2018 ANNUAL REPORT

TRINITY RIVER RESTORATION PROGRAM

Mission Statements

The **Department of the Interior** (DOI) conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

The mission of the **Bureau of Reclamation** (BOR) is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

The mission of the **U.S. Fish and Wildlife Service** (USFW) is working with others to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continuing benefit of the American people.

The **Trinity River Restoration Program** (TRRP) implements the 2000 DOI Record of Decision, which directs DOI to restore the fisheries of the Trinity River impacted by dam construction and related diversions of the Trinity River Division of the Central Valley Project, California.

On the cover: *Photograph titled "Trinity Wild & Scenic River" from the* 50th Anniversary of the National Wild and Scenic Rivers *photo album by photographer Bob Wick, Bureau of Land Management.*

Thank You to the Trinity River Restoration Program partners for their contributions to this report.

Report Names

Flow Study	U.S. Fish and Wildlife Service (USFWS) and Hoopa Valley Tribe (HVT). 1999. Trinity River Flow Evaluation Final Report. USFWS, Arcata, California and HVT, Hoopa, California. *Often referred to as the Trinity River Flow Evaluation Study.* http://www.trrp.net/library/document/?id=226.
ROD	U.S. Department of Interior (DOI). 2000. Record of Decision, Trinity River Mainstem Fishery Restoration Final Environmental Impact Statement/Environmental Impact Report. Decision by the U.S. Department of Interior, December 2000. http://www.trrp.net/library/document/?id=227.
TREIS/EIR	USFWS, Reclamation, HVT, and Trinity County. 2000. Trinity River Mainstem Fishery Restoration Final Environmental Impact Statement/Environmental Impact Statement. http://www.trrp.net/library/document/?id=1238.
Master EIR	North Coast Regional Water Quality Control Board (North Coast RWQCB) and Reclamation. 2009. Channel Rehabilitation and Sediment Management for Remaining Phase 1 and Phase 2 Sites, Final Master Environmental Impact Report, Final Environmental Impact Report. http://www.trrp.net/library/document/?id=365.

Acronyms

2D	two dimensions
BA	Biological Assessment
BLM	Bureau of Land Management
CDFW	California Department of Fish and Wildlife
CDWR	California Department of Water Resources
CEQA	California Environmental Quality Act
CLOMR	Conditional Letter of Map Revision
CWJ/rkm	constructed wood jams per river kilometer
DOI	Department of the Interior
EO	Executive Order
ESA	Endangered Species Act
FEMA	Federal Emergency Management Administration
FIRM	Flood Insurance Rate Map
FNF	full natural flow
FONSI	Finding of No Significant Impact
FY	fiscal year
GPS	global positioning system
HVT	Hoopa Valley Tribe
LiDAR	light detection and ranging
LOMR	Letter of Map Revison
LW/rkm	large wood pieces per river kilometer
msl	mean sea level
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service (now NOAA Fisheries)
NOAA Fisheries	National Oceanic and Atmospheric Administration Fisheries (formerly NMFS)
PT	Pear Tree Gulch rotary screw trap site
RAD	Restoration Action Database
Reclamation	Bureau of Reclamation
RWQCB	Regional Water Quality Control Board
SWRCB	State Water Resources Control Board
TARGETS	Tool to Assess Riparian Germination and Establish on Targeted Surfaces
TMC	Trinity Management Council
TRRP	Trinity River Restoration Program
UAS	unmanned aerial system
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WCT	Willow Creek rotary screw trap site
WY	water year (October through September)
YT	Yurok Tribe

Measurements

ºC	degree Celsius
ºF	degree Fahrenheit
af	acre foot
cfs	cubic feet per second
cms	cubic meters per second
km^3	cubic kilometers
rkm	river kilometer
rm	river mile

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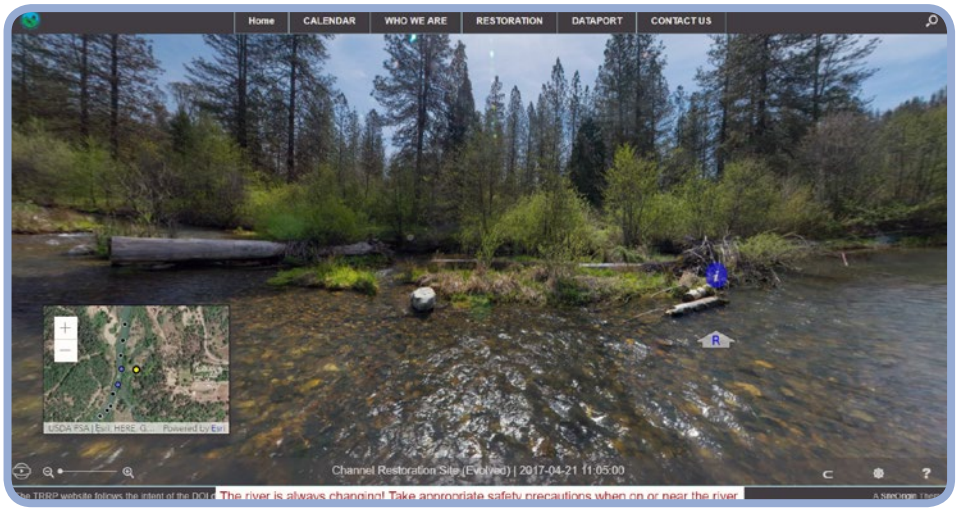
Contents



Sample 360° views of the Trinity River from the new River View System at: http://www.trrp.net/dataport/riverview/. (See articles on pages 39-41, Figure 30 and Figure 31, and back cover.)

Introduction

The Trinity River Restoration Program (TRRP) is a partnership comprised of Federal, State, Tribal, and Trinity County entities that collaborate to restore the Trinity River between Lewiston Dam and the confluence of the North Fork Trinity River, California. The partnership is administered by two U.S. Department of the Interior (DOI) agencies: the Bureau of Reclamation (Reclamation) and the U.S. Fish and Wildlife Service (USFWS). Partners share in the decision-making process through their participation on the Trinity Management Council (TMC). The TMC functions as a board of directors to set the priorities and schedules for strategic implementation by the Program's Executive Director. Trinity Management Council partners include:

- Hoopa Valley Tribe (HVT)
- Yurok Tribe (YT)
- Trinity County
- California Natural Resources Agency (which includes California's Department of Water Resources [CDWR] and Department of Fish and Wildlife [CDFW])
- U.S. Forest Service (USFS)
- National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries)

Partners on the TMC, along with many other participants and stakeholders, work together to achieve the vision of a healthier Trinity River and a more productive naturally spawning fishery. After an extremely wet water year in 2017, the water designation in 2018 was "critically dry." Program highlights in 2018 included:

- Released the allocated volume of 369,00 acre feet from Lewiston Dam
- Developed and reviewed production models related to Trinity River restoration, including Chinook salmon (*Oncorhynchus tshawytscha*) production and willow recruitment
- Collaborated with partners and cooperating agencies to finalize channel rehabilitation designs for the suite of lower canyon sites and the associated environmental permits
- Monitored biological and physical responses to restoration actions and developed associated synthesis reports under the adaptive management process

This annual report for 2018 highlights accomplishments achieved throughout the year as well as the extensive planning activities and environmental permitting to advance future restoration projects and monitoring reports. To learn more about the progress on Trinity River restoration and to review more detailed reports visit TRRP.net.

Laws and Guiding Documents

1955. Congress authorized Trinity River Division of the Central Valley Project.

1963. Trinity and Lewiston Dams were completed.

1981. Interior Secretary increased flows to ~300 cubic feet per second (cfs) (8.5 cubic meters per second [cms]) and initiated Flow Study.

1984. Congress enacted Trinity River Basin Fish and Wildlife Management Act to implement salmon restoration.

1992. Congress enacted Central Valley Project Improvement Act with 340,000 acre-feet (0.42 cubic kilometers [km^3]) of water available to the Trinity River.

1999. Flow Study completed and used as preferred alternative in TREIS/EIR.

2000. ROD signed, establishing modern TRRP with minimum water volume allocations determined annually by the water year type.

2009. Master Environmental Impact Report (EIR) provided all parts and appendices for the Draft and Final Master EIR in one document (North Coast Regional Water Quality Control Board [RWQCB] and Reclamation 2009).

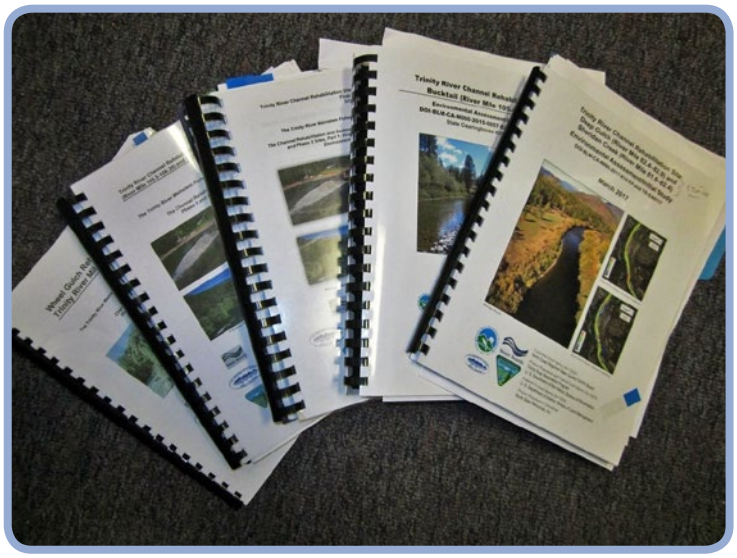
2009. Integrated Assessment Plan identified the scope of research needed to evaluate restoration of the Trinity River and its fisheries.

2014. The Scientific Advisory Board conducted the Phase 1 Review of the Program's restoration actions through the Phase 1 channel rehabilitation sites.

TRRP's Objectives

The TRRP defined goal is to restore the Trinity River's anadromous fishery resources in a managed river with restored characteristics of a healthy alluvial river as set out in the legislation and Federal decision documents that were instrumental in creating the TRRP. As outlined in the U.S. Department of Interior 2000 Record of Decision (ROD)[1] , the TRRP works "to restore the Trinity River's anadromous fishery resources. . . [by]. . . .rehabilitating the river itself" (DOI 2000).

The TRRP resulted from nearly 20 years of studies on the Trinity River and its fishery resources that culminated in the Trinity River Flow Evaluation Study (Flow Study)[2] and the Trinity River Mainstem Fishery Restoration Environmental Impact Statement/ Environmental Impact Report (TREIS/EIR)[3], completed in 2000. The ROD is based on the TREIS/EIR, which is the environmental compliance document under the National Environmental Policy Act of 1969 (NEPA)/California Environmental Quality Act of 1970 (CEQA).



[1]The ROD's full citation is: DOI. 2000. Record of Decision, Trinity River Mainstem Fishery Restoration Final Environmental Impact Statement/Environmental Impact Report. Decision by the U.S. Department of Interior, December 2000.

[2]The Trinity River Flow Evaluation Study's full citation is: USFWS and HVT, 1999. Trinity River Flow Evaluation Final Report. USFWS, Arcata, California and HVT, Hoopa, California.

[3]The TREIS/EIR's full citation is: USFWS, Reclamation, HVT, and Trinity County. 2000. Trinity River Mainstem Fishery Restoration Environmental Impact Statement/ Environmental Impact Report.

TRRP Restoration Strategy

The TRRP does not strive to recreate pre-dam conditions. Rather, the restoration strategy was developed to create a dynamic alluvial channel that exhibits all the characteristics of the pre-dam river but at a smaller scale. Restoration strategy under the 2000 ROD consists of:

- *Flow management*—restoration flow releases designed to help establish and maintain complex habitat features in the river using a variable flow regime based on five water year types that are designated by California Department of Water Resources
- *Mechanical channel rehabilitation*—47 sites along the river below Lewiston Dam were identified in the Flow Study for channel rehabilitation projects designed to reshape the river channel to increase fish habitat across the range of allowable flows (Figure 1)
- *Sediment management*—coarse gravel is added to the river below Lewiston Dam to replenish the supply from the headwaters that is cut off by the dams and is necessary to form bars and other elements of habitat complexity
- *Watershed restoration*—restoration projects in tributaries reduce fine sediment input to the Trinity River and also increase available salmon and steelhead habitat throughout the watershed
- *Infrastructure improvements*—modification of structures in the floodplain to allow the peak restoration flows released from Lewiston Dam
- *Adaptive environmental assessment and monitoring*—a rigorous program to monitoring and analysis program to improve restoration activities
- *Environmental compliance and mitigation*—measures taken to minimize or eliminate short-term impacts on the river and dependent species, including riparian wildlife and vegetation

Restoration activities in the previous 13 years have focused on the first four management elements outlined in the ROD, supported by compliance and infrastructure work in the context of environmental mitigation and adaptive management. The four elements place a priority on physical restoration of the river to create the attributes of an alluvial river system that are known to enhance habitat for anadromous fish species. Monitoring and evaluation under adaptive management show progress toward the expected physical and biological changes from restoration activities.

Spawning salmon photographed below the confluence of Deadwood Creek on the Trinity River in fall of 2018.

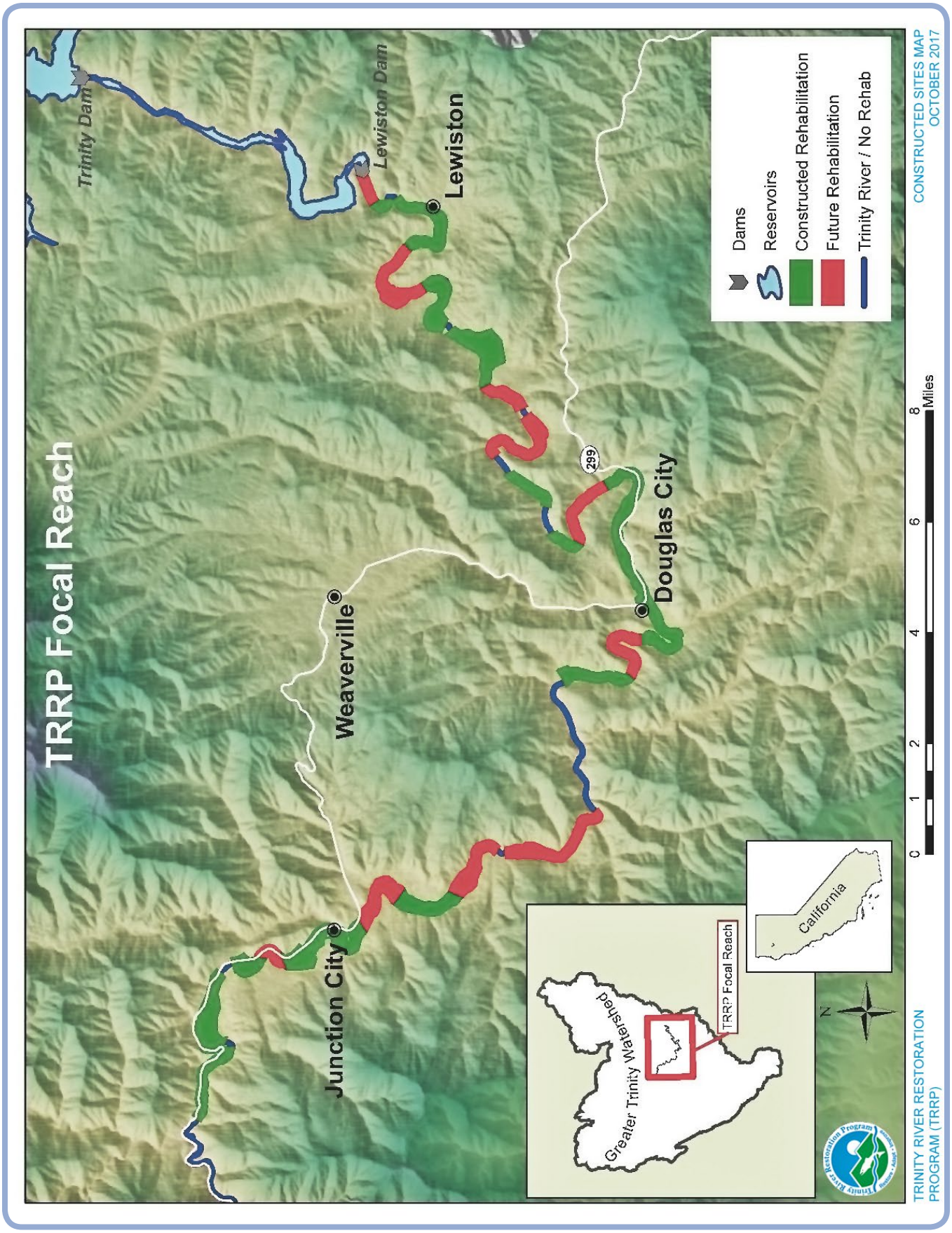


Figure 1. Map of the TRRP Focal Reach as of 2018.
Green shading indicates completed projects.

2018 Highlights

In 2018, the Program:

- Continued to advance channel rehabilitation designs, reviews, and environmental permitting at 34 of the 47 sites within the TRRP Focal Reach (on the Trinity River between Lewiston Dam and the confluence of the North Fork Trinity River) as described in the Flow Study
- Coordinated and scheduled the release of 369,000 acre feet of water (af) from Lewiston Dam allowed under the ROD in a critically dry water year and conducted studies to monitor the results of the release (Figure 2)
- Scheduled daily flows during the spring restoration flow releases to more closely match the daily pattern on natural river systems
- Re-organized the Riparian and Aquatic Ecology Workgroup to better reflect the workgroup's riparian wildfire and vegetation efforts related to Trinity River restoration

Medial bar and point bar at the tail of a new floodplain and meander bend in the Deep Gulch area (2017).

Terri Simon-Jackson, Deputy Forest Supervisor, Shasta Trinity National Forest, Redding, California

Terri has worked on ecological restoration of the Trinity River basin since 2014. She is a California girl, raised on a farm with six siblings north of Sacramento in the Central Valley. In her current position with the USFS, she is responsible for managing public lands including vegetation, watersheds, wildlife, fire/fuels, and recreation, Wilderness areas, and public uses on the largest national forest in California. Except for a 4-year adventure working for USFWS on sea otter management in Alaska, she has spent 38 years managing public lands in California, including the Mendocino, Plumas, Shasta-Trinity, and Tahoe, National Forests in California. She has a bachelor's degree in biology from the University of California at Davis and a Master's degree in wildlife biology from California State University, Sacramento. She worked as a wildlife biologist for 25 years (contributing her extensive expertise on the American marten, spotted owl, and Alaska sea otter) before transitioning to administration of National Forest lands. Terri is a strong advocate for communities of place. Terri, her husband, and grown daughter enjoy spending time together in the out-of-doors and adventures to new places.

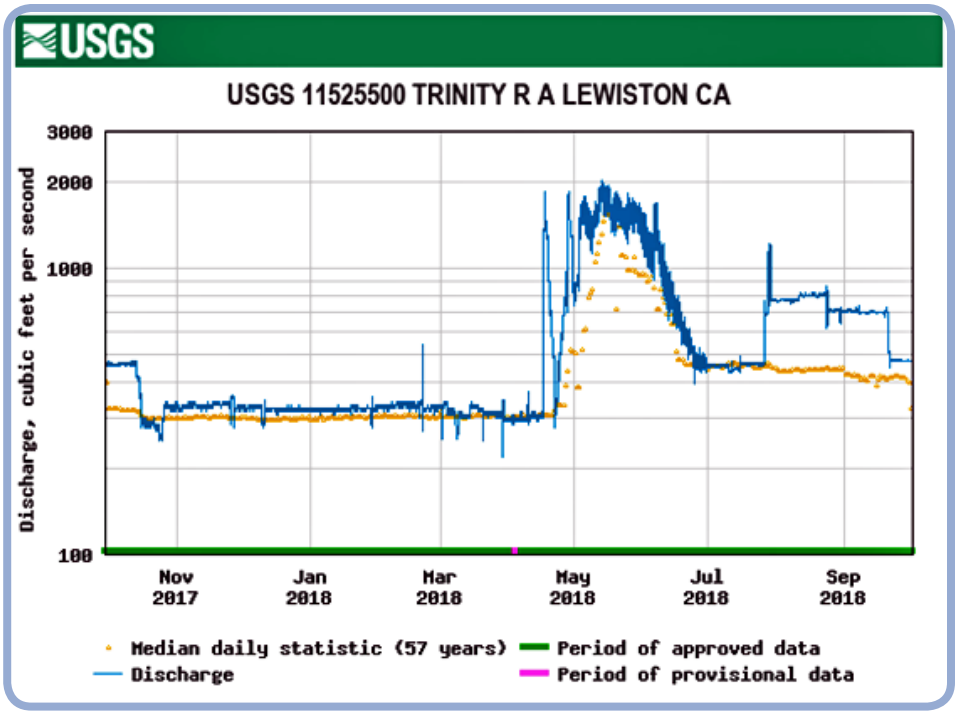


Figure 2. Discharge measured at Lewiston Gage in WY2018 from water.usbr.gov.

The TRRP developed the following set of healthy river attributes as a foundation for ecosystem restoration objectives:

- Variable annual restoration flows, which create a complex channel
- Gravel along the river is frequently mobilized
- Alternating bars are periodically scoured and/or redeposited
- Fine and coarse sediment supplies from the watershed are balanced by river transport
- The mainstem channel periodically migrates across its floodplain
- The river is reconnected with its floodplains that are frequently inundated and are areas for fine sediment deposition
- Infrequent, large floods reorganize the mainstem channel, floodplain, and/or side channels, as well as scour mature riparian vegetation and bring large wood into the river
- Native riparian vegetation is diverse and self-sustaining
- Groundwater in the floodplain is frequently recharged by high flows in the mainstem channel

These attributes found in natural river systems create and maintain channel complexity that creates habitat complexity, which benefits fish.

Environmental Permitting and Design for Channel Rehabilitation Projects

The TRRP continued development, design, and review, along with regulatory and environmental compliance permitting for four upcoming channel rehabilitation projects:

- Environmental compliance, design review, and landowner coordination moved forward for the Chapman Ranch Phase A project in 2019, anticipated to begin in the summer of 2019
- Coordination with cooperating Federal and State agencies to finalize environmental documents for design for the proposed Dutch Creek channel rehabilitation project
- Advanced the design and coordination for proposed projects in the lower Junction City reach of the river, including the Oregon Gulch and Sky Ranch channel rehabilitation projects

Restoration Monitoring

The newly established Riparian and Aquatic Ecology workgroup is working on modeling to help predict cottonwood and willow recruitment and Foothill yellow-legged frog (*Rana boylii*) production for flow release hydrographs and targeting selected surfaces to model recruitment trends in 2019.

Recently, the TRRP integrated hydrodynamic modeling into channel rehabilitation effectiveness monitoring efforts, which assess the effect of channel restoration and fluvial processes on trends in fish habitat availability. This development facilitates closer collaboration between the habitat monitoring group, the science program and the rehabilitation site design team.

Various workgroups in the program have continued to develop their resource area's objectives and targets to better develop a cohesive, program-wide approach for monitoring metrics.

Watershed Restoration Projects

Five watershed and tributary improvement projects were funded in 2018 to reduce fine sediment input in the Trinity River and to enhance salmonid habitat in the tributaries. On the South Fork Trinity River, a large-wood and habitat improvement project was completed in 2018 (Figure 3). Watershed projects funded in 2018 include:

- A project to decrease water withdrawals and increase instream flow on Browns Creek during the dry season
- Removal of an outdated dam on East Weaver Creek to improve tributary habitat used by Coho salmon (*Oncorhynchus kisutch*)
- Riparian improvement project in Sidney Gulch in Weaverville
- Road improvements to decrease fine sediment input in the South Fork Trinity River drainage

Watershed improvement projects are intended to reconnect salmonid habitat in Trinity River tributaries, which includes removing old obstructions (Figure 4.).

Teresa Connor, Civil Engineer, California Department of Water Resources

Teresa has worked on the Trinity River since 1998. She earned a B.S. in Civil Engineering from California State University at Chico. Teresa has worked as a Civil Engineer for the California Department of Water Resources for the past twenty years. Most of her experience includes investigations for fish passage, flood control, water diversions, and environmental restoration projects. When not working, Teresa enjoys golfing, hiking, kayaking, gardening, and spending time with her family and friends.

Figure 3. Large trees were strategically placed by helicopter in 2018 as part of a habitat improvement project on the South Fork Trinity River.

Figure 4. Old infrastructure on the Trinity River.

Funding and Expenditures

TRRP funding has varied between $10 million and $16.66 million per year. In fiscal year (FY) 2018, TRRP received a total of $14,175,487 million, as shown in Table 1.

Table 1. Fiscal Year 2018 Funding

Bureau of Reclamation	
Water and Water-related funds	$12,197,000
Central Valley Project Improvement Act Restoration Fund	$1,500,000
Fish and Wildlife Service	
FY 2018 appropriations	$478,487
Total	**$14,175,487**

Most of the funding supported watershed projects, restoration construction project designs and permitting, and watershed monitoring of physical and biological responses. Other partner agencies contributed in-kind services to support TRRP activities.

Activities and Accomplishments

Flow Management

Restoration Releases

Each water year (WY), the TRRP's Flow Workgroup and the TMC recommend a schedule for releasing restoration flows on the Trinity River. Selection criteria for determining the year's hydrograph include:

- Providing suitable temperatures for all salmonid life stages
- Reducing the travel time for outmigrating smolts
- Managing riparian seed germination
- Reducing fine sediment storage
- Providing monitoring opportunities to support learning and adaptive management strategies

The water volume for the restoration flow release to the Trinity River below Lewiston Dam is based on the forecasted total annual inflow to Trinity and Lewiston reservoirs, grouped into five water year types. Forecasts are used because the actual water year type is not known when the annual release schedules are developed. The CDWR forecasted water year type for 2018 was critically dry (CDWR 2018). Based on the critically dry water year designation, the TMC recommended a restoration release of 369,000 af. Reclamation implemented a modified ROD hydrograph to meet programmatic objectives for the critically dry water year (Figure 5 and Figure 6).

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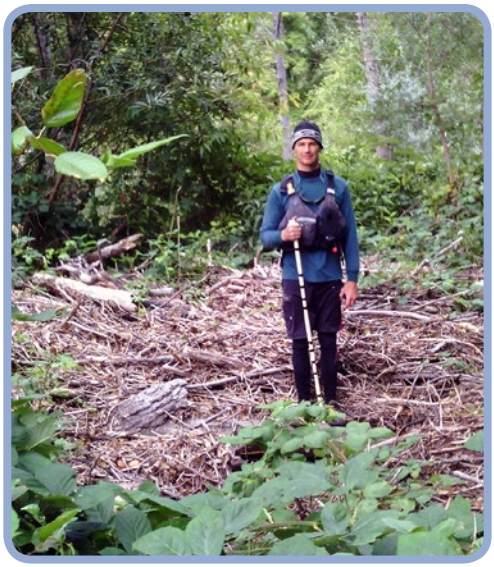

Wes Smith, Geomorphologist, Ocean Associates Inc., NOAA Fisheries

Wes found his passion for rivers during high school, rafting with Explorer Post 20 in New Mexico on the Rio Grande, Colorado, and other western rivers. While pursuing an undergraduate degree in physics, he guided rafts and kayaked on numerous rivers and creeks. During graduate work in geology/ geomorphology at Humboldt State University, Wes collected geomorphic data on the Trinity River and other western rivers, including survey data and bedload samples to support the Flow Study. Since graduate school, Wes has worked as a hydrologist on the Bridger-Teton National Forest in Wyoming, a geology instructor at the College of the Redwoods in California, and a geomorphologist at a consulting firm in California. As a geomorphologist, Wes ran the sediment monitoring contract on the Trinity River for several years. Since 2009, Wes has worked with Ocean Associates Inc. as a contractor for NOAA Fisheries where he has participated in various TRRP partnership roles such as serving on and periodically leading workgroups. Outside of work, Wes spends his time with his family, as well as surfing and kayaking. Wes' favorite kayak run in northern California is Burnt Ranch Gorge on the Trinity River.

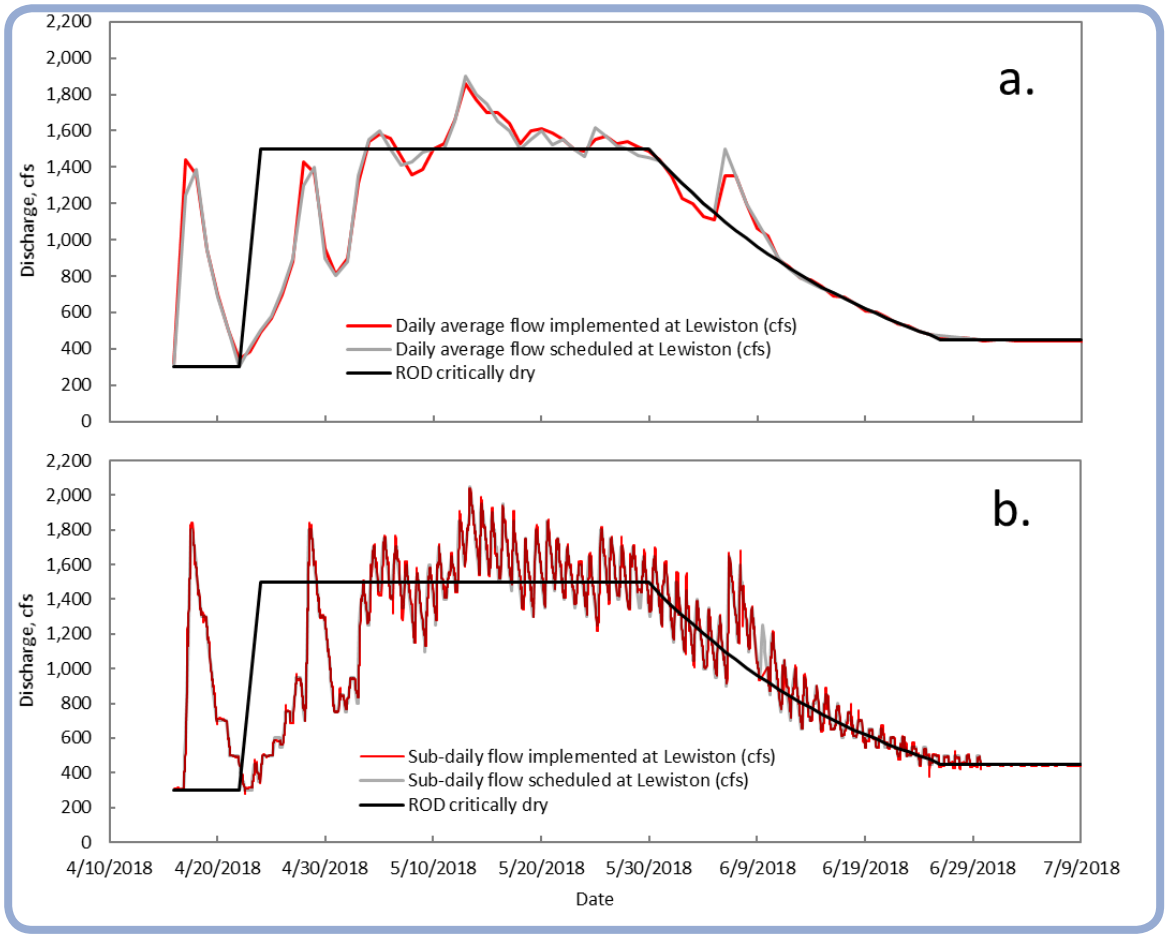

Figure 5. Daily average and sub-daily flows scheduled for the spring flow release period in WY2018. Implemented flows gaged at the U.S. Geological Survey (USGS) gage at Lewiston (USGS #11525500) are also shown along with the ROD critically dry hydrograph comparison.

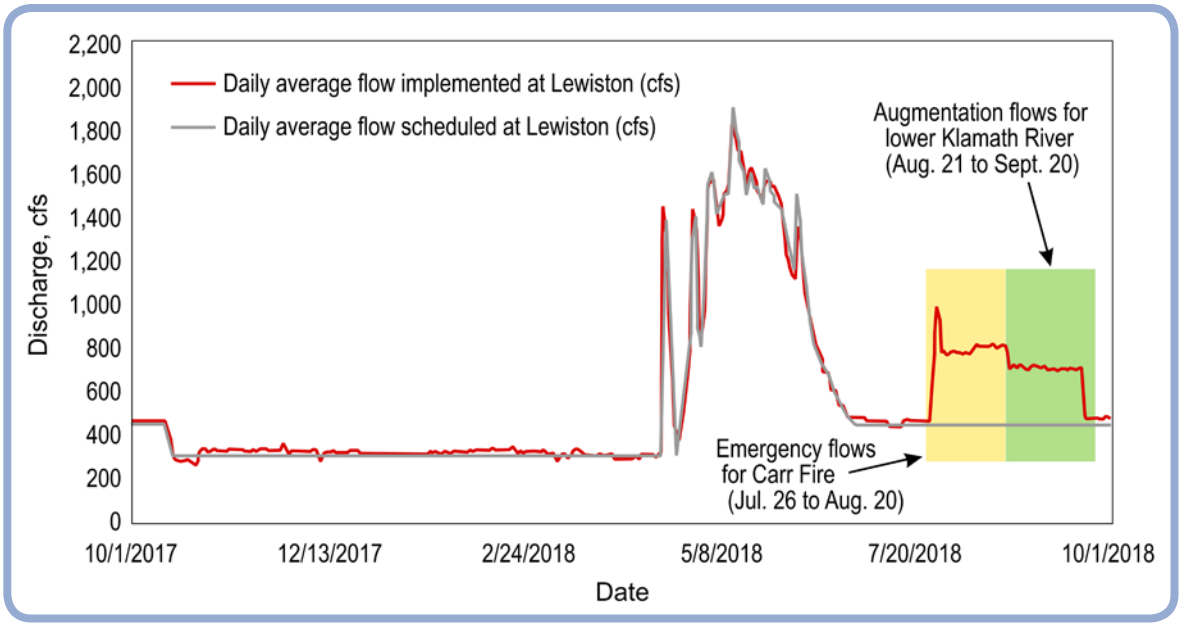

Figure 6. Plots of the TMC recommended flow release and the implemented flow. Unscheduled flow releases for augmentation of lower Klamath River flows and for the Carr fire are also shown. Flows affected by the Carr fire occurred July 26 through August 20, and Klamath flow occurred August 21 through September 20.

—Restoration Releases continued

In addition to meeting ROD objectives for a critically dry water year, the 2018 hydrograph was modified from the ROD hydrograph with elevated flows (1,860 cfs) at the beginning release to disburse steelhead trout (*Oncorhynchus mykiss*) smolt released from Trinity River Hatchery and to accommodate a drift macroinvertebrate study near Lewiston. The 2018 water year marked the first time that daily variability in discharge was prescribed in the schedule for spring flow release to mimic flow changes that occur in natural stream systems (Figure 5). TRRP's technical experts consulted with Reclamation's Central Valley Operations to ensure that specific ramping schedules were observed to protect sensitive species.

Flow Release Rates from Lewiston Dam

Figure 6 shows the daily average WY2018 flow releases from Lewiston Dam to the Trinity River, based on the Lewiston gage (USGS #11525500). Reclamation released flows above the baseline 450 cfs for emergency purposes during the Carr fire (July 26 through August 20) and for augmentation flows for the lower Klamath River (August 21 through September 20). Except for those releases, all other flow releases were conducted for river restoration purposes (the TMC recommended TRRP restoration flow release).

Implementation of Restoration Flow Schedule

Outcome of Hydrograph Implementation

In addition to showing actual water releases, Figure 6 compares the releases from Lewiston Dam to the TMC-specified release schedule, as measured by the Lewiston gage (USGS #11525500). Central Valley Operations was exceptionally accurate at implementing the designed flow. Actual deviations (shown on the red line on Figure 6) were due to operational constraints at Lewiston Reservoir and are within the ten percent measurement accuracy of the gage.

Temperature Targets and Compliance

Scientifically based temperature targets are specified for two locations at multiple time periods to protect all life stages of Trinity River salmonids. River temperature is measured at Douglas City and above the confluence with the North Fork Trinity River to meet regulatory compliance targets specified in State Water Resources Control Board (SWRCB) Order WR 90-5 (SWRCB 1990). The TREIS/EIR added targets for Douglas City and Weitchpec to aide juvenile salmonids in their downstream migration to the Klamath River (Flow Study) (Table 2).

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Table 2. Trinity River Temperature Targets by Reach and Date

Source	Target Reach	Dates	Target
Basin Plan for the North Coast Region (North Coast RWQCB 2011)	Lewiston to Douglas City	July 1–September 14	≤60 °F (15.5 °C)
	Lewiston to Douglas City	September 15–30	≤56 °F (13.3 °C)
NMFS (2000) and WR 90-5 (SWRCB 1990)	Lewiston to North Fork Trinity River	October 1–December 31	≤56 °F (13.3 °C)
ROD Springtime Objectives for the Trinity River (TREIS/EIR)	Lewiston to Weitchpec	**Normal & Wetter Water Years — Optimum**	
		April 15–May 22	≤55.4 °F (12.8 °C)
		May 23–June 4	≤59.0 °F (15.0 °C)
		June 5–July 9	≤62.6 °F (17.0 °C)
		Dry & Critically Dry Water Years — Marginal	
		April 15–May 22	≤59.0 °F (15.0 °C)
		May 23–June 4	≤62.6 °F (17.0 °C)
		June 5–June 15	≤68.0 °F (20.0 °C)

NMFS = National Marine Fisheries Service (now NOAA Fisheries)
ºF = degree Fahrenheit
°C = degree Celsius

—Implementation of Restoration Flow Schedule continued

The Weitchpec temperature target is designed to provide optimal temperatures in normal or wetter years and marginal temperatures in dryer years, based on outmigrating fish studies (Table 2). The Hoopa gage (USGS #11530000) is roughly 12 river miles (rm) (19.5 river kilometers [rkm]) upstream of Weitchpec.

Figure 7 shows water temperatures and temperature targets at Weitchpec and flows at Hoopa during the juvenile Chinook salmon outmigration period (April 15 to July 9) for the critically dry water year. Reclamation measures air temperatures, and USGS measures water temperatures. Mean daily water temperatures were met 41% of the time during the compliance period (32 of 75 days).

The target to not exceed 60 °F at Douglas City from July 1 to September 14 supports summer holding for the spring run Chinook and for rearing juvenile coho salmon. The compliance mandate set forth by the State Water Resources Control Board in WR 90-5 (SWRCB 1990) from September 15 through September 30 (56 °F) supports spawning Chinook salmon and migrating adult coho salmon. River temperatures at Douglas City during the target period are influenced by the release temperatures at Lewiston Dam and local weather.

In WY2018, water temperatures for the Trinity River at Douglas City were within temperature targets for 75% (69 of 92 days) of the time during the compliance period (Figure 8). In the July 1 to September 14 period, temperatures exceeded the target by an average of 0.4 degrees Fahrenheit (°F), with a maximum exceedance of 2.4 ºF. There was no exceedance from September 15 through 30, primarily because flow was increased on the Trinity River due to the Carr fire effects and Klamath River augmentation flow from July 26 through September 20.

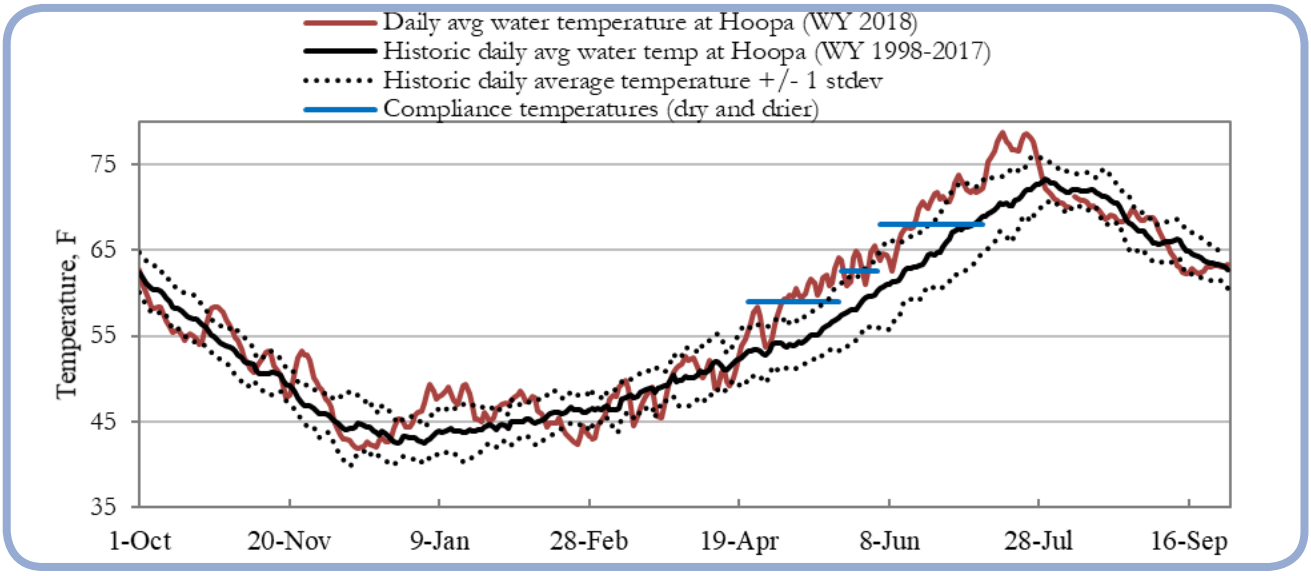


Figure 7. Daily average water temperatures for the Trinity River at Hoopa and the historic daily average and range (+/- 1 standard deviation) of daily temperatures for the period of record (WY 1998-2017).

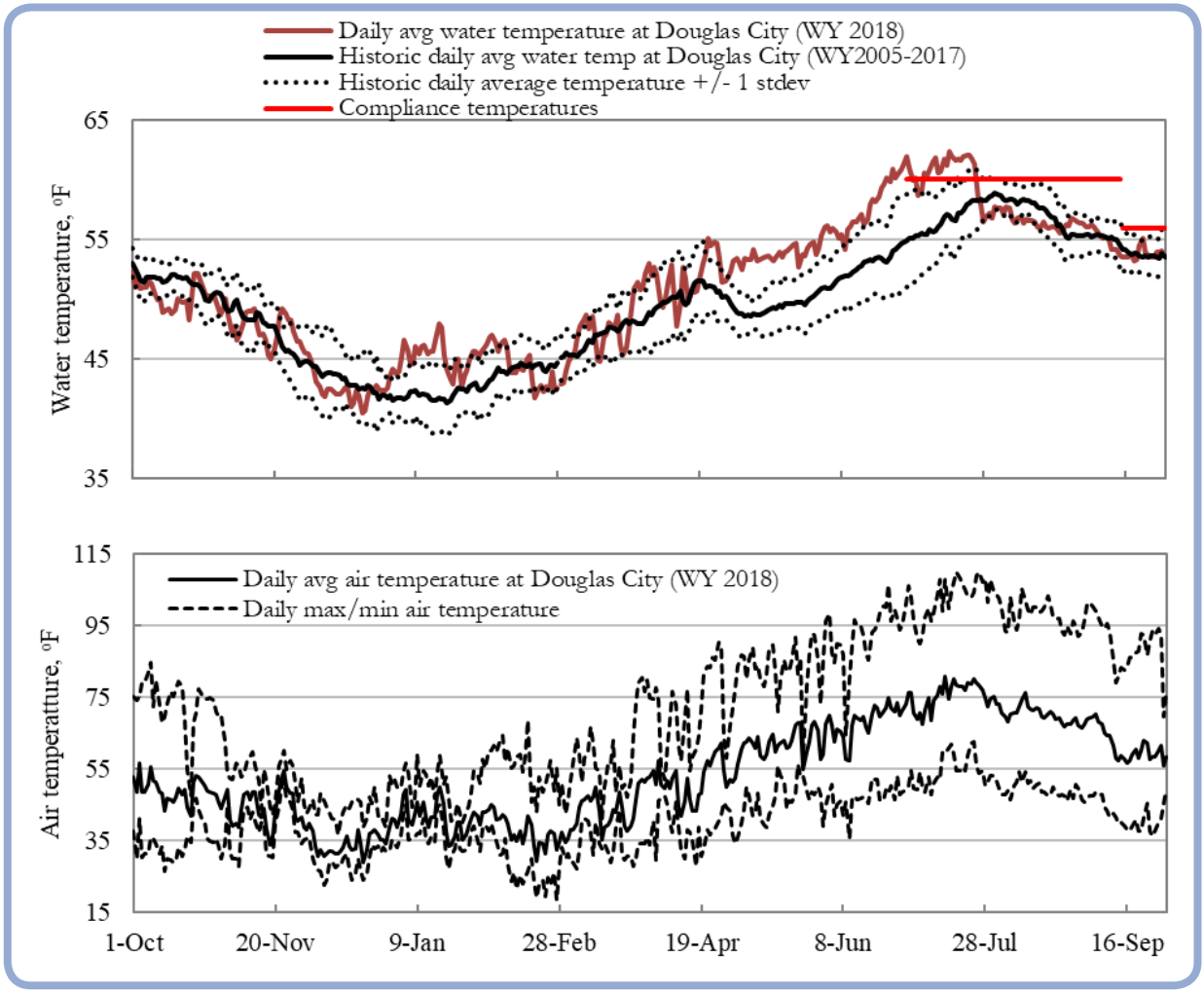


Figure 8. Daily average water and air temperature at the Douglas City compliance point. Observed water temperatures (top) are plotted with compliance targets and the average and range of daily temperatures for the period of record (WY2005 - 2017). The daily average, maximum, and minimum air temperatures at Douglas City for WY2018 are shown in the bottom panel.

—Implementation of Restoration Flow Schedule continued

Nick Som, Statistician, U.S. Fish and Wildlife Service

Nick has worked on the Trinity River since 2011. He earned a B.S. in mathematics from Regis University (Denver, Colorado), a M.S. in statistics from Washington State University, and a Ph.D. in ecological statistics from Oregon State University. Nick and his family love living on the north coast in close proximity to all the amazing outdoor activities—and far away from skyscrapers and crammed roadways. Nick feels lucky to be able to work on fish and aquatic conservation issues in the Trinity and Klamath rivers, continue his involvement with Humboldt State University faculty and students, and participate in the long-term TRRP collaborations he's been a part of since joining USFWS. When Nick's not at work, he's usually coaching one of his kids' sporting teams, sitting in a school board meeting, or doing something outside with friends or family to elevate his heart rate or smile index.

Water Volume Accounting

Table 3 lists flow releases in 2018. The difference between implemented restoration volume (377,071 af) and the scheduled volume for river restoration (369,00 af) was 2.2%, which is less than the ±10% accuracy of the stream gage record. Therefore, the volume of the restoration flow releases was equivalent to the allocated volume when measurement error is considered.

Impacts to water and power infrastructure from the Carr fire required decreased diversions through the Carr Power Plant tunnels from July 26 through August 20.

Water Export Volume

Reclamation exported 389,943 af of water from the Trinity River to the Sacramento River in WY2018 via the Carr Power Plant. Exports in WY2018 to the Carr Power Plant were approximately 4.7% less than the volume of water released to the Trinity River (Table 3). Table 4 provides a perspective of water years 2001 to 2018.

Table 3. Flow Releases in WY2018

Flow release	Acre feet
The total volume of water released from Lewiston Dam to the Trinity River combined with the water exported to the Sacramento River	801,015
Water released for Trinity River restoration purposes	377,071
Lower Klamath River augmentation flows	16,497
Carr fire emergency releases	17,554

Table 4. Water Releases and Diversions as Percent Long-term Average Inflow. Percentages above or below 100% are possible due to changes in reservoir storage

Water Year and WY Designation	Restoration Releases to the Trinity River	Diversions to the Sacramento River	All Other Releases to the Trinity River[1]	Total Releases and Diversions
2001 – Dry	30.3%	53.4%	0.3%	84.0%
2002 – Normal	38.5%	50.2%	0.0%	88.7%
2003 – Wet	35.7%	68.4%	8.6%	112.7%
2004 – Wet	51.9%	78.7%	9.4%	140.0%
2005 – Normal	51.6%	37.2%	0.3%	89.1%
2006 – Ext Wet	64.6%	107.7%	32.4%	204.7%
2007 – Dry	36.2%	49.0%	0.3%	85.5%
2008 – Normal	51.7%	44.3%	0.0%	96.0%
2009 – Dry	35.5%	43.0%	0.9%	79.4%
2010 – Normal	52.4%	21.9%	0.0%	74.3%
2011 – Wet	57.6%	37.7%	0.9%	96.1%
2012 – Normal	51.6%	56.6%	3.1%	111.3%
2013 – Dry	36.0%	68.0%	2.3%	106.3%
2014 – Crit Dry	29.5%	49.3%	5.2%	84.0%
2015 – Dry	35.9%	35.9%	4.6%	76.4%
2016 – Wet	56.5%	22.2%	3.1%	81.9%
2017 – Ext Wet	55.0%	42.1%	3.0%	100.1%
2018 – Crit Dry	30.0%	31.1%	2.7%	63.9%
Average (2001 - 2018)	42.8%	49.8%	4.1%	98.6%
Five Year Average (2014 - 2018)	41.4%	36.1%	3.7%	81.3%

[1]Includes Trinity Reservoir storage management releases, supplemental flow releases for the Lower Klamath River, and tribal ceremonial releases to the Trinity River.

Reservoir Conditions

Water year 2018 began October 1, 2018 with Trinity Reservoir holding 1,788,400 af (73% of capacity) and a water surface elevation of 2,325.8 feet mean sea level (msl) (Figure 9). The water year ended September 30, 2018 with Trinity Reservoir holding 1,499,300 af, (61% of capacity) at 2,303 feet msl. The total release from Trinity Reservoir in WY2018 was 801,015 af, which is 147.2% of the WY2018 full natural flow (FNF) at Lewiston (543,209 af). Total releases and diversions can exceed the FNF measured at Lewiston due to reservoir storage across water years. Total evaporation from Trinity and Lewiston Reservoirs was 43,250 af in WY2018.

The full natural flow (FNF) is the quantity of water that would have passed the gage at Lewiston if Trinity and Lewiston Dams and other diversions or impedances had not been in place.

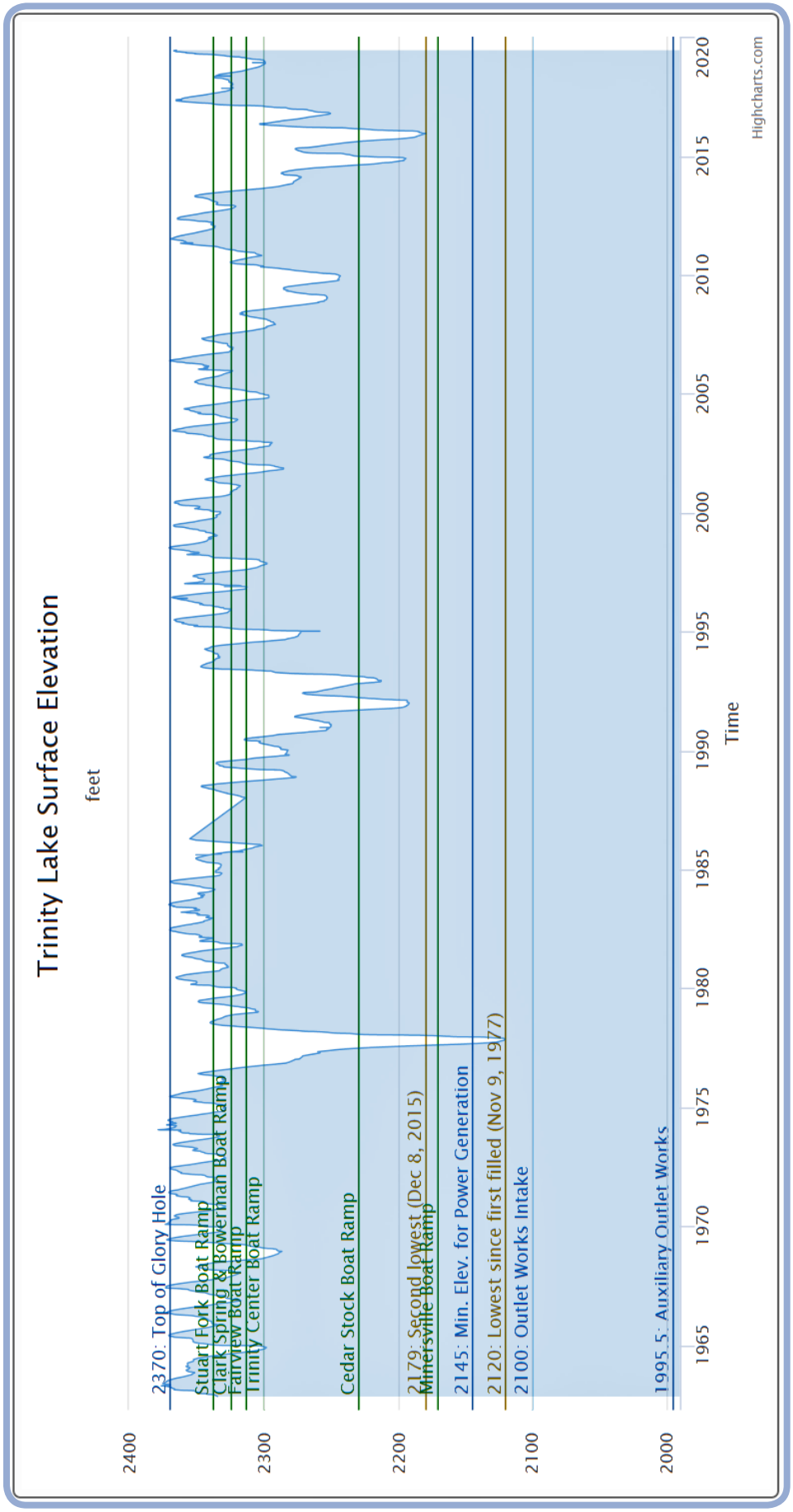


Figure 9. Water surface elevations for Trinity Reservoir in WY2018. Current Trinity Lake elevations are available at: http://www.trrp.net/restoration/flows/lake-conditions/.

Mechanical Channel Rehabilitation

Channel Rehabilitation Site Design and Development

The need to mechanically realign and alter the river channel at select locations was identified in the Trinity Study and the ROD signed in 2000. While the channel rehabilitation design, review, and implementation process has evolved and improved significantly since the ROD was signed, the overall concept remains the same: use a combination of features to encourage a more dynamic river channel (Figure 10) that will jump-start the processes that create and maintain salmon habitat.

In 2018, TRRP focused its efforts on advancing several proposed channel rehabilitation sites. At Chapman Ranch and Dutch Creek in the lower canyon upstream of Junction City, we focused on project design, regulatory permitting, and stakeholder involvement (Figure 11). In addition to Chapman Ranch and Dutch Creek, other projects in the Junction City area, including Oregon Gulch and Sky Ranch progressed through the planning and design phase.

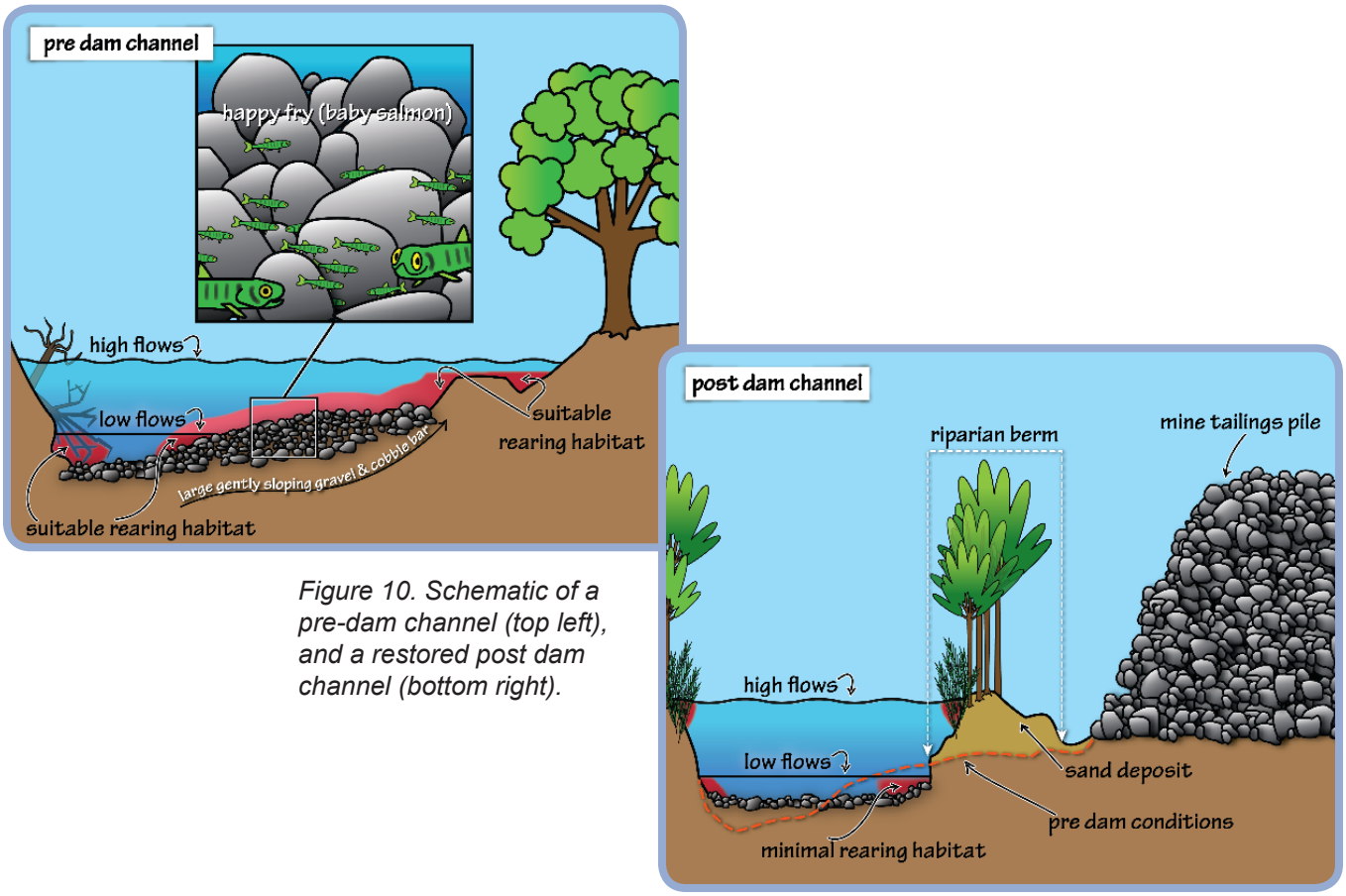


Figure 10. Schematic of a pre-dam channel (top left), and a restored post dam channel (bottom right).

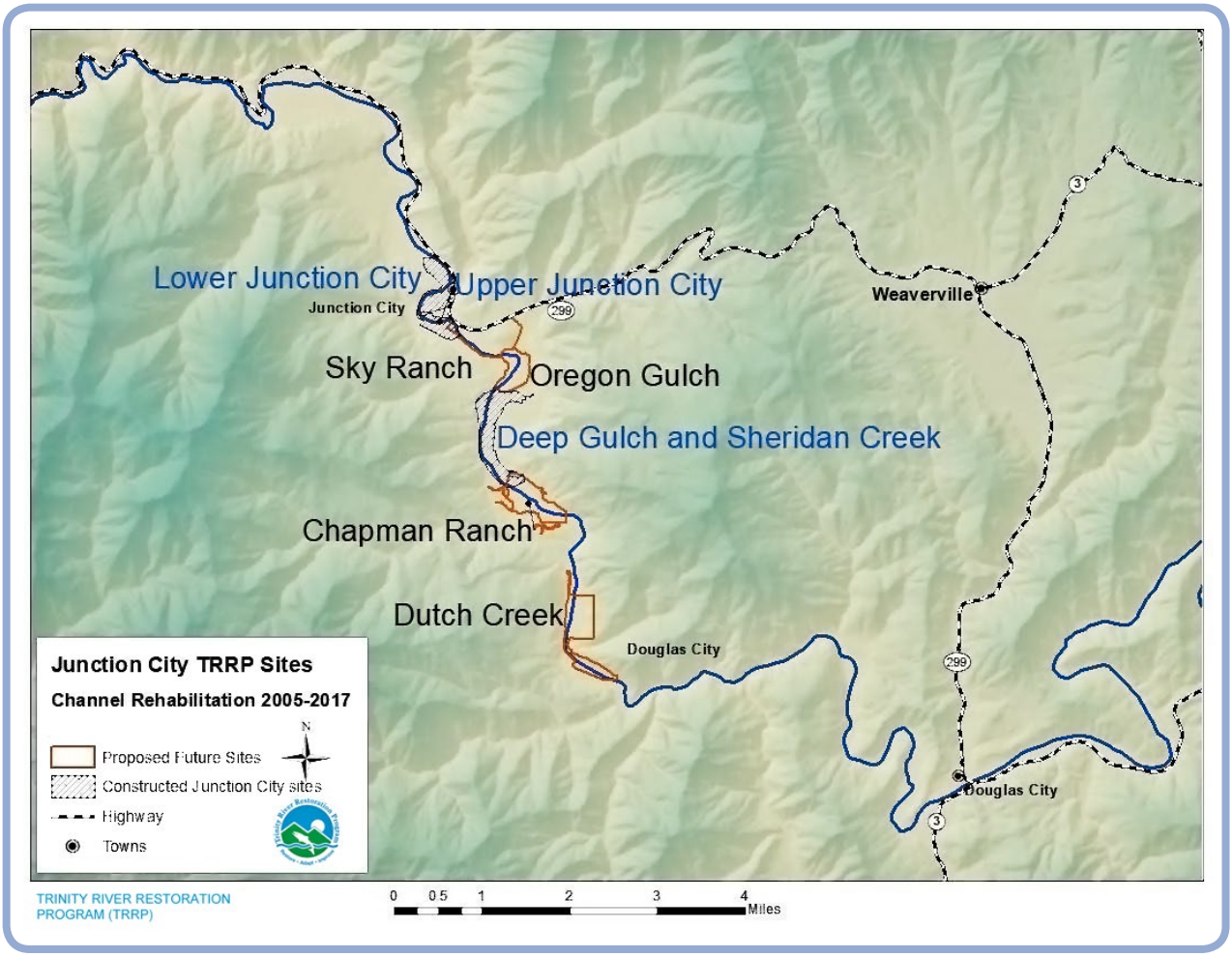


Figure 11. Location of the proposed upcoming channel rehabilitation projects within the Junction City, California area.

Chapman Ranch

The Chapman Ranch project, designed by the TRRP Hoopa Valley Tribe design team, completed the design phase in 2018. These designs by the Hoopa Valley Tribe team went through multiple iterations and incorporated land ownership input, full TRRP design team review, and a Value Engineering study done by independent reviewers to develop alternatives that maximize the project's benefit-to-cost-ratio.

Chapman Ranch is identified under the Master EIR as a single site that encompasses Bureau of Land Management (BLM) and U.S. Forest Service (USFS) managed land, as well as private land. To facilitate planning, environmental permitting, and implementation, the project was separated into two distinct project phases with an upstream (Phase B) and downstream (Phase A) portion. The downstream phase of the Chapman Ranch design, called Phase A, encompasses 103 acres, including 80 acres of BLM-managed land and 23 acres of private land (Figure 12). Phase A was designed to function and meet project objectives independently of the Phase B portion. Phase A consists largely of floodplain lowering and mainstem channel meander complexes while Phase B largely consists of side channel complexes. Both projects were designed so that the upstream portion of the project could be incorporated into the current Phase A design and implementation in the future.

Design Process and Objectives

The design team used topographic and hydraulic modeling to examine and present the potential changes in physical and biological effects from the constructed design features and how those features would function under various flow conditions (Figure 13).

Chapman Ranch Phase A design objectives were separated into three categories: physical, biological, and riparian. Key design objectives include:

- **Physical:** Reestablish a functioning, topographically complex floodplain, while promoting dynamic river processes that would increase in-channel habitat diversity at all flows
- **Biological:** Increase optimal habitat over a wide range of flows for fry and presmolt above existing conditions
- **Riparian:** Preserve and expand multi-story diverse riparian vegetation in conjunction with revegetation of alluvial and upland landforms

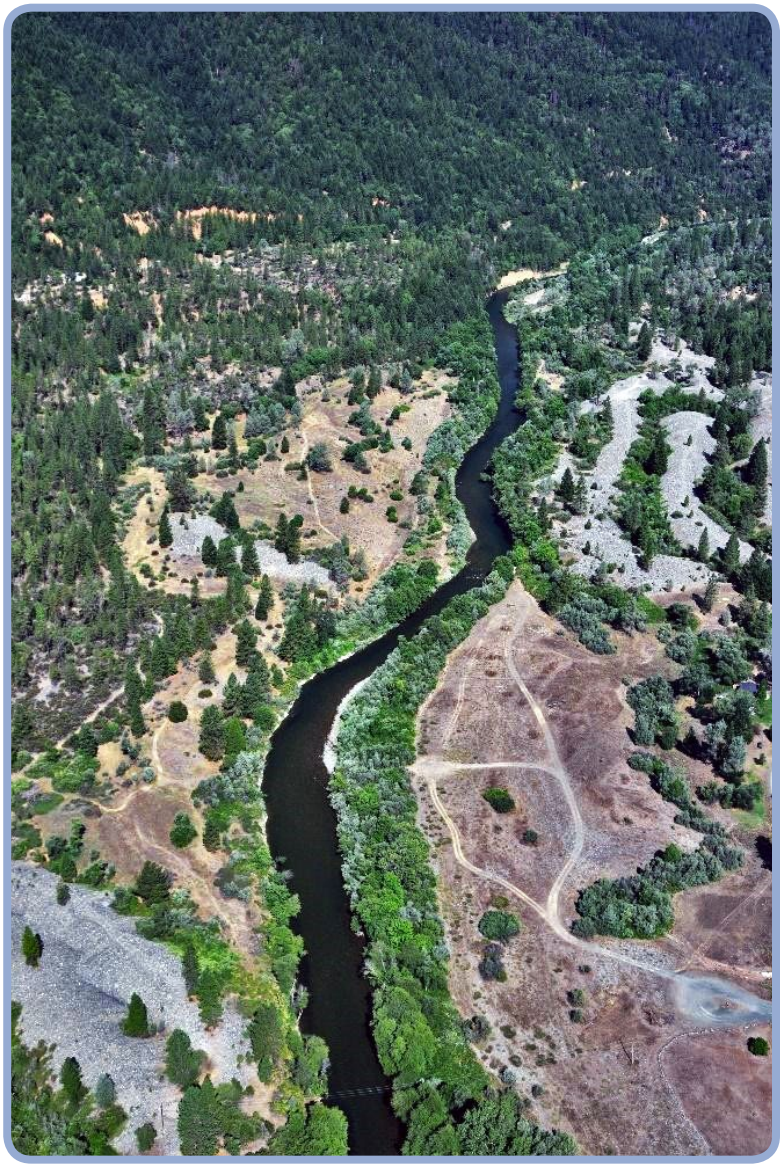


Figure 12. Aerial photography of the Chapman Ranch site taken in 2016 looking downstream.

Environmental Compliance

The TRRP conducted an Environmental Assessment for the project throughout 2018 with the BLM as the Federal cooperating agency under NEPA, and the North Coast RWCB as the state co-lead agency under CEQA. Reclamation and BLM signed a Finding of No Significant Impact (FONSI) on March 2019.

Construction on the project is expected to begin July 1, 2019, with the in-channel work window for the project from July 15 to September 15. Project features and in-river work is anticipated to be complete by Fall 2019, and revegetation efforts will continue for several more years with planting and irrigation to promote native riparian vegetation.

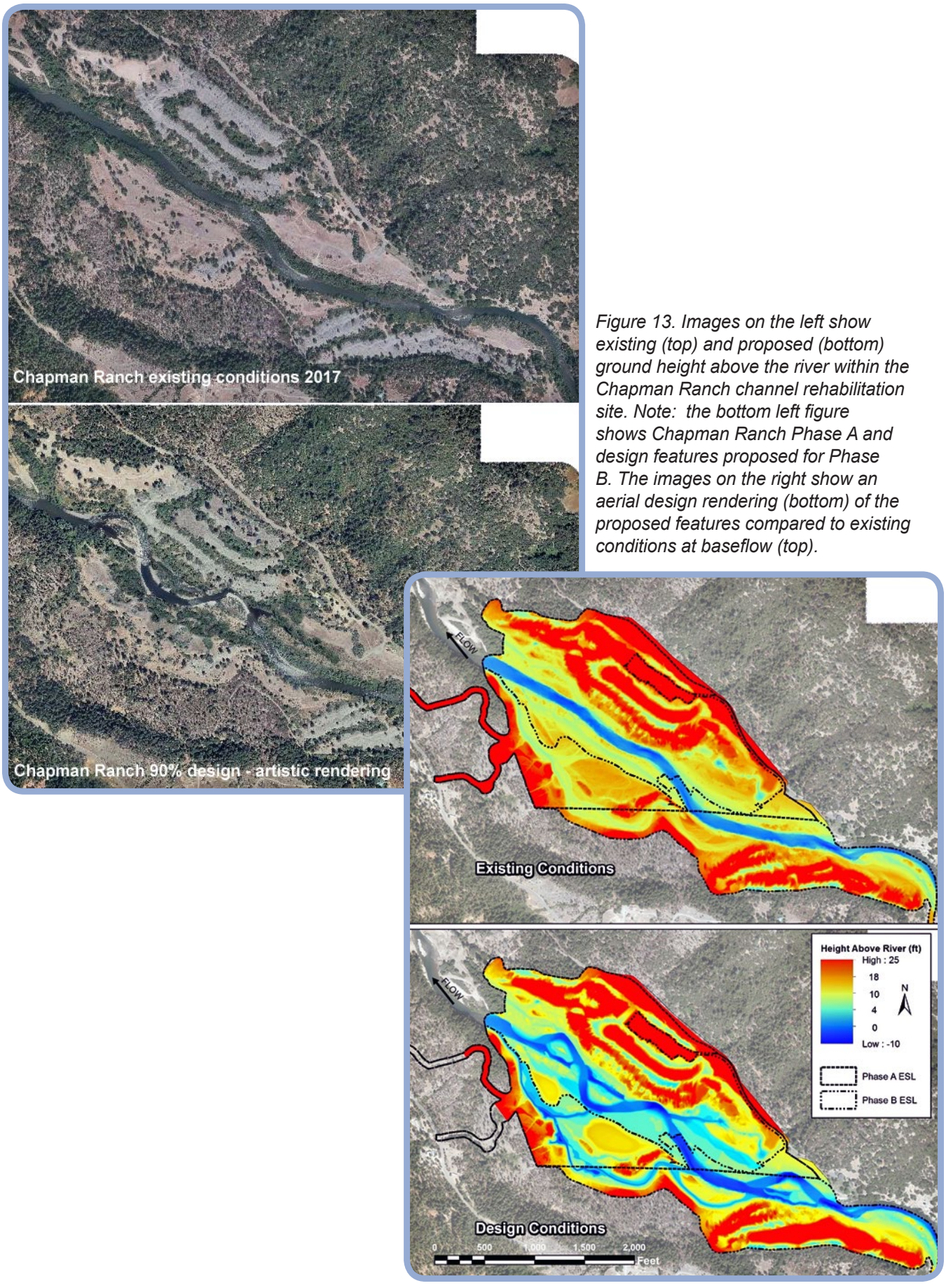


Figure 13. Images on the left show existing (top) and proposed (bottom) ground height above the river within the Chapman Ranch channel rehabilitation site. Note: the bottom left figure shows Chapman Ranch Phase A and design features proposed for Phase B. The images on the right show an aerial design rendering (bottom) of the proposed features compared to existing conditions at baseflow (top).

Dutch Creek

The Dutch Creek project, designed by the TRRP state design team, went through the final review and design stages in 2018. This design also went through multiple iterations and incorporated land ownership input, full TRRP design team review, and a Value Engineering study done by independent reviewers to develop alternatives that maximize the project's benefit-to-cost-ratio.

The Dutch Creek project is the second collaboration on a channel restoration project between the TRRP and USFS. The project area encompasses approximately 155 acres, which includes 32 acres of BLM-managed land, 48 acres of National Forest System land, and 75 acres of private land (Figure 14).

Figure 14. The Dutch Creek channel rehabilitation site in 2016. At this site, the river is disconnected from the large floodplain on river (right) because of the terraced berms that established after water diversions began.

Design Process and Objectives

Specific design objectives for the Dutch Creek site include:

- **Physical:**
  - ◊ Create complex floodplain and side channel habitat for juvenile salmonids
  - ◊ Facilitate historic river processes by excavating berms and mine tailing deposits to establish stable streambanks, floodplain connectivity, and coarse gravel recruitment
  - ◊ Construct large wood structures to channel local flows
- **Biological:** Increase quality of fry and juvenile rearing habitat through a range of base and channel maintenance flows

Figure 15. Specialists from various cooperating agencies met throughout 2018 to advance the design and permitting process for the Dutch Creek project.

Environmental Compliance

The Environmental Assessment for the Dutch Creek project neared completion in 2018. BLM and the USFS, Shasta-Trinity National Forest, are the cooperating Federal agencies under NEPA, and the North Coast RWCB is the state co-lead agency under CEQA (Figure 15). Proposed construction work for the Dutch Creek project could begin in the early summer of 2020.

Coarse Sediment Management

Justin Alvarez, Habitat Division Lead for Hoopa Valley Tribal Fisheries

Justin has worked on the Trinity River since 2006. He earned his B.S. in Wildlife Management and M.S. in Fisheries from Humboldt State University. Justin spent many summers working at a Boy Scout camp in the central Sierra Nevada mountain range teaching kids about the outdoors, and a couple summers working for the USFS in New Mexico before finding his way to the Hoopa Tribal Fisheries Department. Justin focuses on salmonid habitat in the Trinity River and has worked with lamprey and brown trout. Many of his projects require working out of a raft on the Trinity River. To diversify his activities, in his off time he chooses to raft other rivers with his family and friends.

Trinity and Lewiston Dams trap the supply of coarse sediment (gravel and small cobble) above Lewiston Dam. To replace the coarse sediment trapped behind the dams and to balance the coarse sediment transported during high-flow releases, the ROD (DOI 2000) directs a coarse sediment augmentation program below Lewiston Dam. High-flow releases and coarse sediment augmentation are intended to increase the availability and quality of physical habitat by promoting scour and fill processes that maintain bars, pools, juvenile rearing habitat, spawning beds, and other elements of channel complexity. Progress toward these goals is assessed by measuring coarse sediment transport, estimating sediment fluxes, and tracking changes in channel topography.

Water year 2018 was a "critically dry" year in which the annual spring high flow release from Lewiston Dam topped out with a maximum spring flow release of 2,040 cfs. As these lower flows cannot transport coarse sediment transport, no coarse sediment was added to the river in 2018. Thus, for the second time since 2003, no mainstem Trinity River sediment transport monitoring was conducted in 2018.

Physical and Biological Responses to Restoration Flows

Riparian Species Monitoring and the Riparian and Aquatic Ecology Workgroup

Monitoring provides reliable data on longer term trends which informs adaptive management decisions on TRRP's overall effectiveness (TRRP and ESSA Technologies 2009). Much of TRRP's actions for wildlife are guided by the 1984 Trinity River Basin Fish and Wildlife Management Act (Public Law 98-541) that acknowledged the loss of habitat for deer and other wildlife species caused by inundating riparian and upland areas behind Lewiston and Trinity Dams. Congress directed the Secretary of the Interior to take appropriate actions to maintain and propagate such wildlife.

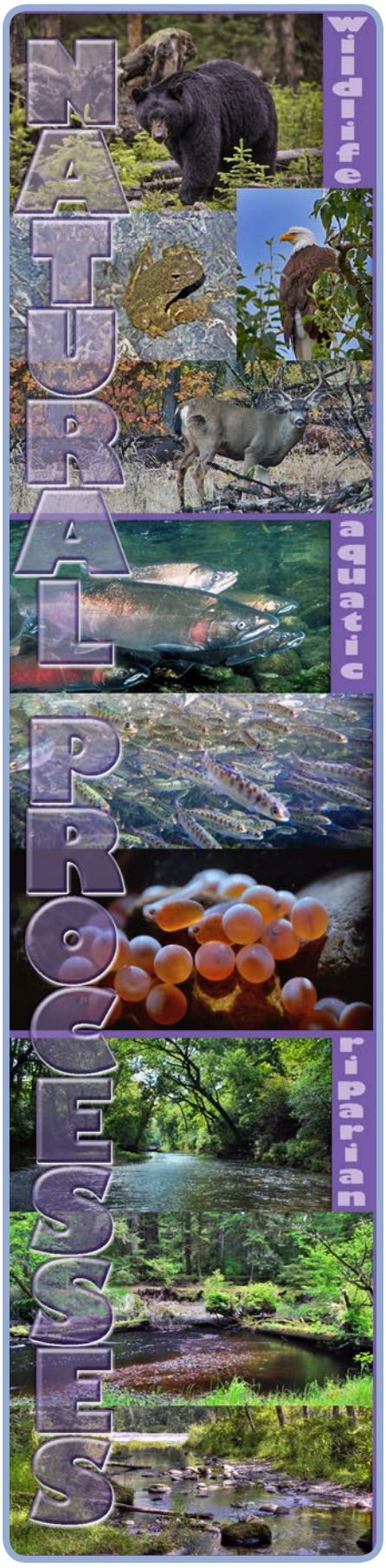
Conventional TRRP monitoring for wildlife and riparian vegetation paused during 2018, while researchers took time to assess data in several draft synthesis reports as part of a Programmatic effort to use long-term data sets to answer long-standing questions. Reports under review include a riparian encroachment synthesis report and a cottonwood seed dispersal synthesis report.

The program's Wildlife and Riparian Workgroup went through a major change in 2018. This had been an *ad hoc* workgroup called to work on very specific issues. The TMC amended the workgroup's charter to so that the workgroup is now activated permanently. This had been the TMC amended the workgroup's charter to activate the workgroup on a permanent basis. Now the workgroup meets quarterly. The charter was also amended to include Aquatic Ecology, focusing on flow-based disturbances and ecosystem responses to those disturbances. The workgroup was renamed the "Riparian and Aquatic Ecology Workgroup" and was approved by the TMC in September and convened for the first time in November 2018. All partner agencies have representatives on the workgroup, and priorities for its first year include planning a programmatic science symposium to be held in 2020 and updating metrics for evaluating wildlife, riparian, and aquatic ecology objectives. This broad objective and metric refinement exercise evaluates the objectives, how to measure these objectives, and how to determine if these objectives are met.

Flow Scheduling

The TRRP intends to indirectly restore the Trinity River fishery by restoring natural processes. An important suite of natural processes includes establishment, growth, and mortality of vital riparian species, such as black cottonwoods (*Populus trichocarpa*). Riparian vegetation provides numerous benefits to fish as a source of cover and shade as well as food for the insects that fish eat. It is also an important source of large woody debris for the river to scour or deposit sediment around. Riparian vegetation also provides habitat elements for songbirds and other wildlife species.

Planting cottonwoods, willows, and other species at individual channel rehabilitation sites is a very visible method of promoting vegetation. However, the TRRP also uses managed flow releases from Lewiston Dam to manage vegetation. Many riparian plants depend strongly on seasonal flow patterns. Scouring flows in the winter and early spring, coupled with a gently receding flow in the late spring and summer, produce a mosaic of vegetation species and age classes that benefit fish and wildlife. The TRRP models the response of vegetation to proposed flow schedules with a computer model called TARGETS (Tool to Assess Riparian Germination and Establishment on Targeted Surfaces). This model, first created in the early 2000s, was updated in 2018 to be used in modern computers. TARGETS plots the positions where cottonwoods and willows are likely to grow on a cross-section of river channel, based on the flow patterns of a proposed dam release schedule (Figure 16).



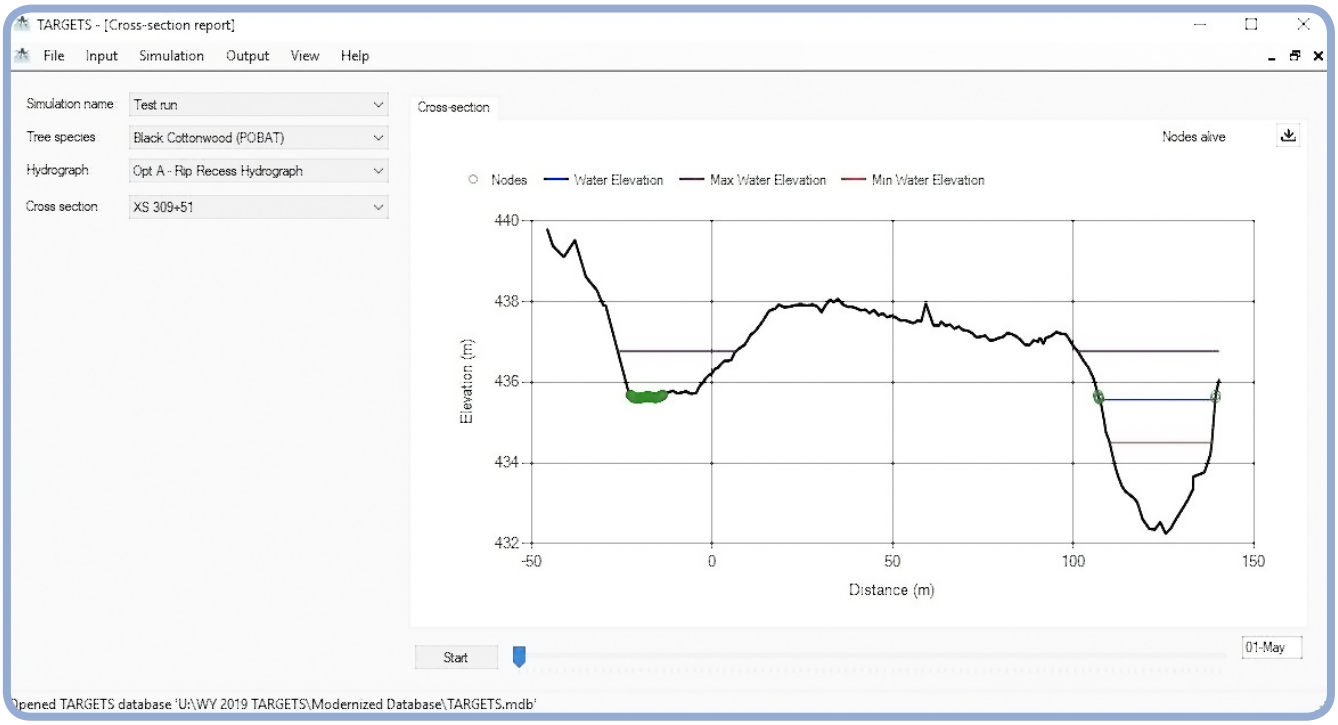


Figure 16. Example of output from TARGETS used to evaluate the potential of flow release schedules to allow riparian plants to become established.

Figure 17. A patch of cottonwood seedlings observed at a side channel constructed at Hoadley Gulch in 2008.

Black Cottonwood Seed Dispersal Period

For successful recruitment, the flow peak needs to occur before the seed dispersal period, the seeds need to fall on suitable surfaces, and the water surface needs to recede slowly enough that the seedling roots can track the water table as it sinks to its late-summer level. The TRRP sets the timing of spring floods to promote the natural recruitment of black cottonwoods.

In addition, the flows need to interact with appropriate surfaces for riparian vegetation to become established (Figure 17).

TRRP creates those surfaces by moving sediment with heavy equipment during channel rehabilitation projects.

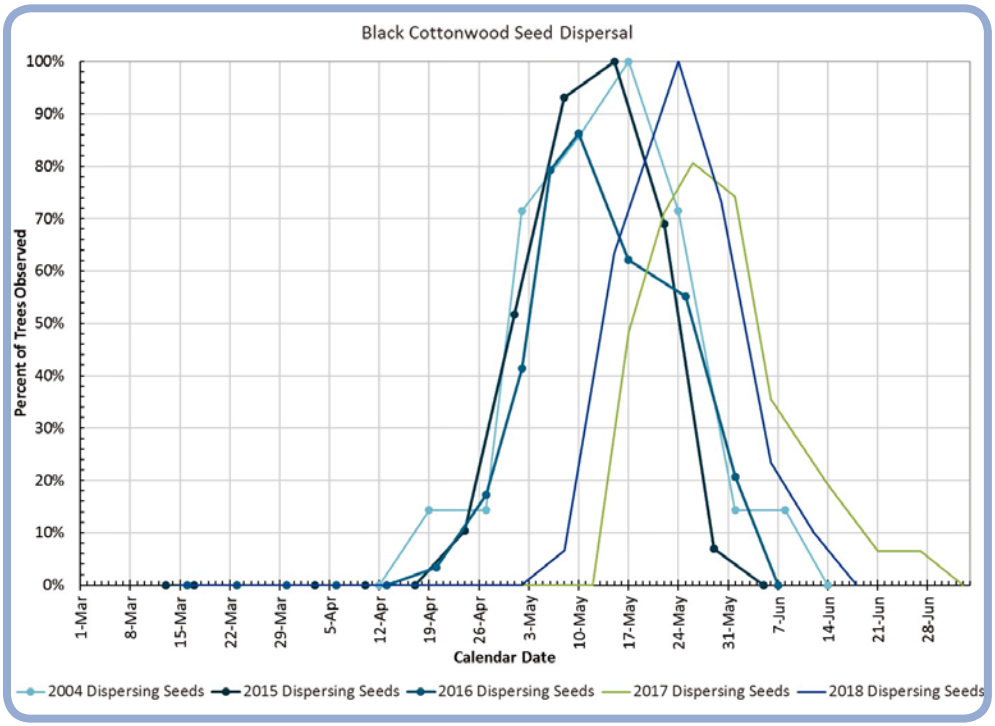


Figure 18. Seed dispersal periods for black cottonwood monitored during 2004 and 2015 to 2018.

Black cottonwood seed dispersal periods are monitored to synchronize the timing of spring ROD releases to the dispersal period to enhance germination. To compare the consistency of seed dispersal timing and to investigate potential environmental factors affecting timing, TRRP researchers quantified seed dispersal in water years 2004, 2015, 2016, 2017, and 2018. This data was synthesized in a report (still under review) to better time flows to enhance black cottonwood recruitment. This will be part of a synthesis report, which is under review. Seed dispersal occurred during a similar period in all monitored years (Figure 18). In the monitored years, seed dispersal never began before April 19 and never continued beyond and July 3. The timing of seed dispersal in 2014, 2015, and 2016 was almost identical, beginning around April 19 and ending around June 10. The timing of seed dispersal in 2017 and 2018 occurred later and was not as similar as 2015 and 2016 (Figure 19). Of all the years measured, the seed dispersal period in 2017 started the latest, ended the latest, and was lasted the longest. Additionally, the maximum number of trees dispersing seeds during a given week was lowest in 2017 (only 80% of trees) (Figure 18).

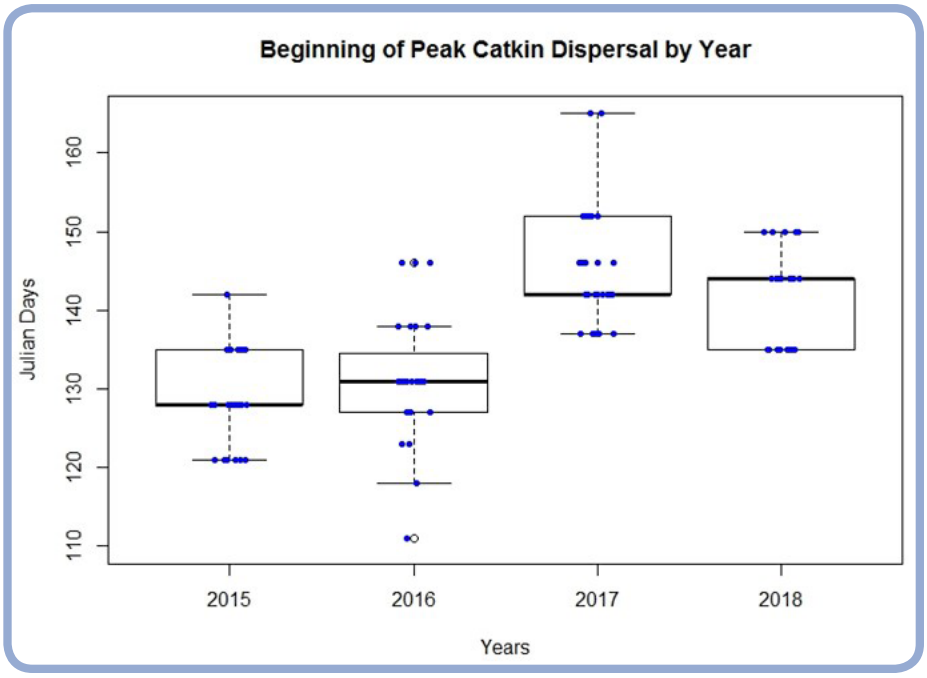


Figure 19. Box plots of seed dispersal timing 2015-2018.

Chris Laskodi, Fish Biologist for Yurok Tribal Fisheries

Chris has been working on the Trinity River since 2015. Chris currently manages the Yurok Tribal Fisheries Trinity River Division's efforts for adult salmonid spawning and various macroinvertebrate projects and coordinates juvenile releases for outmigrant monitoring. Prior to working for the Yurok Tribe, he worked as a fisheries technician for the USFWS out of the TRRP office in Weaverville. Chris has also done fisheries work throughout the Sacramento and San Joaquin Valleys. He received his B.S. in Wildlife, Fisheries, and Conservation Biology from University of California at Davis and is currently working on his M.S. in Fisheries/Aquaculture from the University of Arkansas at Pine Bluff. Chris was born and raised in California and is happy to be back working on a river that he grew up fishing. In his free time, Chris enjoys fishing, mostly fly-fishing, throughout the state and world and spending time with his wife and son.

Riparian Encroachment

Native vegetation provides many resources to the river. However, in regulated rivers such as the Trinity below Lewiston Dam, the loss of large floods, coupled with stable summer flows, can result in continuous bands of unnaturally dense vegetation along the summer water line. The vegetation shapes bars and banks into areas that are undesirable for rearing salmonids and can hasten the development of steep berms along the banks. A long-standing TRRP goal is to use flows to discourage these vegetation patterns from forming. Vegetation monitoring in recent years indicates that TRRP has had success in discouraging unnatural vegetation patterns and riparian berm formations.

Each year, narrowleaf willow (*Salix exigua*) seedlings and root sprouts colonized gravel bars between the 450 and 2,000 cfs water surface elevations. Water year sequencing and associated flood peaks between 2013 and 2016 allowed the 2012 narrowleaf and dusky willow (*salix melanopsis*) seedlings to establish within the 450 to 2,000 cfs bank region (Table 5), despite efforts to prevent that using managed streamflows in 2015. Peak flows during the dry years of 2013-2014 could not scour channel margins and exposed bars, so the number of 1- to 2-year old narrowleaf seedlings were not reduced in 2013 and 2014. In 2015, another dry year, TRRP increased flows to 8,500 cfs to reduce the encroachment risk, among other objectives. This 8,500 cfs release in 2015 scoured the 2014 and 2013 seedlings but not the 3-year old seedlings from the 2012. Berm formation was not documented at cross sections from 2013 to 2016.

Regardless of the sampling frame and methods used to evaluate encroachment, results continue to suggest that the Flow Study prescribed flow thresholds intended to induce narrowleaf willow mortality could maintain a variable low water fringe if seedlings were scoured within the window of opportunity to inhibit the establishment of 3 year-old and older woody plants. If the seedling management window is surpassed (as it was for the 2012 cohort), the Flow Study prescribed streamflow peaks alone are unlikely to inhibit encroachment.

Table 5. Peak flow magnitudes related to the scour of riparian seedlings

Water Year	Instantaneous Maximum Lewiston Discharge (cfs)	Cohorts Scoured	Surviving Cohorts	Established Cohorts
2005	7,640	2004 cohort	None	1993, 1998, 2000 and 2002 cohort
2006	10,400	2003, 2004, and 2005 cohorts		1993, 1998, 2000 and 2002 cohort
2007	4,810	None	2006 cohort	1993, 1998, 2000, 2002 and 2006 cohort
2008	6,890	2007 cohort	2006 cohort	1993, 1998, 2000, 2002 and 2006 cohort
2009	4,630	None	2006 and 2008 cohort	1993, 1998, 2000, 2002, 2006 and 2008 cohort
2010	7,480	2009 cohort	2006 and 2008 cohort	1993, 1998, 2000, 2002, 2006 and 2008 cohort
2011	12,300	2008, 2009, and 2010 cohorts	2006 cohort	1993, 1998, 2000, 2002 and 2006 cohort
2012	6,180	2011 cohort	2006 cohort	1993, 1998, 2000, 2002 and 2006 cohort
2013	4,590	None	2006 and 2012 cohort	1993, 1998, 2000, 2002, 2006 and 2012 cohort
2014	3,460*	None	2006, 2012, and 2013 cohort	1993, 1998, 2000, 2002, 2006, 2012, and 2013 cohort
2015	8,830	2013 and 2014 cohorts	2006 and 2012 cohort	1993, 1998, 2000, 2002, 2006 and 2012 cohort
2016	9,600	2014 and 2015 cohorts	2006 and 2012 cohort	1993, 1998, 2000, 2002, 2006 and 2012 cohort
2017	12,000	2013, 2015, and 2016 cohorts	2006 and 2012 cohort	1993, 1998, 2000, 2002, 2006 and 2012 cohort
2018	2,040	None	2006, 2012, and 2017 cohort	1993, 1998, 2000, 2002, 2006, 2012, and 2017 cohort

*The peak discharge of 2014 was not associated with spring ROD flows, rather it occurred on September 22, 2013, and was associated with Lower Klamath temperature and health flows.

Fisheries Monitoring

Juvenile Salmon Habitat Assessment

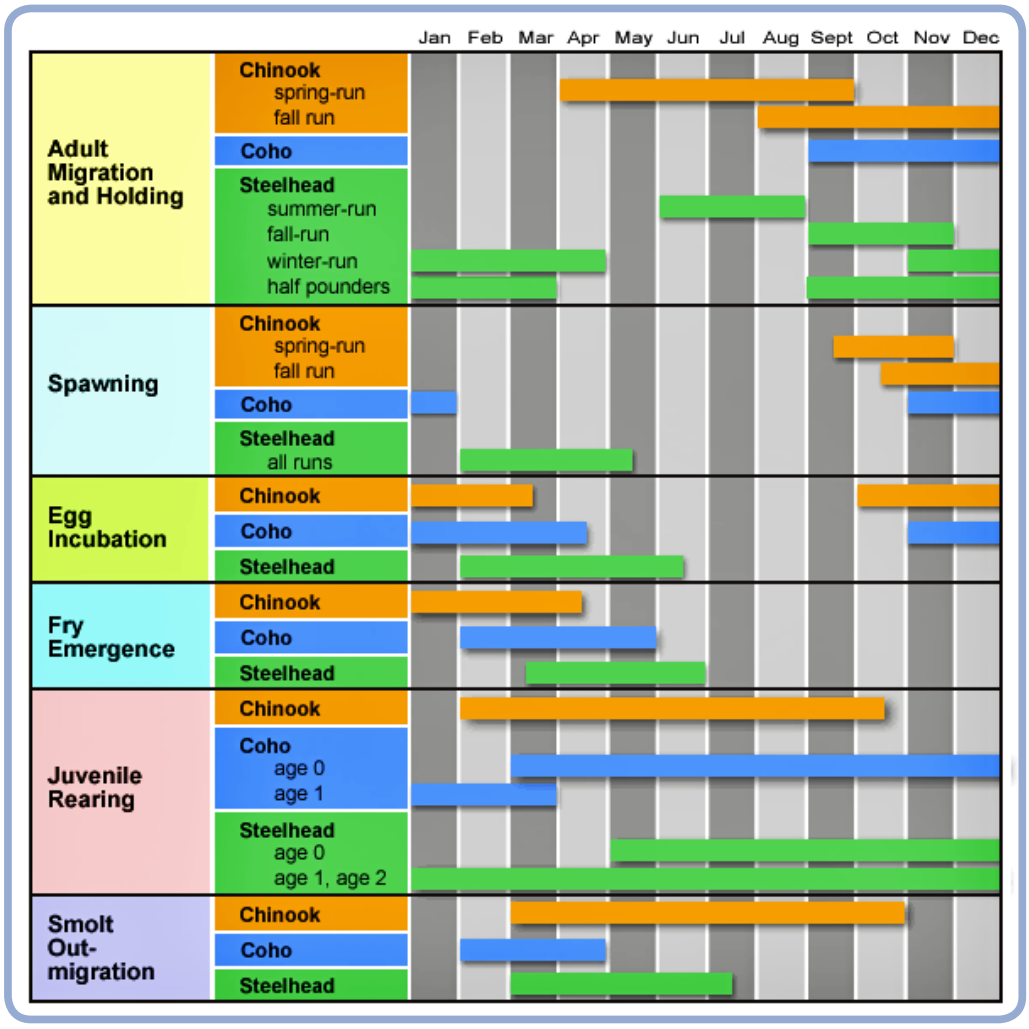
The TRRP uses two-dimensional (2D) hydrodynamic models to estimate aquatic habitat benefits for alternative channel rehabilitation projects during the design process. Recently, the program has integrated hydrodynamic modeling into its channel rehabilitation effectiveness monitoring efforts to assess channel rehabilitation efforts. We can now model the effects of channel restoration and fluvial processes on trends in habitat availability. This development facilitates closer collaboration between the habitat monitoring group, the science program, and the rehabilitation site design team.

Data Collection

In 2018, habitat data collection took 16 days. We collected data at three TRRP rehabilitation sites to help develop hydraulic models of post-construction conditions at Sheridan and Deep Gulch and pre-construction conditions for Chapman Ranch. We measured some combinations of water surface elevation and areas of inundation and depth-averaged velocities at eight streamflows ranging from 300 cfs to 5,600 cfs. We also collected bathymetric and substrate/cover data to create a terrain model and roughness estimate, respectively. These modeling data have been shared with Reclamation's Technical Service Center in a collaborative effort to complete the hydraulic and habitat-modeling portion of the Chapman Ranch Phase A project. A presentation and report evaluating the differences in preconstruction, designed and post construction habitat will be provided to the TRRP in Fall 2019 (Figure 20).

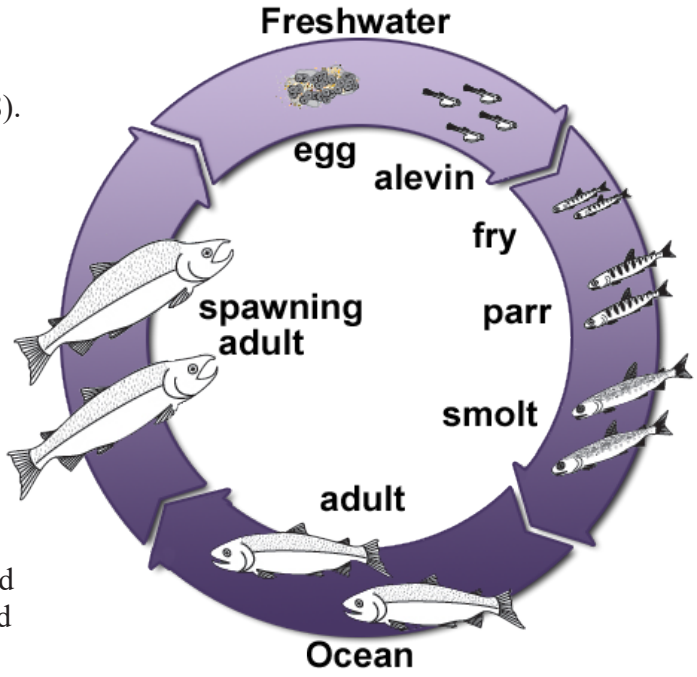
Figure 20. Habitat capacity is estimated to determine the proportion of channel rehabilitation sites with an increase in rearing habitat before and after construction.

Habitat Monitoring Synthesis Report

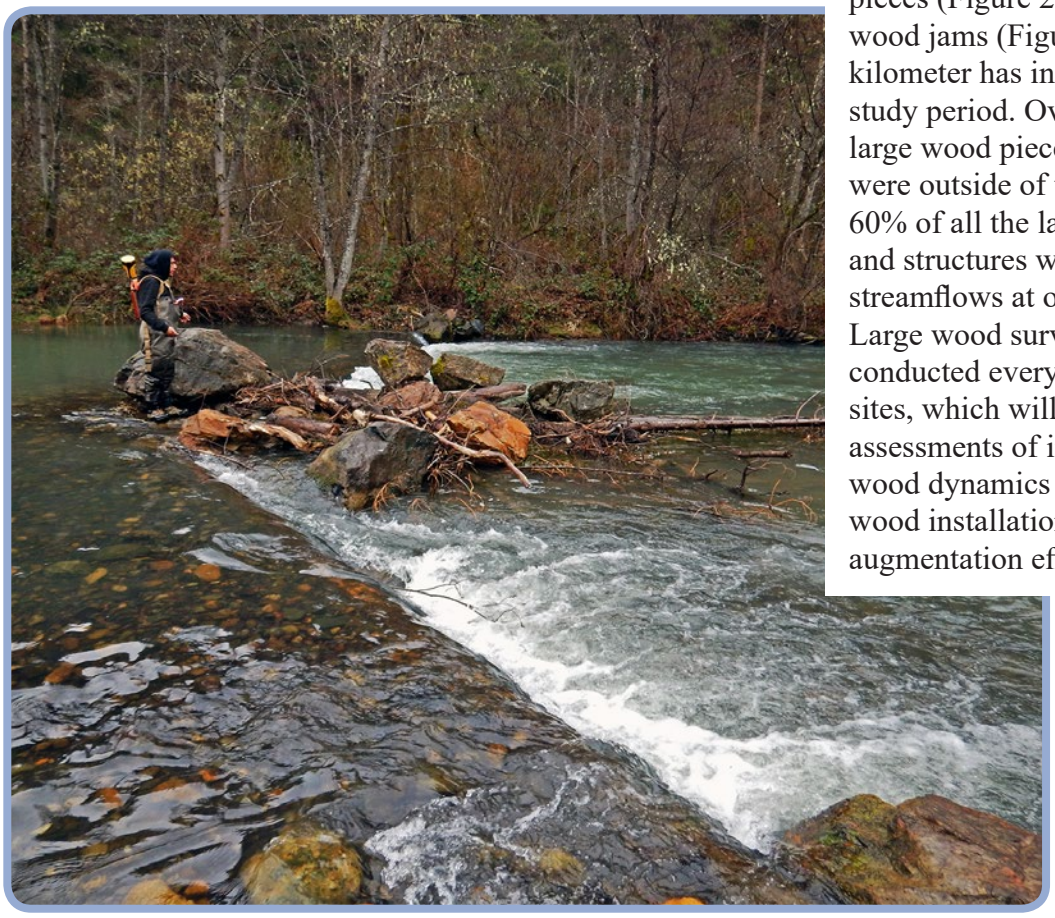


Before using 2D modeling, the habitat monitoring group measured physical habitat area by using mapping grade global positioning systems (GPS) to create geo-referenced and spatially explicit representations of rearing habitat areas. These new methods were used to assess the effects of channel rehabilitation on construction related increases and longer-term trends in rearing habitat availability at:

- Summer base streamflow throughout the restoration reach between 2009 and 2013 (Goodman et al. 2016)
- Rehabilitation sites between 2005 and 2015 as shown in Figure 20 (Boyce and Goodman 2018).



Three additional reporting efforts are being developed for delivery to the TRRP in 2018. Two reports will summarize mapping efforts: one assessing habitat availability at summer base streamflow throughout the restoration reach (2009 to 2017) and another summarizing streamflow to habitat relationships at six rehabilitation sites between 2008 and 2017. The third report estimates habitat capacity in constructed and non-constructed areas of the restoration reach at a range of streamflows using hydrodynamic model outputs of depth, velocity, and distance to cover generated from a TRRP sponsored restoration reach-wide modeling effort in 2016.



Large Wood Monitoring for Juvenile Salmonid Rearing Habitat

The TRRP implements large wood augmentation at channel rehabilitation sites to promote dynamic flows with more natural river processes and provide juvenile salmonid rearing habitat. In 2018, we completed a report on all large wood placement at rehabilitation sites immediately after construction between 2005 and 2016 to help develop a large wood management strategy for the program (Boyce and Goodman 2018). Over the years, as we have determined the value of large wood, we have incorporated more large wood (Figure 21) into rehabilitation projects (Figure 22). Thus, the number of large wood pieces (Figure 21) and constructed wood jams (Figure 22) per river kilometer has increased over the study period. Over 80% of placed large wood pieces and structures were outside of the mainstem. About 60% of all the large wood pieces and structures were inundated at streamflows at or below 500 cfs. Large wood surveys have been conducted every year at multiple sites, which will facilitate assessments of inter-annual large wood dynamics and longevity of wood installations to inform future augmentation efforts.

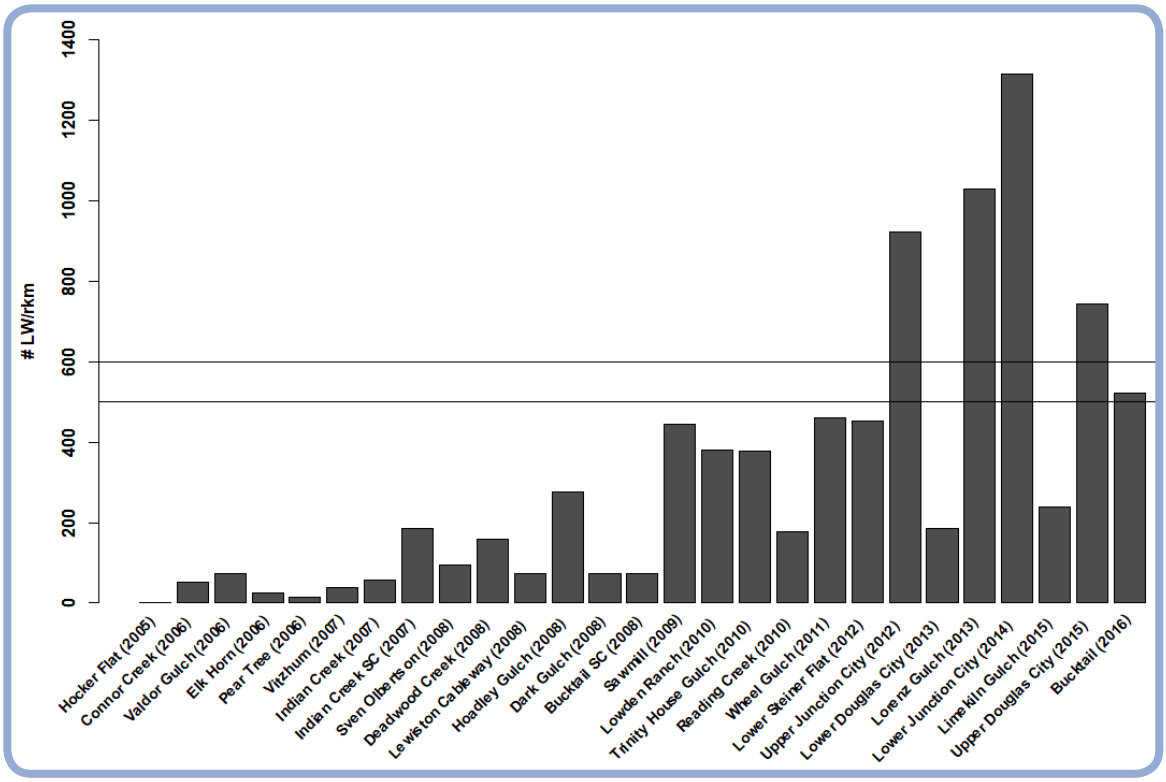


Figure 21. The total number of installed large wood pieces per river kilometer (LW/rkm) for each rehabilitation site after construction. The lines indicate the range of Trinity River-specific recommendations for large wood loading (Cardno Entrix and CH2MHill 2011). Sites are ordered chronologically.

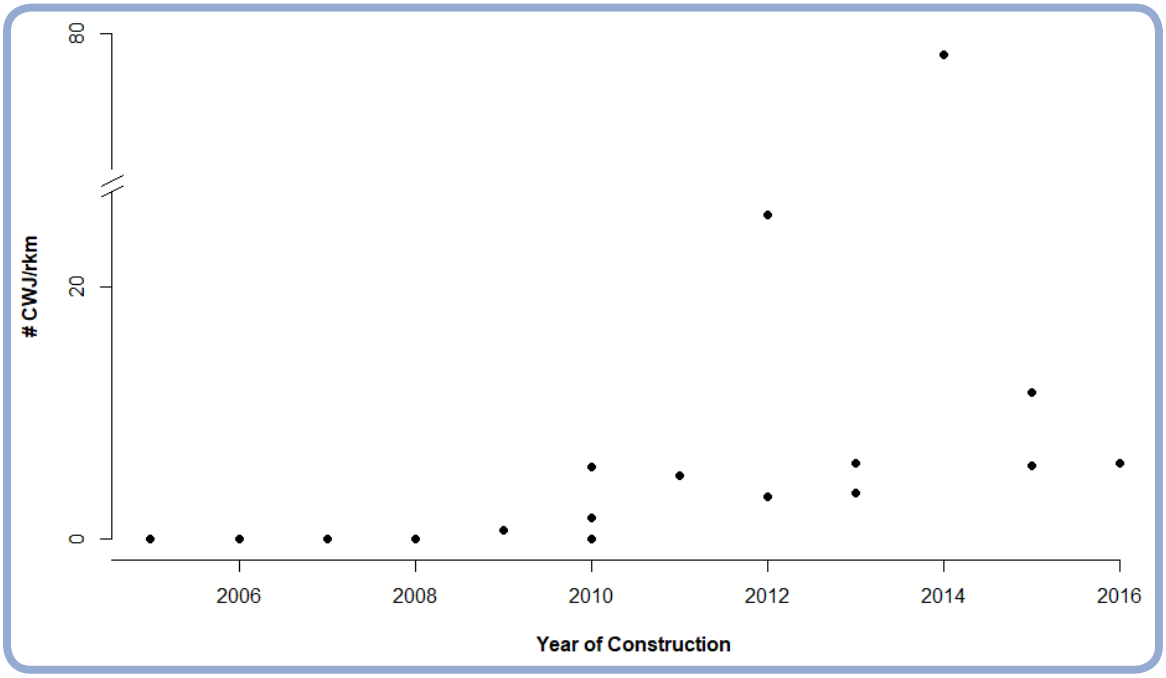


Figure 22. The number of constructed wood jams per river kilometer (CWJ/rkm) over the study period. Note, the y-axis contains a break from 30 to 50, which highlights the increasing trend in wood jam density over time. In certain years, 2010, 2012, 2013, and 2015, multiple channel rehabilitation projects were completed and the constructed wood jams mapped.

Juvenile Chinook Salmon Abundance

We have monitored juvenile Chinook salmon at two sites, Willow Creek Trap and Pear Trap, since 2007. Annual population estimates of naturally produced juvenile Chinook salmon (spring- and fall-run combined) have been conducted on the Trinity River since 1989. Population estimate data is collected at the Willow Creek rotary screw trap site (WCT) and at the Pear Tree Gulch rotary screw trap site (PT) (Figure 23).

Since the TRRP began restoration work on the Trinity River in 2005, instream survival of naturally produced juvenile Chinook salmon has shown an increasing trend, as measured by the estimates of juvenile fish swimming through the rotary screw trap site in Willow Creek on the Trinity River. A severe California drought beginning in 2014 may have influenced the low spawning population size in 2015 and 2016.

Further analyses on population estimates are currently in progress, including relating the size of the spawning population to the number of juveniles produced, as well as examining habitat availability and temperature regimes to assess factors that influence juvenile population sizes.

It is natural for salmon populations to vary dramatically from year to year—reflecting variation in freshwater and marine conditions and the adult harvest levels.

Salmon Redd Distribution and Abundance

To evaluate the distribution and abundance of Chinook salmon spawning activity, the USFWS, USFS, CDFW, the Hoopa Valley Tribe, and the Yurok Tribal Fisheries Program conduct salmon spawning surveys annually on the mainstem Trinity River (Table 6, Figures 24, and 25).

Table 6. Estimated Numbers of Chinook and Coho Salmon Redds Observed in the Mainstem Trinity River in 2018

Species	Origin	2017
Chinook Salmon	All	2,343[b]
	Natural	1,545
	Hatchery	798 (613 - 930)
Coho Salmon[a]	All	15[b]
	Natural	NA
	Hatchery	NA

Bootstrap-generated 95% confidence intervals are in parentheses.
[a]Our survey season only partially covers the Coho salmon spawning period.
[b]Confidence intervals are generated with both Chinook and Coho salmon data. Not enough Coho salmon female carcasses were found in 2018 to calculate a confidence interval.

—continued

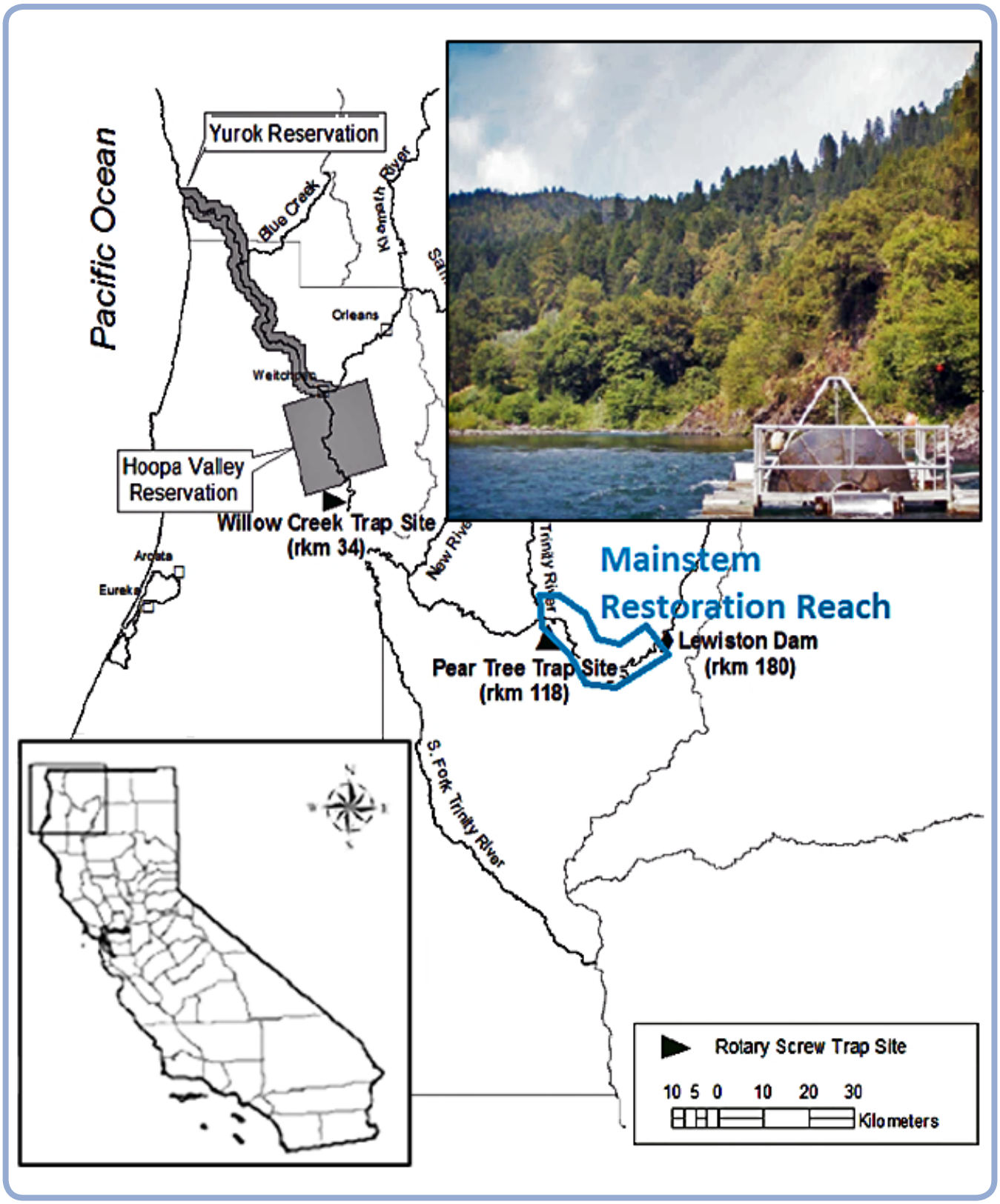


Figure 23. Map of the screw trap sites in 2018 with screw trap inset. The Pear Tree rotary screw trap site captures juvenile salmon that originated from the watershed within the Trinity River restoration reach between Lewiston Dam and the North Fork Trinity River.

Figure 24. TRRP partner agencies conduct redd and carcass surveys on the Trinity River and its tributaries throughout the spawning season.

Figure 25.Sterling Fulford of the USFWS rowing down the Trinity River, California, during a salmon redd/carcass survey on one of the better-weather days.

—Fisheries Monitoring continued

During the 2018 surveys, we located 2,358 salmon redds and examined 2,593 salmon carcasses. Of these, 812 were fresh Chinook salmon and 3 were fresh Coho salmon carcasses. Natural-origin Chinook salmon built an estimated 1,545 redds, hatchery-origin Chinook salmon built 798 redds, and Coho salmon built the remaining 15 redds (Table 6). While slightly improved from 2017, the number of redds observed in 2018 was the fourth lowest since the survey, in its current iteration, was initiated in 2002 (Figure 26).

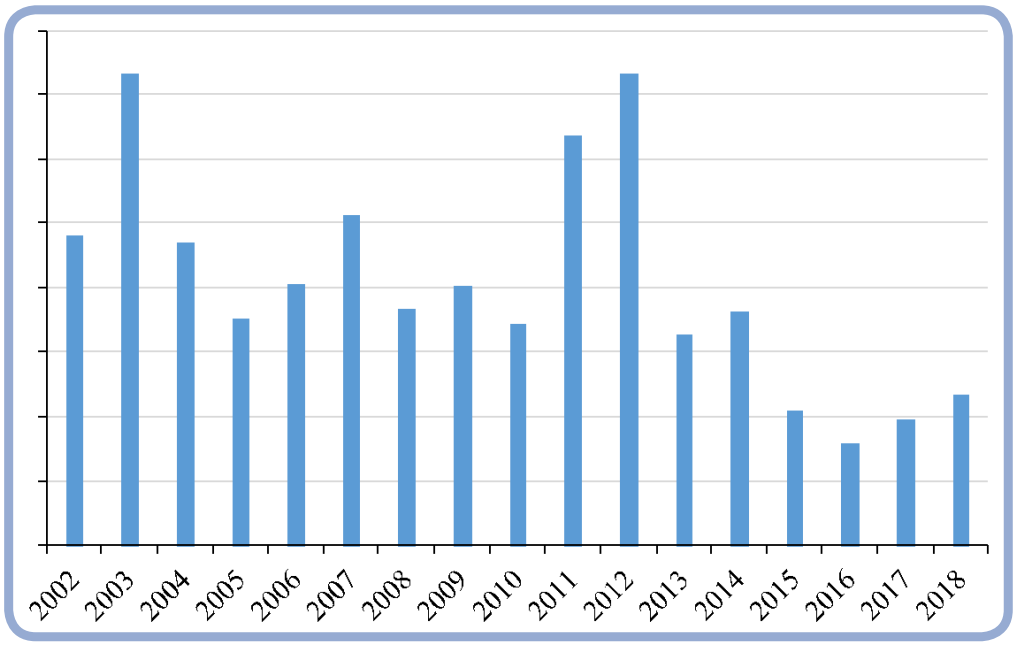


Figure 26. Estimated numbers of Chinook salmon redds in the mainstem Trinity River, California, from 2002 to 2018.

Hatchery-origin Chinook salmon tended to spawn relatively close to Lewiston Dam, the location of the Trinity River Hatchery, while natural-origin Chinook salmon spawned throughout the mainstem, particularly within the restoration reach (Figure 27).

Salmonid Spawning Escapement and Harvest

TRRP supports monitoring for run-size and escapement of naturally-produced and Trinity River hatchery-produced spring and fall run Chinook (Figure 28) and Coho salmon as well as adult fall steelhead. The estimated escapement of adult fall Chinook salmon to natural spawning grounds in the Trinity River Basin in 2018 is 14,499 fish. Estimates for 2018 indicate that 12,260 naturally-produced fall Chinook salmon and 13,628 hatchery-produced fall Chinook salmon returned to natural river areas or the Trinity River Hatchery (including age-2 jacks). Details on the 2018 escapement monitoring for Trinity River salmonids are provided in Table 7 and a recent perspective of adult naturally-produced fall Chinook salmon escapement is presented in Figure 29.

—continued

Table 7. Preliminary 2018 Adult Escapement Estimates for Trinity River Salmonids (Kier et al. 2019 in preparation)

Species	Natural Origin Escapement		Hatchery Origin Escapement	
	2018	Program Goal	2018	Program Goal
Spring Chinook salmon	1,964	6,000	4,902	3,000
Fall Chinook salmon	8,357	62,000	13,284	9,000
Coho salmon	42	1,400	1,017	2,100
Fall steelhead adults	2,326	40,000	3,402	10,000

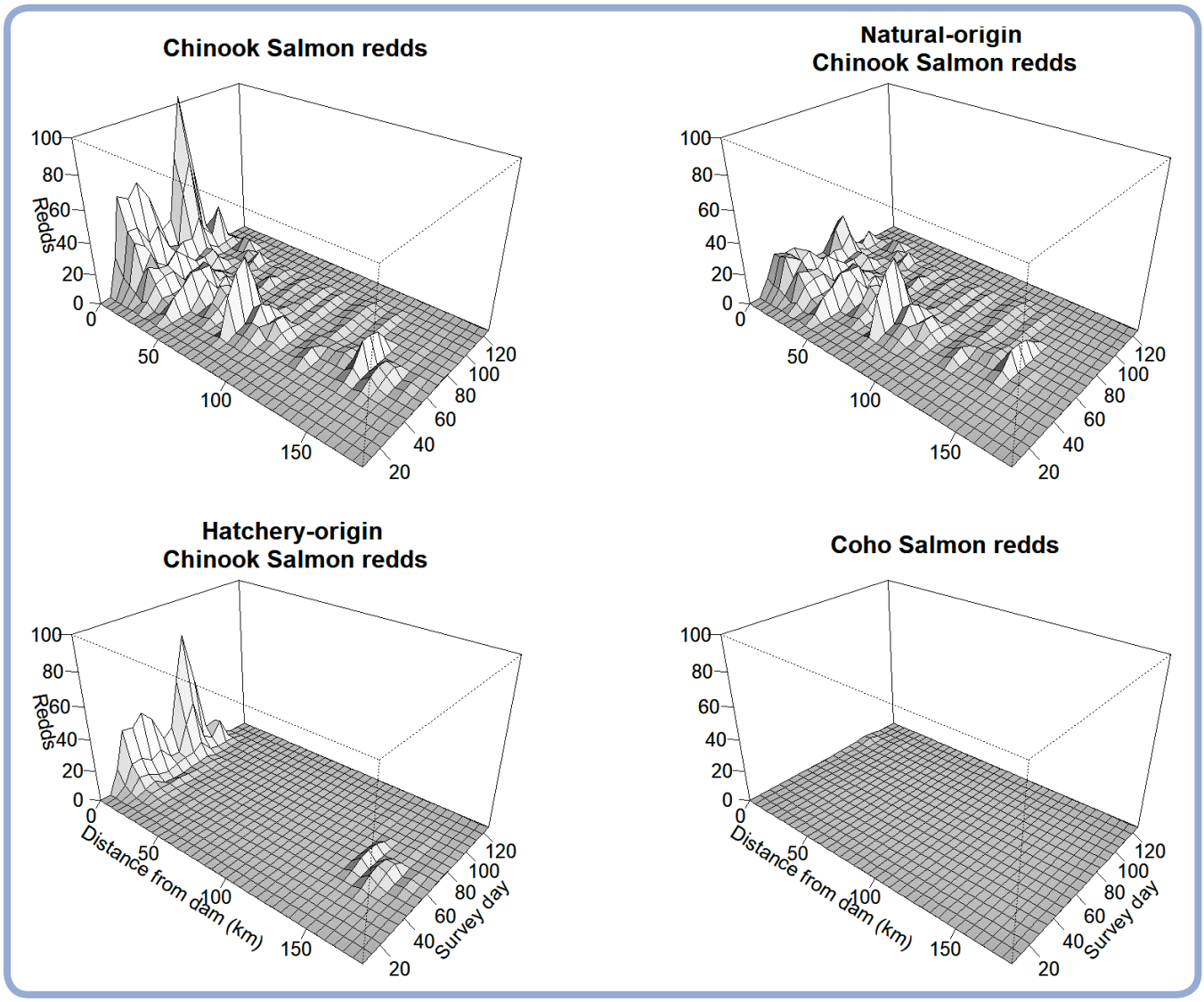


Figure 27. Spatiotemporal distribution of salmon redds observed in the mainstem Trinity River, California, in 2018. Pigeon Point and Burnt Ranch whitewater reaches were not surveyed. Survey Day I = September 1, 2018.

—Fisheries Monitoring continued

Adult Fall Run Chinook Salmon Harvest

TRRP supports dependent ocean fisheries, as well as in-river recreational and tribal fisheries as part of the goal to restore anadromous fish populations. Natural and hatchery-produced fall Chinook salmon from the Trinity River support the recreational fishery and the Hoopa Valley Tribal fishery on the Trinity River and contribute to the recreational fishery and the Yurok Tribal fishery in the lower Klamath River below its confluence with the Trinity River.

Figure 28. Spring-run Chinook holding in the trap at Junction City weir. These fish were tagged and released upstream (to continue their migration) as part of the run-size estimate.

In 2018, the estimated adult fall Chinook salmon harvest for the recreational fishery upstream of Willow Creek weir was 961 fish on the Trinity River and 2,038 fish on the lower Klamath River (river mouth to Weitchpec). The estimated tribal harvest of adult fall Chinook salmon was 2,325 fish by the Hoopa Valley Tribal fishery and 12,444 fish by the Yurok fishery.

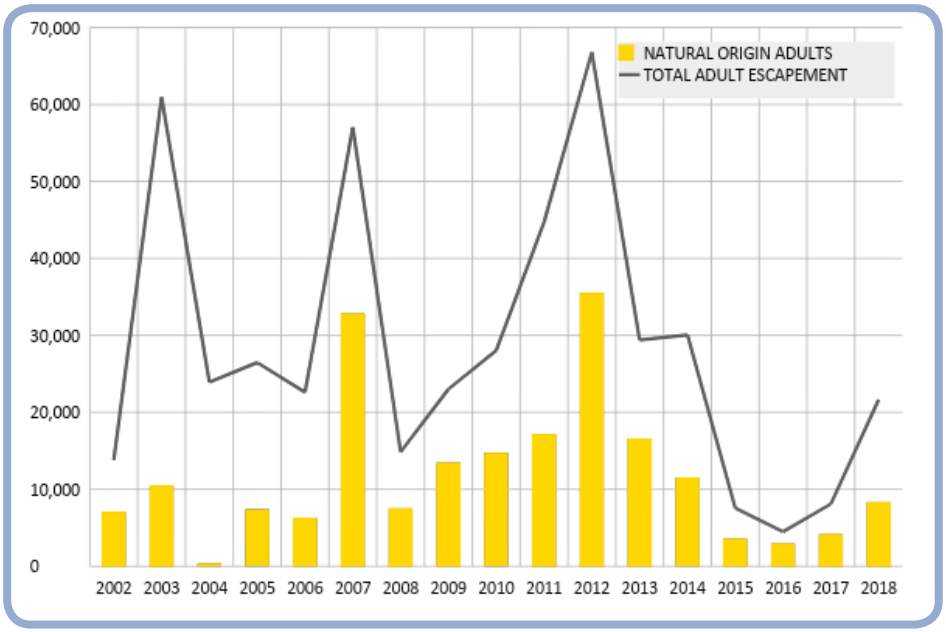


Figure 29. Naturally-produced adult fall Chinook salmon escapement upstream of Willow Creek Weir, 2002 - 2018 (includes returns to natural spawning areas and Trinity River Hatchery).

Data Management

Effective data stewardship improves the efficiency and rigor of data use and provides a foundation for Adaptive Management. The Program's online data portal (DataPort) at www.trrp.net/dataport is a key resource for managing Program information and coordinating data across the partnership. Data stewardship encompasses this information throughout the data life cycle to ensure that data are:

- Developed appropriately
- Accessible for efficient use
- Properly analyzed
- Maintained to enable future use

DataPort Library

The DataPort library (http://www.trrp.net/library) provides convenient access to over 1,500 reports and other documents ass well as over 90 data packages, many of which are scanned reports and documents dating back to 1900. A growing number of data resources are managed through the DataPort, which are integrated into other portions of the website. The TRRP.net home page (http://www.trrp.net) itself has a table of current river flows and multiple graphs that are resourced from the DataPort. The Restoration Action Database (RAD) (http://www.trrp.net/dataport/rad/) is a new resource within the DataPort for summarizing completed restoration activities both on the Trinity River mainstem and within its watershed.

River Views

During the summer of 2018, approximately 1,500 "photospheres" were taken along the Trinity River by raft. Photospheres are like panoramic images, but go all the way around, up, and down, so there is imagery in all directions. These photos were taken by a camera with two fish-eye lenses pointed in opposite directions. These photos seem very distorted when viewed flatly, but specialized viewers allow end-users to pan around to look in any direction. Our intent is to provide access to these through the DataPort at (http://www.trrp.net/riverview) with a feature similar to Google's "Street View." People browsing the website will be able to move up and down the river to see conditions at a point-in-time from a rafting point-of-view (Figure 30 and Figure 31).

Mary Claire Kier, Trinity River Project Environmental Scientist for California Department of Fish and Wildlife

Mary Claire Kier started working for California Fish and Game in the Klamath estuary in 1992 just days after receiving her B.S. in Fisheries from Humboldt State University. She escaped to the Trinity River in 2008 to manage the Willow Creek weir, annually estimating salmonid run-sizes. Upon arriving to the weir site for the first time, Mary Claire couldn't get over the fact that it smelled awfully familiar—she was later to learn that the weir site was upstream a single bend from her grandmother's old cabin, where as a youngster she spent many a summer day wading and watching stream critters. When she's not hanging out in rivers, Mary Claire is hanging out with her husband, Michael, as they navigate life now that their two sons have fledged.

Figure 30. Flat view of a "photosphere" taken by raft from the Trinity River near Lorenz Gulch, July 2018.

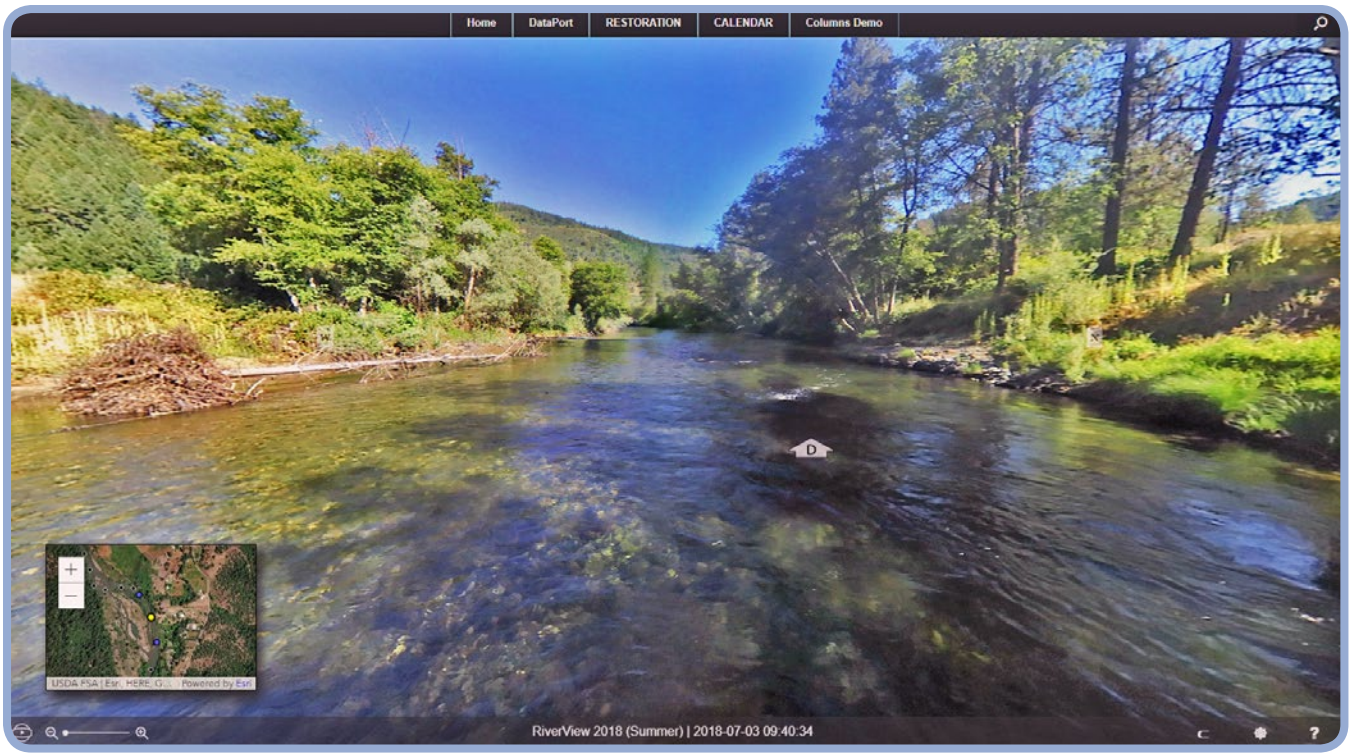


Figure 31. The same "photosphere" as in the previous figure (looking downstream), shown in a specialized viewer. This viewer allows the photo to be rotated any direction and connects to the next photos downstream and upstream.

Aerial Photography

High-resolution aerial photography may be TRRP's most widely used type of data since it provides the context for documenting changes in the river channel, designing restoration actions, planning scientific investigations, and communicating both within the TRRP and with the public. Aerial photography data sets going as far back as 1944 allow the public and TRRP partners to view changes on the river over time and are available at: http://www.trrp.net/dataport/map.

Aerial photography for 2018 was collected July 25, 2018, just before air traffic was shut down by the nearby Carr fire. The river experienced a significant bloom of green algae over the summer; although faint, the algae is visible in the imagery (Figure 32).

In addition to aerial photographs, detailed topographic models from data collected by aerial LiDAR (light detection and ranging), photogrammetry from unmanned aerial systems (UAS, a.k.a. "drones"), and boat-based bathymetric sonar are often completed to document changes at rehabilitation sites or other locations along the river. Reach-wide data collection occurs less frequently due to the cost of data collection. Following a motion by the TMC, all uses of UAS under TRRP activities are now reported on our website: http://www.trrp.net/dataport/uas/.

Figure 32. Aerial images in the Evans Bar area from 2017 and 2018. Admittedly difficult to see in this figure, a green cast due to algae is visible within much of the channel in 2018.

Environmental Compliance and Mitigation

NEPA, CEQA, and Other Mandates

To meet NEPA and CEQA requirements, TRRP continues to inform the Northern California community, including partners, collaborators, and public and private stakeholders, about its proposals. Public meetings are held during the early stages of project site design and gravel augmentation planning (Figure 33). Subsequent meetings also help keep the public informed about any modifications made to the designs based on public or agency input and associated monitoring and evaluation before, during, and after in-channel project construction and revegetation.

The TREIS/EIR serves as the programmatic document under NEPA, and the Master EIR serves as the programmatic document under CEQA.

In addition to NEPA and CEQA, the following statutes, Acts, and Executive Orders (EO) provide regulatory guidance and are programmatically discussed in the Master EIR. These broadly define the type and intensity of actions that the TRRP may perform to benefit the health of the Trinity River fishery:

Figure 33. A public meeting was held November 28 in Junction City to discuss the Chapman Ranch Phase A channel rehabilitation project as well as additional proposed projects in the Junction City area.

- Endangered Species Act (ESA) of 1973
- Clean Water Act
- Wild and Scenic Rivers Act
- National Historic Preservation Act of 1966
- Archaeological Resources Protection Act of 1979
- EO 11988 for Floodplain Management
- EO 11990 for the Protection of Wetlands
- EO 13112 for Invasive Species
- EO 12898 for Environmental Justice

Channel Rehabilitation Compliance

In 2018 TRRP staff worked with partner agencies and the BLM on the environmental and legal permitting for upcoming channel rehabilitation sites, including for the Chapman Ranch Phase A and Dutch Creek sites. Channel rehabilitation projects are designed to enhance natural river processes with the allowable level of flows released from Lewiston Dam.

Activities associated with channel rehabilitation projects have the potential to result in short- and long-term impacts on protected Trinity River resources. Monitoring and mitigation help ensure long-term beneficial results.

Biological Assessments

TRRP continued working towards updating Biological Assessments (BA) to address potential new effects of restoration activities on species (or their habitats) listed as threatened or endangered and to update its programmatic coverage under the ESA. BAs are expected to include:

1. Process-based sections where expert review of proposed actions may facilitate work when site-specific evaluations are not feasible
2. Effects analyses for watershed activities that cover a range of work areas, including habitat and sediment management efforts
3. Monitoring activities that evaluate the effects of restoration activities on fish populations

In the same way that TRRP works with private landowners to implement mutually beneficial projects across individual ownerships, TRRP works with Federal partners to ensure that environmental compliance meets the needs of various government agencies. As part of this effort, Reclamation is working with TMC member agencies and Federal land managers (i.e., BLM and USFS) to update the TRRP impact analyses to meet the satisfaction of all Program partners.

Reclamation anticipates completing draft BAs in collaboration with public land managers in BLM and USFS within the next year and will be in formal consultation with the USFWS and NOAA Fisheries until programmatic Biological Opinions are completed after that. While Reclamation is in formal consultation, the 2000 Biological Opinions (as amended) (NMFS 2000), with guidance from the draft BAs, will remain in effect to meet ESA compliance requirements.

Brandt Gutermuth, TRRP Environmental Scientist, Reclamation

Brandt received a B.S. in biology from the University of Michigan, Ann Arbor in 1982 and his M.S. in Fisheries from the University of Washington, Seattle, in 1987.

After studying statistics and invertebrates (Dungeness crab) in Washington, he left to work for the Utah Division of Wildlife Resources to monitor its diminishing desert fishes. In 1995, he returned westward to work in Oregon for private industry evaluating the effects of algae harvest on endangered suckers in and around Upper Klamath Lake. It's been said that it's Brandt's fault that Reclamation had to screen the A-canal in Klamath Falls.

After monitoring the demise of ecosystems in multiple locations, Brandt wanted to help—to buck the trend and bring back form and function to the Trinity River. So for almost two decades now, he has worked to save salmonids! Working for Reclamation as an environmental scientist, he continues to endeavor to reduce red tape in river restoration at the TRRP. TRRP has put many quality projects on the ground, and Brandt has learned all about complex environmental regulation. Unfortunately it is still not easy to put restoration on this earth.

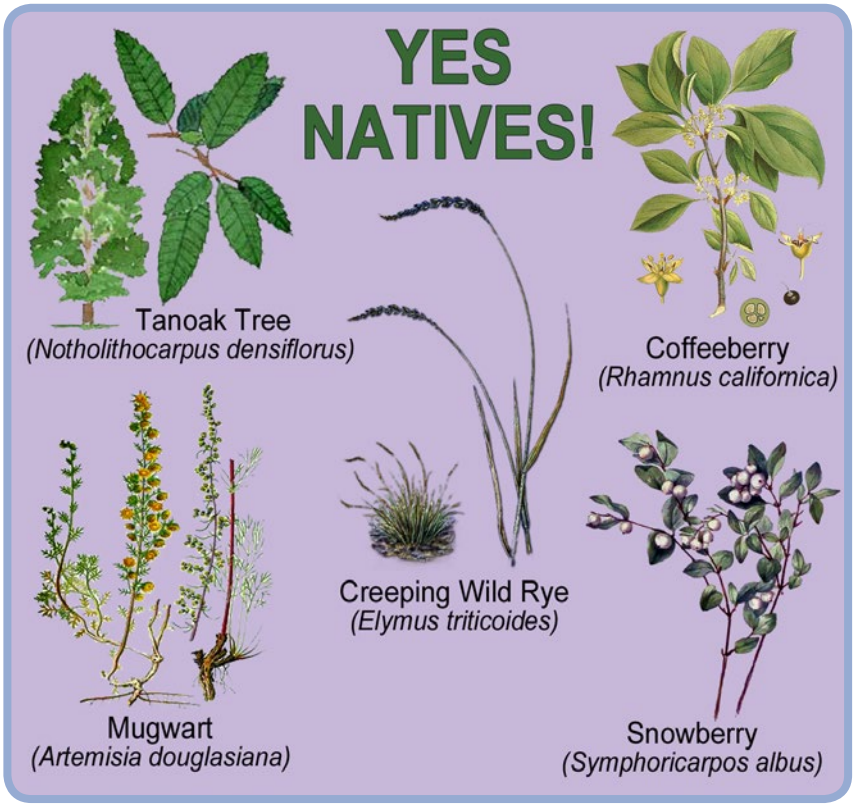
Brandt and his wife, Angela, feel blessed to bring their daughters up in Trinity County. In their family free time they all love to get out—on the trails and rivers and in the mountains.

Figure 34. Invasive species harm native vegetation and habitats.

Environmental Mitigation

To support long-term benefits to the Trinity River fishery and associated habitats, specific measures are required to avoid, minimize, and mitigate short-term adverse effects, such as removing riparian and wetland vegetation. TRRP uses performance monitoring to determine the success of mitigation efforts during and after construction. Environmental permits require no net loss of riparian lands and wetlands. This monitoring has enhanced understanding of vegetation performance and contributed to new methods to increase vegetation survival. These new methods now include irrigation, soil amendments (to fertilize and hold water), and increased excavation to lower floodplains so that plants may access the groundwater table more frequently.

Other methods are used to counter invasive species which can out-compete native vegetation, such as Dyer's woad (*Isatis tinctoria*), star-thistle (*Centaurea solstitialis*), and tree-of-heaven (*Ailanthus altissima*) (Figure 34). Drought and high temperatures can substantially reduce the survival rate of native plants, which means that crews must return to the project sites to monitor and counter vegetation losses to keep native plant survival at or above replacement requirements.



Cultural Resources

The TRRP works with BLM, USFS, and Reclamation archaeologists to evaluate the status of cultural resources (e.g., old homesteads, apple orchards, and mining remnants) at proposed channel rehabilitation sites (Figure 35). This work helps meet guidelines of the Archaeological Resources Protection Act of 1979 when working on federally managed and private lands adjacent to the Trinity River.

Much of TRRP's work is confined to the floodplain, where historic resources have lost much of their integrity during flood events. However, the large scope of the channel rehabilitation projects and the remaining historic sites along the river (e.g., the Trinity Historical Mining District) highlight the need for a comprehensive analysis of historic resources throughout the restoration reach. Pre-project surveys at channel rehabilitation sites enable TRRP to design around areas that might be of historic interest. Cultural resource reports summarizing surveys at Chapman Ranch and Dutch Creek are underway to support current channel rehabilitation proposals.

Figure 35.Cultural Resource Specialist, Eric Ritter from BLM during a site visit at a proposed channel rehabilitation site in Junction City.

Floodplain Mapping

New Flood Insurance Rate Maps (FIRM), also called Flood Hazard Maps, for Trinity River Federal Emergency Management Agency (FEMA) became effective in 2016. The TRRP works with Reclamation's Technical Service Center, Trinity County and FEMA to update the FIRMs to include changes from projects constructed in 2015 and 2016 through the Letter of Map Revision (LOMR) process.

Trinity County submits a Conditional Letter of Map Revision (CLOMR) application prior to construction and follows up with a LOMR application based on surveyed conditions and hydraulic modeling post-construction to ensure that projects maintain or decrease flood elevations around structures.

Reclamation conducts hydraulic modeling of the design condition to evaluate impacts of the proposed project on flood elevations and assists the County in submittal of the CLOMR application. At the Bucktail project (built in 2016), hydraulic modeling of the post-project surveyed "as-built" condition was completed. The County submitted the LOMR application to FEMA and notified local landowners that the floodplain modeling predicted during the CLOMR notification was correct and LOMR modeling confirms that 100-year flood elevations have not increased near structures (Figure 36).

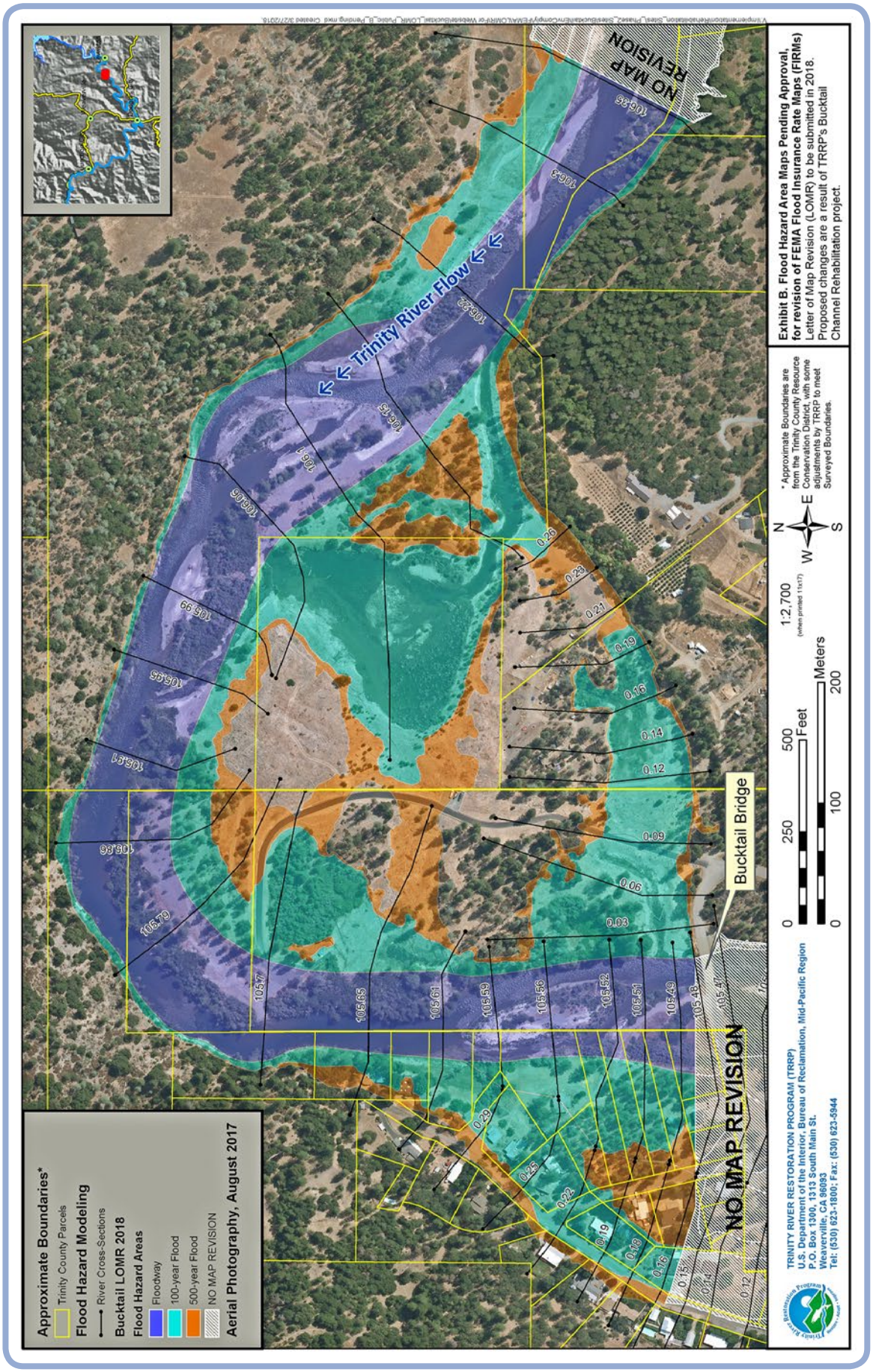


Figure 36. In the 2018, the FEMA Flood Hazard Zone boundary review at the Bucktaill subdivision near the Bucktail channel rehabilitation project was completed, and no map revisions were needed.

Public Outreach in 2018

The TRRP is committed to engaging the community and stakeholders in a variety of ways. Whether through public events, education opportunities, public meetings, or online resources, TRRP strives to inform and work with a diverse group of stakeholders.

Public Events

TRRP engages with community members to share our habitat restoration approach at a variety of public events. Two public rafting trips on the river in 2018 provided opportunities for the community, stakeholders, river-front private property owners, and people interested in learning more about the Trinity River to see the river from a unique perspective with a host of natural resource and river restoration professionals (Figure 37).

Figure 37. TRRP sponsors free rafting trips for the public as an opportunity to share information about the river and the efforts to recover naturally spawning salmon and steelhead. Here TRRP Geomorphologist, Dave Gaeuman, points out several constructed habitat features at the lower Junction City channel rehabilitation site.

Public Meetings and Workshops

TRRP holds formal and informal public meetings to increase public knowledge and understanding of program activities. Improving public understanding will help facilitate a collaborative process that incorporates public input. Several of these meetings were held to describe projects proposed for implementation in 2018 and to provide information to the public on restoration objectives.

Formal public meetings were held to November 28, 2018 on the proposed channel rehabilitation projects in the Junction City area.

TRRP held a Flow and Gravel Recommendation informational meeting on April 12, 2018 to provide a forum for residents to learn about the 2018 flow release schedule based on the forecasted critically dry water year designation and the associated gravel augmentation recommendations.

In addition to formal meetings to describe proposed projects and their potential environmental impacts, TRRP staff regularly meet with various stakeholders in a variety of field and office visits.

These meetings provide an important venue for the community to ask questions on restoration activities and provide input and feedback on restoration activities.

Figure 38. TRRP Riparian Ecologist James Lee provides a lesson on aquatic ecology to a group of fourth graders from Weaverville Elementary School.

Community Events and Education

The TRRP continues to provide financial support to the Trinity County Resource Conservation District for the Trinity River Salmon Festival, Trinity County Fair, Day at the Wetlands, Weaverville Summer Day Camp, and sixth grade Environmental Camp (Figure 38). Supporting interactive learning opportunities designed to connect community youth with the species, natural cycles and cultural importance of the Trinity River inspires the next generation of river stewards.

Community events offer opportunities for people dedicated to improving the Trinity River to share information.

Conservation Almanac

TRRP continued funding for the publication and distribution of Trinity County Resource Conservation District's newsletter, the Conservation Almanac (http://tcrcd.net/index.php/publications-and-downloads/conservation-almanac). The almanac reaches over 300 people every quarter and highlights the importance of Trinity County's natural resources and the benefits of a healthy watershed.

Internet and Media Presence

In addition to resources on Trinity River flows, calendar announcements, scientific data, technical papers, and other information are regularly updated on the TRRP website (http://www.trrp.net/).

Several articles regarding the Program's 2018 activities appeared in various regional media. The Program also funds the outreach website.

Trinity River Restoration Program

Looking Ahead: 2019 Program Activities

In 2019, the Program continues to execute the restoration strategy based on the ROD, the TREIS/EIR, and the Flow Study. Activities proposed for the year include:

- Provide flow schedule modeling, planning, and implementation
- Continue supporting efforts to identify priority watershed improvement projects
- Develop recommendations for coarse sediment augmentation, depending on the water year type
- Add gravel based on how much water is available to mobilize it
- Continue monitoring and assessment projects
- Continue channel rehabilitation site design and implementation

Flow Management

The Program will continue its consultation for flow management with NOAA Fisheries and the USFWS under Section 7 of the ESA to broaden the area of the analysis so that BAs may be used to support restoration activities on federally managed lands throughout the Trinity River watershed.

Environmental Compliance

Restoration activities continue to evolve through adaptive management as new information is collected and evaluated.

TRRP continues its consultation with NOAA Fisheries and the USFWS under Section 7 of the ESA for environmental compliance. As the consultation progress, we are working to broaden the area of the analysis so that BAs may be used to support restoration activities on federally managed lands throughout the Trinity River watershed.

TRRP continues to consult with FEMA on FIRM maps for recently completed Deep Gulch and Sheridan Creek.

Stakeholder Involvement

Outreach and other forms of stakeholder involvement continue through:

- Updating and adding new features to the TRRP website (http://www.trrp.net/) to share program information in easily accessible platforms
- Creating new opportunities with new stakeholder groups, such as fishing guides
- Working with river-front property owners and private landowners on rehabilitation projects in the Junction City area

TMC partners in 2018 touring sites completed in 2017 (Deep Gulch and Sheridan Creek).

Implementation Monitoring

TRRP continues to expand its approaches to monitor gravel movement, physical habitat attributes, and juvenile rearing to track the effectiveness of sediment management and channel rehabilitation projects.

To develop a cohesive program-wide approach to monitoring, TRRP workgroups are coordinating with the TMC and leadership to refine their various area's targets and objectives. By 2019, this will result in workgroups:

- Identifying and justifying recommendations of objectives to be dropped
- Determining revise objectives and targets for metrics that have been agreed upon
- Identifying highest priorities of objectives to refine or drop targets

Channel Rehabilitation

TRRP will begin construction on the Chapman Ranch Phase A channel rehabilitation project, several miles upstream from Junction City, California. In addition to the Chapman Ranch Phase and Dutch Creek projects, TRRP design teams will continue to develop and review designs and regulatory permitting for the Sky Ranch and Oregon Gulch channel rehabilitation projects.

Important Terms

Anadromous Fish. Fish that spawn in fresh water, migrate to the ocean to grow, and then return to fresh water to spawn (e.g., salmon and steelhead).

Fossilization. The process of stabilization and "hardening" of gravel bars by rooted riparian vegetation, which also contributes to increased deposition of alluvial silts on the bars, promoting establishment of yet more vegetation and so on.

Geomorphology. The science of landforms, with an emphasis on their origin, evolution, form, and distribution across the physical landscape.

Hydraulic action. Moving or wearing down of material by flowing water. In geographic processes, hydraulic action is also known as erosion.

Hydrograph. A chart that displays the change of a hydrologic variable over time. A discharge hydrograph, for example, shows the rate of flow (discharge) past a specific point in a river on the x axis and the time on the y axis.

Hyporheic zone. A region beneath and alongside a streambed where shallow groundwater and surface water mix.

LiDAR—light detection and ranging. An optical remote-sensing technique that uses laser light to densely sample the surface of the earth, producing highly accurate depth, width, and height (x,y,z) measurements.

Morphodynamic. The study of landscape changes due to erosion and sedimentation.

Point bars. Features of alluvial river channels formed by the deposition of sediment on the convex bank of a curve in the channel as erosion of the opposite concave bank occurs.

Point cloud. A set of three-dimensional point locations that provide a digital representation of an object or surface. Point clouds for natural resource sciences are typically derived from laser scanning methods, including aerial LiDAR and ground-based scanners, sonar methods for bathymetry (underwater topography), and recent methods for processing photographs with computer vision techniques. Point clouds often include thousands to millions of points.

Programmatic environmental document. A programmatic environmental impact statement evaluates the effects of broad proposals or planning-level decisions that may include any or all of the following: a wide range of individual projects; implementation over a long timeframe; and implementation across a large geographic area.

Record of Decision (ROD). A legally binding document that identifies a Federal agency's decision on how it will proceed with the proposed action identified in an environmental document prepared to comply with the National Environmental Policy Act (NEPA).

Restoration flows. All ROD-mandated flows, including summer and winter base flows and peak flows in the spring.

Riparian. On the bank of a river or other water body or the area of direct two-way interactions between aquatic and terrestrial systems.

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On the back cover: *Several views from the new River Ware system, developed in 2018, that can now be viewed at: http://www.trrp.net/dataport/riverview/*

Visit http://www.trrp.net/dataport/riverview/ to view the new River View system.

The map in the lower left corner will show where you are at on the river. Any dot can be clicked on to transport you there. Click and drag the photo to turn your view a full 360°, stopping at any angle. On a cell phone or similar device with directional sensors, you should be able to turn the phone to turn your view.

An orange arrow pointing to the right can be clicked on to display a description that may include links to other information. Clicking anywhere else rotates the photo to that spot. More information can be found by clicking on the question mark in the lower right hand corner of the screen.