><td>2015</td></tr>
<tr><td>2016</td></tr>
<tr><td>2017</td></tr>
<tr><td>2018</td><td colspan="2"></td></tr>
<tr><td>2019</td><td colspan="2"></td></tr>
<tr><td>2020</td><td colspan="2"></td></tr>
</table>

<table>
<tr><th>Site #</th><th colspan="2">Site Name</th><th>GPS: N</th><th>GPS - W</th><th>Comments</th></tr>
<tr><td>53</td><td colspan="2">NAWCA - 4</td><td>38.525339</td><td>-121.95444</td><td>Shaded Riffles</td></tr>
<tr><td colspan="6">Scarification and Salmon Spawning - History at Site</td></tr>
<tr><td>Year</td><td>Scarified?</td><td colspan="2">Salmon Spawn at Site?</td><td colspan="2">Comments</td></tr>
<tr><td>Pre-2013</td><td>NA</td><td colspan="2" rowspan="9">No</td><td colspan="2" rowspan="6">Site is too deep, wide and slow for salmon spawning.</td></tr>
<tr><td>2013</td><td rowspan="8">No</td></tr>
<tr><td>2014</td></tr>
<tr><td>2015</td></tr>
<tr><td>2016</td></tr>
<tr><td>2017</td></tr>
<tr><td>2018</td><td colspan="2"></td></tr>
<tr><td>2019</td><td colspan="2"></td></tr>
<tr><td>2020</td><td colspan="2"></td></tr>
</table>

Scarification Sites & Salmon Spawning History

<table>
<tr><th>Site #</th><th colspan="2">Site Name</th><th>GPS: N</th><th>GPS - W</th><th>Comments</th></tr>
<tr><td>54</td><td colspan="2">I- 505 - 1</td><td>38.52571</td><td>-121.9527</td><td>Weir</td></tr>
<tr><td colspan="6">Scarification and Salmon Spawning - History at Site</td></tr>
<tr><td>Year</td><td>Scarified?</td><td colspan="2">Salmon Spawn at Site?</td><td colspan="2">Comments</td></tr>
<tr><td>Pre-2013</td><td>NA</td><td colspan="2">No</td><td colspan="2" rowspan="3">I-505 Weir has allowed salmon to attempt spawning just above the weir.</td></tr>
<tr><td>2013</td><td rowspan="8">No</td><td colspan="2">No</td></tr>
<tr><td>2014</td><td colspan="2">No</td></tr>
<tr><td>2015</td><td colspan="2">No</td><td colspan="2"></td></tr>
<tr><td>2016</td><td colspan="2">Yes</td><td colspan="2"></td></tr>
<tr><td>2017</td><td colspan="2">No</td><td colspan="2"></td></tr>
<tr><td>2018</td><td colspan="2">No</td><td colspan="2"></td></tr>
<tr><td>2019</td><td colspan="2">No</td><td colspan="2"></td></tr>
<tr><td>2020</td><td colspan="2">No</td><td colspan="2"></td></tr>
</table>

<table>
<tr><th>Site #</th><th colspan="2">Site Name</th><th>GPS: N</th><th>GPS - W</th><th>Comments</th></tr>
<tr><td>55</td><td colspan="2">I- 505 - 2</td><td>38.525779</td><td>-121.95218</td><td>Shaded Pool / Riffles</td></tr>
<tr><td colspan="6">Scarification and Salmon Spawning - History at Site</td></tr>
<tr><td>Year</td><td>Scarified?</td><td colspan="2">Salmon Spawn at Site?</td><td colspan="2">Comments</td></tr>
<tr><td>Pre-2013</td><td>NA</td><td colspan="2" rowspan="9">No</td><td colspan="2" rowspan="6">Site has potential. Possible claypan issues.</td></tr>
<tr><td>2013</td><td rowspan="8">No</td></tr>
<tr><td>2014</td></tr>
<tr><td>2015</td></tr>
<tr><td>2016</td></tr>
<tr><td>2017</td></tr>
<tr><td>2018</td><td colspan="2"></td></tr>
<tr><td>2019</td><td colspan="2"></td></tr>
<tr><td>2020</td><td colspan="2"></td></tr>
</table>

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
56	I- 505 - 3	38.526369	-121.99503	Riffle / Run

Scarification and Salmon Spawning - History at Site			
Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Site has potential. Possible claypan issues.
2013	No		
2014			
2015			
2016			
2017			
2018			
2019			
2020			

Site #	Site Name	GPS: N	GPS - W	Comments
57	I- 505 - North Channel	38.52639	-122.950261	Riffle / Run

Scarification and Salmon Spawning - History at Site			
Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	Yes	Site is just upstream from a split in the creek. The southern channel goes adjacent to Putah Creek Road. Salmon have attempted to spawn in this area. Site too sandy and in the shadow of Putah Creek Road. North Channel has ideal gravel / cobble resources.
2013	No	No	
2014	No	No	
2015	No	No	
2016	Yes	Yes	
2017	No	Yes	
2018	No	No	
2019	No	No	
2020	No	No	

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
58	I- 505 -North Channel 2	38.526551	-121.949895	Riffle / Run
Scarification and Salmon Spawning - History at Site				
Year	Scarified?	Salmon Spawn at Site?	Comments	
Pre-2013	NA	No	Straight, narrow channel that has supported numerous salmon. Section too straight, needs structure.	
2013	No	No		
2014	No	No		
2015	No	No		
2016	No	Yes		
2017	No	Yes		
2018	No	No		
2019	No	No		
2020	No	No		

Site #	Site Name	GPS: N	GPS - W	Comments
59	I- 505 - North Channel 3	38.526727	-121.949445	Riffle / Run
Scarification and Salmon Spawning - History at Site				
Year	Scarified?	Salmon Spawn at Site?	Comments	
Pre-2013	NA	-	Straight, narrow channel that has supported numerous salmon. Section too straight, needs structure.	
2013	No	-		
2014	No	-		
2015	No	-		
2016	No	Yes		
2017	Yes	Yes		
2018	No	-		
2019	No	-		
2020	No	-		

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
60	I- 505 -North Channel 4	38.526807	-121.951672 *	Riffle / Run

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	-	Straight, narrow channel that has supported numerous salmon. Section too straight, needs structure.
2013	-	-	
2014	-	-	
2015	-	-	
2016	Yes	Yes	
2017	-	Yes	
2018	-	-	
2019	-	-	
2020	-	-	

Site #	Site Name	GPS: N	GPS - W	Comments
61	Kilkenny - 1	38.531476	-121.93178	Deep Pool

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Site of a weir with landowner crossing. Salmon have no use the crossing or the section below the weir which is too deep with inappropriate benthic structure.
2013	No		
2014			
2015			
2016			
2017			
2018			Section was tested and failed due to copious mud and sand.
2019			
2020			

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
62	Kilkenny - 2	38.531267	-121.931202	Deep Run

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA		
2013			
2014			
2015			
2016	Tested	Attempted & failed	Section was tested and failed due to copious mud and sand.
2017			
2018			
2019			
2020			

Site #	Site Name	GPS: N	GPS - W	Comments
63	Kilkenny - 3	38.53116	-121.09308	Deep Run

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Section tested for benthic quality. Failed due to poor benthic structure.
2013	No		
2014			
2015			
2016			
2017			
2018			
2019			
2020			

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Scarification Sites & Salmon Spawning History

<table>
<tr><th>Site #</th><th>Site Name</th><th colspan="2">GPS: N</th><th>GPS - W</th><th>Comments</th></tr>
<tr><td>64</td><td>Kilkenny - 4</td><td colspan="2">38.535452</td><td>-121.930269</td><td>Deep Run</td></tr>
<tr><td colspan="6">Scarification and Salmon Spawning - History at Site</td></tr>
<tr><td>Year</td><td>Scarified?</td><td colspan="2">Salmon Spawn at Site?</td><td colspan="2">Comments</td></tr>
<tr><td>Pre-2013</td><td>NA</td><td colspan="2" rowspan="9">No</td><td colspan="2" rowspan="2">Site of W - Weir. Not currently appropriate for spawning. Might have potential.</td></tr>
<tr><td>2013</td><td rowspan="8">No</td></tr>
<tr><td>2014</td><td colspan="2"></td></tr>
<tr><td>2015</td><td colspan="2"></td></tr>
<tr><td>2016</td><td colspan="2"></td></tr>
<tr><td>2017</td><td colspan="2"></td></tr>
<tr><td>2018</td><td colspan="2"></td></tr>
<tr><td>2019</td><td colspan="2"></td></tr>
<tr><td>2020</td><td colspan="2"></td></tr>
</table>

<table>
<tr><th>Site #</th><th>Site Name</th><th colspan="2">GPS: N</th><th>GPS - W</th><th>Comments</th></tr>
<tr><td>65</td><td>McNamera -1</td><td colspan="2">38.529755</td><td>-122.915928</td><td>Deep Run</td></tr>
<tr><td colspan="6">Scarification and Salmon Spawning - History at Site</td></tr>
<tr><td>Year</td><td>Scarified?</td><td colspan="2">Salmon Spawn at Site?</td><td colspan="2">Comments</td></tr>
<tr><td>Pre-2013</td><td>NA</td><td colspan="2"></td><td colspan="2" rowspan="3">Site has potential. Salmon have attempted to spawn but not confirmation that the spawn was successful.</td></tr>
<tr><td>2013</td><td>No</td><td colspan="2"></td></tr>
<tr><td>2014</td><td>No</td><td colspan="2"></td></tr>
<tr><td>2015</td><td>No</td><td colspan="2">Yes</td><td colspan="2" rowspan="3">Some early “scarification” was primarily disturbance created by landowners cross-ing the section in quads.</td></tr>
<tr><td>2016</td><td>Yes</td><td colspan="2">Yes</td></tr>
<tr><td>2017</td><td>Minor</td><td colspan="2">Yes</td></tr>
<tr><td>2018</td><td>No</td><td colspan="2">No</td><td colspan="2"></td></tr>
<tr><td>2019</td><td>No</td><td colspan="2">No</td><td colspan="2"></td></tr>
<tr><td>2020</td><td>No</td><td colspan="2">No</td><td colspan="2"></td></tr>
</table>

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
66	Vickrey -1	38.52959	-121.917755	Shallow Run

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	-	
2013	No	-	
2014	No	-	
2015	Yes	Yes	Narrow, shaded area that has potential for a good spawning area.
2016	No	Yes	
2017	No	-	
2018	No	-	
2019	No	-	
2020	No	-	

Site #	Site Name	GPS: N	GPS - W	Comments
67	Vickrey - 2			Shallow Run

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	-	Section has a history of salmon attempting to spawn in marginal sites. Scarification helped. Copious amounts of sand and mud.
2013	-	-	
2014	-	-	
2015	Yes	Yes	
2016	-	Yes	
2017	-	-	
2018	-	-	
2019	-	-	
2020	-	-	

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
68	Vickrey - 3	38.52556	-121.90919	Shallow Run

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA		Attempted spawning in poor quality site. Limited benthic structure to protect eggs.
2013	-		
2014	-		
2015	-	Yes (attempt)	
2016	-	Yes (attempt)	
2017	Yes		
2018	-		
2019	-		
2020	-		

Site #	Site Name	GPS: N	GPS - W	Comments
69	Vickrey - 4	38.5308213	-121.905454	Shallow Run

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA		Attempted spawning in poor quality site. Limited benthic structure to protect eggs.
2013	No		
2014			
2015		Yes (attempted)	
2016		Yes (attempted)	
2017			
2018			
2019			
2020			

Scarification Sites & Salmon Spawning History

Site #	Site Name	GPS: N	GPS - W	Comments
70	Lester -1	38.531371	-121.902951	Shallow Riffles

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Section has great potential with great cobble resources and shaded sections.
2013	-		
2014	-		
2015	-		
2016	-		Only section has been scarified and also has ideal features and salmon have NOT used the area for spawned. I suspect that we need more structure as the run is relatively straight.
2017	Yes		
2018	-		
2019	Yes		
2020	-		

Site #	Site Name	GPS: N	GPS - W	Comments
71	Lester -2	38.531967	-121.902101	Shaded Riffles

Scarification and Salmon Spawning - History at Site

Year	Scarified?	Salmon Spawn at Site?	Comments
Pre-2013	NA	No	Section has great potential with great cobble resources and shaded sections.
2013	-		
2014	-		
2015	-		Only section has been scarified and also has ideal features and salmon have NOT used the area for spawned. I suspect that we need more structure as the run is relatively straight.
2016	-		
2017	Yes		
2018	-		
2019	Yes		
2020			

Scarification Sites & Salmon Spawning History

<table>
<tr><th>Site #</th><th colspan="2">Site Name</th><th>GPS: N</th><th>GPS - W</th><th>Comments</th></tr>
<tr><td>72</td><td colspan="2">Lester -3 (North)</td><td>38.532115</td><td>-121.901456</td><td>Shallow Run</td></tr>
<tr><td colspan="6">Scarification and Salmon Spawning - History at Site</td></tr>
<tr><td>Year</td><td>Scarified?</td><td colspan="2">Salmon Spawn at Site?</td><td colspan="2">Comments</td></tr>
<tr><td>Pre-2013</td><td>NA</td><td colspan="2" rowspan="9">NO</td><td colspan="2" rowspan="5">Section where the north channel meets with the deeper south channel.</td></tr>
<tr><td>2013</td><td rowspan="8">NO</td></tr>
<tr><td>2014</td></tr>
<tr><td>2015</td></tr>
<tr><td>2016</td></tr>
<tr><td>2017</td><td colspan="2">Site has potential for spawning.</td></tr>
<tr><td>2018</td><td colspan="2"></td></tr>
<tr><td>2019</td><td colspan="2"></td></tr>
<tr><td>2020</td><td colspan="2"></td></tr>
</table>

END - Scarification Sites & Salmon Spawning History - **END**

Scarification and Turbidity

2016 image of post-storm turbidity near the Winters Car Bridge. Ken W. Davis image.

Turbidity in Lower Putah Creek is a relatively common event after storm events or over-flow of the Lake Berryessa Glory Hole. Sediment from upstream tributaries that are highly incised is significant (Pleasant Creek - Page 14). Generally, any action, even wading across Lower Putah Creek causes a sediment bloom. Sediment loading can be expected during any scarification action using a creekside excavator. The issue is, how to handle the sediment .

From the CDFW approved Monitoring Plan:

"A. Turbidity and settleable matter will be measured before in-water work begins and every 4 hours during in-water work. There parameters will be measured via grab samples that will be collected immediately upstream of the work area and approximately 300 feet downstream of the work area. The time, location, and results of the samples will be recorded and reported to the Central Valley Regional Water Quality Control Board after the project is complete. Per the project's Section 401 Water Quality Certification, work shall not cause turbidity to increase more than 15 NTUs over background turbidity and settleable matter shall not increase more than 0.1 mL/L, as measured via grab sample approximately 300 feet downstream of the work area. If these parameters exceed the maximum amount of units allowed, then in-water work will cease until the parameters recede to the acceptable range.

B. If a visible sediment plume is created by in-water work, then in-water work will cease every 45 minutes and will not resume until the plume dissipates from the work area."

Measuring turbidity during Scarification: We measure the amount of fine sediment in water with a measure of turbidity, or how murky the water is, on a scale using Nephelometric Turbidity Units (NTUs).

Equipment: HACH 2100Q Portable Turbidity Meter. Cleaned and calibrated before each use at every site.

DISCUSSION: Turbidity during Scarification Process
Lower Putah Creek is routinely inundated with sediment from upstream tributaries during storm events. Sediment deposition is significant and has caused "cementation" a benthic condition that essentially embeds cobble (see image on Page 7) making if difficult if not impossible for salmonids and other fish to spawn. It also affects the species composition and life cycles of many benthic macroinvertebrates (BMIs). It is well understood the aquatic invertebrates are the base of the aquatic and riparian food chain. Fixing the sediment problem or managing the benthic composition is essential for restoring the "health" of Lower Putah Creek.

Mechanical scarification is the best solution. One of the issues with scarification is that it can create turbidity. Unfortunately, the suspended sediment creates an embedded condition that prevents salmon, trout and lamprey eels from robust spawning. To remedy the problem and facilitate spawning, the choice is simple: develop an effective scarification program. Being that sediment is routinely introduced into LPC we either accept the condition that prevents effective spawning or deal with the inevitable turbidity caused by scarification. In some areas, the sediment condition is launched into the water column by simply wading across the creek. On 10/25, 2017, I measured the turbidity after I waded across the creek near the Dry Creek confluence. I have provided the UTU data in the chart below:

Date: 10/25/2017				
Site: Near the Dry Creek Confluence				
Comments: Turbidity created from WADING across Lower Putah Creek				
Time	**NTU**	**Site Water Sample Collected**	**Distance from Work Site**	**Comments**
1:50 PM	1.89			Before Wading Test
1:55 PM	165			Wade
	155			
	156			
2 min.	148			2 minutes post wade
3 min.	131			
5 min.	113	Downstream	100 feet	
10 min.	93.5			
15 min.	79.1			
20 min.	64.5			
30 min.	14.2			
45 min.	2.02			
50 min.	1.91			Return to background level
** NOTE: This area tends to "clear" slowly due to a wide section upstream				
END				

Date: 10/24/2017				
Site: Dry Creek Confluence				**Site #:** 31
Comments: From upstream for background data - Taken at Pickerel Weir				
Time	**NTU**	**Site Water Sample Collected**	**Distance from Work Site**	**Comments**
12.30 PM	1.48	Pickerel Weir	2.1 miles upstream	Background Data
	1.62			
	1.49			
	1.51			
DOWNSTREAM: Background data from DOWNSTREAM prior to scarification				
1:16 PM	1.00	WPCP - 3	0.86 Miles	Background Data
	0.98			
	0.90			
	0.97			
Date: 10/25/2017 - SCARIFICATION SITE				
ON-SITE DATA				
1:30 PM	67.8	Dry Creek (downstream)	300 feet	**ACTION TAKEN:** Work stopped for 15 minutes
	70.5			
	67.0			
2:05	72.6	Dry Creek (downstream)	300 feet	**ACTION TAKEN:** Work Stopped for 18 minutes
	70.0			
	68.8			
	75.7			
2:46	101.0	Dry Creek (downstream)	200 feet	**ACTION TAKEN:** Work stopped for 30 minutes
	98.5			
	89.6			
	100.1			
3:26	78.8	Dry Creek (downstream)	300 feet	**ACTION TAKEN: Work stopped. Site completed**
	76.4			
	81.5			
	79.0			
SITE COMPLETED - WORK STOPPED AT SITE				

Date: 10/18/2018

Site: Bertinoia -3 | **Site #:** 34

Comments: Downstream sediment stream before Scarification. Determined the sediment was created by a SCWA Fisheries e-fishing team

Time	NTU	Site Water Sample Collected	Distance from Work Site	Comments
NA	5.59	I-505 Split (Downstream)	1.54 Miles from Work Site.	Background Data (Sediment load was caused by SCWA e-fishing team)
	5.71			
	5.49			
	5.66			
UPSTREAM: Background data from UPSTREAM prior to scarification				
12:36 PM	0.80	Pickerel Crossing (Upstream)	2.05 Miles	Background Data
	0.82			
	0.84			
	0,83.5			
ON-SITE DATA				
1:30 PM	225.0	Bertinoia - 3	300 feet	**ACTION TAKEN:** Work stopped for 30 minutes.
	217.4			
	212.5			
2:15	230.5	Bertinoia - 3	300 feet	**ACTION TAKEN:** Work Stopped for 32 minutes
	225.7			
	231.8			
	230.2			
3:04	228.0	Bertinoia - 3	200 feet	**ACTION TAKEN:** Work stopped for 30 minutes
	231.6			
	231.0			
	228.2			
3:50	241.0	Bertinoia - 3	300 feet	**ACTION TAKEN: Work stopped. Site completed**
	242.3			
	238.3			
	245.8			
SITE COMPLETED - WORK STOPPED AT SITE				

Date: 10/22/2018 & 10/23/2018

Site: Morales Reach - (Old Crossing) | **Site #:** 22

Comments: Downstream check PRIOR to scarification. Tainted water at WPCP Phase 3 (2.3 miles) and I-505 (4.25 miles) downstream. NO KNOWN cause for the tainted water.

Time	NTU	Site Water Sample Collected	Distance from Work Site	Comments
2.35 PM	1.90	WPCP - Phase 3	2.3 miles	No known cause
	1.89			
	1.88			
	1.96			
UPSTREAM: Background data from upstream prior to scarification				
3:42 PM	1.00	CODY - Control 1	930 Meters	
	0.98			
	0.90			
	0.97			
ON-SITE DATA				
4:05 PM	69.9	Morales Work Site (downstream)	300 feet	**ACTION TAKEN:** Work stopped for the day.
	68.5			
	69.3			
Date: 10/23/2018 - SAME SITE				
9:40 AM	58.6	Morales Work Site (downstream)	300 feet	**ACTION TAKEN:** Work stopped until sediment plume dissipated. Stopped for 15 minutes.
	57.6			
	68.6			
	71.1			
10:14AM	58.6	Morales Work Site (downstream)	500 feet	**ACTION TAKEN:** Work stopped until sedi- ment plume dissipated. Work stopped for 20 minutes
	63.6			
	66.8			
	70.6			
11:46	66.5	Morales Work Site (downstream)	300 feet	**ACTION TAKEN:** Work stopped until sediment plume dissipated. Site completed.
	67.5			
	68.3			
	69.0			
SITE COMPLETED - WORK STOPPED AT SITE				

Scarification and Benthic Macroinvertebrates - Discussion and Data

A healthy population of aquatic phase benthic macroinvertebrates, that includes mayflies, caddisflies and stoneflies, requires clean water, cool water, and open interstitial spaces for foraging and refugia from predators. Their requirements are similar to those of rainbow trout. It is my opinion that Lower Putah Creek can provide those requirements given scarification to remedy gravel cementation and clean water. Unfortunately during the six years of the LPC Scarification Project the creek was subject to two significant flood events that essentially buried every scarification site selected for the project. In addition four (4) of those years significant wildfires occurred on the banks of Putah Creek, in major tributaries, and along the banks of Lake Berryessa which is the provides water to Putah Creek. Although I saw glimmers of improved species composition, diversity and increased density, I cannot fully document those metrics. I have provided below a recommendation, image documentation concerning the floods and wildfires and sample data on the BMI community that was subjected to negative forces of floods and wildfires.

2014

12/13/2014 Image: Sediment tainted flood water from a significant storm on 12/12/2014. Most species of BMIs cannot generally tolerate such water conditions for extended periods of time. Being that their gills are external, sensitive species such as mayflies and stoneflies will succumb. The tainted water probably originated in Pleasant Creek an upstream tributary.

2015

7/29/2015 Image: The Wragg Fire on 7/22/2015 contributed significant amounts of burned material and other fire dregs into Putah Creek. Most of those materials are toxic to benthic macroinvertebrates.

2016

3/15/2016 Image: Confluence of Putah Creek and Cold Creek. Sediment and fire dregs in the middle of the image was 5 feet deep. It was coming out of Cold Creek as a result of storm events carrying sediment from the Wragg Fire.

2016

8/2/2016 Image: Cold Fire as it burns near Monticello Dam. It eventually crossed over Putah Creek to the north bank.

Sediment and fire dregs washed downstream during storm events.

2016

12/16/2016 Image: Neil Crossing (Winters Putah Creek Park) during a flood event.

NOTE: The sediment load is from upstream erosion, NOT from a scarification procedure.

2017

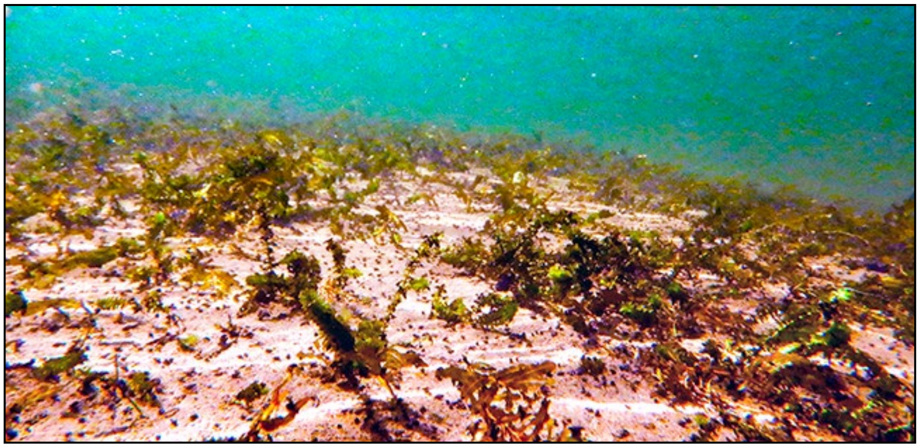
1/9/2017 Image: Image at the Pickerel Weir / Crossing after a series of high water events. The Lake Berryessa Glory Hole over-flowed on 2/17/2017 which increased the deluge on Lower Putah Creek. Many species of BMIs were either buried or suffocated by the suspended sediment.

2017

2/7/2017 Image: Winters Putah Creek Parkway inundated with the flood water even before the Glory Hole at Lake Berryessa breached. The sediment load is from upstream erosion, NOT mechanical scarification.

2017

3/2/2017 Image: Pleasant Creek draining sediment and some fire debris. Pleasant Creek (and upstream tributaries) is the main corridor for the recruitment of BMIs into Lower Putah Creek.



2018

9/20/2018 Image: Subsurface image taken at the Pickerel Scarification Complex. Shows several feet of (deep) sand that has been colonized by aquatic weeds. BMI populations in this condition are typically mudsnails, other snails and midges (Chironomidae).

2018

8/3/2018 Image: Subsurface image of the Cody Control Site that was inundated with 5-6 feet of sand from the 2017 high water events and the overflow of the Lake Berryessa Glory Hole. BMIs here are primarily New Zealand Mudsnails.

2019

1/10/2019 Image: Image show a side channel (Scarification Site) with plant cages covered with aquatic plants swept downstream by floodwaters.

2020

8/17/2020 Image: LNU Lightning Complex fire at Lake Berryessa. Fire dregs will eventually reach Lower Putah Creek.

2020

Shows some watercraft that were burned at Markley Cove Marina during the LNU Lightning Complex fire.

No Scarification in 2020 - Discussion

For several reasons, Lower Putah Creek was NOT scarified in 2020. I believe it was important to monitor the spawning areas as much as possible to compare redds, size of cobble, BMIs, etc.

Depth of Redds: The chart below shows a comparison of redds (2017) after scarification and spawning to redds from 2020 after spawning (NO scarification). The survey supports the fact that scarification helps salmon digg deeper redds.

Depth of Redds 2017 compared to 2020 (In scarified and non-scarified sections)					
Study Section	Redd #	Scarified	Depth (cm.) **2017** (inside redd)	**Redd #**	Depth (cm.) **2020** (inside redd)
1	1A	Control (No)	7	1A	5
	2B		8	2B	6
	3C		10	3C	8
2		No gravel	No Redds	No Redds	
3	3A	Yes	25	3A	11
	3B		20	3B	8
	3C		27	3C	13
4	4A	Yes	30	4A	8
	4B		31	4B	13
	4C		41	4C	9
	4D		37	4D	14
5	5A	Yes	25	5A	9
	5B		33	5B	18
6	6A	Yes	26	6A	14
	6B		44	6B	9
	6C		40	6C	18
	6D		32	6D	10
	6E		25	6E	18
	6F		28	6F	11

Size of Cobble in Redds:
Scarification tends to uncover larger cobble / particles and create a better size mix to help salmon create better "quality" redds. Improved quality redds (with large cobble) tend to protect eggs and provide some refugia for alevin and juveniles. They also appear to protect redds during small storm events.

It appears that (data below) that scarification helps salmon to develop better quality redds by eliminating embeddness and creating a better mix of cobble.

% Embeddedness in salmon redd - Post spawn (NO SCARIFICATION)			
Site: Pickerel Run			
Date: March 29, 2021			
Cobble #	Length (cm)	Depth (cm)	% Embedded
1	3	2	0
2	2	1	0
3	3	3	0
4	2	2	0
5	3	3	0
6	4	1	0
7	1	1	**0**
8	3	2	0
9	2	2	0
10	2	1	0
11	1	1/2	0
12	3	2	0
13	5	3	0
14	4	3	0
15	3	2	0

% Embeddedness in salmon redd - Post spawn (NO SCARIFICATION			
Site: Morales -2			
Date: March 30, 2021			
Cobble #	Length (cm)	Depth (cm)	% Embedded
1	4	1	0
2	3	2	0
3	5	1	0
4	3	2	0
5	4	3	0
6	4	2	0
7	5	3	**5**
8	3	2	0
9	6	3	0
10	4	5	0
11	4	2	0
12	5	1	0
13	4	2	0
14	2	2	0
15	3	2	0

Benthic Macroinvertebrates and Scarification:
The following page shows a list of BMI species that have hysterically been documented in Lower Putah Creek. The environmental conditions during the Scarification Project did not support the development of a healthy BMI Community. Throughout the lower creek, the invertebrate community is dominated by New Zealand Mud-snails, midges (Chironomidae), Glossosoma (Tricoptera) and Hydrophyche (Tricoptera. I strongly recommend that the BMI surveys continue as the development of a healthy community will take a number of years without fires and flood conditions.

Benthic macroinvertebrates are a better choice to determine the health of Lower Putah Creek than any other species or complex, which includes salmon.

Wildlife Survey & Photo Service
2443 Fair Oaks Blvd., # 209 • Sacramento, CA 95825 • (916) 747-8537

SITE NAME: Pickerel Island North			SITE #: 2		
Species	8/2/16	7/9/17	4/2/2018	10/2/19	3/23/2021
GASTROPODA (snails)					
Potamopyrgus antipodarum (NZMS)	546 (70%)		345 (61%)	304 (62%)	277 (46%)
Physa acuta	8		5	10	14
Stagnicola sp.	9	NA (sand)	12	5	4
Planorbis sp.	3		3	1	5
Radix auricularia					2
Heliosoma sp.			3		1
TRICOPTERA (caddisflies)					
Brachycentrus					4
Glossosoma (larvae)	8		12	1	14
Gossosoma (pupae)	17		24		56
Hydropsyche californica (l)	8		5	3	4
Hydropsyche californica (p)			4	1	6
Nectopyche					
Amiocentrus				3	3
EPHEMEROPTERA (mayflies)					
Attenella					
Baetis tricaudatus	12		12	2	24
Callibaetis					
Ephemerella					2
Nixe			1		
Tricorythodes					5
Epeorus					2
PLECOPTERA (stoneflies)					
Isoperla					1
DIPTERA (flies)					
Simulium (larvae)			23		34
Simulium (pupae)					
Chironomids	154		112	156	145
OTHER					
Sigara	12		2	2	3
Grammarus	2		2	1	1
TOTALS	779		565	489	606

RECOMMENDATIONS

After reviewing my original report, I stand by the recommendations on Page 41 plus the following:

1. Continue the benthic macroinvertebrate studies to expand knowledge and documentation that scarification absolutely benefits the benthic macroinvertebrate community and the complex food web that results. The attached report (2040c Design Channel) supports that contention.

Submitted 4/30/2021

Sincerely,

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